U.S. DEPARTMENT OF ENERGY

SUMMARY

Final Environmental Impact Statement for the Disposal of Greater-Than-Class C (GTCC) Low-Level Radioactive Waste and GTCC-Like Waste (DOE/EIS-0375)

January 2016

U.S. DEPARTMENT OF ENERGY

COVER SHEET

Lead Agency: U.S. Department of Energy (DOE)

Cooperating Agency: U.S. Environmental Protection Agency (EPA)

Title: Final *Environmental Impact Statement for the Disposal of Greater-Than-Class C (GTCC) Low-Level Radioactive Waste and GTCC-Like Waste* (DOE/EIS-0375)[1]

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Abstract: The U.S. Department of Energy (DOE) has prepared this Final *Environmental Impact Statement for the Disposal of Greater-Than-Class C (GTCC) Low-Level Radioactive Waste and GTCC-Like Waste* (GTCC EIS) to evaluate the potential environmental impacts associated with the proposed development, operation, and long-term management of a disposal facility or facilities for GTCC low-level radioactive waste (LLRW) and DOE GTCC-like waste. GTCC LLRW has radionuclide concentrations exceeding the limits for Class C LLRW established by the U.S. Nuclear Regulatory Commission (NRC). These wastes are generated by activities licensed by the NRC or Agreement States and cannot be disposed of in currently licensed commercial LLRW disposal facilities. DOE has prepared and is issuing this EIS in accordance with the National Environmental Policy Act, Section 631 of the Energy Policy Act of 2005 (Public Law 109-58), and Section 3 (b) of the Low-Level Radioactive Waste Policy Amendments Act of 1985 (Public Law 99-240).

The NRC LLRW classification system does not apply to radioactive wastes generated or owned by DOE and disposed of in DOE facilities. However, DOE owns or generates LLRW and non-defense-generated transuranic (TRU) radioactive waste, which have characteristics similar to those of GTCC LLRW and for which there may be no path for disposal at the present time. DOE has included these wastes for evaluation in this EIS because similar approaches may be used to dispose of both types of radioactive waste. For the purposes of this EIS, DOE refers to this waste as GTCC-like waste. The total volume of GTCC LLRW and GTCC-like waste

[1] Vertical change bars in the margins of this Final EIS indicate revisions and new information added since the Draft EIS was issued in February 2011. Editorial changes are not marked.

addressed in the EIS is about 12,000 m^3 (420,000 ft^3), and it contains about 160 million curies of radioactivity. About three-fourths of this volume is GTCC LLRW, with GTCC-like waste making up the remaining one-fourth of the volume. Much of the GTCC-like waste is TRU waste. DOE has evaluated the potential environmental impacts associated with the range of reasonable alternatives for disposal of GTCC LLRW and GTCC-like waste in this GTCC EIS.

Alternatives Considered: DOE evaluated five alternatives in this GTCC EIS, including a No Action Alternative. One of the four action alternatives is disposal of GTCC LLRW and GTCC-like waste in a geologic repository at the Waste Isolation Pilot Plant (WIPP). The other three action alternatives involve the use of land disposal methods at six federally owned sites and at generic commercial sites. The land disposal alternatives consider the use of intermediate-depth borehole, enhanced near-surface trench, and above-grade vault facilities. The land disposal alternatives cover a spectrum of concepts that could be implemented to dispose of these wastes in order to enable an appropriate site and disposal technology to be selected. Each alternative is evaluated with regard to the transportation and disposal of the entire inventory, but the evaluation of human health and transportation impacts is done on a waste-type basis, so decisions can be made on this basis in the future, as appropriate.

Preferred Alternative: The preferred alternative for the disposal of GTCC and GTCC-like waste is the WIPP geologic repository (Alternative 2) and/or land disposal at generic commercial facilities (Alternatives 3-5). These land disposal conceptual designs could be altered or enhanced, as necessary, to provide the optimal application at a given location. The preferred alternative does not include land disposal at DOE sites. In addition, there is presently no preference among the three land disposal technologies at the generic commercial sites. The analysis in this Final GTCC EIS has provided the Department with the integrated insight needed to identify a preferred alternative with the potential to enable the disposal of the entire waste inventory analyzed in this EIS. Due to the uncertainty regarding the need for legislative changes and/or licensing or permitting changes, further analysis will be needed before a Record of Decision is announced. The Department has determined the preferred alternative would satisfy the needs of the Department for the disposal of GTCC and GTCC-like waste. Prior to making a final decision on which disposal alternative to implement, DOE will submit a Report to Congress to fulfill the requirement of Section 631(b)(1)(B)(i) of the Energy Policy Act of 2005 and await action by Congress. Section 631(b)(1)(B)(i) requires that the report include all alternatives under consideration and all the information required in the comprehensive report to ensure safe disposal of GTCC LLRW that was submitted by the Secretary to Congress in February 1987. DOE will not issue a Record of Decision until its required Report to Congress has been provided and appropriate action has been taken by Congress in accordance with the Energy Policy Act of 2005.

Public Comments: DOE issued an Advance Notice of Intent (ANOI) in the *Federal Register* on May 11, 2005, inviting the public to provide preliminary comments on the potential scope of the EIS. DOE then issued a Notice of Intent (NOI) to prepare this EIS on July 23, 2007; a printing correction was issued on July 31, 2007. The NOI provided responses to the major issues identified by commenters on the ANOI, identified the preliminary scope of the EIS, and announced nine public scoping meetings and a formal scoping comment period lasting from

July 23 through September 21, 2007. DOE used all input received during the scoping process to prepare the Draft GTCC EIS.

A 120-day public comment period on the Draft GTCC EIS began with the publication of the EPA Notice of Availability in the *Federal Register* on February 25, 2011 and closed on June 27, 2011. DOE conducted public hearings at nine locations during April and May of 2011. All comments received on the Draft GTCC EIS were considered in the preparation of this Final GTCC EIS.

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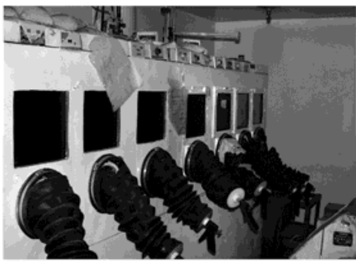
SUMMARY



Final Environmental
Impact Statement for the

Disposal of Greater-Than-Class C (GTCC) Low-Level Radioactive Waste and GTCC-Like Waste (DOE/EIS-0375)

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ACRONYMS AND ABBREVIATIONS

ags	above ground surface
ANOI	Advance Notice of Intent
bgs	below ground surface
BWR	boiling water reactor
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	*Code of Federal Regulations*
CGTO	Consolidated Group of Tribes and Organizations
CH	contact-handled
CTUIR	Confederated Tribes of the Umatilla Indian Reservation
DOE	U.S. Department of Energy
EIS	environmental impact statement
EPA	U.S. Environmental Protection Agency
FR	*Federal Register*
FTE	full-time equivalent
GMS/OSRP	Office of Global Material Security/Off-Site Source Recovery Project (NNSA)
GTCC	greater-than-Class C
HOSS	hardened on-site storage
INL	Idaho National Laboratory
K_d	distribution coefficient
LANL	Los Alamos National Laboratory
LCF	latent cancer fatality
LLRW	low-level radioactive waste
LLRWPAA	Low-Level Radioactive Waste Policy Amendments Act of 1985
LWA	Land Withdrawal Act (WIPP)
LWB	Land Withdrawal Boundary (WIPP)
NDA	NRC-Licensed Disposal Area
NEPA	National Environmental Policy Act of 1969
NOI	Notice of Intent
NRC	U.S. Nuclear Regulatory Commission
NNSS	Nevada National Security Site (formerly the Nevada Test Site or NTS)
ORR	Oak Ridge Reservation

P.L.	Public Law
PWR	pressurized water reactor
RH	remote-handled
RH LLW EA	Remote-Handled Low-Level Waste Environmental Assessment (INL)
ROD	Record of Decision
SDA	State-Licensed Disposal Area
SRS	Savannah River Site
TA	Technical Area (LANL)
TC&WM EIS	Tank Closure and Waste Management EIS (Hanford)
TRU	transuranic
USC	*United States Code*
VOC	volatile organic compound
WIPP	Waste Isolation Pilot Plant

RADIONUCLIDES

Am-241	americium-241
Am-243	americium-243
C-14	carbon-14
Co-60	cobalt-60
Cs-137	cesium-137
Fe-55	iron-55
I-129	iodine-129
Mn-54	manganese-54
Mo-99	molybdenum-99
Nb-94	niobium-94
Ni-59	nickel-59
Ni-63	nickel-63
Pu-238	plutonium-238
Pu-239	plutonium-239
Pu-240	plutonium-240
Sr-90	strontium-90
Tc-99	technetium-99

UNITS OF MEASURE

ac	acre(s)
ft	foot (feet)
ft^3	cubic foot (feet)
h	hour(s)
ha	hectare(s)
km	kilometer(s)
km^2	square kilometer(s)
m	meter(s)
m^3	cubic meter(s)
MCi	megacurie(s)
mi	mile(s)
mi^2	square mile(s)
mrem	millirem
rad	radiation absorbed dose
rem	roentgen equivalent man
yr	year(s)

CONVERSION TABLE[a]

Multiply	By	To Obtain
acres (ac)	0.4047	hectares (ha)
cubic feet (ft^3)	0.02832	cubic meters (m^3)
feet (ft)	0.3048	meters (m)
miles (mi)	1.609	kilometers (km)
square miles (mi^2)	2.590	square kilometers (km^2)
cubic meters (m^3)	35.31	cubic feet (ft^3)
hectares (ha)	2.471	acres (ac)
kilometers (km)	0.6214	miles (mi)
meters (m)	3.281	feet (ft)
square kilometers (km^2)	0.3861	square miles (mi^2)

[a] Values presented in this Summary have been converted (as necessary) using the above conversion table and rounded to two significant figures.

RADIATION BASICS

A number of terms and concepts related to radiation and radiation doses are used in this Summary. The following text boxes are provided to describe these terms and concepts to aid the readers in understanding the information provided in this Summary.

Radiation Terms and Concepts

What Is Radioactivity? Radioactivity (or activity) is the property of unstable (radioactive) atoms that causes them to spontaneously release energy (radiation) in the form of subatomic particles or photons. Radioactivity is generally measured in curies, which is a rate of radioactive decay. One curie is defined to be 37 billion disintegrations per second.

What Is Radiation? Radiation consists of energy, generally in the form of subatomic particles (neutrons and alpha and beta particles) or photons (x-rays and gamma rays) given off by unstable (radioactive) atoms as they decay to reach a more stable configuration.

How Can Radiation Be Classified? Radiation can be classified as being in one of two categories: ionizing and nonionizing (such as from a laser). The radiation associated with GTCC LLRW and GTCC like waste is ionizing radiation.

What Is Ionizing Radiation? Ionizing radiation is radiation that has sufficient energy to displace electrons from atoms or molecules when it interacts with matter, creating ion pairs. Ionizing radiation is a known human carcinogen.

What Types of Ionizing Radiation Are Associated with GTCC LLRW and GTCC Like Waste? There are five types of ionizing radiation associated with GTCC LLRW and GTCC-like waste.

Alpha Particle An alpha particle consists of two protons and two neutrons and is identical to the nucleus of a helium atom. An alpha particle has a short range in air and cannot penetrate a sheet of paper or the outer layer of skin.

Beta Particle – A beta particle can be either negative (negatron) or positive (positron) and has the mass of an electron. A high-energy beta particle can travel a few meters in air and pass through a sheet of paper but is generally stopped by a thin layer of plastic or aluminum.

Gamma Ray A gamma ray is electromagnetic radiation (photon) given off by the nucleus of an atom as a means of releasing excess energy. A high energy gamma ray can travel several hundred meters in air and requires the use of lead, steel, and concrete shielding to stop it.

X-ray An x-ray is similar to a gamma ray but originates external to the nucleus (from movement of electrons between energy shells). X-rays have less energy than gamma rays, have a shorter range, and are easier to shield.

Neutron – A neutron is one of the two primary building blocks of the nucleus (the other being a proton), and it has no electrical charge. High-energy neutrons can travel long distances in air (similar to gamma rays) and are most effectively stopped with shielding having high concentrations of hydrogen, such as water, concrete, paraffin, and plastic.

What Is Half-Life? The half life of a radionuclide is the length of time for a given amount of a radionuclide to decrease to one-half of its initial amount by radioactive decay.

Radiation Dose

What Is Radiation Dose? In general terms, radiation dose is simply a measure of the amount of energy deposited by ionizing radiation per unit mass of any material and is generally reported in rad (acronym for radiation absorbed dose). One rad is equal to 100 ergs per gram or 0.00001 joule per gram or 0.0000024 calorie per gram. An erg, a joule, and a calorie are units of measures of energy.

How Is Radiation Dose Measured in Humans? The radiation dose to humans is typically given in rem (acronym for roentgen equivalent man) and is the product of the absorbed dose (in rad) and factors related to the relative biological effectiveness of the radiation.

What Are Sources of Radiation? Radiation can come from natural sources and man-made sources. Natural sources of radiation include cosmic radiation, radioactive elements naturally present in the earth's crust and human body, and radon gas naturally present in soil and rock. Man-made sources of radiation include medical procedures, consumer products, nuclear technology (including nuclear power plants), and fallout from past atmospheric nuclear weapons tests.

How Much Radiation Dose Does an Individual Receive? The amount of radiation dose that an individual receives depends on several factors. Cosmic radiation increases with altitude, and terrestrial radiation varies by location in the country. The National Council on Radiation Protection and Measurements recently estimated that an average individual in the United States receives an annual radiation dose of about 620 mrem/yr; half of this dose is from natural sources, and half is from man-made sources, most of which is associated with medical sources.

Typical doses from various natural and man made sources and activities are provided as follows for additional context. These examples were obtained from a website of the U.S. Environmental Protection Agency, which can be consulted for further information (http://www.epa.gov/radiation/understand/calculate.html).

Source	Average Annual Dose (mrem/yr)	Source	Average Annual Dose (mrem/yr)
Cosmic radiation (from outer space)		Internal radiation (in your body)	
At sea level	26	From food and water (e.g., potassium-40)	40
Elevation up to 1,000 ft	28	From indoor air (radon and its decay products)	200
Elevation from 1,000 to 2,000 ft	31	Plutonium-powered pacemaker	100
Elevation from 2,000 to 3,000 ft	35	Air travel by jet	
Elevation from 3,000 to 4,000 ft	41	For each 1,000 miles traveled	1
Elevation from 4,000 to 5,000 ft	47		
Elevation from 5,000 to 6,000 ft	55	Medical diagnostic procedures	
Elevation from 6,000 to 7,000 ft	66	Each medical x ray	40
Elevation from 7,000 to 8,000 ft	79	Each nuclear medicine procedure	14
Above 8,000 ft	96		
		Nuclear weapons fallout (global average)	1
Terrestrial radiation (from soil and rocks)		Household sources	
Gulf States and Atlantic Coast	23	House constructed of brick, stone, or concrete	7
Colorado Plateau	90	Watching television	1
Elsewhere in the United States	46	Computer use	0.1
		Smoke detector	0.08

S.1 INTRODUCTION

This Summary provides an overview of the Final *Environmental Impact Statement for the Disposal of Greater-Than-Class C (GTCC) Low-Level Radioactive Waste and GTCC-Like Waste* (GTCC EIS) prepared by the U.S. Department of Energy (DOE). This Summary describes the wastes and the range of reasonable disposal alternatives evaluated in the GTCC EIS and provides a brief compilation of the major results of the evaluation included in this impact statement. In addition, guidance is provided for locating more detailed information on specific topics in the main body of the document.

Informing the public and fostering public participation are important requirements of the GTCC EIS process. At the end of this Summary is a discussion of the public review opportunities that includes representative comments received from stakeholders during the public scoping period and public comment period for the Draft GTCC EIS. For the GTCC EIS, stakeholders are the people or organizations who have an interest in or may be affected by (1) the lack of disposal capability for these wastes, (2) transportation of these wastes to an alternative disposal site, and (3) activities at the alternative disposal sites for these wastes. Stakeholders include members of the general public; representatives of environmental groups, industry, educational groups, unions, and other organizations; and representatives of Congress, federal agencies, American Indian tribes, state agencies, and local governments.

Readers interested primarily in the major issues and results presented in the GTCC EIS should find their information needs met by this Summary. Key information is presented about the purpose and need for agency action, the proposed action, the range of reasonable alternatives, the potential short- and long-term impacts of implementing each of the alternatives, uncertainties in the analyses, and the public participation process for this EIS. Considerations for developing the preferred alternative are included near the end of this Summary in Section S.7. A preferred alternative has been identified in Section S.8 and included in the Final GTCC EIS following public comment on the Draft GTCC EIS. In addition to the preferred alternative, other major changes made between the Draft and Final GTCC EIS are also summarized in Section S.9. Readers who would like more detail on these and other topics are directed to the pertinent sections of the GTCC EIS. Figure S-1 shows the organization of the GTCC EIS and relationships of its components.

S.1.1 What Is the Purpose and Need for Agency Action?

At this time, there is no disposal capability for GTCC low-level radioactive waste (LLRW). GTCC LLRW is generated by U.S. Nuclear Regulatory Commission (NRC) or Agreement State (i.e., a state that has signed an agreement with NRC to regulate certain uses of radioactive materials within the state) licensees. The NRC identifies four classes of LLRW in Title 10 of the *Code of Federal Regulations* (10 CFR 61.55) for disposal purposes on the basis of the concentrations of specific long- and short-lived radionuclides: Class A, B, C, and GTCC. GTCC LLRW has radionuclide concentrations exceeding the limits for Class C LLRW as

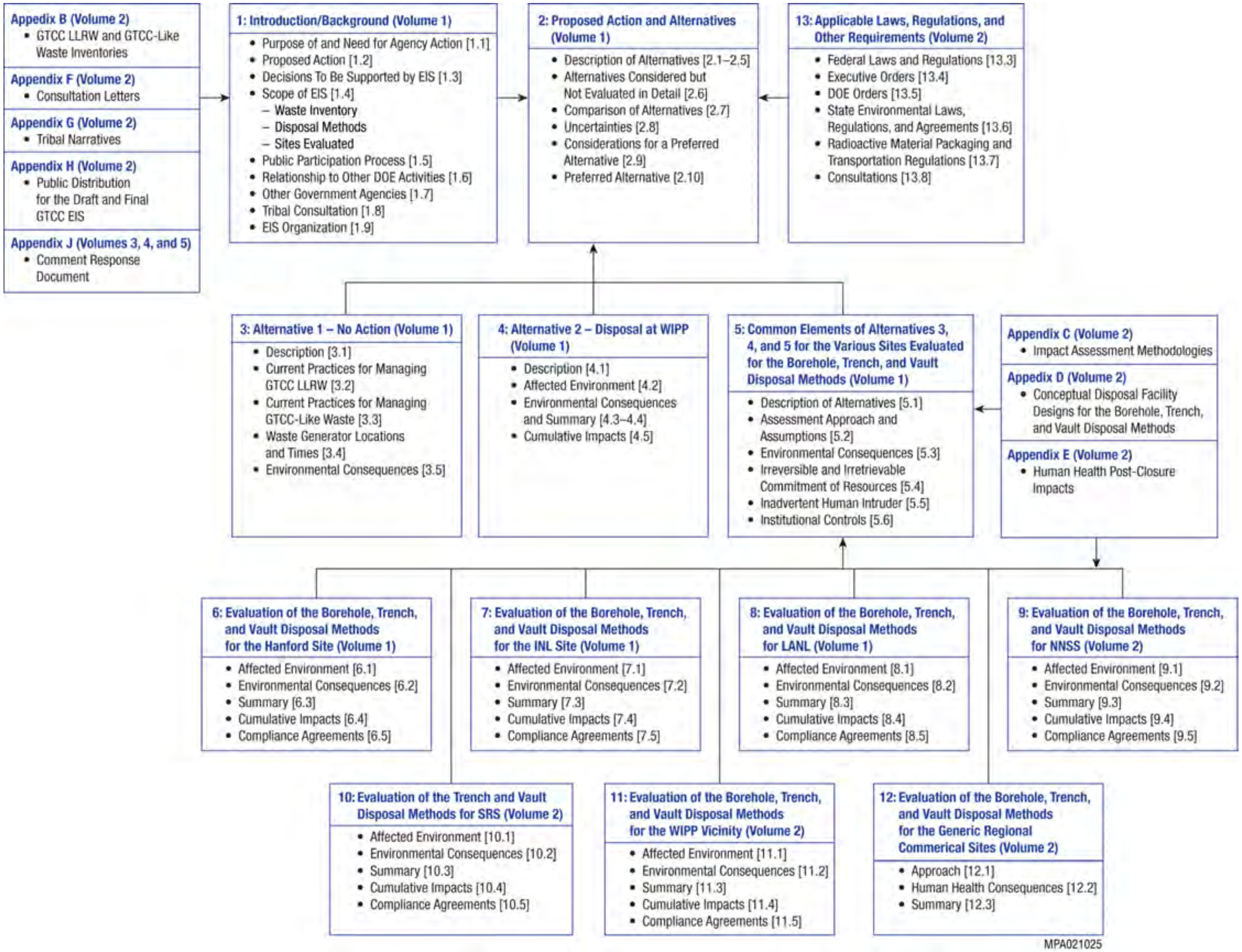


FIGURE S-1 Organization of the GTCC EIS and Relationships of Its Components (Note that in addition to this Summary, the main body of the GTCC EIS is made up of five volumes; the specific volume in which each component is contained is indicated in the figure above.)

provided in 10 CFR 61.55 and requires isolation from the human environment for a longer period of time than do Class A, B, and C LLRW, which are disposed of in existing commercial disposal facilities. GTCC LLRW consists of activated metals from the decommissioning of nuclear reactors, disused or unwanted sealed sources, and Other Waste (i.e., GTCC LLRW that is not activated metals or sealed sources). Other Waste consists of contaminated equipment, debris, scrap metal, filters, resins, soil, and solidified sludges.

Legislative Requirements

Section 3(b)(1)(D) of the LLRWPAA

- Specifies that the federal government is responsible for the disposal of GTCC LLRW.
- Specifies that GTCC LLRW be disposed of in a facility licensed by the NRC.

Section 631 of the Energy Policy Act of 2005

- Requires DOE to submit a report to Congress on disposal alternatives under consideration and await Congressional action before issuing a Record of Decision.

The Low-Level Radioactive Waste Policy Amendments Act of 1985 (LLRWPAA, Public Law [P.L.] 99-240) specifies that the GTCC LLRW that is designated a federal responsibility under Section 3(b)(1)(D) is to be disposed of in a facility that is adequate to protect public health and safety and is licensed by the NRC. In addition, DOE owns and generates both LLRW and non-defense-generated TRU waste, which have characteristics similar to those of GTCC LLRW and for which there may be no path for disposal at the present time. DOE is referring to these wastes as GTCC-like wastes. The use of the term “GTCC-like” is not intended to and does not create a new DOE classification of radioactive waste. Although GTCC-like waste is not subject to the requirements in the LLRWPAA, DOE also intends to determine a path to disposal that is similarly protective of public health and safety.

The September 11, 2001, terrorist attacks and subsequent threats in the U.S. have heightened concerns that terrorists could gain possession of radioactive sealed sources (see text box on page S-11), including sealed sources requiring management as GTCC LLRW, and use them for malevolent purposes. Such an attack has been of particular concern because of the widespread use of sealed sources and other radioactive materials in the United States for beneficial uses by hospitals and other medical establishments, industries, and academic institutions. While secure storage of disused sealed sources is a temporary measure, a disposal capability is needed. The interagency Radiation Source Protection and Security Task Force, established under Section 651(d) of the Energy Policy Act of 2005 (P.L. 109-58), is charged with evaluating and providing recommendations related to the security of radiation sources in the United States from potential terrorist threats, including the use of a radiological source in a radiological dispersal device (e.g., dirty bomb). In August 2006, August 2010, and August 2014 the Task Force submitted reports to the President and

Disused radioactive sealed sources previously used in medical treatments and other applications are one of the GTCC LLRW types for which a disposal capability is needed. Every year, thousands of sealed sources become disused and unwanted in the United States. While secure storage is a temporary measure, unlike permanent disposal, the longer sources remain disused or unwanted, the greater the chance that they will become unsecured or abandoned. Due to their concentrated activity and portability, radioactive sealed sources could be used in radiological dispersal devices (RDDs), commonly referred to as “dirty bombs.” An attack using an RDD could result in extensive economic loss, significant social disruption, and potentially serious public health problems.

U.S. Congress. The 2006 report (NRC 2006) stated that "providing disposal methods for GTCC LLRW will have the greatest effect on reducing the total risk of long-term storage for risk significant sources." The 2010 report (NRC 2010) further stated that "by far the most significant challenge identified is access to disposal for disused radioactive sources." The 2014 report (NRC 2014) recommended that "DOE should continue its ongoing efforts to develop GTCC [LLRW] disposal capability." Since 2003, the U.S. Government Accountability Office has issued several reports on matters related to the security of uncontrolled sealed sources. In particular, the 2003 report (GAO 2003, Executive Summary page) stated a concern with DOE's progress in developing a GTCC LLRW disposal facility. In addition, the Energy Policy Act of 2005 (P.L. 109-58) contains several provisions directed at improving the control of sealed sources, including disposal availability.

Accordingly, DOE has prepared this EIS to evaluate the range of reasonable alternatives for the safe and secure disposal of GTCC LLRW and GTCC-like waste. The range of reasonable alternatives addresses approximately 12,000 m^3 (420,000 ft^3) of in-storage and projected (anticipated through 2083) GTCC LLRW and GTCC-like waste. Waste quantity data obtained in 2008 had verification updates made in 2010 as needed, see Sandia (2008) and Argonne (2010). In performing its due diligence in the preparation of this Final EIS, DOE reviewed the waste quantity data and has determined that the expected waste quantity estimates remain valid and are conservative and bounding for the comparative analysis in the Final EIS, and revisions to this information are not necessary.

Disposal Method and Sites

Geologic Repository	WIPP
Intermediate-Depth Borehole	Hanford, INL, LANL, NNSS, WIPP Vicinity, and generic commercial sites
Enhanced Near-Surface Trench	Hanford, INL, LANL, NNSS, SRS, WIPP Vicinity, and generic commercial sites
Above-Grade Vault	Hanford, INL, LANL, NNSS, SRS, WIPP Vicinity, and generic commercial sites

S.1.2 What Is the Proposed Action?

DOE proposes to construct and operate a new facility or facilities or to use an existing facility for the disposal of GTCC LLRW and GTCC-like waste. DOE would then close the facility or facilities at the end of each facility's operational life. Institutional controls, including monitoring, would be employed for a period of time determined during the implementation phase. A combination of disposal methods and locations might be appropriate, depending on the characteristics of the waste among other factors. Disposal methods evaluated are the use of deep geologic disposal (via a geologic repository), an intermediate-depth borehole, an enhanced near-surface trench, and an above-grade vault. The disposal locations evaluated are the Hanford Site, the Idaho National Laboratory (INL) Site, Los Alamos National Laboratory (LANL), the Nevada National Security Site (NNSS), which was formerly known as the Nevada Test Site or NTS, the Savannah River Site (SRS), the Waste Isolation Pilot Plant (WIPP), and the WIPP Vicinity (where two locations are evaluated – one within and one outside the land withdrawal boundary of WIPP). Generic (commercial) sites are also evaluated for the borehole, trench, and vault methods, as applicable. The assumed locations of the generic sites coincide with the four NRC regions. Figures S-2 and S-3 show the sites being considered and the four NRC regions.

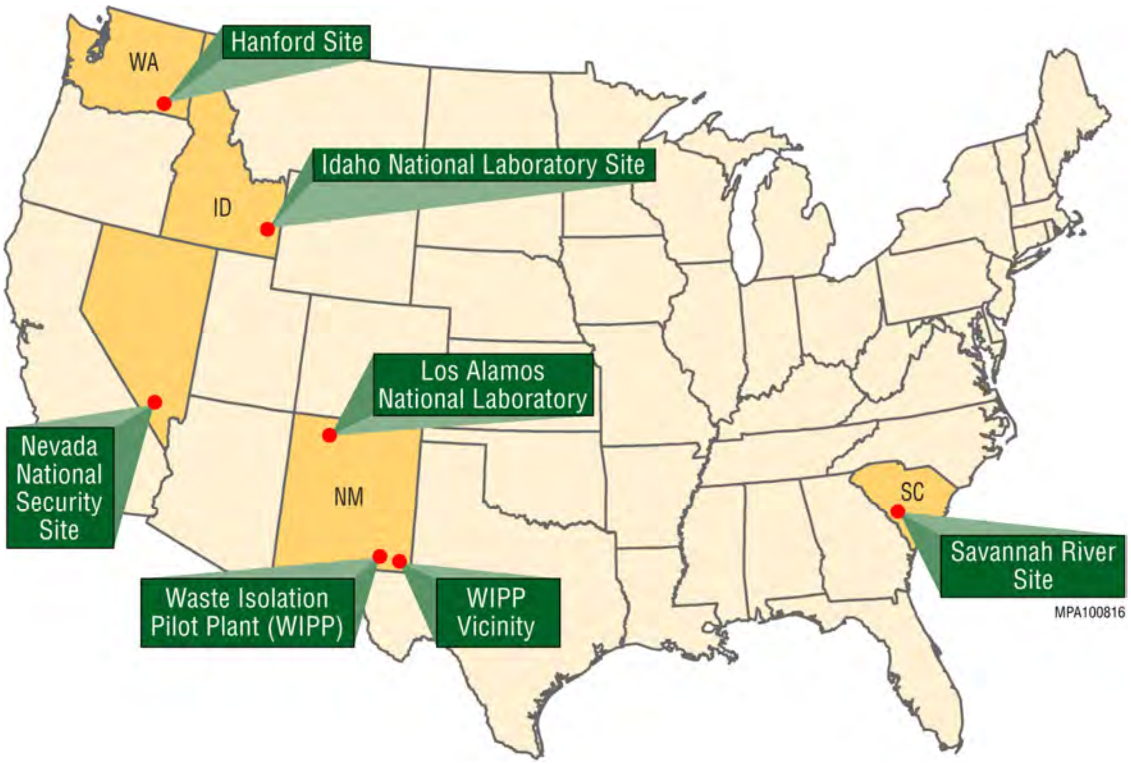


FIGURE S-2 Map of DOE Sites Being Considered for Disposal of GTCC LLRW and GTCC-Like Waste

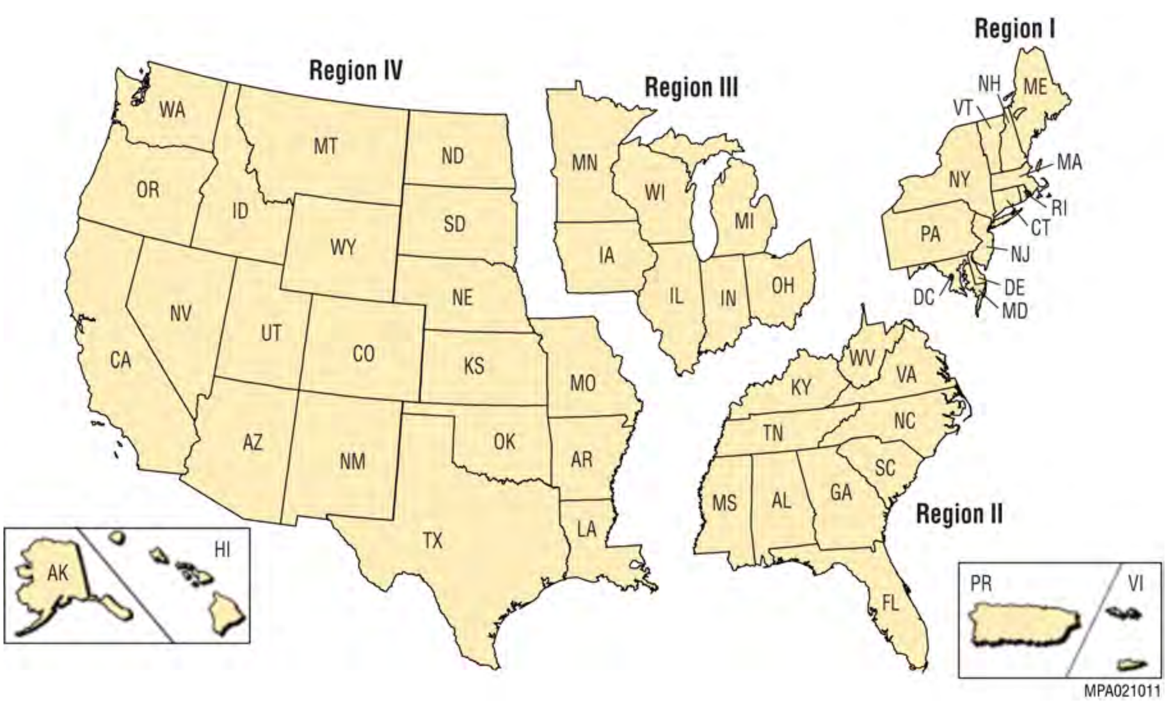


FIGURE S-3 Map Showing the Four NRC Regions Used as the Basis for the Evaluation of the Generic Commercial Sites

S.1.3 What Decisions Are Being Made?

DOE intends for this EIS to provide the information that supports the selection of disposal method(s) and site(s) for the GTCC LLRW and GTCC-like waste. DOE would conduct additional reviews under the National Environmental Policy Act of 1969 (NEPA) to evaluate the potential impacts from constructing and operating the selected disposal method(s) at the selected site(s), as needed.

Before issuing a Record of Decision (ROD) for the selection of disposal method(s) and site(s), DOE will submit a report to Congress to fulfill the requirement of Section 631(b)(1)(B)(i) of the Energy Policy Act of 2005 (P.L. 109-58). Section 631(b)(1)(B)(i) requires that the report include a description of all alternatives under consideration, and all the information required in the comprehensive report on ensuring the safe disposal of GTCC LLRW waste that was submitted by the Secretary to Congress in February 1987. Also, Section 631(b)(1)(B)(ii) requires DOE to await Congressional action. DOE will not issue a ROD until its required Report to Congress has been provided and appropriate action has been taken by Congress in accordance with the Energy Policy Act of 2005.

S.1.4 What Other Government Agencies Are Participating?

Because of its technical expertise in radiation protection, the U.S. Environmental Protection Agency (EPA) participated as a cooperating agency in the preparation of this EIS. The EPA's role as a cooperating agency does not imply its endorsement of DOE's selection of specific approaches, alternatives, or methods. The EPA conducted independent reviews of the Draft and Final EIS and associated documents in accordance with Section 309 of the Clean Air Act (*United States Code*, Volume 42, page 7609 [42 USC 7609]). The NRC participated as a commenting agency on the EIS.

Before implementation of any final decision, DOE would consult with appropriate Federal and state agencies, tribes, the Advisory Council on Historic Preservation, the appropriate State Historic Preservation Officer(s), and pertinent Regional Fish and Wildlife Service Office(s).

S.1.5 What Tribal Consultations Have Been Conducted?

DOE initiated consultation and communication activities on the GTCC EIS with 14 participating American Indian tribal governments that have cultural or historical ties to DOE sites being evaluated in this EIS, as identified in the text box. The consultation activities are being conducted in accordance with President Obama's Memorandum on Tribal Consultation (dated November 5, 2009), Executive Order 13175 (dated November 6, 2000) entitled "Consultation and Coordination with American Indian Tribal Governments," Executive Memorandum (dated September 23, 2004) entitled "Government-to-Government Relationship with Tribal Governments" (White House 2004), and DOE Order 144.1, *American Indian Tribal Government Interaction and Policy*, January 2009. The consultation activities include technical briefings, development of written tribal narratives included in the GTCC EIS related to the specific site affiliated with the tribe, and/or discussions with elected tribal officials, based on individual tribal preferences and mutually agreed-upon protocols.

DOE respects the unique and special relationship between American Indian tribal governments and the Government of the United States, as established by treaty, statute, legal precedent, and the U.S. Constitution. For this reason, DOE has presented tribal views and perspectives in the GTCC EIS to ensure full and fair consideration of tribal rights and concerns before making decisions or implementing programs that could affect tribes. While DOE may not necessarily agree with these views, DOE is committed to its government-to-government relationship with American Indian tribal governments. DOE will continue to work with tribal governments and their designated representatives to protect American Indian cultural resources, sacred sites, and potential traditional cultural properties and to implement appropriate mitigation measures that may reduce potential adverse effects to American Indian resources and interests.

Tribes and Tribal Organizations Participating in GTCC EIS Consultation Activities

Hanford

- Confederated Tribes of the Umatilla Indian Reservation (CTUIR), Pendleton, OR
- Nez Perce, Lapwai, ID
- Wanapum People, Ephrata, WA
- Yakama Nation, Union Gap, WA

Idaho

- Western Shoshone-Bannock Tribes, Fort Hall, ID

Los Alamos

- Acoma Pueblo, Acoma, NM
- Cochiti Pueblo, Cochiti, NM
- Laguna Pueblo, Laguna, NM
- Nambe Pueblo, Santa Fe, NM
- Pojoaque Pueblo, Santa Fe, NM
- Pueblo de San Ildefonso, Santa Fe, NM
- Pueblo of Jemez, Jemez, NM
- Santa Clara Pueblo, Española, NM

Nevada

- The Consolidated Group of Tribes and Organizations (CGTO) representing 16 Paiute and Western Shoshone Tribes. Consultation with these tribal nations is being conducted through the CGTO.

Tribal narratives, which describe the tribe's unique perspective on the DOE sites and environmental resource areas being analyzed in the GTCC EIS, are presented in the GTCC EIS. The following tribes, by site, chose to participate in the development of tribal narratives: Hanford (Confederated Tribes of the Umatilla Indian Reservation [CTUIR], Nez Perce, Wanapum, Yakama Nation); LANL (Cochiti Pueblo, Nambe Pueblo, Pueblo de San Ildefonso, Santa Clara Pueblo); and NNSS (Consolidated Group of Tribes and Organizations [CGTO], consisting of the Pahrump Paiute Tribe, Colorado River Indian Tribes, Duckwater Western Shoshone Tribe, Moapa Paiute Tribe, Bishop Paiute Tribe, Big Pine Paiute Tribe, Ely Western Shoshone Tribe). In addition to developing written narratives, other agreed-upon consultation activities have been initiated. Tribes contributed to the preparation of the Draft EIS and participated in the review of the Draft EIS by attending public meetings regarding GTCC and submitting comments that are addressed in Appendix J of this EIS. Since the receipt of tribal comments in 2011 on the Draft EIS, DOE has continued routine consultation with tribes as part of normal operations at the DOE sites evaluated in this EIS. DOE will continue to involve the tribes in the decision making process for the disposal of GTCC.

Some common issues identified by the tribes include the following:

Climate change. The climate has changed in the past 10,000 years. Tribes perceived that the lives of American Indian people have changed during these climatic shifts, that plant and animal communities have shifted, and that such shifts would occur again in the future (perhaps in the near future, given the potential impacts of global climate change).

Soils and minerals. At each of the potential GTCC disposal locations, regional soils and minerals found at or around the site play an important role in cultural and ceremonial activities.

Ecological impacts on the traditional use of plant and animal species by American Indians. Ecological concerns relate to the fact that the analyses tend to focus on threatened and endangered species and plants. The full range of species needs to be evaluated, especially in terms of American Indian use of plants and animals. Plants are used for medicine, food, basketry, tools, homes, clothing, fire, and social and healing ceremonies. Animals and insects are culturally important, and the relationship between them, the earth, and American Indian people are represented by the roles they play in the stories of American Indian people.

Human health impacts and American Indian pathways analysis. Tribes raised concerns that pathways specific to American Indian peoples be analyzed. They believe that standard calculations of human health exposure as used in the GTCC EIS for the general public are not applicable to American Indian populations.

Cultural resources. Tribal cultural resources include all physical, artifactual, and spiritual aspects for each of the potential areas being evaluated at Hanford, LANL, and NNSS. All things of the natural environment contribute to the cultural resources for the tribal lifestyle.

Visual resources. Views are important cultural resources that contribute to the location and performance of American Indian ceremonies. Viewscapes are typically experienced from high places or tend to provide panoramic views.

Tribal perspectives, comments, and concerns identified during the consultation process, those received during the public scoping process (also see Section S.7.4.2), and all comments received on the Draft GTCC EIS were considered by DOE in identifying the preferred alternative discussed in Section S.8.

S.2 WHAT DOES THE EIS ADDRESS?

S.2.1 What Is GTCC LLRW?

GTCC LLRW is waste that is not generally acceptable for near-surface disposal and for which the waste form and disposal methods must be different and, in general, more stringent than those specified for Class C LLRW. NRC regulations require GTCC LLRW to be disposed of in a geologic repository as defined in 10 CFR Parts 60 and 63, unless proposals for an alternative method are approved by NRC under 10 CFR 61.55(a)(2)(iv).[1]

The concentrations of radionuclides in Classes A, B, and C LLRW limit the length of time that these wastes are generally considered to be hazardous to about 500 to 1,000 years. 10 CFR 61.7(a)(2) notes that near-surface disposal site characteristics for these wastes should be considered in terms of the indefinite future and evaluated for a time frame of at least 500 years. Radioactive decay and the slow migration of radionuclides from the disposal units should reduce the hazard from the radionuclides to safe levels at that time. In contrast, some of the radionuclides in the GTCC LLRW and GTCC-like waste either have long half-lives (in excess of 10,000 years) or are present in high concentrations.

Class A LLRW has the lowest radionuclide concentration limits of the four classes of waste and is usually segregated from other LLRW at the disposal site. Class B LLRW has higher radionuclide concentration limits

NRC Classification System for LLRW

The NRC classification system for the four classes of LLRW (A, B, C, and GTCC) is established in 10 CFR 61.55 and is based on the concentrations of specific short and long-lived radionuclides given in two tables. Classes A, B, and C LLRW are generally acceptable for disposal in near-surface land disposal facilities. GTCC LLRW is LLRW "that is not generally acceptable for near-surface disposal" as specified in 10 CFR 61.55(a)(2)(iv). As stated in 10 CFR 61.7(b)(5), there may be some instances in which waste with radionuclide concentrations greater than permitted for Class C would be acceptable for near-surface disposal with special processing or design.

GTCC LLRW and GTCC-Like Waste

GTCC LLRW refers to LLRW that has radionuclide concentrations that exceed the limits for Class C LLRW given in 10 CFR 61.55. This waste is generated by activities of NRC and Agreement State licensees, and it cannot be disposed of in currently licensed commercial LLRW disposal facilities. The federal government is responsible for the disposal of GTCC LLRW.

GTCC-like waste refers to radioactive waste that is owned or generated by DOE and has characteristics sufficiently similar to those of GTCC LLRW such that a common disposal approach may be appropriate. GTCC-like waste consists of LLRW and non-defense-generated TRU waste that has no identified path for disposal at the present time. The use of the term "GTCC-like" is not intended to and does not create a new DOE classification of radioactive waste.

[1] The GTCC LLRW inventory in the EIS includes GTCC LLRW from the decommissioning of commercial nuclear reactors that are covered by a Standard Contract for Disposal of Spent Nuclear Fuel and/or High-Level Radioactive Waste. A Federal Circuit Court panel ruled that for purposes of determining damages in the spent nuclear fuel litigation, GTCC LLRW waste is considered high-level radioactive waste under the terms of DOE's Standard Contract (*Yankee Atomic Electric Co. v. U.S.*, 536 F. 3d 1268 (Fed. Cir. 2008) and *Pacific Gas & Electric Co. v. U.S.*, 536 F. 3d 1282 (Fed. Cir. 2008)). The court's decision does not affect DOE's responsibility to evaluate reasonable alternatives for a disposal facility or facilities for GTCC LLRW – including GTCC LLRW covered by the Standard Contract – in accordance with applicable law.

than Class A and must meet more rigorous requirements with regard to waste form to ensure its stability after disposal. Class C LLRW is waste that represents a higher long-term risk than does Class A or Class B LLRW. Like Class B waste, Class C waste must meet the more rigorous requirements with regard to waste form to ensure its stability, and it also requires additional measures to be taken at the disposal facility to protect against inadvertent human intrusion.

S.2.2 What Is GTCC-Like Waste?

Consistent with NRC's and DOE's authorities under the Atomic Energy Act of 1954, amended (P.L. 83-703), the NRC LLRW classification system does not apply to radioactive waste that is owned or generated by DOE and disposed of in DOE facilities. However, DOE owns or generates both LLRW and non-defense-generated TRU waste,[2] which have characteristics similar to those of GTCC LLRW and for which there may be no path for disposal. DOE has included these wastes, otherwise known as "GTCC-like waste," for evaluation in the GTCC EIS because a common approach and/or facility could be used. For the purposes of the EIS, the use of the term "GTCC-like" is not intended to and does not create a new DOE classification of radioactive waste.

Three Waste Types

The wastes being addressed in this EIS are divided into three distinct types. These three waste types and their estimated total volumes and radionuclide activities are as follows:

- Activated metals: 2,000 m^3 (71,000 ft^3) and 160 MCi
- Sealed sources: 2,900 m^3 (100,000 ft^3) and 2.0 MCi
- Other Waste: 6,700 m^3 (240,000 ft^3) and 1.3 MCi

About three-fourths of the waste by volume is GTCC LLRW; GTCC-like waste accounts for the remainder.

S.2.3 How Much GTCC LLRW and GTCC-Like Waste Is Addressed in the EIS?

The combined GTCC LLRW and GTCC-like waste inventory addressed in this EIS has a packaged volume of about 12,000 m^3 (420,000 ft^3) and contains a total activity of about 160 million curies (MCi) (see Figure S-4).

For the purposes of analysis in this EIS, both GTCC LLRW and GTCC-like waste are comprised of three waste types: activated metals, sealed sources, and other waste. The waste inventory addressed in the EIS includes both stored inventory (wastes that were already generated and are in storage as of 2008) and projected inventory (wastes that are expected to be generated in the future through 2083). Waste quantity data obtained in 2008 had verification

2 Defense-generated TRU waste is radioactive waste generated by atomic energy defense activities. "Atomic energy defense activity," as defined by the Nuclear Waste Policy Act of 1982, as amended, means "any activity of the Secretary of Energy performed in whole or in part in carrying out any of the following functions: naval reactors development; weapons activities including defense inertial confinement fusion; verification and control technology; defense nuclear materials production; defense nuclear waste and materials byproducts management; defense nuclear materials security and safeguards and security investigations; and defense research and development." TRU waste that is not generated by atomic energy defense activities is considered non-defense-generated TRU.

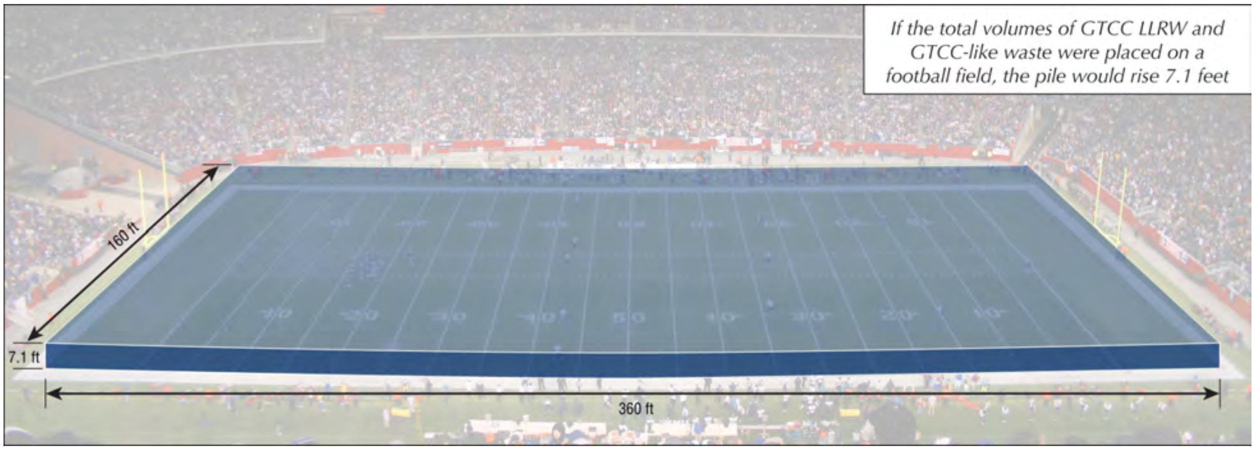
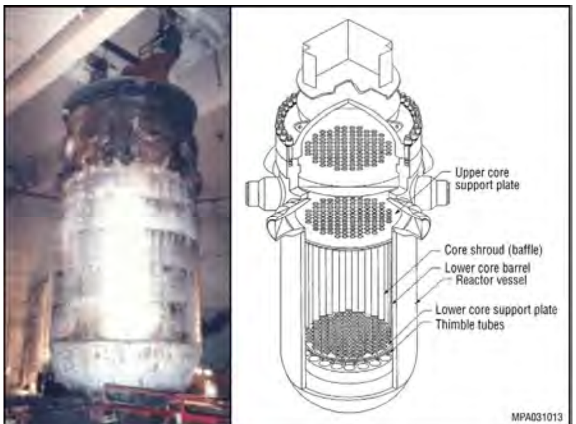


FIGURE S-4 Total Volume of GTCC LLRW and GTCC-Like Waste Addressed in the EIS



Activated Metals at a Glance
(2,000 m^3 [71,000 ft^3] containing 160 MCi)

- Largely generated from the decommissioning of nuclear reactors.
- Include portions of the nuclear reactor vessel, such as the core shroud and core support plate.
- Prevalent radionuclides in activated metals include C 14, Mn 54, Fe 55, Ni 59, Ni-63, Nb-94, and Co-60.
- In the United States, 104 commercial nuclear reactors are operating in 31 states, and more reactors are planned.
- Most reactors are not scheduled to undergo decommissioning for several decades.

Sealed Sources at a Glance
(2,900 m^3 [100,000 ft^3] containing 2.0 MCi)

- Widely used in equipment to diagnose and treat illnesses (particularly cancer), sterilize medical devices, irradiate blood for transplant patients, nondestructively test structures and industrial equipment, and explore geologic formations to find oil and gas.
- Located in hospitals, universities, and industries throughout the United States.
- Unsecured or abandoned sealed sources are a national security concern because of their potential to be used by terrorists in a "dirty bomb."
- Commonly consist of concentrated radioactive materials encapsulated in small metal containers.
- Radionuclides commonly used in sealed sources include Cs-137, Am 241, and Pu-238.

Other Waste at a Glance
(6,700 m^3 [240,000 ft^3] containing 1.3 MCi)

- Other Waste primarily includes contaminated equipment, debris, scrap metal, filters, resins, soil, and solidified sludges. These wastes are associated with the:
  - Production of Mo-99, which is used in about 16 million medical procedures (e.g., to detect cancer) each year. The United States depends on aging foreign reactors to produce Mo-99, and shortages in recent years due to the unexpected shutdowns of the foreign facilities have highlighted the need to produce Mo 99 in the United States.
  - Production of radioisotope power systems in support of space exploration (e.g., from the plutonium 238 production project) and national security.
  - Environmental cleanup of radioactively contaminated sites including the West Valley Site in New York.
- A wide range of radionuclides may be present in Other Waste, including Tc-99, Cs-137, and a number of transuranic radionuclides including isotopes of plutonium, americium, and curium.

Transuranic (TRU) Waste

TRU waste is radioactive waste containing more than 100 nanocuries of alpha-emitting transuranic isotopes with half-lives greater than 20 years, except for (1) high-level radioactive waste; (2) waste that the Secretary 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 the 40 CFR Part 191 disposal regulations; or (3) waste that the NRC has approved for disposal on a case-by case basis in accordance with 10 CFR Part 61. Examples of TRU radionuclides include Pu-238, Pu-239, Pu-240, Am-241, and Am-243.

Contact-Handled and Remote-Handled Waste

As used in this EIS, contact handled (CH) waste refers to GTCC LLRW and GTCC-like waste that has a dose rate of less than 200 mrem/h on the surface of the package. Remote-handled (RH) waste refers to GTCC LLRW and GTCC-like waste that has a surface dose rate of 200 mrem/h or more. These definitions are consistent with the way that these terms are defined for disposal of TRU waste at WIPP.

updates made in 2010 as needed, see Argonne (2010). In performing its due diligence in the preparation of this final EIS, DOE reviewed the waste quantity data and has determined that the expected waste quantity estimates remain valid and are conservative and bounding. The stored inventory includes waste in storage at sites licensed by the NRC or Agreement States (GTCC LLRW) and at certain DOE sites (GTCC-like waste) and consists of all three waste types (activated metals, sealed sources, and Other Waste).

> **Two Waste Groups**
>
> For purposes of analysis in this EIS, wastes are considered to be in one of two groups.
>
> - Group 1 consists of wastes from currently operating facilities. Some of the Group 1 wastes have already been generated and are in storage awaiting disposal.
> - Group 2 consists of projected wastes from proposed actions or planned facilities not yet in operation.

For analysis in this EIS, the three waste types fall into two groups on the basis of uncertainties associated with their generation. Group 1 consists of wastes from currently operating facilities that are either already in storage or are expected to be generated from these facilities (such as commercial nuclear power plants by 2083); all currently operational plants were assumed to have their license renewed for an additional 20 years of operation. All stored GTCC LLRW and GTCC-like wastes are included in Group 1.

Group 2 consists of projected wastes from proposed actions or planned facilities not yet in operation. These actions include those proposed by DOE and those to be conducted by commercial entities (including electric utilities) for an assumed number of new (i.e., still to be licensed or constructed) nuclear power plants. Some or all of the Group 2 waste may never be generated, depending on the outcome of the proposed actions that are independent of this EIS. Such actions include the potential exhumation of previously disposed-of wastes at the West Valley Site in New York, wastes from the production of Mo-99, and wastes from the planned plutonium-238 production project. No stored GTCC LLRW and GTCC-like wastes are included in Group 2. Any potential nuclear fuel cycles involving advanced reactors or recycling of used fuel and the GTCC LLRW and GTCC-like waste associated with these activities are uncertain at this time and therefore not estimated in this EIS. Either of these scenarios could have an impact on the volume of GTCC LLRW and GTCC-like waste generated and requiring disposal, which would be subject to future NEPA review including a review of the types and amount of waste generated and the need for disposal capacity.

The waste volumes and radionuclide activities of the wastes addressed in this EIS are summarized in Table S-1.

The total waste volume in Group 1 is estimated to be 5,300 m^3 (190,000 ft^3), and this waste contains a total of 110 MCi of activity. The radionuclide activity is mainly from the decommissioning of commercial nuclear power reactors currently in operation (see Figure S-5). Group 2 has an estimated waste volume of 6,400 m^3 (230,000 ft^3) and contains a total activity of 49 MCi. Some of this waste is associated with the environmental cleanup of the West Valley Site in New York (a former commercial facility for reprocessing of spent nuclear fuel that has two disposal areas for radioactive waste). The radionuclide activity in the Group 2 wastes would result mainly from the decommissioning of proposed new commercial nuclear power reactors.

TABLE S-1 Summary of Group 1 and Group 2 GTCC LLRW and GTCC-Like Waste Packaged Volumes and Radionuclide Activities[a]

Waste Type	In Storage		Projected		Total Stored and Projected	
	Volume (m^3)	Activity (MCi)[b]	Volume (m^3)	Activity (MCi)	Volume (m^3)	Activity (MCi)
Group 1						
GTCC LLRW						
Activated metals (BWRs)[c] – RH	7.1	0.22	200	30	210	31
Activated metals (PWRs) – RH	51	1.1	620	76	670	77
Sealed sources (Small)[d] – CH	–[e,f]	–	1,800	0.28	1,800	0.28
Sealed sources (Cs-137 irradiators) - CH	–	–	1,000	1.7	1,000	1.7
Other Waste[g] – CH	42	0.000011	–	–	42	0.000011
Other Waste – RH	33	0.0042	1.0	0.00013	34	0.0043
Total	130	1.4	3,700	110	3,800	110
GTCC-like waste						
Activated metals – RH	6.2	0.23	6.6	0.0049	13	0.24
Sealed sources (Small) – CH	0.21	0.0000060	0.62	0.000071	0.83	0.000077
Other Waste – CH	430	0.016	310	0.0062	740	0.022
Other Waste – RH	520	0.096	200	0.17	720	0.26
Total	960	0.34	510	0.18	1,500	0.52
Total Group 1	1,100	1.7	4,200	110	5,300	110
Group 2						
GTCC LLRW						
Activated metals (BWRs) – RH	–	–	73	11	73	11
Activated metals (PWRs) – RH	–	–	300	37	300	37
Activated metals (Other) – RH[h]	–	–	740	0.14	740	0.14
Sealed sources – CH[h]	–	–	23	0.000020	23	0.000020
Other Waste – CH[h]	–	–	1,600	0.024	1,600	0.024
Other Waste – RH[h]	–	–	2,300	0.51	2,300	0.51
Total	–	–	5,000	49	5,000	49
GTCC-like waste						
Activated metals – RH	–	–	–	–	–	–
Sealed sources – CH	–	–	–	–	–	–
Other Waste – CH	–	–	490	0.012	490	0.012
Other Waste – RH	–	–	870	0.48	870	0.48
Total	–	–	1,400	0.49	1,400	0.49
Total Group 2			6,400	49	6,400	49

TABLE S-1 (Cont.)

Waste Type	In Storage		Projected		Total Stored and Projected	
	Volume (m^3)	Activity (MCi)[b]	Volume (m^3)	Activity (MCi)	Volume (m^3)	Activity (MCi)
Groups 1 and 2						
GTCC LLRW						
Activated metals – RH	59	1.4	1,900	160	2,000	160
Sealed sources – CH	–	–	2,900	2.0	2,900	2.0
Other Waste – CH	42	0.00091	1,600	0.024	1,600	0.024
Other Waste – RH	33	0.0042	2,300	0.51	2,300	0.51
Total	130	1.4	8,700	160	8,800	160
GTCC-like waste						
Activated metals – RH	6.2	0.23	6.6	0.0049	13	0.24
Sealed sources – CH	0.21	0.0000060	0.62	0.000071	0.83	0.000077
Other Waste – CH	430	0.016	800	0.02	1,200	0.036
Other Waste – RH	520	0.096	1,100	0.65	1,600	0.75
Total	960	0.34	1,900	0.67	2,800	1.0
Total Groups 1 and 2	1,100	1.7	11,000	160	12,000	160

[a] All values have been rounded to two significant figures. Some totals may not equal sum of individual components because of independent rounding. BWR = boiling water reactor, CH = contact-handled (waste), PWR = pressurized water reactor, RH = remote-handled (waste). Includes waste in storage as of 2008 and projected through 2083. Waste quantity data obtained in 2008 had verification updates made in 2010 as needed, see Argonne (2010). In performing its due diligence in the preparation of this final EIS, DOE reviewed the waste quantity data and has determined that the expected waste quantity estimates remain valid and are conservative and bounding.

[b] MCi means megacurie or 1 million curies.

[c] There are two types of commercial nuclear reactors in operation in the United States, BWRs and PWRs. Different factors were used to estimate the volumes and activities of activated metal wastes for these two types of reactors.

[d] Sealed sources may be physically small but have high concentration of radionuclides.

[e] There are sealed sources currently possessed by NRC licensees that may become GTCC LLRW when no longer needed by the licensee. The current status of individual sources (i.e., whether they are in use, waste, etc.) is subject to change over time. Therefore, due to uncertainty of when the licensees will declare their sources a waste, an estimated volume and activity has been included in the projected inventory.

[f] A dash means that there is no value for that entry.

[g] Other Waste consists of those wastes that are not activated metals or sealed sources; it includes contaminated equipment, debris, scrap metals, filters, resins, soil, solidified sludges, and other materials.

[h] Wastes from the West Valley Site NDA and SDA are reflected in the inventories listed under Group 2 activated metals, sealed sources, and Other Waste - RH/CH. Of the 740 m^3 under activated metals, 210 m^3 is from the NDA and 525 m^3 is from the SDA; 23 m^3 of sealed sources is from the SDA; 1,600 m^3 of Other Waste - CH is from the SDA; and 1,950 m^3 of Other Waste - RH included 1,943 m^3 from the NDA and 7.34 m^3 from the SDA.

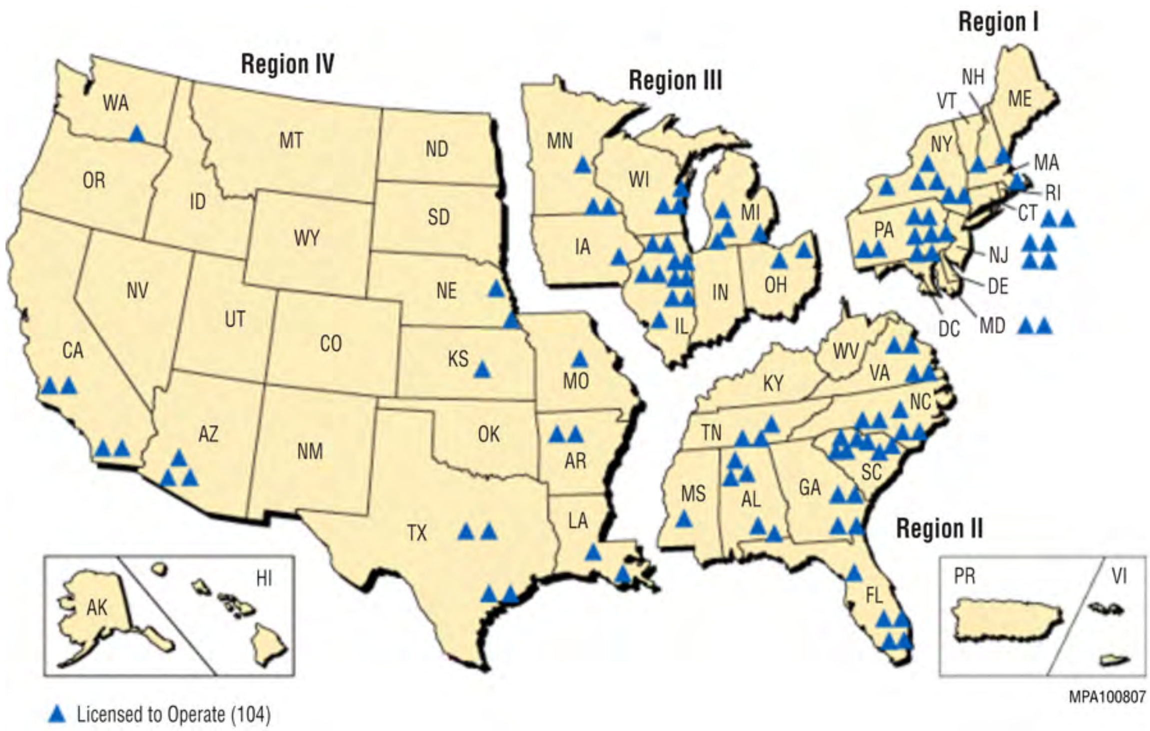


FIGURE S-5 Map Showing the Four NRC Regions and the Locations of Currently Operating Commercial Nuclear Power Plants

The total estimated volume of mixed waste (waste containing hazardous chemical constituents in addition to radionuclides) in Group 1 is about 170 m^3 (6,000 ft^3). Current information is insufficient to allow a reasonable estimate of the amount of Group 2 waste that could be mixed waste. Most of the Group 1 mixed waste is GTCC-like waste; only 4 m^3 (140 ft^3) is GTCC LLRW. Available information indicates that much of this waste is characteristic hazardous waste as regulated under the Resource Conservation and Recovery Act; therefore, this EIS assumes that for the land disposal methods, the generators will treat the waste to render it nonhazardous under federal and state laws and requirements. WIPP, however, can accept defense-generated TRU mixed waste as provided in the WIPP Land Withdrawal Act (LWA) of 1992 as amended (P.L. 102-579 as amended by P.L. 104-201).

S.2.4 What Is the Assumed Time Frame for GTCC LLRW and GTCC-Like Waste Disposal?

Waste would be received at the disposal facilities over an extended period of time. The actual start date for operations is uncertain at this time and dependent upon, among other things, the alternative or alternatives selected, additional NEPA review as required, characterization studies, and other actions necessary to initiate and complete construction and operation of a GTCC LLRW and GTCC-like waste disposal facility. For purposes of analysis in the GTCC EIS, DOE assumed a start date of disposal operations in 2019. However, given these uncertainties, the actual start date could vary. The receipt rate of the various waste types assumed for purposes of analysis in the GTCC EIS is shown in Figure S-6. Approximately 8,500 m^3 (300,000 ft^3) of the total GTCC LLRW and GTCC-like waste inventory of 12,000 m^3 (420,000 ft^3) is projected to be available for disposal during the first 16 years of disposal operations (i.e., the years 2019–2035). Most of this waste consists of disused sealed sources, which present a national security concern and therefore have a greater near-term disposal need, and Other Waste (e.g., debris from DOE environmental cleanup activities, waste from the planned production of radioisotope power systems in support of space exploration and national security, and waste from the planned production of Mo-99 for cancer treatment and other important medical procedures). Beyond the year 2035, the primary waste volumes are projected to be disused sealed sources and GTCC LLRW activated metal waste from decommissioning nuclear reactors. This future activated metal waste accounts for approximately 98% of the total activity of the GTCC LLRW and GTCC-like waste inventory.

S.2.5 What Is the Range of Reasonable Alternatives Evaluated in the EIS?

DOE evaluated the following five alternatives in the EIS:

- Alternative 1: No Action,

- Alternative 2: Disposal at the WIPP geologic repository,

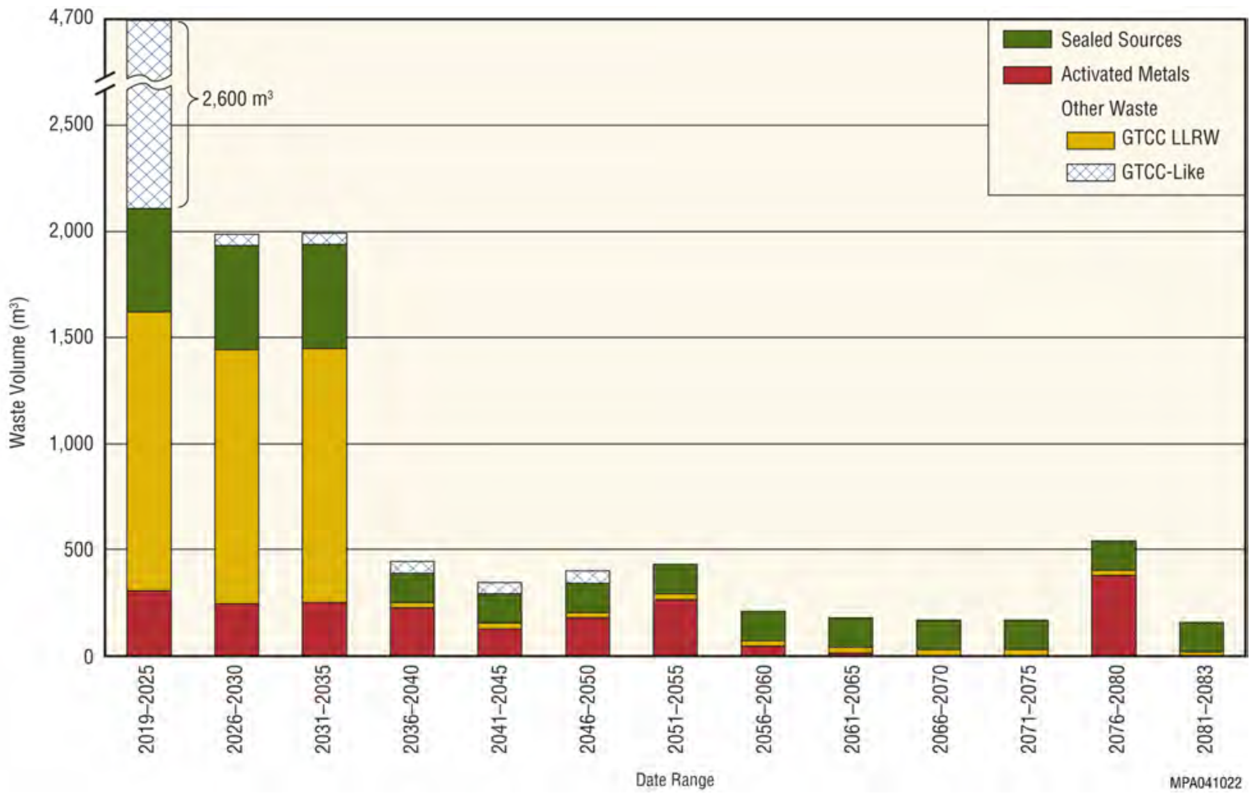


FIGURE S-6 Assumed Timeline for Receipt of GTCC LLRW and GTCC-Like Waste for Disposal

- Alternative 3: Disposal in a new borehole disposal facility,
- Alternative 4: Disposal in a new trench disposal facility, and
- Alternative 5: Disposal in a new vault disposal facility.

For the purposes of the analysis, DOE assumed construction of a new borehole, trench, or vault at all sites analyzed. This assumption provided conservatism in the evaluation methodology. However, an existing borehole, trench, or above-grade vault that meets the conceptual designs discussed in the EIS could be used.

Figure S-7 illustrates the disposal depths associated with the four action alternatives (Alternatives 2 through 5). DOE evaluated the use of an existing geologic repository (WIPP in New Mexico) and/or the construction of a new borehole, trench, or vault facility or facilities to safely dispose of the GTCC LLRW and GTCC-like waste. Combinations of disposal alternatives may be appropriate based on the characteristics of the waste type and other considerations (e.g., waste volumes, physical and radiological characteristics, and operational considerations). The new facility or facilities could be located at DOE sites having waste disposal missions, including the Hanford Site in Washington, the INL Site in Idaho, LANL in New Mexico, NNSS (formerly NTS) in Nevada, and SRS in South Carolina. In addition, such a disposal facility could be located on lands in the vicinity of WIPP (within or outside the land withdrawal boundaries of WIPP) or on generic nonfederal (commercial or private) lands.

DOE developed the four action alternatives after careful consideration of the waste inventory, disposal methods, and comments received during the public scoping period for the GTCC EIS. The WIPP repository is evaluated to determine the feasibility of the disposal of GTCC

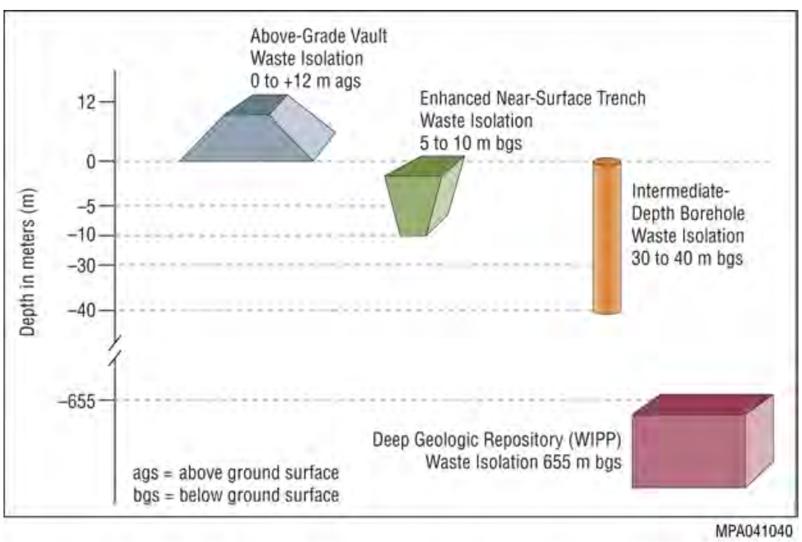


FIGURE S-7 Waste Isolation Depths for Proposed GTCC LLRW and GTCC-Like Waste Disposal Methods

LLRW and GTCC-like waste at a geologic repository. The designs for the land disposal facilities that are evaluated in this EIS are conceptual and generic in nature so that the performance of the sites with regard to employing the disposal methods considered in this EIS can be compared. These land disposal conceptual designs could be altered or enhanced, as necessary, to provide the optimal application at a given location.

Reference locations are identified for evaluating Alternatives 3 to 5 (borehole, trench, and vault) since these alternatives involve the construction of new disposal facilities. The reference locations, which have characteristics representative of the actual location that could be used for waste disposal purposes, are used in this EIS to compare disposal methodologies and sites. These reference locations at the DOE sites are generally in areas of these sites that have been used for other waste disposal activities or in which other disposal facilities or activities are also planned. If a site or sites were selected for possible implementation of a land disposal method or methods, a follow-on site-specific NEPA evaluation and documentation, as appropriate, along with a further optimization by a selection study, would be conducted to identify the location or locations within a given site that would be considered the best ones to accommodate the land disposal method(s). Figures indicating the reference locations of the land disposal facilities are given in this Summary. Reference locations have not been identified for the generic commercial disposal facilities, and these facilities are evaluated for potential human health impacts in this EIS on a regional basis (coinciding with the four NRC regions) by using input parameters assumed to be representative of each of the regions as a whole.

The five alternatives are described here.

S.2.5.1 Alternative 1: No Action

Under the No Action Alternative, current practices for storing GTCC LLRW and GTCC-like waste would continue in accordance with current requirements (e.g., NRC, state, DOE). The GTCC LLRW generated by the operation of commercial nuclear reactors (mainly activated metal waste) would continue to be stored at the various nuclear reactor sites that generated this waste or at other reactors owned by the same utility. Sealed sources would continue to be stored at interim storage and generator sites. Other Waste would also remain stored and managed at the generator or interim storage sites. In a similar manner, all stored and projected GTCC-like waste would remain at current DOE storage and generator locations (these wastes are being stored at several DOE sites as identified in Table S-2). Under this alternative, DOE would take no further action to develop disposal capability for these wastes, and current practices for managing these wastes would continue into the future. It is further assumed that for the short term, management of the stored wastes would continue for 100 years (a time period typically assumed for active institutional controls), and long-term impacts are analyzed for the period beyond 100 years and up to 10,000 years to be consistent with the time frame analyzed for the proposed disposal alternatives (i.e., Alternatives 2 to 5). National security concerns over the lack of a disposal capability for sealed sources that are GTCC LLRW would not be addressed.

TABLE S-2 Current Storage and Generator Locations of the GTCC LLRW and GTCC-Like Waste Addressed in the GTCC EIS[a]

Waste Type	GTCC LLRW	GTCC-Like Waste
Group 1		
Activated metals - RH	Various states (see Figure S-5)	INL Site (Idaho) ORR (Tennessee)
Sealed sources - CH	Various states	LANL (New Mexico)
Other Waste - CH	Babcock and Wilcox (Virginia) Waste Control Specialists (Texas)	West Valley Site (New York) INL Site (Idaho) Babcock and Wilcox (Virginia)
Other Waste - RH	Virginia and Texas	West Valley Site (New York) INL Site (Idaho) ORR (Tennessee) Babcock and Wilcox (Virginia)
Group 2		
Activated metals - RH	Various states	–
Sealed sources - CH	West Valley Site (New York)	–
Other Waste - CH	West Valley Site (New York)	West Valley Site (New York) ORR (Tennessee)
Other Waste - RH	West Valley Site (New York) Missouri University Research Reactor (Missouri) Babcock and Wilcox (Virginia)	West Valley Site (New York) ORR (Tennessee)

[a] Other Waste consists of those wastes that are not activated metals or sealed sources; it includes contaminated equipment, debris, scrap metal, filters, resins, soil, solidified sludges, and other materials. A dash means no volume for that waste type. INL = Idaho National Laboratory, LANL = Los Alamos National Laboratory, ORR = Oak Ridge Reservation.

S.2.5.2 Alternative 2: Disposal at WIPP

This alternative involves the disposal of GTCC LLRW and GTCC-like waste at WIPP. The operation at WIPP involves disposal of TRU waste generated by atomic energy defense activities by emplacement in underground disposal rooms that are mined as part of a panel and an access drift. Each mined panel consists of seven rooms. Contact-handled (CH) TRU waste containers are emplaced on disposal room floors, and remote-handled (RH) TRU waste containers are currently emplaced in horizontal boreholes in disposal room wall spaces. However, the EPA and New Mexico Environment Department have approved DOE use of shielded containers for safe emplacement of selected RH TRU waste streams with lower activity levels on the floor of the repository. The use of the shielded containers will enable DOE to significantly increase the efficiency of transportation and disposal operations for RH TRU waste at WIPP. For RH TRU waste streams with higher activity levels, such as those levels exhibited in the near term by activated metals removed from recently shutdown nuclear reactors, a similar, more heavily shielded container could be used. Consistent with the approval for the shielded container and the potential extension to a more heavily shielded container, this EIS assumes all activated metal waste and Other Waste - RH would be packaged in shielded containers that would be emplaced on the floor of the mined panel rooms in a manner similar to that used for the emplacement of CH waste.

The analysis discussed in this EIS assumes that disposal procedures and practices at WIPP would continue, except for the emplacement of activated metals and Other Waste - RH on room floors (not in wall spaces, as is the current procedure). It is also assumed that all aboveground support facilities would be available for the disposal of GTCC LLRW and GTCC-like waste and that construction of additional aboveground facilities would not be required to dispose of the entire inventory of GTCC LLRW and GTCC-like waste. However, the construction of up to 26 additional underground rooms would be required. Underground rooms are constructed by conventional mining techniques that use an electric-powered continuous miner rather than blasting. The mined salt is transported underground by haul trucks; once there, the salt is placed on the salt hoist and lifted to the surface. The exact locations and orientations of these rooms would be determined on the basis of mining engineering, safety, and other factors. Refer to Section 4.1.4.1 and Figure 4.1.4 1 in the EIS for additional information on construction. Figure S-8 shows the current WIPP layout including underground shafts.

Prior to implementation of this alternative, further evaluation and analysis of alternative technologies and methods to optimize the transport, handling, and emplacement of the wastes would be conducted to identify those technologies and methods that would minimize to the extent possible any potential impacts to human health or the environment. Follow-on WIPP-specific NEPA review would be conducted to examine in greater detail the potential impacts associated with the disposal of GTCC LLRW and GTCC-like waste at WIPP, as appropriate. DOE acknowledges that only defense-generated TRU waste is currently authorized for

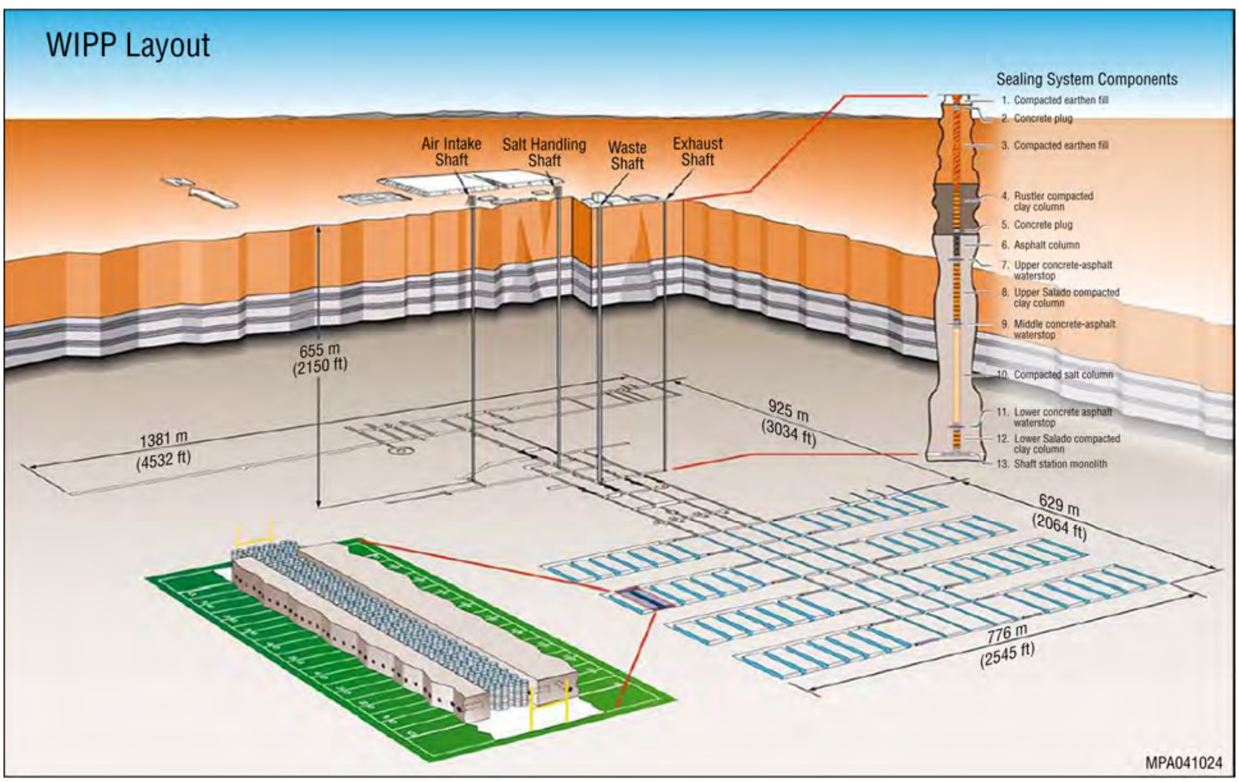


FIGURE S-8 Current WIPP Layout

disposal at the WIPP geologic repository under the WIPP LWA as amended (P.L. 102-579 as amended by P.L. 104-201), and that legislation would be required to allow disposal of waste other than TRU waste generated by atomic energy defense activities at WIPP and/or for siting a new facility within the land withdrawal area.

It should be noted that waste disposal operations at WIPP were suspended on February 5, 2014, following a fire involving an underground vehicle. Nine days later, on February 14, 2014, a radiological event occurred underground at WIPP, contaminating a portion of the mine primarily along the ventilation path from the location of the incident and releasing a small amount of contamination into the environment.

DOE will resume disposal operations at WIPP when it is safe to do so. The schedule for restart of limited operations is currently under review. DOE is continuing to characterize and certify TRU waste at the Idaho National Laboratory, Oak Ridge National Laboratory, Savannah River Site, and Argonne National Laboratory for eventual shipment to WIPP. TRU waste continues to be generated at the Hanford site and Lawrence Livermore National Laboratory. DOE is carefully evaluating and analyzing the impacts on storage requirements and commitments with state regulators at the generator sites. These efforts will inform decisions related to the availability of storage for certified TRU waste until waste shipments to WIPP can resume. Detailed information on the status of recovery activities at WIPP can be found at http://www.wipp.energy.gov/wipprecovery/recovery.html.

S.2.5.3 Alternative 3: Disposal in a New Intermediate-Depth Borehole Disposal Facility

Alternative 3 involves the construction, operations, and post-closure performance of a new borehole facility for the GTCC LLRW and GTCC-like waste inventory. Reference locations at the following five sites are evaluated for this alternative: the Hanford Site, the INL Site, LANL, NNSS, and the WIPP Vicinity. Because of the shallow depth to groundwater at SRS, this alternative is not evaluated for this site. Of the four NRC regions considered for the generic commercial facility, only NRC Region IV was evaluated for this alternative, since the depth to groundwater at the other three regions is considered too shallow for application of the borehole method. A cross section of a conceptual borehole design is shown in Figure S-9. For purposes of the EIS analysis, a borehole with a depth of 40 m (130 ft) was evaluated.

To dispose of the entire inventory of GTCC LLRW and GTCC-like waste, the conceptual design indicates that about 44 ha (110 ac) of land would be required for the 930 boreholes needed to accommodate the waste packages of GTCC LLRW and GTCC-like waste (see Figure S-10). This acreage would include land required for supporting infrastructure, such as facilities or buildings for receiving and handling waste packages or containers, and space for a stormwater retention pond (to collect stormwater runoff and truck washdown). Less acreage and fewer boreholes would be required if a decision were made to only dispose of certain GTCC LLRW and GTCC-like waste types in a borehole facility. The borehole method entails borehole designs constructed at depths below 30 m (100 ft) but above 300 m (1,000 ft) below ground surface (bgs). Boreholes can vary widely in diameter (from 0.3 to 3.7 m [1 to 12 ft]), and the

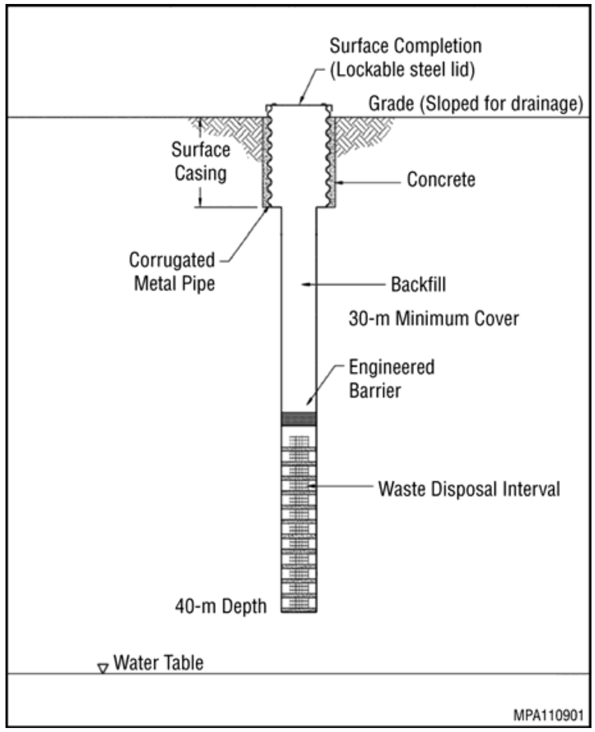


FIGURE S-9 Cross Section of the Conceptual Design for an Intermediate-Depth Borehole

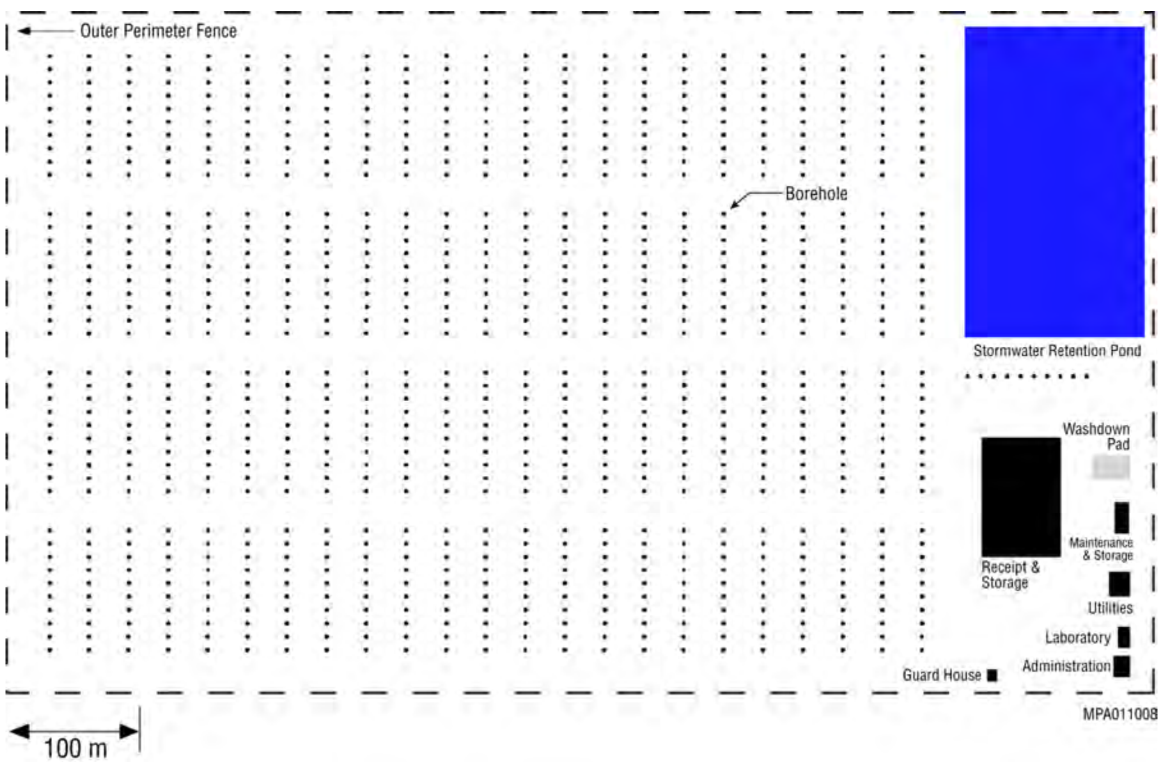


FIGURE S-10 Layout of Conceptual Borehole Facility

proximity of one borehole to another can vary depending on the design of the facility. GTCC LLRW and GTCC-like waste disposal placement is assumed to be about 30 to 40 m (100 to 130 ft) bgs. After placement of the wastes in the borehole, an engineered barrier (reinforced concrete) would be added above the disposal containers to deter inadvertent drilling into the isolated waste during the post-closure period, and backfill would be added to the surface level.

S.2.5.4 Alternative 4: Disposal in a New Enhanced Near-Surface Trench Disposal Facility

Alternative 4 involves the construction, operations, and post-closure performance of a new trench disposal facility. This alternative is evaluated for the Hanford Site, the INL Site, LANL, NNSS, SRS, and the WIPP Vicinity. The conceptual design of the trench is shown in Figure S-11. Alternative 4 is evaluated for the generic commercial sites in NRC Regions II and IV in order to allow for a comparison with the federal sites in these two regions.

To dispose of the entire inventory of GTCC LLRW and GTCC-like waste, the conceptual design for the trench method includes 29 trenches occupying a footprint of about 20 ha (50 ac) (see Figure S-12). This acreage includes land required for supporting infrastructure, such as facilities or buildings for receiving and handling waste packages or containers, and space for a stormwater retention pond (to collect stormwater runoff and truck washdown). Each trench would be approximately 3-m (10-ft) wide, 11-m (36-ft) deep, and 100-m (330-ft) long. GTCC LLRW and GTCC-like waste disposal placement is assumed to be about 5 to 10 m (15 to 30 ft) bgs. After wastes were placed in the trench, an engineered barrier (a reinforced concrete layer)

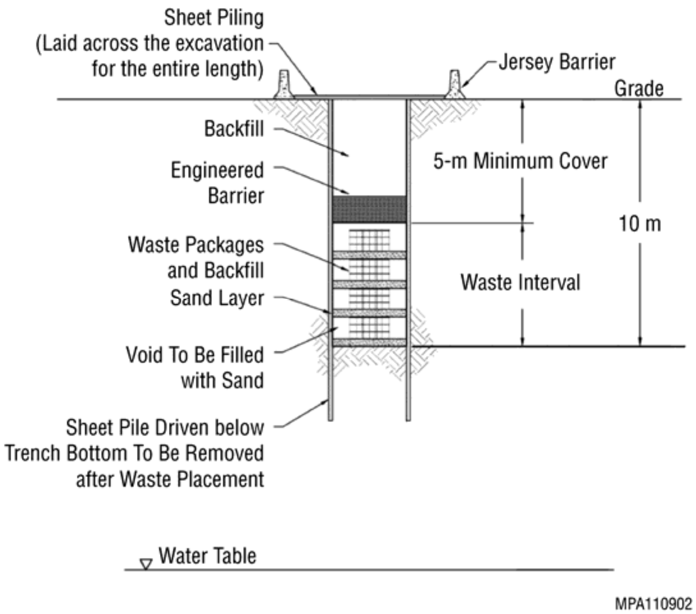


FIGURE S-11 Cross Section of the Conceptual Design for a Trench

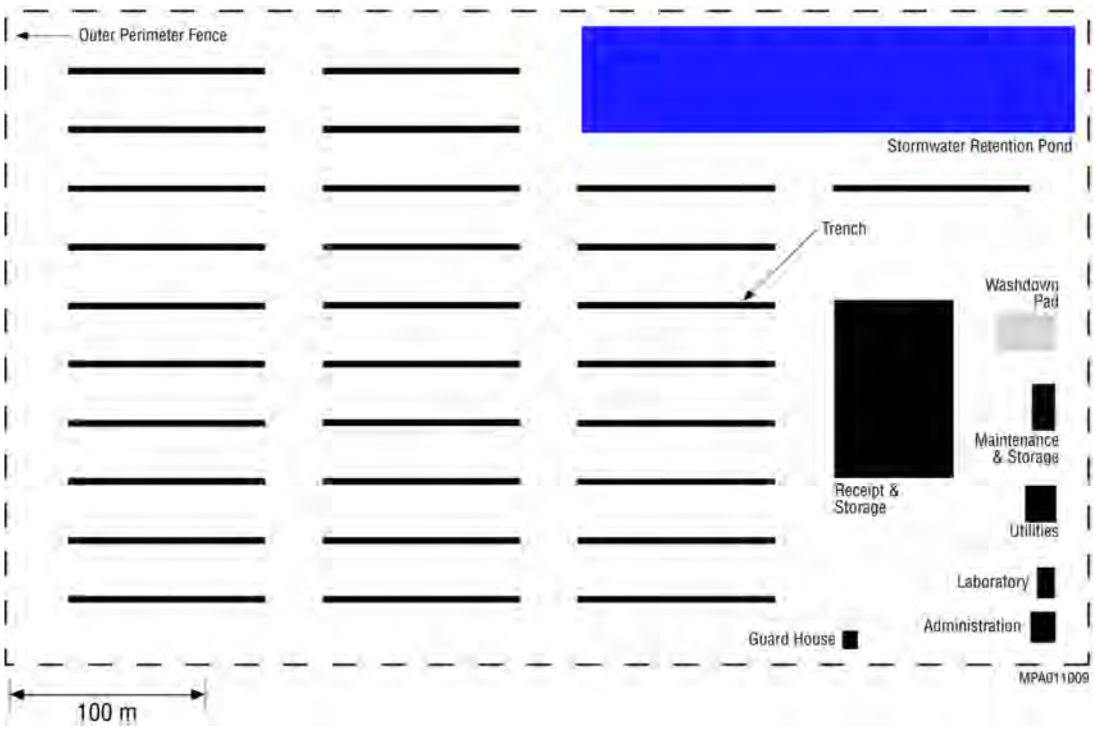


FIGURE S-12 Layout of a Conceptual Trench Facility

would be placed on top, and backfill would be added to the surface level. The additional concrete layer would provide additional shielding during the operational period, and at some sites where the material through which drilling would be done is typically soft (e.g., sand or clay), the layer could deter inadvertent drilling into the buried waste during the post-closure period. Measures would be included in the designs of the facilities to reduce the likelihood for future inadvertent human intrusion. In addition to the concrete cover noted above, the conceptual design for the trench is deeper and narrower than conventional near-surface LLRW disposal facilities to minimize this potential intrusion during the post-closure period. Additional intruder barriers would also be adopted for those sites in hard rock settings. Protecting against an inadvertent human intruder would be a key feature of the final facility design.

S.2.5.5 Alternative 5: Disposal in a New Above-Grade Vault Disposal Facility

Alternative 5 involves the construction, operations, and post-closure performance of a new vault disposal facility at the Hanford Site, the INL Site, LANL, NNSS, SRS, and the WIPP Vicinity. The conceptual design of the vault is shown in Figure S-13. Alternative 5 is evaluated for the generic commercial site in all four NRC regions. The conceptual design for the vault disposal employs a reinforced concrete vault constructed near grade level, with the footings and floors of the vault situated in a slight excavation just below grade.

The vault disposal facility to emplace the entire GTCC LLRW and GTCC-like waste inventory would consist of 12 vaults (each with 11 vault cells) and occupy a footprint of about 24 ha (60 ac) (see Figure S-14). This acreage would include land required for supporting

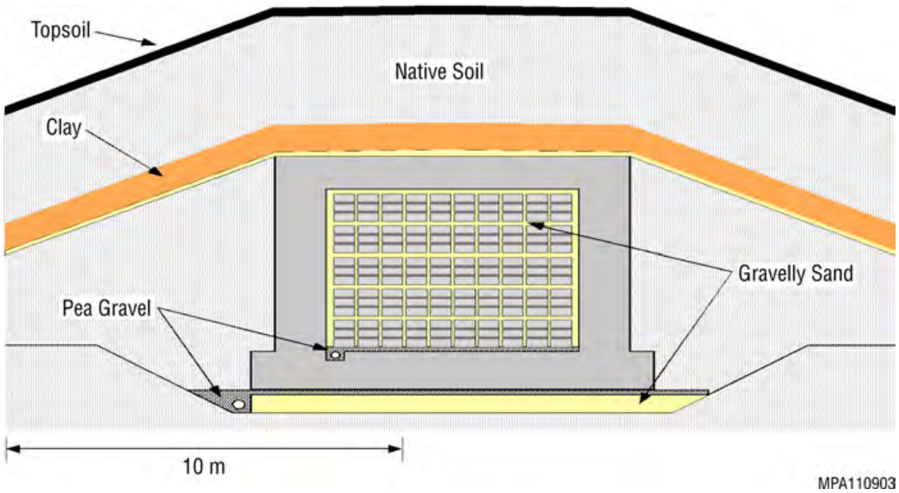


FIGURE S-13 Schematic Cross Section of the Conceptual Design for a Vault Cell

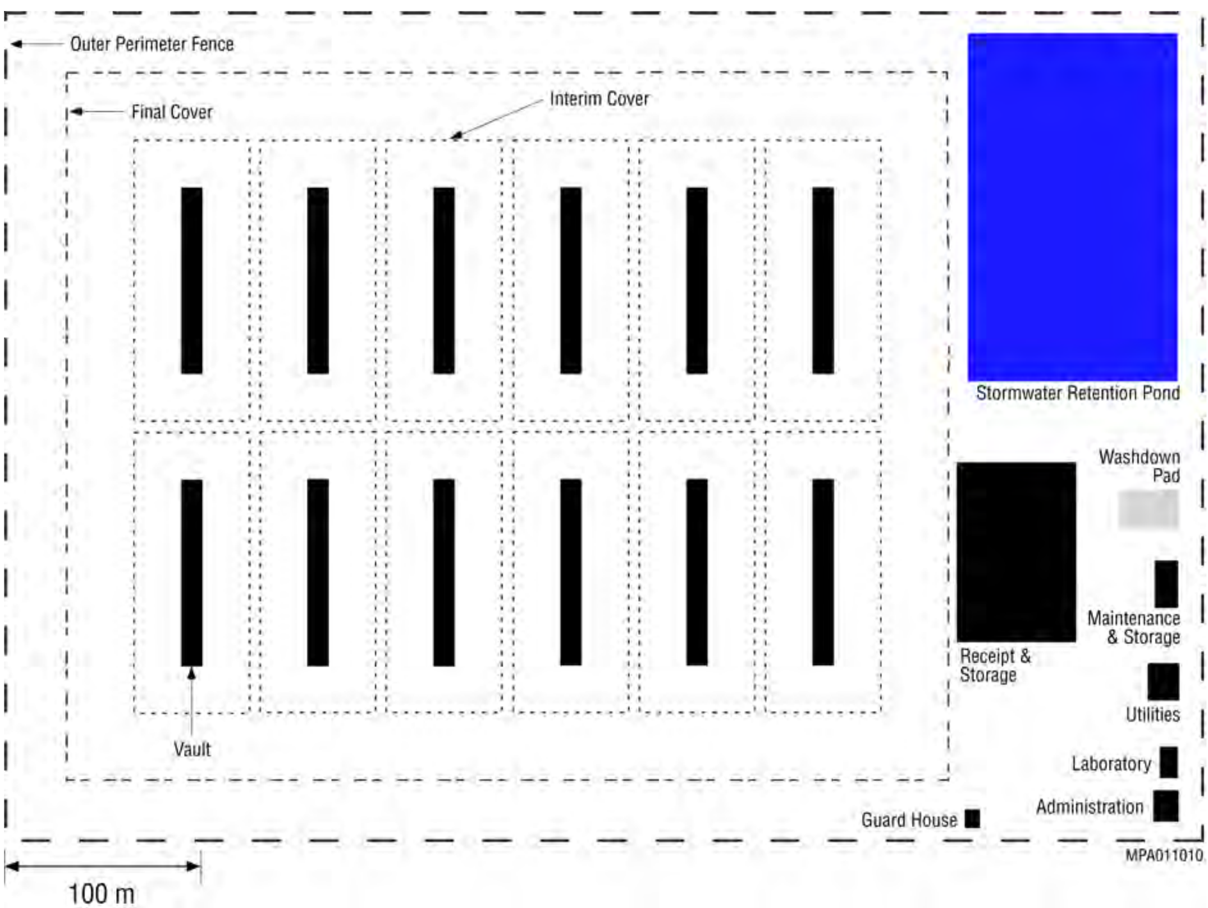


FIGURE S-14 Layout of a Conceptual Vault Disposal Facility

infrastructure, such as facilities or buildings for receiving and handling waste packages or containers, and space for a stormwater retention pond (to collect stormwater runoff and truck washdown). Each vault would be about 11-m (36-ft) wide, 94-m (310-ft) long, and 7.9-m (26-ft) tall, with 12 vaults situated in a linear array. The interior cell would be 8.2-m (27-ft) wide, 7.5-m (25-ft) long, and 5.5-m (18-ft) high, with an internal volume of 340 m^3 (12,000 ft^3) per cell. Double interior walls with an expansion joint would be included after every second cell. The thick concrete walls and earthen cover would minimize inadvertent intrusion into the vault. GTCC LLRW and GTCC-like waste disposal placement is assumed to be about 4.3 to 5.5 m (14 to 18 ft) above ground surface.

S.2.6 Which Sites Are Evaluated for a GTCC LLRW and GTCC-Like Waste Disposal Facility?

For deep geologic disposal, DOE evaluated WIPP in New Mexico because of its characteristics as a geologic repository. For the borehole method, DOE evaluated reference locations at five federally owned sites: Hanford Site, INL, LANL, NNSS, and the WIPP Vicinity. For the trench, and vault disposal methods, DOE evaluated reference locations at six federally owned sites: Hanford Site, INL, LANL, NNSS, SRS, and the WIPP Vicinity. In addition, the three land disposal methods were evaluated for generic commercial sites in the four regions that make up the United States (coinciding with NRC's four regions), as shown in Figure S-3. The evaluations of the reference locations are intended to serve as a starting point for each of the sites being considered, and if a site was selected for possible implementation of any of the three land disposal methods, follow-on-site-specific NEPA evaluation and documentation, as appropriate, along with further optimization by a selection study, would be conducted to identify the location or locations within a given site that would be considered the best ones to accommodate a borehole, trench, or vault disposal facility.

S.2.6.1 Waste Isolation Pilot Plant (WIPP)

WIPP is a DOE facility and is the first deep underground geologic repository in the United States. It is permitted by the EPA and the State of New Mexico to safely and permanently dispose of defense-generated TRU waste (WIPP LWA as amended [P.L. 102-579 as amended by P.L. 104-201]). The facility began disposal operations in 1999. WIPP is located 42 km (26 mi) east of Carlsbad, New Mexico, in the Chihuahuan Desert in the southeast corner of the state (see Figure S-15). The WIPP facility sits in the approximate center of a 41-km^2 (16-mi^2) area that was withdrawn from public domain and transferred to DOE (see Figure S-16). Project facilities include disposal rooms that are mined 655 m (2,150 ft) under the ground in a salt formation (the Salado Formation) that is 610-m (2,000-ft) thick and has been stable for more than 200 million years.

The facility footprint itself encompasses 14 fenced ha (35 fenced ac) of surface space and about 12 km (7.5 mi) of underground excavations in the Salado Formation. There are four shafts to the underground: the waste shaft, salt handling shaft, air intake shaft, and exhaust shaft (see Figure S-8). There are several miles of paved and unpaved roads in and around the WIPP site, and an 18-km-long (11-mi-long) access road runs north from the site to U.S. Highway 62-180.

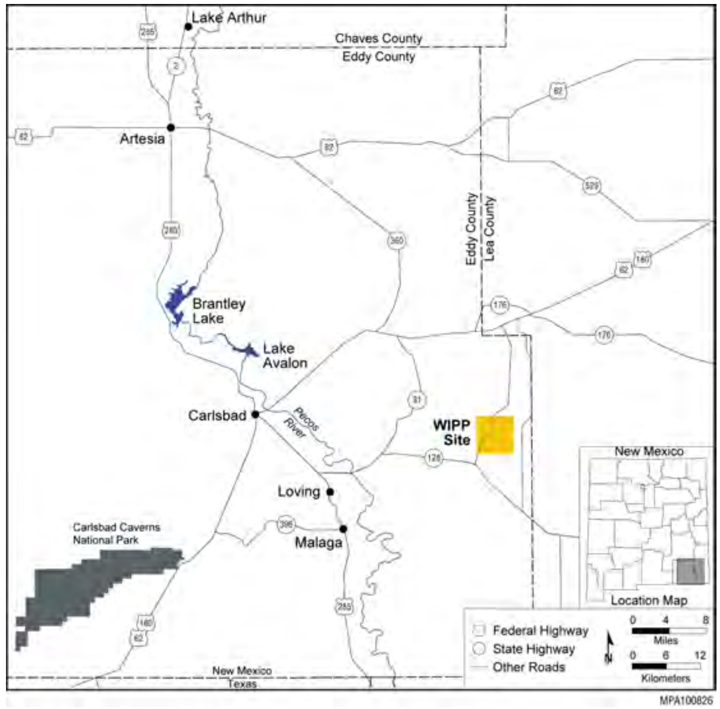


FIGURE S-15 General Location of WIPP in Eddy County, New Mexico

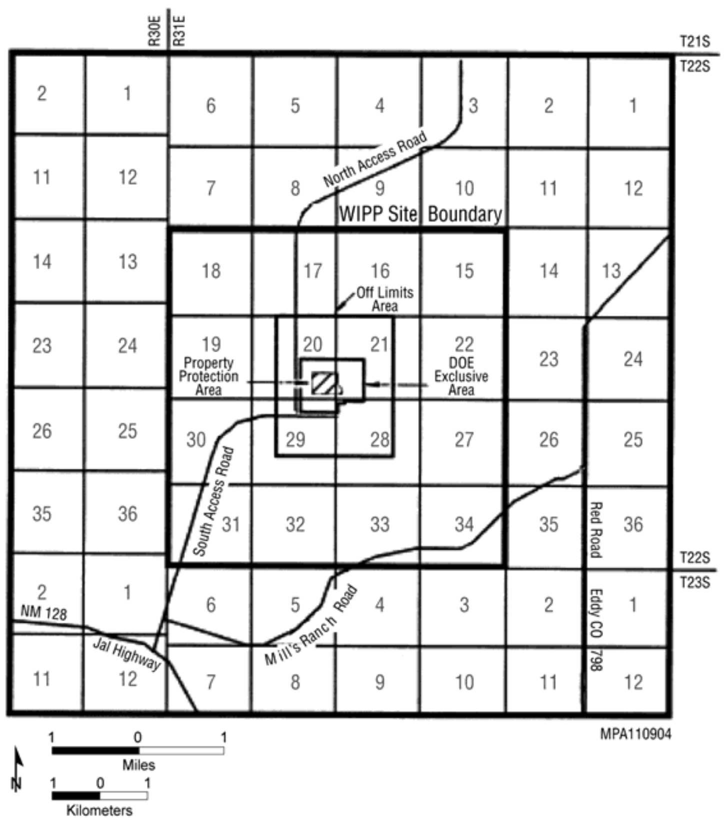


FIGURE S-16 Land Withdrawal Area Boundary at WIPP

The access road that is used to bring TRU waste shipments to WIPP is a wide, two-lane road with paved shoulders.

S.2.6.2 Hanford Site

The GTCC reference location at the Hanford Site is south of the 200 East Area in the central portion of the Hanford Site (Figure S-17). The 200 East and West Areas are located on a plateau about 11 and 8 km (7 and 5 mi), respectively, south of the Columbia River. Historically, these areas have been dedicated to fuel reprocessing and to waste management and disposal activities.

Current waste management activities at the Hanford Site include the treatment and disposal of LLRW on-site, the processing and certification of TRU waste pending its disposal at WIPP, and the storage of high-level radioactive waste on-site pending treatment and ultimate disposal. DOE will continue to defer the importation of off-site waste at Hanford, at least until the Waste Treatment Plant (WTP) is operational, subject to appropriate NEPA review and consistent with its previous preferred alternative for waste management (74 FR 67189). The limitations and exemptions defined in DOE's January 6, 2006, Settlement Agreement with the State of Washington (as amended on June 5, 2008) regarding *State of Washington v. Bodman* (Civil No. 2:03-cv-05018-AAM), signed by DOE, the State of Washington Department of Ecology, the Washington State Attorney General's Office, and the U.S. Department of Justice, will remain in place. The main areas where waste management activities occur are the 200 West Area and the 200 East Area. These 200 Areas cover about 16 km^2 (6 mi^2). Activities at the 200 Areas include the operation of lined trenches for the disposal of LLRW and mixed LLRW and the operation of the Environmental Restoration Disposal Facility for the disposal of LLRW generated by environmental restoration activities that are being conducted at the Hanford Site to comply with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). DOE will dispose of LLW and MLLW at the Integrated Disposal Facility from the tank treatment operations, WTP and effluent treatment operations, on-site non-CERCLA sources, Fast Flux Test Facility decommissioning and onsite waste management (74 FR 67189). U.S. Ecology, Inc., operates a commercial LLRW disposal facility on a 40-ha (100-ac) site leased by the State of Washington near the 200 East Area. The facility is licensed by the State of Washington.

S.2.6.3 Idaho National Laboratory (INL) Site

The GTCC reference location at the INL Site, which is southwest of the Advanced Test Reactor Complex in the south central portion of the INL Site (Figure S-18), serves as a basis for evaluation. If the INL Site is selected, the final location for a GTCC land disposal facility will be based on further analysis. The Advanced Test Reactor is dedicated to research supporting DOE missions, including nuclear technology research. The Remote-Handled Low-Level Waste Environmental Assessment (RH LLW EA; INL 2011) identified its preferred site to be one that is located to the southwest of the ATR Complex in the same area as the GTCC reference location. The GTCC site, if sited at the INL Site, would not be expected to affect the preferred site selected by the RH LLW EA.

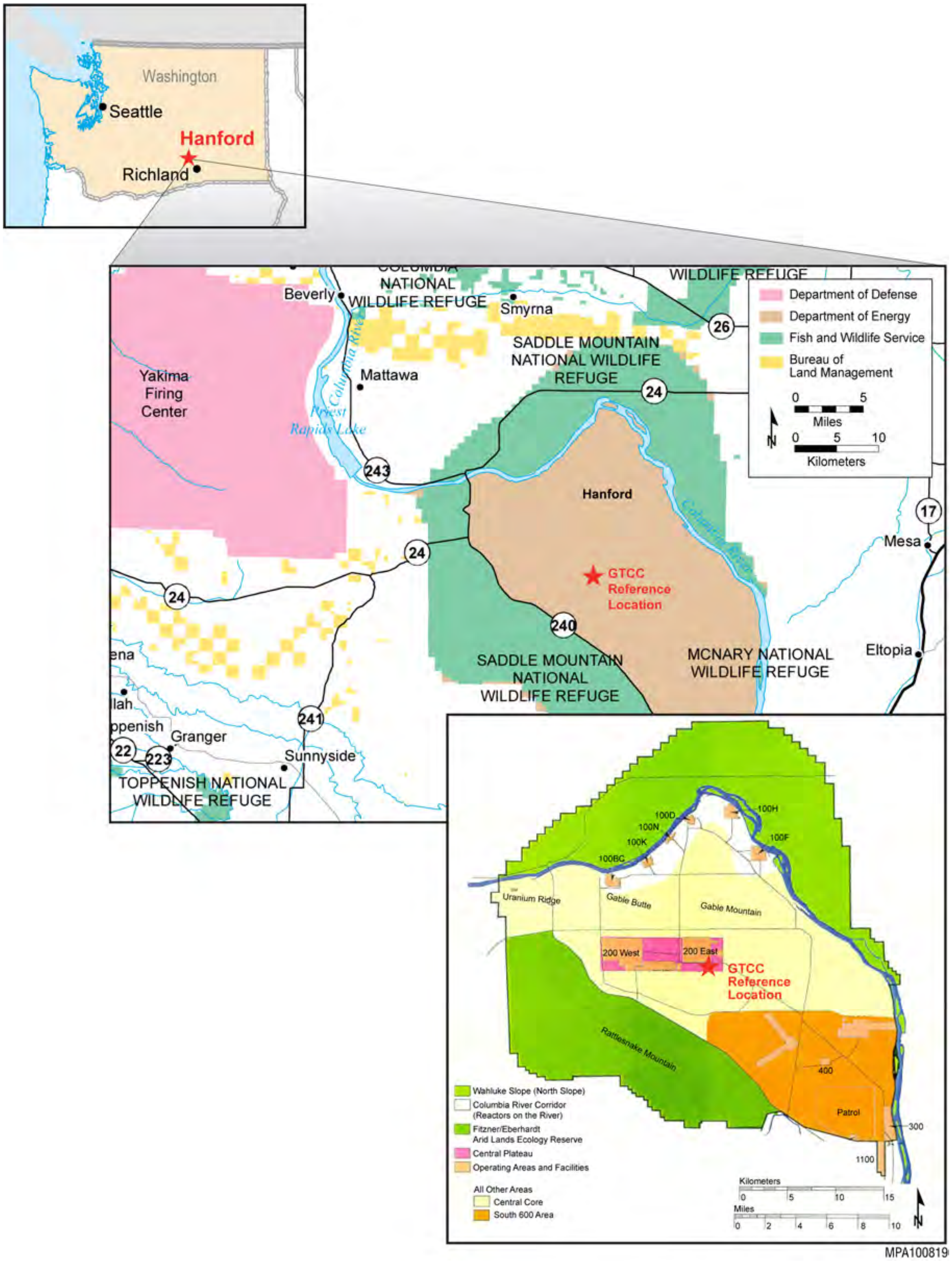


FIGURE S-17 GTCC Reference Location at the Hanford Site

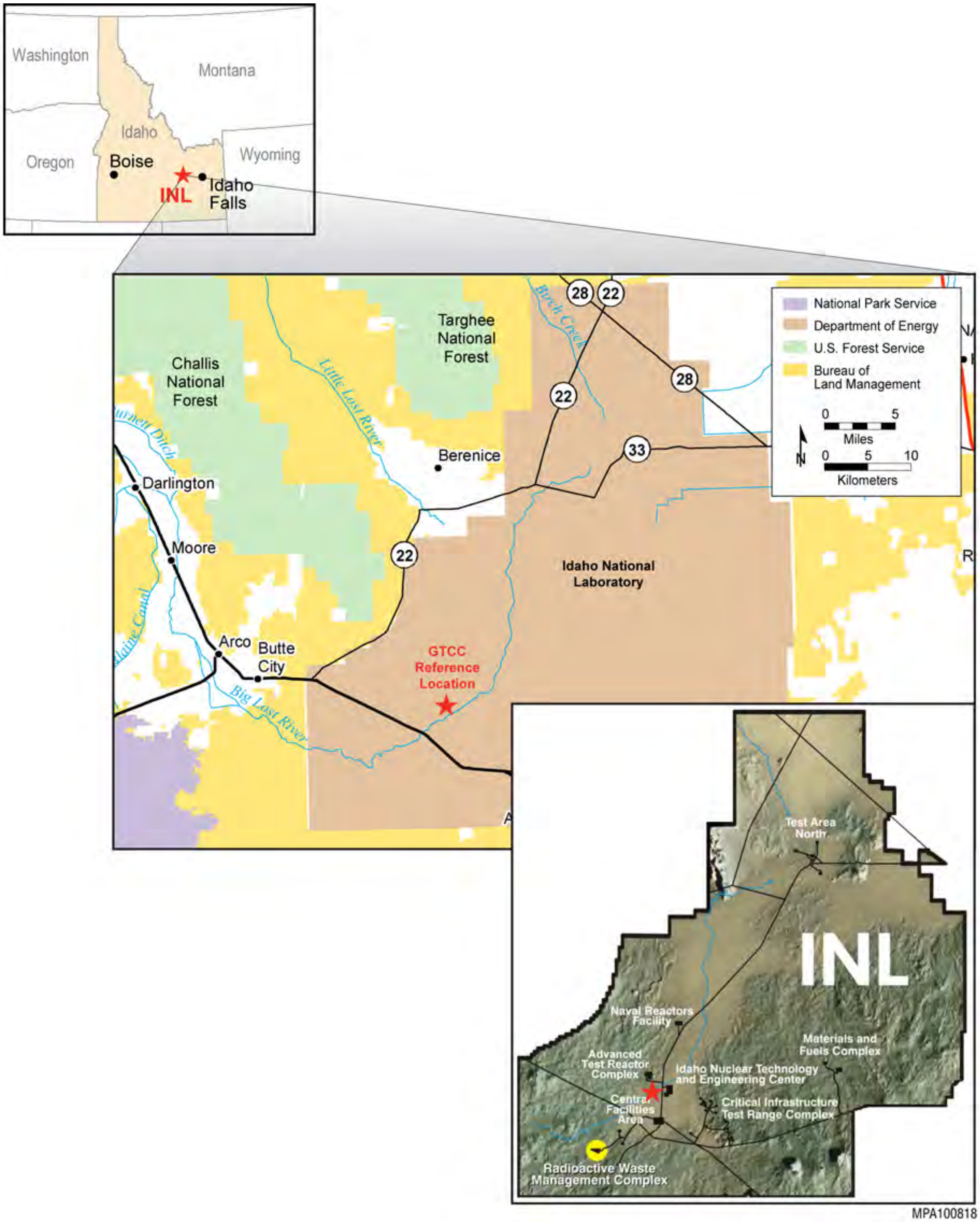


FIGURE S-18 GTCC Reference Location at the INL Site

Current waste management activities at the INL Site include the treatment and storage of mixed LLRW on-site, the treatment of LLRW on-site and its disposal on-site or off-site in DOE or commercial facilities, the storage of TRU waste on-site and its preparation for and shipment to WIPP, and the storage of high-level radioactive waste and spent nuclear fuel on-site pending the disposal of these last two materials. These wastes originate from DOE activities and from the on-site Naval Reactors Program. LLRW (RH waste) from INL Site operations is disposed of at the Subsurface Disposal Area at the Radioactive Waste Management Complex. CH LLRW is sent off-site. TRU waste is also stored and treated at the Radioactive Waste Management Complex and Idaho Nuclear Technology and Engineering Center to prepare it for disposal at WIPP.

S.2.6.4 Los Alamos National Laboratory (LANL)

The GTCC reference location at LANL is situated in three undeveloped and relatively undisturbed areas within Technical Area (TA)-51 and TA-54 on Mesita del Buey: Zone 6, North Site, and North Site Expanded (Figure S-19). Zone 6 is slightly less than 7 ha (17 ac) in area. It is not fenced, but access by road is controlled by a gate. The total area of the North Site is about 16 ha (39 ac). The North Site Expanded section adds another 23 ha (57 ac). The primary function of TA-54 is the management of radioactive and hazardous chemical wastes. Its northern border coincides with the boundary between LANL and the Pueblo de San Ildefonso; its southeastern boundary borders the community of White Rock. A subsurface volatile organic compound (VOC) vapor plume is present in the vadose zone at the Material Disposal Area L within TA-54. The primary source of these subsurface VOC vapors are the two shaft fields at Material Disposal Area L.

Current waste management activities at LANL include the storage of mixed LLRW, the disposal of LLRW on-site, the storage of TRU waste on-site, and the storage of sealed sources recovered by the Office of Global Material Security/Off-Site Source Recovery Project (GMS/OSRP) for national security or public health and safety reasons pending disposal. Area G at TA-54 currently accepts on-site LLRW for disposal; also, in special cases, off-site waste has been accepted from other DOE sites for disposal. Engineered shafts are actively used to dispose of RH LLRW.

Since 1989, DOE has funded the Environmental Program at LANL to complete the cleanup of the environmental legacy contamination brought about from seven decades of nuclear weapons development and management, as well as government-sponsored nuclear science and energy research.[3] Groundwater sampling data from monitoring wells at LANL indicate the presence of chromium groundwater contamination beneath Mortandad Canyon near the property boundary between LANL and the Pueblo de San Ildefonso. This chromium contamination is a result of historical use of potassium dichromate – a corrosion inhibitor – in non-nuclear cooling-tower water that was discharged to an outfall as part of LANL operational maintenance

[3] Legacy contamination is generally defined as the contamination of the environment resulting from pre-1999 Los Alamos National Laboratory activities and waste-management practices within DOE's environmental management scope.

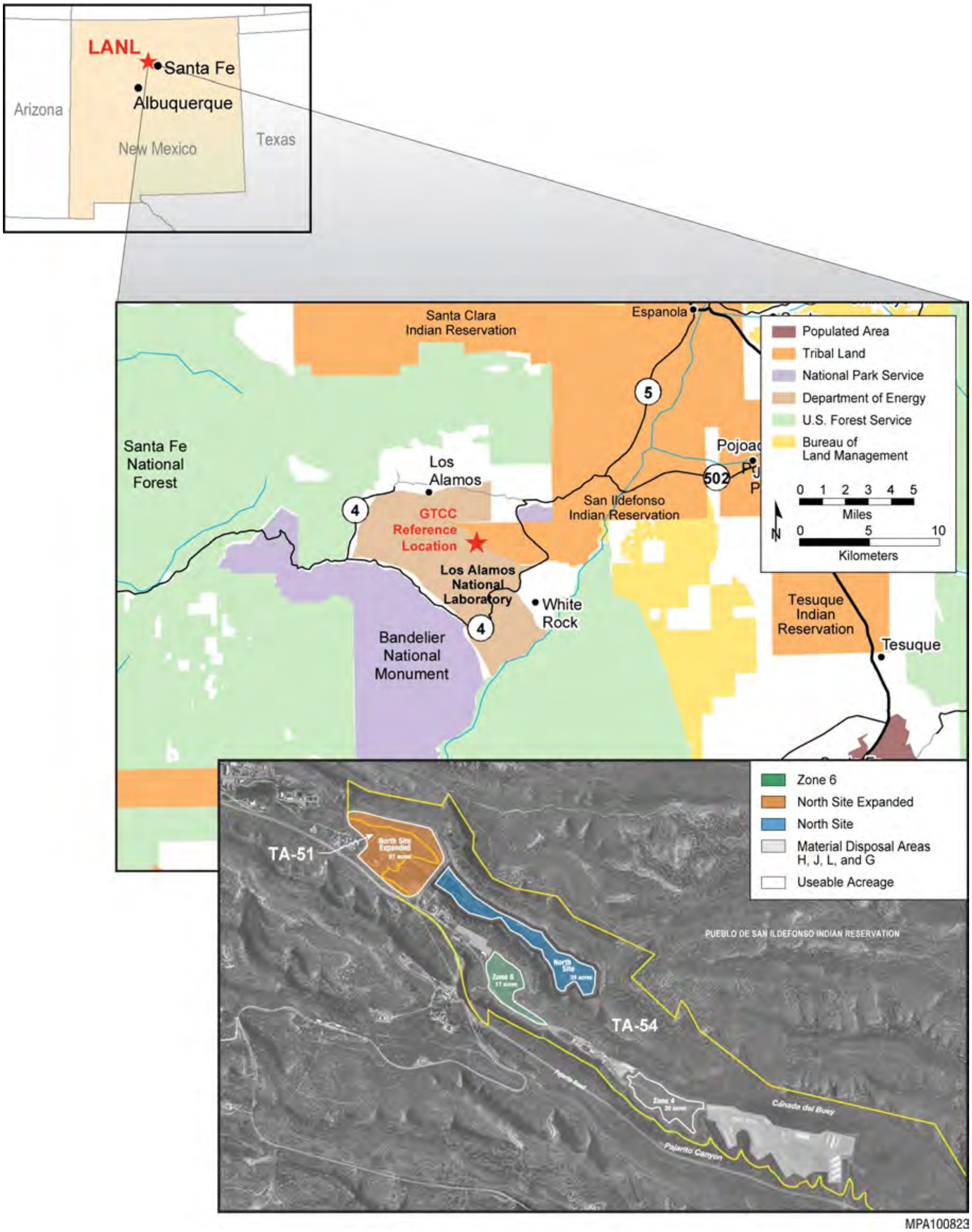


FIGURE S-19 GTCC Reference Location at LANL activities. DOE evaluated a proposed interim measure that would control migration of the chromium groundwater contamination plume off LANL lands and the feasibility of long-term corrective actions intended to remediate the chromium plume in an environmental assessment (DOE/EA-2005).[4]

S.2.6.5 Nevada National Security Site (NNSS)

The GTCC reference location for NNSS is identified within Area 5 and serves as a basis for evaluation (Figure S-20). Area 5 is one of two areas (the second is Area 3) at NNSS that support the site's radioactive waste management program. Area 5 is located in the southeastern section of NNSS in Frenchman Flat. If NNSS is selected, the final location for a GTCC disposal facility will be based on further analysis. NNSS presently serves as a disposal site for LLRW and mixed LLRW generated by DOE facilities. It is also an interim storage site for a limited amount of newly generated TRU mixed wastes pending transfer to WIPP for disposal. From 1984 through 1989, boreholes (at depths of 21 to 37 m [70 to 120 ft]) were used at the Area 5 Radioactive Waste Management Site to dispose of higher-activity LLRW and TRU waste.

S.2.6.6 Savannah River Site (SRS)

The GTCC reference location is situated on an upland ridge within the Tinker Creek drainage, about 3.2 km (2 mi) to the northeast of Z-Area in the north-central portion of SRS (Figure S-21). The area is not currently being used for waste management.

SRS currently manages high-level waste, TRU waste, LLRW, and mixed LLRW. High-level waste is vitrified at the Defense Waste Processing Facility and stored on-site pending disposal. TRU waste is stored, prepared for shipment, and shipped to WIPP for disposal. LLRW is treated and disposed of on-site, or it is prepared for shipment to be disposed of at other DOE sites (e.g., NNSS) or commercial facilities. On-site facilities for LLRW disposal include engineered trenches and vaults.

S.2.6.7 WIPP Vicinity

WIPP Vicinity refers to Township 22 South, Range 31 East, Sections 27 and 35, with each section containing a total of 260 ha (640 ac) or 2.6 km^2 (1 mi^2). Only a portion of Section 27 or Section 35, if selected, would be needed to accommodate a new GTCC LLRW and GTCC-like waste disposal facility. Section 27 is within the WIPP Land Withdrawal Boundary (LWB), while Section 35 is just outside the WIPP LWB to the southeast (Figure S-22). Section 27 is administered by DOE, and Section 35 is administered by the Bureau of Land Management in the U.S. Department of the Interior. WIPP is located in Eddy County in southeastern New Mexico, about 42 km (26 mi) east of the city of Carlsbad. The land is a

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[4] *Final Environmental Assessment for Chromium Plume Control Interim Measure and Plume-Center Characterization, Los Alamos National Laboratory, Los Alamos, New Mexico* (December 2015). http://energy.gov/nepa/ea-2005-chromium-plume-control-interim-measure-and-plume-center-characterization-los-alamos.

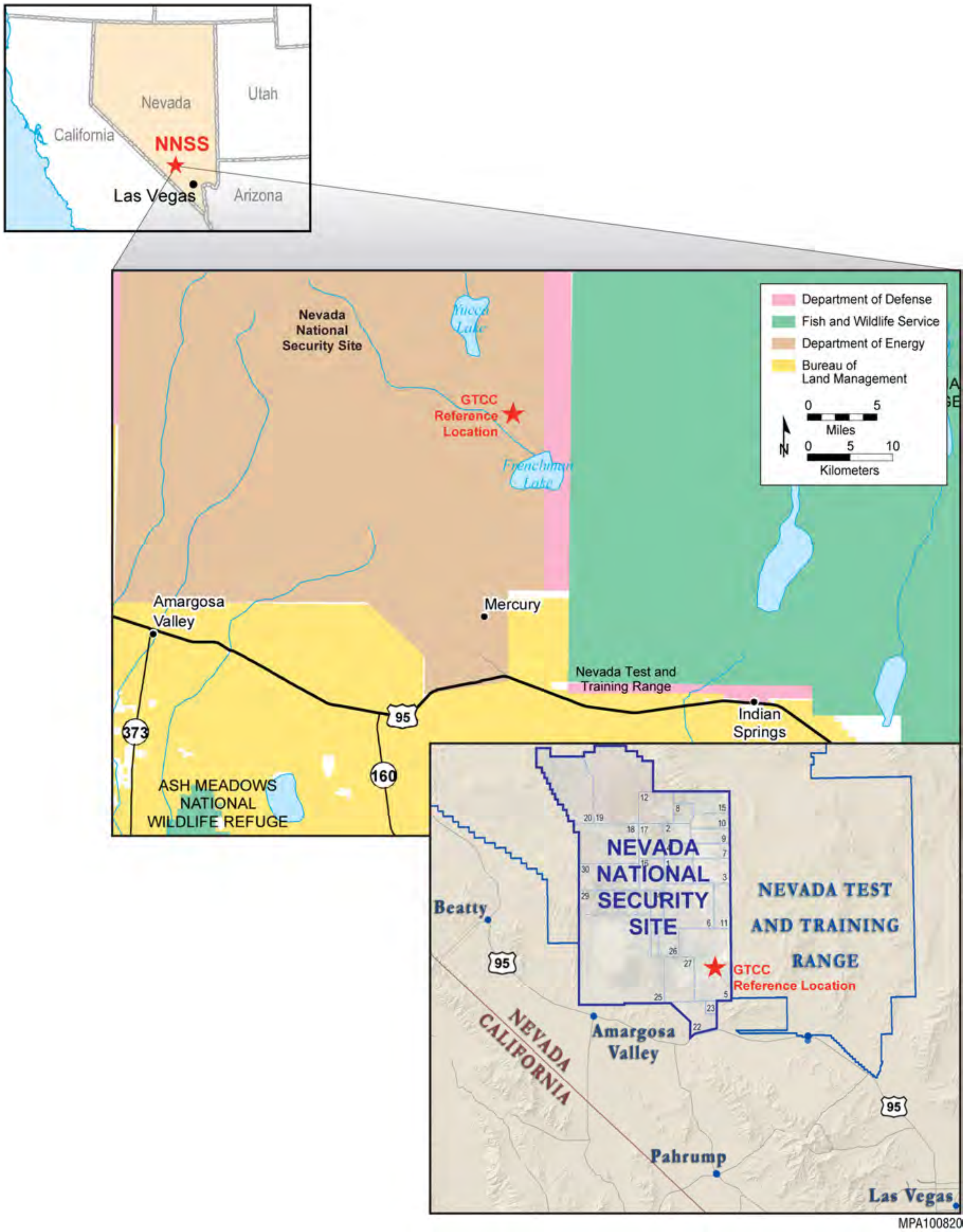

FIGURE S-20 GTCC Reference Location at NNSS

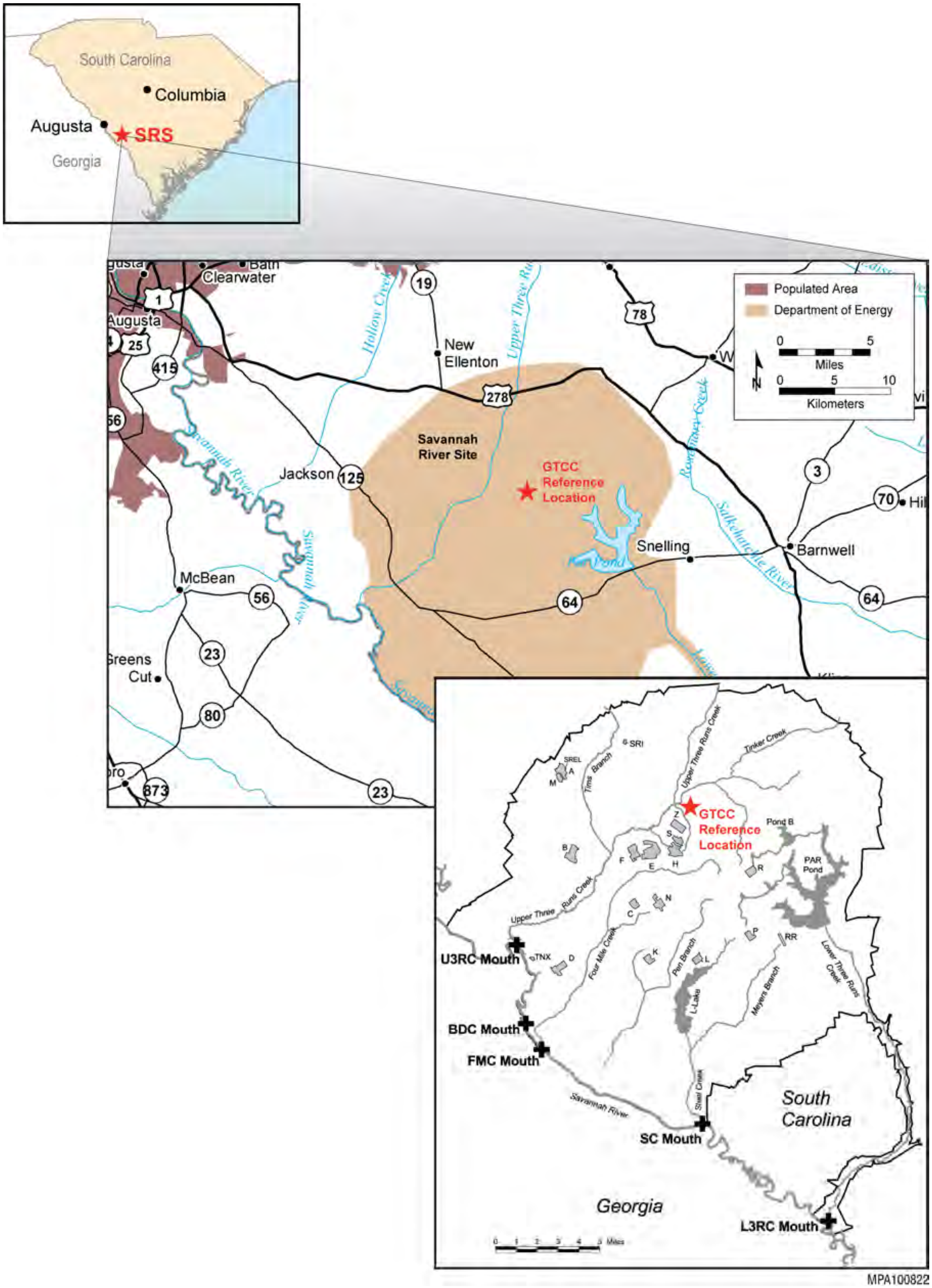

FIGURE S-21 GTCC Reference Location at SRS

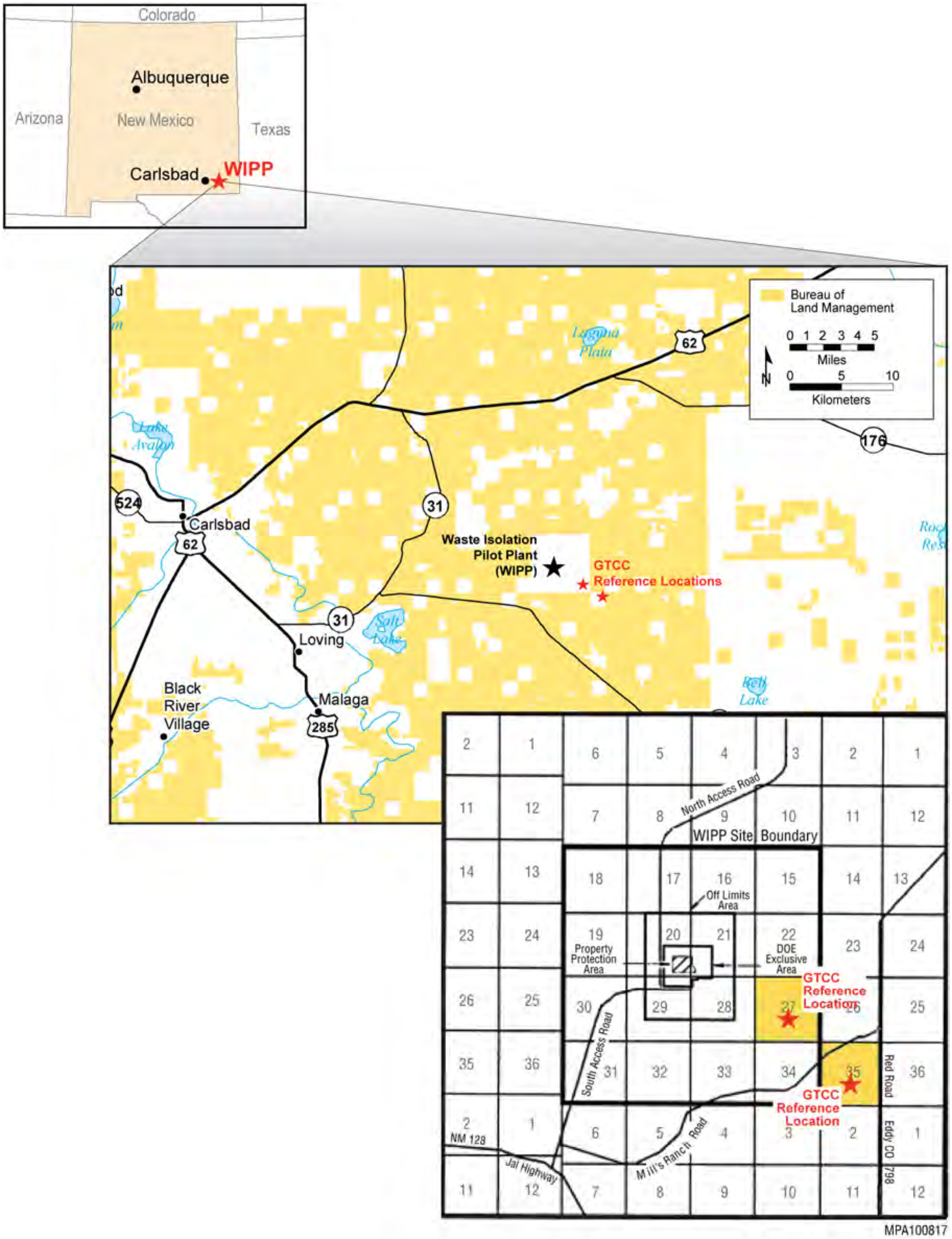

FIGURE S-22 GTCC Reference Locations (Sections 27 and 35) at the WIPP Vicinity

relatively flat, sparsely inhabited area (about 118,556 people in an 80-km [50-mi] radius, according to the 2010 census), known as Los Medaños (Spanish for “the dunes”).

There are no potash or oil and gas leases on Section 27 since it is part of the land that has been withdrawn. Section 35 contains oil and gas leases. Currently, no waste management activities are being conducted at Section 27 or Section 35.

S.2.6.8 Generic Regional Commercial Disposal Sites

In the absence of specific commercial sites, DOE evaluated generic commercial facilities in the EIS to allow DOE to make a determination regarding disposal of GTCC LLRW and GTCC-like waste in such a facility. DOE solicited technical capability statements from commercial vendors that might be interested in constructing and operating a GTCC LLRW and GTCC-like waste disposal facility in a request for information in the *FedBizOpps* on July 1, 2005. Although at the time, several commercial vendors expressed an interest, no vendors provided specific information on disposal locations and methods for analysis in the EIS. On June 20, 2014 Waste Control Specialists, LLC, (WCS), filed (and resubmitted on July 21, 2014) a Petition for Rulemaking with the Texas Commission on Environmental Quality (TCEQ) requesting the State of Texas to revise certain provisions of the Texas Administrative Code to remove prohibitions on disposal of GTCC LLRW, GTCC-like waste and TRU waste at its TCEQ licensed facilities. On January 30, 2015, TCEQ sent a letter to the NRC requesting guidance on the State of Texas’s authority to license disposal of GTCC LLRW, GTCC-like waste and TRU waste. This matter is under review by NRC.

Should DOE identify a specific commercial facility or facilities for the disposal of GTCC LLRW and GTCC-like waste, DOE would conduct site-specific NEPA reviews, as appropriate. The generic commercial sites are evaluated in the GTCC EIS on the basis of a regional approach that divides the United States into four regions consistent with the designations of Regions I through IV of the NRC. The states that make up each of these four regions are shown in Figure S-3. Region I comprises the 11 states in the northeast; Region II comprises the 10 states in the southeast; Region III comprises the 7 states in the Midwest; and Region IV comprises the remaining 22 states in the western part of the country.

Current commercially operated LLRW disposal facilities for non-GTCC LLRW are located in Region II (a facility in Barnwell, South Carolina, which receives Class A, B, and C waste) and Region IV (facilities in Richland, Washington, and in Clive, Utah, which receive Class A, B, and C wastes and Class A waste, respectively). Another disposal facility (located in Region IV in Andrews County, Texas) has been licensed and is now operating and available to dispose of Class A, B, and C wastes. The federal sites evaluated in the EIS are also located within these same two regions.

S.2.7 Alternatives Considered but Not Evaluated in Detail

DOE identified the alternatives for detailed analysis in the EIS on the basis of the rationale provided in the Notice of Intent (NOI) for the GTCC EIS (72 FR 40135). Several comments received during the scoping process indicated that DOE should include alternatives in addition to those identified in the NOI. However, none of the suggested alternatives were determined to be a reasonable alternative.

In the NOI for the GTCC EIS, DOE identified co-disposal of the GTCC LLRW and GTCC-like waste at the then-proposed Yucca Mountain repository as one alternative to be considered; however, DOE did not include this as an alternative in the GTCC EIS because since publication of the NOI, the Secretary of Energy determined that developing a permanent repository for high-level waste and spent nuclear fuel at Yucca Mountain, Nevada, is not a workable option, and the repository will not be developed. Therefore, DOE concluded that co-disposal at a Yucca Mountain repository is not a reasonable alternative and has eliminated it from evaluation in this EIS.

DOE did not evaluate developing a geologic repository exclusively for disposal of GTCC LLRW and GTCC-like wastes because DOE determined that such an alternative is not reasonable due to the time and cost associated with siting a deep geologic repository and the relatively small volume of GTCC LLRW and GTCC-like wastes identified in the GTCC EIS. The results presented in this EIS for the WIPP geologic repository alternative are indicative of the high degree of waste isolation that would be provided by disposal in a geologic repository.

In addition, the NOI for the GTCC EIS also identified ORR as a site to be evaluated for potential disposal of GTCC LLRW and GTCC-like waste by using a land disposal method because of its ongoing waste disposal mission. Based on internal reviews conducted by the Low-Level Waste Disposal Facility Federal Review Group, DOE determined that the site is not appropriate for disposal of LLRW containing high concentrations of long-lived radionuclides (such as those found in GTCC LLRW and GTCC-like waste), especially those with high mobility in the subsurface environment. For this reason, DOE concluded that ORR is not a reasonable disposal site alternative and eliminated it from detailed evaluation in this EIS.

S.2.8 Which Resource Areas Are Analyzed in the EIS?

DOE evaluated each alternative for its potential consequences on the following 11 environmental resource areas, as shown in Figure S-23:

Climate, air quality, and noise,
Geology and soils,
Water resources,
Human health,
Ecology,
Socioeconomics,
Environmental justice,
Land use,
Transportation,
Cultural resources, and
Waste management.

In addition to the above resource areas, DOE evaluated inadvertent human intrusion and cumulative impacts to address the impacts that could result from implementation of the proposed GTCC action at each site in combination with past, present, and future planned activities (including federal and nonfederal activities) at or in the vicinity of that site.

S.3 SUMMARY AND COMPARISON OF POTENTIAL ENVIRONMENTAL IMPACTS

DOE has evaluated the resource areas shown in Figure S-23 for each of the alternatives in the GTCC EIS for disposal of the entire inventory of GTCC LLRW and GTCC-like waste. The resource areas are evaluated for the construction, operations, and post-closure phases of the proposed action. The decommissioning of the disposal facility is also part of the proposed action, but because the facility would not be closed and properly decommissioned until some time in the far future (decades), the impact analysis for the decommissioning phase would be conducted at that time. These evaluation results are presented in Table S-3. This table presents a comparison of the potential impacts of the five alternatives on the resource areas shown in Figure S-23.

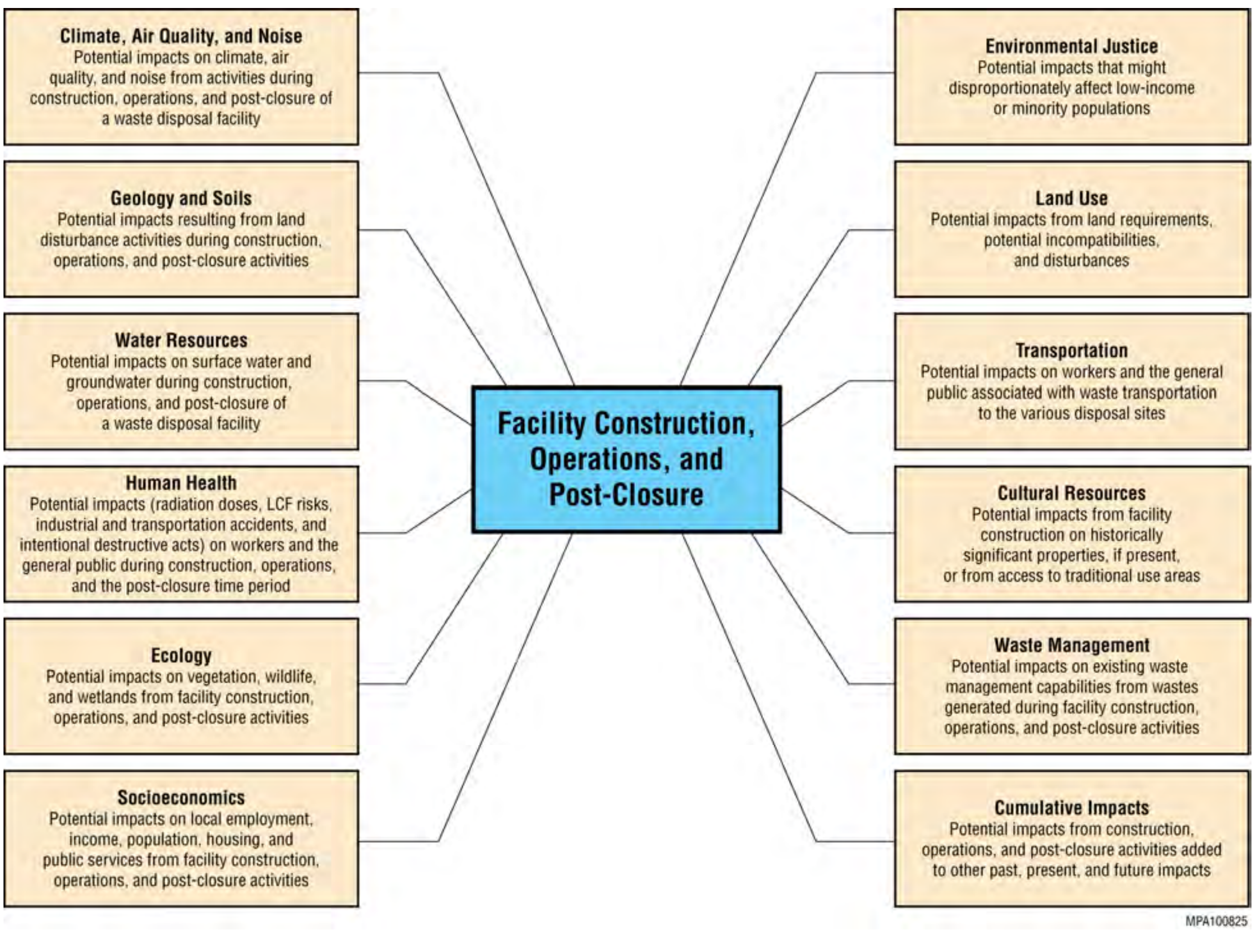

FIGURE S-23 Environmental Resource Areas on Which the Impacts of the Alternatives Are Evaluated

TABLE S-3 Comparison of Potential Impacts

Resource Area	Alternative: Alternative 1 No Action	Alternative: Alternative 2 WIPP Geologic Repository	Alternative: Alternative 3 Borehole	Alternative: Alternative 4 Trench	Alternative: Alternative 5 Vault
Climate, Air Quality, and Noise	No incremental impacts due to construction activities for a disposal facility are expected because none would be undertaken. It is assumed that the current facility operations in the storage sites would continue and result in minimal impacts.	Impacts would be low because most construction and operational activities would occur below ground. Emissions associated with Alternative 2 are lower than those for Alternatives 3 to 5.	Construction and operational activities would be within the boundaries of all the sites evaluated, and these activities would contribute little to concentrations of airborne pollutants or noise at or beyond the site boundaries. For most sites, during the construction phase, peak annual emissions associated with the borehole method would be between those associated with the trench and vault methods, with the vault method resulting in the highest relative emissions and the trench method having the lowest of the three methods. Construction related emissions from all three disposal methods would generally add 1% or less to emissions in the nearby areas surrounding the various sites (the exception would be at NNSS where SO_2 and NO_x emissions could add about 3%). Peak annual emissions from the operation of a borehole, trench, and vault facility at the various sites would be lower than those for the peak annual construction phase. Emissions of greenhouse gases are expected to be low and not result in significant climate change concerns. Noise levels at a distance of 690 m (2,300 ft) from the source would be below the EPA guideline of 55 dBA or decibels for all the sites evaluated. This distance is smaller than the distance between the GTCC reference locations and the respective nearest off-site residences. Estimated distances of the GTCC reference locations from the respective nearest known off-site residences are as follows: >6 km (4 mi) at the Hanford Site; >11 km (7 mi) at the INL Site; about 3.5 km (2.2 mi) at LANL (nearest residence in White Rock); >6 km (4 mi) at NNSS; >14 km (9 mi) at SRS; and >5 km (3 mi) at the WIPP Vicinity.		
Geology and Soils	No incremental impacts due to construction activities for a disposal facility are expected because none would be undertaken. It is assumed that the current facility operations in the storage sites would continue and result in minimal impacts.	No incremental impacts are expected because construction, operational, and post-closure activities would not involve additional land disturbance.	Impacts would be proportional to the total land area affected. The borehole method would disturb the most land, followed by the trench and vault methods. No adverse impacts are expected, and no significant changes to surface topography would occur. The potential for erosion would be lower at the five western sites evaluated (Hanford Site, INL Site, LANL, NNSS, and WIPP Vicinity) than at the eastern site (SRS) because of the low precipitation rates at the western sites.		

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TABLE S-3 (Cont.)

Resource Area	Alternative 1 No Action	Alternative 2 WIPP Geologic Repository	Alternative 3 Borehole	Alternative 4 Trench	Alternative 5 Vault
Water Resources	No incremental impacts due to construction activities for a disposal facility are expected because none would be undertaken. It is assumed that the facility operations in the storage sites would continue and result in minimal impacts.	Incremental impacts would be minor when added to those associated with operations at WIPP.	Impacts on water resources would generally be small at all sites evaluated. The increase in water use is less than 1% of the current annual use as capacity at the sites evaluated. Impacts on surface water and groundwater resources from surficial spills would be expected to be low. Water consumption associated with the borehole method during construction would be about 530,000 L/yr (140,000 gal/yr), which is the smallest amount associated with the three land disposal methods. The corresponding values for the trench and vault methods are 1,000,000 L/yr (270,000 gal/yr) and 3,300,000 L/yr (860,000 gal/yr), respectively. The initial construction period was assumed to be about 3.4 years for all three land disposal methods. The amount of potable and raw water consumed during the operational phase of the borehole method would also be the smallest of the three disposal methods; it would be about 2,500,000 L/yr (650,000 gal/yr). A total of 5,300,000 L/yr (1,400,000 gal/yr) would be required for operating either the trench or the vault method.		
Human Health Annual Collective Worker Dose[a]	Human health impacts from waste storage activities would be low. The annual occupational dose from these activities is estimated to be 4 person-rem, which corresponds to an annual LCF risk of 0.002.	The annual collective worker dose at WIPP is estimated to be 0.29 person-rem, which corresponds to an annual LCF risk of 0.0002. No fatalities and 3 lost workdays per year could occur due to occupational injuries.	The annual collective worker dose estimates for the disposal facility would be the same for all the sites evaluated because the same number of workers are assumed; the dose estimates, however, vary by disposal method. The annual collective worker doses are estimated to be 2.6 person-rem for the borehole method, 4.6 person-rem for the trench method, and 5.2 person-rem for the vault method. These doses correspond to annual LCF risks of 0.002, 0.003, and 0.003, respectively. No fatalities are expected to occur during waste disposal operations, and the number of lost workdays per year due to occupational injuries would range from 1 to 2 for the three alternatives, with the borehole method having the lowest number and the vault method having the highest number.		

TABLE S-3 (Cont.)

Resource Area	Alternative 1 No Action	Alternative 2 WIPP Geologic Repository	Alternative 3 Borehole	Alternative 4 Trench	Alternative 5 Vault
Human Health (Cont.) Maximum Long-Term Impacts	The estimated maximum long-term human health impacts could range up to 470 rem/yr, which corresponds to an annual LCF risk of 0.3.	Both the annual dose and LCF risk would be zero because there would be no releases to the accessible environment and therefore no radiation doses and LCF risks during the first 10,000 years following closure of the WIPP repository. This is noted in Section 5.1.12.1 of the *Waste Isolation Pilot Plant Disposal Phase Final Supplemental Environmental Impact Statement* issued in 1997 (DOE/EIS-0026-S-2).	The estimated maximum long-term human health impacts for the borehole method range from 0 mrem/yr (NNSS, WIPP Vicinity, and generic commercial Region IV) to 820 mrem/yr (INL Site). These doses correspond to an annual LCF risk of 0 to 0.0005. For the trench method, the estimates range from 0 mrem/yr (NNSS, WIPP Vicinity, and generic commercial Region IV) to 2,100 mrem/yr (INL Site), with a corresponding annual LCF risk of 0 to 0.001. For the vault method, the estimates range from 0 mrem/yr (NNSS, WIPP Vicinity, and generic commercial Region IV) to 2,300 mrem/yr (INL Site), with a corresponding annual LCF risk of 0 to 0.001. The estimates for the vault method are generally highest, followed by the trench and then the borehole methods. Table S-4 presents a tabulation of the estimates for long-term human health impacts.		
Human Health (Cont.) Waste Handling Accident to an Individual	The impacts from a waste handling accident to an individual from storage activities were not analyzed; storage practices are assumed to follow applicable requirements.	The impacts from a waste handling accident to an individual from current storage activities were not re-analyzed in this EIS as analysis was performed in Chapter 5 of "The WIPP Disposal Phase Final Supplement EIS (EIS-0026-S-2, September 1997); the accident analysis in the EIS has been reviewed by EM and is still representative and bounding. It is expected that the dose and LCF risk to an individual from this accident would be similar to those estimated for disposal at the WIPP Vicinity (i.e., highest individual dose of 7.5 rem with corresponding LCF risk of 0.005).	For the borehole, trench, and vault methods, the highest individual dose and LCF risk from a waste handling accident is for an individual assumed to be located 100 m (330 ft) from a fire involving an SWB. This individual is expected to be a noninvolved worker. While the estimates for all the sites evaluated are fairly comparable, they vary from site to site, depending on local meteorology and the assumed location of the nearest individual. The estimates are the same for all three methods. The estimates are as follows (the dose in rem is given first, followed by the LCF risk in parentheses): 16 (0.009) for the Hanford Site, 11 (0.007) for the INL Site, 12 (0.007) for LANL, 2.4 (0.001) for NNSS, and 7.5 (0.005) for the WIPP Vicinity. Because the calculations depend on the specific meteorology and location of the nearest individual, estimates were not performed for the generic commercial disposal facilities; however, it is expected that the impacts would be comparable to those listed above for the federal sites.		

TABLE S-3 (Cont.)

Resource Area	Alternative 1 No Action	Alternative 2 WIPP Geologic Repository	Alternative 3 Borehole	Alternative 4 Trench	Alternative 5 Vault
Human Health (Cont.) Waste Handling Accident to Nearby Population	The impacts from a waste handling accident to the nearby population from current storage activities were not analyzed. Current storage practices are assumed to follow applicable requirements.	The impacts from a waste handling accident involving a fire involving an SWB were not calculated for disposal of GTCC LLRW and GTCC-like waste at the WIPP repository; however, it is expected that the dose and LCF risk to a population from this accident would be similar to those estimated for disposal at the WIPP Vicinity (i.e., highest population dose of 7.0 person-rem with corresponding LCF risk of 0.004).	For the borehole, trench, and vault methods, the highest population dose and LCF risk from a waste handling accident is for a nearby population assumed to be located 100 m (330 ft) from a fire involving an SWB. The estimates are the same for all three methods but vary from site to site, depending on the local meteorology and assumed locations and number of the nearest population, with the highest estimate generated for LANL. The estimates are as follows (the dose in person-rem is given first, followed by the LCF risk in parentheses): 95 (0.06) for the Hanford Site, 13 (0.008) for the INL Site, 160 (0.1) for LANL, 0.47 (0.0003) for NNSS, and 7.0 (0.004) for the WIPP Vicinity. Because the calculations depend on the specific meteorology and locations and number of nearby populations, estimates were not performed for the generic commercial disposal facilities; however, it is expected that the impacts would be comparable to those listed above for the federal sites.		
Ecological Resources	No incremental impacts due to construction activities for a disposal facility are expected because none would be undertaken. It is assumed that the current facility operations in the storage sites would continue and result in minimal impacts.	Incremental impacts on habitat and wildlife would be localized and not result in adverse population-level effects.	Impacts on ecological resources would generally be small at all sites evaluated because of the relatively small amount of land affected. Impacts would be incurred by the individuals using the impacted areas, but population-level impacts are not expected. There are no federally listed or state-listed threatened or endangered species reported to be in the GTCC project areas at the INL Site or WIPP Vicinity. Construction activities could affect federal or state candidate species or species under review for federal listing at the INL Site or WIPP Vicinity. Impacts on these species would likely be small, since the area of habitat disturbance would be small relative to the overall size of such habitat in the area. Several federally listed or state-listed bird and mammal species occur within the GTCC project areas at the Hanford Site, SRS, LANL, and NNSS. Impacts on these species would likely be small, since the area of habitat disturbance would be small relative to the overall size of such habitat in the area. Adverse impacts would be minimized by conducting biological surveys in the project area and using good engineering practices to minimize impacts on the environment.		

TABLE S-3 (Cont.)

Resource Area	Alternative Alternative 1 No Action	Alternative 2 WIPP Geologic Repository	Alternative 3 Borehole	Alternative 4 Trench	Alternative 5 Vault
Socioeconomics	No incremental impacts due to construction activities for a disposal facility are expected because none would be undertaken. It is assumed that the current facility operations in the storage sites would continue and result in minimal impacts.	Impacts would be small because all construction and waste disposal activities could be conducted by the current workforce at WIPP.	The socioeconomic impacts would be small for all three alternatives at all of the sites considered. Estimated peak construction year in-migration would range from a low of 10 (borehole method at NNSS) to a high of 127 (vault method at WIPP Vicinity), requiring less than 1% of the vacant housing in the peak year. Operations would create about 38 to 51 direct jobs and about the same number of indirect jobs, resulting in an increase of less than 0.1% in the annual employment growth rate. The income during operations would be about $4 to $5 million per year.		
Environmental Justice	No incremental impacts due to construction activities for a disposal facility are expected because none would be undertaken. It is assumed that the current facility operations in the storage sites would continue and result in minimal impacts.	There would be no incremental impacts beyond those that have already occurred on the minority and low-income populations near the site.	The construction, operations, and post-closure of the land disposal facilities are not expected to result in the potential for disproportionately high and adverse impacts on minority and low-income populations in the vicinity of the sites considered in this EIS. DOE will continue to consult with American Indian tribes and coordinate with them to ensure that their concerns are considered. Subsequent NEPA review to support any GTCC implementation would consider any unique exposure pathways (such as subsistence fish, vegetation or wildlife consumption, and well water use) to determine any additional potential health and environmental impacts.		
Land Use	No incremental impacts due to construction activities for a disposal facility are expected because none would be undertaken. It is assumed that the current facility operations in the storage sites would continue and result in minimal impacts.	No changes in land use at the WIPP site or surrounding area would occur. No additional land surface within the existing footprint of the WIPP site would be affected by the construction of the additional underground rooms at WIPP to emplace the GTCC LLRW and GTCC-like waste, except for the small increased amount of land within the existing facility boundary needed to store excavated material (salt) from the repository.	The amounts of land required for the three alternatives are 20 ha (50 ac) for the trench method, 24 ha (60 ac) for the vault method, and 44 ha (110 ac) for the borehole method. Sufficient space is available at all of the sites to allow for disposal of GTCC LLRW and GTCC-like waste in a manner compatible with ongoing nearby activities. It may be necessary to modify the current land use classification at the reference locations at SRS and the WIPP Vicinity in order to allow disposal facility construction and operational activities to occur.		

TABLE S-3 (Cont.)

Resource Area	Alternative				
	Alternative 1 No Action	Alternative 2 WIPP Geologic Repository	Alternative 3 Borehole	Alternative 4 Trench	Alternative 5 Vault
Transportation	No transportation impacts would occur because no wastes would be shipped.	A total of 33,700 truck shipments or 11,800 rail shipments would be required to transfer the GTCC LLRW and GTCC-like waste to WIPP. This could result in 1 non-radiological fatality from rail accidents and 2 non-radiological fatalities for trucks. For truck transportation, the collective population dose is estimated to be 68 person-rem (with an LCF risk of 0.04, which includes an accident risk of 3 × 10^{-5} LCF), and the worker dose is estimated to be 180 person-rem (with an LCF risk of 0.1). The values for truck transportation are larger by factors of 1.6 and 3, respectively, than the corresponding values for rail transportation. The impacts are lower for use of rail than trucks because the number of shipments required is smaller. The number of estimated shipments to the WIPP repository is larger than the number associated with the other three action alternatives, primarily due to the assumption that activated metals and RH wastes with higher external dose rates would be packaged in shielded canisters for disposal at WIPP prior to being loaded onto the transport vehicles. All wastes being shipped to WIPP are assumed to be CH wastes, and the external dose rates are taken to be 0.5 and 1.0 mrem/h at 1 m for use of truck and rail, respectively. Although the number of estimated shipments to the WIPP repository is larger than the number associated with the other alternatives, the overall estimated public and worker doses are less because the wastes are shipped as CH wastes. Should the WIPP repository be selected as the option for disposal of these wastes, further evaluation and analysis to optimize the waste	A total of 12,600 truck shipments or about 5,000 rail shipments would be required to transfer the GTCC LLRW and GTCC-like waste to the various alternate disposal sites. This could result in 1 non-radiological fatality from accidents for both truck and rail. The collective population dose for truck transportation ranges from 69 person-rem (SRS) to 170 person-rem (Hanford Site) and could result in an LCF risk of up to 0.1, which includes an accident risk of up to 5 × 10^{-5} LCF. The worker doses for truck transportation range from 170 person-rem (SRS) up to 500 person-rem and could result in an LCF risk of up to 0.3. The values for truck transportation are larger by factors of 1 to 3 than the corresponding values for rail transportation, depending on which disposal site is addressed. The impacts are lower for use of rail than truck because a smaller number of shipments is required. The external dose rates for CH packages are assumed to be 0.5 and 1.0 mrem/h at 1 m for truck and rail, respectively, which are the same as those used for Alternative 2. The external dose rates for RH packages are taken to be 2.5 and 5.0 mrem/h at 1 m for truck and rail, respectively. About 94% of all shipments would be composed of RH waste. Because of the large percentage of RH shipments, the radiological transportation impacts for Alternatives 3, 4, and 5 are generally greater than those for Alternative 2. Should one of the land disposal methods be selected as the option for disposal of these wastes, further evaluation and analysis to optimize the waste shipment configuration would be conducted to minimize to the extent possible the number of shipments and potential transportation impacts.		

TABLE S-3 (Cont.)

Resource Area	Alternative				
	Alternative 1 No Action	Alternative 2 WIPP Geologic Repository	Alternative 3 Borehole	Alternative 4 Trench	Alternative 5 Vault
Transportation (Cont.)		shipment configuration would be conducted to minimize to the extent possible the number of shipments and potential transportation impacts.			
Cultural Resources	No incremental impacts would occur because continued waste storage would not result in disturbance of additional areas that were not already affected.	No incremental impacts are expected because construction, operational, and post-closure activities would not involve additional land disturbance.	The likelihood of impacting cultural resources is proportional to the amount of land disturbed, with the borehole method requiring the greatest amount of land disturbance. Procedures given in Section 106 of the National Historic Preservation Act would be followed as appropriate to mitigate any impacts on these resources. Local American Indian tribes would be consulted to ensure no traditional cultural properties were impacted. There are no known cultural resources within the GTCC reference locations at the Hanford Site and INL Site. Eighteen cultural resources are reported to be in and near the GTCC reference location at LANL, with some sites considered eligible for listing under the National Historic Preservation Act. A handful of very small lithic scatters are located within the GTCC reference location at NNSS. There are seven archaeological sites within the GTCC reference location at SRS. Some isolated prehistoric artifacts and possibly some larger prehistoric cultural resources would be found in the GTCC reference locations at the WIPP Vicinity.		
Waste Management	No incremental impacts are expected because no construction or operational activities for disposal of GTCC LLRW and GTCC-like waste would be performed.	The small quantities of hazardous and nonhazardous waste produced during waste disposal activities would be managed in the same manner as similar wastes generated by operations at WIPP.	The small quantities of nonradioactive (hazardous and nonhazardous waste) and radioactive (solid and liquid LLRW) waste produced during construction and waste disposal activities would be managed in the same manner as wastes produced by ongoing operations at the various DOE sites evaluated. Specific waste management plans would be prepared as necessary to address these wastes for the WIPP Vicinity.		

[a] The annual occupational doses for the three land disposal alternatives were based on an average annual dose rate of 0.2 rem per full-time equivalent (FTE) worker and the annual number of FTE workers estimated for waste disposal. An "FTE worker" for waste disposal purposes would not actually be one worker but would likely consist of several individually badged workers, since the workers would perform other tasks in addition to waste disposal. The worker dose estimates for Alternative 2 were based on actual doses that have occurred during defense-generated TRU waste disposal operations.

Potential environmental consequences under the No Action Alternative would result from continuing the practices currently used to manage these wastes for both the short term and long term. However, it is assumed that current facility operations in the storage sites would continue for the short term and result in minimal impacts on most resource areas (e.g., air quality, geology, water resources, ecological resources, socioeconomics, land use, transportation, and cultural resources). The main concerns are associated with the long-term human health impacts that could result from storage of this waste. Calculations performed for the GTCC EIS indicate that long-term human health impacts for the No Action Alternative (analyzed for the period beyond 100 years and up to 10,000 years to be consistent with the time frame analyzed for Alternatives 2 to 5) could be as high as 470 rem/yr with a lifetime latent cancer fatality (LCF) risk of 0.3 associated with that one year of exposure (as compared to the highest estimate of 12 rem/yr and LCF risk of 0.007 [in generic commercial Region I] or 2.3 rem/yr and LCF risk of 0.001 [at federal sites] for the action alternatives [i.e., Alternatives 2 to 5]), depending on the region of the country in which a storage site might be located.

The results of the EIS analysis indicate that the potential impacts on the various environmental resource areas (shown in Figure S-23) from the action alternatives (i.e., Alternatives 2 to 5) would be small and would not vary significantly among the sites evaluated. Like the No Action Alternative, but potentially to a much lesser extent, the exception would be the long-term human health impacts in the post-closure phase for Alternatives 3 to 5 (borehole, trench, and vault disposal) as calculated on the basis of impacts to a hypothetical resident farmer near a disposal facility. For Alternative 2, there would be no releases to the accessible environment and therefore no radiation doses or LCF risks during the first 10,000 years following closure of the WIPP repository. Table S-4 presents a more detailed comparison of the long-term human health impacts. The radiological impacts to members of the general public as described in this EIS are incremental to, and, in most cases, small, compared to those from natural and man-made sources of radiation, which result in an annual exposure of about 310 mrem/yr each, for a total of about 610 mrem/yr per individual (NCRP 2009).

On the basis of the site-specific precipitation rates that were assumed, it is estimated that the federal sites located in the arid regions of the country (Hanford Site, LANL, NNSS, and WIPP Vicinity) would generally have lower long-term human health impacts from the groundwater pathway than would the sites located in more humid regions (such as SRS). The exception is the INL Site, which is shown in Table S-4 to have the highest dose and LCF risk estimates (estimated to be up to 2.3 rem/yr and 0.001, respectively). The INL Site results are primarily due to the distribution coefficient (K_d) of zero assumed in the calculations for the radionuclides identified in the waste inventory; this assumption was made as a conservative approach to account for the basalt layer that is present in some parts of the INL Site (including the GTCC reference location). Essentially, this assumption considers radionuclides to be released to the full extent once the basalt layer has been penetrated. Estimates of long-term human health impacts from the groundwater pathway for the No Action Alternative also indicate that the arid regions would result in lower doses and LCF risks.

Site- and radionuclide-specific K_ds were assumed in the long-term human health calculations and can vary significantly between sites. K_ds provide an indication of the degree to which the radionuclide would adhere to soil and not move with the percolating water. The higher

TABLE S-4 Comparison of Estimated Potential Maximum Human Health Long-Term Impacts for Alternatives 1 to 5[a]

	Maximum Human Health Long-Term Impacts[b]	
Alternative	**Annual Dose (rem/yr)**	**Annual LCF Risk**
1: No Action	470	0.3
2: WIPP (geologic repository)	0[c,d]	0[c,d]
3: Borehole method		
Hanford Site	0.0048	0.000003
INL Site	0.82	0.0005
LANL	0.16	0.00009
NNSS	0	0
WIPP Vicinity	0	0
Generic Commercial Region IV	0	0
4: Trench method		
Hanford Site	0.048	0.00003
INL Site	2.1	0.001
LANL	0.38	0.0002
NNSS	0	0
SRS	1.7	0.001
WIPP Vicinity	0	0
Generic Commercial Region II	1.2	0.0007
Generic Commercial Region IV	0	0
5: Vault method		
Hanford Site	0.049	0.00003
INL Site	2.3	0.001
LANL	0.43	0.0003
NNSS	0	0
SRS	1.3	0.0008
WIPP Vicinity	0	0
Generic Commercial Region I	12	0.007
Generic Commercial Region II	1.2	0.0007
Generic Commercial Region III	0.53	0.0003
Generic Commercial Region IV	0	0

[a] Radiation doses are given to two significant figures, and LCF risks are given to one significant figure. A value of zero for long-term human health impacts means that the radioactive contamination does not reach the well of the hypothetical receptor (for Alternatives 1, 3, 4, and 5) or the Culebra Dolomite at WIPP for Alternative 2.

Footnotes continued on next page.

TABLE S-4 (Cont.)

[b] For Alternatives 1, 3, 4, and 5, these impacts are the peak long-term annual radiation doses and LCF risks estimated to occur within the first 10,000 years after closure of the waste disposal facility to a hypothetical resident farmer 100 m (330 ft) downgradient from the edge of the disposal facility. For Alternative 2, there would be no releases to the accessible environment and therefore no radiation doses and LCF risks during the first 10,000 years following closure of the WIPP repository, as noted in Section 5.1.12.1 of the *Waste Isolation Pilot Plant Disposal Phase Final Supplemental Environmental Impact Statement* issued in 1997 (DOE/EIS-0026-S-2).

[c] The disposal of defense-generated TRU waste at WIPP is conducted in accordance with the standards and criteria in 40 CFR Parts 191 and 194. As noted in footnote b, there would be no releases to the accessible environment for disposal of defense-generated TRU wastes at WIPP in the first 10,000 years following closure, and the corresponding annual dose and LCF risk are both reported as zero.

[d] The post-closure impacts from disposing of the GTCC LLRW and GTCC-like waste at WIPP were evaluated in the same manner as was done for disposal of defense TRU waste in this repository. This analysis indicates that the GTCC LLRW and GTCC-like waste inventory could be disposed of at WIPP in compliance with existing regulations. However from a statute perspective, DOE acknowledges that only defense-generated TRU waste is currently authorized for disposal at the WIPP geologic repository under the WIPP LWA as amended (P.L. 102-579 as amended by P.L. 104-201), and that legislation would be required to allow disposal of waste other than TRU waste generated by atomic energy defense activities at WIPP and/or for siting a new facility within the land withdrawal area.

the K_d for a specific radionuclide, the more that radionuclide would adhere to soil particles. Sites that have high K_ds would generally result in lower groundwater radionuclide concentrations than those with lower K_ds.

SRS was estimated to have the second-highest potential dose and LCF risks after the INL Site. The peak annual dose to the hypothetical resident farmer receptor at SRS is estimated to be about 1.7 rem/yr, with C-14, Tc-99, and I-129 being the major radionuclide contributors to the dose. The K_ds assumed for these three radionuclides are very low and generally the same as those used for all the federal sites evaluated in the EIS. As a result, these same three radionuclides are also the major contributors to the dose and LCF risk to the hypothetical resident farmer for the groundwater pathway to the federal sites in the western part of the country. However, the low precipitation rates for these sites resulted in generally lower peak annual doses and LCF risks than those for SRS, which is located in a more humid region.

Finally, of the three waste types, the activated metals and sealed sources would result in lower peak annual doses and LCF risks than would the Other Waste. This would occur because the Other Waste type is physically the most leachable of the three waste types. In the GTCC EIS, it is assumed that the Other Waste would be stabilized with grout to minimize degradation over time. This would also reduce leaching of radionuclides. The activated metal and sealed source wastes are much more durable than the stabilized Other Waste, and leaching from these two waste types would be much lower over the long term.

These results are intended to be viewed in a comparative manner, given the uncertainties associated with this analysis. A number of simplifying assumptions are made for the purposes of the comparative analysis in this EIS, especially in terms of the long-term performance of engineered materials assumed for the borehole, trench, and vault disposal facilities. It is expected that detailed, site-specific assessments that would include more specific calculations on the physical and chemical performance of different engineered materials would be made before implementation of any alternative.

The results presented here should not be used for regulatory compliance purposes in the future, and they should not be compared with site-specific performance assessments that have been conducted for existing waste disposal facilities. Such assessments are based on site-specific exposure scenarios and conditions. However, the assessment in this EIS does provide useful information to guide the decision-making process for identifying the most appropriate alternative to manage these GTCC LLRW and GTCC-like waste.

S.4 CUMULATIVE IMPACTS

Potential impacts of the GTCC proposed action are considered in combination with the impacts of past, present, and reasonably foreseeable future actions. Cumulative impacts are evaluated for Alternatives 2 to 5. DOE did not evaluate the cumulative impacts of the No Action Alternative at the many privately-owned and operated locations, since such an evaluation would involve making speculative assumptions about environmental conditions and future activities at those locations where GTCC LLRW could be stored.

For Alternative 2, the low potential impacts of that alternative indicate that the cumulative impacts from the construction, operations, and post-closure phases of the proposed action at the WIPP site would be small and would not exceed regulatory requirements established for the WIPP facility. The post-closure performance analysis performed for emplacement of all GTCC LLRW and GTCC-like waste at WIPP demonstrates that disposal of these wastes would result in WIPP still being in compliance with existing regulatory requirements for technical performance.

For Alternatives 3 to 5 at the federal sites, the estimated impacts from the GTCC proposed action are not expected to contribute substantially to cumulative impacts for the various resource areas evaluated, with the likely exception of potential human health impacts in the long term. That is, during the post-closure phase of the proposed action, potential leaching of radionuclides from the GTCC LLRW and GTCC-like waste inventory into groundwater could contribute to doses and LCF risks to a hypothetical resident farmer located about 100 m (330 ft) from the edge of the borehole, trench, or vault disposal facility at the federal reference locations (i.e., at the Hanford Site, the INL Site, LANL, and SRS). For the Hanford Site, as stated in the

Final Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington (DOE 2012), when the impacts of technetium-99 from past leaks and cribs and trenches (ditches) are combined, DOE believes it may not be prudent to add significant additional technetium-99 to the existing environment. Therefore, one means of mitigating this impact would be for DOE to limit disposal of off-site waste streams containing iodine-129 or technetium-99 at Hanford. The post-closure doses and LCF risks are summarized in Table S-4. The resident farmer scenario is assumed to be conservative (i.e., one that overestimates the expected dose and LCF risk) because it assumes a total loss of institutional control and institutional memory with regard to the disposal facility. The sites evaluated are on federal land and would most likely continue to be managed by the federal government for a long time. Follow-on NEPA evaluations to support further considerations of siting a new borehole, trench, or vault disposal facility at the sites evaluated in this EIS would provide more detailed analyses of site-specific issues relative to cumulative impacts.

S.5 UNCERTAINTIES ASSOCIATED WITH THE EVALUATIONS IN THE GTCC EIS

The impact analyses conducted for the GTCC EIS used methodologies and approaches consistent with Council on Environmental Quality and DOE requirements and guidance for preparing an EIS. Uncertainties associated with the various environmental resource areas evaluated in this EIS are not unique to the GTCC EIS. As previously discussed, the results of the impact analyses for the action alternatives (summarized in Sections S.3 and S.4) indicate that the impacts on the various resource areas from the proposed action would be generally small and that they would not vary much among the sites evaluated, with the possible exception of potential post-closure impacts on human health. The results from the analysis of human health impacts in the post-closure phase indicate that potential future doses and LCF risks to a hypothetical resident farmer could vary significantly by site. Hence, the discussion on uncertainties focuses on this aspect of the analysis because it provides information useful in identifying a preferred alternative.

Several factors could alter the estimated human health impacts associated with disposal of these wastes, including changes in (1) the waste volume and radionuclide inventory, (2) the assumptions about the design and layout of the facilities, (3) the assumptions used to simulate how long the integrity of the engineered barriers and waste stabilizing agents would stay intact, and (4) the assumptions about site characteristics used as input for the calculations.

The radiological impacts on human health would depend mostly on the total radioactivity and the mix of radionuclides that would make up the waste. That is, if the waste volumes doubled but total activity remained the same, it is anticipated that there would be no major change in the potential radiological impacts. Increasing the total radionuclide activity by a factor of two with the same mix of radionuclides, however, would essentially double the potential radiological impacts. Because the uncertainty with regard to the waste inventory is generally low to moderate, the inventory does not represent a major source of uncertainty in the human health impact analysis.

Changes in the design and layout of the disposal facility could also change the potential human health impacts. For purposes of analysis in the EIS, the depths of the disposal area available for waste placement are assumed to be 4.3 to 5.5 m (14 to 18 ft) above ground surface (ags) for vaults, at 5 to 10 m (15 to 30 ft) bgs for trenches, and from 30 to 40 m (100 to 130 ft) bgs for boreholes. Changes in the design and layout of the disposal facility could result in changes in the total area and the subsequent depths of the waste disposal horizon in the EIS analyses. The footprint of the disposal facility, along with the distance from the edge of the facility to an off-site hypothetical well where potential radiation exposures are assumed to occur, determines the total distance that the radionuclides need to travel in the groundwater aquifer to cause a radiation dose. For example, a decrease in the footprint of the disposal facility would shorten the distance from the midpoint of the waste zone to the off-site well. This shorter distance would increase the radionuclide concentrations in the groundwater at an off-site well because there would be less dilution, and it would result in somewhat higher doses from the use of this groundwater. Calculations based on actual distances during implementation should provide a more representative estimate.

Changes to the design of the disposal facility could result in changes to the area potentially exposed to infiltrating water. A larger disposal area would allow more water infiltration and result in more radionuclides leaching out to deeper soils. Alternatively, a smaller area (with a subsequent greater depth of waste disposal) would result in a shorter soil column beneath the disposal units through which radionuclides leaching from the disposal area would need to travel to reach the groundwater table. The overall effect that could result from changes in the geometrical configuration of the disposal cells needs to be assessed with regard to the time frame used to evaluate the potential impacts and the specific site in question. However, these changes would not add a significant amount of uncertainty to the results, unless major changes were made to the current conceptual facility designs used in these analyses.

For the GTCC EIS, it is assumed that the engineered barriers (including the cover) would remain effective for the first 500 years after closure of the disposal facility and that during this time, essentially no infiltrating water would reach the wastes from the top of the disposal facility. It is assumed that after 500 years, some amount of infiltrating water (20% of the site-specific natural infiltration rate reported for each of the sites evaluated) would contact the wastes through the top of the disposal facility, and that the water infiltration rate to the perimeter and beneath the disposal facilities would be 100% of the site-specific natural infiltration rate. It should be noted that if the infiltration rate to the top of the disposal facility is increased, the dose estimates would also increase. It is also assumed that the Other Waste would be stabilized with grout or other material and that this stabilizing agent would be effective for 500 years. No credit is taken for the effectiveness of this stabilizing agent after 500 years. The radionuclides in the disposed-of wastes would be available for leaching by infiltrating water after 500 years.

Many of the radionuclides in the GTCC LLRW and GTCC-like wastes have very long half-lives, so the 500-year effectiveness period assumed for purposes of analysis in this EIS is relatively short and would not result in an appreciable reduction in the total hazard associated with these wastes as a result of radioactive decay, especially when the time it would take for these radionuclides to reach the hypothetical off-site receptor is considered. The uncertainty is related to how much longer the engineered barriers and stabilization process could remain effective for the sites at which the potential impacts are estimated to be high.

In addition, global climate change impacts might add another aspect of uncertainty with regard to the long-term performance of the borehole, trench, and vault waste disposal facilities at the sites evaluated in the GTCC EIS. Since 1990, the average annual precipitation over the United States has increased by about 5%, but there were regional differences, e.g., increases mostly in the Northeast, Midwest, and southern Great Plains and a mix of increases and decreases in much of the Southeast and Southwest (Melillo et al. 2014). The global climate change model predictions indicate that in the Southwestern United States, drier or prolonged drought conditions could arise notably in the spring, whereas Northern areas could become wetter.

Although the global climate change impacts are modeled only to the year 2100, these initial indications can be used to provide a perspective on what impacts global climate change might have on the proposed borehole, trench, and vault waste disposal facilities at the various reference locations or regions evaluated in this EIS. As discussed previously, the water infiltration rate is one of the key input parameters that affect how much radioactivity could leach from waste in the disposal facility. On the basis of the global climate change predictions under a higher (i.e., worst-case) emission scenario (Melillo et al. 2014), average annual infiltration rates at the sites located in the Southwest (e.g., LANL, NNSS, WIPP Vicinity, and the generic commercial location in the southern part of NRC Region IV) are expected to decrease slightly or remain the same, while rates at the sites located in the Northwest (e.g., Hanford and INL Sites) and in the Southeast (e.g., SRS), would increase slightly.

On the basis of Melillo et al. (2014), it can be said that the maximum increase or decrease in precipitation under a higher emission scenario would be up to 20% depending on the season. Under a lower emission scenario, these percentages would be lower, and thus climate changes would probably not have any significant impacts on GTCC LLRW and GTCC-like waste disposal operations. This is because slight increases in precipitation are expected in humid sites such as SRS. For sites located in drier areas, such as Hanford, INL, LANL, NNSS, and WIPP/WIPP Vicinity, changes of up to about 20% by season would be expected under a higher emission scenario but these changes are not significant due to its lower annual precipitation. However, because the post-closure human health estimates presented in the GTCC EIS are for 10,000 years or more, and because current global climate change model projections extend only to the year 2100, it is uncertain whether the indications discussed here would continue for the 10,000-year post-closure period analyzed in the GTCC EIS.

Most of the long-term radiation doses and LCF risks associated with the groundwater pathway would be attributable to leaching of the Other Waste. By using robust engineering designs and redundant measures to contain the radionuclides in the disposal unit (i.e., increasing the time period of effectiveness of covers and stabilizing agents), the potential releases of radionuclides would be delayed and reduced to very low levels, thereby minimizing the potential groundwater contamination and its associated human health impacts in the future.

The modeling simulation conducted for the GTCC EIS is a simplified representation of more complex soil and groundwater processes, and this simplification adds uncertainty to the results. The RESRAD-OFFSITE computer code was used for this analysis, and input parameters were determined on a site-specific basis, as available; most were obtained from previous analyses performed at these sites. In addition, the site-specific distribution coefficients used as input into the model calculations have inherent uncertainties associated with them, and it is difficult to assign values for the level and direction of uncertainty that exist in the distribution coefficients for each site and from site to site.

It is assumed in this EIS that a resident farmer would be located 100 m (330 ft) downgradient from the edge of the disposal facility and would develop a well as a source of drinking water. This assumption is considered to be conservative because the distance from the edge of the disposal facility to such an individual (given the current configurations of the alternative sites evaluated in this EIS) would be much longer. Use of a more realistic distance would result in much lower doses than those presented in this EIS. This distance adds a great deal of uncertainty and conservatism to the results presented in this EIS.

Finally, the human health impacts estimated for a hypothetical resident farmer (provided in Table S-3) are intended to serve as indicators of the performance or effectiveness of each of the land disposal methods at each of the sites evaluated and are expected to provide a metric for comparing the relative performance of the land disposal methods at these sites. When considering which GTCC disposal alternative to select, DOE will consider the potential dose to the hypothetical resident farmer as well as other factors described in Section S.7 of this Summary.

S.6 PUBLIC INVOLVEMENT

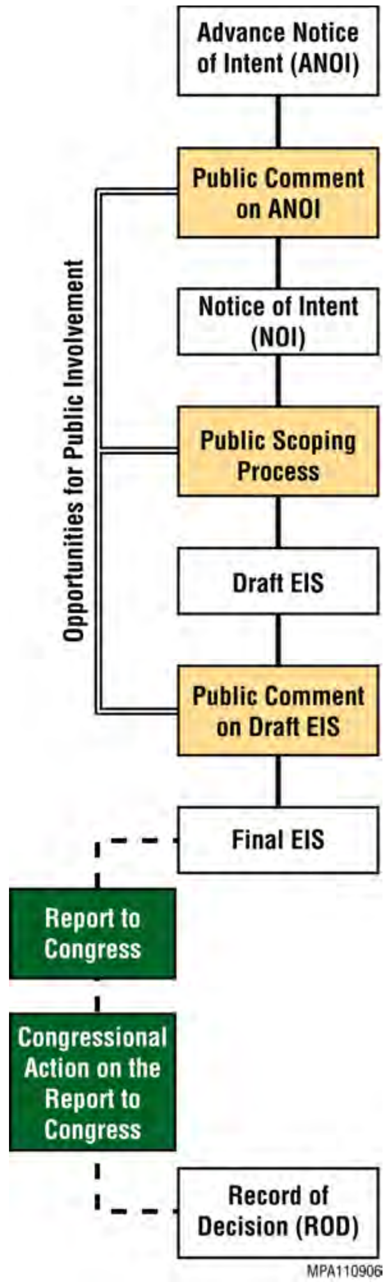

FIGURE S-24 GTCC EIS NEPA Process

DOE is committed to communicating to the public information about the GTCC EIS to ensure that potentially affected communities, tribal groups, and other interested parties understand DOE's proposed action and are given the opportunity to participate in decisions that may affect them. DOE issued the Advance Notice of Intent on May 11, 2005 (70 FR 24775) and the NOI on July 23, 2007. DOE issued a printing correction for the NOI on July 31, 2007. DOE also established a public website at the same time it issued the NOI (www.gtcceis.anl.gov) in order to give the public access to information on the NEPA process, the EIS, and public involvement opportunities. The NEPA process followed by DOE for the GTCC EIS is shown in Figure S-24.

The NOI announced nine public scoping meetings and a comment period from July 23 through September 21, 2007, during which time DOE solicited comments from stakeholders, including federal, state, and local agencies; American Indian tribal representatives; and the general public to assist in defining the proposed action, alternatives, and issues requiring analysis.

S.6.1 Public Scoping Comments on the Notice of Intent

DOE received 249 comment records via emails, faxes, letters, and transcripts of oral comments. DOE considered all oral and written public comments in identifying the range of alternatives for the EIS.

Comments received during the public scoping period focused on the amount of inventory being included for evaluation in the EIS, the sites that would be considered, the disposal methods or technologies that would be considered, the resource areas to be evaluated, and the impact assessment methodologies. Representative comments and DOE responses are provided as follows. The first set of comments presents those determined to be within the EIS scope, and the second set presents those determined to be outside the scope of the EIS.

S.6.1.1 Comments Determined To Be Within EIS Scope

- *Disposal of GTCC LLRW and GTCC-like waste at the sites proposed in the NOI should not be considered because these sites are still undergoing cleanup. In addition, these sites either have regulatory conditions or site characteristics (e.g., geology) that make them unsuitable for consideration in the EIS.*

  The basis for proposing the sites to be considered in the NOI and evaluated in the EIS was their mission compatibility, in the sense that all of these sites have radioactive waste disposal operations as part of their current missions. These sites are thus considered viable for analysis for disposal of this waste in the EIS. The scope of the EIS includes the identification of potential disposal sites and the evaluation of the feasibility and effectiveness of these sites for hosting a safe disposal facility for GTCC LLRW and GTCC-like waste.

- *The preferred alternative for disposal of GTCC LLRW and GTCC-like waste should be a geologic repository.*

  Disposal at WIPP, a geologic repository, is one of the alternatives evaluated in the Draft EIS, and a preferred alternative in the Final EIS. In addition, DOE is evaluating alternative methods of disposal (i.e., borehole, trench, and vault disposal). NRC regulations governing disposal of GTCC LLRW contemplate that nongeologic disposal alternatives may be approved (see 10 CFR 61.55(a)(2)(iv)).

- *More detailed characterization information should be provided on the waste inventory, including the source of the waste, its location (by state), and its specific characteristics. It is not clear how the volumes and activities for stored and projected waste were developed, and the distinction between what is considered stored versus what is considered projected is not clear either. The sources of information and important assumptions used to develop this information should be provided in the EIS, along with an indication of the accuracy of the estimates.*

  The GTCC EIS and supporting documents provide characterization information on wastes to allow for a comparative analysis of potential environmental impacts associated with the disposal of these wastes. The approach used by DOE to develop the inventory information are provided in the EIS and in supporting documents, including the identification of relevant resources and DOE's due diligence in determining that current expected waste quantity estimates remain valid, and are conservative and bounding for the purposes of this comparative analysis (see Sections S.2.1 and S.2.4). The EIS also provides information on the current location of GTCC LLRW and GTCC-like waste producers (e.g., Table S-2 of this Summary).

- *The EIS should identify the quantity of mixed waste requiring disposal and identify the process for working with the EPA and respective state agencies to manage these wastes.*

  The GTCC LLRW and GTCC-like waste inventory includes a very small volume of mixed waste that may require disposal. It is assumed that the generator of the waste will treat it to remove the hazardous waste characteristic or obtain a waiver from the appropriate regulatory authority so that the waste is no longer regulated as mixed waste. No mixed GTCC LLRW or GTCC-like waste is assumed to be disposed of in the sites being evaluated in the EIS. The volume of potential mixed waste is about 170 m^3 (6,000 ft^3).

- *What is the scope of the EIS and evaluation endpoints (e.g., period of time with respect to risk of release)? The EIS should identify long-term monitoring requirements for the disposal sites.*

  The scope of the EIS addresses all aspects associated with disposal of GTCC LLRW and GTCC-like waste. Impacts are evaluated at the various time periods associated with the actions needed to safely dispose of these wastes. The long-term impacts on groundwater are evaluated for 10,000 years or to the point of maximum dose and LCF risk, whichever is longer. The EIS identifies the need for long-term monitoring of disposal sites, as appropriate.

- *The EIS should incorporate available site-specific data for the generic commercial facility evaluations. In addition, the evaluation of the disposal of*

GTCC LLRW and GTCC-like waste in boreholes for all sites being evaluated should be based on actual site data.

Site-specific data were used to identify the important parameters necessary to site and operate a disposal facility for GTCC LLRW and GTCC-like waste at arid and humid generic sites. The analyses of the various disposal technologies (including the use of boreholes) in the EIS were based on actual site data to the extent necessary to provide reliable evaluations. A site-specific evaluation would be done in a subsequent NEPA review as appropriate.

- *Consultation with tribal nations should be initiated early in the process.*

  Tribes contributed to the preparation of the Draft EIS and participated in the review of the Draft EIS by attending public meetings regarding GTCC and submitting comments that are addressed in Appendix J of this EIS. Since the receipt of tribal comments in 2011 on the Draft EIS, DOE has continued routine consultation with tribes as part of normal operations at the DOE sites evaluated in this EIS. DOE will continue to involve the tribes in the decision making process for the disposal of GTCC.

- *The EIS should identify all federal and state agencies and any jurisdictional authority by law and/or special expertise. Also, the EIS should address all pertinent regulatory issues and standards, including NRC regulation of a facility at a DOE site.*

  The EPA is a cooperating agency on the EIS because of its expertise in radiation protection. The NRC is a commenting agency. Pertinent regulatory issues and standards associated with disposal of GTCC LLRW and GTCC-like waste are addressed in the EIS.

S.6.1.2 Comments Determined To Be Outside EIS Scope

- *In addition to considering disposal at WIPP in the EIS, efforts should be initiated to site and construct a new geologic repository for GTCC LLRW and GTCC-like waste in case this repository is not acceptable.*

  As discussed in the NOI (72 FR 40135), DOE does not plan to evaluate an additional deep geologic repository facility because siting another deep geologic repository facility for GTCC LLRW and GTCC-like waste would be impractical due to the cost and time involved and the relatively small volume of GTCC LLRW and GTCC-like waste.

- *Hardened on-site storage (HOSS) should be added to the alternatives evaluated in the EIS. In addition, HOSS should be the preferred alternative.*

HOSS and other waste storage approaches beyond the No Action Alternative are considered to be outside the scope of the EIS because they do not meet the purpose and need for agency action. Consistent with Congressional direction in Section 631 of the Energy Policy Act of 2005 (P.L. 109-58), DOE plans to complete an EIS and a ROD for a permanent disposal facility for this waste, not for long-term storage options. In addition, the No Action Alternative evaluates storage of this waste consistent with ongoing practices.

- *The EIS should include disposal options for Class B and Class C LLRW in its scope.*

  Inclusion of Class B and Class C LLRW is beyond the scope of the EIS. DOE is responsible under the LLRWPAA (P.L. 99-240) for the disposal of GTCC LLRW and DOE wastes. States and Compacts are responsible for the disposal of Class A, B, and C LLRW.

- *The GTCC LLRW inventory needs to be expanded to address the disposal and possible consolidation and concentration of Class B and Class C LLRW by commercial nuclear utilities, resulting in additional GTCC LLRW.*

  The waste inventory is based on the best available information on GTCC LLRW, and it considers utility waste resulting from decommissioning activities. Data on the GTCC LLRW that might be generated by the concentration and consolidation of Class B and Class C LLRW are difficult to ascertain at this time because of the speculative nature of these events. The uncertainty that would be introduced in the EIS process by including this potential volume is not warranted.

- *Additional radioactive wastes should not continue to be produced until there is a waste disposal solution for these materials.*

  This issue is beyond the scope of the EIS, which is limited to the evaluation of the potential environmental impacts from using various disposal options for GTCC LLRW and GTCC-like waste.

- *The EIS should address the increased sensitivity of children, the elderly, pregnant women, and women in general to radiation exposure. The analysis should not be based on a reference man but on the reference family concept. In addition to radiation doses, estimates of the cancer risks should be provided in the EIS to allow for a comparison to EPA carcinogenic risk standards.*

  The concerns with regard to the increased sensitivity of various elements of the population are noted. The EIS presents a comparative analysis of the potential radiation doses and LCF risks to members of the general public (as represented by an adult receptor) from use of the various disposal alternatives presented in the NOI. As such, the level of detail requested here is not necessary for the purposes of the EIS, and the hazards associated with management of these wastes are presented in terms of the annual dose and LCF risk to a potentially exposed adult receptor.

The estimates for dose and LCF risk were based on a resident farmer receptor, which is considered a conservative scenario that accounts for the largest number of pathways of potential exposure. The primary pathway of concern, however, is the ingestion of groundwater potentially contaminated with radionuclides released from wastes at the proposed disposal facility. The estimated dose and LCF risk to an adult receptor presented in the EIS are considered conservative (relative to any other potential receptor) because the ingestion rate assumed for water intake is the 90th percentile value for the general public recommended by the EPA (i.e., two liters per day for 365 days per year) (EPA 2000).

Follow-on NEPA evaluations will be conducted, as needed, to assess potential human health impacts on a site-specific basis (accounting for sensitive populations as applicable) when a disposal site or location is identified.

- *Further research on and/or investigation of other treatment and disposal technologies currently being developed should be considered to ensure that these wastes are managed safely. The hazards posed by GTCC LLRW and GTCC-like waste are comparable to those from high-level radioactive wastes and should be managed in a similar manner.*

  Further research on treatment and disposal technologies is not needed to ensure these wastes are safely managed and that disposal complies with the LLRWPAA (P.L. 99-240), which makes the federal government responsible for the disposal of GTCC LLRW. It would not be reasonable to analyze in detail an essentially unlimited number of additional non-DOE or nonfederal sites. Nevertheless, DOE also conducted a generic evaluation of commercial disposal facilities on nonfederal lands in the EIS in order to provide, to the extent possible, information regarding the potential long-term performance of other (nonfederal) locations for siting a GTCC LLRW and GTCC-like waste land disposal facility.

S.6.2 Public Comments on Draft EIS

All scoping comments received were considered in the preparation of the EIS. A Notice of Availability (NOA) for the Draft GTCC EIS was published in the *Federal Register* on February 25, 2011 (76 FR 10574), and it began a 120-day public comment period that ended on June 27, 2011. All comments received on the Draft EIS were considered in the preparation of the Final GTCC EIS.

DOE received a total of 1,196 comment records, which accounted for 3,982 individual comments. Of the 1,196 comment records received, 154 were from organizations or federal or state agencies; 495 were from private citizens; and 547 were campaign letters, emails, or web comments received from six organizations (i.e., Snake River Alliance, Friends of the Gorge, Concerned Citizens for Nuclear Safety, Nuclear Watch, Citizen Letter, and the Brookfield Assisted Living Facility). Written comments were received via letter, email, or through submission of a comment form provided at the public hearings or on the project website. Oral comments are included in transcripts documenting each of the public hearings held on the Draft GTCC EIS.

Comments were reviewed and responses prepared by policy experts, technical subject matter experts, and NEPA experts. Comments were evaluated to determine whether alternatives and analyses presented in the Draft EIS should be modified, whether additional or corrected information is needed, and whether additional or revised text would clarify the information being conveyed. The comments received have been summarized into 10 comment topics, which are presented here, along with corresponding responses (detailed responses to each of the comment records can be found in Appendix J, Section J.3):

1. *Disposal of GTCC LLRW and GTCC-Like Waste at a New Near-Surface Land Disposal Facility at DOE Sites Evaluated (i.e., at the Hanford Site, INL Site, LANL, SRS, NNSS, and the WIPP Vicinity) – Comments received recommended that specific sites should be removed from consideration in developing a GTCC LLRW and GTCC-like waste near-surface land disposal facility.*

   The disposal methods and sites evaluated in the EIS encompass the range of reasonable alternatives for the disposal of GTCC LLRW and GTCC-like waste, consistent with NEPA implementing regulations in the *Code of Federal Regulations* at 40 CFR Parts 1500–1508. In this GTCC EIS, DOE analyzed a range of disposal methods (i.e., geologic repository, near-surface trench, intermediate-depth borehole, and above-grade vault) and federally owned sites (i.e., Hanford Site, INL Site, LANL, NNSS, SRS, and the WIPP Vicinity, for which two reference locations – one within and one outside the WIPP LWB – were considered). DOE has determined that it was reasonable to analyze these six sites because they currently have operating radioactive waste disposal facilities, except for the WIPP Vicinity, which is near an operating geologic repository and has basic infrastructure to support the facility.

2. *Disposal of GTCC LLRW and GTCC-Like Waste at WIPP – Commenters were opposed to the possible use of WIPP for disposal of GTCC LLRW and GTCC-like waste based on legal and technical considerations.*

   DOE acknowledges that only defense-generated TRU waste is currently authorized for disposal at the WIPP geologic repository under the WIPP LWA as amended (P.L. 102-579 as amended by P.L. 104-201), and that legislation would be required to allow disposal of waste other than TRU waste generated by atomic energy defense activities at WIPP and/or for siting a new facility within the land withdrawal area. It would also be necessary to revise the *Agreement for Consultation and Cooperation between Department of Energy and the State of New Mexico for the Waste Isolation Pilot Plant*, the WIPP compliance certification with EPA, and the WIPP Hazardous Waste Facility Permit. In addition, follow-on NEPA project-specific review, including further characterization of the waste (e.g., radionuclide inventory and heat loads) as well as the proposed packaging for disposal would have to be conducted. The WIPP has been certified by the EPA as an acceptable facility for the disposal of defense-generated TRU waste. The physical and chemical characteristics of the GTCC LLRW and GTCC-like waste proposed for disposal in the WIPP repository are comparable to the TRU wastes currently being disposed of in the repository. Based on the GTCC EIS evaluation, disposal of GTCC LLRW and GTCC-like waste at WIPP would result in minimal environmental impacts on all resource areas evaluated, including human health and transportation.

3. *Consideration of Other Alternatives Not Evaluated in Detail in the EIS Including Use of HOSS, the Proposed Yucca Mountain Repository, a New Geologic Repository, and Other Disposal Methods (e.g., Mined Cavities) and Alternatives (e.g., Treatment of Waste and Alternative Sources of Energy) – Some commenters requested that the EIS include HOSS as a reasonable alternative for managing all or a portion of the GTCC LLRW and GTCC-like waste inventory, and others indicated that the best approach for disposal of GTCC LLRW and GTCC-like wastes would be to dispose of the entire inventory in a new geologic repository.*

   The use of HOSS and other approaches for long-term storage of GTCC LLRW and GTCC-like wastes are outside the scope of this EIS because they do not meet the purpose and need for agency action. Consistent with Congressional direction in Section 631 of the Energy Policy Act of 2005 (P.L. 109-58), DOE plans to complete an EIS and a ROD for a permanent disposal facility for this waste, not for long-term storage options. The action alternatives evaluated in the GTCC EIS also did not include interim storage of GTCC LLRW and GTCC-like waste until a geologic repository for spent nuclear fuel and high-level radioactive waste becomes available because such interim storage is outside the scope of the GTCC EIS. The purpose of the GTCC EIS is to evaluate the range of reasonable alternatives for the safe and secure disposal of GTCC LLRW and GTCC-like wastes.

4. *NEPA Process and Procedures – The Draft EIS does not comply with NEPA because it did not identify a preferred alternative and because sufficient opportunity for public comment was not provided. Many commenters suggested that DOE do a better job of getting the word out about the EIS and the public hearings.*

DOE believes that this EIS complies with NEPA. NEPA implementing regulations, 40 CFR 1502.14(e), do not require a preferred alternative to be included in a Draft EIS if an agency does not have one. DOE's notification about the public hearings followed normal practices, with advance notice in the Federal Register and notices in local media. DOE held nine public hearings during the 120-day public comment period on the Draft GTCC EIS which extended from February 25, 2011 through June 27, 2011 – a length of time substantially longer than the 45-day minimum Council on Environmental Quality requirement for public comment on a Draft EIS (40 CFR Part 1506.10 (c)).

5. *Tribal and Cultural Resources Concerns – The EIS should consider American Indian tribal concerns. Comments including those from the Santa Clara Pueblo, the Pueblo de San Ildefonso, and the Confederated Tribes and Bands of the Yakama Nation, raised several concerns that DOE proposals rely on institutional controls.*

   DOE appreciates the input provided by the Santa Clara Pueblo, the Pueblo de San Ildefonso, and the Confederated Tribes and Bands of the Yakama Nation on the EIS, both in the tribal narratives and in comments on the Draft EIS. This input was considered by DOE in identifying a preferred alternative. DOE initiated government-to-government consultations with potentially affected American Indian tribes in a timely manner consistent with DOE Order 144.1. These consultations were done at a time that DOE had compiled and developed adequate information for the Draft EIS (including identification of the GTCC LLRW and GTCC-like waste inventory) to allow for an informed consultation with potentially affected American Indian tribes. In the EIS, it was assumed that institutional controls of the land disposal units would be maintained for 100 years and that corrective measures could be implemented during this time period to ensure that the engineered barriers lasted for at least 500 years. This assumption is consistent with the institutional control time frame given in both NRC and DOE requirements and was determined to be a reasonable approach for assessing the long-term performance of the disposal units in the EIS.

6. *Transportation Analysis and Impacts – Radioactive waste that has been generated off-site should not be transported to the sites evaluated for disposal and for which the EIS does not identify specific routes or the proportion of wastes that would likely travel those routes. Commenters said that the transportation analysis should consider larger-volume packages and that the supporting information for the facility and transportation accident analyses should have been available.*

   Transportation of GTCC LLRW and GTCC-like waste from generating facilities to a GTCC LLRW disposal facility is a required component of the disposal process that would be identified for the GTCC LLRW and GTCC-like waste because the disposal site(s) or location(s) would not be the same as the generator sites as stated in the EIS. Based on the analysis conducted for this EIS, the transportation of GTCC LLRW and GTCC-like waste to a centralized disposal facility or facilities would result in lower overall human health risks compared to the No Action Alternative and can be conducted in a safe manner based in compliance with federal and state comprehensive regulatory requirements. The primary radiological transportation risk to the public for any alternative is from the low level of radiation emanating from the transport vehicle. The EIS shows that such risks are small. The magnitude of the collective population risk is primarily determined by the number of routes, the length of each route, the number of shipments along each route, the external dose rate of each shipment, and the population density along a given route. The primary differences among alternatives from the standpoint of transportation are the lengths of the routes as determined by the location of the disposal sites (destination of the shipments). Thus, higher collective population risks are associated with alternatives that require transportation over longer distances. All alternatives involve routes that have similar characteristics, with no significant differences for comparison among alternatives; all require transportation through a range of rural and urban areas. In addition, the routes used in the analysis are considered representative routes because the actual routes used would be determined in the future. For each disposal site, the routes most affected would be the interstate highways that are closest to the site. The transportation analysis as presented in the EIS is conservative in that consideration of the larger volume TRUPACT III and spent nuclear fuel casks could result in potentially reduced impact estimates than those presented due to fewer required shipments. However, while these packages are viable options for transport of the GTCC LLRW and GTCC-like waste, consideration of their use as an option in the EIS did not influence the identification of the preferred alternative.

7. *Model Assumptions for Post-Closure Human Health Impacts – Commenters indicated a number of issues associated with the long-term modeling in the EIS, such as conceptual designs that were too generic, assumptions about uniform environmental conditions, and other unsupported assumptions.*

   The EIS analyses are based on conceptual engineering information and necessitated the use of a number of simplifying assumptions. This approach is consistent with NEPA, which requires such analyses to be made early in the decision-making process. The various land disposal conceptual designs were assumed to be constructed and operated in a comparable manner at each of the various sites. In performing these evaluations, a number of engineering measures were included in the conceptual facility designs to minimize the likelihood of contaminant migration from the disposal units. No facility design can guarantee that radionuclide migration from the facility would not occur over and beyond a 10,000-year time period. It was assumed that these measures would perform similarly for all conceptual designs, remaining intact for 500 years after the disposal facility closed. After 500 years, the barriers would gradually fail. It should be emphasized that project- and site-specific engineering factors would be incorporated into the actual facility designs of the site or sites selected in the ROD to dispose of GTCC LLRW and GTCC-like waste. DOE recognizes that modeling potential releases of radionuclides from the conceptual disposal sites far into the future approximates what might actually occur and is therefore subject to technical uncertainty.

8. *Waste Inventory – The GTCC LLRW and GTCC-like waste inventory addressed in the EIS is much too limited.*

The GTCC LLRW and GTCC-like waste inventory evaluated in the Draft EIS included all GTCC LLRW and GTCC-like waste in storage as of 2008, plus GTCC LLRW and GTCC-like waste including buried wastes at the West Valley site, as well as wastes that could reasonably be expected to be generated in the near future. For the purposes of this analysis, waste disposal is assumed to occur from 2019 through 2083. The GTCC LLRW and GTCC-like waste inventory includes stored and projected wastes from the 104 nuclear power plants currently in operation as well as from the 18 commercial reactors that have already been shut down. It also includes projected GTCC LLRW from another planned 33 new reactors that have not yet been constructed. It is not reasonable to extend data beyond existing information on the commercial nuclear power industry to develop estimates of GTCC LLRW that could result from future decommissioning of these reactors, some of which may never be built. In addition, it is possible that new reactor technology could change the projected volumes of GTCC LLRW. In performing its due diligence in the preparation of this final EIS, DOE determined the GTCC LLRW and the GTCC-like waste inventory estimates used in the EIS to be conservative and bounding. This inventory remains valid and is appropriate for use in the EIS and for the development of the preferred alternative for disposal of GTCC LLRW and GTCC-like waste.

9. *Cumulative Impacts – Commenters suggested that the environmental impacts of all potential sources of radioactive contamination at the site, in addition to the impacts associated with transportation of the GTCC LLRW and GTCC-like waste to the Hanford Site, need to be addressed in the cumulative impacts analyses presented in this EIS.*

DOE has analyzed cumulative impacts at the Hanford Site in this GTCC EIS and indicates that the disposal of GTCC LLRW and GTCC-like waste at the Hanford Site could result in a radiation dose estimate to a nearby hypothetical future resident farmer of about 49 mrem/yr within the first 10,000 years, and most of this dose would be due to I-129 or Tc-99 in groundwater. Based on the cumulative impacts discussed in the Hanford TC&WM EIS (DOE 2012), when the impacts of Tc-99 from past leaks and cribs and trenches (ditches) are combined, DOE believes it may not be prudent to add significant additional

Tc-99 to the existing environment. Therefore, one means of mitigating this impact would be for DOE to limit disposal of off-site waste streams containing these radionuclides at the Hanford Site.

10. *Statutory/Regulatory and Policy Issues – Commenters indicated that any facility used for the disposal of GTCC LLRW and GTCC-like waste will have to be licensed by the NRC as provided in Section 3(b)(1)(D) of the LLRWPAA, and, as such, disposal criteria would need to be established. Commenters suggested that since GTCC LLRW is commercially generated radioactive waste, it should be disposed of at a commercial site and not at one or more DOE sites. Commenters also questioned how the requirement for NRC licensing of a GTCC LLRW disposal facility would be done if this facility was located at a DOE site, especially if such a facility was used for commercial GTCC LLRW and GTCC-like waste. Commenters suggested that the NRC should have been a more active participant in this process to ensure that the proposed alternatives could actually be implemented.*

    DOE determined that the most efficient approach was to address both GTCC LLRW and GTCC-like waste, which have many similar physical and radioactive characteristics, in a single NEPA process. DOE's intent is to facilitate the overall process for addressing the disposal needs of both waste types.

    The LLRWPAA (P.L. 109-58) specifies that GTCC LLRW, designated a federal responsibility under section 3(b)(1)(D) that results from activities licensed by the NRC, is to be disposed of in an NRC-licensed facility that has been determined to be adequate to protect public health and safety. However, unless specifically provided by law, the NRC does not have authority to license and regulate facilities operated by or on behalf of DOE. Further, the LLRWPAA does not limit DOE to using only non-DOE facilities or sites for GTCC LLRW disposal. Accordingly, if DOE selects facility operated by or on behalf of DOE for disposal of GTCC LLRW for which it is responsible under section 3(b)(1)(D), clarification from Congress would be needed to determine NRC's role in licensing such a facility and related issues. In addition, clarification from Congress may be needed on NRC's role if DOE selects a commercial GTCC LLRW disposal facility licensed by an Agreement State rather than by NRC.

    The NRC served as a commenting agency on the GTCC EIS and therefore did not actively participate in the preparation of the GTCC EIS. Issues associated with potential regulatory changes or NRC licensing would be addressed as necessary to enable implementation.

S.7 WHAT DID DOE CONSIDER IN DEVELOPING THE PREFERRED ALTERNATIVE?

DOE is selecting a combination of alternatives as the preferred alternative identified in the Final GTCC EIS and discussed in Section S.8 of this summary. DOE's preferred alternative would fulfill DOE's statutory mission and responsibilities and considers (1) comments received on the Draft GTCC EIS from the public; (2) DOE and NRC requirements for the disposal of LLRW, such as those as found in 10 CFR Part 61 and DOE Order 435.1, Radioactive Waste Management; and (3) environmental, technical, economic and other findings presented in the GTCC EIS.

The following text summarizes key considerations related to the alternatives analyzed in the EIS. In addition to public comments, these considerations include waste type characteristics, disposal method considerations, and disposal location considerations.

S.7.1 Public Comments

DOE has considered all comments received on the Draft EIS in identifying the preferred alternative presented in the Final GTCC EIS. See Section S.6 for additional information regarding the public involvement process for the GTCC EIS. The Draft GTCC EIS considered the public scoping comments on the NOI that were received, and it evaluated the conceptual designs for enhanced land disposal methods as alternatives to the deep geologic disposal method, which the NRC currently considers to be an acceptable method for disposing of GTCC LLRW. A summary of the public comments on the Draft GTCC EIS is in the Final GTCC EIS, and a synopsis of that summary is presented in Section S.8 of this summary.

S.7.2 Waste Type Characteristics

The three types of GTCC LLRW and GTCC-like waste (activated metals, sealed sources, and Other Waste) addressed in the EIS come from different sources and have different physical, chemical, and radiological characteristics. In addition, some waste types differ in terms of their availability for disposal at specific times. Thus, it might be appropriate to use different disposal methods for different waste types. Key factors related to the three GTCC LLRW and GTCC-like waste types that might determine whether one disposal method would be more appropriate than another include the following:

- *Radionuclide inventory.* The GTCC LLRW and GTCC-like waste include a wide range of radionuclides. Sealed sources generally consist of one (or possibly a few) radionuclides, whereas activated metal waste and the Other Waste type contain a larger number of radionuclides. Some of these radionuclides (such as strontium-90 [Sr-90] and Cs-137) have relatively short half-lives of about 30 years, whereas others (such as Pu-239) have half-lives of more than 10,000 years. Both the total inventory and mix of radionuclides are important to consider when selecting (an) appropriate disposal method(s) for a particular waste type.

A number of TRU radionuclides decay to radioactive progeny, and the presence of these in-growth radionuclides needs to be addressed. Also, some radionuclides emit significant amounts of gamma radiation (such as Co-60 and Cs-137), whereas others emit very little or no such radiation. The activated metals are expected to have the highest gamma exposure rates of the three waste types, and the sealed sources are expected to have the lowest exposure rates. The Other Waste is divided into CH and RH wastes, because some of the Other Waste could contain significant concentrations of fission products and neutron activation products that could decay and release significant amounts of gamma radiation, whereas others might have very little of these radionuclides.

The concentrations of long-lived radionuclides in waste determine how long it will remain hazardous. Many of the GTCC-like wastes have long-lived TRU radionuclides, and so they will remain hazardous for many thousands of years. Similar wastes are currently being disposed of in a geologic repository (WIPP) because of this concern. Also, the relative mobility of the radionuclides in groundwater systems varies widely; some radionuclides (such as Tc-99 and I-129) are quite mobile, while radioactive metals tend to bind with the soil particles and move more slowly in the environment.

- *Waste form stability*. While all of the GTCC LLRW and GTCC-like waste are solids, some are much more durable than others. It is assumed that activated metal wastes would retain their integrity for very long periods, while the Other Waste would be stabilized in a grout matrix to ensure the integrity of its waste form. Sealed sources are also very robust and are expected to retain their form for long time periods. Waste form stability influences the longevity of a disposal facility, with forms that could degrade more quickly being a long-term concern.

- *Size*. Some GTCC activated metal wastes are large metallic items that can be disposed of more readily in a near-surface trench or vault than in a borehole or geologic repository (WIPP). Use of boreholes or a geologic repository might require more waste handling to make the physical size of the waste manageable than use of trenches or vaults and could result in greater worker doses.

- *Availability for disposal*. While some GTCC LLRW and GTCC-like waste are currently in storage and available for disposal, much of the GTCC LLRW and GTCC-like waste will not be generated for several decades (see Figure S-6). The activated metal wastes are mainly associated with commercial nuclear power plants, and most of them are expected to operate for 20 years or more. Excess or unwanted radioactive sealed sources represent a national security concern, so their disposal is a high priority.

On the basis of these factors, it is important to take into account the characteristics of a specific waste type with the site and disposal method under consideration to ensure the timely, cost-effective, and safe disposal of GTCC LLRW and GTCC-like waste. Sealed sources (which are generally small and durable) might be good candidates for borehole disposal, whereas other large wastes (such as activated metal wastes) might be better suited for trenches and vaults. Many of the sealed sources recovered by the DOE GMS/OSRP for national security or public health and safety purposes meet the criteria for disposal at existing DOE facilities (when GMS/OSRP recovers sealed sources, DOE typically takes ownership of the sources and may dispose of them at DOE facilities if they meet waste acceptance criteria for such facilities). The long-term hazards associated with GTCC LLRW and GTCC-like waste might preclude the use of certain disposal sites and methods, especially those that could result in groundwater contamination.

S.7.3 Disposal Methods

Key factors considered in identifying a preferred disposal method for GTCC LLRW and GTCC-like waste include (1) protecting the inadvertent human intruder, (2) leveraging operational experience, (3) minimizing institutional controls, and (4) achieving cost-effective disposal. Each of these factors is discussed here.

Disposal Method Considerations

Factor	Criterion
Inadvertent human intrusion	Favors methods that minimize the potential for inadvertent human intrusion
Construction and operational experience	Favors methods that have been successfully used in the past to manage similar wastes
Post-closure care	Favors methods that minimize the potential need for long-term maintenance after the facility has closed
Cost	Favors methods that result in cost effective waste disposal

S.7.3.1 Inadvertent Human Intrusion

An inadvertent intruder is a person who might occupy the disposal site after closure and engage in normal activities, such as agricultural activities or the construction of buildings, or other pursuits in which the person might be unknowingly exposed to radiation from the waste (10 CFR 61.2). Human intrusion impacts might be mitigated by the waste form and packaging, institutional controls, and engineered and natural barriers (e.g., grouting and depth of disposal). All four disposal methods analyzed in this EIS include a combination of some or all these mitigation features.

S.7.3.2 Construction and Operational Experience

All four disposal methods have been used to some degree in the United States or other countries to dispose of radioactive waste similar to the three waste types analyzed in the GTCC EIS.

- *Deep geologic disposal.* The DOE WIPP facility is currently the only operating deep geologic repository in the United States. Since it began operations in 1999, the facility has successfully received more than 64,000 m^3 (2,300,000 ft^3) of CH and RH TRU waste generated by DOE atomic energy defense activities. This waste includes radioactive sealed sources, debris, and other waste similar to GTCC LLRW and GTCC-like waste. Most of the GTCC-like waste is similar to waste currently being disposed of at WIPP, except that it may not be authorized for disposal at WIPP under the WIPP LWA as amended (P.L. 102-579 as amended by P.L. 104-201).

- *Boreholes.* DOE demonstrated the use of borehole facilities to dispose of radioactive waste at NNSS (formerly NTS), which operated from 1984 through 1989 and received DOE waste similar to GTCC LLRW. Borehole disposal is receiving increased attention from the International Atomic Energy Agency as an option for disposal of disused sealed sources. Currently, there are no NRC-licensed borehole facilities in the United States. The advantages of the borehole method are as follows: (1) it may be amenable to receiving intermittent or low-volume waste like GTCC LLRW and GTCC-like waste; (2) it is visually unobtrusive; (3) it has the potential for robust long-term isolation of wastes; and (4) no workers need to enter the disposal borehole, which thereby minimizes worker hazards. Boreholes also provide the greatest amount of natural shielding (the surrounding soil) of any of the three land disposal methods. A disadvantage of the borehole method is the low volume capacity of the borehole and the much higher volume of unused space surrounding each borehole. Consequently, a very large number of boreholes (approximately 930 boreholes) would be required to manage the entire GTCC LLRW and GTCC-like waste volume. As mentioned above, the technology might be better suited to specific waste types (e.g., sealed sources), for which fewer boreholes would be required. Also, use of boreholes may be limited by underground injection control regulations or other requirements, such as the Safe Drinking Water Act.

- *Trenches.* Trenches are used for the disposal of LLRW in the United States and at a number of sites around the world. Commercial facilities dispose of Class A, B, and C LLRW in trenches and vaults. In addition, DOE uses trenches to dispose of its LLRW, including LLRW comparable to GTCC LLRW (e.g., Sr-90 radioisotope thermoelectric generators) on the basis of performance assessment analyses (systematic analyses of the potential risks posed by waste management systems). SRS currently disposes of large equipment (e.g., large cesium sources and other LLRW) in trenches by using the components-in-grout technique. This technique allows large equipment to be disposed of in trenches, and the waste form is surrounded with grout on all sides (bottom, sides, top). This approach will limit future subsidence and the release of radionuclides. The conceptual design for the trench that is evaluated in the GTCC EIS employs a deeper (11-m or 35-ft deep) and narrower (3-m or 10-ft wide) design than conventional belowground, near-surface radioactive waste disposal facilities in order to protect the facility from inadvertent human intrusion. Potential operational advantages of the trench include (1) its visual unobtrusiveness, (2) its ease of construction, and (3) the relative ease with which the wastes can be disposed of. Potential disadvantages include (1) the increased possibility of exposing workers to radiation hazards (i.e., more than that presented by boreholes), unless temporary covers or shields would be used, and (2) the possibility that this method might provide less protection from future intrusion into the wastes, as compared to boreholes and deep geologic disposal.

- *Vaults.* Vaults similar to the design presented in the GTCC EIS have been operated by DOE at SRS and other DOE facilities for the disposal of LLRW. This disposal method is more commonly used in humid environments, where belowground disposal methods might be limited by shallow groundwater. The conceptual design for the vault includes thick reinforced concrete walls, floors, and ceilings. To further isolate the waste, an engineered cover system is included in the design. Potential advantages of the vault include these: (1) it can be inspected visually and be more easily monitored than the other alternative land disposal methods; (2) because of its high visibility, inadvertent human intrusion is unlikely; and (3) it does not rely on waste packages for structural support (i.e., structural support is provided by the concrete cells). Potential disadvantages include these: (1) its active maintenance requirements (including active institutional controls) are likely to be more extensive than those of the other methods because of its visibility and exposure to the elements; (2) the costs to construct and operate it are higher than those of the other alternative land disposal methods; (3) it has a higher potential for exposing workers to radiation hazards than the other land disposal methods, unless temporary shielding or waste covers are used; and (4) it could attract intentional intruders because of its visibility.

S.7.3.3 Post-Closure Care Requirements

Some disposal methods might need to rely more on post-closure care than others. Because an above-grade vault is exposed to the elements, it might require more active institutional controls than the trench, borehole, and deep geologic disposal methods, extending to times beyond the period of active institutional control normally considered when evaluating the safety of waste management facilities. If post-closure care is not maintained, vaults could pose a greater potential for radiological exposures to the public. Consequently, maintenance of active institutional controls is considered particularly important for this technology to achieve post-closure safety. Long term post-closure care requirements for the trench, borehole, and deep geologic methods should be less.

S.7.3.4 Construction and Operating Costs

The estimated cost to construct and operate a GTCC LLRW and GTCC-like waste disposal facility ranges from $250 million for disposal at a new trench facility to $570 million for disposal at the WIPP geologic repository, as shown in Table S-5. The cost estimates for each disposal method are based on the assumption that all GTCC LLRW and GTCC-like waste would

TABLE S-5 Costs of GTCC LLRW and GTCC-Like Waste Disposal Alternatives[a]

Disposal Method	Cost to Construct Facility (in millions of $)[b]	Cost to Operate Facility (in millions of $)[c]	Total Cost to Construct and Operate Facility (in millions of $)
WIPP	14	560	570
Borehole	210	120	330
Trench	88	160	250
Vault	360	160	520

[a] Costs are rounded to two significant figures.

[b] Construction costs for the WIPP facility are for 26 new rooms. Construction costs for the borehole, trench, and vault disposal facilities are for 930 boreholes, 29 trenches, and 12 vaults (consisting of 130 total vault cells), respectively, and the supporting infrastructure.

[c] The operational cost for WIPP is based on the actual per-shipment cost for fiscal year 2008. Operational costs assume 20 years of facility operations for the borehole, trench, and vault disposal methods. On the basis of the assumed receipt rates, the majority of the wastes would be available for emplacement during the first 15 years of operations. The actual start date for operations is uncertain at this time and dependent upon, among other things, the alternative or alternatives selected, additional NEPA review as required, characterization studies, and other actions necessary to initiate and complete construction and operation of a GTCC LLRW and GTCC-like waste disposal facility. For purposes of analysis in the GTCC EIS, DOE assumed a start date of disposal operations in 2019. However, given these uncertainties, the actual start date could vary.

be disposed of by that method, although different combinations of disposal methods could be used for the different waste types. Costs for facility permits, licenses, transportation, packaging, and post-closure activities are not included in the estimates.

S.7.4 Disposal Location Considerations

The GTCC EIS evaluates six federal locations for the potential disposal of GTCC LLRW and GTCC-like waste, of which one is in a humid environment (SRS) and five are in semi-arid or arid environments (Hanford, INL, LANL, NNSS,WIPP/WIPP Vicinity). In addition, the GTCC EIS evaluates generic commercial locations in four regions of the United States. On the basis of the results presented in the GTCC EIS, key factors to be

Disposal Location Considerations

Factor	Criterion
Human health risk	Favors alternatives that reduce human health risk to both workers and the public.
Cultural resources	Favors alternatives that avoid adverse impacts to known cultural sites.
Laws, regulations, and other requirements	Favors alternatives that would not be inconsistent with current laws and other requirements.

considered in identifying a preferred disposal location for GTCC LLRW are potential human health risks for the post-closure long-term phase (including potential cumulative human health impacts from the post-closure phase); cultural resources and tribal concerns; and existing laws, regulations, and other requirements.

S.7.4.1 Human Health Impacts

Potential human health impacts include (1) potential exposure of workers and the general public to radiation during routine conditions and accidents and (2) direct impacts on workers and the public from industrial and transportation accidents. All potential impacts were considered in developing the preferred alternative. A primary consideration is the potential long-term (post-closure) impacts on members of the general public who might be exposed to radioactive contaminants released from the waste packages that are transported in groundwater and migrate to an accessible location, such as a groundwater well. Consequently, potential cumulative long-term human health impacts at each of the sites evaluated would likewise be of primary consideration. For example, the long-term doses and LCF risks estimated for the GTCC proposed action for the Hanford Site should be considered relative to the findings presented in the *Final Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington* (TC&WM EIS) (DOE 2012). According to the TC&WM EIS, receipt of off-site waste streams that contain specific amounts of certain isotopes, specifically I-129 and Tc-99, could cause an adverse impact on the environment. The Tc-99 inventory from off-site waste streams evaluated in the TC&WM EIS shows potential impacts that are less significant than those of I-129. However, when the impacts of Tc-99 from past leaks and cribs and trenches (ditches) are combined, DOE believes it may not be prudent to add significant additional Tc-99 to the existing environment. Therefore, one means of mitigating this impact would be for DOE to limit disposal of off-site waste streams containing I-129 or Tc-99 at Hanford.

With regard to transportation impacts, the optimal location would be one that is close to the waste-generating sources. This location would minimize the overall transportation distance and would have the lowest potential impacts on human health. However, most of the waste generators are located in the eastern half of the United States, and these areas have more humid climates than do sites in the western part of the country. The more humid sites (SRS and generic Regions I and II) were shown to generally have greater long-term impacts from the groundwater pathway, and this concern is a major consideration in identifying an acceptable location for a GTCC LLRW and GTCC-like waste disposal facility. This does not mean that a site in a humid region could not be used for such a facility. Rather, a facility in a humid environment would have to rely more on engineering measures and institutional controls to ensure that the long-term hazards were maintained at acceptable levels.

S.7.4.2 Cultural Resources and Tribal Concerns

Cultural resources include, among other things, definitive locations of traditional cultural or religious importance to specified social or cultural groups, such as American Indian tribes ("traditional cultural properties"). DOE consulted with participating tribes who have cultural or historical ties to DOE sites being analyzed in the GTCC EIS. Tribal perspectives, comments, and concerns (e.g., environmental justice issues) identified during the consultation process were considered by DOE in selecting disposal alternative(s) for analysis in this EIS. DOE will continue to consult the tribes throughout the implementation of the disposal.

S.7.4.3 Laws, Regulations, and Other Requirements

A number of laws, regulations, and requirements (including state permits) apply to the disposal alternatives considered in the GTCC EIS. These include requirements that generally apply to all proposed disposal locations as well as those that apply to a specific site (e.g., WIPP LWA as amended [P.L. 102-579 as amended by P.L. 104-201] and other required state permits). DOE considered all applicable laws, regulations, and other requirements in developing the preferred alternative. In 10 CFR Part 61, "Licensing Requirements for Land Disposal of Radioactive Waste," the NRC classifies LLRW into four classes (Classes A, B, and C, and GTCC LLRW) on the basis of the concentrations of short-lived and long-lived radionuclides (10 CFR 61.55). By controlling isotope concentrations in each class, the NRC regulations seek to control potential radiation exposures to future receptors, including inadvertent human intruders (e.g., a water well driller) after the period of active institutional control has ended. The NRC states in 10 CFR 61.7(b)(5) that GTCC LLRW is "generally unacceptable" for near-surface disposal but also recognizes that "there may be some instances where waste with concentrations greater than permitted for Class C waste would be acceptable for near-surface disposal with special processing or design."

The NRC regulations require GTCC LLRW to be disposed of in a geologic repository, as defined in 10 CFR Part 60 or 63, unless proposals for an alternative method are approved by NRC under 10 CFR 61.55(a)(2)(iv). The NRC regulations identify one approved method for the disposal of GTCC LLRW and GTCC-like waste (a geologic repository), but they acknowledge that other disposal methods could be approved.

In addition to protecting individuals from inadvertent intrusion, the preferred disposal alternative must protect the general population and involved workers from potential releases of radioactivity during facility construction and disposal operations. Long-term impacts after completion of the disposal operations and closure of the disposal facility also need to be considered. DOE developed the preferred alternative by considering these aspects along with the various other environmental resource areas discussed in this EIS. DOE structured the GTCC EIS so that the preferred alternative could be identified on the basis of a waste type, site, and disposal method. The preferred alternative is discussed in Section S.8 of this Summary.

S.8 PREFERRED ALTERNATIVE IDENTIFIED

In developing the preferred alternative for the disposal of GTCC LLRW and GTCC-like wastes, DOE considered national security concerns, the projected timing of waste generation and the potential long-term impacts on human health and the environment at the various disposal locations evaluated in the GTCC EIS. DOE also took into consideration applicable laws and requirements (e.g., WIPP LWA as amended [P.L. 102-579 as amended by P.L. 104-201], the LLRWPAA [P.L. 99-240]; other required state permits), costs, compliance with agreements, public input on the Draft EIS, national and state priorities, and other appropriate information.

Given the diverse characteristics (e.g., different radionuclide inventories, range of physical conditions, and derived from both commercial and DOE sources) of GTCC and GTCC-like waste analyzed in this EIS, the preferred alternative selected is not limited to one disposal technology. The preferred alternative for the disposal of GTCC and GTCC-like waste is the WIPP geologic repository (Alternative 2) and/or land disposal at generic commercial facilities (Alternatives 3-5). These land disposal conceptual designs could be altered or enhanced, as necessary, to provide the optimal application at a given location. The preferred alternative does not include land disposal at DOE sites. In addition, there is presently no preference among the three land disposal technologies at the generic commercial sites. The factors considered during the development of the preferred alternative include those discussed in Section S.7 and in the GTCC EIS in Section 2.9: public comment provided on the draft GTCC EIS; disposal site impacts including potential human health impacts, cultural resources and tribal concerns; waste types impacts including radionuclide inventory and characteristics and availability for disposal; and disposal method impacts including inadvertent human intrusion, construction and operation and cost. The analysis in this Final GTCC EIS has provided the Department with the integrated insight needed to identify a preferred alternative with the potential to enable the disposal of the entire waste inventory analyzed in this EIS. Due to the uncertainty regarding the need for legislative changes and/or licensing or permitting changes, further analysis will be needed before a Record of Decision is announced. The Department has determined that the preferred alternative would satisfy the needs of the Department for the disposal of GTCC and GTCC-like waste.

As required by NEPA, DOE will not issue a ROD sooner than 30 days after the issuance of the Final EIS. Prior to issuing a ROD regarding which disposal alternative to implement, DOE must submit a Report to Congress to fulfill the requirement of Section 631(b)(1)(B)(i) of the Energy Policy Act of 2005 (P.L. 109-58) and await action by Congress. Section 631(b)(1)(B)(i) requires that the report include all alternatives under consideration and all the information required in the comprehensive report to ensure safe disposal of GTCC LLRW that was submitted by the Secretary to Congress in February 1987.[5]

[5] In accordance with the requirements in section 3(b)(3) the LLRWPAA, the 1987 report (http://www.gtcceis.anl.gov/documents/docs/DOE_NE-0077.pdf) included: (1) an identification of the radioactive waste involved, including the source of such waste, and the volume, concentration, and other relevant characteristics of the waste; (2) an identification of the federal and non-federal options for disposal of the waste; (3) a description of actions proposed to ensure the safe disposal of the waste; (4) a description of the projected costs of undertaking such actions; (5) an identification of the options for ensuring that the beneficiaries of the activities resulting in the generation of the waste bear all reasonable costs of disposing of such wastes; and (6) an identification of any statutory authority required for disposal of the waste.

S.9 PRIMARY CHANGES MADE TO THE EIS

On the basis of the public comments received (as summarized in Section S.6.2), the primary change made to the Draft EIS to prepare the Final EIS was the addition of Appendix J, which provides a comment response summary that addresses the comments received on the Draft EIS as well as detailed responses to individual comments, in addition to the discussion of the preferred alternative for the disposal of GTCC LLRW and GTCC-like wastes, which is presented in Section S.8. In performing its due diligence in preparation of this Final EIS, DOE reviewed the waste quantity data and determined that the current expected waste quantity estimates remain valid, are conservative and bounding for the comparative analysis in the Final EIS, and revisions to this information are not necessary. Information that related to census data was also updated to reflect the 2010 census data for the Final EIS; including, for example, socioeconomic, transportation, and environmental justice impacts. The transportation accident analysis was reviewed, and the source terms used in the accident consequence assessment were included in the presentation of the analysis. Other revisions (for clarification or editorial purposes) were also made as a result of public comments received on the Draft GTCC EIS. Finally, site information was also updated on the basis of the further review conducted by DOE Field Offices and information from annual site environmental reports (for the year 2014).

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THE U.S. DEPARTMENT OF ENERGY

Final Environmental Impact Statement for the

Disposal of Greater-Than-Class C (GTCC) Low-Level Radioactive Waste and GTCC-Like Waste (DOE/EIS-0375)

Volume 1: Chapters 1 through 8

January 2016

U.S. DEPARTMENT OF ENERGY

COVER SHEET

Lead Agency: U.S. Department of Energy (DOE)

Cooperating Agency: U.S. Environmental Protection Agency (EPA)

Title: Final *Environmental Impact Statement for the Disposal of Greater-Than-Class C (GTCC) Low-Level Radioactive Waste and GTCC-Like Waste* (DOE/EIS-0375)[1]

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Abstract: The U.S. Department of Energy (DOE) has prepared this Final *Environmental Impact Statement for the Disposal of Greater-Than-Class C (GTCC) Low-Level Radioactive Waste and GTCC-Like Waste* (GTCC EIS) to evaluate the potential environmental impacts associated with the proposed development, operation, and long-term management of a disposal facility or facilities for GTCC low-level radioactive waste (LLRW) and DOE GTCC-like waste. GTCC LLRW has radionuclide concentrations exceeding the limits for Class C LLRW established by the U.S. Nuclear Regulatory Commission (NRC). These wastes are generated by activities licensed by the NRC or Agreement States and cannot be disposed of in currently licensed commercial LLRW disposal facilities. DOE has prepared and is issuing this EIS in accordance with the National Environmental Policy Act, Section 631 of the Energy Policy Act of 2005 (Public Law 109-58), and Section 3 (b) of the Low-Level Radioactive Waste Policy Amendments Act of 1985 (Public Law 99-240).

The NRC LLRW classification system does not apply to radioactive wastes generated or owned by DOE and disposed of in DOE facilities. However, DOE owns or generates LLRW and non-defense-generated transuranic (TRU) radioactive waste, which have characteristics similar to those of GTCC LLRW and for which there may be no path for disposal at the present time. DOE has included these wastes for evaluation in this EIS because similar approaches may be used to dispose of both types of radioactive waste. For the purposes of this EIS, DOE refers to this waste as GTCC-like waste. The total volume of GTCC LLRW and GTCC-like waste

[1] Vertical change bars in the margins of this Final EIS indicate revisions and new information added since the Draft EIS was issued in February 2011. Editorial changes are not marked.

addressed in the EIS is about 12,000 m^3 (420,000 ft^3), and it contains about 160 million curies of radioactivity. About three-fourths of this volume is GTCC LLRW, with GTCC-like waste making up the remaining one-fourth of the volume. Much of the GTCC-like waste is TRU waste. DOE has evaluated the potential environmental impacts associated with the range of reasonable alternatives for disposal of GTCC LLRW and GTCC-like waste in this GTCC EIS.

Alternatives Considered: DOE evaluated five alternatives in this GTCC EIS, including a No Action Alternative. One of the four action alternatives is disposal of GTCC LLRW and GTCC-like waste in a geologic repository at the Waste Isolation Pilot Plant (WIPP). The other three action alternatives involve the use of land disposal methods at six federally owned sites and at generic commercial sites. The land disposal alternatives consider the use of intermediate-depth borehole, enhanced near-surface trench, and above-grade vault facilities. The land disposal alternatives cover a spectrum of concepts that could be implemented to dispose of these wastes in order to enable an appropriate site and disposal technology to be selected. Each alternative is evaluated with regard to the transportation and disposal of the entire inventory, but the evaluation of human health and transportation impacts is done on a waste-type basis, so decisions can be made on this basis in the future, as appropriate.

Preferred Alternative: The preferred alternative for the disposal of GTCC and GTCC-like waste is the WIPP geologic repository (Alternative 2) and/or land disposal at generic commercial facilities (Alternatives 3-5). These land disposal conceptual designs could be altered or enhanced, as necessary, to provide the optimal application at a given location. The preferred alternative does not include land disposal at DOE sites. In addition, there is presently no preference among the three land disposal technologies at the generic commercial sites. The analysis in this Final GTCC EIS has provided the Department with the integrated insight needed to identify a preferred alternative with the potential to enable the disposal of the entire waste inventory analyzed in this EIS. Due to the uncertainty regarding the need for legislative changes and/or licensing or permitting changes, further analysis will be needed before a Record of Decision is announced. The Department has determined the preferred alternative would satisfy the needs of the Department for the disposal of GTCC and GTCC-like waste. Prior to making a final decision on which disposal alternative to implement, DOE will submit a Report to Congress to fulfill the requirement of Section 631(b)(1)(B)(i) of the Energy Policy Act of 2005 and await action by Congress. Section 631(b)(1)(B)(i) requires that the report include all alternatives under consideration and all the information required in the comprehensive report to ensure safe disposal of GTCC LLRW that was submitted by the Secretary to Congress in February 1987. DOE will not issue a Record of Decision until its required Report to Congress has been provided and appropriate action has been taken by Congress in accordance with the Energy Policy Act of 2005.

Public Comments: DOE issued an Advance Notice of Intent (ANOI) in the *Federal Register* on May 11, 2005, inviting the public to provide preliminary comments on the potential scope of the EIS. DOE then issued a Notice of Intent (NOI) to prepare this EIS on July 23, 2007; a printing correction was issued on July 31, 2007. The NOI provided responses to the major issues identified by commenters on the ANOI, identified the preliminary scope of the EIS, and announced nine public scoping meetings and a formal scoping comment period lasting from

July 23 through September 21, 2007. DOE used all input received during the scoping process to prepare the Draft GTCC EIS.

A 120-day public comment period on the Draft GTCC EIS began with the publication of the EPA Notice of Availability in the *Federal Register* on February 25, 2011 and closed on June 27, 2011. DOE conducted public hearings at nine locations during April and May of 2011. All comments received on the Draft GTCC EIS were considered in the preparation of this Final GTCC EIS.

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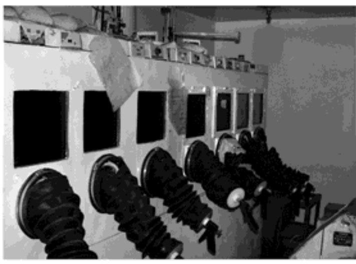
U.S. DEPARTMENT OF ENERGY



Final Environmental
Impact Statement for the

Disposal of Greater-Than-Class C (GTCC) Low-Level Radioactive Waste and GTCC-Like Waste (DOE/EIS-0375)

Volume 1: Chapters 1 through 8

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NOTATION

ACRONYMS AND ABBREVIATIONS

ACHP	Advisory Council on Historic Preservation
AEA	Atomic Energy Act of 1954
AEC	U.S. Atomic Energy Commission
AIP	Agreement in Principle
AIRFA	American Indian Religious Freedom Act of 1978
ALARA	as low as reasonably achievable
AMC	activated metal canister
AMWTP	Advanced Mixed Waste Treatment Project
ANOI	Advanced Notice of Intent
AQRV	air-quality-related value
ARP	Actinide Removal Process
ATR	Advanced Test Reactor (INL)
bgs	below ground surface
BLM	Bureau of Land Management
BLS	Bureau of Labor Statistics
BNSF	Burlington Northern Santa Fe
BRC	Blue Ribbon Commission on America's Nuclear Future
BSL	Biosafety Level
BWR	boiling water reactor
CAA	Clean Air Act
CAAA	Clean Air Act Amendments
CAP88-PC	Clean Air Act Assessment Package 1988-Personal Computer (code)
CCDF	complementary cumulative distribution function
CEDE	committed effective dose equivalent
CEQ	Council on Environmental Quality
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFA	Central Facilities Area (INL)
CFR	*Code of Federal Regulations*
CGTO	Consolidated Group of Tribes and Organizations
CH	contact-handled
CRMD	Cultural Resource Management Office
CTUIR	Confederated Tribes of the Umatilla Indian Reservation
CWA	Clean Water Act
CX	Categorical Exclusion
DCF	dose conversion factor
DCG	derived concentration guide
DOE	U.S. Department of Energy
DOE-EM	DOE-Office of Environmental Management

DOE-ID	DOE-Idaho Operations Office
DOE-NV	DOE-Nevada Operations Office
DOE-RL	DOE-Richland Operations Office
DOI	U.S. Department of the Interior
DOT	U.S. Department of Transportation
DRZ	disturbed rock zone
DTRA	Defense Threat Reduction Agency
DWPF	Defense Waste Processing Facility
EAC	Early Action Area
EDE	effective dose equivalent
EDNA	Environmental Designation for Noise Abatement
EIS	environmental impact statement
EPA	U.S. Environmental Protection Agency
ERDF	Environmental Restoration Dispersal Facility
ESA	Endangered Species Act of 1973
ESRP	Eastern Snake River Plain (INL)
FFTF	Fast Flux Test Facility (Hanford)
FGR	Federal Guidance Report
FONSI	Finding of No Significant Impact
FR	*Federal Register*
FTE	full-time equivalent
FY	fiscal year
GAO	U.S. Government Accountability (formerly General Accounting) Office
GMS/OSRP	Office of Global Material Security/Off-Site Source Recovery Project
GSA	General Separations Area (SRS)
GTCC	greater-than-Class C
HAP	hazardous air pollutant
HC	Hazard Category
HEPA	high-efficiency particulate air
HEU	highly enriched uranium
HF	hydrogen fluoride
HFIR	High Flux Isotope Reactor (ORNL)
HMS	Hanford Meteorology Station
HOSS	hardened on-site storage
h-SAMC	half-shielded activated metal canister
HSW EIS	Final Hanford Site Solid (Radioactive and Hazardous) Waste Program Environmental Impact Statement
ICRP	International Commission on Radiological Protection
IDA	intentional destructive act
IDAPA	Idaho Administrative Procedures Act
IDEQ	Idaho Department of Environmental Quality

IDF	Integrated Disposal Facility
INL	Idaho National Laboratory
INTEC	Idaho Nuclear Technology and Engineering Center (INL)
ISFSI	independent spent fuel storage installation
LANL	Los Alamos National Laboratory
LCF	latent cancer fatality
L_{dn}	day-night sound level
L_{eq}	equivalent-continuous sound level
LEU	low-enriched uranium
LLRW	low-level radioactive waste
LLRWPAA	Low-Level Radioactive Waste Policy Amendments Act of 1985
LMP	Land Management Plan (WIPP)
LWA	Land Withdrawal Act (WIPP)
LWB	Land Withdrawal Boundary (WIPP)
MCL	maximum contaminant level
MCU	modular caustic side solvent extraction unit
MDA	material disposal area (LANL)
MOA	Memorandum of Agreement
MOU	Memorandum of Understanding
MOX	mixed oxides
MPSSZ	Middleton Place-Summerville Seismic Zone
MSL	mean sea level
NAAQS	National Ambient Air Quality Standard(s)
NAGPRA	Native American Graves Protection and Repatriation Act of 1990
NASA	National Aeronautics and Space Administration
NCRP	National Council on Radiation Protection and Measurements
NDA	NRC-licensed disposal area (West Valley Site)
NEPA	National Environmental Policy Act of 1969
NERP	National Environmental Research Park
NESHAP	National Emission Standard for Hazardous Air Pollutants
NHPA	National Historic Preservation Act
NI PEIS	Nuclear Isotope PEIS
NLVF	North Las Vegas Facility
NMAC	*New Mexico Administrative Code*
NMED	New Mexico Environment Department
NMFS	National Marine Fisheries Services
NNHP	Nevada Natural Heritage Program
NNSA	National Nuclear Security Administration (DOE)
NNSA/NSO	NNSA/Nevada Site Office
NNSS	Nevada National Security Site (formerly Nevada Test Site or NTS)
NOAA	National Oceanic and Atmospheric Administration
NOI	Notice of Intent
NPDES	National Pollutant Discharge Elimination System

NPS	National Park Service
NRC	U.S. Nuclear Regulatory Commission
NRHP	*National Register of Historic Places*
NTS SA	Nevada Test Site Supplemental Analysis
NTTR	Nevada Test and Training Range
ORNL	Oak Ridge National Laboratory
ORR	Oak Ridge Reservation
PA	programmatic agreement
PCB	polychlorinated biphenyl
PCS	primary constituent standard
PEIS	programmatic environmental impact statement
P.L.	Public Law
PM	particulate matter
$PM_{2.5}$	particulate matter with an aerodynamic diameter of 2.5 μm or less
PM_{10}	particulate matter with an aerodynamic diameter of 10 μm or less
PPV	Peak Particle Velocity
PSD	Prevention of Significant Deterioration
PSHA	Probabilistic Seismic Hazards Assessment
PWR	pressurized water reactor
R&D	research and development
RCRA	Resource Conservation and Recovery Act
RDD	radiological dispersal device
RH	remote-handled
RH LLW EA	Remote-Handled Low-Level Waste Environmental Assessment (INL)
RLWTF-UP	Radioactive Liquid Waste Treatment Facility-Upgrade (LANL)
ROD	Record of Decision
ROI	region of influence
ROW	right-of-way
RPS	Radioisotopic Power Systems
RSL	Remote Sensing Laboratory
RWMC	Radioactive Waste Management Complex (INL)
RWMS	Radioactive Waste Management Site (NNSS)
SA	Supplemental Analysis
SAAQS	State Ambient Air Quality Standards
SALDS	State-Approved Land Disposal Site
SCDHEC	South Carolina Department of Health and Environmental Control
SCE&G	South Carolina Electric Gas
SDA	state-licensed disposal area (West Valley Site)
SDWA	Safe Drinking Water Act
SHPO	State Historic Preservation Office(r)
SNF	spent nuclear fuel
SR	State Route

SRS	Savannah River Site
SWB	standard waste box
SWEIS	Site-Wide Environmental Impact Statement
TA	Technical Area (LANL)
TC&WM EIS	Tank Closure and Waste Management EIS (Hanford)
TEDE	total effective dose equivalent
TEDF	Treated Effluent Disposal Facility
TEF	Tritium Extraction Facility
TLD	thermoluminescent dosimeter
TRU	transuranic
TRUPACT-II	Transuranic Package Transporter-II
TSCA	Toxic Substances Control Act
TSP	total suspended particulates
TTR	Tonapah Test Range
TVA	Tennessee Valley Authority
US	United States
USACE	U.S. Army Corps of Engineers
USC	*United States Code*
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
VOC	volatile organic compound
WAC	waste acceptance criteria or *Washington Administrative Code*
WHB	Waste Handling Building (WIPP)
WIPP	Waste Isolation Pilot Plant
WSRC	Westinghouse Savannah River Company
WTP	Waste Treatment Plant (Hanford)
WVDP	West Valley Demonstration Project

UNITS OF MEASURE

ac	acre(s)
ac-ft	acre-foot (feet)
°C	degree(s) Celsius
cfs	cubic foot (feet) per second
Ci	curie(s)
cm	centimeter(s)
cms	cubic meter(s) per second
d	day(s)
dB	decibel(s)
dBA	A-weighted decibel(s)
°F	degree(s) Fahrenheit
ft	foot (feet)
ft^2	square foot (feet)
ft^3	cubic foot (feet)
g	gram(s) or acceleration of gravity (9.8 m/s/s)
gal	gallon(s)
gpd	gallon(s) per day
gpm	gallon(s) per minute
h	hour(s)
ha	hectare(s)
hp	horsepower
in.	inch(es)
kg	kilogram(s)
km	kilometer(s)
km^2	square kilometer(s)
kph	kilometer(s) per hour
kV	kilovolt(s)
L	liter(s)
lb	pound(s)
m	meter(s)
m^2	square meter(s)
m^3	cubic meter(s)
MCi	megacurie(s)
mg	milligram(s)
mi	mile(s)
mi^2	square mile(s)
min	minute(s)
mL	milliliter(s)
mm	millimeter(s)
mph	mile(s) per hour
mR	milliroentgen(s)
mrem	millirem
mSv	millisievert(s)
MW	megawatt(s)
MWh	megawatt-hour(s)
nCi	nanocurie(s)
oz	ounce(s)
pCi	picocurie(s)
ppb	part(s) per billion
ppm	part(s) per million
R	roentgen(s)
rad	radiation absorbed dose
rem	roentgen equivalent man
s	second(s)
t	metric ton(s)
VdB	vibration velocity decibel(s)
yd	yard(s)
yd^2	square yard(s)
yd^3	cubic yard(s)
yr	year(s)
µg	microgram(s)
µm	micrometer(s)

CONVERSION TABLE[a]

Multiply	By	To Obtain
English/Metric Equivalents		
acres (ac)	0.4047	hectares (ha)
cubic feet (ft^3)	0.02832	cubic meters (m^3)
cubic yards (yd^3)	0.7646	cubic meters (m^3)
degrees Fahrenheit (ºF) –32	0.5555	degrees Celsius (ºC)
feet (ft)	0.3048	meters (m)
gallons (gal)	3.785	liters (L)
gallons (gal)	0.003785	cubic meters (m^3)
inches (in.)	2.540	centimeters (cm)
miles (mi)	1.609	kilometers (km)
pounds (lb)	0.4536	kilograms (kg)
short tons (tons)	907.2	kilograms (kg)
short tons (tons)	0.9072	metric tons (t)
square feet (ft^2)	0.09290	square meters (m^2)
square yards (yd^2)	0.8361	square meters (m^2)
square miles (mi^2)	2.590	square kilometers (km^2)
yards (yd)	0.9144	meters (m)
Metric/English Equivalents		
centimeters (cm)	0.3937	inches (in.)
cubic meters (m^3)	35.31	cubic feet (ft^3)
cubic meters (m^3)	1.308	cubic yards (yd^3)
cubic meters (m^3)	264.2	gallons (gal)
degrees Celsius (ºC) +17.78	1.8	degrees Fahrenheit (ºF)
hectares (ha)	2.471	acres (ac)
kilograms (kg)	2.205	pounds (lb)
kilograms (kg)	0.001102	short tons (tons)
kilometers (km)	0.6214	miles (mi)
kilometers per hour (kph)	0.6214	miles per hour (mph)
liters (L)	0.2642	gallons (gal)
meters (m)	3.281	feet (ft)
meters (m)	1.094	yards (yd)
metric tons (t)	1.102	short tons (tons)
square kilometers (km^2)	0.3861	square miles (mi^2)
square meters (m^2)	10.76	square feet (ft^2)
square meters (m^2)	1.196	square yards (yd^2)

[a] Values presented in this GTCC EIS have been converted (as necessary) by using the above conversion table and rounded to two significant figures.

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GLOSSARY

Accident	An unplanned event or sequence of events that results in undesirable consequences.
Actinide	Any member of the group of elements with atomic numbers from 89 (actinium) to 103 (lawrencium), including uranium and plutonium. All members of this group are radioactive.
Activated metal	Metal that has been irradiated by neutrons, protons, or other nuclear particles (such as what occurs in a nuclear reactor), producing radionuclides that can emit significant gamma radiation.
Activation product	An element that is formed by absorption of neutrons, protons, or other nuclear particles and thus may be radioactive. (See neutron and proton.)
Acute exposure	A single, short-term exposure to radiation, a toxic substance, or other stressors that may result in biological harm. Pertaining to radiation, the exposure incurred during and shortly after a large radiological release.
Administrative control	Provisions related to organization and management, procedures, record-keeping, assessment, and reporting that are necessary to ensure the safe operation of a facility.
Affected environment	The existing biological, physical, social, and economic conditions of an area that are subject to direct and/or indirect changes as a result of a proposed human action.
Air pollutant	Generally, an airborne substance that could, in high enough concentrations, harm living things or cause damage to materials. From a regulatory perspective, an air pollutant is a substance for which emissions or atmospheric concentrations are regulated or for which maximum guideline levels have been established because of its potential to have harmful effects on human health and welfare.

Air quality	The cleanliness of the air as measured by the levels of pollutants relative to standards or guideline levels established to protect human health and welfare. Air quality is often expressed in terms of the pollutant for which concentrations are the highest percentage of a standard (e.g., air quality may be unacceptable if the level of one pollutant is 150% of its standard, even if levels of other pollutants are well below their respective standards).
ALARA	Acronym for as low as reasonably achievable.
Alkaline	Having the properties of a soluble mineral salt capable of neutralizing acids.
Alluvium (alluvial)	Unconsolidated, poorly sorted detrital sediments deposited by streams and ranging in size from clay to gravel.
Alpha activity	The emission of alpha particles by radioactive materials.
Alpha particle	A positively charged particle ejected spontaneously from the nuclei of some radioactive elements. It is identical to a helium nucleus and has a mass number of 4 and a charge of +2. It has low penetrating power and a short range (a few centimeters in air).
Alpha radiation	A strongly ionizing, but weakly penetrating, form of radiation consisting of positively charged alpha particles emitted spontaneously from the nuclei of certain elements during radioactive decay. Alpha radiation is the least penetrating of the four common types of ionizing radiation (alpha, beta, gamma, and neutron). Even the most energetic alpha particle generally fails to penetrate the dead layers of cells covering the skin and can be easily stopped by a sheet of paper. Alpha radiation is most hazardous when an alpha-emitting source is inside an organism.

Alternative	One of two or more actions, processes, or propositions from which a decision-maker will determine the course to be followed. The National Environmental Policy Act of 1969 (NEPA), as amended, states that in preparing an environmental impact statement (EIS), an agency "shall ... study, develop, and describe appropriate alternatives to recommended courses of action in any proposal which involves unresolved conflicts concerning alternative uses of available resources" (Title 42 of the *United States Code,* Section 4322(2)(E)). Council on Environmental Quality NEPA-implementing regulations indicate that the alternatives section in an EIS is "the heart of the environmental impact statement" (40 CFR 1502.14), and the regulations include procedures for presenting the alternatives, including the no action alternative, and their estimated impacts.
Ambient	Surrounding.
Ambient air	The atmosphere surrounding people, plants, and structures.
Ambient air quality standards	As prescribed by regulations, the level of pollutants in the air that may not be exceeded during a specified time in a defined area. Air quality standards are used to provide a measure of the health-related and visual characteristics of the air.
Amphibian	Class of cold-blooded, scaleless vertebrates that usually begin life with gills and then develop lungs.
Anadromous	Fish (such as salmon) that ascend freshwater streams from saltwater bodies of water to spawn.
Anion	A negatively charged ion.
Aquatic	Living or growing in, on, or near water.
Aquatic biota	The sum total of living organisms within any designated aquatic area.
Aquifer	A body of rock or sediment that is capable of transmitting groundwater and yielding usable quantities of water to wells or springs.
Aquitard	A semipermeable geologic unit that inhibits the flow of water.

Archaeological sites — Any location where humans have discarded artifacts or otherwise altered the terrain during prehistoric or historic times.

Artifact — An object produced or shaped by human workmanship that is of archaeological or historical interest.

As low as reasonably achievable (ALARA) — An approach to radiation protection designed to manage and control worker and public exposures (both individual and collective) and releases of radioactive material to the environment to as far below applicable limits as social, technical, economic, practical, and public policy considerations permit. ALARA is not a dose limit but a process for minimizing doses to as far below limits as is practicable.

Atmospheric dispersion — The distribution of pollutants from their source into the atmosphere by wind, turbulent air motion attributable to solar heating of the earth's surface, or air movement over rough terrain and variable land and water surfaces.

Atomic number — The number of positively charged protons in the nucleus of an atom or the number of electrons on an electrically neutral atom.

Attainment area — An area that the U.S. Environmental Protection Agency has designated as being in compliance with one or more of the National Ambient Air Quality Standards (NAAQS) for sulfur dioxide, nitrogen dioxide, carbon monoxide, ozone, lead, and particulate matter. An area may be in attainment for some pollutants but not for others.

Attenuate — In the context of this environmental impact statement, to reduce, over time, the concentration of a chemical (usually through adsorption, degradation, dilution, and/or transformation) or a radionuclide (through radioactive decay).

Background radiation — Radiation from (1) natural sources of radiation including cosmic rays, (2) naturally occurring radionuclides in the environment such as radon, (3) radionuclides in the body such potassium-40, and (4) man-made sources of radiation including medical procedures and consumer products. The average annual dose from background radiation to an individual in the United States is about 620 mrem/yr.

Backfill Excavated earth or other material transferred into an open trench, cavity, or other opening in the earth.

Barrier Any material or structure that prevents or substantially delays movement of constituents toward the accessible environment, especially an engineered structure used to isolate contaminants from the environment in accordance with appropriate regulations.

Basalt The most common volcanic rock, dark gray to black in color, high in iron and magnesium, low in silica, and typically found in lava flows.

Baseline The existing environmental conditions against which the impacts of the proposed actions and their alternatives can be compared.

Basin Geologically, a circular or elliptical downwarp or depression in the earth's surface that collects sediment. Younger sedimentary beds occur in the center of basins. Topographically, a depression into which water from the surrounding area drains.

Becquerel A unit of radioactivity equal to one disintegration per second. Thirty-seven billion becquerels equal 1 curie.

Bedrock The solid rock that lies beneath soil and other loose surface materials.

BEIR VII The seventh in a series of committee reports from the National Research Council on the biological effects of ionizing radiation, published in 2006. BEIR VII updates BEIR V, using epidemiologic and experimental research information accumulated since the BEIR V report to develop the best possible risk estimate for exposure experienced by radiation workers and members of the general public.

Beryllium An extremely lightweight element with the atomic number 4. It is metallic and is used in nuclear reactors as a neutron reflector.

Best management practices (BMPs)	Structural, nonstructural, and managerial techniques, other than effluent limitations, to prevent or reduce pollution of the environment. They are the most effective and practical means to control pollutants that are compatible with the productive use of the resource to which they are applied. BMPs can include schedules of activities; prohibitions of practices; maintenance procedures; treatment requirements; operating procedures; and practices to control plant site runoff, spillage or leaks, sludge or waste disposal, or drainage from raw material storage.
Beta emitter	A radioactive substance that decays by releasing a beta particle.
Beta particle	A particle emitted in the radioactive decay of many radionuclides. A beta particle can be either positive (positron) or negative (negatron), and a negatron is identical to an electron. It has a short range in air and a limited ability to penetrate other materials; it can be stopped by clothing or a thin sheet of metal.
Beta radiation	Ionizing radiation consisting of fast-moving, positively or negatively charged elementary particles emitted from atomic nuclei during radioactive decay. Beta radiation is more penetrating but less ionizing than is alpha radiation. Beta particles can be stopped by clothing or a thin sheet of metal.
Biodiversity	The diversity of life forms and their levels of organization.
Biota (biotic)	The plant and animal life of a region.
Block	U.S. Census Bureau term for small areas bounded on all sides by visible features or political boundaries; used in tabulation of census data.
Borehole	As used in this environmental impact statement, a deep and relatively narrow hole drilled into the surface of the earth that can be used for the disposal of radioactive waste.
Borrow	Excavated material that has been taken from one area to be used as raw material or fill at another location.
Borrow area (pit, site)	An area designated as the excavation site for geologic resources, such as rock/basalt, sand, gravel, or soil, that are to be used elsewhere for fill.

BWR Acronym for boiling water reactor, one of two reactor types used in commercial nuclear power plants in the United States. The other reactor type is a pressurized water reactor (PWR).

Byproduct material (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; (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; (3)(A) any discrete source of radium–226 that is produced, extracted, or converted after extraction, before, on, or after August 8, 2005, for use for a commercial, medical, or research activity; or (B) any material that–(i) has been made radioactive by use of a particle accelerator; and (ii) is produced, extracted, or converted after extraction, before, on, or after the date of enactment of this paragraph for use for a commercial, medical, or research activity; and (4) any discrete source of naturally occurring radioactive material, other than source material, that – (A) the Commission, in consultation with the Administrator of the Environmental Protection Agency, the Secretary of Energy, the Secretary of Homeland Security, and the head of any other appropriate Federal agency, determines would pose a threat similar to the threat posed by a discrete source of radium–226 to the public health and safety or the common defense and security; and (B) before, on, or after August 8, 2005 is extracted or converted after extraction for use in a commercial, medical, or research activity.

Cancer The name given to a group of diseases characterized by uncontrolled cellular growth in which the cells have invasive characteristics that enable the disease to transfer from one organ to another.

Candidate species Plant or animal native to the United States for which the U.S. Fish and Wildlife Service or the National Marine Fisheries Service has sufficient information on its biological vulnerability and threats to justify proposing to add it to the threatened and endangered species list, but for which the Service cannot do so immediately because other species have a higher priority for listing. The Services determine the relative listing priority of candidate taxa in accordance with general listing priority guidelines published in the *Federal Register.* (See endangered species and threatened species.)

Canister — A general term for a metal container, usually cylindrical, used in the handling, storage, transportation, or disposal of waste.

Canyon — A large, heavily shielded, concrete building containing a remotely operated plutonium or uranium processing facility.

Cap — A cap used to cover a radioactive burial ground with soil, rock, vegetation, or other materials as part of the facility closure process. The cap is designed to reduce the migration of radioactive and hazardous materials in the waste caused by the infiltration of water or the intrusion of humans, plants, or animals from the surface.

Capable fault — In general, a geologic fault along which it is mechanically feasible for sudden slip (i.e., earth motion) to occur.

Carbonate — A salt or ester of carbonic acid.

Carbon dioxide — A colorless, odorless gas that is a normal component of ambient air and a product of fossil fuel combustion, animal expiration, or the decay or combustion of animal or vegetable matter.

Carbon monoxide — A colorless, odorless, poisonous gas produced by incomplete fossil fuel combustion.

Carcinogen — A substance or agent that produces or incites cancerous growth.

Cask — A heavily shielded container used to store or ship radioactive materials.

Cation — A positively charged ion.

Characteristic waste — Solid waste that is classified as hazardous waste because it exhibits any of the following properties or characteristics: ignitability, corrosivity, reactivity, or toxicity, as described in 40 CFR 261.20 through 261.24.

Chronic exposure	The continuous or intermittent exposure of an organism to a stressor (e.g., a toxic substance or ionizing radiation) over an extended period of time or a significant fraction (often 10% or more) of the life span of the organism. Generally, chronic exposure is considered to produce effects that can be observed only some time after the initial exposure. Examples of these effects include impaired reproduction or growth, genetic effects, cancer, precancerous lesions, benign tumors, cataracts, skin changes, and congenital defects.
Class I area	A specifically designated area where the degradation of air quality is stringently restricted; examples include many national parks and wilderness areas.
Class II area	Areas that are generally cleaner than air quality standards require and in which moderate increases in new pollution are allowed after a regulatory-mandated impacts review. Most of the country that is not designated as Class I is designated as Class II.
Clastic	Rock or sediment made up of primarily broken fragments of preexisting rocks or minerals.
Clay	A family of finely crystalline sheet silicate minerals that commonly form as a product of rock weathering; also, any particle that is about 0.002 millimeter (0.00008 inch) or smaller in diameter.
Clean Air Act	An act that mandates and provides for the enforcement of regulations to control air pollution from various sources.
Clean Water Act of 1972, 1987	An act that regulates the discharge of pollutants from a point source into navigable waters of the United States in compliance with a National Pollutant Discharge Elimination System permit and that regulates discharges to or the dredging of wetlands.

Closure	The deactivation and stabilization of a waste treatment, storage, or disposal unit (such as a waste treatment tank, waste storage building, or landfill) or hazardous materials storage unit (such as an underground storage tank). For storage units, closure typically includes removal of all residues, contaminated system components, and contaminated soil. For disposal units (i.e., where waste is left in place), closure typically includes site stabilization and emplacement of caps or other barriers. Specific requirements for the closure process are found in the regulations applicable to many types of waste management units and hazardous material storage facilities.
***Code of Federal Regulations* (CFR)**	Publication in which all federal regulations that are in effect are published in codified form.
Collective dose	The sum of the individual doses received in a given period of time by a specified population as a result of exposure to a specified source of radiation. It is expressed in units of person-rem.
Committed effective dose equivalent (CEDE)	The dose value obtained by (1) multiplying the committed dose equivalents for the organs or tissues that are irradiated and the weighting factors applicable to those organs or tissues and (2) summing all the resulting products. It is expressed in units of rem.
Community	As used for analyzing environmental justice concerns, a group of people or a site within a spatial scope that is exposed to risks that could threaten health, ecology, or land values or that is exposed to an activity or industry that could stimulate unwanted noise, smell, industrial traffic, particulate matter, or other nonaesthetic impacts.
Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA)	A federal law (also known as Superfund), enacted in 1980 and reauthorized in 1986 that provides the legal authority for emergency response and cleanup of hazardous substances released into the environment and for the cleanup of inactive waste sites.

Conformity	Defined in the Clean Air Act as the action's compliance with an implementation plan's purpose of eliminating or reducing the severity and number of violations of the National Ambient Air Quality Standards and achieving expeditious attainment of such standards. Such activities will not cause or contribute to any new violation of any standard in any area; increase the frequency or severity of any existing violation of any standard in any area; or delay timely attainment of any standard, any required interim emission reduction, or other milestones in any area.
Contact-handled waste	As used in this EIS, contact-handled (CH) waste refers to GTCC LLRW and GTCC-like waste that has a dose rate of less than 200 mrem per hour on the surface of the package.
Container	With regard to radioactive waste, the outside envelope in the waste package that provides the primary containment function of the waste package.
Contamination	Deposition of undesirable material in air, soils, water, or ecological resources or on the surfaces of structures, areas, objects, or personnel.
Cooperating agency	According to 40 CFR 1508.5, "Any federal agency (other than a lead agency) that has jurisdiction by law or special expertise with respect to any environmental impact involved in a proposal (or a reasonable alternative) for legislation or other major federal action significantly affecting the quality of the human environment."
Criteria pollutant	An air pollutant that is regulated by National Ambient Air Quality Standards (NAAQS). The U.S. Environmental Protection Agency must describe the characteristics and potential health and welfare effects that form the basis for setting or revising the standard for each regulated pollutant. Criteria pollutants include sulfur dioxide, nitrogen dioxide, carbon monoxide, ozone, lead, and two size classes of particulate matter: equal to or less than 10 micrometers (0.0004 inch) in diameter, and equal to or less than 2.5 micrometers (0.0001 inch) in diameter. New pollutants may be added to or removed from the list of criteria pollutants as more information becomes available. (See National Ambient Air Quality Standards.) Note: Sometimes pollutants regulated by state laws are also called criteria pollutants.

Critical habitat Habitat essential to the conservation of an endangered or threatened species that has been designated as critical by the U.S. Fish and Wildlife Service or the National Marine Fisheries Service by following the procedures outlined in the Endangered Species Act and its implementing regulations (50 CFR Part 424). (See endangered species and threatened species.) The lists of critical habitats can be found in 50 CFR 17.95 for fish and wildlife, 50 CFR 17.96 for plants, and 50 CFR Part 226 for marine species.

Critical organ The body organ receiving a radionuclide or radiation dose that would result in the greatest overall damage to the body. Specifically, that organ in which the dose equivalent would be most significant due to a combination of the organ's radiological sensitivity and the dose distribution throughout the body.

Criticality The condition in which a system is capable of sustaining a nuclear chain reaction. A chain reaction occurs when a neutron induces a nucleus to fission and the fissioning nucleus releases one or more neutrons that induce other nuclei to fission.

Cultural resources Archaeological sites, historical sites, architectural features, traditional use areas, and American Indian sacred sites. (See archaeological sites and historic resources.)

Cumulative impacts Impacts on the environment that result when the incremental impact of a proposed action is added to the impacts from other past, present, and reasonably foreseeable future actions regardless of what agency (federal or non-federal) or person undertakes the other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time.

Curie (Ci) A unit of radioactivity equal to 37 billion disintegrations per second (i.e., 37 billion becquerels); also, a quantity of any radionuclide or mixture of radionuclides having 1 curie of radioactivity.

Deactivation Placing a facility in a stable and known condition (including removing hazardous and radioactive materials) to ensure adequate protection of workers, public health and safety, and the environment, which thereby limits the long-term cost of surveillance and maintenance. Actions include the removing fuel, draining and/or de-energizing nonessential systems, and removing stored radioactive and hazardous materials. Deactivation does not include all the decontamination necessary for the dismantlement and demolition phase of decommissioning (e.g., removing contamination remaining in fixed structures and equipment after deactivation).

Decay, radioactive The decrease in the amount of any radioactive material with the passage of time due to spontaneous nuclear disintegration at a characteristic rate specified by the radionuclide's half-life.

Decibel A unit for expressing the relative intensity of sounds on a logarithmic scale, from zero for the average least perceptible sound to about 130 for the average level at which sound causes pain to humans. For traffic and industrial noise measurements, the A-weighted decibel (dBA), a frequency-weighted noise unit, is widely used. The A-weighted decibel scale corresponds approximately to the frequency response of the human ear and thus correlates well with loudness.

Decommissioning The process of closing and securing a nuclear facility or nuclear material storage facility to provide adequate protection from radiation exposure and to isolate radioactive contamination from the human environment. It takes place after deactivation and includes surveillance, maintenance, decontamination, and/or dismantlement. These actions are taken at the end of the facility's life to retire it from service with adequate regard for the health and safety of workers and the public and protection of the environment.

Decontamination The removal or reduction of residual chemical, biological, or radiological contaminants and hazardous materials by mechanical, chemical, or other techniques to achieve a stated objective or end condition.

Defense-generated TRU waste Radioactive waste that is generated by atomic energy defense activities. Atomic energy defense activity, as defined by the Nuclear Waste Policy Act of 1982, as amended, means any activity of the Secretary of Energy performed in whole or in part in carrying out any of the following functions: naval reactor development; weapons activities, including defense inertial confinement fusion; verification and control technology; defense nuclear materials production; defense nuclear waste and material by-product management; defense nuclear material security and safeguards and security investigations; and defense research and development.

Deposition In geology, the laying down of potential rock-forming materials; sedimentation. In atmospheric transport, the settling out of atmospheric aerosols and particles on ground and building surfaces (“dry deposition”) or their removal from the air to the ground by precipitation (“wet deposition” or “rainout”).

Derived concentration guide The concentration of a radionuclide in air or water that would, under conditions of continuous exposure for 1 year by one exposure mode (i.e., ingestion of water, submersion in air, or inhalation), result in an effective dose equivalent of 100 millirem.

Dermal Of or pertaining to the skin or other external body covering.

Design basis For nuclear facilities, information that identifies the specific functions to be performed by a structure, system, or component and the specific values (or ranges of values) chosen for controlling parameters for reference bounds for design. These values may be (1) restraints derived from generally accepted state-of-the-art practices for achieving functional goals; (2) requirements derived from analysis (based on calculations and/or experiments) of the effects of a postulated accident for which a structure, system, or component must meet its functional goals; or (3) requirements derived from federal safety objectives, principles, goals, or requirements.

Dip A measure of the angle between the flat horizon and the slope of a sedimentary layer, fault plane, metamorphic foliation, or other geologic structure.

Direct jobs	The number of workers required at a site to implement an alternative.
Discharge	In surface water hydrology, the amount of water issuing from a spring or in a stream that passes a specific point in a given period of time.
Disintegration	Any transformation of a nucleus, whether spontaneous or induced by irradiation, in which the nucleus emits one or more particles or photons.
Disposal	As generally used in this EIS, the emplacement of waste with no intent to retrieve.
DOE Order	Contains requirements internal to the U.S. Department of Energy and its contractors that establish policy and procedures, including those to follow in order to comply with applicable laws.
Dose (radiological)	A generic term meaning absorbed dose, dose equivalent, effective dose equivalent, committed dose equivalent, committed effective dose equivalent, or committed equivalent dose, as defined elsewhere in this glossary.
Dose commitment	The total dose equivalent that a body, organ, or tissue would receive during a specified period of time (e.g., 50 years) as a result of intake (as by ingestion or inhalation) of one or more radionuclides from a defined release.
Dose equivalent	A measure of radiological dose that correlates with biological effect on a common scale for all types of ionizing radiation. Defined as a quantity equal to the absorbed dose in tissue multiplied by a quality factor (the biological effectiveness of a given type of radiation) and all other necessary modifying factors at the location of interest.
Dose rate	The radiation dose delivered per unit of time (e.g., rem per year). (See dose, ionizing radiation, and roentgen equivalent man [rem].)
Drinking water standards	The maximum permissible levels of constituents or characteristics in a drinking water supply as specified by the Safe Drinking Water Act (Title 42 of the *United States Code,* Section 300(f) et seq.).

Ecology A branch of science dealing with the interrelationships of living organisms with one another and with their nonliving environment.

Ecosystem A community of organisms and their physical environment interacting as an ecological unit.

Effective dose equivalent The dose value obtained by multiplying the dose equivalents received by specified tissues or organs of the body by the appropriate weighting factors applicable to the tissues or organs irradiated, and then summing all of the resulting products. It includes the dose from radiation sources internal and external to the body. The effective dose equivalent is expressed in units of rem or mrem.

Effluent A waste stream flowing into the atmosphere, surface water, groundwater, or soil. Most frequently, it applies to wastes discharged to surface waters.

Electron An elementary particle with a mass of 9.107×10^{-28} grams (or 1/1,837 of a proton) and a negative charge. Electrons surround the positively charged nucleus and determine the chemical properties of the atom.

Emission A material discharged into the atmosphere from a source operation or activity.

Emission standard A requirement established by the applicable state or the U.S. Environmental Protection Agency that limits the quantity, rate, or concentration of air pollutant emissions on a continuous basis, including any requirement related to (1) the operation or maintenance of a source to ensure a continuous emission reduction and (2) any design, equipment, work practice, or operational standard.

Endangered species Plant or animal that is in danger of extinction through all or a significant portion of its range and that has been listed as endangered by the U.S. Fish and Wildlife Service or the National Marine Fisheries Service following the procedures outlined in the Endangered Species Act and its implementing regulations (50 CFR Part 424). The lists of endangered species can be found in 50 CFR 17.11 for wildlife, 50 CFR 17.12 for plants, and 50 CFR 222.23(a) for marine organisms. Note: Some states also list species as endangered. Thus, in certain cases, a state definition would also be appropriate.

Enhanced near-surface disposal As used in this environmental impact statement, near-surface disposal methods that include additional measures beyond those typically used to dispose of low-level radioactive waste. A near-surface land disposal facility is where radioactive waste is disposed of in or within the upper 30 meters of the earth's surface.

Environmental impact statement (EIS) The detailed written statement that is required by Section 102(2)(C) of the National Environmental Policy Act (NEPA) for a proposed major federal action significantly affecting the quality of the human environment. A U.S. Department of Energy EIS is prepared in accordance with applicable requirements of the Council on Environmental Quality NEPA regulations in 40 CFR Parts 1500–1508 and the DOE NEPA regulations in 10 CFR Part 1021. The statement includes, among other information, discussions of (1) the environmental impacts of the proposed action and all reasonable alternatives, (2) adverse environmental effects that cannot be avoided should the proposal be implemented, (3) the relationship between short-term uses of the human environment and enhancement of long-term productivity, and (4) any irreversible and irretrievable commitments of resources.

Environmental justice The fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies. Fair treatment means that no group of people, including racial, ethnic, or socioeconomic groups, should bear a disproportionate share of the negative environmental consequences resulting from industrial, municipal, and commercial operations or the execution of federal, state, local, and tribal programs and policies. Executive Order 12898 directs federal agencies to make achieving environmental justice part of their missions by identifying and addressing disproportionately high and adverse effects from agency programs, policies, and activities on minority and low-income populations.

Epicenter The point on the earth's surface directly above the focus of an earthquake.

Ephemeral stream A stream that flows only after a period of heavy precipitation.

Erosion Removal of material by water, wind, or ice.

Exposure The condition of being subject to the effects of or acquiring a dose of a potential stressor such as a hazardous chemical agent or ionizing radiation. Exposure can be quantified as the amount of the agent available at various boundaries of the organism (e.g., skin, lungs, gut) and available for absorption. In the radiological context, exposure refers to the state of being irradiated by ionizing radiation or the incidence of radiation on living or inanimate material. More specifically, radiation exposure is a dosimetric quantity for ionizing radiation that is based on the ability of radiation to produce ionizations in air.

Exposure pathway The course a chemical or physical agent takes from the source to the exposed organism. An exposure pathway describes a mechanism by which chemicals or physical agents at or originating from a release site reach an individual or population. Each exposure pathway includes a source or release from a source, an exposure route, and an exposure point. If the exposure point differs from the source, a transport/exposure medium such as air or water is also included.

External dose or exposure The portion of the dose equivalent received from radiation sources external to the body.

Fault A fracture or a zone of fractures within a rock formation along which vertical, horizontal, or transverse slippage has occurred. A normal fault occurs when the hanging wall has been depressed in relation to the footwall. A reverse fault occurs when the hanging wall has been raised in relation to the footwall.

Fill material Soil, rock, gravel, or other matter that is placed at a specified location to bring the ground surface up to a desired elevation.

Fission A nuclear transformation that is typically characterized by the splitting of a heavy nucleus into at least two other nuclei, the emission of one or more neutrons, and the release of a relatively large amount of energy. Fission of heavy nuclei can occur spontaneously or be induced by neutron bombardment.

Fission products Nuclei (fission fragments) formed by the fission of heavy elements, plus the nuclides formed by the fission fragments' radioactive decay.

Floodplains The lowlands and relatively flat areas adjoining inland and coastal waters and the floodprone areas of offshore islands. Floodplains include, at a minimum, the area that has at least a 1% chance of being inundated by a flood in any given year. The base floodplain is defined as the area that has a 1% or more chance of being flooded in any given year. Such a flood is known as a 100-year flood. The critical action floodplain is defined as the area that has a 0.2% or more chance of being flooded in any given year. Such a flood is known as a 500-year flood. Any activity for which even a slight chance of flooding would be too great (e.g., the storage of highly volatile, toxic, or water-reactive materials) should not occur in the critical action floodplain.

Fluvial Produced by the action of flowing water.

Flux Rate of flow through a unit area; in nuclear reactor operation, the apparent flow of neutrons in a defined energy range. (See nuclear reactor.)

Formation In geology, the primary unit of formal stratigraphic mapping or description. Most formations possess certain distinctive features.

Fugitive emissions Defined as (1) emissions that do not pass through a stack, vent, chimney, or similar opening where they could be captured by a control device and (2) any air pollutant emitted to the atmosphere from something other than a stack. Sources of fugitive emissions include pumps, valves, flanges, seals, area sources (e.g., ponds, lagoons, landfills, piles of stored material such as coal), and road construction areas or other areas where earthwork is occurring.

Gamma radiation High-energy, short-wavelength, electromagnetic radiation emitted from the nucleus of an atom during radioactive decay. Gamma radiation frequently accompanies alpha and beta emissions and always accompanies fission. Gamma rays are very penetrating and are best stopped or shielded by dense materials, such as lead or depleted uranium.

GENII	A computer code used to predict the radiological impacts on individuals and populations associated with the release of radioactive material into the environment during normal operations and postulated accidents.
Geologic repository	As used in this EIS, a system that is intended to be used for or may be used for the disposal of radioactive waste in excavated geologic media.
Geology	The science that studies the materials, processes, environments, and history of the earth, including rocks and their formation and structure.
Glove box	A large enclosure that separates workers from equipment used to process hazardous material while allowing the workers to be in physical contact with the equipment. Glove boxes are normally constructed of stainless steel, with large acrylic/lead glass windows. Workers access equipment by using heavy-duty, lead-impregnated rubber gloves, the cuffs of which are sealed in portholes in the glove box windows.
Greater-than-Class C (GTCC) low-level radioactive waste (LLRW)	Low-level radioactive waste generated by NRC licensees or Agreement State licensees that exceeds the concentration limits of radionuclides established for Class C waste in 10 CFR 61.55.
Groundwater	Water below the ground surface in a zone of saturation. A related definition from 40 CFR 192.01 follows: Subsurface water is all water that exists in the interstices of soil, rocks, and sediment below the land surface, including soil moisture, capillary fringe water, and groundwater. That part of subsurface water in interstices completely saturated with water is called groundwater.
Grout	A fluid mixture of cement-like materials and liquid waste that sets up as a solid mass and is used for waste fixation, immobilization, and stabilization.

GTCC-like waste	As used in this EIS, GTCC-like waste refers to radioactive waste that is owned or generated by the U.S. Department of Energy (DOE) and has characteristics similar to those of GTCC low-level radioactive waste (LLRW) such that a common disposal approach may be appropriate. GTCC-like waste consists of LLRW and non-defense-generated transuranic waste that has no identified path for disposal. The term is not intended to, and does not, create a new DOE classification of radioactive waste.
Habitat	The environment occupied by individuals of a particular species, population, or community.
Half-life (radiological)	The time in which one half of the atoms of a particular radionuclide decay to another radionuclide. Half-lives for specific radionuclides vary from millionths of a second to billions of years.
Hazardous air pollutants (HAPs)	Air pollutants not covered by ambient air quality standards but that may present a threat of adverse human health effects or adverse environmental effects. Those specifically listed in 40 CFR 61.01 are asbestos, benzene, beryllium, coke oven emissions, inorganic arsenic, mercury, radionuclides, and vinyl chloride. More broadly, HAPs are any of the 189 pollutants listed in or pursuant to Section 112(b) of the Clean Air Act. Very generally, HAPs are any air pollutants that may realistically be expected to pose a threat to human health or welfare.
Hazardous waste	A category of waste regulated under the Resource Conservation and Recovery Act (RCRA). To be considered hazardous, a waste must be a solid waste under RCRA and must exhibit at least one of four characteristics described in 40 CFR 261.20 through 261.24 (i.e., ignitability, corrosivity, reactivity, or toxicity) or be specifically listed by the U.S. Environmental Protection Agency in 40 CFR 261.31 through 261.33. Source materials, special nuclear materials, or byproduct materials as defined by the Atomic Energy Act are not hazardous waste because they are not solid waste under RCRA.
HEPA (high-efficiency particulate air) filter	Air filter capable of removing at least 99.97% of particles that are 0.3 micrometer (about 0.00001 inch) in diameter. These filters include a pleated fibrous medium (typically fiberglass) capable of capturing very small particles.

Highest-exposed individual A hypothetical individual whose location and habits result in the highest total radiological or chemical exposure (and thus dose) from a particular source for all exposure routes (e.g., inhalation, ingestion, direct exposure).

High-level waste or high-level radioactive waste (HLW) The highly radioactive material resulting from the reprocessing of spent nuclear fuel, including liquid waste produced directly in reprocessing and any solid material derived from such liquid waste that contains fission products in sufficient concentrations; and other highly radioactive material that the U.S. Nuclear Regulatory Commission, consistent with existing law, determines by rule requires permanent isolation.

Historic resources One definition is archaeological sites, architectural structures, and objects produced after the advent of written history or dating to the time of the first European-American contact in an area. (See archaeological sites.) According to the National Historic Preservation Act of 1966, as amended (Title 16 of the *United States Code,* Part 470 et seq.), they are any prehistoric or historic district, site, building, structure, or object included in, or eligible for inclusion on, the *National Register of Historic Places,* including artifacts, records, and material remains related to such a property or resource.

Hydraulic head A specific measurement of the potential for water to flow, expressed in units of length relative to a vertical datum. For an unconfined aquifer (as modeled in this EIS), the hydraulic head is nearly equivalent to the water table elevation. In this EIS, hydraulic head is expressed in meters relative to the North American Vertical Datum of 1988 (NAVD88).

Hydrology The science dealing with the properties, distribution, and circulation of natural water systems.

Inadvertent intruder As defined in 10 CFR 61.2, a person who might occupy the disposal site after closure and engage in normal activities such as agriculture, the construction of dwellings, or other pursuits in which the person might be unknowingly exposed to radiation from the waste.

Infrastructure The basic facilities, services, and utilities needed for the functioning of an industrial facility. Transportation and electrical systems are part of the infrastructure.

Ingestion	The action of taking solids or liquids into the digestive system.
Inhalation	The action of taking airborne material into the respiratory system.
Institutional control	Measures taken by federal or state organizations to maintain waste management facilities safely for a period of time. The measures, active or passive, may include site access control, site monitoring, facility maintenance, and erosion control.
Intensity (of an earthquake)	Measure of the effects (due to ground shaking) of an earthquake at a particular location that is based on observed damage to structures built by humans, changes in the earth's surface, and reports of how people felt the earthquake. Earthquake intensity is measured in numerical units on the Modified Mercalli scale.
Interbedded (geological)	Occurring between beds (layers) or lying in a bed parallel to other beds of a different material.
Intermediate depth	As used for the disposal of radioactive waste, disposal at depths greater than about 30 meters (98 feet) but less than several hundred meters.
Internal dose	That portion of the dose equivalent received from radioactive material taken into the body.
Invertebrate	Of or pertaining to animals that do not have a backbone.
Involved worker	Worker who would participate in a proposed action. (See noninvolved worker.)
Ion	An atom that is electrically charged due to an imbalance between protons and electrons.
Ion exchange resin	An organic polymer that functions as an acid or base. These resins are used to remove ionic material from a solution. Cation exchange resins are used to remove positively charged particles (cations); anion exchange resins are used to remove negatively charged particles (anions).

Ionizing radiation Alpha particles, beta particles, gamma rays, high-speed electrons, high-speed protons, and other particles or electromagnetic radiation that can displace electrons from atoms or molecules, thereby producing ions. (See alpha radiation, beta particle, electron, gamma radiation, ion, and proton.)

Irradiated Exposed to ionizing radiation. The condition of reactor fuel elements and other materials in which atoms bombarded with nuclear particles have undergone nuclear changes.

Isotope Any of two or more variations of an element in which the nuclei have the same number of protons (i.e., the same atomic number) but different numbers of neutrons so that their atomic masses differ. Isotopes of a single element possess almost identical chemical properties but often have different physical properties (e.g., carbon-12 and -13 are stable, whereas carbon-14 is radioactive).

Latent cancer fatality (LCF) Death from cancer resulting from, and occurring some time after, exposure to ionizing radiation or other carcinogens.

Leachate As applied to mixed low-level radioactive waste trenches, any liquid, including any suspended components in the liquid, that has percolated through, or drained from, hazardous waste.

Lost workdays The total number of workdays (consecutive or not) during which employees were away from work or limited to restricted work activity because of an occupational injury or illness.

Low-income population Defined in terms of U.S. Bureau of the Census annual statistical poverty levels (Current Population Reports, Series P-60 on Income and Poverty), this term may refer to groups or individuals who live in geographic proximity to one another or who are geographically dispersed or transient (such as migrant workers or Native Americans), where either type of group experiences common conditions or effects of environmental exposure.

Low-level radioactive waste (LLRW)	(A) IN GENERAL– The term “low - level radioactive waste” means radioactive material that – (i) is not high-level radioactive waste, spent nuclear fuel, or byproduct material (as defined in section 11e.(2) of the Atomic Energy Act of 1954 (42 USC 2014(e)(2))); and (ii) the Nuclear Regulatory Commission, consistent with existing law and in accordance with paragraph (A), classifies as low-level radioactive waste. (B) EXCLUSION–The term “low-level radioactive waste” does not include byproduct material (as defined in paragraphs (3) and (4) of section 11e. of the Atomic Energy Act of 1954 (42 USC 2014(e)).
Magnitude (of an earthquake)	Characteristic of an earthquake that describes the quantity of total energy it releases (as contrasted to intensity, a characteristic that describes an earthquake’s effects or damage at a particular place). Magnitude is determined by taking the common logarithm (base 10) of the largest ground motion recorded on a seismograph during the arrival of a seismic wave type and applying a standard correction factor for distance to the epicenter. Three common types of magnitude are Richter or local (ML), P body wave (mb), and surface wave (Ms). Additional magnitude scales, notably the moment magnitude (Mw), have been introduced to increase uniformity in representing earthquake size. Moment magnitude is defined as the rigidity of the rock multiplied by the area of faulting multiplied by the amount of slip. A one-unit increase in magnitude (for example, from magnitude 6 to magnitude 7) represents a 30-fold increase in the amount of energy released.
Mammal	Warm-blooded, hairy vertebrates whose offspring are fed by milk secreted by the female.

Maximum contaminant level (MCL)	The designation for U.S. Environmental Protection Agency (EPA) standards for drinking water quality under the Safe Drinking Water Act. The maximum contaminant level for a given substance is the maximum permissible concentration of that substance in water delivered by a public water system. The primary MCLs (40 CFR Part 141) are intended to protect public health and are federally enforceable. They are based on health factors but are also required by law to reflect the technological and economic feasibility of removing the contaminant from the water supply. Secondary MCLs (40 CFR Part 143) are set by the EPA to protect the public welfare. The secondary drinking water regulations control substances in drinking water that primarily affect aesthetic qualities (such as taste, odor, and color) related to the public acceptance of water.
Megawatt	A unit of power equal to 1 million watts. Megawatt-thermal is commonly used to describe heat produced, while megawatt-electric describes electricity produced.
Meteorology	Science dealing with the atmosphere and its phenomena, especially as related to weather.
Migration	Natural movement of a material through the air, soil, or groundwater; also, seasonal movement of animals from one area to another.
Millirem (mrem)	One-thousandth of a rem (0.001 rem).
Minority population	Minority populations exist where either (1) they exceed 50% of the population in the affected area or (2) their percentage in the affected area is meaningfully greater than it is in the general population or other appropriate unit of geographic analysis (such as a governing body's jurisdiction, a neighborhood, census tract, or other similar unit). Minority refers to individuals who are members of the following population groups: American Indian or Alaskan Native; Asian or Pacific Islander; Black, not of Hispanic origin; or Hispanic. Minority populations may include either a single minority group or the total of all minority persons in the affected area. They may consist of groups of individuals living in geographic proximity to one another or a geographically dispersed/transient set of individuals (such as migrant workers or Native Americans), where either type of group experiences common conditions of environmental exposure or effects.

Mitigation
Mitigation includes (1) avoiding an impact altogether by not taking a certain action or parts of an action; (2) minimizing impacts by limiting the degree or magnitude of an action and its implementation; (3) rectifying an impact by repairing, rehabilitating, or restoring the affected environment; (4) reducing or eliminating the impact over time by preservation and maintenance operations during the life of an action; or (5) compensating for an impact by replacing or providing substitute resources or environments.

Mixed waste
Waste that contains both hazardous waste, as defined under the Resource Conservation and Recovery Act, and source, special nuclear, or byproduct material subject to the Atomic Energy Act.

Modified Mercalli Intensity scale
A standard of relative measurement of earthquake intensity, developed to fit construction conditions in most of the United States. It is a 12-step scale, with values from I (not felt except by a very few people) to XII (damage total). A Modified Mercalli Intensity is a numerical value on the Modified Mercalli scale.

National Ambient Air Quality Standards (NAAQS)
Standards that define the highest allowable levels of certain pollutants in the ambient air (i.e., the outdoor air to which the public has access). Because the U.S. Environmental Protection Agency must establish the criteria for setting these standards, the regulated pollutants are called criteria pollutants. Criteria pollutants include sulfur dioxide, nitrogen dioxide, carbon monoxide, ozone, lead, and two size classes of particulate matter: equal to or less than 10 micrometers (0.0004 inch) in diameter and equal to or less than 2.5 micrometers (0.0001 inch) in diameter. Primary standards are established to protect public health; secondary standards are established to protect public welfare (e.g., visibility, crops, animals, buildings).

National Emissions Standards for Hazardous Air Pollutants (NESHAPs)
Emissions standards set by the U.S. Environmental Protection Agency for air pollutants that are not covered by National Ambient Air Quality Standards (NAAQS) and that may, at sufficiently high levels, cause increased fatalities, irreversible health effects, or incapacitating illness. These standards are given in 40 CFR Parts 61 and 63. NESHAPs are given for many specific categories of sources (e.g., equipment leaks, industrial process cooling towers, dry cleaning facilities, petroleum refineries).

National Environmental Policy Act of 1969 (NEPA) The basic national charter for protection of the environment. It establishes policy, sets goals (in Section 101), and provides means (in Section 102) for carrying out the policy. Section 102(2) contains action-forcing provisions to ensure that federal agencies follow the letter and spirit of the Act. For major federal actions significantly affecting the quality of the human environment, Section 102(2)(C) of NEPA requires federal agencies to prepare a detailed statement that includes the environmental impacts of the proposed action and other specified information.

National Pollutant Discharge Elimination System (NPDES) A provision of the Clean Water Act that prohibits discharge of pollutants into waters of the United States unless a special permit is issued by the U.S. Environmental Protection Agency, a state, or, where delegated, a tribal government on an Indian reservation. The NPDES permit lists either the permissible discharges or the level of cleanup technology required for wastewater, or both.

***National Register of Historic Places* (NRHP)** The official list of the nation's cultural resources that are worthy of preservation. The National Park Service maintains the list under direction of the Secretary of the Interior. Buildings, structures, objects, sites, and districts are included in the NRHP because of their importance in American history, architecture, archeology, culture, or engineering. Properties included in the NRHP range from large-scale buildings of monumental proportions to smaller-scale, regionally distinctive buildings. The properties listed are not just those of national importance; in fact, most are significant primarily at the state or local level. Procedures for listing properties on the NRHP are found in 36 CFR Part 60.

Neutron An uncharged elementary particle with a mass slightly greater than that of the proton. Neutrons are found in the nucleus of every atom heavier than hydrogen-1.

Noise Any sound that is undesirable because it interferes with speech and hearing, is intense enough to damage hearing, or is otherwise annoying or undesirable.

Nonattainment area An area that the U.S. Environmental Protection Agency has designated as not meeting (i.e., not being in attainment with) one or more of the National Ambient Air Quality Standards (NAAQS) for sulfur dioxide, nitrogen dioxide, carbon monoxide, ozone, lead, and particulate matter. An area may be in attainment for some pollutants but not for others.

Non-defense-generated TRU	Transuranic waste that is not generated by atomic energy defense activities.
Noninvolved worker	A worker who would be on the site of an action but would not participate in the action.
Notice of Intent	An announcement of the initiation of an environmental impact scoping process. The Notice of Intent is usually published in both the *Federal Register* and a local newspaper. The scoping process includes holding at least one public meeting and requesting written comments on issues and environmental concerns that an environmental impact statement should address.
Nuclear reactor	A device that sustains a controlled nuclear-fission chain reaction that releases energy in the form of heat.
Nucleus	The positively charged central portion of an atom that composes nearly all of the atomic mass. It consists of protons and neutrons, except in hydrogen-1, where it consists of one proton only.
Nuclide	A species of atom characterized by the constitution of its nucleus (the number of protons and neutrons and the energy content).
Other Waste	As used in this environmental impact statement, waste that is not activated metals or sealed sources. It includes contaminated equipment, debris, scrap metals, filters, resins, soil, solidified sludges, and other materials.
Ozone	The triatomic form of oxygen. In the stratosphere, ozone protects the earth from the sun's ultraviolet rays, but in lower levels of the atmosphere, ozone is considered an air pollutant.
Package	For radioactive materials, the packaging and its radioactive contents.
Packaging	With regard to hazardous or radioactive materials, the assembly of components needed to ensure compliance with federal regulations for storage and transport. It may consist of one or more receptacles, absorbent materials, spacing structures, thermal insulation, radiation shielding, and devices for cooling or absorbing mechanical shocks. The vehicle tie-down system and auxiliary equipment may be designated part of the packaging.

Particulate matter (PM), PM_{10}, $PM_{2.5}$ — Any finely divided solid or liquid material, other than uncombined (i.e., pure) water. A subscript denotes the upper limit of the diameter of particles included. Thus, PM_{10} includes only those particles equal to or less than 10 micrometers (0.0004 inch) in diameter, and $PM_{2.5}$ includes only those particles equal to or less than 2.5 micrometers (0.0001 inch) in diameter.

Partitioning or distribution coefficient — A quantity that relates the amount or concentration of a substance in a unit of soil or sediment to the amount or concentration in the overlying or pore water that is in contact with the solid medium.

Pathway (exposure) — The means by which a substance moves from an environmental source to an organism.

Perched (aquifer/groundwater) — A body of groundwater of small lateral dimensions that is separated from an underlying body of groundwater by an unsaturated zone.

Performance assessment — An analysis that predicts the behavior of a system or system component under a given set of conditions. In the context of U.S. Department of Energy waste management activities, it refers to the systematic analysis of the potential risks posed by waste management systems to the public and the environment and to the comparison of those risks to established performance objectives.

Permeability — In geology, the ability of rock or soil to transmit a fluid.

Person-rem — A unit of collective radiation dose applied to populations or groups of individuals (see collective dose); that is, a unit for expressing the dose when summed across all persons in a specified population or group.

pH — Measure of the relative acidity or alkalinity of a solution, expressed on scale of 0 to 14, with the neutral point being 7.0. Acid solutions have pH values lower than 7.0, and basic (i.e., alkaline) solutions have pH values higher than 7.0.

Picocurie — One trillionth (10^{-12}) of a curie.

Pliocene — The latest geologic epoch of the Tertiary period, beginning about 5.3 million years ago and ending 1.6 million years ago.

Plume	The elongated volume of contaminated water or air originating at a pollutant source such as an outlet pipe or a smokestack. A plume eventually diffuses into a larger volume of less contaminated material as it is transported away from the source.
Plutonium	A heavy, radioactive, metallic element with the atomic number 94. It is produced artificially by neutron bombardment of uranium. Plutonium has 15 isotopes with atomic masses ranging from 232 to 246 and half-lives ranging from 20 minutes to 76 million years.
Population dose	See collective dose.
Post-closure	As used in this environmental impact statement, the time period that follows the closure of the waste disposal facility.
Preferred alternative	As used in this environmental impact statement, the alternative preferred by the U.S. Department of Energy.
Prevention of Significant Deterioration (of air quality) (PSD) regulations	Regulations established to prevent significant deterioration of air quality in areas that already meet National Ambient Air Quality Standards (NAAQS). Specific details of PSD are found in 40 CFR 51.166. Among other provisions, cumulative increases in sulfur dioxide, nitrogen dioxide, and particulate matter (specifically PM_{10}) levels after specified baseline dates must not exceed specified maximum allowable amounts. These allowable increases, also known as increments, are especially stringent in areas designated as Class I areas (e.g., national parks, wilderness areas) where the preservation of clean air is particularly important. All areas not designated as Class I are currently designated as Class II. Maximum increments in pollutant levels are also given in 40 CFR 51.166 for Class III areas, if any such areas should be so designated by the EPA. Class III increments are less stringent than those for Class I or Class II areas.

Priority habitat A habitat type with unique or significant value to many species that may be described by (1) a unique type of vegetation or a dominant plant species of primary importance to fish and wildlife (e.g., oak woodlands, eelgrass meadows) or (2) a successional stage (e.g., old growth or mature forest). Alternatively, a priority habitat may consist of a specific habitat element (e.g., consolidated marine/estuarine shorelines, talus slopes, caves, snags) of key value to fish and wildlife.

Proton An elementary nuclear particle with a positive charge equal in magnitude to the negative charge of the electron; it is a constituent of all atomic nuclei. The atomic number of an element indicates the number of protons in the nucleus of each atom of that element.

PWR Acronym for pressurized water reactor, one of two reactor types used in commercial nuclear power plants in the United States. The other reactor type is a boiling water reactor (BWR).

Rad Acronym for radiation absorbed dose, this represents the amount of energy deposited in any material per unit mass of the material. One rad is equal to an absorbed dose of 0.01 joule of energy per kilogram of any material.

Radiation (ionizing) Subatomic particles (alpha, beta, neutrons, and other subatomic particles) or photons (e.g., gamma rays and x-rays) emitted during radioactive decay that are capable of creating ion pairs when they interact with matter.

Radioactive decay The decrease in the amount of any radioactive material with the passage of time due to spontaneous nuclear disintegration at a characteristic rate specified by the radionuclide's half-life.

Radioactive waste In general, as used in this EIS, waste that is managed for its radioactive content.

Radioactivity The spontaneous transformation of unstable atomic nuclei, usually accompanied by the emission of ionizing radiation.

Radioisotope or radionuclide An unstable isotope that undergoes radioactive decay, emitting radiation.

Radiological risk	A measure of potential harm to populations or individuals due to the presence or occurrence of an environmental or human-made radiological hazard.
Radon	A gaseous, radioactive element with the atomic number 86 that is produced from the radioactive decay of radium. Radon occurs naturally in the environment and can collect in unventilated enclosed areas, such as basements. Large concentrations of radon can cause lung cancer in humans.
RADTRAN	Computer code that combines user-determined meteorological, demographic, transportation, packaging, and material factors with health physics data to calculate the expected radiological consequences and accident risk that could result from transporting radioactive material.
Record of Decision (ROD)	A concise public document that records a federal agency's decision(s) concerning a proposed action for which the agency has prepared an environmental impact statement (EIS). The ROD is prepared in accordance with the requirements of Council on Environmental Quality NEPA regulations (40 CFR 1505.2). It identifies the alternatives considered in reaching the decision, the environmentally preferable alternative(s), factors balanced by the agency in making the decision, whether all practicable means to avoid or minimize environmental harm have been adopted, and if not, why they were not.
Reference location	As used in this environmental impact statement, the location at a U.S. Department of Energy site selected for the analysis of environmental impacts. This location is considered to have characteristics representative of the actual location that could be used for waste disposal purposes.
Region of influence	A site-specific geographic area in which the principal direct and indirect effects of actions are likely to occur and are expected to be of consequence.
Release	Any spilling, leaking, pumping, pouring, emitting, emptying, discharging, injecting, escaping, leaching, dumping, or disposing of a material into the environment. Statutory or regulatory definitions of release may differ.

Rem	Acronym for Roentgen equivalent man, a unit of dose equivalent. The dose equivalent in rem equals the absorbed dose in rad in tissue multiplied by the appropriate quality factor and possibly other modifying factors.
Remote-handled waste	As used in this EIS, remote-handled (RH) waste refers to GTCC LLRW and GTCC-like waste that has a surface dose rate of 200 mrem/h or more.
Resource Conservation and Recovery Act (RCRA)	A law that gives the U.S. Environmental Protection Agency the authority to control hazardous waste from cradle to grave (i.e., from the point of generation to the point of ultimate disposal), including its minimization, generation, transportation, treatment, storage, and disposal. RCRA also sets forth a framework for the management of nonhazardous solid wastes.
RESRAD-OFFSITE	RESRAD-OFFSITE is an extension of the RESRAD (on-site) computer code that was developed to estimate the radiological consequences to a human receptor located on-site or outside (off-site) the area of primary contamination. It calculates radiological dose and excess lifetime cancer risk with the predicted radionuclide concentrations in the environment. This computer code was used to generate estimates for human health impacts for the post-closure phase of the land disposal methods (borehole, trench, and vault) in the Final GTCC EIS.
Riparian	Of or pertaining to the banks of a river or stream.
Risk	The probability of a detrimental effect from exposure to a hazard.
Roentgen	Unit of exposure to x-rays or gamma rays that is equal to or produces one electrostatic unit of charge per cubic centimeter of air.
Roentgen equivalent man (rem)	Unit of dose equivalent. The dose equivalent in rem equals the absorbed dose in rad in tissue multiplied by the appropriate quality factor and possibly other modifying factors.
Runoff	Portion of rainfall, melted snow, or irrigation water that flows across the ground surface and eventually enters streams.
Safe Drinking Water Act	Act that protects the quality of public water supplies, water supply and distribution systems, and all sources of drinking water.

Sanitary waste	Liquid or solid waste generated by normal housekeeping activities (including sludge) that is not hazardous or radioactive.
Scope	Range of actions, alternatives, and impacts to be considered in a document prepared pursuant to the National Environmental Policy Act of 1969.
Scoping	An early and open process used to determine the scope of issues to be addressed in an environmental impact statement (EIS) and identify the significant issues related to a proposed action.
Sealed source	A source manufactured, obtained, or retained for the purpose of utilizing the emitted radiation from the contained radionuclide(s). It consists of a known or estimated quantity of radioactive material that is either contained within a sealed capsule, sealed between layers of nonradioactive material, or firmly fixed to a nonradioactive surface by electroplating or some other means intended to prevent the radioactive material from leaking or escaping.
Sediment	Soil, sand, and minerals washed from land into water and deposited on the bottom of a water body.
Seismic	Pertaining to any earth vibration, especially an earthquake.
Seismicity	The frequency and distribution of earthquakes.
Shielding	With regard to radiation, any material that obstructs (bulkheads, walls, or other construction) and absorbs radiation to protect personnel or equipment.
Shrub steppe	Plant community consisting of short-statured, widely spaced, small-leaved shrubs, sometimes aromatic, with brittle stems and an understory dominated by perennial bunch grasses.
Shutdown	Facility condition during which operations and/or construction activities have ceased.
Silt	Loose particles of rock or mineral sediment ranging in size from about 0.002 to 0.0625 millimeter (0.00008 to 0.0025 inch) in diameter. Silt is finer than sand but coarser than clay.

Site	A geographic entity that comprises leased or owned land, buildings, and other structures that are needed in order to perform program activities.
Soils	All unconsolidated materials above bedrock; natural earthy materials on Earth's surface, in places modified or even made by human activity, that contain living matter and either support or are capable of supporting plants outdoors.
Solid waste	In general, nonliquid, nonsoluble, discarded materials ranging from municipal garbage to industrial wastes that contain complex and sometimes hazardous substances. They include sewage sludge, agricultural refuse, demolition wastes, and mining residues.
Source material	(1) Uranium, thorium, or any other material which is determined by the Commission, pursuant to the provisions of Section 61 of the Atomic Energy Act of 1954, as amended, to be source material; or (2) ores containing one or more of the foregoing materials, in such concentration as the Commission may by regulation determine from time to time.
Source term	The amount of a specific pollutant (e.g., chemical, radionuclide) emitted or discharged to a particular environmental medium (e.g., air, water) from a source or group of sources. It is usually expressed as a rate (i.e., amount per unit of time).
Species of concern (federal)	Species whose conservation standing is of concern to the U.S. Fish and Wildlife Service but for which status information is still needed.
Spent nuclear fuel	Fuel that has been withdrawn from a nuclear reactor following irradiation, the constituent elements of which have not been separated by reprocessing.
Storage	The holding of waste for a temporary period, at the end of which the waste is treated, disposed of, or stored elsewhere.
Stratigraphy	Science of the description, correlation, and classification of strata in sedimentary rocks, including the interpretation of the depositional environments of those strata.
Surface water	All bodies of water on the surface of the Earth and open to the atmosphere, such as rivers, lakes, reservoirs, ponds, seas, and estuaries.

Surficial material (deposit)	Any loose, unconsolidated sedimentary deposit lying on or above bedrock.
Tectonic	Of or relating to motion in the Earth's crust and occurring along geologic faults.
Terrestrial	Of or pertaining to life on land.
Threatened species	Any plants or animals that are likely to become endangered species within the foreseeable future throughout all or a significant portion of their ranges and that have been listed as threatened by the U.S. Fish and Wildlife Service or the National Marine Fisheries Service by following the procedures set out in the Endangered Species Act and its implementing regulations (50 CFR Part 424). (See endangered species.) The lists of threatened species can be found at 50 CFR 17.11 for wildlife, 17.12 for plants, and 227.4 for marine organisms.
Total effective dose equivalent (TEDE)	Sum of the effective dose equivalent (for external exposures) and the committed effective dose equivalent (for internal exposures).
Total recordable cases	Total number of cases recorded of work-related (1) deaths or (2) illnesses or injuries that resulted in loss of consciousness, restriction of work or motion, transfer to another job, or required medical treatment beyond first aid.
Toxic Substances Control Act (TSCA) of 1976	Law requiring that the health and environmental effects of all new chemicals be reviewed by the U.S. Environmental Protection Agency before they are manufactured for commercial purposes. It also imposes strict limitations on the use and disposal of polychlorinated biphenyls, chlorofluorocarbons, asbestos, dioxins, certain metal-working fluids, and hexavalent chromium.
Traditional cultural property	A property or place that is eligible for inclusion in the *National Register of Historic Places* because of its association with cultural practices and beliefs that are (1) rooted in the history of a community and (2) important to maintaining the continuity of that community's traditional beliefs and practices.
Transuranic	Any element whose atomic number is higher than that of uranium (atomic number 92), including neptunium, plutonium, americium, and curium.

Transuranic (TRU) waste Waste containing more than 100 nanocuries of alpha-emitting transuranic isotopes per gram of waste, with half-lives greater than 20 years, except for (1) high-level radioactive waste; (2) waste that the Secretary of DOE has determined, with the concurrence of the Administrator of the EPA, does not need the degree of isolation required by the disposal regulations; or (3) waste that the NRC has approved for disposal on a case-by-case basis in accordance with 10 CFR Part 61.

Trench As used in this EIS, near-surface excavation used for the disposal of radioactive waste. A trench has a dominant direction (it is much longer than it is wide) and is capped by an engineered cover after it is filled with waste.

Tritium A radioactive isotope of hydrogen whose nucleus contains one proton and two neutrons.

Type A packaging A regulatory category of packaging used to transport radioactive materials. It must be designed and demonstrate its ability to retain its containment and shielding integrity under normal conditions of transport. Examples of Type A packaging include 55-gallon drums and standard waste boxes. Type A packaging is used to transport materials with low radioactivity levels and usually does not require special handling, packaging, or transportation equipment.

Type B packaging A regulatory category of packaging used to transport radioactive materials. The U.S. Department of Transportation and U.S. Nuclear Regulatory Commission (NRC) require Type B packaging for shipping highly radioactive material. Type B packages must be designed and demonstrate their ability to retain their containment and shielding integrity under severe accident conditions as well as under normal conditions of transport. The current NRC testing criteria for Type B package designs (10 CFR Part 71) are intended to simulate severe accident conditions, including those involving impact, puncture, fire, and immersion in water. The most widely recognized Type B packages are the massive casks used for transporting spent nuclear fuel. Large-capacity cranes and mechanical lifting equipment are usually needed to handle Type B packages.

Uranium A radioactive, metallic element with atomic number 92; the heaviest naturally occurring element. Uranium has 14 known isotopes, of which uranium-238 is the most abundant in nature. Uranium-235 is commonly used as a fuel for nuclear fission.

Vadose zone The region of soil and rock between the ground surface and the top of the water table in which pore spaces are only partially filled with water. Over time, contaminants in the vadose zone often migrate downward to the underlying aquifer.

Vault As used in this environmental impact statement, an above-grade, engineered structure constructed of concrete or a similar material that is used for the disposal of radioactive waste. An engineered cap is expected to be placed over and around vaults after they are filled with radioactive waste.

Volatile organic compound Any of a broad range of organic compounds, often halogenated, that vaporize at ambient or relatively low temperatures; examples are benzene, chloroform, and methyl alcohol. With regard to air pollution, any organic compound that participates in an atmospheric photochemical reaction, except those determined by the U.S. Environmental Protection Agency Administrator to have negligible photochemical reactivity.

Waste acceptance criteria Technical and administrative requirements that a waste must meet in order for it to be accepted at a treatment, storage, or disposal facility.

Waste characterization The identification of a waste's composition and properties by reviewing process knowledge, nondestructive examination, nondestructive assay, or sampling and analysis. Characterization provides the basis for determining appropriate storage, treatment, handling, transportation, and disposal requirements.

Waste Isolation Pilot Plant (WIPP) A U.S. Department of Energy facility designed and authorized to permanently dispose of defense-generated transuranic radioactive waste in a mined underground facility in deep geologic salt beds. It is located in southeastern New Mexico, 26 miles (42 kilometers) east of the city of Carlsbad.

Waste management The planning, coordination, and direction of those functions related to the generation, handling, treatment, storage, transportation, and disposal of waste, as well as associated surveillance and maintenance activities.

Water table The boundary between the unsaturated zone and the deeper, saturated zone. The upper surface of an unconfined aquifer.

Wetlands Areas that are inundated by surface water or groundwater often enough that, under normal circumstances, they do or could 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 (e.g., sloughs, potholes, wet meadows, river overflow areas, mudflats, natural ponds). Jurisdictional wetlands are wetlands protected by the Clean Water Act. They must have a minimum of one positive wetland indicator from each parameter (i.e., vegetation, soil, and hydrology). The U.S. Army Corps of Engineers requires a permit to fill or dredge jurisdictional wetlands.

Wind rose Circular diagram showing, for a specific location, the percentage of the time the wind is from each compass direction. Wind roses that are used to assess the consequences of airborne releases also show the frequency of different wind speeds for each compass direction.

X-rays Penetrating electromagnetic radiation having a wavelength much shorter than that of visible light. X-rays are identical to gamma rays but originate outside the nucleus.

1 INTRODUCTION

Greater-than-Class C (GTCC) low-level radioactive waste (LLRW) is defined by the U.S. Nuclear Regulatory Commission (NRC) as LLRW that has radionuclide concentrations exceeding the limits for Class C LLRW established in Title 10, Part 61, of the *Code of Federal Regulations* (10 CFR Part 61), "Licensing Requirements for Land Disposal of Radioactive Waste." In 10 CFR 61.55, the NRC classifies LLRW as A, B, and C according to the concentration of specific short- and long-lived radionuclides, with Class C having the highest radionuclide concentration limits. GTCC LLRW is generated by activities licensed by the NRC or Agreement States and cannot be disposed of in currently licensed commercial LLRW disposal facilities.

Section 3(b)(1)(D) of the Low-Level Radioactive Waste Policy Amendments Act of 1985 (Public Law [P.L.] 99-240) (LLRWPAA) assigned the responsibility for the disposal of GTCC LLRW to the federal government. The LLRWPAA specifies that GTCC LLRW covered under Section 3(b)(1)(D) is to be disposed of in a facility that is licensed by the NRC and that the NRC has determined is adequate for protecting public health and safety. The U.S. Department of Energy (DOE) is the federal agency responsible for disposing of GTCC LLRW.

Section 631 of the Energy Policy Act of 2005 (P.L. 109-58) requires the Secretary of Energy to (1) notify Congress of the DOE office responsible for completing the activities needed to provide for safe disposal of GTCC LLRW; (2) submit to Congress a report containing an estimate of the cost and schedule to complete an environmental impact statement (EIS) and Record of Decision (ROD) for a permanent disposal facility for GTCC LLRW; (3) submit to Congress a plan that ensures the continued recovery and storage of GTCC LLRW sealed sources that pose a security threat until a permanent disposal facility is available; and (4) prior to issuing a ROD, submit to Congress a report that includes a description of the alternatives considered in the EIS and await action by Congress. In response to these requirements, DOE designated its Office of Environmental Management (EM) as the lead organization responsible for developing GTCC LLRW disposal capability. In February and July 2006, DOE submitted the report and plan described in items 2 and 3, respectively, to Congress. Copies of these documents are available on the GTCC EIS website (http://www.gtcceis.anl.gov/).

Consistent with NRC's and DOE's authorities under the Atomic Energy Act of 1954, amended (P.L. 83-703), the NRC LLRW classification system does not apply to radioactive wastes generated or owned by DOE and disposed of in DOE facilities. However, DOE owns or generates both LLRW and

GTCC LLRW and GTCC-Like Waste

GTCC LLRW refers to LLRW that has radionuclide concentrations that exceed the limits for Class C LLRW given in 10 CFR 61.55. This waste is generated by activities of NRC and Agreement State licensees, and it cannot be disposed of in currently licensed commercial LLRW disposal facilities. The federal government is responsible for the disposal of GTCC LLRW.

GTCC-like waste refers to radioactive waste that is owned or generated by DOE and has characteristics sufficiently similar to those of GTCC LLRW such that a common disposal approach may be appropriate. GTCC-like waste consists of LLRW and non-defense-generated TRU waste that has no identified path for disposal. The use of the term "GTCC-like" is not intended to and does not create a new DOE classification of radioactive waste.

non-defense-generated transuranic (TRU) radioactive waste,[1] which have characteristics similar to those of GTCC LLRW and for which there may be no path for disposal at the present time. DOE has included these wastes, otherwise known as “GTCC-like waste,” for evaluation in this EIS because their disposal requirements may be similar to those for GTCC LLRW, such that a common approach and/or facility could be used for these wastes. The use of the term “GTCC-like” is not intended to and does not create a new DOE classification of radioactive waste.

DOE has considered all public scoping comments received in response to the Notice of Intent (NOI) to prepare the GTCC EIS (Volume 72, page 40135, of the *Federal Register* [72 FR 40135]) and all public comments received on the Draft GTCC EIS. Summaries of the comments received during the public scoping and public comment period are presented in Appendix J of this EIS. Detailed responses to the comments are provided in Appendix J, Section J.3.

1.1 PURPOSE AND NEED FOR AGENCY ACTION

At this time, there is no disposal capability for GTCC LLRW. The LLRWPAA (P.L. 99-240) specifies that the GTCC LLRW that is designated a federal responsibility under Section 3(b)(1)(D) is to be disposed of in a facility that is adequate to protect public health and safety and is licensed by the NRC. Although GTCC-like waste is not subject to the requirements in the LLRWPAA, DOE also intends to determine a path to disposal that is similarly protective of public health and safety for the GTCC-like waste that it owns or generates.

Sealed Sources

Disused radioactive sealed sources used in medical treatments and other applications are one of the GTCC LLRW waste types for which a disposal capability is needed. Every year, thousands of sealed sources become disused and unwanted in the United States. While secure storage is a temporary measure, unlike permanent disposal, the longer sources remain disused or unwanted, the greater is the chance that they will become unsecured or abandoned. Due to their concentrated activity and portability, radioactive sealed sources could be used in radiological dispersal devices (RDDs), commonly referred to as “dirty bombs.” An attack using an RDD could result in extensive economic loss, significant social disruption and potentially serious public health problems. (Source: NNSA News 2010)

The September 11, 2001, terrorist attacks and subsequent threats have heightened concerns that terrorists could gain possession of radioactive sealed sources, including sealed sources requiring management as GTCC LLRW, and use them for malevolent purposes. Such an attack has been of particular concern because of the widespread use of sealed sources and other radioactive materials in the United States for

[1] Defense-generated TRU waste is radioactive waste generated by atomic energy defense activities. “Atomic energy defense activity,” as defined by the Nuclear Waste Policy Act of 1982, as amended, means “any activity of the Secretary of Energy performed in whole or in part in carrying out any of the following functions: naval reactors development; weapons activities including defense inertial confinement fusion; verification and control technology; defense nuclear materials production; defense nuclear waste and materials byproducts management; defense nuclear materials security and safeguards and security investigations; and defense research and development.” TRU waste that is not generated by atomic energy defense activities is considered non-defense-generated TRU.

beneficial uses by hospitals and other medical establishments, industries, and academic institutions. While secure storage of disused sealed sources is a temporary measure, a disposal capability is needed. The Radiation Source Protection and Security Task Force, established under Section 651(d) of the Energy Policy Act of 2005 (P.L. 109-58), is charged with evaluating and providing recommendations related to securing radiation sources in the United States from potential terrorists threats, including their use in a radiological dispersal device (RDD, such as a dirty bomb). In August 2006, August 2010, and August 2014, the Task Force submitted reports to the President and U.S. Congress. The 2006 report (NRC 2006) stated that "providing disposal methods for GTCC waste will have the greatest effect on reducing the total risk of long-term storage for risk-significant sources." The 2010 report (NRC 2010) further stated that "by far the most significant challenge identified is access to disposal for disused radioactive sources." The 2014 report (NRC 2014) recommended that "DOE should continue its ongoing efforts to develop GTCC [LLRW] disposal capability." Since 2003, the U.S. Government Accountability Office (GAO) has issued several reports on matters related to the security of uncontrolled sealed sources. In particular, the 2003 report (GAO 2003, Executive Summary page) stated a concern with DOE's progress in developing a GTCC LLRW disposal facility. In addition, the Energy Policy Act of 2005 (P.L. 109-58) contains several provisions directed at improving the control of sealed sources, including disposal availability.

Accordingly, DOE has prepared this EIS to evaluate the range of reasonable alternatives for the safe and secure disposal of GTCC LLRW and GTCC-like waste. The range of reasonable alternatives addresses approximately 12,000 m^3 (420,000 ft^3) of in-storage (as of 2008) and projected (anticipated through 2083) GTCC LLRW and GTCC-like waste. Waste quantity data obtained in 2008 had verification updates made in 2010 as needed, see Argonne (2010). In performing its due diligence in the preparation of this final EIS, DOE reviewed the waste quantity data and has determined that the expected waste quantity estimates remain valid and are conservative and bounding.

1.2 PROPOSED ACTION

DOE proposes to construct and operate a new facility or facilities or to use an existing facility or facilities for the disposal of GTCC LLRW and GTCC-like waste. DOE would then close the facility or facilities at the end of each facility's operational life. Institutional controls, including monitoring, would be employed for a period of time determined during the implementation phase. A combination of disposal methods and locations may be appropriate, depending on the characteristics of the waste among other factors.

1.3 DECISIONS TO BE SUPPORTED BY THIS ENVIRONMENTAL IMPACT STATEMENT

DOE intends for this EIS to provide the information that will support the selection of disposal method(s) and site(s) for the GTCC LLRW and GTCC-like waste inventory included in Groups 1 and 2, as described in Section 1.4.1. The specific design for such a facility would be developed once a decision was made on the most appropriate approach for disposing of this waste. The conceptual designs described in Section 1.4.2 of this EIS incorporate a number of engineering enhancements beyond those typically used in designs of LLRW disposal facilities (see also Section 5.1.4 and Appendix D), and the post-closure performance calculations were performed for long time frames (10,000 years or longer to determine peak annual doses) commensurate with the need to protect the general public. DOE would conduct appropriate National Environmental Policy Act (NEPA) reviews to address the impacts from constructing and operating the selected disposal method(s) at alternative locations at the selected site(s).

Before issuing a ROD on the selection of disposal method(s) and site(s), DOE will submit a report to Congress to fulfill the requirement of Section 631(b)(1)(B)(i) of the Energy Policy Act of 2005 (P.L. 109-58). Section 631(b)(1)(B)(i) requires that the report include a description of all alternatives under consideration, and all the information required for the comprehensive report on ensuring the safe disposal of GTCC LLRW that was submitted by the Secretary to Congress in February 1987. Section 631(b)(1)(B)(ii) also requires DOE to await Congressional action. DOE will not issue a ROD until its required Report to Congress has been provided and appropriate actions have been taken by Congress in accordance with the Energy Policy Act of 2005.

1.4 SCOPE OF THIS ENVIRONMENTAL IMPACT STATEMENT

In addition to evaluating the impacts from the No Action Alternative, as required by NEPA implementing regulations (40 CFR Parts 1500–1508), this EIS evaluates the impacts on human health and the environment that could result from the range of reasonable alternatives for the disposal of GTCC LLRW and GTCC-like waste. DOE's evaluation of the range of action alternatives addresses various methods and sites. The methods include (1) deep geologic disposal, (2) intermediate-depth borehole disposal, (3) enhanced near-surface trench disposal, and (4) above-grade vault disposal. The latter three methods are hereinafter referred to as the borehole, trench, and vault disposal methods, as appropriate. The effectiveness of these disposal methods is evaluated at an existing repository and at various GTCC land disposal locations.

The Waste Isolation Pilot Plant (WIPP) is evaluated for deep geologic disposal. Land disposal methods (i.e., borehole, trench, and vault methods) are evaluated at six federally owned sites: (1) Hanford Site; (2) Idaho National Laboratory (INL) Site; (3) Los Alamos National Laboratory (LANL); (4) Nevada National Security Site (NNSS), which was formerly known as the Nevada Test Site or NTS; (5) Savannah River Site (SRS); and (6) WIPP Vicinity. Two WIPP Vicinity locations are evaluated in this EIS as follows: (1) Section 27, which is located inside the WIPP Land Withdrawal Boundary (LWB) managed by DOE, and (2) Section 35, which is located just outside the WIPP LWB to the southeast and is managed by the Bureau of Land Management (BLM) of the U.S. Department of the Interior (DOI). A map of the United States showing these sites that are being considered for waste disposal is provided in Figure 1.4-1. In addition to these federally owned sites, generic commercial disposal sites for the four regions that make up the United States (coinciding with the NRC's designated regions, as shown in Figure 1.4-2) are also being evaluated for the land disposal methods. DOE is also evaluating each alternative with regard to the transportation and disposal of the entire inventory. The human health and transportation impacts are evaluated on a waste-type basis, so decisions can be made on a waste-type basis in the future, as appropriate.

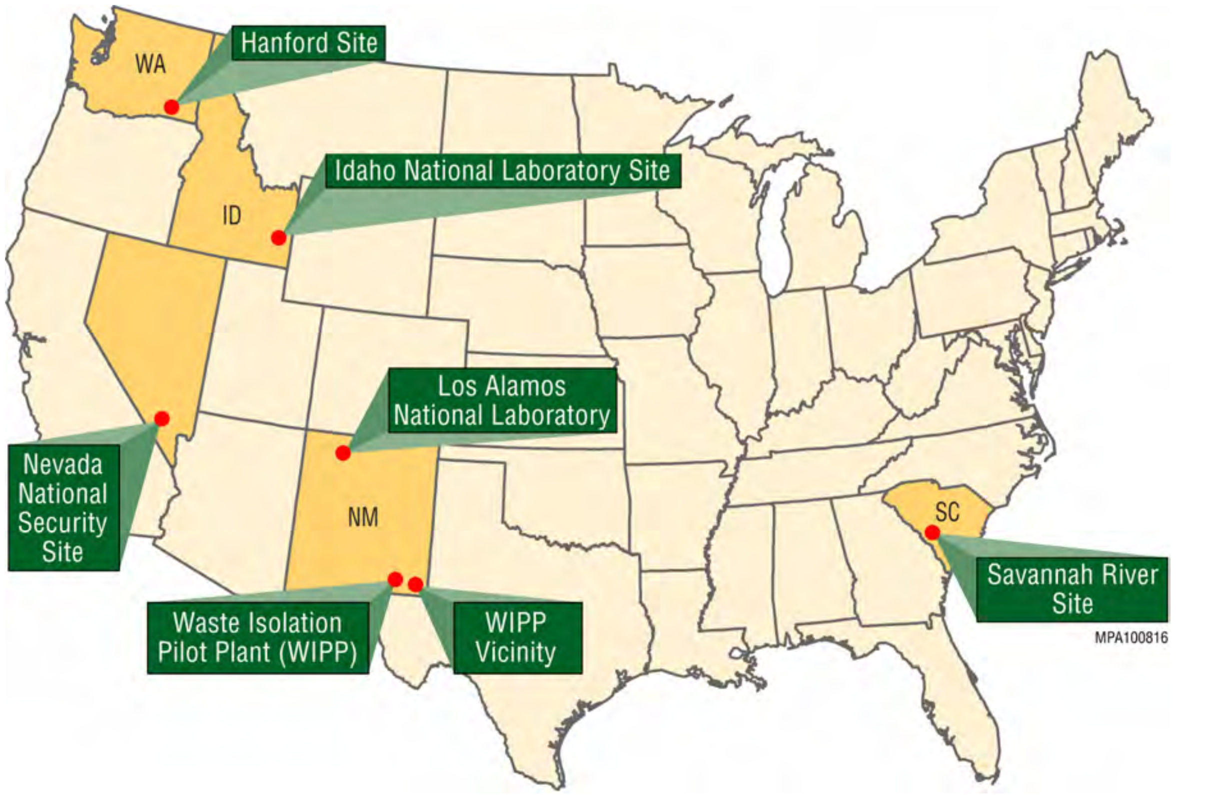

FIGURE 1.4-1 Map of DOE Sites Being Considered for Disposal of GTCC LLRW and GTCC-Like Waste

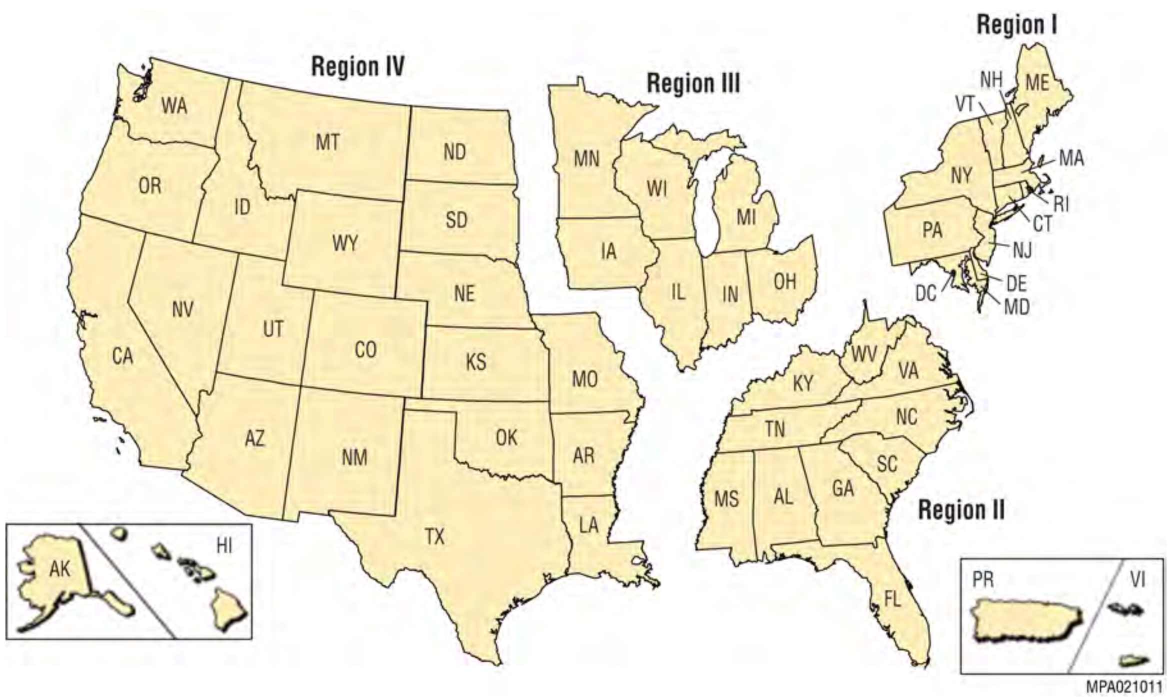

FIGURE 1.4-2 Map Showing the Four NRC Regions

The combined GTCC LLRW and GTCC-like waste inventory addressed in this EIS has a packaged volume of approximately 12,000 m^3 (420,000 ft^3) and contains a total activity of about 160 million curies (MCi). Section 1.4.1 summarizes the types and estimated quantities of waste, Section 1.4.2 discusses the types of disposal methods evaluated, and Section 1.4.3 describes the sites evaluated as potential disposal locations.

1.4.1 Types and Estimated Quantities of GTCC LLRW and GTCC-Like Waste

GTCC LLRW is radioactive waste that is generated by NRC or Agreement State (i.e., a state that has signed an agreement with NRC to regulate certain uses of radioactive materials within the state) licensees and contains radionuclide concentrations in excess of the limits for Class C LLRW given in two tables in 10 CFR 61.55. These two tables are shown in Table 1.4.1-1. 10 CFR 61.55 identifies four classes of LLRW for disposal purposes: Classes A, B, C, and GTCC. Classes A, B, and C LLRW can be disposed of in near-surface disposal facilities licensed by the NRC or an Agreement State. Examples of Class A, B, and C LLRW include radioactively contaminated protective clothing, resins, and filters from nuclear power plants; radiopharmaceutical wastes; and debris and soil from decommissioning of nuclear facilities. Class A LLRW has the lowest radionuclide concentration limits of the four types of waste and is usually segregated from other LLRW at the disposal site. Class B LLRW has higher radionuclide concentration limits than Class A and must meet more rigorous requirements with regard to waste form to ensure its stability after disposal. Class C LLRW is waste that represents a higher long-term risk than does Class A or Class B LLRW. Like Class B waste, Class C waste must meet the more rigorous requirements with regard to waste form to ensure its stability, and it also requires additional measures to be taken at the disposal facility to protect against inadvertent intrusion. GTCC LLRW is waste that is not generally acceptable for near-surface disposal and for which the waste form and disposal methods must be different and, in general, more stringent than those specified for Class C LLRW. In addition to the radionuclides listed in Table 1.4.1-1, other potential radionuclides of concern that are contained in the GTCC LLRW are included in the evaluations in this EIS for completeness (see Appendix B). NRC regulations in 10 CFR 61.55 specify that in the absence

NRC Classification System for LLRW

The NRC classification system for the four classes of LLRW (A, B, C, and GTCC) is established in 10 CFR 61.55 and is based on the concentrations of specific short- and long-lived radionuclides given in two tables. Classes A, B, and C LLRW are generally acceptable for disposal in near-surface land disposal facilities. GTCC LLRW is LLRW "that is not generally acceptable for near-surface disposal" as specified in 10 CFR 61.55(a)(2)(iv). As stated in 10 CFR 61.7(b)(5), there may be some instances where waste with radionuclide concentrations greater than permitted for Class C would be acceptable for near-surface disposal with special processing or design.

Transuranic Waste

Transuranic or TRU waste is radioactive waste containing more than 100 nanocuries (nCi) of alpha-emitting transuranic isotopes per gram of waste with half-lives greater than 20 years, except for (1) high-level radioactive waste; (2) waste that the Secretary 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 the 40 CFR Part 191 disposal regulations; or (3) waste that the NRC has approved for disposal on a case-by-case basis in accordance with 10 CFR Part 61. Examples of TRU radionuclides include plutonium-238 (Pu-238), Pu-239, Pu-240, americium-241 (Am-241), and Am-243.

TABLE 1.4.1-1 Tables in 10 CFR 61.55 Used to Determine LLRW Classes[a]

Table 1

Radionuclide	Concentration, curies per cubic meter
C-14	8
C-14 in activated metal	80
Ni-59 in activated metal	220
Nb-94 in activated metal	0.2
Tc-99	3
I-129	0.08
Alpha emitting transuranic nuclides with half-life greater than 5 years	[1] 100
Pu-241	[1] 3,500
Cm-242	[1] 20,000

[1] Units are nanocuries per gram.

Table 2

Radionuclide	Concentration, curies per cubic meter Col. 1	Col. 2	Col. 3
Total of all nuclides with less than 5-year half-life	700	([1])	([1])
H-3	40	([1])	([1])
Co-60	700	([1])	([1])
Ni-63	3.5	70	700
Ni-63 in activated metal	35	700	7000
Sr-90	0.04	150	7000
Cs-137	1	44	4600

[1] There are no limits established for these radionuclides in Class B or C wastes. Practical considerations such as the effects of external radiation and internal heat generation on transportation, handling, and disposal will limit the concentrations for these wastes. These wastes shall be Class B unless the concentrations of other nuclides in Table 2 determine the waste to be Class C independent of these nuclides.

[a] Table 1 is long-lived radionuclides; Table 2 is short-lived radionuclides. The procedures for how these values are to be used to determine LLRW classes are provided in 10 CFR 61.55. See text for explanation of how columns are applied in Table 2. C-14 = carbon-14, Ni-59 = nickel-59, Nb-94 = niobium-94, Tc-99 = technetium-99, I-129 = iodine-129, Pu-241 = plutonium-241, Cm-242 = curium-242, H-3 = hydrogen-3, Co-60 = cobalt-60, Ni-63 = nickel-63, Sr-90 = strontium-90, Cs-137 = cesium-137.

of specific requirements, such waste must be disposed of in a geologic repository unless alternative methods for disposal of such waste are proposed to and approved by the NRC.[2]

10 CFR 61.55 provides explicit procedures on how the values in these two tables are to be used to determine waste class. A brief summary of these procedures is as follows. If the LLRW contains only the long-lived radionuclides listed in Table 1, it is Class A if the concentration is less than 10% of the value and Class C if the concentration is between 10% and 100% of the value. The LLRW cannot be Class B based solely on the concentration of long-lived radionuclides. If the radionuclide concentration exceeds 100% of the value in Table 1, it is GTCC. A “sum of fractions” approach is used if more than one of these radionuclides is present in the LLRW.

The approach used for the short-lived radionuclides in Table 2 is as follows. The LLRW is Class A if the concentration does not exceed the value in Column 1, Class B if the concentration is between the values in Columns 1 and 2, Class C if the concentration is between the values in Columns 2 and 3, and GTCC if the concentration exceeds Column 3. As done above in the approach used for long-lived radionuclides, a sum of fractions approach is used when multiple radionuclides are present.

If both long-lived and short-lived radionuclides are present, the waste classification is based on the short-lived radionuclides according to the values in Table 2, provided that the concentrations of the long-lived radionuclides do not exceed 10% of their values in Table 1. If the concentrations exceed 10% of the value in Table 1, the LLRW is Class C, provided the concentrations of the radionuclides in Table 2 do not exceed the values given in Column 3. The waste is GTCC if the concentrations exceed the limits for Class C, and a sum of fractions approach is used for multiple long- and short-lived radionuclides. The waste is Class A if the LLRW does not contain any of the radionuclides listed in these two tables.

Currently there is a limited number of commercial facilities available to receive and dispose of Class A, B, and C LLRW; no facilities are currently available to dispose of GTCC LLRW.[3] These wastes are currently being stored and will continue to be generated and stored at a number of sites in the country pending the availability of a suitable disposal facility, which is the purpose of and need for agency action. Most of the GTCC-like waste consists of TRU waste that may not meet the waste acceptance criteria for disposal at WIPP as defense-generated TRU waste and has no other currently identified path to disposal.

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[2] The GTCC LLRW inventory in the EIS includes GTCC LLRW from the decommissioning of commercial nuclear reactors that are covered by a Standard Contract for Disposal of Spent Nuclear Fuel and/or High-Level Radioactive Waste. A Federal Circuit Court panel ruled that for purposes of determining damages in the spent nuclear fuel litigation, GTCC LLRW waste is considered high-level radioactive waste under the terms of DOE’s Standard Contract (Yankee Atomic Electric Co. v. U.S., 536 F. 3d 1268 (Fed. Cir. 2008) and Pacific Gas & Electric Co. v. U.S., 536 F. 3d 1282 (Fed. Cir. 2008)). The court’s decision does not affect DOE’s responsibility to evaluate reasonable alternatives for a disposal facility or facilities for GTCC LLRW – including GTCC LLRW covered by the Standard Contract – in accordance with applicable law.

[3] The LLRWPAA (P.L. 99-240) gave the federal government responsibility for disposal of GTCC LLRW and each state responsibility for the disposal of Class A, B, and C LLRW generated within the state (except for certain waste generated by the federal government). The Act authorized the states to enter into compacts for the establishment and operation of regional LLRW disposal facilities.

For the purpose of analysis in this EIS, DOE has categorized GTCC LLRW and GTCC-like waste as being one of three waste types: activated metals, sealed sources, or "Other Waste." The waste inventory being addressed in the EIS includes both stored inventory (wastes that were already generated and are in storage as of 2008) and projected inventory (wastes that are expected to be generated in the future through 2083). Waste quantity data obtained in 2008 had verification updates made in 2010 as needed, see Sandia (2008b) and Argonne (2010). In performing its due diligence in the preparation of this Final EIS, DOE reviewed the waste quantity data and has determined that the expected waste quantity estimates remain valid, are conservative and bounding for the comparative analysis in the Final EIS, and revisions to this information are not necessary. The stored inventory includes waste in storage at sites licensed by the NRC and Agreement States (GTCC LLRW) and at certain DOE sites (GTCC-like waste) and consists of all three waste types (activated metals, sealed sources, and Other Waste).

For analysis in this EIS, the three waste types fall into two groups on the basis of uncertainties associated with their generation. Group 1 consists of wastes that are either already in storage or are expected to be generated from existing facilities (such as commercial nuclear power plants by 2083); all currently operational plants were assumed to have their license renewed for an additional 20 years of operation. All stored GTCC LLRW and GTCC-like waste are included in Group 1.

Group 2 consists of wastes that may be generated in the future as the result of actions proposed by DOE or commercial entities, such as wastes from proposed commercial reactors that have not been licensed or constructed. Some or all of the Group 2 waste may never be generated, depending on the outcomes of proposed actions that are independent of this EIS. No stored GTCC LLRW and GTCC-like wastes are included in Group 2.

The waste volumes and radionuclide activities of the wastes addressed in this EIS are shown in Table 1.4.1-2 and Figure 1.4.1-1. The volume of GTCC LLRW in Groups 1 and 2 is estimated to be about 8,800 m^3 (310,000 ft^3) and to contain about 160 MCi. Less than 2% of this

Three Waste Types

The wastes being addressed in this EIS are divided into three distinct types. These three waste types and their estimated total volumes and radioactivities are as follows:

- Activated metals: 2,000 m^3 (71,000 ft^3) and 160 MCi
- Sealed sources: 2,900 m^3 (100,000 ft^3) and 2.0 MCi
- Other Waste: 6,700 m^3 (240,000 ft^3) and 1.3 MCi

About three-fourths of the waste by volume is GTCC LLRW; GTCC-like waste accounts for the remainder. Much of the GTCC-like waste meets the DOE definition of TRU waste (see Table 1.4.1-2).

Two Waste Groups

For purposes of analysis in this EIS, wastes are considered to be in one of two groups.

- Group 1 consists of wastes from currently operating facilities. Some of the Group 1 wastes have already been generated and are in storage awaiting disposal.
- Group 2 consists of projected wastes from proposed actions or planned facilities not yet in operation.

TABLE 1.4.1-2 Summary of Group 1 and Group 2 GTCC LLRW and GTCC-Like Waste Packaged Volumes and Radionuclide Activities[a]

Waste Type	In Storage Volume (m^3)	In Storage Activity (MCi)[b]	Projected Volume (m^3)	Projected Activity (MCi)	Total Stored and Projected Volume (m^3)	Total Stored and Projected Activity (MCi)
Group 1						
GTCC LLRW						
Activated metals (BWRs)[c] - RH	7.1	0.22	200	30	210	31
Activated metals (PWRs) - RH	51	1.1	620	76	670	77
Sealed sources (Small)[d] - CH	–[e,f]		1,800	0.28	1,800	0.28
Sealed sources (Cs-137 irradiators) - CH	–	–	1,000	1.7	1,000	1.7
Other Waste[g] - CH	42	0.000011	–	–	42	0.000011
Other Waste - RH	33	0.0042	1.0	0.00013	34	0.0043
Total	130	1.4	3,700	110	3,800	110
GTCC-like waste						
Activated metals - RH	6.2	0.23	6.6	0.0049	13	0.24
Sealed sources (Small) - CH	0.21	0.0000060	0.62	0.000071	0.83	0.000077
Other Waste - CH	430	0.016	310	0.0062	740	0.022
Other Waste - RH	520	0.096	200	0.17	720	0.26
Total	960	0.34	510	0.18	1,500	0.52
Total Group 1	1,100	1.7	4,200	110	5,300	110
Group 2						
GTCC LLRW						
Activated metals (BWRs) - RH	–	–	73	11	73	11
Activated metals (PWRs) - RH	–	–	300	37	300	37
Activated metals (Other) - RH[h]	–	–	740	0.14	740	0.14
Sealed sources - CH[h]	–	–	23	0.000020	23	0.000020
Other Waste - CH[h]	–	–	1,600	0.024	1,600	0.024
Other Waste - RH[h]	–	–	2,300	0.51	2,300	0.51
Total	–	–	5,000	49	5,000	49
GTCC-like waste						
Activated metals - RH	–	–	–	–	–	–
Sealed sources - CH	–	–	–	–	–	–
Other Waste - CH	–	–	490	0.012	490	0.012
Other Waste - RH	–	–	870	0.48	870	0.48
Total	–	–	1,400	0.49	1,400	0.49
Total Group 2	–	–	6,400	49	6,400	49

TABLE 1.4.1-2 (Cont.)

	In Storage		Projected		Total Stored and Projected	
Waste Type	Volume (m^3)	Activity (MCi)[b]	Volume (m^3)	Activity (MCi)	Volume (m^3)	Activity (MCi)
Groups 1 and 2						
GTCC LLRW						
Activated metals - RH	59	1.4	1,900	160	2,000	160
Sealed sources - CH	–	–	2,900	2.0	2,900	2.0
Other Waste - CH	42	0.00091	1,600	0.024	1,600	0.024
Other Waste - RH	33	0.0042	2,300	0.51	2,300	0.51
Total	130	1.4	8,700	160	8,800	160
GTCC-like waste						
Activated metals - RH	6.2	0.23	6.6	0.0049	13	0.24
Sealed sources - CH	0.21	0.0000060	0.62	0.000071	0.83	0.000077
Other Waste - CH	430	0.016	800	0.02	1,200	0.036
Other Waste - RH	520	0.096	1,100	0.65	1,600	0.75
Total	960	0.34	1,900	0.67	2,800	1.0
Total Groups 1 and 2	1,100	1.7	11,000	160	12,000	160

[a] All values have been rounded to two significant figures. Some totals may not equal sum of individual components because of independent rounding. BWR = boiling water reactor, CH = contact-handled (waste), PWR = pressurized water reactor, RH = remote-handled (waste). Includes waste in storage as of 2008 and projected through 2083. Waste quantity data obtained in 2008 had verification updates made in 2010 as needed, see Sandia (2008b) and Argonne (2010). In performing its due diligence in the preparation of this Final EIS, DOE reviewed the waste quantity data and has determined that the expected waste quantity estimates remain valid, are conservative and bounding for the comparative analysis in the Final EIS, and revisions to this information are not necessary.

[b] MCi means megacurie or 1 million curies.

[c] There are two types of commercial nuclear reactors in operation in the United States, BWRs and PWRs. Different factors were used to estimate the volumes and activities of activated metal wastes for these two types of reactors.

[d] Sealed sources may be physically small but have high concentration of radionuclides.

[e] There are sealed sources currently possessed by NRC licensees that may become GTCC LLRW when no longer needed by the licensee. Due to the lack of information on the current status of the sources (i.e., whether they are in use, waste, etc.), the estimated volume and activity of these sources are included in the projected inventory.

[f] A dash means that there is no value for that entry.

[g] Other Waste consists of those wastes that are not activated metals or sealed sources; it includes contaminated equipment, debris, scrap metals, filters, resins, soil, solidified sludges, and other materials.

[h] Wastes from the West Valley Site NDA and SDA are reflected in the inventories listed under Group 2 activated metals, sealed sources, and Other Waste - RH/CH. Of the 740 m^3 under activated metals, 210 m^3 is from the NDA and 525 m^3 is from the SDA; 23 m^3 of sealed sources is from the SDA; 1,600 m^3 of Other Waste - CH is from the SDA; and 1,950 m^3 of Other Waste - RH included 1,943 m^3 from the NDA and 7.34 m^3 from the SDA.

commercially generated waste volume is currently in storage; most of this waste is expected to be generated in the future. The volume of GTCC-like waste is considerably less than that of GTCC LLRW; it is estimated to be about 2,800 m^3 (99,000 ft^3) and to contain about 1.0 MCi. A higher percentage (about 34%) of the GTCC-like waste than of the GTCC LLRW is already in storage at a number of DOE sites; the remaining 66% is expected to be generated in the future. The GTCC LLRW and GTCC-like waste contain both short-lived and long-lived radionuclides listed in 10 CFR 61.55, Tables 1 and 2 (see Table 1.4.1-1). The major radionuclides in the GTCC LLRW are generally neutron activation and fission products. These include carbon-14 (C-14), iron-55 (Fe-55), cobalt-60 (Co-60), nickel-59 (Ni-59), nickel-63 (Ni-63), strontium-90 (Sr-90), technetium-99 (Tc-99), and cesium-137 (Cs-137). Much of the GTCC-like waste is non-defense-related TRU waste containing relatively high concentrations of actinides, including isotopes of uranium (U), neptunium (Np), plutonium (Pu), americium (Am), and curium (Cm).

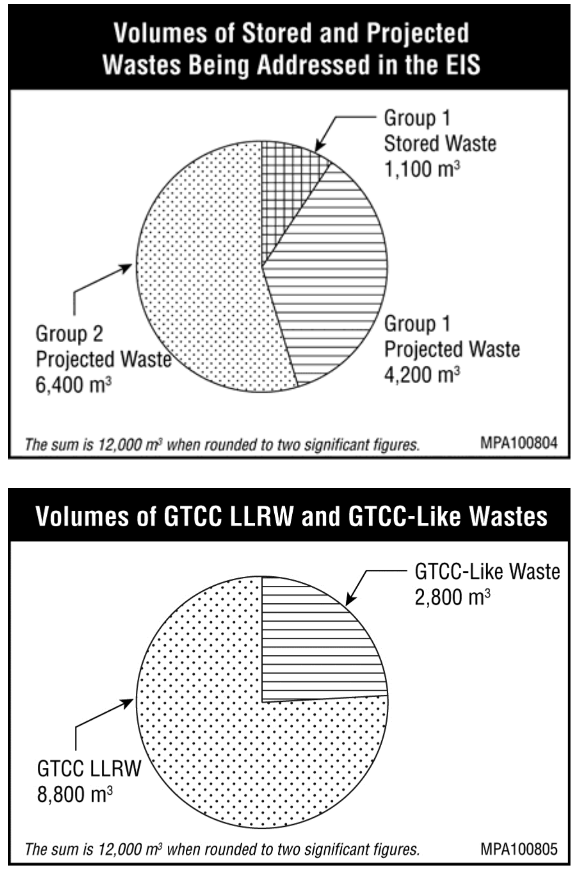

FIGURE 1.4.1-1 Current and Projected Volumes of Waste Needing Disposal

The total estimated volume of mixed waste in Group 1 is about 170 m^3 (6,000 ft^3). This volume represents less than 4% of the total volume of Group 1 waste. Of the 170 m^3 (6,000 ft^3), about 4 m^3 (140 ft^3) is GTCC LLRW, with the remainder being GTCC-like waste (Sandia 2007). Current information is insufficient to allow a reasonable estimate of the amount of Group 2 waste that could be mixed waste. Available information indicates that the Group 1 mixed waste is characteristic hazardous waste as regulated under the Resource Conservation and Recovery Act (RCRA); therefore, this EIS assumes that for the land disposal methods, the generators will treat the waste to render it nonhazardous under federal and state laws and requirements. WIPP, however, can accept mixed waste as provided in the WIPP Land Withdrawal Act (LWA) as amended (P.L. 102-579 as amended by P.L. 104-201).

Estimates of the volumes and radionuclide activities of GTCC LLRW were first developed and reported in DOE (1994). That report was limited to GTCC LLRW and did not consider GTCC-like waste. Updated estimates (including estimates for GTCC-like waste) were developed by Sandia National Laboratories for DOE in 2007 to support issuance of the NOI for this EIS (Sandia 2007). Additional information on the characteristics of the GTCC LLRW and GTCC-like wastes to support EIS analyses are provided in a more recent report (Sandia 2008b). The approach used to develop estimates of the volumes and activities for Group 1 wastes is described in Sandia (2007, 2008b), and the approach used to develop comparable estimates for Group 2 wastes is described in Argonne (2010).

Additional information on the characteristics of the wastes included in Groups 1 and 2 is provided in the following sections. More detailed information on these wastes is given in Appendix B and the references cited in that appendix.

1.4.1.1 Activated Metals

> **Activated Metals at a Glance**
>
> - They are largely generated from the decommissioning of nuclear reactors.
> - They include portions of the nuclear reactor vessel, such as the core shroud and core support plate.
> - They are not spent nuclear fuel.
> - Prevalent radionuclides in activated metals include carbon-14, manganese-54, iron-55, nickel-59 and -63, niobium-94, and cobalt-60.
> - In the United States, 104 commercial nuclear reactors are operating in 31 states, and more reactors are planned.
> - Most of the reactors are not scheduled to undergo decommissioning for several decades.
> - Commercial nuclear reactors provide 19% of the nation's electricity (EIA 2010).

The activated metal wastes consist of steel, stainless-steel, and a number of specialty alloys used in nuclear reactors (a typical reactor is shown in Figure 1.4.1-2). Portions of the reactor assembly and other components near the nuclear fuel are activated by high fluxes of neutrons during reactor operations for long periods of time, producing high concentrations of some radionuclides. Many of these have very short half-lives (i.e., days to several weeks, such as Co-58, zirconium-95 [Zr-95], and niobium-95 [Nb-95]) and decay quite rapidly, while others have longer half-lives (in some cases, such as C-14 and Ni-59, thousands of years) and remain radioactive for an extended period of time. Most of the activated metal waste will be generated in the future by the decommissioning of commercial nuclear power reactors. The neutron activation products expected to be most prevalent in these wastes at the time the wastes are available for disposal are C-14, manganese-54 (Mn-54), Fe-55, Co-60, Ni-59, Ni-63, molybdenum-93 (Mo-93), and Nb-94. Lower concentrations of some fission products (including Sr-90, Tc-99, and Cs-137) and actinides (such as various isotopes of plutonium) are also expected to be present on these materials as surface contamination.

Only a very small fraction of the metallic waste generated from the decommissioning of commercial nuclear power plants will be GTCC LLRW. Most of the waste is expected to be Class A, B, or C LLRW. For the purpose of analysis in the EIS, all of the GTCC LLRW activated metal waste is assumed to be remote-handled (RH) waste, since high concentrations of gamma-emitting radionuclides are expected in this material. These wastes will need a significant amount of shielding to reduce the levels of radiation to acceptable levels and/or will have to be handled remotely. RH waste refers to radioactive waste that must be handled at a distance (remotely) to protect workers from unnecessary exposure (e.g., waste with a dose rate of 200 millirem per hour [mrem/h] at the surface of the waste package). The physical form of this waste is solid metal.

Group 1 activated metal wastes are largely those associated with currently operating or decommissioned reactors. The GTCC LLRW resulting from the reactors that have already been decommissioned is currently being stored, generally at the reactor site. Most of the Group 1 GTCC LLRW activated metal waste volume results from the future decommissioning of

Contact-Handled and Remote-Handled Waste

As used in this EIS, contact-handled (CH) waste refers to GTCC LLRW and GTCC-like waste that has a dose rate of less than 200 mrem/h on the surface of the package. Remote-handled (RH) waste refers to GTCC LLRW and GTCC-like waste that has a surface dose rate of 200 mrem/h or more. These definitions are consistent with the way that these terms are defined for disposal of TRU waste at WIPP.

Reactor Types

There are two types of commercial nuclear reactors used in the United States: pressurized water reactors (PWRs) and boiling water reactors (BWRs). The reactor pressure vessels for these two reactor types are significantly different and will result in different volumes and radionuclide activities of GTCC LLRW activated metal wastes. The reactor pressure vessel for a typical PWR (shown in Figure 1.4.1-2) is about 13 m (43 ft) high with a diameter of about 4.3 m (14 ft). The reactor pressure vessel for a typical BWR is larger, with a height of about 22 m (72 ft) and a diameter of about 6.4 m (21 ft). A greater volume of GTCC LLRW is produced by the decommissioning of a PWR than a BWR (see Argonne 2010).

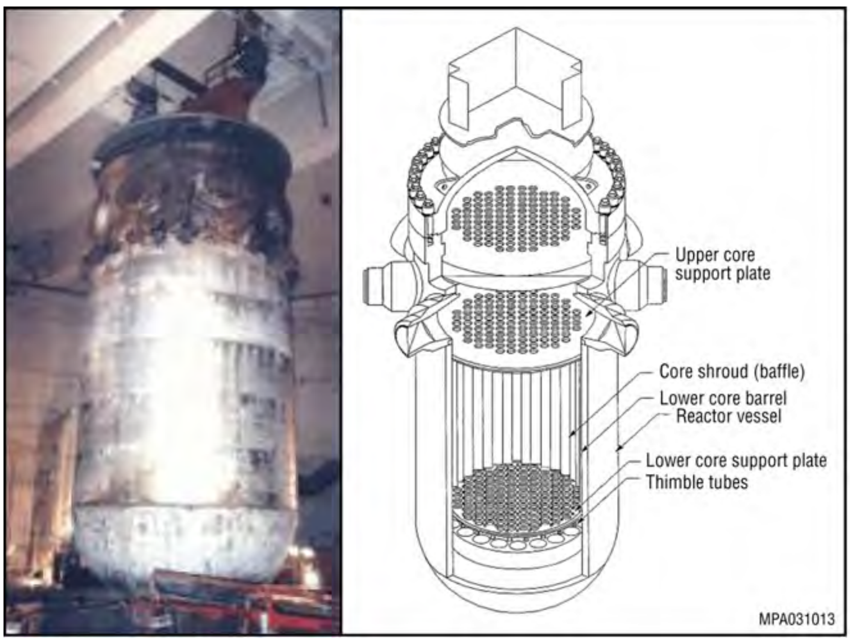

FIGURE 1.4.1-2 Activated Metal Waste, Including Portions of the Reactor Vessel, Such as the Core Shroud and Core Support Plates

currently operating commercial nuclear power plants, which will not occur for several decades. Group 1 activated metal GTCC-like wastes were identified at two DOE sites (the INL Site and Oak Ridge National Laboratory [ORNL]). The total volume of activated metal waste (stored and projected) at these two DOE sites was determined to be about 13 m^3 (450 ft^3); about half of this volume is currently in storage, and the other half is projected to be generated in the future. The total activity in the GTCC-like activated metal wastes is estimated to be about 0.24 MCi, as shown in Table 1.4.1-2.

The total volume of Group 1 GTCC LLRW activated metal from decommissioning existing commercial nuclear reactors is estimated to be about 880 m^3 (31,000 ft^3). The electric utility industry is currently operating 104 NRC-licensed commercial nuclear reactors; the volume of GTCC LLRW from decommissioning these 104 operating reactors is expected to be about 820 m^3 (29,000 ft^3). Another 18 reactors have been shut down and decommissioned. The waste volume associated with the 18 decommissioned reactors is estimated to be about 59 m^3 (2,100 ft^3). Hence, only a small amount of GTCC LLRW activated metal waste is currently in storage, with more than 90% yet to be generated in the future. The total activity in the GTCC LLRW activated metal wastes is about 110 MCi (Table 1.4.1-2).

The Group 2 activated metal wastes include the GTCC LLRW from the future decommissioning of proposed commercial nuclear reactors that have not yet been licensed or constructed. The NRC has estimated that 33 new commercial nuclear power plants may be constructed in the future, and this number is used in this EIS to estimate the amount of GTCC LLRW activated metal waste that could be generated in the future from these activities (NRC 2009). A further increase in the number of new commercial nuclear power plants in and the volume of GTCC LLRW associated with the decommissioning of these additional new commercial nuclear power plants is uncertain at this time and therefore not estimated in this EIS. Similarly, any potential nuclear fuel cycles involving advanced reactors or recycling of used fuel and the GTCC LLRW and GTCC-like waste associated with these activities are uncertain at this time and therefore not estimated in this EIS. Either of these scenarios could have an impact on the volume of GTCC LLRW and GTCC-like waste generated and requiring disposal, which would be subject to future NEPA review, including an analysis of the types and amount of waste generated and the need for disposal capacity.

In addition, activated metal waste (and sealed sources and Other Waste) may be generated if a decision is made to excavate two disposal areas at the West Valley Site (NRC-licensed disposal area [NDA] and state-licensed disposal area [SDA]) as part of the Phase 2 decommissioning activities for the closure of the site (DOE 2010a,b). Although no decision has been made at this time to exhume the two West Valley disposal areas, inclusion of the GTCC LLRW and GTCC-like waste volumes in these disposal areas supports a bounding analysis for the GTCC EIS. The GTCC LLRW and GTCC-like waste from the two disposal areas at West Valley Site is considered to be GTCC LLRW, except for a small quantity (31 m^3 [1,100 ft^3]) of GTCC-like waste in one of the disposal areas. This 31 m^3 (1,100 ft^3) of GTCC-like waste is included with the volume of GTCC LLRW from these two disposal areas for purposes of analysis in the EIS. There is no GTCC-like Group 2 activated metal waste.

The total volume of Group 2 activated metal wastes from decommissioning the proposed 33 new reactors is estimated to be about 380 m^3 (13,000 ft^3), and the total volume of activated metal waste associated with the exhumation of the two West Valley Site disposal areas is estimated to be 740 m^3 (26,000 ft^3). Hence, the total volume of Group 2 activated metal waste is about 1,100 m^3 (39,000 ft^3). This waste has an estimated total activity of about 48 MCi, largely associated with the future decommissioning of new commercial reactors (Table 1.4.1-2). The exhumed metal waste from the West Valley disposal areas would account for less than 1% of the total activity in Group 2 activated metal waste.

In summary, the total volume of activated metal wastes in Groups 1 and 2 is about 2,000 m^3 (71,000 ft^3), and the total activity is about 160 MCi. More than 99% of this waste is GTCC LLRW, with GTCC-like waste accounting for the remainder. Additional information on these waste volumes and activities is given in Table 1.4.1-2, and more detailed information on the radionuclide activities in these wastes is given in Appendix B and Argonne (2010).

1.4.1.2 Sealed Sources

The possession and use of sealed sources in the commercial sector are licensed by the NRC and its Agreement States. The term "sealed radioactive source" refers to a radioactive source manufactured, obtained, or retained for the purpose of utilizing the emitted radiation. A sealed radioactive source consists of a known or estimated quantity of radioactive material that is (1) contained within a sealed capsule, (2) sealed between layer(s) of nonradioactive material, or (3) firmly fixed to a nonradioactive surface by electroplating or other means intended to prevent leakage or escape of the radioactive material. These sources are commonly used to sterilize medical products, detect flaws and failures in pipelines and metal welds, determine moisture content in soil and other materials (moisture gauges), and diagnose and treat illnesses such as cancer (teletherapy units) (Figure 1.4.1-3).

Sealed Sources at a Glance

- They are widely used in equipment to diagnose and treat illnesses (particularly cancer), sterilize medical devices, irradiate blood for transplant patients, nondestructively test structures and industrial equipment, and explore geologic formations to find oil and gas.
- They are located in hospitals, universities, and industries throughout the United States.
- Unsecured or abandoned sealed sources are a national security concern because of their potential to be used in a "dirty bomb."
- They commonly consist of small, concentrated radioactive materials encapsulated in metal containers.
- Not all sealed sources are GTCC LLRW when they are disposed of.
- Radionuclides commonly used in sealed sources include cesium-137, americium-241, and plutonium-238.

Essentially all of the sealed sources being addressed in this EIS are in Group 1. The total packaged volume of Group 1 sealed sources is estimated to be about 2,800 m^3 (99,000 ft^3), with almost all of this volume being GTCC LLRW. The total packaged volume of GTCC-like sealed source waste is estimated to be about 0.83 m^3 (29 ft^3).

The only sealed sources in Group 2 are those associated with the potential exhumation of the SDA at the West Valley Site in western New York. The total in-place volume of sealed sources in the SDA is estimated to be about 22 m^3 (790 ft^3). When exhumed and packaged for disposal, it is estimated that this volume would increase to about 23 m^3 (810 ft^3) (Table 1.4.1-2).

Sealed sources can encompass several physical forms, including ceramic oxides, salts, or metals. Cesium chloride (CsCl) salt was generally used in older Cs-137 sources. While large Cs-137 sources still employ CsCl, newer small sources typically have the radionuclide bonded in a ceramic. Of these two forms, CsCl salt is much more water soluble. For the EIS, all of the Cs-137 sources are conservatively assumed to be present as CsCl salt. In addition to Cs-137, the

FIGURE 1.4.1-3 Sealed Sources

radionuclides expected to be present in these sealed sources include Pu-238, Pu-239, Pu-240, Am-241, Am-243, and curium-244 (Cm-244). For the purpose of analysis in this EIS, these radionuclides are conservatively assumed to be present in the sealed sources in the form of oxides. These oxide sources are likely to be in the form of pellets (Sandia 2008b).

Sealed sources generally have relatively low exposure rates when packaged for disposal. All of the packaged sealed sources are expected to be CH waste, with the possible exception of two Am-241/beryllium sources. For purposes of analysis in the EIS, CH waste is considered to be waste that has a dose rate at the surface of the package of less than 200 mrem/h. Should RH sealed source waste be generated, appropriate precautions would be taken during waste handling and disposal operations to protect workers. Sealed sources other than the Cs-137 irradiators are assumed to be packaged in 208-L (55-gal) drums in accordance with packaging factor limits developed by the DOE Global Material Security/Off-Site Source Recovery Project (GMS/OSRP) at LANL (Sandia 2007). It is estimated that approximately 8,700 drums would be required for packaging these sealed sources.

Sources recovered by GMS/OSRP for national security or public health and safety reasons are staged at LANL or off-site contractor facilities pending disposal. Typically, DOE takes ownership of sealed sources recovered under the GMS/OSRP program. The transfer of ownership from the source owner to DOE is officially documented through an *Authorization to Transfer/Relinquishment of Ownership/Custody* form. Sources owned by DOE may be disposed of at DOE facilities if the sources meet the waste acceptance criteria for those facilities.

The inventory of GTCC-like sealed sources in storage includes only those sealed sources from other DOE activities that may not have an identified disposal path. The projected inventory for GTCC-like sealed sources does not include sources that may, in the future, be recovered by GMS/OSRP. Any such sources are the responsibility of the licensees until the point at which they are recovered by GMS/OSRP; therefore, they are included in the projected inventory for commercial GTCC sealed sources.

The sealed source waste inventory also includes 1,435 large Cs-137 irradiators that are in the possession of commercial licensees. These projected GTCC LLRW sources cannot be packaged in standard 208-L (55-gal) drums; it is assumed they would be disposed of individually in their original shielded devices.[4] For purposes of analysis in the EIS, each Cs-137 irradiator is assumed to have a packaged waste volume of about 0.71 m^3 (25 ft^3) with dimensions of about 150 × 65 × 67 cm (59 × 26 × 27 in.) (Sandia 2008b). Hence, the 1,435 commercial Cs-137 irradiators would have a waste volume of about 1,000 m^3 (35,000 ft^3). In these irradiators, the Cs-137 source is contained within a robust shielded device that is expected to retain its integrity for many years following disposal.

In summary, the total packaged volume of all (Group 1 and Group 2) GTCC LLRW sealed sources is estimated to be approximately 2,900 m^3 (100,000 ft^3), and the volume of GTCC-like sealed sources is estimated to be about 0.83 m^3 (29 ft^3). Nearly all of this waste is projected to be generated in the future. For conservatism, it is assumed that none of the sealed sources would be recycled. The total activity of the sealed sources is estimated to be about 2.0 MCi, with Cs-137 accounting for most (86%) of this total. Nearly all of this volume and activity are associated with Group 1 wastes. Additional information on these waste volumes and activities is given in Table 1.4.1-2, and detailed information on the radionuclide activities in these wastes is provided in Appendix B and Argonne (2010).

1.4.1.3 Other Waste

Other Waste consists of a wide variety of materials, such as contaminated equipment, sludges, salts, charcoal, scrap metal, glove boxes, solidified solutions, particulate solids, filters, and organic and inorganic debris, including debris from future decontamination and decommissioning activities, the production of Pu-238 radioisotope power systems, and the production of medical isotopes (Mo-99) (Figure 1.4.1-4). This category of waste includes the GTCC LLRW and GTCC-like waste that do not fall into one of the other two categories (activated metals or sealed sources). These wastes can come in a number of physical forms, and a wide range of radionuclides may be present.

[4] The final packaging configuration will be designed to meet the disposal site's waste acceptance criteria.

While some of this waste is produced in the commercial sector as a result of radionuclide manufacturing, research, and other activities, much of this waste is associated with DOE activities and considered to be GTCC-like waste. Most of the wastes in this category are associated with the cleanup of the West Valley Site and the potential exhumation of wastes from two disposal areas at this site. The total volume of Group 1 and Group 2 GTCC LLRW and GTCC-like Other Waste is about 6,700 m^3 (240,000 ft^3). Of this total, the West Valley Site accounts for about 5,700 m^3 (200,000 ft^3). About 61% of the West Valley Site Other Waste volume is GTCC LLRW (from the possible exhumation of the two disposal areas), and 39% is GTCC-like waste (largely from ongoing and future cleanup activities).

The GTCC-like wastes associated with the cleanup of the West Valley Site are largely composed of building, piping, and process equipment debris, and the volume of the waste is estimated to be about 2,250 m^3 (79,000 ft^3). About 56% of this waste is in Group 1 Other

Other Waste at a Glance

- Other Waste primarily includes contaminated equipment, debris, scrap metal, and decommissioning waste from the:
  - Production of Mo-99, which is used in about 16 million medical procedures (e.g., to detect cancer) each year (Coalition of Professional Organizations 2009). The United States depends on aging foreign reactors to produce Mo-99, and shortages in recent years due to the unexpected shutdowns of the foreign facilities have highlighted the need to produce Mo-99 in the United States.
  - Production of radioisotope power systems in support of space exploration (e.g., from the plutonium-238 production project) and national security.
  - Environmental cleanup of the West Valley Site in New York.
- A wide range of radionuclides may be present in Other Waste, including Tc-99, Cs-137, and a number of transuranic radionuclides, including isotopes of plutonium, americium, and curium.

FIGURE 1.4.1-4 Other Waste (Glove Boxes)

Waste, and 44% is in Group 2 Other Waste. Much of this waste may not meet the waste acceptance criteria for disposal at WIPP as defense-generated TRU waste. Wastes from the NDA and SDA at the West Valley Site that could potentially be exhumed account for about 4,300 m^3 (150,000 ft^3) of GTCC LLRW Other Waste. Most of the wastes in these two disposal areas were produced by commercial activities and are GTCC LLRW. A small quantity (31 m^3 [1,100 ft^3]) of waste in the NDA is considered to be GTCC-like waste. This GTCC-like waste is included with the volume of GTCC LLRW from the NDA and SDA for purposes of analysis in the EIS.

Two commercial generators of GTCC LLRW Other Waste were identified for inclusion in the EIS, and these sites are located in Virginia and Texas. The volume of stored waste is reported to be 75 m^3 (2,600 ft^3), and an additional 1 m^3 (35 ft^3) is projected to be generated in the future. These wastes are included in the Group 1 inventory. The remainder of the Other Waste in Group 1 is largely associated with GTCC-like wastes at two DOE facilities (the INL Site and the Oak Ridge Reservation [ORR]). A spectrum of radionuclides is present in these wastes, with the isotopes of various actinides (uranium, neptunium, plutonium, americium, and curium) being of most concern for long-term management. The total activity in the Group 1 and Group 2 Other Waste is 1.3 MCi, and many of the radionuclides present in this waste have very long half-lives (see related discussion in Appendix B).

The total volume of Group 1 Other Waste (GTCC LLRW and GTCC-like waste) is estimated to be about 1,500 m^3 (53,000 ft^3). About 67% of the Group 1 waste in this category has already been generated and is in storage; the remainder is projected to be generated in the future. Most of the stored waste is at the West Valley Site. Much of the waste in this category is expected to meet the DOE definition for TRU waste (i.e., waste that contains more than 100 nCi/g of alpha-emitting TRU radionuclides with half-lives longer than 20 years). This TRU waste may not meet the waste acceptance criteria for disposal at WIPP as defense-generated TRU waste and has no other currently identified path to disposal. About half of the Group 1 waste in this category is RH waste and half is CH waste. The total activity in this Group 1 Other Waste is about 0.28 MCi.

The total volume of Group 2 Other Waste (GTCC LLRW and GTCC-like waste) is estimated to be about 5,300 m^3 (190,000 ft^3). All of this waste is in the projected inventory, and it may or may not be generated, depending on future decisions. In addition to wastes associated with the West Valley Site, this category includes GTCC LLRW associated with Mo-99 production projects and GTCC-like waste associated with a planned DOE Pu-238 production project. The wastes associated with these two activities are described in Argonne (2010) and are summarized in Appendix B. It is estimated that the Mo-99 projects would generate a total of about 390 m^3 (14,000 ft^3) of GTCC LLRW[5] and that the planned DOE Pu-238 project would generate a total of about 380 m^3 (13,000 ft^3) of GTCC-like waste.

---

[5] Waste from Mo-99 production will be generated by NRC and Agreement State licensees and is therefore, for purposes of analysis in this EIS, considered to be GTCC LLRW. In the event Mo-99 producers enter into Uranium Lease and Take-Back Contracts with DOE pursuant to applicable provisions in the American Medical Isotopes Production Act of 2012 (Title XXXI, Subtitle F, National Defense Authorization Act for Fiscal Year 2013, Public Law 112-239), it is possible that waste resulting from Mo-99 production included in the current estimates of GTCC LLRW may be determined to be waste for which DOE is responsible for final disposition.

In summary, the total volume of Other Waste in Groups 1 and 2 is about 6,700 m^3 (240,000 ft^3), and it has a total activity of about 1.3 MCi. About 58% of this waste is GTCC LLRW, and 42% is GTCC-like waste. The West Valley Site accounts for 5,700 m^3 (200,000 ft^3) of the waste in this category. Additional information on these waste volumes and activities is provided in Table 1.4.1-2. Detailed information on the radionuclide activities in these wastes is given in Appendix B and Argonne (2010).

1.4.2 Disposal Methods Considered

NRC regulations at 10 CFR 61.55 (a)(2)(iv) require that GTCC LLRW must be disposed of in a geologic repository unless alternative methods of disposal are proposed to the NRC and approved by the Commission. The NRC states in 10 CFR 61.7 (b)(5) that "there may be some instances where waste with Class C concentrations greater than permitted for Class C waste would be acceptable for near-surface disposal with special processing or design." For this EIS, DOE is considering four disposal methods at varying depths of waste isolation (see Figure 1.4.2-1): (1) deep geologic disposal, (2) boreholes, (3) trenches, and (4) vaults.

In the early 1990s, DOE conducted a review of potential technologies for disposing of GTCC LLRW (Henry 1993). This review followed a similar review of near-surface technologies for disposing of LLRW that the NRC had conducted (Bennett et al. 1984). In these reviews, the disposal technologies were categorized as near-surface, intermediate-depth, and deep geologic methods. All of the technologies identified in these reports included the use of high-integrity containers or high-level radioactive waste containers. High-integrity containers are also assumed in this EIS, as described in Appendix B. DOE selected methods that represent the range of technology methods considered in these previous studies for evaluation in this EIS. The WIPP repository alternative represents the deep geologic concept, the borehole method represents the intermediate-depth concept, and the trench and vault methods represent the near-surface concept with enhanced engineering features.

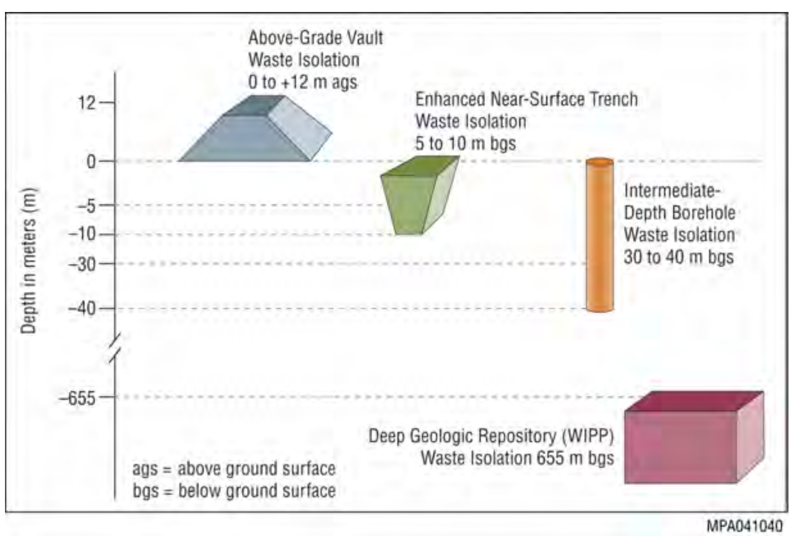

FIGURE 1.4.2-1 Waste Isolation Depths for Proposed Waste Disposal Methods

The designs for the land disposal facilities that are evaluated in this EIS are conceptual and generic in nature so that the performance of the sites with regard to employing the disposal methods considered in this EIS can be compared. Section 5.1.4 and Appendix D present additional details on the conceptual designs of the land disposal methods. These land disposal conceptual designs could be altered or enhanced, as necessary, to provide the optimal application at a given location.

The borehole, trench, and vault disposal methods, which are also referred to as land disposal methods or facilities in this EIS, must provide sufficient distance to the water table so that the intrusion of groundwater (perennial or otherwise) into the waste will not occur.

1.4.2.1 Deep Geologic Disposal

A deep geological repository is a radioactive waste disposal facility excavated generally below 300 m (1,000 ft) within bedrock. It entails a combination of waste form, waste package, and engineered seals that is designed to provide for disposal without future maintenance.

A geologic repository is a system intended to be used for the disposal of radioactive wastes in excavated geologic media and is composed of an operations area and the portion of the geologic setting that isolates the radioactive waste. The operations area typically includes a radioactive waste facility (including both surface and subsurface areas) where waste handling activities are conducted. The geologic setting includes the geologic, hydrologic, and geochemical systems of the region in which a geologic repository operations area is or may be located.

1.4.2.2 Intermediate-Depth Borehole Disposal

Intermediate-depth borehole disposal entails the emplacement of waste in boreholes below 30-m (100-ft) deep but no deeper than 300 m (1,000 ft). The boreholes can vary widely in diameter from 0.3 to 3.7 m (1 to 12 ft), and the proximity of one borehole to another can also vary, depending on the design of the facility. GTCC LLRW and GTCC-like waste disposal placement is assumed to be about 30 to 40 m (100 to 130 ft) below ground surface (bgs). The technology for drilling larger-diameter boreholes is simple and widely available. The conceptual design used as the basis for the evaluation in this EIS employs boreholes that are about 2.4 m (8 ft) in diameter and are located 40-m (130-ft) deep in unconsolidated to semiconsolidated soils, as shown in Figure 1.4.2-2. The borehole diameter was selected to accommodate various disposal packages that might be used to contain the three waste types evaluated in this EIS. The depth was selected on the basis of a consideration of the subsurface characteristics of the sites being evaluated in this EIS.

A bucket auger or other commercially available drilling device would be used to drill the large-diameter borehole, and a smooth steel casing would be advanced to the depth of the borehole during its drilling and construction. The casing would help stabilize the borehole walls and ensure that waste packages would not snag and plug the borehole as they were lowered; this would also ensure that the packages would sit in an upright position when they reached the

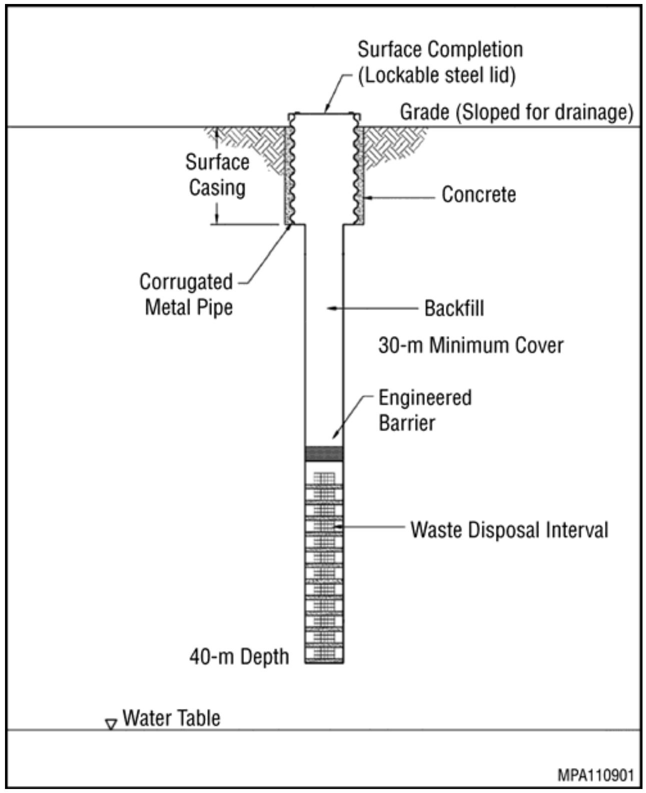

FIGURE 1.4.2-2 Cross Section of the Conceptual Design for an Intermediate-Depth Borehole

bottom. The upper 30 m (100 ft) of smooth steel casing would be removed upon closure of the borehole. An engineered barrier (i.e., reinforced concrete) would be placed on the top of the waste to deter inadvertent human intrusion during the post-closure period. The remainder of the borehole above the barrier would be backfilled with clean fill.

1.4.2.3 Enhanced Near-Surface Disposal

Near-surface disposal involves disposal within the top 30 m (100 ft) of the earth's surface (10 CFR 61.2). Two types of enhanced near-surface disposal methods are considered in this EIS: a trench facility and a vault facility.

1.4.2.3.1 Enhanced Trench Design. In the conceptual design for the trench disposal facility, the trenches are about 3-m (10-ft) wide, 11-m (36-ft) deep, and 100-m (330-ft) long. GTCC LLRW and GTCC-like waste disposal placement is assumed to be about 5 to 10 m (15 to 30 ft) bgs. The width and depth were selected to optimize the disposal capacity of each trench within the limits of readily available excavation equipment and commercially available shoring equipment. Figure 1.4.2-3 illustrates the trench design features and approximate dimensions.

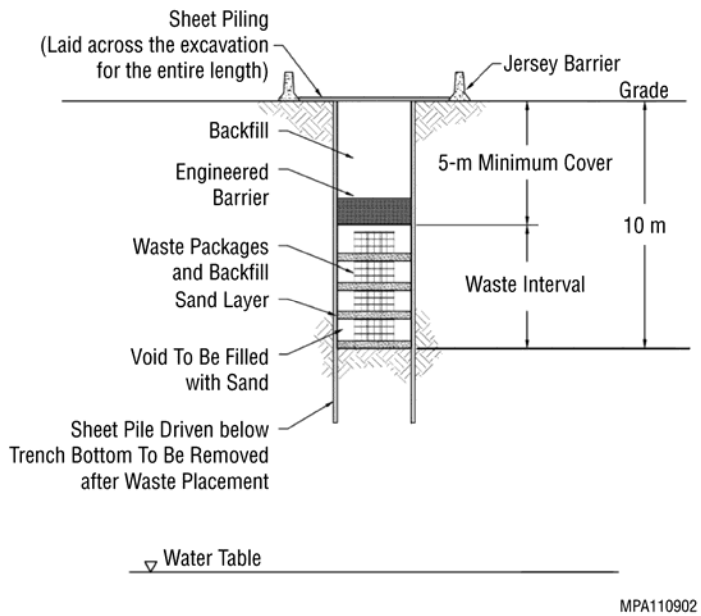

FIGURE 1.4.2-3 Cross Section of the Conceptual Design for a Trench

Narrow trenches like this are often referred to as slit trenches, and they are often used for high-activity LLRW because the soil provides greater shielding when this configuration is used.

The side walls of the trench would be vertical. A well-compacted material would be placed on top of the native material in the floor of the trench. A 0.3-m (1-ft) layer of sand or gravel would then be placed on top of the compacted material to improve stability. The nature of the compacted material would be selected to be compatible with surrounding geologic material. The trench sidewalls would be constructed by using temporary metal shoring, which would be removed when the trench was closed.

Wastes would be contained in packages designed to retain their integrity for an extended time period, and these wastes would be carefully emplaced into the trenches. A fine-grained, cohesionless fill (sand) would be used to backfill around the waste containers and fill voids. After the trench was filled with the waste containers and backfill, an engineered barrier (i.e., reinforced concrete) would be placed over the waste packages. It is anticipated that clean fill from the construction-site would be used to backfill the trench above the engineered barrier.

1.4.2.3.2 Above-Grade Vault Design. The conceptual design for the above-grade disposal of GTCC LLRW would employ a reinforced concrete vault constructed near grade level, with the footings and floors of the vault situated in a slight excavation just below the frost line that might occur at the sites being evaluated for the vault method in this EIS. The design is a modification of a disposal concept proposed by Henry (1993) for GTCC LLRW, and it is similar to a belowground vault option for LLRW disposal (Denson et al. 1987) that was previously investigated by the U.S. Army Corps of Engineers (USACE). A similar concrete vault structure is currently in use for the below-grade disposal of higher-activity LLRW at SRS (MMES et al. 1994).

Each vault would be about 11-m (36-ft) wide, 94-m (310-ft) long, and 7.9-m (26-ft) tall, with 11 disposal cells situated in a linear array. Interior cell dimensions would be 8.2-m (27-ft) wide, 7.5-m (25-ft) long, and 5.5-m (18-ft) high, with an internal volume of 340 m^3 (12,000 ft^3) per cell. Double interior walls with an expansion joint would be included after every second cell. GTCC LLRW and GTCC-like waste disposal placement is assumed to be about 4.3 to 5.5 m (14 to 18 ft) above ground surface. Figure 1.4.2-4 shows a schematic cross section of a vault cell.

The exterior walls and roof would be composed of reinforced concrete that is 1.1-m (3.8-ft) thick. In addition to adding strength and durability to the vault, the thick concrete would attenuate the gamma radiation associated with some of the RH waste. An engineered cover (i.e., about 5-m [17-ft] thick) would be placed over the vault after disposal activities were completed to isolate the waste from the environment over the long term.

1.4.3 Sites Considered for Disposal Locations

For deep geologic disposal, WIPP in New Mexico was included for evaluation in this EIS because of its characteristics as a geologic repository. DOE also evaluated three land disposal methods (borehole, trench, and vault) at six federally owned sites: Hanford Site, INL Site, LANL, NNSS, SRS, and the WIPP Vicinity. Two different locations were evaluated for the WIPP Vicinity site: Section 27 (which is located within the WIPP LWB) and Section 35 (which is on BLM-managed land that is just outside the WIPP LWB). In addition to the six federally owned sites, the land disposal methods were evaluated for generic commercial sites in the four regions that make up the United States, as shown in Figure 1.4-2.

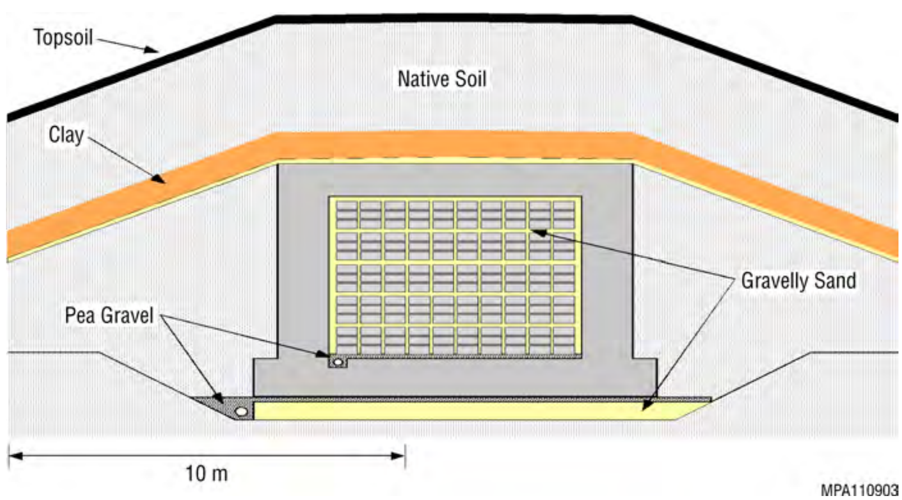

FIGURE 1.4.2-4 Schematic Cross Section of the Conceptual Design for a Vault Cell

As shown in Table 1.4.3-1, because of shallow water considerations, the borehole method is evaluated for all sites except SRS and the generic commercial sites in Regions I, II, and III; the trench method is evaluated for all sites except the generic commercial sites in Regions I and III; and the vault method is evaluated for all sites, both the federally owned sites and the generic commercial sites in all four regions. (See Table 1.4.3-1 for a summary of which land disposal method was evaluated.)

TABLE 1.4.3-1 Land Disposal Methods Evaluated at the Six Federal Sites and Generic Regional Commercial Sites

Site	Borehole	Trench	Vault
Hanford Site	√	√	√
INL Site	√	√	√
LANL	√	√	√
NNSS	√	√	√
SRS	No	√	√
WIPP Vicinity	√	√	√
Region I[a]	No	No	√
Region II[a]	No	√	√
Region III[a]	No	No	√
Region IV[a]	√	√	√

[a] Based on the NRC Regions.

The DOE sites evaluated for the land disposal methods were identified on the basis of mission compatibility (i.e., only DOE sites that currently have radioactive waste disposal as part of their ongoing mission were considered). These DOE sites would also have supporting infrastructure already in place that might be useful for future potential GTCC LLRW and GTCC-like waste disposal activities. The WIPP Vicinity was identified for evaluation because of its proximity to waste disposal operations at WIPP and the potential for using supporting infrastructure.

Aside from mission compatibility, site factors that were considered in identifying an acceptable area for developing a GTCC LLRW and GTCC-like waste disposal facility were that it should (1) have sufficient depth to groundwater; (2) not be located within the 100-year floodplain or in wetlands; (3) be consistent with current land use plans; and (4) have a low probability for erosion, mass wasting, faulting, folding, and seismic activity that would occur often enough and to a large enough extent that the facility's performance would be affected. All of these are mentioned in 10 CFR Part 61 as requirements for siting a commercial LLRW disposal facility and are consistent with the siting requirements in the *Radioactive Waste Management Manual*, DOE M 435.1-1 (DOE 1999).

For each of the DOE sites identified above for inclusion, a reference location was identified in order to serve as the basis for the evaluations presented in this EIS. These evaluations are intended to serve as a starting point for each of the sites being considered. In other words, if a site or sites were selected for possible implementation of a land disposal method or methods, a follow-on site-specific NEPA evaluation and documentation, as appropriate, along with further optimization by a selection study, would be conducted to identify the location or locations within a given site that would be considered the best ones to accommodate the land disposal method(s). The use of the reference locations for the EIS is considered to be an acceptable approach to meet the objective of identifying the site and technology combination that could provide the most suitable option for GTCC LLRW and GTCC-like waste disposal.

It is expected that the potential environmental impacts identified in this EIS for the various sites and disposal methods would be representative of those that would occur if the disposal facility was located at a given site. In other words, these results are expected to represent how each site would perform under each of the three land disposal methods being considered in this EIS and provide a basis for comparison among sites. Once a site and a disposal method are selected, additional studies would be necessary to identify the most appropriate location for this facility. While institutional knowledge was used to select the reference locations evaluated in this EIS, more in-depth, site-specific, follow-on studies and appropriate NEPA reviews would be needed to ensure proper land use planning, assure protection of local ecological and cultural resources, and account for local variations in hydrology and geology to minimize potential waste migration.

> The selection of site(s) for GTCC LLRW and GTCC-like waste disposal considered existing laws, regulations, and agreements. The site-specific chapters (4 and 6–11) and Chapter 13 identified relevant laws, regulations, and agreements that were considered in the decision-making process.

Sections 1.4.3.1 through 1.4.3.9 provide brief descriptions of the site locations considered in this EIS for the disposal of GTCC LLRW and GTCC-like waste.

1.4.3.1 Waste Isolation Pilot Plant

WIPP is a DOE facility that is the first deep underground geologic repository in the United States. It is permitted by the U.S. Environmental Protection Agency (EPA) and the State of New Mexico to safely and permanently dispose of defense-generated TRU radioactive waste (WIPP LWA as amended [P.L. 102-579 as amended by P.L. 104-201]). WIPP is located 42 km (26 mi) east of Carlsbad, New Mexico, in the Chihuahuan Desert in the southeast corner of the state (Figure 1.4.3-1). The WIPP facility sits in the approximate center of a 41-km^2 (16-mi^2) area that was withdrawn from public domain and transferred to DOE (Figure 1.4.3-2). Project facilities include disposal rooms that are mined 655 m (2,150 ft) under the ground in a salt formation (the Salado Formation) that is 610-m (2,000-ft) thick and has been stable for more than 200 million years.

The facility footprint itself encompasses 14 fenced ha (35 fenced ac) of surface space and about 12 km (7.5 mi) of underground excavations in the Salado Formation. There are four shafts to the underground: the waste shaft, salt handling shaft, air intake shaft, and exhaust shaft (Figure 1.4.3-3). There are several miles of paved and unpaved roads in and around the WIPP site, and an 18-km-long (11-mi-long) access road runs north from the site to U.S. Highway (US) 62-180. The access road that is used to bring TRU waste shipments to WIPP is a wide, two-lane road with paved shoulders.

The initial construction of WIPP began in the 1980s. The first shipments of CH TRU and RH TRU waste were received at WIPP on March 26, 1999, and January 23, 2007, respectively. The total capacity for the disposal of TRU waste established under the WIPP LWA as amended (P.L. 102-579 as amended by P.L. 104-201) is 175,675 m^3 (6.2 million ft^3). The Consultation and Cooperative Agreement with the State of New Mexico (1981) established a total RH capacity of 7,080 m^3 (250,000 ft^3), with the remaining capacity for CH TRU at 168,500 m^3 (5.95 million ft^3). In addition, the WIPP LWA as amended limits the total radioactivity of RH waste to 5.1 million curies. Current plans include receipt and emplacement of TRU waste in

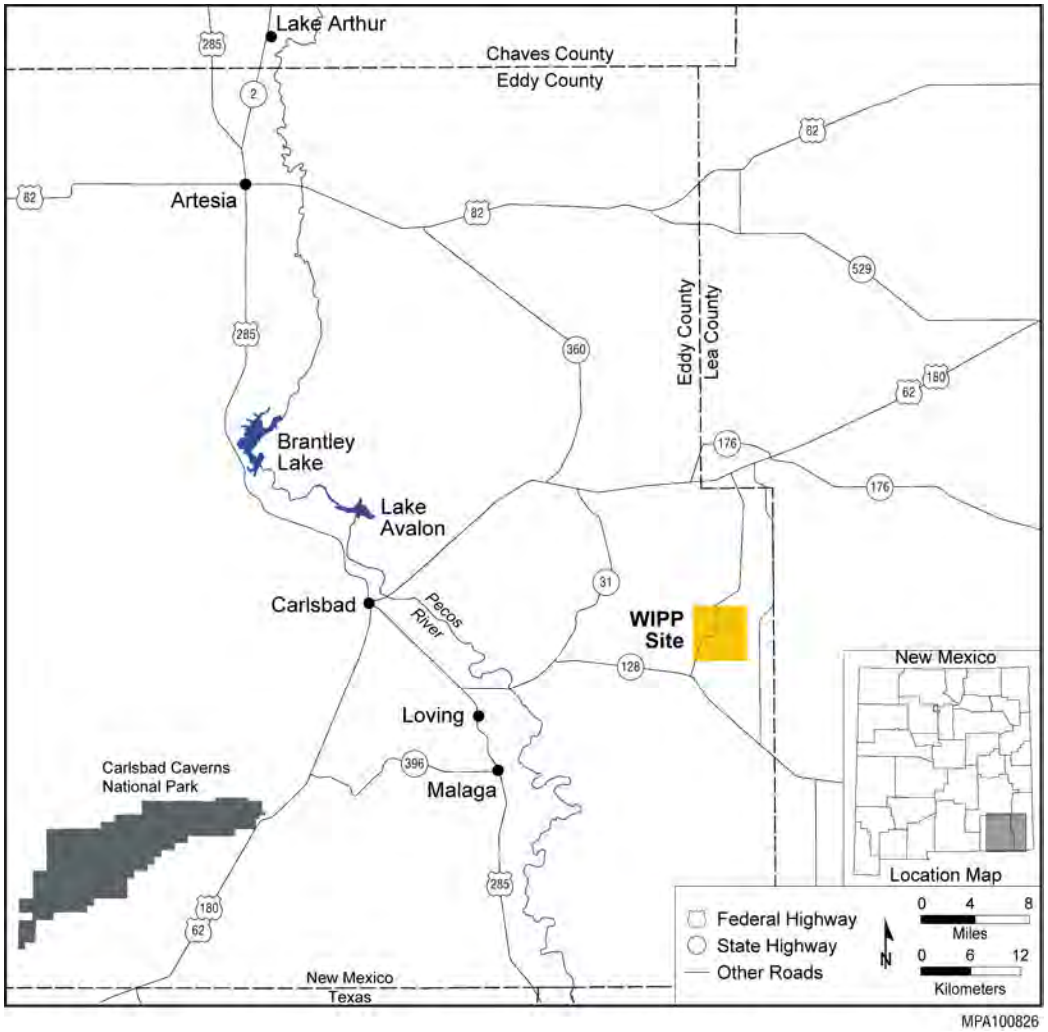

FIGURE 1.4.3-1 General Location of WIPP in Eddy County, New Mexico (Source: Sandia 2008a)

10 waste disposal panels (there are seven rooms in each panel) through fiscal year (FY) 2030. As of FY 2012, waste emplacement in five panels was completed, with emplacement in the sixth panel and mining of the seventh panel completed.

1.4.3.2 Hanford Site

The Hanford Site is located in south-central Washington State on 151,775 ha (375,040 ac) of land between the Cascade Range and the Rocky Mountains (Figure 1.4.3-4). The Columbia River flows through the northern portion of the site and forms part of its eastern boundary. Hanford has been operated by DOE and its predecessors (the Manhattan Engineer District, U.S. Atomic Energy Commission [AEC], and U.S. Energy Research and Development Administration) since it was created in 1943. Its primary mission was to produce nuclear materials in support of national defense and research. Operations associated with those

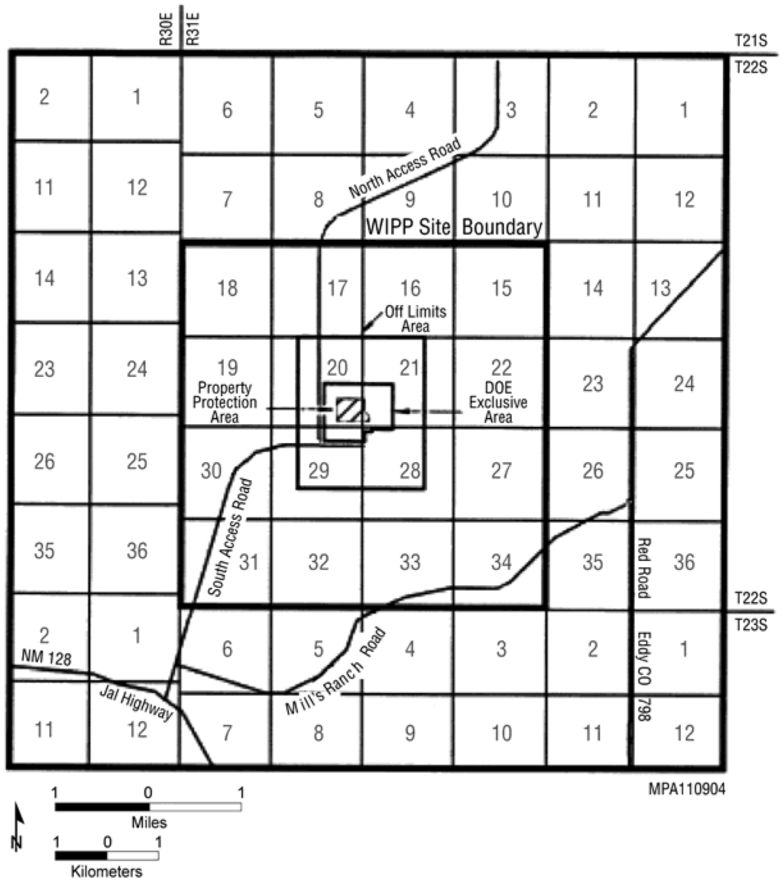

FIGURE 1.4.3-2 Land Withdrawal Area Boundary at WIPP (Source: Sandia 2008a)

programs used facilities for the fabrication of nuclear reactor fuel, reactors for nuclear materials production, chemical separation plants, nuclear material processing facilities, research laboratories, and waste management facilities. Current activities include research, environmental restoration, and waste management (Bunn et al. 2005). The Hanford Reach National Monument (Monument) covers an area of 78,900 ha (195,000 ac) on DOE's Hanford Reservation. Of this, the U.S. Fish and Wildlife Service (USFWS) manages approximately 66,773 ha (165,000 ac) through a DOE permit and other agreements with DOE. DOE directly manages approximately 11,736 ha (29,000 ac), and the Washington Department of Fish and Wildlife currently manages the remainder (approximately 324 ha [800 ac]) under a DOE permit. Because DOE is currently the underlying land holder, it retains approval authority over certain management aspects of the Monument (USFWS 2009).

Current waste management activities at the Hanford Site include the treatment and disposal of LLRW on-site, the processing and certification of TRU waste pending its disposal at WIPP, and the storage of high-level radioactive waste on-site pending treatment and ultimate disposal. DOE will continue to defer the importation of off-site waste at Hanford, at least until

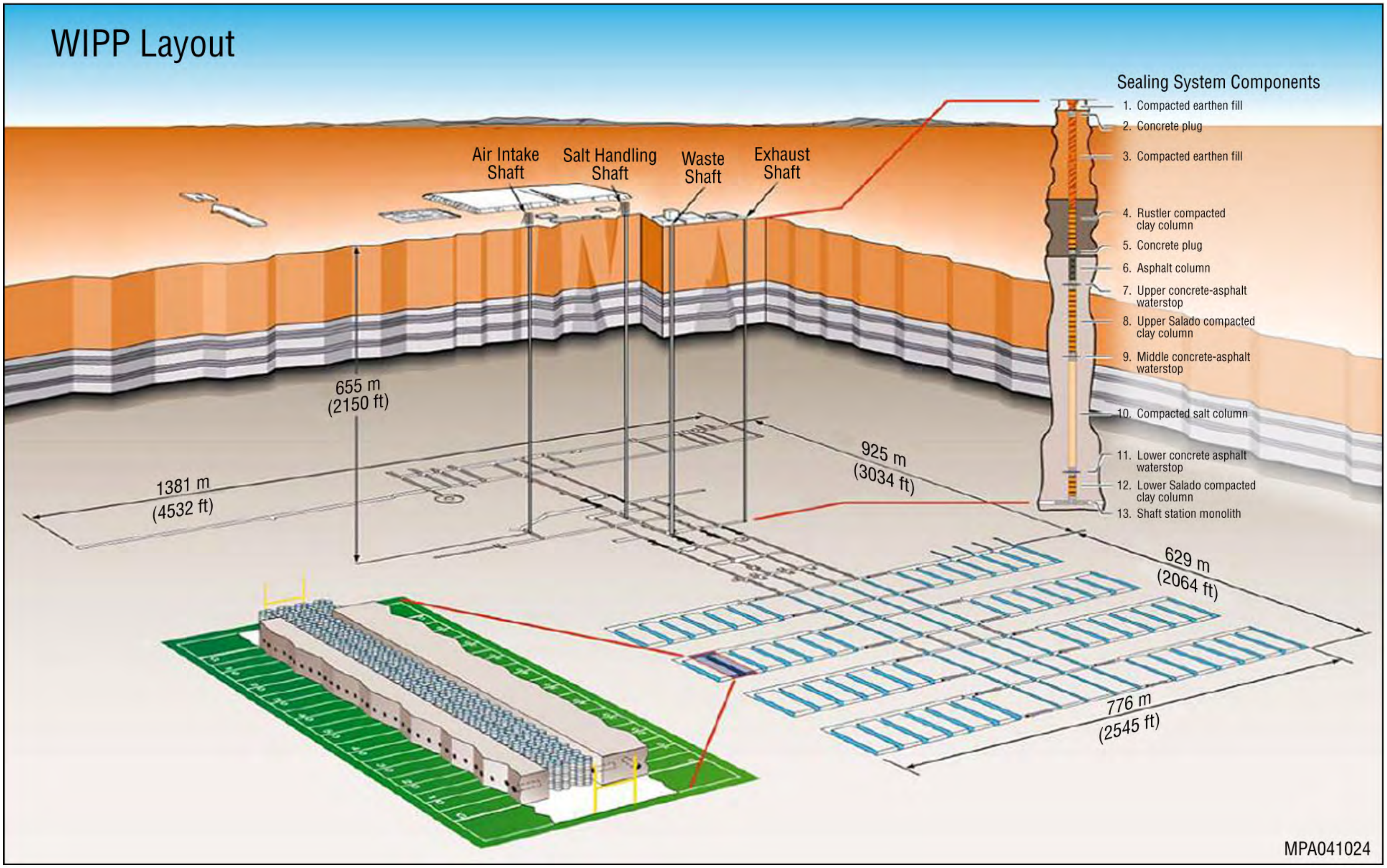

FIGURE 1.4.3-3 Spatial View Showing Underground Shafts at WIPP (Source: Sandia 2008a)

the Waste Treatment Plant (WTP) is operational, subject to appropriate NEPA review and consistent with its previous Preferred Alternative for waste management (74 FR 67189). The limitations and exemptions defined in DOE's January 6, 2006, Settlement Agreement with the State of Washington (as amended on June 5, 2008) regarding State of Washington v. Bodman (Civil No. 2:03-cv-05018-AAM), signed by DOE, the State of Washington Department of Ecology, the Washington State Attorney General's Office, and the U.S. Department of Justice, will remain in place. The main areas where waste management activities occur are the 200 West Area and the 200 East Area, which are south of the Columbia River. These 200 Areas cover about 16 km^2 (6 mi^2). Activities at the 200 Areas include the operation of lined trenches for the disposal of LLRW and mixed LLRW and the operation of the Environmental Restoration Disposal Facility for the disposal of LLRW generated by environmental restoration activities that are being conducted at the Hanford Site to comply with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). DOE will dispose of LLW and MLLW at the Integrated Disposal Facility from the tank treatment operations, WTP and effluent treatment operations, on-site non-CERCLA sources, Fast Flux Test Facility decommissioning and onsite waste management (74 FR 67189). US Ecology, Inc., operates a commercial LLRW disposal facility on a 40-ha (100-ac) site leased by the State of Washington near the 200 East Area. The facility is licensed by the State of Washington.

The GTCC reference location (see Section 1.4.3) is south of the 200 East Area (Figure 1.4.3-4). The 200 East and West Areas are located on a plateau about 11 and 8 km (7 and 5 mi), respectively, south of the Columbia River. Historically, these areas have been dedicated to fuel reprocessing and to waste management and disposal activities (Bunn et al. 2005).

1.4.3.3 Idaho National Laboratory Site

The INL Site is located on 230,000 ha (580,000 ac) of relatively undisturbed DOE land in the upper Snake River Plain in southeastern Idaho (Figure 1.4.3-5). Basalt flows cover most of the plain, producing a rolling topography. The average elevation at the site is 1,500 m (4,900 ft). The INL Site is bordered by mountain ranges on the north and by volcanic buttes and open plain on the south. Lands immediately adjacent to the INL Site consist of open rangeland, foothills, and agricultural fields. About 60% of the site is open to livestock grazing (DOE 2006).

The laboratory was created by the AEC in 1949 to build and test nuclear power reactors. During the 1970s, its mission broadened to include areas such as biotechnology, energy and materials research, conservation, and renewable energy. In 2003, DOE announced that Idaho National Engineering and Environmental Laboratory and Argonne National Laboratory-West would be the lead laboratories for the development of the next generation of power reactors. In 2005, the two laboratories became INL (DOE 2006).

Key facilities consist of clusters of buildings and structures that are typically less than a few square miles each, separated from each other by miles of gently rolling, sagebrush-covered, semi-arid desert. In addition to the INL Site, DOE owns or leases laboratories and administrative offices in the city of Idaho Falls, about 40 km (25 mi) east of the INL Site boundary.

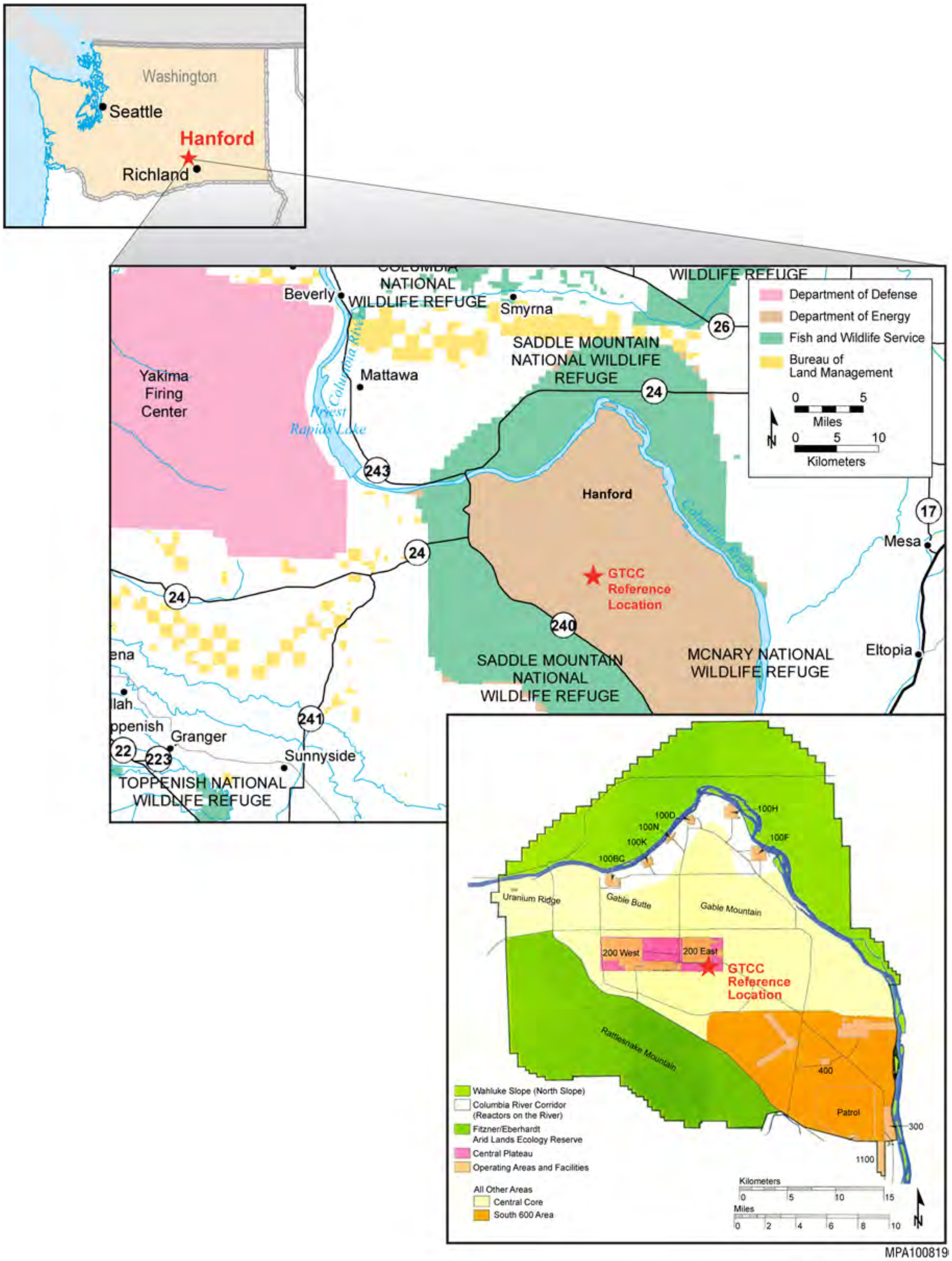

FIGURE 1.4.3-4 GTCC Reference Location at the Hanford Site

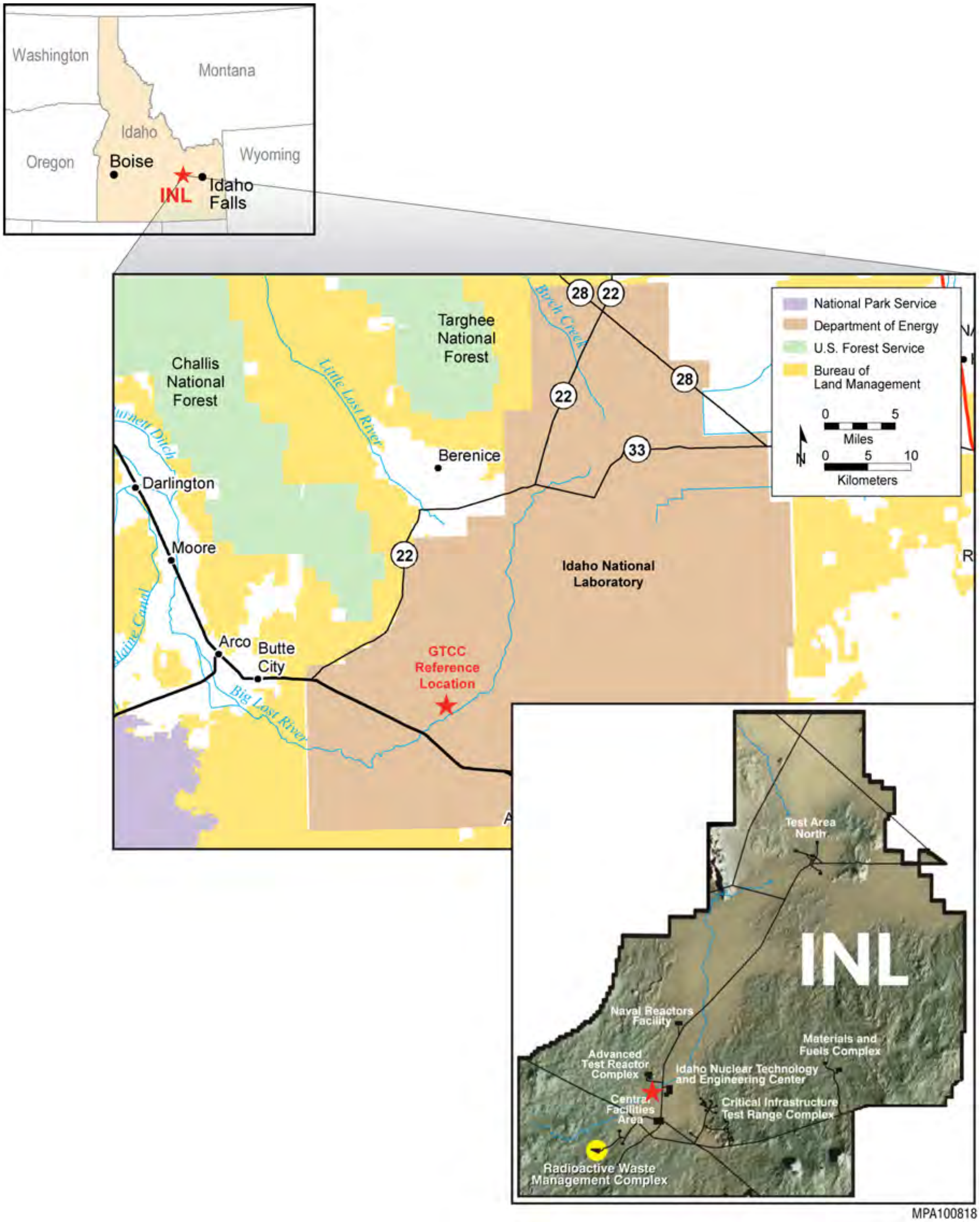

FIGURE 1.4.3-5 GTCC Reference Location at the INL Site

Current waste management activities at the INL Site include the treatment and storage of mixed LLRW (waste containing hazardous constituents in addition to radionuclides) on-site, the treatment of LLRW on-site and its disposal on-site or off-site in DOE or commercial facilities, the storage of TRU waste on-site and its preparation for and shipment to WIPP, and the storage of high-level radioactive waste and spent nuclear fuel (SNF) on-site pending the disposal of these last two materials. These wastes originate from DOE activities and from the on-site Naval Reactors Program. LLRW (RH waste) from INL Site operations is disposed of at the Subsurface Disposal Area at the Radioactive Waste Management Complex (RWMC). CH LLRW is sent off-site. TRU waste is also stored and treated at the RWMC and Idaho Nuclear Technology and Engineering Center (INTEC) to prepare it for disposal at WIPP. The *Environmental Assessment for the Replacement Capability for Disposal of Remote-Handled Low-Level Radioactive Waste Generated at the Department of Energy's Idaho Site* (RH LLW EA; INL 2011) identified its preferred site to be one that is located to the southwest of the Complex in the same area as the GTCC reference location. The GTCC site, if sited at the INL Site, would not be expected to affect the preferred site selected by the RH LLW EA.

The GTCC reference location, which is southwest of the Advanced Test Reactor (ATR) Complex in the south central portion of the INL Site (Figure 1.4.3-5), serves as a basis for evaluation. If the INL Site is selected, the final location for a GTCC land disposal facility will be based on further analysis. The ATR is dedicated to research supporting DOE missions, including nuclear technology research. The RH LLW EA (INL 2011) identified its preferred site to be one that is located to the southwest of the ATR Complex in the same area as the GTCC reference location. The GTCC site, if sited at the INL Site, would not be expected to affect the preferred site selected by the RH LLW EA.

1.4.3.4 Los Alamos National Laboratory

LANL is located in northern New Mexico, within Los Alamos County, on 9,320 ha (23,040 ac) of land owned by the U.S. Government and administered by DOE's National Nuclear Security Administration (NNSA) (Figure 1.4.3-6). The site is situated on the eastern flank of the Jemez Mountains along an area known as the Pajarito Plateau. The terrain in the LANL area consists of mesa tops and canyon bottoms that trend in a west-to-east direction, with the canyons intersecting the Rio Grande River to the east of LANL. Elevations range from about 2,380 m (7,800 ft) at the highest elevation on the western side of the site to about 1,890 m (6,200 ft) at the lowest point along the eastern boundary at the Rio Grande. Laboratory operations are conducted in numerous facilities located in 48 designated Technical Areas (TAs) and at other leased properties located nearby. The laboratory's core mission since its creation in 1943 has been to maintain the effectiveness of the nation's nuclear deterrent. As one of the world's leading research institutions, it performs scientific, technological, and engineering work that supports nuclear materials handling, processing, and fabrication; stockpile management; materials and manufacturing technologies; nonproliferation programs; and waste management activities (LANL 2008).

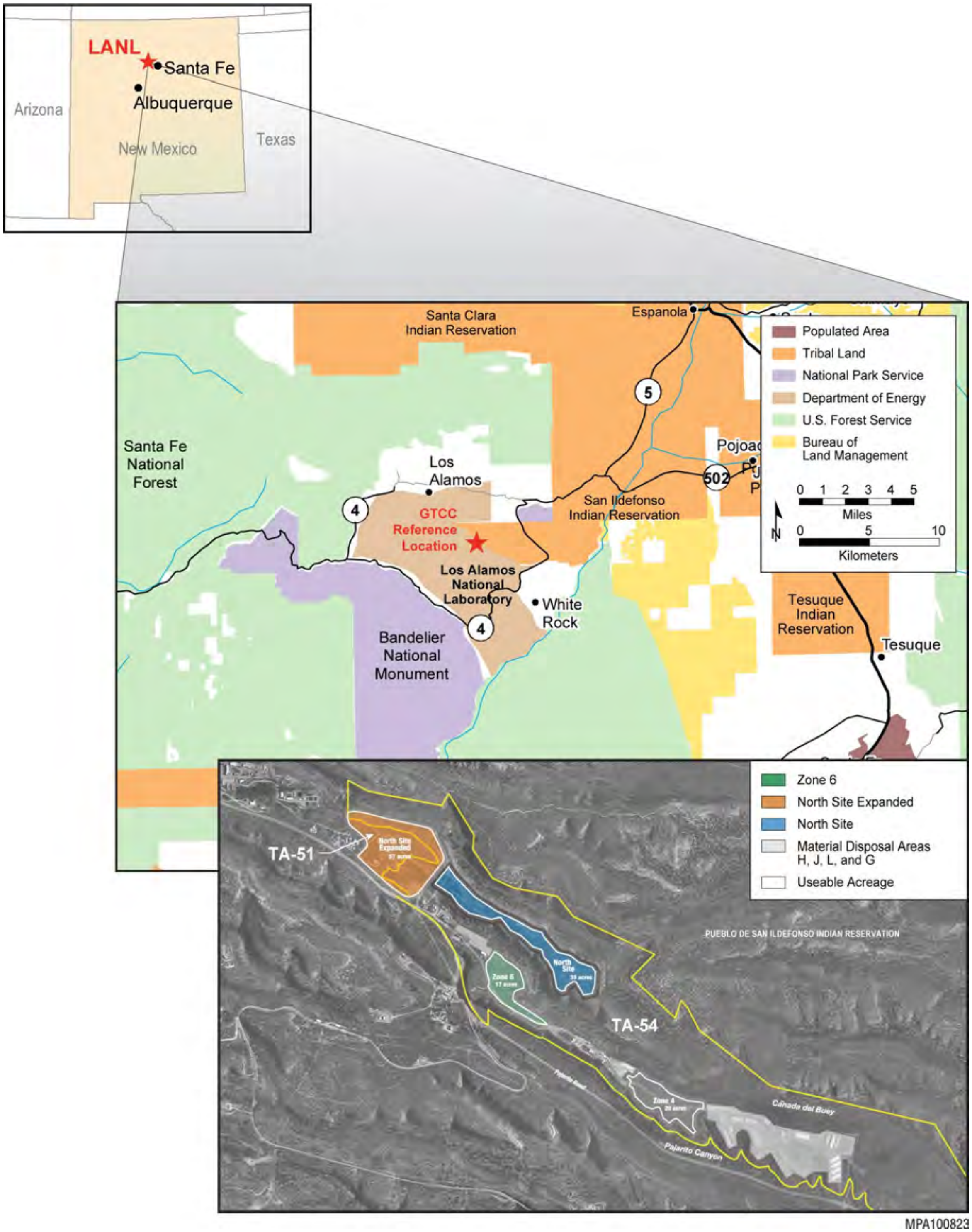

FIGURE 1.4.3-6 GTCC Reference Location at LANL[6]

6 The map is not to scale and should not be relied on for a legal description of land boundaries.

There are more than 1,100 structures on the site, providing about 743,000 m^2 (8.0 million ft^2) of covered space. About half of the square footage at LANL is considered laboratory or production space; the remaining area is considered administrative, storage, service, or other space. Most of the site is undeveloped, which provides a buffer for security and safety and offers the possibility of expansion for future use. LANL is one of the largest institutions in northern New Mexico and has more than 12,500 employees, including laboratory, protective force, and support contractor personnel (LANL 2012).

Current waste management activities at LANL include the storage of mixed LLRW, the disposal of LLRW on-site, the storage of TRU waste on-site, and staging of sealed sources recovered by the GMS/OSRP for national security or public health and safety reasons pending disposal. Area G at Technical Area-54 (TA-54) currently accepts on-site LLRW for disposal; also, in special cases, off-site waste has been accepted from other DOE sites for disposal. Engineered shafts are actively used to dispose of RH LLRW.

Since 1989, DOE has funded the Environmental Program at LANL to complete the cleanup of the environmental legacy contamination brought about from seven decades of nuclear weapons development and management, as well as government-sponsored nuclear science and energy research.[7] Groundwater sampling data from monitoring wells at LANL indicate the presence of chromium groundwater contamination beneath Mortandad Canyon near the property boundary between LANL and the Pueblo de San Ildefonso. This chromium contamination is a result of historical use of potassium dichromate – a corrosion inhibitor – in non-nuclear cooling-tower water that was discharged to an outfall as part of LANL operational maintenance activities. DOE evaluated a proposed interim measure that would control migration of the chromium groundwater contamination plume off LANL lands and the feasibility of long-term corrective actions intended to remediate the chromium plume in an environmental assessment (DOE/EA-2005).[8]

In March 2005, LANL, DOE, and the New Mexico Environment Department signed the Compliance Order on Consent. In this document, LANL agreed to a schedule for completion of cleanup at various locations on the LANL site. In January 2012, DOE and the State of New Mexico issued a nonbinding Framework Agreement as a blueprint on how to clean up LANL. It specifically calls for the cleanup of TRU waste currently stored in aboveground containers on the LANL grounds at Area G. The Framework Agreement sets a deadline for disposal of over 3,700 m^3 (130,000 ft^3) of TRU waste from Area G by June 30, 2014. That disposal involves physically packing the radioactive TRU waste into approved transportation containers that are then shipped by truck to WIPP in Carlsbad for permanent underground emplacement. The Framework Agreement also includes a DOE/LANL commitment to complete

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[7] Legacy contamination is generally defined as the contamination of the environment resulting from pre-1999 Los Alamos National Laboratory activities and waste-management practices within DOE's environmental management scope.

[8] *Final Environmental Assessment for Chromium Plume Control Interim Measure and Plume-Center Characterization, Los Alamos National Laboratory, Los Alamos, New Mexico* (December 2015). http://energy.gov/nepa/ea-2005-chromium-plume-control-interim-measure-and-plume-center-characterization-los-alamos.

the removal of all newly generated TRU waste that was received at Area G during FY 2012 and FY 2013 by December 31, 2014. The Framework Agreement continues to prioritize groundwater and surface water monitoring to ensure protection of human health and the environment.[9]

In June 2011, a major fire began in the vicinity of LANL: the Las Conchas fire. The fire burned over 17,000 ha (43,000 ac) on the first day. By the time it was fully contained, the Las Conchas fire had burned approximately 64,000 ha (156,000 ac). Approximately 52 ha (133 ac) of LANL were burned in the Las Conchas fire and related back burns. Although the fire burned only a small area of LANL, it affected areas above it, which created areas with little or no vegetation, increasing the risk of flooding and erosion at LANL and in surrounding communities. Following the Las Conchas fire, another wildfire in the Gila National Forest (Whitewater-Baldy Wildfire) that burned in May/June of 2012, has surpasses the acreage burned in the Las Conchas wildfire.

1.4.3.5 Nevada National Security Site

NNSS is located about 96 km (60 mi) northwest of Las Vegas in southern Nevada on 352,512 ha (870,400 ac) of land managed by DOE (Figure 1.4.3-7). NNSS is surrounded by federal installations and lands with strictly controlled access and by federal lands on the southern border of NNSS that are open to the public. Its terrain is characterized by high relief, with elevations ranging from about 823 m (2,700 ft) at Frenchman Flat in the southeastern portion of the site to about 2,340 m (7,680 ft) on Rainier Mesa. Historically, the primary mission of NNSS was to conduct nuclear weapons tests. The tests have altered the natural topography of NNSS, creating craters in the Yucca Flat and Frenchman Flat basins and on the Pahute and Rainier Mesas. Since the moratorium on nuclear testing in the United States began in October 1992, the mission of NNSS has been to maintain the readiness to conduct nuclear tests in the future. The site also supports DOE’s waste management program, as well as other national-security-related research and development (R&D) and testing programs (DOE 1996).

NNSS presently serves as a disposal site for LLRW and mixed LLRW generated by DOE facilities. It is also an interim storage site for a limited amount of newly-generated TRU mixed wastes pending transfer to WIPP for disposal. Radioactive waste management activities are conducted in Areas 3 and 5. From 1984 through 1989, boreholes (at depths of 21 to 37 m [70 to 120 ft]) were used at the Area 5 Radioactive Waste Management Site (RWMS) to dispose of LLRW and TRU waste.

The GTCC reference location at NNSS is within Area 5 and serves as a basis for evaluation for this EIS (Figure 1.4.3-7).

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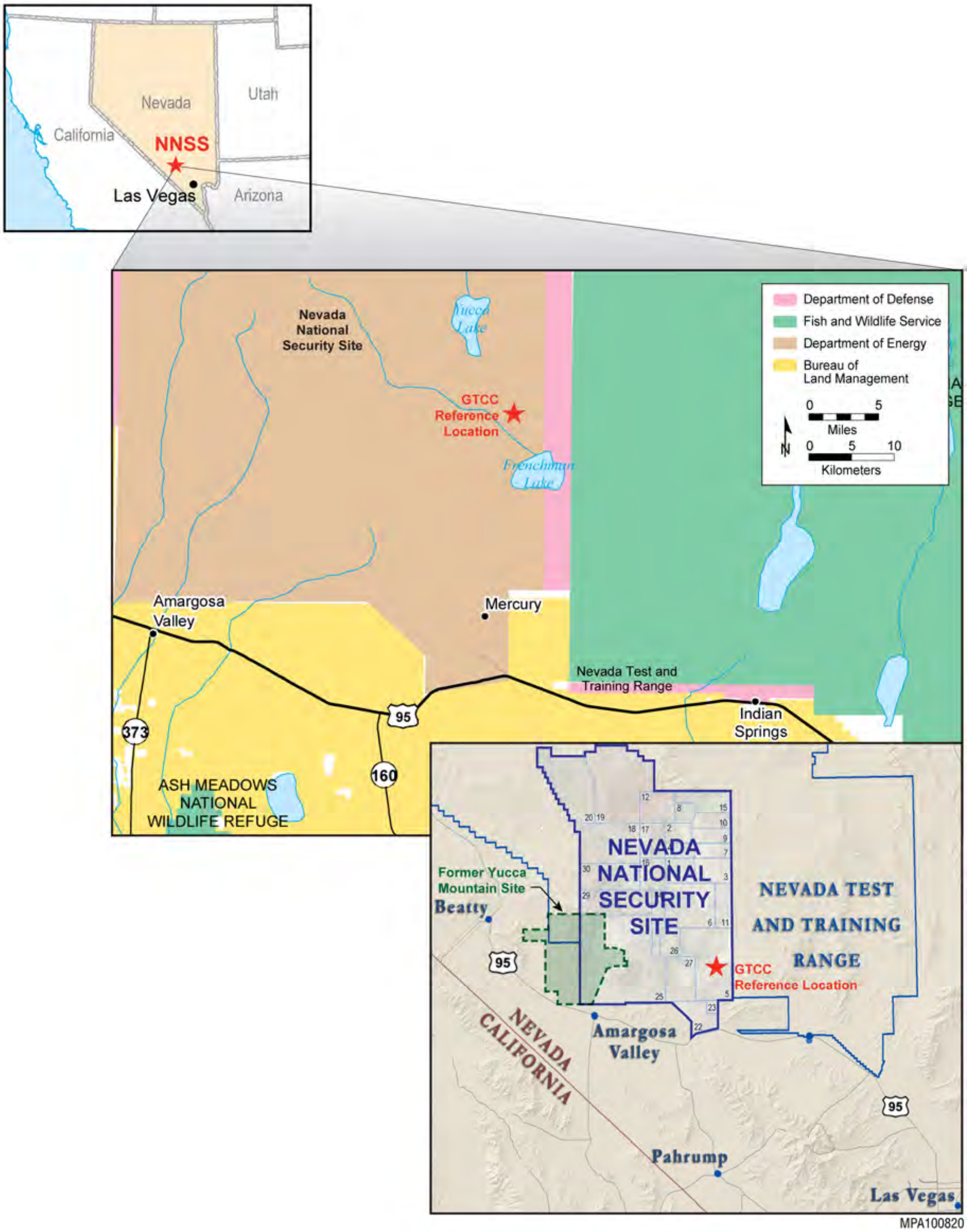
9 The 2005 Consent Order is currently under re-negotiation with NMED. Once the agreement is finalized (projected in 2016), it will supersede the 2005 Consent Order.



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2 **FIGURE 1.4.3-7 GTCC Reference Location at NNSS**

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1.4.3.6 Savannah River Site

SRS occupies 80,130 ha (198,000 ac) in Aiken, Allendale, and Barnwell Counties in South Carolina. SRS is approximately 19 km (12 mi) south of Aiken, South Carolina, and 24 km (15 mi) southeast of Augusta, Georgia. It is bounded on the southwest by the Savannah River (Figure 1.4.3-8).

The AEC established SRS in the early 1950s, and until the early 1990s, its primary mission was the production of nuclear materials to support national programs. The Savannah River National Laboratory was so designated in 2004. Currently the site's missions are environmental management, which includes the treatment, storage, and disposal of radioactive waste; defense programs, which include tritium services to meet stockpile stewardship requirements; and nuclear nonproliferation, which includes the construction of the Mixed Oxide Fuel Fabrication Facility. The SRS management and operations contractor is currently Savannah River Nuclear Solutions, LLC, while Savannah River Remediation operates the liquid radioactive waste program.

SRS currently manages high-level waste, TRU waste, LLRW, and mixed LLRW. High-level waste is vitrified at the Defense Waste Processing Facility and stored on-site pending disposal. TRU waste is stored, prepared for shipment, and shipped to WIPP for disposal. LLRW is treated and disposed of on-site, or it is prepared for shipment to be disposed of at other DOE sites (e.g., NNSS) or commercial facilities. On-site facilities for LLRW disposal include engineered trenches and vaults.

The GTCC reference location at SRS is situated on an upland ridge within the Tinker Creek drainage, about 3.2 km (2 mi) to the northeast of Z-Area in the north-central portion of SRS (Figure 1.4.3-8). The area is not currently being used for waste management.

1.4.3.7 WIPP Vicinity

WIPP Vicinity refers to Township 22 South, Range 31 East, Sections 27 and 35, with each section containing a total of 260 ha (640 ac) or 2.6 km^2 (1 m^2). Section 27 is within the WIPP LWB, while Section 35 is just outside the WIPP LWB to the southeast and is managed by BLM (Figure 1.4.3-9). Only a portion of Section 27 and 35, if selected, would be needed to accommodate a new GTCC LLRW and GTCC-like waste disposal facility. WIPP is located in Eddy County in southeastern New Mexico, about 50 km (30 mi) east of the city of Carlsbad. The land is a relatively flat, sparsely inhabited area (118,556 people in an 80-km [50-mi] radius, according to the 2010 census), known as Los Medaños (Spanish for "the dunes"). There are no potash or oil and gas leases on Section 27 since it is part of the land that has been withdrawn. Section 35 contains oil and gas leases. Currently, no waste management activities are being conducted at Section 27 or Section 35.

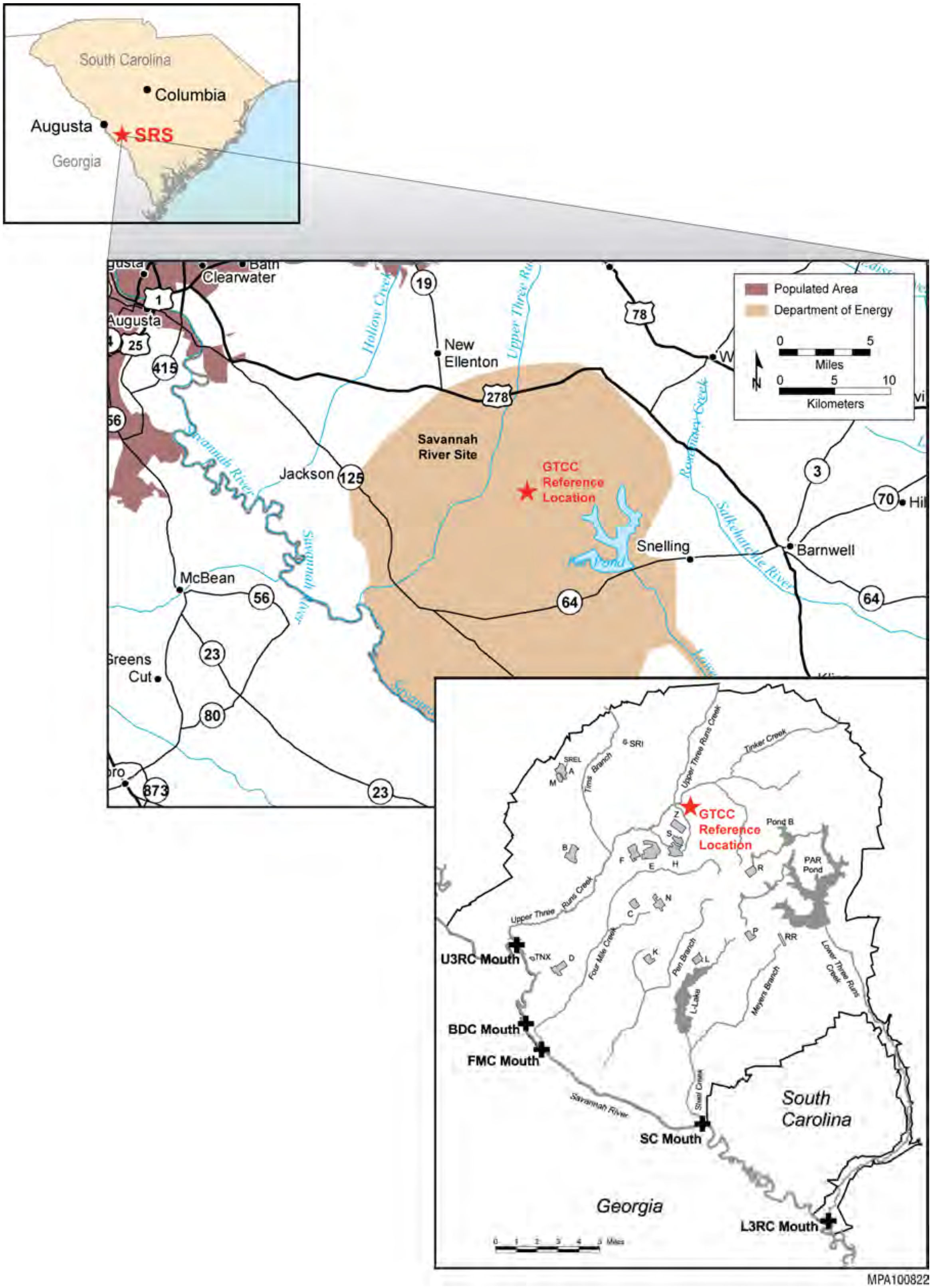
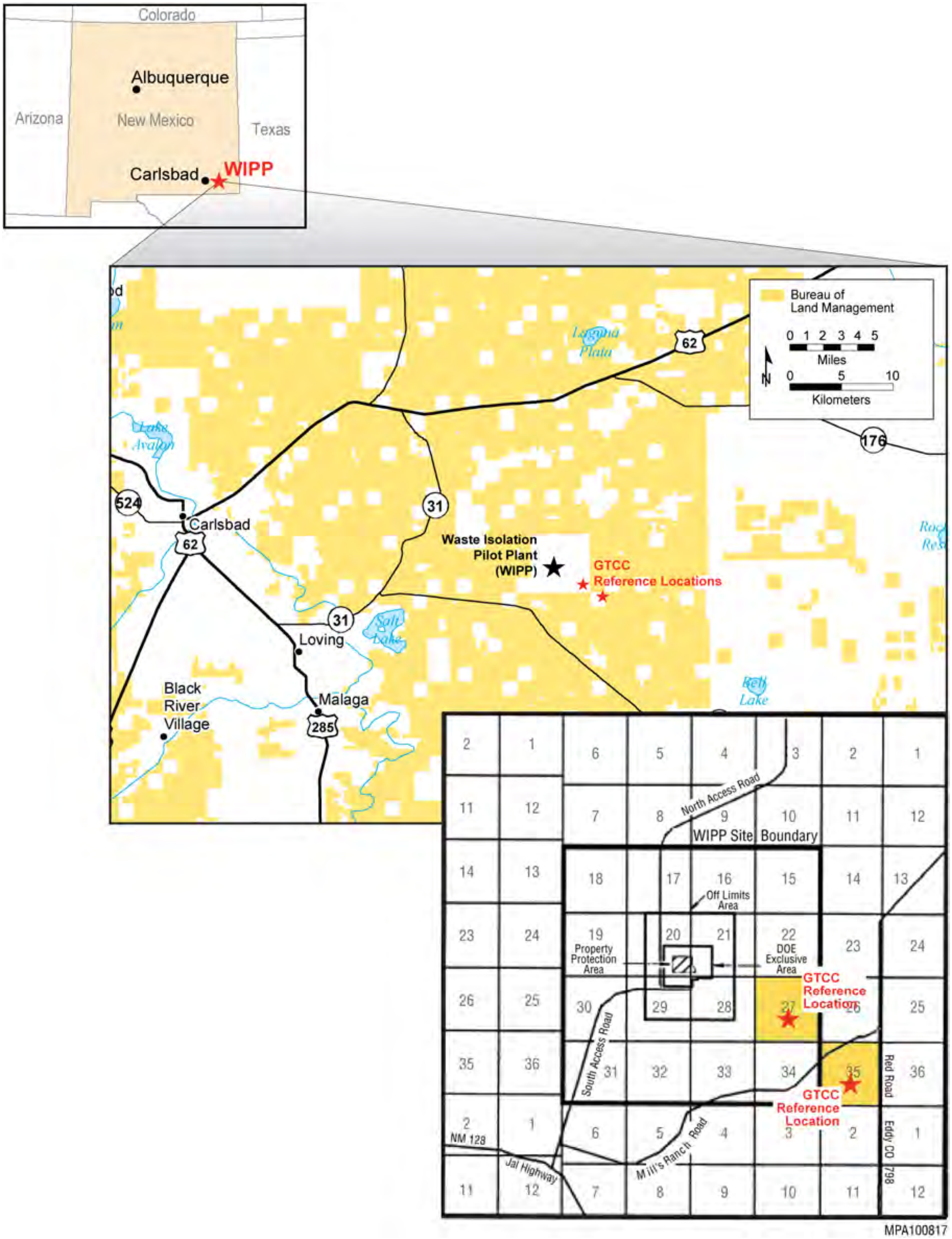


FIGURE 1.4.3-8 GTCC Reference Location at SRS



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2 **FIGURE 1.4.3-9 GTCC Reference Locations (Sections 27 and 35) at the WIPP Vicinity**

3

1.4.3.8 Generic Regional Commercial Disposal Sites

The generic commercial sites are evaluated in this EIS on the basis of a regional approach that divides the United States into four regions consistent with the designations of Regions I through IV of the NRC. The states that make up each of these four regions are shown in Figure 1.4-2. Region I comprises the 11 states in the northeast; Region II comprises the 10 states in the southeast; Region III comprises the 7 states in the Midwest; and Region IV comprises the remaining 22 states in the western part of the United States.

Current commercially operated LLRW disposal facilities for non-GTCC LLRW are located in Region II (Barnwell in South Carolina, which receives Class A, B, and C waste) and Region IV (facilities in Richland, Washington, and in Clive, Utah, which receive Class A, B, and C waste, and Class A waste, respectively). Another disposal facility (located in Region IV in Andrews County, Texas) has been licensed and is now operating and available to dispose of Class A, B, and C wastes. The federal sites evaluated in this EIS are also located within these same two regions.

1.5 PUBLIC PARTICIPATION PROCESS

Several opportunities for public participation were provided during the preparation of this EIS. Consistent with requirements of the Council on Environmental Quality (CEQ) (40 CFR 1501.7) and DOE NEPA implementation procedures, an early and open scoping process was carried out to determine the scope of the EIS and identify the significant issues related to the proposed action; that is, an Advance Notice of Intent (ANOI) (70 FR 24775) and an NOI (72 FR 40135) were issued for public review. Public participation was also solicited during the review of the Draft EIS during the public comment period. NEPA requires that comments on the Draft EIS be evaluated and considered during the preparation of the Final EIS and that a response to comments be provided. Figure 1.5-1 shows the NEPA process for this EIS. Section 1.5.1 provides details on the public scoping period, and Section 1.5.2 provides the same for the public comment period.

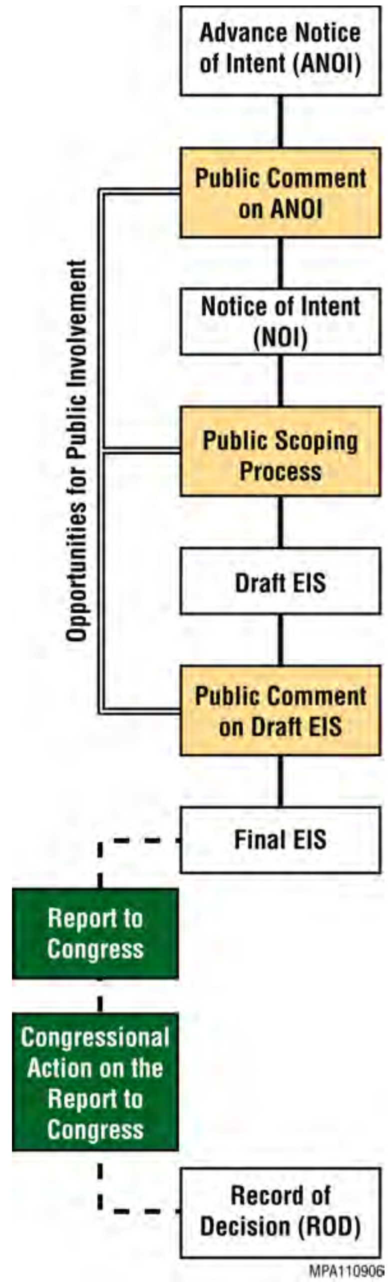

FIGURE 1.5-1 GTCC EIS NEPA Process

1.5.1 Public Scoping Period

The ANOI was issued on May 11, 2005 (70 FR 24775). The NOI was issued on July 23, 2007 (72 FR 40135), with a printing correction issued on July 31, 2007 (72 FR 41819). Nine public scoping meetings were held during the 60-day comment period from July 23 through September 21, 2007. A meeting was held at each of the following cities: (1) Carlsbad, New Mexico; (2) Los Alamos, New Mexico; (3) Oak Ridge, Tennessee; (4) North Augusta, South Carolina; (5) Troutdale, Oregon; (6) Pasco, Washington; (7) Idaho Falls, Idaho; (8) Las Vegas, Nevada; and (9) Washington, D.C. Approximately 330 members of the public attended these meetings.

Oral comments were made and written comments were received at the meetings. Transcripts of each meeting were generated, and the oral comments included in these transcripts were reviewed for consideration in preparing this EIS. Written comments submitted at the meetings and other comments received via the project website, by electronic mail, and in letters were also considered and incorporated as appropriate in preparing this EIS. Approximately 250 comments (oral and written) were received. A summary of the public scoping process conducted in 2007 and a summary of the comments received are presented in Appendix J of this EIS. The summaries and transcripts of the public scoping meetings can be viewed on the project website at www.gtcceis.anl.gov.

Comments received during the public scoping period focused on the amount of inventory being included for evaluation in the EIS, the sites that would be considered, the disposal methods or technologies that would be considered, the resource areas to be evaluated, and the impact assessment methodologies. Representative comments and DOE responses are provided as follows. The first set of comments presents those determined to be within the EIS scope, and the second set presents those determined to be outside the scope of the EIS.

1.5.1.1 Comments Determined To Be Within EIS Scope

- *Disposal of GTCC LLRW and GTCC-like waste at the sites proposed in the NOI should not be considered because these sites are still undergoing cleanup. In addition, these sites either have regulatory conditions or site characteristics (e.g., geology) that make them unsuitable for consideration in the EIS.*

  The basis for proposing the sites to be considered in the NOI and evaluated in the EIS was their mission compatibility, in the sense that all of these sites have radioactive waste disposal operations as part of their current missions. These sites are thus considered viable for analysis for disposal of this waste in the EIS. The scope of the EIS includes the identification of potential disposal sites and the evaluation of the feasibility and effectiveness of these sites for hosting a safe disposal facility for GTCC LLRW and GTCC-like waste.

- *The preferred alternative for disposal of GTCC LLRW and GTCC-like waste should be a geologic repository.*

  Disposal at WIPP, a geologic repository, is one of the alternatives evaluated in the Draft EIS, and a preferred alternative in the Final EIS. In addition, DOE is evaluating alternative methods of disposal (i.e., borehole, trench, and vault disposal). NRC regulations governing disposal of GTCC LLRW contemplate that nongeologic disposal alternatives may be approved (see 10 CFR 61.55(a)(2)(iv)).

- *More detailed characterization information should be provided on the waste inventory, including the source of the waste, its location (by state), and its specific characteristics. It is not clear how the volumes and activities for stored and projected waste were developed, and the distinction between what is considered stored versus what is considered projected is not clear either. The sources of information and important assumptions used to develop this information should be provided in the EIS, along with an indication of the accuracy of the estimates.*

  The GTCC EIS and supporting documents provide characterization information on wastes to allow for a comparative analysis of potential environmental impacts associated with the disposal of these wastes. The approach used by DOE to develop the inventory information are provided in the EIS and in supporting documents, including the identification of relevant resources and DOE's due diligence in determining that current expected waste quantity estimates remain valid, and are conservative and bounding for the purposes of this comparative analysis (see Sections S.2.1 and S.2.4). The EIS also provides information on the current location of GTCC LLRW and GTCC-like waste producers (e.g., Table B-2).

- *The EIS should identify the quantity of mixed waste requiring disposal and identify the process for working with the EPA and respective state agencies to manage these wastes.*

  The GTCC LLRW and GTCC-like waste inventory includes a very small volume of mixed waste that may require disposal. It is assumed that the generator of the waste will treat it to remove the hazardous waste characteristic or obtain a waiver from the appropriate regulatory authority so that the waste is no longer regulated as mixed waste. No mixed GTCC LLRW or GTCC-like waste is assumed to be disposed of in the sites being evaluated in the EIS. The volume of potential mixed waste is about 170 m^3 (6,000 ft^3).

- *What is the scope of the EIS and evaluation endpoints (e.g., period of time with respect to risk of release)? The EIS should identify long-term monitoring requirements for the disposal sites.*

The scope of the EIS addresses all aspects associated with disposal of GTCC LLRW and GTCC-like waste. Impacts are evaluated at the various time periods associated with the actions needed to safely dispose of these wastes. The long-term impacts on groundwater are evaluated for 10,000 years or to the point of maximum dose and latent cancer fatality (LCF) risk, whichever is longer. The EIS identifies the need for long-term monitoring of disposal sites, as appropriate.

- *The EIS should incorporate available site-specific data for the generic commercial facility evaluations. In addition, the evaluation of the disposal of GTCC LLRW and GTCC-like waste in boreholes for all sites being evaluated should be based on actual site data.*

Site-specific data were used to identify the important parameters necessary to site and operate a disposal facility for GTCC LLRW and GTCC-like waste at arid and humid generic sites. The analyses of the various disposal technologies (including the use of boreholes) in the EIS were based on actual site data to the extent necessary to provide reliable evaluations. A site-specific evaluation would be done in a subsequent NEPA review as appropriate.

- *Consultation with tribal nations should be initiated early in the process.*

Tribes contributed to the preparation of the Draft EIS and participated in the review of the Draft EIS by attending public meetings regarding GTCC and submitting comments that are addressed in Appendix J of this EIS. Since the receipt of tribal comments in 2011 on the Draft EIS, DOE has continued routine consultation with tribes as part of normal operations at the DOE sites evaluated in this EIS. DOE will continue to involve the tribes in the decision making process for the disposal of GTCC.

- *The EIS should identify all federal and state agencies and any jurisdictional authority by law and/or special expertise. Also, the EIS should address all pertinent regulatory issues and standards, including NRC regulation of a facility at a DOE site.*

The EPA is a cooperating agency on the EIS because of its expertise in radiation protection. The NRC is a commenting agency. Pertinent regulatory issues and standards associated with disposal of GTCC LLRW and GTCC-like waste are addressed in the EIS.

1.5.1.2 Comments Determined To Be Outside EIS Scope

- *In addition to considering disposal at WIPP in the EIS, efforts should be initiated to site and construct a new geologic repository for GTCC LLRW and GTCC-like waste in case this repository is not acceptable.*

  As discussed in the NOI (72 FR 40135), DOE does not plan to evaluate an additional deep geologic repository facility because siting another deep geologic repository facility for GTCC LLRW and GTCC-like waste would be impractical due to the cost and time involved and the relatively small volume of GTCC LLRW and GTCC-like waste.

- *Hardened on-site storage (HOSS) should be added to the alternatives evaluated in the EIS. In addition, HOSS should be the preferred alternative.*

  HOSS and other waste storage approaches beyond the No Action Alternative are considered to be outside the scope of this EIS because they do not meet the purpose and need for agency action. Consistent with Congressional direction in Section 631 of the Energy Policy Act of 2005, DOE plans to complete an EIS and a ROD for a permanent disposal facility for this waste, not for long-term storage options. In addition, the No Action Alternative evaluates storage of this waste consistent with ongoing practices.

- *The EIS should include disposal options for Class B and Class C LLRW in its scope.*

  Inclusion of Class B and Class C LLRW is beyond the scope of this EIS. DOE is responsible under the LLRWPAA (P.L. 99-240) for the disposal of GTCC LLRW and DOE wastes. States and Compacts are responsible for the disposal of Class A, B, and C LLRW.

- *The GTCC LLRW inventory needs to be expanded to address the disposal and possible consolidation and concentration of Class B and Class C LLRW by commercial nuclear utilities, resulting in additional GTCC LLRW.*

  The waste inventory is based on the best available information on GTCC LLRW, and it considers utility waste resulting from decommissioning activities. Data on the GTCC LLRW that might be generated by the concentration and consolidation of Class B and Class C LLRW are difficult to ascertain at this time because of the speculative nature of these events. The uncertainty that would be introduced in the EIS process by including this potential volume is not warranted.

- *Additional radioactive wastes should not continue to be produced until there is a waste disposal solution for these materials.*

This issue is beyond the scope of the EIS, which is limited to the evaluation of the potential environmental impacts from using various disposal options for GTCC LLRW and GTCC-like waste.

- *The EIS should address the increased sensitivity of children, the elderly, pregnant women, and women in general to radiation exposure. The analysis should not be based on a reference man but on the reference family concept. In addition to radiation doses, estimates of the cancer risks should be provided in the EIS to allow for a comparison to EPA carcinogenic risk standards.*

  The concerns with regard to the increased sensitivity of various elements of the population are noted. The EIS presents a comparative analysis of the potential radiation doses and LCF risks to members of the general public (as represented by an adult receptor) from use of the various disposal alternatives presented in the NOI. As such, the level of detail requested here is not necessary for the purposes of this EIS, and the hazards associated with management of these wastes are presented in terms of the annual dose and LCF risk to a potentially exposed adult receptor.

  The estimates for dose and LCF risk were based on a resident farmer receptor, which is considered a conservative scenario that accounts for the largest number of pathways of potential exposure. The primary pathway of concern, however, is the ingestion of groundwater potentially contaminated with radionuclides released from wastes at the proposed disposal facility. The estimated dose and LCF risk to an adult receptor presented in the EIS are considered conservative (relative to any other potential receptor) because the ingestion rate assumed for water intake is the 90th percentile value for the general public recommended by the EPA (i.e., two liters per day for 365 days per year) (EPA 2000).

  Follow-on NEPA evaluations will be conducted, as needed, to assess potential human health impacts on a site-specific basis (accounting for sensitive populations as applicable) when a disposal site or location is identified.

- *Further research on and/or investigation of other treatment and disposal technologies currently being developed should be considered to ensure that these wastes are managed safely. The hazards posed by GTCC LLRW and GTCC-like waste are comparable to those from high-level radioactive wastes and should be managed in a similar manner.*

  Further research on treatment and disposal technologies is not needed to ensure these wastes are safely managed and that disposal complies with the LLRWPAA (P.L. 99-240), which makes the federal government responsible for the disposal of GTCC LLRW. It would not be reasonable to analyze in detail an essentially unlimited number of additional non-DOE or nonfederal sites. Nevertheless, DOE also conducted a generic evaluation of commercial disposal facilities on nonfederal lands in the EIS in order to provide, to the extent possible, information regarding the potential long-term performance of other (nonfederal) locations for siting a GTCC LLRW and GTCC-like waste land disposal facility.

1.5.2 Public Comment Period

A Notice of Intent (NOI) to prepare the Draft GTCC EIS was published in the *Federal Register* on July 23, 2007 (72 FR 40135), and it began a 60-day public scoping period that ended on September 21, 2007. All scoping comments received were considered in the preparation of the EIS. A Notice of Availability (NOA) for the Draft GTCC EIS was published in the *Federal Register* on February 25, 2011 (76 FR 10574), and it began a 120-day public comment period that ended on June 27, 2011. All comments received on the Draft EIS were considered in the preparation of the Final GTCC EIS.

DOE received a total of 1,196 comment documents, which accounted for 3,982 individual comments. Of the 1,196 comment records received, 154 were from organizations or federal or state agencies; 495 were from private citizens; and 547 were campaign letters, emails, or web comments received from six organizations (i.e., Snake River Alliance, Friends of the Gorge, Concerned Citizens for Nuclear Safety, Nuclear Watch, Citizen Letter, and the Brookfield Assisted Living Facility). Written comments were received via letter, email, or through submission of a comment form provided at the public hearings or on the project website. Oral comments are included in transcripts documenting each of the public hearings held on the Draft GTCC EIS.

Comments were reviewed and responses prepared by policy experts, technical subject matter experts, and NEPA experts. Comments were evaluated to determine whether alternatives and analyses presented in the Draft EIS should be modified, whether additional or corrected information is needed, and whether additional or revised text would clarify the information being conveyed. The comments received and responses provided are presented in Appendix J of this EIS. The comments received have been summarized into 10 comment topics, which are presented here, along with corresponding responses (detailed responses to each of the comment records can be found in Appendix J, Section J.3):

1. *Disposal of GTCC LLRW and GTCC-Like Waste at a New Near-Surface Land Disposal Facility at DOE Sites Evaluated (i.e., at the Hanford Site, INL Site, LANL, SRS, NNSS, and the WIPP Vicinity) – Comments received recommended that specific sites should be removed from consideration in developing a GTCC LLRW and GTCC-like waste near-surface land disposal facility.*

   The disposal methods and sites evaluated in the EIS encompass the range of reasonable alternatives for the disposal of GTCC LLRW and GTCC-like waste, consistent with NEPA implementing regulations in the *Code of Federal*

Regulations at 40 CFR Parts 1500–1508. In this GTCC EIS, DOE analyzed a range of disposal methods (i.e., geologic repository, near-surface trench, intermediate-depth borehole, and above-grade vault) and federally owned sites (i.e., Hanford Site, INL Site, LANL, NNSS, SRS, and the WIPP Vicinity, for which two reference locations – one within and one outside the WIPP LWB – were considered). DOE has determined that it was reasonable to analyze these six sites because they currently have operating radioactive waste disposal facilities, except for the WIPP Vicinity, which is near an operating geologic repository and has basic infrastructure to support the facility.

It would not be reasonable to analyze in detail an essentially unlimited number of additional non-DOE or nonfederal sites. Nevertheless, DOE also conducted a generic evaluation of commercial disposal facilities on non-federal lands in the EIS in order to provide, to the extent possible, information regarding the potential long-term performance of other (nonfederal) locations for siting a GTCC waste land disposal facility.

2. *Disposal of GTCC LLRW and GTCC-Like Waste at WIPP – Commenters were opposed to the possible use of WIPP for disposal of GTCC LLRW and GTCC-like wastes based on legal and technical considerations.*

   DOE acknowledges that only defense-generated TRU waste is currently authorized for disposal at the WIPP geologic repository under the WIPP LWA as amended (P.L. 102-579 as amended by P.L. 104-201) and that legislation would be required to allow disposal of waste other than TRU waste generated by atomic energy defense activities at WIPP and/or for siting a new facility within the land withdrawal area. It would also be necessary to revise the *Agreement for Consultation and Cooperation between Department of Energy and the State of New Mexico for the Waste Isolation Pilot Plant*, the WIPP compliance certification with the EPA, and the WIPP Hazardous Waste Facility Permit. In addition, follow-on NEPA project-specific review, including further characterization of the waste (e.g., radionuclide inventory and heat loads) as well as the proposed packaging for disposal would have to be conducted. The WIPP has been certified by the EPA as an acceptable facility for the disposal of defense-generated TRU waste. The physical and chemical characteristics of the GTCC LLRW and GTCC-like waste proposed for disposal in the WIPP repository are comparable to the TRU wastes currently being disposed of in the repository. Based on the GTCC EIS evaluation, disposal of GTCC LLRW and GTCC-like waste at WIPP would result in minimal environmental impacts on all resource areas evaluated, including human health and transportation.

3. *Consideration of Other Alternatives Not Evaluated in Detail in the EIS, Including Use of HOSS, the Proposed Yucca Mountain Repository, a New Geologic Repository, and Other Disposal Methods (e.g., Mined Cavities) and Alternatives (e.g., Treatment of Waste and Alternative Sources of Energy) – Some commenters requested that the EIS include HOSS as a reasonable alternative for managing all or a portion of the GTCC LLRW and GTCC-like waste inventory, and others indicated that the best approach for disposal of GTCC LLRW and GTCC-like wastes would be to dispose of the entire inventory in a new geologic repository.*

   The use of HOSS and other approaches for long-term storage of GTCC LLRW and GTCC-like waste are outside the scope of this EIS because they do not meet the purpose and need for agency action. The action alternatives evaluated in the GTCC EIS also did not include interim storage of GTCC LLRW and GTCC-like waste until a geologic repository for SNF and high-level radioactive waste becomes available because such interim storage is outside the scope of the GTCC EIS. The purpose of the GTCC EIS is to evaluate the range of reasonable alternatives for the safe and secure disposal of GTCC LLRW and GTCC-like waste.

4. *NEPA Process and Procedures – The Draft EIS does not comply with NEPA because it did not identify a preferred alternative and because sufficient opportunity for public comment was not provided. Many commenters suggested that DOE do a better job of getting the word out about the EIS and the public hearings.*

   This EIS complies with NEPA. NEPA implementing regulations, 40 CFR 1502.14(e), do not require a preferred alternative to be included in a Draft EIS if an agency does not have one. DOE's notification about the public hearings followed normal practices, with advance notice in the Federal Register and notices in local media. DOE held nine public hearings during the 120-day public comment period on the Draft GTCC EIS which extended from February 25, 2011 through June 27, 2011 – a length of time substantially longer than the 45-day minimum CEQ requirement for public comment on a Draft EIS (40 CFR Part 1506.10 (c)).

5. *Tribal and Cultural Resources Concerns – The EIS should consider American Indian tribal concerns. Comments including those from the Santa Clara Pueblo, the Pueblo de San Ildefonso, and the Confederated Tribes and Bands of the Yakama Nation, raised several concerns that DOE proposals rely on institutional controls.*

   DOE appreciates the input provided by the Santa Clara Pueblo, the Pueblo de San Ildefonso, and the Confederated Tribes and Bands of the Yakama Nation on the EIS, both in the tribal narratives and in comments on the Draft EIS. This input was considered by DOE in identifying a preferred alternative. DOE initiated government-to-government consultations with potentially affected American Indian tribes in a timely manner consistent with DOE Order 144.1 and DOE's NEPA implementing guidelines. These consultations were done at a time that DOE had compiled and developed adequate information for the Draft EIS (including identification of the GTCC LLRW and GTCC-like waste inventory) to allow for an informed consultation with potentially affected American Indian tribes. In the EIS, it was assumed that institutional controls of the land disposal units would be maintained for 100 years and that corrective measures could be implemented during this time period to ensure that the engineered barriers lasted for at least 500 years. This assumption is consistent with the institutional control time frame given in both NRC and DOE requirements and was determined to be a reasonable approach for assessing the long-term performance of the disposal units in the EIS.

6. *Transportation Analysis and Impacts – Radioactive waste that has been generated off-site should not be transported to the sites evaluated for disposal and for which the EIS does not identify specific routes or the proportion of wastes that would likely travel those routes. Commenters said that the transportation analysis should consider larger-volume packages and that the supporting information for the facility and transportation accident analyses should have been available.*

   Transportation of GTCC LLRW and GTCC-like waste from generating facilities to a GTCC LLRW disposal facility is a required component of the disposal process that would be identified for the GTCC LLRW and GTCC-like waste because the disposal site(s) or location(s) would not be the same as the generator sites as stated in the EIS. Based on the analysis conducted for this EIS, the transportation of GTCC LLRW and GTCC-like waste to a centralized disposal facility or facilities would result in lower overall human health risks and can be conducted in a safe manner based on compliance with federal and state comprehensive regulatory requirements. The primary radiological transportation risk to the public for any alternative is from the low level of radiation emanating from the transport vehicle. The EIS shows that such risks are small. The magnitude of the collective population risk is primarily determined by the number of routes, the length of each route, the number of shipments along each route, the external dose rate of each shipment, and the population density along a given route. The primary differences among alternatives from the standpoint of transportation are the lengths of the routes as determined by the location of the disposal sites (destination of the shipments). Thus, higher collective population risks are associated with alternatives that require transportation over longer distances. All alternatives involve routes that have similar characteristics, with no significant differences for comparison among alternatives; all require transportation through a range of rural and urban areas. In addition, the routes used in the analysis are considered representative routes because the actual routes used would be determined in the future. For each disposal site, the routes most affected would be the interstate highways that are closest to the site. The transportation analysis as presented in the EIS is conservative in that consideration of the larger volume TRUPACT III and SNF casks could result in potentially reduced impact estimates than those presented due to fewer required shipments. However, while these packages are viable options for transport of the GTCC LLRW and GTCC-like waste, consideration of their use as an option in the EIS did not influence the identification of the preferred alternative.

7. *Model Assumptions for Post-Closure Human Health Impacts – Commenters indicated a number of issues associated with the long-term modeling in the EIS, such as conceptual designs that were too generic, assumptions about uniform environmental conditions, and other unsupported assumptions.*

   The EIS analyses are based on conceptual engineering information and necessitated the use of a number of simplifying assumptions. This approach is consistent with NEPA, which requires such analyses to be made early in the decision-making process. The various land disposal conceptual designs were assumed to be constructed and operated in a comparable manner at each of the various sites. In performing these evaluations, a number of engineering measures were included in the conceptual facility designs to minimize the likelihood of contaminant migration from the disposal units. No facility design can guarantee that radionuclide migration from the facility would not occur over and beyond a 10,000-year time period. It was assumed that these measures would perform similarly for all conceptual designs, remaining intact for 500 years after the disposal facility closed. After 500 years, the barriers would gradually fail. It should be emphasized that project- and site-specific engineering factors would be incorporated into the actual facility designs of the site or sites selected in a ROD to dispose of GTCC LLRW and GTCC-like waste. DOE recognizes that modeling potential releases of radionuclides from the conceptual disposal sites far into the future approximates what might actually occur and is therefore subject to technical uncertainty.

8. *Waste Inventory – The GTCC LLRW and GTCC-like waste inventory addressed in the EIS is much too limited.*

   The GTCC LLRW and GTCC-like waste inventory evaluated in the Draft EIS included all GTCC LLRW and GTCC-like waste in storage, plus GTCC LLRW and GTCC-like waste including buried wastes at the West Valley site, as well as wastes that could reasonably be expected to be generated in the near future. For the purposes of this analysis, waste disposal is assumed to occur from 2019 through 2083. The GTCC LLRW and GTCC-like waste inventory includes stored and projected wastes from the 104 nuclear power plants currently in operation as well as from the 18 commercial reactors that have already been shut down. It also includes projected GTCC LLRW from another planned 33 new reactors that have not yet been constructed. It is not reasonable to extend data beyond existing information on the commercial nuclear power industry to develop estimates of GTCC LLRW that could result from future decommissioning of these reactors, some of which may never be built. In addition, it is possible that new reactor technology could change the projected volumes of GTCC LLRW. In performing its due diligence in the preparation of this Final EIS, DOE reviewed the waste quantity data and determined the GTCC LLRW and the GTCC-like waste inventory estimates remain valid, are conservative and bounding for the comparative analysis in the Final EIS, and revisions to this information are not necessary. This inventory remains valid and is appropriate for use in the EIS and for the development of the preferred alternative for disposal of GTCC LLRW and GTCC-like waste.

9. *Cumulative Impacts – Commenters suggested that the environmental impacts of all potential sources of radioactive contamination at the site, in addition to the impacts associated with transportation of the GTCC LLRW and GTCC-like waste to the Hanford Site, need to be addressed in the cumulative impacts analyses presented in this EIS.*

   DOE has analyzed cumulative impacts at the Hanford Site in this GTCC EIS and indicates that the disposal of GTCC LLRW and GTCC-like waste at the Hanford Site could result in a radiation dose estimate to a nearby hypothetical future resident farmer of about 49 mrem/yr within the first 10,000 years, and most of this dose would be due to I-129 or Tc-99 in groundwater. Based on the cumulative impacts discussed in the *Final Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington* (TC&WM EIS; DOE 2012b), when the impacts of Tc-99 from past leaks and cribs and trenches (ditches) are combined, DOE believes it may not be prudent to add significant additional Tc-99 to the existing environment. Therefore, one means of mitigating this impact would be for DOE to limit disposal of off-site waste streams containing these radionuclides at the Hanford Site.

10. *Statutory/Regulatory and Policy Issues – Commenters indicated that any facility used for the disposal of GTCC LLRW and GTCC-like waste will have to be licensed by the NRC as provided in Section 3(b)(1)(D) of the LLRWPAA (P.L. 99-240) and, as such, disposal criteria would need to be established. Commenters suggested that since GTCC LLRW is commercially generated radioactive waste, it should be disposed of at a commercial site and not at one or more DOE sites. Commenters also questioned how the requirement for NRC licensing of a GTCC LLRW disposal facility would be done if this facility was located at a DOE site, especially if such a facility was used for commercial GTCC LLRW and GTCC-like waste. Commenters suggested that the NRC should have been a more active participant in this process to ensure that the proposed alternatives could actually be implemented.*

DOE determined that the most efficient approach was to address both GTCC LLRW and GTCC-like waste, which have many similar physical and radioactive characteristics, in a single NEPA process. DOE's intent is to facilitate the overall process for addressing the disposal needs of both waste types.

The LLRWPAA (P.L. 99-240) specifies that GTCC LLRW designated a federal responsibility under section 3(b)(1)(D) that results from activities licensed by the NRC is to be disposed of in an NRC-licensed facility that has been determined to be adequate to protect public health and safety. However, unless specifically provided by law, the NRC does not have authority to license and regulate facilities operated by or on behalf of DOE. Further, the LLRWPAA does not limit DOE to using only non-DOE facilities or sites for GTCC LLRW disposal. Accordingly, if DOE selects a facility operated by or on behalf of DOE for disposal of GTCC LLRW for which it is responsible under section 3(b)(1)(D),clarification from Congress would be needed to determine NRC's role in licensing such a facility and related issues. In addition, clarification from Congress may be needed on NRC's role if DOE selects a commercial GTCC LLRW disposal facility licensed by an Agreement State rather than by NRC.

The NRC served as a commenting agency on the GTCC EIS and therefore did not actively participate in the preparation of the GTCC EIS. Issues associated with potential regulatory changes or NRC licensing would be addressed as necessary to enable implementation.

1.6 RELATIONSHIP OF PROPOSED ACTION TO OTHER DOE ACTIVITIES AND PROGRAMS

Other DOE NEPA documents were reviewed to identify other concurrent or proposed NEPA actions that relate to the proposed action described in this EIS.

1.6.1 Final Site-Wide Environmental Impact Statement for Continued Operation of Los Alamos National Laboratory, Los Alamos, New Mexico (DOE/EIS-0380, May 2008)

DOE's GMS/OSRP recovers unwanted or disused sealed sources that pose a national security or public health and safety threat from NRC and Agreement State licensees. These recovered sources are being staged at LANL and off-site commercial staging facilities under contract to LANL pending disposal.

The creation of GMS/OSRP stemmed from early efforts at LANL to recover and disposition excess Pu-239 sealed sources that were distributed in the 1960s and 1970s under the Atoms for Peace Program. After being transferred to the NNSA to be part of GMS, OSRP's mission was expanded to include recovery of materials based on national security considerations.

The ROD issued for the LANL Site-Wide EIS (SWEIS; DOE 2008) adopted an expanded alternative providing NEPA coverage for LANL recovery, storage, and disposition of types and activities of sources in addition to those originally managed by GMS/OSRP. In addition to the actinide sources that will continue to be managed at LANL pending disposal at WIPP, the SWEIS addressed issues associated with the recovery and non-LANL storage of other radionuclides not eligible for disposal at WIPP. These radionuclides, which are brought to LANL only when off-site storage and management are not possible, will either be maintained in storage at the off-site facilities or be disposed of at commercial or DOE disposal facilities if waste acceptance criteria can be met. In November 2012, the Los Alamos Site Office issued a Categorical Exclusion (CX) covering the recovery of up to 4,000 domestic sealed sources in FY 2013 as it continues to implement the NNSA GMS/OSRP Program (DOE 2012a).

1.6.2 Final Environmental Impact Statement for Decommissioning and/or Long-Term Stewardship at the West Valley Demonstration Project and Western New York Nuclear Service Center (DOE/EIS-0226, January 2010)

As announced in the April 20, 2010, ROD (DOE 2010b) for the *Final Environmental Impact Statement for Decommissioning and/or Long-Term Stewardship at the West Valley Demonstration Project and Western New York Nuclear Service Center* (DOE 2010a), DOE decided to implement the Preferred Alternative, Phased Decision-making. Under this alternative, decommissioning will be completed in two phases. Phase 1 involves near-term decommissioning and removal actions for certain facilities and areas and undertakes characterization work and studies that could facilitate future decision-making for the remaining facilities or areas on the property. DOE intends to complete any remaining West Valley Demonstration Project (WVDP) decommissioning decision-making with its Phase 2 decision (to be made within 10 years of the ROD) and expects to select either removal or in-place closure, or a combination of the two, for those portions of the site for which it has decommissioning responsibility. The Phase 2 decision will include whether to remove or close in-place buried waste at the NDA and SDA. If a decision is made to remove the buried waste, the volume of GTCC LLRW and GTCC-like waste that could be generated is projected to be about 4,300 m^3 (150,000 ft^3) and is included in the Group 2 inventory evaluated in this GTCC EIS. The 4,300 m^3 (150,000 ft^3) includes 3,500 m^3 (120,000 ft^3) of Other Waste, 740 m^3 (26,000 ft^3) of activated metals, and 22 m^3 (780 ft^3) of sealed sources.

Currently stored GTCC-like waste (non-defense-generated TRU waste) at the West Valley Site has also been included in the Group 1 inventory for this EIS. The volume of stored GTCC-like waste at the West Valley Site is 880 m^3 (31,000 ft^3). In addition to this stored waste, a total of 1,400 m^3 (49,000 ft^3) of GTCC-like waste would be generated from decontamination and decommissioning (exclusive of the NDA and SDA) at the West Valley Site in the future. About 370 m^3 (13,000 ft^3) of this projected waste is included in the Group 1 inventory, and 980 m^3 (35,000 ft^3) is included in the Group 2 inventory for this GTCC EIS (Argonne 2010).

1.6.3 Final Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington (DOE/EIS-0391, December 2012)

The TC&WM EIS analyzes alternatives for three types of actions: (1) retrieving and managing waste from 177 underground storage tanks at Hanford and closing the single-shell tanks; (2) decommissioning the Fast Flux Test Facility and its auxiliary facilities; and (3) continuing and expanding solid waste management operations on-site, including disposing of Hanford's LLRW and mixed LLRW and limited volumes of LLRW and mixed LLRW from other DOE sites in the IDF at Hanford. Further, the TC&WM EIS implements a Settlement Agreement signed on January 6, 2006, by DOE, the Washington State Department of Ecology, and the Washington State Attorney General's Office. The agreement settles NEPA claims made in the case State of Washington v. Bodman (Civil No. 2:03-cv-05018-AAM), which addressed the January 2004 *Final Hanford Site Solid (Radioactive and Hazardous) Waste Program Environmental Impact Statement, Richland, Washington*.

The TC&WM EIS includes several preferred alternatives for the actions analyzed, including disposing of Hanford's LLRW and mixed LLRW on-site and deferring Hanford's importation of off-site waste at least until the WTP was operational, consistent with DOE's recently proposed Settlement Agreement with the State of Washington. Off-site waste would be addressed after the WTP was operational, subject to appropriate NEPA reviews. Similar to its preference regarding the importation of LLRW and mixed LLRW, DOE announced in the December 18, 2009, *Federal Register* (74 FR 67189) that, consistent with its preference regarding receipt at Hanford of off-site LLRW and mixed LLRW, DOE would not ship GTCC LLRW to Hanford until, at the earliest, the WTP was operational. As stated in the Hanford TC&WM EIS, when the impacts of Tc-99 from past leaks and cribs and trenches (ditches) are combined, DOE believes it may not be prudent to add significant additional Tc-99 to the existing environment. Therefore, one means of mitigating this impact would be for DOE to limit disposal of off-site waste streams containing I-129 or Tc-99 at Hanford.

1.6.4 Supplemental Environmental Impact Statement for the Long-Term Management and Storage of Elemental Mercury (DOE/EIS-0423-S1, September 2013)

As required by the Mercury Export Ban Act of 2008 (the Act; P.L. 110-414), DOE plans to identify a facility or facilities for the long-term management and storage of elemental mercury generated in the United States. To this end, DOE prepared a supplement to the January 2011 *Final Long-Term Management and Storage of Elemental Mercury Environmental Impact Statement* (Mercury Storage EIS; DOE 2011) to analyze additional alternatives, in accordance with NEPA (*Final Long-Term Management and Storage of Elemental Mercury Supplemental Environmental Impact Statement*, DOE/EIS-0423-S1, September 2013; DOE 2013a). This supplemental EIS evaluates alternatives for a facility in the vicinity of the WIPP near Carlsbad, New Mexico. As also indicated in the Mercury Storage EIS, DOE proposes to construct one or more new facilities and/or select one or more existing facilities (including modification as needed) for the long-term management and storage of elemental mercury in accordance with the Act.

The Mercury Storage EIS evaluated seven candidate locations for the elemental mercury storage facility, as well as the No Action Alternative. Those candidate locations are the DOE Grand Junction Disposal Site near Grand Junction, Colorado; DOE Hanford Site near Richland, Washington; Hawthorne Army Depot near Hawthorne, Nevada; DOE INL Site near Idaho Falls, Idaho; DOE Kansas City Plant in Kansas City, Missouri; DOE SRS near Aiken, South Carolina; and the Waste Control Specialists, LLC, site near Andrews, Texas. Since publication of the Final Mercury Storage EIS, DOE has reconsidered the range of reasonable alternatives evaluated in that EIS. Accordingly, in a Supplement to the EIS, published in September 2013, three additional locations were evaluated for a long-term mercury storage facility in the vicinity of the WIPP, near Carlsbad, New Mexico, which DOE operates for the disposal of defense TRU waste. One of the additional locations evaluated is in Section 20, Township 22 South, Range 31 East, within the land subject to the WIPP LWA as amended (P.L. 102-579 as amended by P.L. 104-201), across the WIPP access road from the WIPP facility. The second is in the vicinity of the WIPP but outside the lands withdrawn by the WIPP LWA as amended, in Section 10, Township 22 South, Range 31 East, approximately 5.6 km (3.5 mi) north of the WIPP facility. Finally, Section 35 was also evaluated. Section 35 is located in Township 22 South, Range 31 East, approximately 5.6 km (3.5 mi) southeast of the WIPP facility.

1.6.5 Final Site-Wide Environmental Impact Statement for the Continued Operation of the Department of Energy/National Nuclear Security Administration Nevada National Security Site and Off-Site Locations in the State of Nevada (DOE/EIS-0426, February 2013) (NNSS SWEIS)

The Final NNSS SWEIS (NNSA 2013) was issued on February 22, 2013 (78 FR 12309). It analyzes the potential environmental impacts of proposed alternatives for continued management and operation of the NNSS (formerly known as NTS) and other DOE/NNSA-managed sites in Nevada, including the Remote Sensing Laboratory (RSL) on Nellis Air Force Base in North Las Vegas, the North Las Vegas Facility (NLVF), the Tonopah Test Range (TTR), and environmental restoration areas on the U.S. Air Force Nevada Test and Training Range (NTTR). The purpose and need for agency action are to provide support for meeting NNSA’s core missions established by Congress and the President and to satisfy the requirements of Executive Orders and comply with Congressional mandates to promote, expedite, and advance the production of environmentally sound energy resources, including renewable energy resources such as solar and geothermal energy systems.

The NNSS SWEIS analyzes the environmental impacts of three reasonable alternatives for continued operations at the NNSS, RSL, NLVF, and NTTR during the 10-year period following the issuance of a ROD. These alternatives include a No Action Alternative and two action alternatives: Expanded Operations and Reduced Operations. The No Action Alternative, which is analyzed as a baseline for evaluating the two action alternatives, would continue implementation of the 1996 NTS EIS ROD (DOE/EIS-0243) and subsequent amendments (61 FR 65551 and 65 FR 10061), as well as other decisions supported by separate NEPA analyses completed since issuance of the final 1996 NTS EIS. The No Action Alternative reflects activity levels consistent with those seen since 1996. The Expanded Operations Alternative analyzes adding reasonably foreseeable new work at the NNSS in the areas of nonproliferation and counterterrorism, high-hazard and other experiments, research and development, and testing. Such expanded operations could include developing test beds for concept testing of sensors, mitigation strategies, and weapons effectiveness. The Reduced Operations Alternative would reduce the overall level of operations and close specific buildings and structures. NNSA would also consider allowing the development of solar power generation facilities under each alternative. The preferred alternative is a "hybrid" that comprises various programs, capabilities, projects, and activities selected from among the three alternatives. Thus the environmental impacts generally fall within the range of magnitudes seen between the No Action and Expanded Use Alternatives.

1.6.6 Supplement Analysis for the Nuclear Infrastructure Programmatic Environmental Impact Statement for Plutonium-238 Production for Radioisotope Power Systems (DOE/EIS-0310-SA-02)

DOE prepared the supplement analysis (DOE 2013b) to evaluate the potential environmental impacts associated with its determination that the 2001 ROD (66 FR 7877) offers the optimum approach for production of Pu-238. The supplement analysis helped to determine if there are significant new circumstances or information relevant to environmental concerns which would warrant preparation of a supplement to the *Programmatic Environmental Impact Statement for accomplishing Expanded Civilian Nuclear Research and Development and Isotope Production Missions in the United States, Including the Role of the Fast Flux Facility* (NI PEIS) (DOE/EIS-0310) or a new EIS, or that the 2001 decision can be implemented without any further NEPA review. DOE completed the supplement analysis in September 2013 and has made the determination that there are no substantial changes to the original proposal for production of Pu-238 analyzed in the NI PEIS or new circumstances or information relevant to environmental concerns that would warrant preparation of a supplement to the NI PEIS or a new EIS, and that the 2001 decision made in the NI PEIS ROD for Pu-238 production can be implemented without further NEPA review.

1.7 OTHER GOVERNMENT AGENCIES

Because of its technical expertise in radiation protection, the EPA participated as a cooperating agency in the preparation of this EIS. The EPA's role as a cooperating agency does not imply its endorsement of DOE's selection of specific approaches, alternatives, or methods. The EPA conducted independent reviews of the Draft and Final EIS and associated documents in accordance with Section 309 of the Clean Air Act (CAA) (*United States Code*, Volume 42, page 7609 [42 USC 7609]). The NRC participated as a commenting agency on the EIS.

Before implementation of the preferred alternative, DOE would consult with appropriate Federal and state agencies, tribes, the Advisory Council on Historic Preservation, the appropriate State Historic Preservation Officer(s) (SHPOs), and pertinent Regional Fish and Wildlife Service Office(s).

1.8 TRIBAL CONSULTATION FOR THE GTCC EIS

DOE and Tribal Representatives have been working cooperatively over the last decade to improve consultation and communication related to decision making. This is an ongoing dialog, and DOE is committed to formal and meaningful consultation and interaction, at the earliest practical stages in the decision-making process, consistent with DOE's American Indian and Alaska Natives Tribal Government Policy (DOE Order 144.1). This Order communicates the Departmental, programmatic, and field responsibilities for interacting with American Indian governments and establishes the Department's Indian policy, including its guiding principles and framework for implementing the policy. Tribal governments affected by DOE-EM activities have been and are invited to participate and assist in the implementation of the policy. The GTCC EIS, directed by Congress under the LLRWPAA (P.L. 99-240) and the Energy Policy Act of 2005 (P.L. 109-58), has created a unique opportunity for the tribes to participate in this EIS process.

DOE initiated consultation and communication activities on the GTCC EIS with 14 participating American Indian tribal governments that have cultural or historical ties to the DOE sites being analyzed in this EIS, as identified in the text box. The consultation activities are being conducted in accordance with President Obama's Memorandum on Tribal Consultation (dated November 5, 2009); Executive Order 13175 (dated November 6, 2000) entitled "Consultation and Coordination with American Indian Tribal Governments"; Executive Memorandum (dated September 23, 2004) entitled "Government-to-Government Relationship with Tribal Governments" (White House 2004); and DOE Order 144.1, "American Indian Tribal Government Interaction and Policy" (dated January 2009). The consultation activities include technical briefings, the development of the written tribal narratives included in this EIS related to the specific site affiliated with the tribe, and/or discussions with elected tribal officials, based on individual tribal preferences and mutually agreed-upon protocols.

In response to tribal requests for consultation at the October 2007 State and Tribal Government Working Group meeting in Snowbird, Utah, DOE, in a January 2008 letter to tribal government officials, communicated its interest in consulting with tribal nations on the GTCC EIS. DOE proposed several consultation activities and invited tribal nations to identify their preferences on the consultation approach to be used for the EIS. Proposed consultation activities included, but are not limited to, formal government-to-government consultations between senior DOE officials and elected tribal officials, staff-to-staff technical briefings, and participation in the development of written narratives on tribal views and beliefs related to the specific site affiliated with the tribe for inclusion in the EIS, such as the cultural resources, socioeconomics, and environmental justice sections.

On February 10 and 11, 2009, DOE met with representatives from the participating tribes and organizations. DOE shared background information on the GTCC EIS; obtained input on technical issues from tribal representatives; identified possible topics for government-to-government consultations; presented information on the opportunity for tribes to submit written narratives describing their unique perspectives on the DOE sites and environmental resource areas being analyzed in this EIS; and obtained preliminary feedback from tribal representatives as to their interest in submitting written narratives. Representatives from the Confederated Tribes of the Umatilla Indian Reservation (CTUIR), Consolidated Group of Tribes and Organizations (CGTO), Duckwater Western Shoshone, Moapa Paiute, Nambe Pueblo, Nez Perce, Pueblo de San Ildefonso, Pueblo of Jemez, Pueblo of Pojoaque, Santa Clara Pueblo, Western Shoshone-Bannock Tribes, Wanapum People, and Yakama Nation participated in the meeting. DOE provided meeting materials to the tribes that were unable to attend the meeting.

The tribes held follow-up discussions to determine if they were interested in developing tribal narratives. Based on the discussions, the following tribes, by site, agreed to participate in developing written narratives: Hanford (CTUIR, Nez Perce, Wanapum), LANL (Cochiti Pueblo, Nambe Pueblo, Pueblo de San Ildefonso, Santa Clara Pueblo), and NNSS (CGTO–Pahrump Paiute Tribe, Colorado River Indian Tribes, Duckwater Western Shoshone Tribe, Moapa Paiute Tribe, Bishop Paiute Tribe, Big Pine Paiute Tribe, Ely Western Shoshone Tribe). In addition to the development of written narratives, other agreed-upon consultation activities began. Tribes contributed to the preparation of the Draft EIS and participated in the review of the Draft EIS by attending public meetings regarding GTCC and submitting comments that are addressed in Appendix J of this EIS. Since the receipt of tribal comments in 2011 on the Draft EIS, DOE has continued routine consultation with tribes as part of normal operations at the DOE sites evaluated in this EIS. DOE will continue to involve the tribes in the decision making process for the disposal of GTCC.

Tribal Nations Participating in GTCC EIS Consultation Activities

Hanford Site

- Confederated Tribes of the Umatilla Indian Reservation (CTUIR), Pendleton, OR
- Nez Perce, Lapwai, ID
- Wanapum People, Ephrata, WA
- Yakama Nation, Union Gap, WA

INL Site

- Western Shoshone-Bannock Tribes, Fort Hall, ID

LANL

- Acoma Pueblo, Acoma, NM
- Cochiti Pueblo, Cochiti, NM
- Laguna Pueblo, Laguna, NM
- Nambe Pueblo, Santa Fe, NM
- Pojoaque Pueblo, Santa Fe, NM
- Pueblo de San Ildefonso, Santa Fe, NM
- Pueblo of Jemez, Jemez, NM
- Santa Clara Pueblo, Española, NM

NNSS

- Consolidated Group of Tribes and Organizations (CGTO) (representing 16 Paiute and Western Shoshone Tribes). Consultation with these tribal nations is being conducted through the CGTO.

Although tribes from the Yakama Nation and the Western Shoshone-Bannock declined at that time to participate in the development of written narratives for the Draft GTCC EIS, these tribes had an opportunity to review the tribal narrative contained in the Draft EIS and submit an update to the existing narrative or provide written narrative for inclusion in the Final GTCC EIS. DOE continues to work with these and the other tribes in the development of the GTCC EIS and provide opportunities for communication and consultation, as needed.

In the development of the tribal narrative, DOE held three facilitated week-long workshops with participating tribes to develop the written tribal narratives. Workshops were held in Las Vegas, Nevada (May 10–15, 2009); Los Alamos, New Mexico (June 8–12, 2009), and Richland, Washington (June 15–19, 2009). During the workshops, the tribes reviewed each of the environmental resource areas being evaluated as part of the GTCC EIS for their specific site (Hanford Site, LANL, or NNSS) and prepared their respective tribal narrative. The CGTO and Pueblos developed a consolidated tribal narrative. The CTUIR and the Nez Perce developed their own stand-alone narratives (Appendix G), with the Wanapum integrating their views into the tribal narrative found in the Hanford Chapter (Chapter 6) along with the narrative related to the Wanapum People found in Appendix G. As presented in the Hanford chapter (Chapter 6), tribal views reflect the views of the CTUIR, Nez Perce, and Wanapum People unless otherwise noted. The written tribal narratives related to specific resource areas are included in the EIS chapters on Hanford, LANL, and NNSS. Some common issues identified by the tribes include the following:

- *Climate change*. The climate has changed in the past 10,000 years. Tribes perceived that the lives of American Indian people have changed during these climatic shifts, that plant and animal communities have shifted, and that such shifts would occur again in the future (perhaps in the near future, given the potential impacts of global climate change).

- *Soils and minerals*. At each of the potential GTCC locations, regional soils and minerals found at or around the site play an important role in cultural and ceremonial activities.

- *Ecological impacts on the traditional use of plant and animal species by American Indians*. Ecological concerns relate to the fact that the analyses tend to focus on threatened and endangered species and plants. The full ranges of species need to be evaluated, especially in terms of American Indian use of plants and animals. Plants are used for medicine, food, basketry, tools, homes, clothing, fire, and social and healing ceremonies. Animals and insects are culturally important, and the relationship between them, the earth, and American Indian people are represented by the roles they play in the stories of American Indian people.

- *Human health impacts and American Indian pathways analysis*. Tribes raised concerns that pathways specific to American Indian peoples be analyzed. They believe that standard calculations of human health exposure as used in the GTCC EIS for the general public are not applicable to American Indian populations.

- *Cultural resources*. Tribal cultural resources include all physical, artifactual, and spiritual aspects for each of the potential areas being evaluated at Hanford, LANL, and NNSS. All things of the natural environment contribute to the cultural resources for the tribal lifestyle.

- *Visual resources*. Views are important cultural resources that contribute to the location and performance of American Indian ceremonies. Viewscapes are typically experienced from high places or tend to provide panoramic views.

Tribal perspectives, comments, and concerns identified during the consultation process, those received during the public scoping process (see Appendix J), and those received from the Draft GTCC EIS public comment period were considered by DOE in identifying the preferred alternative discussed in Section 2.10. Since the receipt of tribal comments in 2011 on the Draft EIS, DOE has continued routine consultation with tribes as part of normal operations at the DOE sites evaluated in this EIS. DOE will continue to involve the tribes in the decision-making process for the disposal of GTCC.

1.9 PRIMARY CHANGES MADE TO THE EIS

> **Revisions to the Draft Environmental Impact Statement (EIS)**
>
> Sidebars in this final EIS identify revisions made to the draft EIS in response to comments, revised information or updates.

On the basis of the public comments received (as summarized in the Topics of Interest discussed in Appendix J, Section J.2), the primary change made to the Draft EIS to prepare this Final EIS was the addition of Appendix J, which provides a comment response summary that addresses the comments received on the Draft EIS as well as detailed responses to individual comments, in addition to the discussion of the preferred alternative for the disposal of GTCC LLRW and GTCC-like wastes, which is presented in Section 2.10. In performing its due diligence in preparation of this Final EIS, DOE reviewed the waste quantity data and determined that the current expected waste quantity estimates remain valid, are conservative and bounding for the comparative analysis in the Final EIS, and revisions to this information are not necessary. Information that related to census data was also updated to reflect the 2010 census data for this Final EIS; including, for example, socioeconomic, transportation, and environmental justice impacts. The transportation accident analysis was reviewed, and the source terms used in the accident consequence assessment were included in Section 5.3.9.3. Other revisions (for clarification or editorial purposes) were also made as a result of public comments received on the Draft GTCC EIS. Finally, site information was also updated on the basis of the further review conducted by DOE Field Offices and information from annual site environmental reports (for the year 2014).

1.10 ORGANIZATION OF THIS ENVIRONMENTAL IMPACT STATEMENT

In this EIS, each chapter has its own reference list. The chapters that present the assessments for each of the action alternatives (i.e., Chapters 4 through 12) provide descriptions of the affected environment, an impacts analysis, a summary of the impacts, and a cumulative impacts analysis. The appendices provide additional supporting information for the analyses discussed in Chapters 1 through 13. Figure 1.10-1 further provides a guide on where key sections are presented in this EIS.

- Chapter 1 provides an introduction that explains the purpose and need for DOE action and describes the proposed action by DOE. It also briefly describes the waste inventory, the disposal methods being considered, and the potential sites for disposal that were evaluated.

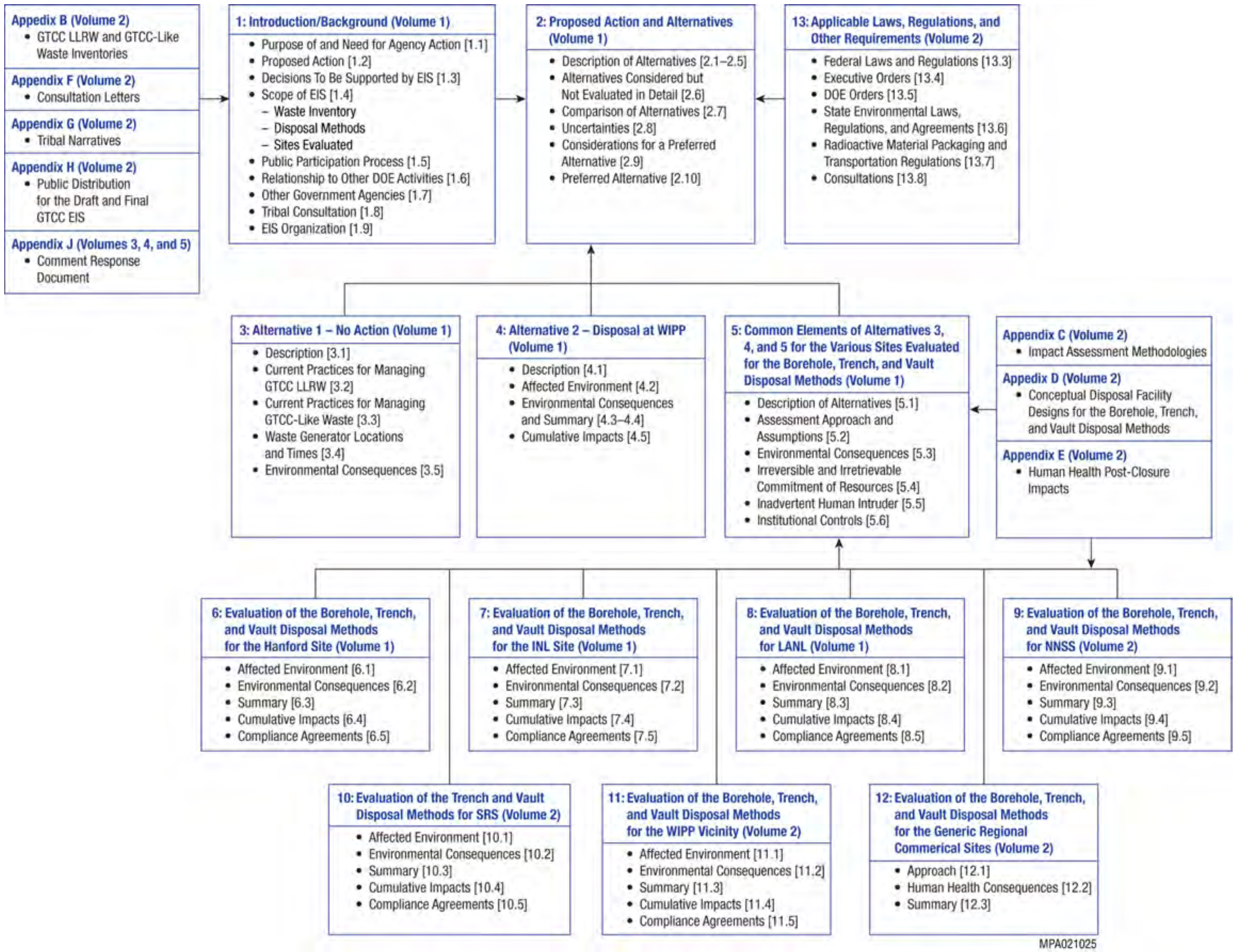

FIGURE 1.10-1 Organization of the GTCC EIS and Relationships of Its Components (Note that the GTCC EIS is made up of five volumes; the specific volume in which each component is contained is indicated in the figure above.)

- Chapter 2 describes the preferred alternative and the alternatives evaluated in this EIS and compares them with regard to the environmental and human health impacts they would have.

- Chapter 3 presents an evaluation of the No Action Alternative (Alternative 1).

- Chapter 4 presents the evaluation of geologic disposal at WIPP (Alternative 2).

- Chapter 5 describes disposal in a new intermediate-depth borehole facility (Alternative 3) and disposal in new enhanced near-surface facilities using the trench method (Alternative 4) or vault method (Alternative 5). Chapter 5 also describes the EIS assessment approaches, assumptions, and impacts that are common to these methods at the sites evaluated.

- Chapters 6 through 11 present results of the assessments of the borehole, trench, and vault disposal methods, as applicable, by site for the federally owned sites (Hanford Site, INL Site, LANL, NNSS, SRS, and WIPP Vicinity). Tribal narratives as provided by the tribes are also incorporated in the Hanford, LANL, and NNSS chapters (Chapters 6, 8, and 9, respectively).

- Chapter 12 presents the results of the assessments of the borehole, trench, and vault disposal methods at the generic commercial sites for Regions I to IV (based on NRC regions).

- Chapter 13 summarizes applicable laws, regulations, and other requirements that are relevant to the activities and sites considered in this EIS.

- Chapter 14 is an index.

- Appendix A is a disclosure statement.

- Appendix B discusses the waste inventory in more detail.

- Appendix C provides information on the potential impacts, assessment methodology, and other considerations.

- Appendix D presents details on the borehole, trench, and vault conceptual facility designs and information on the construction and operations associated with the design concepts.

- Appendix E provides supporting information for the calculations performed to estimate groundwater concentrations and doses from the disposal facilities extended to 10,000 years after closure of the facility and beyond.

- Appendix F provides consultation letters.

- Appendix G provides the tribal narratives for the Hanford Site, the INL Site, and LANL.

- Appendix H provides a distribution list for this EIS.

- Appendix I provides a list of the preparers of this EIS.

- Appendix J presents the comment response document for the Draft EIS.

1.11 REFERENCES FOR CHAPTER 1

Argonne (Argonne National Laboratory), 2010, *Supplement to Greater-Than-Class C (GTCC) Low-Level Radioactive Waste and GTCC-Like Waste Inventory Reports*, ANL/EVS/R-10/1, prepared by Argonne, Argonne, Ill., for U.S. Department of Energy, Office of Environmental Management, Oct.

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2 PROPOSED ACTION AND ALTERNATIVES

Consistent with the purpose and need described in Chapter 1, DOE is evaluating the range of reasonable alternatives for the disposal of GTCC LLRW and GTCC-like waste, which consists of four action alternatives in addition to the No Action Alternative. The action alternatives address a range of disposal depths, from deep disposal (geologic repository), to intermediate-depth disposal (borehole facility), to enhanced near-surface disposal (trench and vault facilities). DOE is evaluating the use of an existing geologic repository (WIPP) and/or the construction of a new borehole, trench, or vault facility or facilities to safely dispose of the GTCC LLRW and GTCC-like waste. The new facility or facilities could be located at the Hanford Site, INL Site, LANL, NNSS, SRS, or the WIPP Vicinity, or at generic nonfederal (commercial or private) lands. Combinations of disposal alternatives may be appropriate based on the characteristics of the waste types and other considerations (e.g., waste volumes, physical and radiological characteristics, and generation rates), as discussed in Section 2.9.

DOE developed these action alternatives after careful consideration of the waste inventory, disposal technologies, and comments received during the public scoping period for this EIS. The WIPP repository is evaluated to determine the feasibility of the disposal of GTCC LLRW and GTCC-like waste at a geologic repository. The proposed land disposal methods (i.e., borehole, trench, and vault) are being evaluated because NRC regulations allow other disposal methods to be proposed for NRC approval and state that there might be some instances when GTCC LLRW would be acceptable for near-surface disposal with special processing or design.

In summary, DOE evaluated the following five alternatives in this EIS:

- Alternative 1: No Action,

- Alternative 2: Disposal in the WIPP geologic repository,

- Alternative 3: Disposal in a new borehole disposal facility,

- Alternative 4: Disposal in a new trench disposal facility, and

- Alternative 5: Disposal in a new vault disposal facility.

For the purposes of the analysis, DOE assumed construction of a new borehole, trench, or vault at all sites analyzed. This assumption provided conservatism in the evaluation methodology. However, an existing borehole, trench, or above-grade vault that meets the conceptual designs discussed in the EIS could be used.

DOE has identified reference locations for evaluating Alternatives 3 to 5 since these alternatives involve the construction of new disposal facilities. These reference locations are generally in areas within the various sites that have been used for other waste disposal activities or in which other disposal facilities or activities are also planned. Figures showing the reference locations of the land disposal facilities can be found in Section 1.4.3 and Chapters 6 through 11 of this EIS, which correspond to the six federal sites being evaluated for the borehole, trench, and vault methods. Reference locations have not been identified for the generic commercial disposal facilities (Chapter 12), and these facilities are evaluated for potential human health impacts in this EIS on a regional basis (coinciding with the four NRC regions) by using generalized input parameters assumed to be representative of each of the regions as a whole.

DOE has evaluated each alternative for its potential consequences on the following 11 environmental resource areas (see also Figure 2-1).

Climate, air quality, and noise;
Geology and soils;
Water resources;
Human health;
Ecology;
Socioeconomics;
Environmental justice;
Land use;
Transportation;
Cultural resources; and
Waste management.

In addition to the above resource areas, DOE evaluated inadvertent human intrusion and cumulative impacts to address the impacts that could result from implementation of the proposed GTCC action at each site in combination with past, present, and planned activities (including federal and nonfederal activities) at or in the vicinity of that site.

DOE has evaluated each of the alternatives in this EIS for disposal of the entire waste inventory in Groups 1 and 2 (i.e., 12,000 m^3 [420,000 ft^3]). The analyses of impacts on two environmental resource areas — human health and transportation — are presented on a waste-type basis and consider whether the waste is stored or projected. This approach provides more details on the alternatives' potential impacts on these two resource areas so that decisions can be made on a waste-type basis, as appropriate. In other words, an alternative might be considered for only a particular waste type; or a combination of alternatives that account for various waste types, waste generation times, disposal site features, and other factors (including regulatory requirements and limitations) might be considered to optimize disposal decisions. The entire inventory, for conservatism, was also analyzed for each site as a total for the other remaining environmental resource areas (climate, air quality, and noise; geology/seismic and soils; water resources; ecology; socioeconomics; environmental justice; land use; cultural resources; and waste management).

The resource areas above are evaluated for the construction, operations, and post-closure phases of the proposed action. However, the proposed disposal facility would not be closed until far into the out-years and would be properly decommissioned at that time. The impact

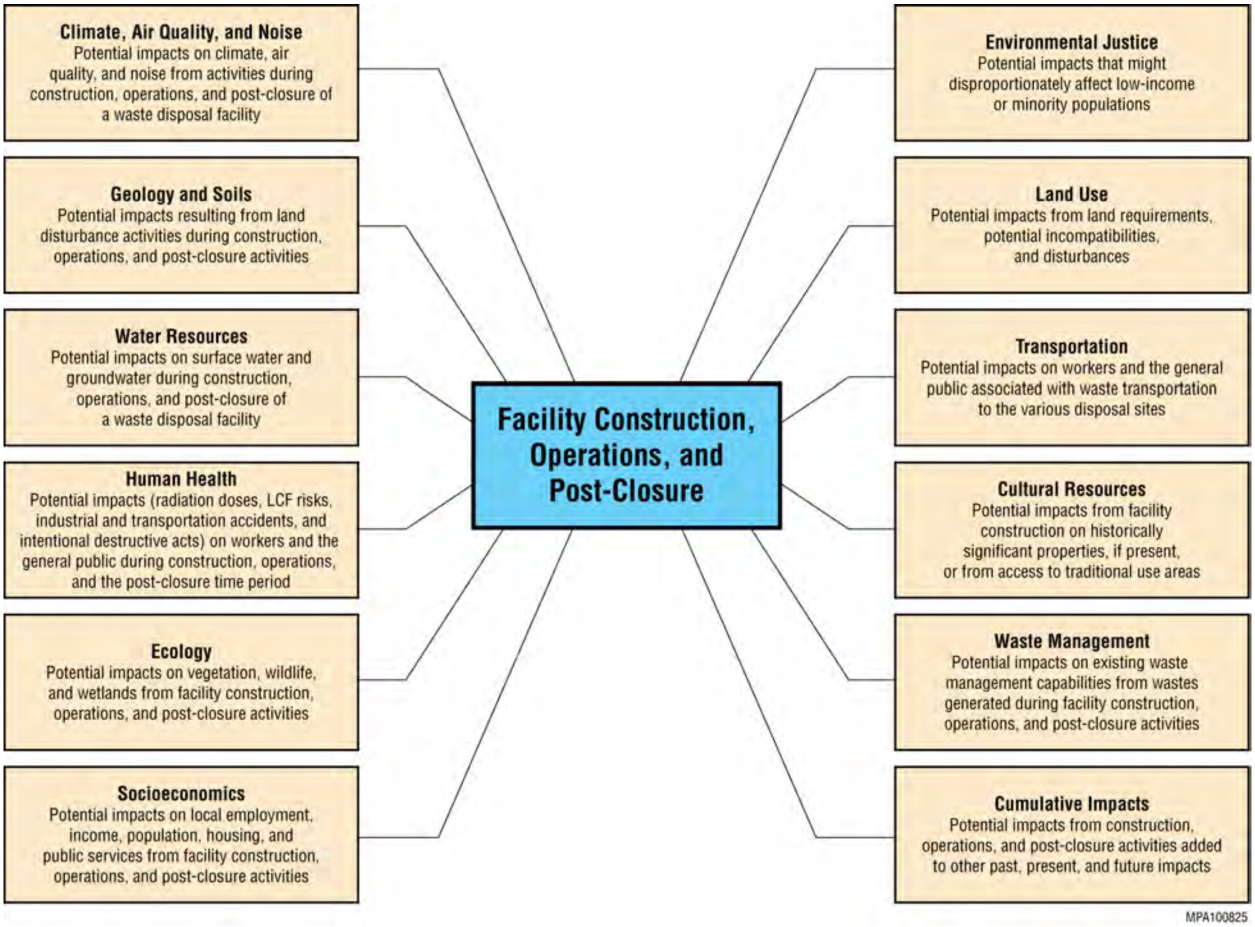

FIGURE 2-1 Environmental Resource Areas on Which the Impacts of the Alternatives Are Evaluated

analysis for the decommissioning phase has not been included in this EIS but would be conducted at a later time, as appropriate.

Sections 2.1 through 2.5 of this chapter describe the five alternatives, including no action. Alternatives considered but not analyzed in detail are discussed in Section 2.6. The environmental consequences of the alternatives that are evaluated are summarized and compared in Section 2.7. The uncertainties associated with key areas of this EIS (i.e., human health evaluations) are discussed in Section 2.8. Key information gleaned from this GTCC EIS that has been summarized in Section 2.9 was considered in developing the preferred alternative, which is identified in Section 2.10.

2.1 ALTERNATIVE 1: NO ACTION

Under the No Action Alternative, current practices for storing GTCC LLRW and GTCC-like waste would continue in accordance with current requirements (e.g., NRC, state, DOE). The

GTCC LLRW generated by the operation of commercial nuclear reactors (mainly activated metal waste) would continue to be stored at the various nuclear reactor sites that generated this waste or at other reactors owned by the same utility. Sealed sources would also remain at generator or other licensee sites. GMS/OSRP would continue to recover disused or unwanted sealed sources that present a national security or public health and safety threat. The third category of waste, "Other Waste," would also remain stored and managed at the generator or other interim storage sites. In a similar manner, all stored and projected GTCC-like waste would remain at current DOE storage and generator locations (these wastes are being stored at several DOE sites). Many of the GTCC-like wastes meet the definition of TRU waste but may not have been generated from atomic energy defense activities and therefore may not meet the current waste acceptance criteria for disposal at WIPP.

Under this alternative, DOE would take no further action to develop disposal capability for these wastes, and current practices for managing these wastes would continue into the future, as described in Chapter 3. No impacts from construction of a disposal facility or from operations to emplace the waste in a disposal facility at the federal sites or generic commercial locations would be incurred, since these activities would not be conducted there. However, potential impacts could occur at the generator or current storage sites as a result of constructing storage structures or additional storage capacities (as in the case where wastes are already being stored). In the evaluation of the No Action Alternative in Chapter 3 of this EIS, it is further assumed that for the short term, management of the stored wastes would continue for 100 years (a time period typically assumed for active institutional controls), and long-term impacts are analyzed for the period beyond 100 years up to 10,000 years to be consistent with the time frame analyzed for the action alternatives.

2.2 ALTERNATIVE 2: DISPOSAL IN THE WIPP GEOLOGIC REPOSITORY

This alternative involves the evaluation of the incremental environmental consequences that would occur at WIPP from the disposal of the 12,000 m^3 (420,000 ft^3) of GTCC LLRW and GTCC-like waste included in Groups 1 and 2. This evaluation is performed on a waste-type basis for the human health and transportation analyses, as discussed previously.

The operation at WIPP involves disposal of TRU waste by emplacement in underground disposal rooms that are mined as part of a panel and an access drift. Each mined panel consists of seven rooms. CH TRU waste containers are emplaced on disposal room floors, and RH TRU waste containers are currently emplaced in horizontal boreholes in disposal room wall spaces. However, the EPA and New Mexico Environment Department have approved DOE use of shielded containers for safe emplacement of selected RH TRU waste streams with lower activity levels on the floor of the repository. The use of the shielded containers will enable DOE to significantly increase the efficiency of transportation and disposal operations for RH TRU waste at WIPP. For RH TRU waste streams with higher activity levels, such as those exhibited in the near term by activated metals removed from recently shutdown nuclear reactors, a similar, more heavily shielded container could be used. Consistent with the approval for the shielded container and the potential extension to a more heavily shielded container, this EIS assumes all activated metal waste and Other Waste - RH would be packaged in shielded containers that would be emplaced on the floor of the mined panel rooms in a manner similar to that used for the emplacement of CH waste.

The analysis discussed in this EIS assumes that disposal procedures and practices at WIPP would continue, except for the emplacement of activated metals and Other Waste - RH on room floors (not in wall spaces, as is the current procedure). It is also assumed that all aboveground support facilities would be available for the disposal of GTCC LLRW and GTCC-like waste and that construction of additional aboveground facilities would not be required to dispose of the entire inventory of GTCC LLRW and GTCC-like waste.

Underground rooms are constructed by conventional mining techniques that use an electric-powered continuous miner rather than blasting. The mined salt is transported underground by haul trucks; once there, the salt is placed on the salt hoist and lifted to the surface. The exact locations and orientations of those rooms would be determined on the basis of mining engineering, safety, and other factors.

The total capacity for disposal of TRU waste established under the WIPP LWA as amended (P.L. 102-579 as amended by P.L. 104-201) is 175,675 m^3 (6.2 million ft^3). The Consultation and Cooperative Agreement with the State of New Mexico (1981) established a total RH capacity of 7,080 m^3 (250,000 ft^3), with the remaining capacity for CH TRU at 168,500 m^3 (5.95 million ft^3). In addition, the WIPP LWA as amended (P.L. 102-579 as amended by P.L. 104-201) limits the total radioactivity of RH waste to 5.1 million curies. For comparison, the GTCC LLRW and GTCC-like CH volume, RH volume, and RH total radioactivity are approximately 6,650 m^3 (235,000 ft^3), 5,050 m^3 (178,000 ft^3), and 157 million curies, respectively. On the basis of emplaced and anticipated waste volumes, the disposal of all GTCC LLRW and GTCC-like waste at WIPP would exceed the limits for RH volume and RH total activity. The majority of the GTCC LLRW and GTCC-like RH volume is from the Other Waste category (e.g., DOE non-defense TRU), and activated metal waste contributes to most of the RH activity. The WIPP LWA as amended (P.L. 102-579 as amended by P.L. 104-201) also limits disposal in WIPP to defense-generated TRU waste. Under the current schedule for WIPP, DOE would complete its operations in 2035. However, this EIS assumes that WIPP operations would continue beyond 2035, allowing for disposal of GTCC LLRW and GTCC-like waste that is projected to be generated after 2035.

Most of the GTCC-like waste consists of TRU waste that may not have been generated from atomic energy defense activities. Disposing of these wastes and GTCC LLRW in WIPP would require a change in law to allow disposal of wastes other than TRU waste generated by atomic energy defense activities. The total estimated inventory of GTCC LLRW and GTCC-like waste, added to the DOE defense-generated TRU waste disposed of or scheduled to be disposed of at WIPP, could exceed the WIPP LWA as amended (P.L. 102-579 as amended by P.L. 104-201) and the Consultation and Cooperative Agreement RH volume and curie limits for WIPP, as discussed above. The WIPP LWA as amended (P.L. 102-579 as amended by P.L. 104-201) would require modification (see Chapter 13), and the additional GTCC LLRW and GTCC-like wastes would need to be analyzed as part of the performance assessment for EPA certification.

The affected environment and the potential environmental and human health consequences at the WIPP facility are discussed in Sections 4.2 and 4.3, respectively. The number of additional rooms needed to emplace the GTCC LLRW and GTCC-like waste is estimated to be about 26 (Sandia 2008a,b).

The GTCC LLRW and GTCC-like waste inventory would be packaged in approximately 63,000 waste disposal packages. The types of containers or packages used would depend on the type of waste in the inventory. It is assumed that waste disposal containers would include 208-L (55-gal) drums, standard waste boxes (SWBs), and shielded containers, and that Cs-137 irradiators would be disposed of individually in their original shielded devices. The size of these irradiators is assumed to be approximately 150 × 65 × 67 cm (59 × 26 × 27 in.) (Sandia 2008c).

Prior to implementation of this alternative, further evaluation and analysis of alternative technologies and methods to optimize the transport, handling, and emplacement of the wastes would be conducted to identify those technologies and methods that would minimize to the extent possible any potential impacts to human health or the environment. Follow-on WIPP-specific NEPA review would be conducted to examine in greater detail the potential impacts associated with the disposal of GTCC LLRW and GTCC-like waste at WIPP, as appropriate. DOE acknowledges that only defense-generated TRU waste is currently authorized for disposal at the WIPP geologic repository under the WIPP LWA as amended (P.L. 102-579 as amended by P.L. 104-201), and that legislation would be required to allow disposal of waste other than TRU waste generated by atomic energy defense activities at WIPP and/or for siting a new facility within the land withdrawal area.

It should be noted that waste disposal operations at WIPP were suspended on February 5, 2014, following a fire involving an underground vehicle. Nine days later, on February 14, 2014, a radiological event occurred underground at WIPP, contaminating a portion of the mine primarily along the ventilation path from the location of the incident and releasing a small amount of contamination into the environment.

DOE will resume disposal operations at WIPP when it is safe to do so. The schedule for restart of limited operations is currently under review. DOE is continuing to characterize and certify TRU waste at the Idaho National Laboratory, Oak Ridge National Laboratory, Savannah River Site, and Argonne National Laboratory for eventual shipment to WIPP. TRU waste continues to be generated at the Hanford site and Lawrence Livermore National Laboratory. DOE is carefully evaluating and analyzing the impacts on storage requirements and commitments with state regulators at the generator sites. These efforts will inform decisions related to the availability of storage for certified TRU waste until waste shipments to WIPP can resume. Detailed information on the status of recovery activities at WIPP can be found at http://www.wipp.energy.gov/wipprecovery/recovery.html.

2.3 ALTERNATIVE 3: DISPOSAL IN A NEW INTERMEDIATE-DEPTH BOREHOLE DISPOSAL FACILITY

Alternative 3 involves the evaluation of the environmental consequences from the construction, operations, and post-closure of a new borehole facility for the Groups 1 and 2

GTCC LLRW and GTCC-like waste inventory. Reference locations at the following five sites are evaluated for this alternative: the Hanford Site, INL Site, LANL, NNSS, and the WIPP Vicinity. Because of the shallow depth to groundwater at SRS, this alternative is not evaluated for this site. Of the four NRC regions considered for the hypothetical commercial facility analysis, human health impacts are analyzed for the NRC Region IV generic commercial location only because the depth to groundwater at the other three regions is considered too shallow for application of this method for the purposes of this EIS.

The conceptual design (see Section 5.1.1) indicates that about 44 ha (110 ac) of land would be required for the 930 boreholes needed to accommodate the waste packages containing the 12,000 m^3 (420,000 ft^3) of GTCC LLRW and GTCC-like waste. This acreage would include land required for supporting infrastructure, such as facilities or buildings for receiving and handling waste packages or containers, and space for a stormwater retention pond to collect stormwater runoff and truck washdown. The borehole method entails emplacement of waste in boreholes at depths below 30 m (100 ft) but above 300 m (1,000 ft) bgs. Boreholes can vary widely in diameter (from 0.3 to 3.7 m [1 to 12 ft]), and the proximity of one borehole to another can vary depending on the design of the facility. The technology for drilling larger-diameter boreholes is simple and widely available. The conceptual design evaluated in this EIS employs boreholes that are 2.4 m (8 ft) in diameter and 40-m (130-ft) deep in unconsolidated to semiconsolidated soils, as shown in Figure 1.4.2-2, with a spacing of 30 m (100 ft) between boreholes. Deeper or shallower boreholes than those evaluated in this EIS could be used, depending on site-specific considerations (e.g., depth to groundwater).

A bucket auger would be used to drill the large-diameter boreholes (see Figure 5.1.1-2), and a smooth steel casing would be advanced to the depth of the borehole during the drilling and construction of the borehole. The casing would provide stability to the borehole walls and ensure that waste packages would not snag and plug the borehole as they were lowered and that they would sit in an upright position when they reached the bottom. The upper 30 m (100 ft) of smooth steel casing would be removed upon closure of the borehole. In some cases where consolidated materials might be encountered, a more robust drilling technology would be required. A casing would also be used in this case as an aid in placing the waste package. After placement of the waste in the borehole, a reinforced concrete barrier would be added above the disposal containers to deter inadvertent drilling into the isolated waste during the post-closure period, and backfill would be added to the surface level. Details describing facility construction, operations, and integrity are provided in Section 5.1.4.

Adequate acreage (44 ha or 110 ac) is available at the GTCC reference locations for the sites being considered for the borehole method (Hanford Site, INL Site, LANL, NNSS, and the WIPP Vicinity). At LANL, the reference location is composed of three separate parcels of land located in Technical Area-54 (TA-54).

2.4 ALTERNATIVE 4: DISPOSAL IN A NEW TRENCH DISPOSAL FACILITY

Under Alternative 4, the construction, operations, and post-closure performance of a new trench disposal facility at the Hanford Site, INL Site, LANL, NNSS, SRS, and the WIPP Vicinity are evaluated for disposal of GTCC LLRW and GTCC-like waste. The conceptual design of the trench is described further in Section 5.1.2. Alternative 4 is also evaluated for the generic commercial location in NRC Regions II and IV in order to allow for a comparison of these methods with the federal sites in these two regions.

For disposal of the entire 12,000 m^3 (420,000 ft^3) of GTCC LLRW and GTCC-like waste, the conceptual design for the trench method includes 29 trenches occupying a footprint of about 20 ha (50 ac) (see Table 5.1-1 and Figure 5.1.4-2). This acreage includes land required for supporting infrastructure, such as facilities or buildings for receiving and handling waste packages or containers, and space for a stormwater retention pond to collect stormwater runoff and truck washdown. Each trench would be approximately 3-m (10-ft) wide, 11-m (36-ft) deep, and 100-m (330-ft) long. After wastes were placed in the trench, a concrete barrier would be placed on top, and backfill would be added to the surface level. The cover would be a minimum of 5 m (16 ft). The additional concrete barrier would provide additional shielding during the operational period, and at some sites where the material through which drilling would be done is typically soft (e.g., sand or clay), the layer could deter inadvertent drilling into the buried waste during the post-closure period. Additional intruder barriers could be adopted for those sites in a hard rock environment on the basis of final engineering designs.

Additional features would be necessary in the trenches where RH waste would be emplaced in order to provide shielding for the workers once the waste was in place. The RH waste packages would be disposed of in vertical cylinders with concrete shield plugs on the top of each cylinder. A mating flange would enable coupling of the bottom-loading transfer cask to a given cylinder for transfer of the waste package into the disposal unit. The transfer cask would be moved off an on-site transport truck and moved into position by an overhead crane. The facility construction, operations, and post-closure activities assumed in the evaluation of the trench disposal method are discussed in Section 5.1.4.

2.5 ALTERNATIVE 5: DISPOSAL IN A NEW VAULT DISPOSAL FACILITY

Under Alternative 5, the construction, operations, and post-closure performance of a new vault disposal facility at the Hanford Site, INL Site, LANL, NNSS, SRS, and the WIPP Vicinity are evaluated for disposal of GTCC LLRW and GTCC-like waste. The conceptual design of the vault is described further in Section 5.1.3. Alternative 5 is evaluated for the generic commercial location at all four NRC regions.

The conceptual design for the vault disposal of GTCC LLRW and GTCC-like waste that is evaluated in this EIS employs a reinforced concrete vault constructed near grade level, with the footings and floors of the vault situated in a slight excavation just below grade (see Figure 1.4.2-4). The design is a modification of a disposal concept proposed by Henry (1993) for GTCC LLRW, and it is similar to a belowground vault LLRW disposal option (Denson et al. 1987) previously investigated by USACE. A similar concrete vault structure is currently in use (mostly below grade) for the disposal of higher-activity LLRW at SRS (MMES et al. 1994).

The vault disposal facility to emplace 12,000 m^3 (420,000 ft^3) of waste would consist of 12 vault units (each with 11 vault cells) and occupy a footprint of about 24 ha (60 ac). This acreage includes land required for supporting infrastructure, such as facilities or buildings for receiving and handling waste packages or containers, and space for a stormwater retention pond. Each vault would be about 11-m (36-ft) wide, 94-m (310-ft) long, and 7.9-m (26-ft) tall, with 12 vault units situated in a linear array (see Table 5.1-1 and Figure 5.1.4-3). The vault cell would be 8.2-m (27-ft) wide, 7.5-m (25-ft) long, and 5.5-m (18-ft) high, with an internal volume of 340 m^3 (12,000 ft^3) per vault cell. Double interior concrete walls with an expansion joint would be included after every second cell.

Vault cells for disposal of RH waste would be similar in design to the trenches. Waste containers would be emplaced from a bottom-loading transfer cask into vertical concrete cylinders with thick concrete shield plugs within each cell. The cylinder loading would be the same as that for the trench method. Two engineered cover systems would be used for the vaults. If needed, rock armor[1] could also be incorporated into the final cover to further protect against erosion. Construction, operations, and post-closure activities for the vault method are discussed in Section 5.1.4, with additional details provided in Appendix D.

2.6 ALTERNATIVES CONSIDERED BUT NOT EVALUATED IN DETAIL

DOE identified the alternatives for detailed analysis in this EIS on the basis of the rationale provided in the NOI for the GTCC EIS (72 FR 40135). Several comments received during the scoping process indicated that DOE should include alternatives in addition to those identified in the NOI. However, none of the suggested alternatives was determined to be a reasonable alternative (see Section 1.5.1.2).

In the NOI for the GTCC EIS, DOE identified co-disposal of the GTCC LLRW and GTCC-like waste at the then-proposed Yucca Mountain repository as one alternative to be considered; however, DOE did not include this as an alternative in the EIS because since publication of the NOI, the Secretary of Energy determined that a permanent repository for high-level waste and spent nuclear fuel at Yucca Mountain, Nevada, is not a workable option, and the repository will not be developed. Therefore, DOE concluded that co-disposal at a Yucca Mountain repository is not a reasonable alternative and eliminated it from evaluation in the EIS.

DOE did not evaluate developing a geologic repository exclusively for disposal of GTCC LLRW and GTCC-like wastes because DOE determined that such an alternative is not reasonable due to the time and cost associated with siting a deep geologic repository and the relatively small volume of GTCC LLRW and GTCC-like waste identified in the GTCC EIS. The results presented in this EIS for the WIPP geologic repository alternative are indicative of the high degree of waste isolation that would be provided by disposal in a geologic repository.

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[1] Rock armor is irregularly broken and random-sized pieces of quarry rock; individual stones ranging from very large (2 to 3 yd^3 or 1.5 to 2.3 m^3) to small (0.5 ft or 0.014 m^3) are placed into the final cover to further protect against erosion.

The Blue Ribbon Commission (BRC) on America's Nuclear Future, in its final report to DOE on January 26, 2012, provided recommendations, which included the development of one or more permanent deep geologic facilities for the safe disposal of spent nuclear fuel and high-level radioactive waste and the development of one or more consolidated interim storage facilities as part of an integrated, comprehensive plan for managing the back end of the nuclear fuel cycle. In its *Strategy for the Management and Disposal of Spent Nuclear Fuel and High Level Radioactive Waste* (DOE 2013), developed in response to the BRC Report, the Administration agreed "that the development of geologic disposal capacity is currently the most cost-effective way of permanently disposing of used nuclear fuel and high-level radioactive waste while minimizing the burden on future generations" and proposed to "engage in a consent-based siting process and begin to conduct preliminary site investigations for a geologic repository." The Administration's goal is to have a repository constructed and its operations started by 2048. The Administration will work with Congress using the strategy as an actionable framework for building a national program for the management and disposal of the nation's used nuclear fuel and high-level radioactive waste (DOE 2013).

In addition, the NOI for the GTCC EIS also identified the Oak Ridge Reservation as a site to be evaluated for potential disposal of GTCC LLRW and GTCC-like waste by using a land disposal method because of its ongoing waste disposal mission. Based on internal reviews conducted by the Low-Level Waste Disposal Facility Federal Review Group, DOE determined that the site is not appropriate for disposal of LLRW containing high concentrations of long-lived radionuclides (such as those found in GTCC LLRW and GTCC-like waste), especially those with high mobility in the subsurface environment. For this reason, DOE concluded that the Oak Ridge Reservation (ORR) is not a reasonable disposal site alternative and has eliminated it from detailed evaluation in this EIS.

In developing Alternatives 3 to 5 for this EIS, all DOE sites were carefully considered for inclusion. The DOE sites with an ongoing waste disposal mission are included in the scope of this EIS. Of these DOE sites, the evaluation for SRS is limited to the trench and vault methods because of the relatively shallow depth to groundwater at SRS.

The reference locations being evaluated in this EIS are limited to federal sites. DOE solicited technical capability statements from commercial vendors that might be interested in constructing and operating a GTCC LLRW and GTCC-like waste disposal facility in a request for information in the *FedBizOpps* on July 1, 2005. Although at the time, several commercial vendors expressed an interest, no vendor provided specific information on disposal locations and methods for analysis in the EIS. On June 20, 2014 Waste Control Specialists, LLC, (WCS), filed (and resubmitted on July 21, 2014) a Petition for Rulemaking with the Texas Commission on Environmental Quality (TCEQ) requesting the State of Texas to revise certain provisions of the Texas Administrative Code to remove prohibitions on disposal of GTCC LLRW, GTCC-like waste and TRU waste at its TCEQ licensed facilities. On January 30, 2015, TCEQ sent a letter to the NRC requesting guidance on the State of Texas's authority to license disposal of GTCC LLRW, GTCC-like waste and TRU waste. This matter is under review by NRC.

Commercial disposal locations are evaluated in this EIS by using a generic approach in which the United States is divided into four regions, as the NRC has done. The estimates for the four regions could be used in the future as a basis for considering the feasibility of siting a borehole, trench, or vault disposal facility on private or commercial land in the United States.

2.7 COMPARISON OF THE POTENTIAL CONSEQUENCES FROM THE FIVE ALTERNATIVES

The following sections describe the consequences from the five alternatives (including No Action) evaluated for each of the environmental resource areas (see Tables 2.7-1 through 2.7-6, which are presented consecutively following the discussion for Section 2.7).

- Alternative 1: No Action
- Alternative 2: Disposal in the WIPP geologic repository
- Alternative 3: Disposal in a new borehole disposal facility
- Alternative 4: Disposal in a new trench disposal facility
- Alternative 5: Disposal in a new vault disposal facility

2.7.1 Climate, Air Quality, and Noise

Potential air quality and noise impacts for the alternatives evaluated are discussed in Sections 3.5, 4.3.1, 5.3.1.1, 6.2.1, 7.2.1, 8.2.1, 9.2.1, 10.2.1, and 11.2.1. There would be no changes to the current air quality and noise under Alternative 1, since no additional construction activities would occur. The incremental air quality and noise impacts under Alternative 2 would be very low, because no new surface facilities would be constructed at the WIPP repository. There would be very minor increases in the impacts from the surface storage of mined materials at WIPP to allow for the increased disposal capacity. However, the impacts would be in terms of time more than magnitude; the time frame over which the impacts would occur would be extended more than would their magnitude. The ambient air concentrations of criteria pollutants, volatile organic compounds (VOCs), and carbon dioxide (CO_2) would not likely change as a result of disposing of GTCC LLRW and GTCC-like wastes at WIPP.

Under Alternatives 3 to 5, the air quality and noise impacts are expected to be low, but higher than they would be under Alternative 2. It is estimated that during construction, total peak-year emission rates for criteria pollutants, VOCs, and CO_2 associated with all three Alternatives (3 to 5) would be low. Construction activities would take place well within the site boundaries at all sites evaluated (except at LANL, where construction activities could take place within about 200 m [660 ft] of the boundary), so emissions would contribute little to concentrations at or beyond the site boundaries. For most sites, during the construction phase, emission levels associated with the borehole method would be between those associated with the trench method and the vault method, with the vault method having the most relative emissions and the trench method having the least. Construction-related emissions from all three disposal methods would add 1% or less to emissions in the nearby areas surrounding the various sites.

During operations, total peak-year emission rates for criteria pollutants, VOCs, and CO_2 for the three disposal methods would be low (even lower than during construction). Operational activities would be well within the site boundaries at all candidate sites (except for LANL, as discussed above), so emissions from operational activities would contribute little to the concentrations at or beyond the site boundaries. At all sites, the borehole method would emit the least emissions of all three disposal methods during the operations phase.

The impacts of construction-related and operations-related emissions (e.g., fugitive dust) on ambient air quality would be reduced by implementing best management practices, such as watering unpaved roads and other sources of dust. Ozone (O_3) levels in the counties encompassing the evaluated sites are currently in attainment, and O_3 precursor emission levels from construction and operational activities would be relatively small and much lower than those for the regional air shed in which emitted precursors are transported and formed into O_3. As a result, the potential impacts of O_3 precursor releases from construction and operational activities for the three land disposal methods would not be of concern. The highest peak-year amount of CO_2 emissions would occur during construction, but those emissions would be considered small at all the sites evaluated (less than 0.00005% of U.S. emissions).

The highest composite noise during construction at any of the sites under Alternatives 3 to 5 would be about 92 dBA at a distance of 15 m (50 ft) from the source (noise generated from operations would be less than the noise in the construction phase). Sound levels would actually be lower because of air absorption and ground effects due to terrain and vegetation. Noise levels at a distance of 690 m (2,300 ft) from the source would be below the EPA guideline of 55 dBA or decibels for all the sites evaluated. This distance is smaller than the distance between the GTCC reference locations and the respective nearest known off-site residences. Estimated distances of the GTCC reference locations from the respective nearest known off-site residences are as follows: >6 km (4 mi) at the Hanford Site; >11 km (7 mi) at the INL Site; approximately 3.5 km (2.2 mi) at LANL (nearest residence in White Rock); >6 km (4 mi) at NNSS; >14 km (9 mi) at SRS; and >5 km (3 mi) at the WIPP Vicinity.

2.7.2 Geology and Soils

Potential impacts on geology and soils are discussed in Sections 3.5, 4.3.2, 6.2.2, 7.2.2, 8.2.2, 9.2.2, 10.2.2, and 11.2.2. Under Alternative 1, the land currently used for storage would continue to be used. Under Alternative 2, no surface support structures in addition to those already in place at the WIPP facility would be needed; the construction of additional underground rooms would not increase the current footprint of the WIPP site.

Under Alternatives 3 to 5, impacts from land disturbance would be proportional to the total area of land disturbed during site preparation and construction. The borehole method would disturb more land than would the trench and vault methods. Of the three land disposal methods, the borehole method also would result in the greatest disturbance with depth. The vault disposal method would disturb more land than the trench method. No adverse impacts from the extraction and use of geologic and soil resources are expected at any of the six sites, and no significant changes in surface topography would occur. No changes in natural drainages are expected. Potential impacts at soil resource areas (borrow areas) that might be needed to implement the vault disposal facility in particular (because of the larger amount of soil required for the cover system) would have to be considered in follow-on evaluations to support implementation of this method.

The potential for erosion would be lower at the five western sites evaluated (Hanford Site, INL Site, LANL, NNSS, and WIPP Vicinity) than at the eastern site (SRS) because of the low precipitation rates at the western sites. Erosion rates at all six evaluated sites would be reduced by employing best management practices. For most of the sites, the borehole and the trench methods would be completed in unconsolidated sediments. However, these two disposal methods could penetrate the upper surface of the basalt interlayered with sediment at the INL Site and the Bandelier Tuff at LANL.

2.7.3 Water Resources

Potential impacts on water resources are discussed in Sections 3.5, 4.3.3, 5.3.3, 6.2.3, 7.2.3, 8.2.3, 9.2.3, 10.2.3, and 11.2.3. Under Alternative 1 (No Action Alternative), no potential impacts on water resources in terms of water consumption are expected other than those that already exist as a result of waste storage. The impacts associated with any surficial spills are expected to be the same as those from storage activities practiced currently. The incremental water resource impacts under Alternative 2 are expected to be very low, since the facilities for unloading, managing, transporting, and decontaminating waste packages and equipment would already be in place. The increased water needs for potable purposes would not result in any additional significant impacts in the region of the WIPP repository. As is the case for the air quality impacts, the most significant incremental effects associated with adding the GTCC LLRW and GTCC-like waste to the wastes being disposed of at the WIPP repository is that the impacts would occur over a longer time period. There would be very little, if any, change in the magnitude of the impacts.

Under Alternatives 3 to 5 (borehole, trench, or vault), water consumption associated with the borehole method during construction would be about 530,000 L/yr (140,000 gal/yr), which is the smallest amount associated with the three land disposal methods. The corresponding values for the trench and vault methods are 1,000,000 L/yr (270,000 gal/yr) and 3,300,000 L/yr (860,000 gal/yr), respectively. The initial construction period was assumed to be about 3.4 years for all three land disposal methods. The amount of potable and raw water consumed during the operational phase of the borehole method would also be the smallest of the three disposal methods; it would be about 2,500,000 L/yr (650,000 gal/yr). A total of 5,300,000 L/yr (1,400,000 gal/yr) would be required for operating either the trench or the vault method.

The increase in annual water use under Alternatives 3 to 5 would be low for all of the sites evaluated. However, at the WIPP Vicinity, the increase in demand would have to be considered in conjunction with the water demands of the nearby WIPP repository operation. Construction of a GTCC disposal facility at the WIPP Vicinity reference locations (at either Section 27 or 35) could increase the water usage in that area by as much as 0.24% of the pumpage for the Carlsbad Double Eagle South Well Field (i.e., 3,300,000 L/yr or 860,000 gal/yr versus a capacity of 1,400 million L or 360 million gal). Operations would increase water use by as much as 0.39% of the pumpage for the Carlsbad Double Eagle South Well Field. Off-site wells (i.e., Double Eagle South Well Field system) are the source of water at the WIPP Vicinity reference locations.

Potential impacts on underlying aquifers and any surface waters at the Hanford Site, INL Site, LANL, NNSS, SRS, and WIPP Vicinity from sanitary and other nonhazardous waste (including surficial spills) from construction and operations of the three land disposal methods would be small. Groundwater quality at the Hanford Site, INL Site, LANL, and SRS could be impacted by leaching of waste constituents resulting in concentrations of radionuclides at some time in the future (within 10,000 years after closure of the proposed land disposal facilities). Groundwater quality at NNSS and the WIPP Vicinity would not be impacted because disposal facility post-closure estimates presented in this EIS indicate that radionuclides would not reach groundwater during the 10,000-year period of analysis.

2.7.4 Human Health

Potential human health impacts are discussed in Sections 3.5, 4.3.4, 5.3.4, 6.2.4, 7.2.4, 8.2.4, 9.2.4, 10.2.4, 11.2.4, and 12.2. Human health impacts are evaluated separately for workers and members of the general public in the EIS. The two major worker impacts that are addressed quantitatively are the radiation doses and LCF risks to the workforce who would implement the various alternatives and the estimated numbers of injuries and fatalities that could occur as a result of a construction project of this size. The worker impacts are generally comparable for all of the action alternatives. Data on worker impacts for the No Action Alternative in this EIS were obtained from documents prepared by some of the sites expected to generate GTCC LLRW.

2.7.4.1 Worker Impacts

Worker doses are estimated on the basis of projected worker requirements during the operations phase under the various action alternatives. Under the No Action Alternative, the annual incremental collective radiation dose to the workforce associated with the storage of GTCC LLRW and GTCC-like waste is estimated to be 4 person-rem on the basis of the storage of activated metal waste (see Table 2.7-3). The annual collective worker dose estimate associated with Alternative 2 is 0.29 person-rem/yr, while those for Alternatives 3, 4, and 5 are 2.6, 4.6, and 5.2 person-rem/yr, respectively. The estimates for Alternatives 3 to 5 are applicable to all sites considered, because the same procedures would generally be used at each site.

These differences in worker doses are attributable to the different assumptions used to develop the estimates for the various alternatives and do not reflect actual benefits of one alternative over the other in terms of worker doses. Actual worker dose information was used for Alternative 2, while conservative assumptions were used to develop worker dose estimates for Alternatives 3, 4, and 5. Comparable doses would likely occur under any of the four action alternatives. The maximum annual dose to any individual worker would be kept below the DOE limit of 5 rem/yr and would be no more than the DOE administrative control level of 2 rem/yr and a project-specific administrative control level that could be lower still. In addition, worker exposures would follow the ALARA (as low as reasonably achievable) principle to further reduce doses. It is expected that none of these worker doses would result in an estimated LCF. The estimates of LCFs were obtained by using a risk factor of 0.0006 LCF per rem (see Section 5.2.4.3).

It is projected that no worker fatalities would occur during operational activities under any of the alternatives, and the annual number of lost workdays due to occupational injuries and illnesses for the land disposal methods are estimated to range from 1 day for the borehole method to 2 days for the trench and vault methods (see Table 2.7-3). Under Alternative 2, the annual number of lost workdays due to occupational injuries and illnesses is estimated to be 3 days, and this is an incremental value over the number estimated to occur as a result of the geologic repository's implementing its current missions to dispose of defense TRU waste. The value for Alternative 2 is larger than that for the other three action alternatives as a result of assuming that the GTCC LLRW and GTCC-like waste would be managed as CH wastes at WIPP, which requires more workers to dispose of the larger number of waste packages. The accident rates are comparable for all four action alternatives. As is the case for the estimates of worker doses, these differences are not considered significant and would likely be attributable to the different assumptions used to develop these estimates.

2.7.4.2 Impacts on Members of the General Public

The human health impacts on members of the general public and on-site noninvolved workers are evaluated for waste handling accidents that could occur prior to completion of disposal activities and also for the long-term impacts from disposal of the GTCC LLRW and GTCC-like waste. The highest impacts would be from an accidental fire affecting an SWB. The doses to the highest-exposed individual (i.e., the individual who could receive the highest dose estimated) located 100 m (330 ft) from the fire range from 2.4 to 16 rem and result in no LCFs for the various sites (see Table 2.7-3). The collective dose to the population in the sector downwind of the fire ranges from 0.47 to 160 person-rem and no LCFs. These results indicate that accidents involving waste packages could have significant impacts, so care needs to be taken to minimize the likelihood of such accidents. Information on accidents at the WIPP repository is included in safety documentation for the site, and the wastes being addressed in this EIS generally fall within the safety envelope of that evaluation. Such impacts are thus not quantified for the WIPP repository in this EIS.

The potential long-term human health impacts of the No Action Alternative could amount to as much as 470,000 mrem/yr or an annual LCF risk of about 0.3 (see Table 2.7-3) from the continued storage of GTCC LLRW and GTCC-like waste in NRC Region I. With regard to the wastes assumed to remain in storage in NRC Regions II to IV, estimates indicate much lower potential doses and no LCFs. To assess the impacts of Alternative 1, it is assumed that GTCC LLRW and GTCC-like waste would generally remain in the NRC region where the facilities that generate them are located. Most of the expected inventory is in NRC Region I, which is one of the reasons that the doses in this region are so much higher than those in the other three NRC regions. These health impacts would be on a hypothetical resident farmer residing 100 m (330 ft) from the edge of the disposal facility. This scenario is described further below.

For Alternative 2, there would be no releases to the accessible environment and therefore no radiation doses and LCF risks during the first 10,000 years following closure of the WIPP repository.

Under Alternatives 3 to 5, the long-term human health impacts are addressed by considering the future radiation dose and LCF risk to a hypothetical individual who resides 100 m (330 ft) from the edge of the disposal facility and develops a farm. This resident farmer scenario is assumed to be conservative (i.e., one that overestimates the expected dose and LCF risk) because it assumes a total loss of institutional control and institutional memory with regard to the disposal facility and because the radiation doses and LCF risks estimated to occur to this individual would likely never occur. These results are provided in tables in the site-specific chapters (i.e., Chapters 6, 7, 8, 9, 10, and 11) and are summarized in Table 2.7-3. The peak doses and LCF risks for each waste type are also provided in Appendix E.

There are three release mechanisms considered in the RESRAD-OFFSITE computer model that can lead to contamination at off-site locations: wind erosion, surface runoff, and leaching (see Section E.1). However, only two of these mechanisms are considered applicable to disposal of GTCC LLRW and GTCC-like waste in land disposal facilities in the long term: (1) airborne emissions and (2) leaching of radioactive contaminants from the waste packages with transport to groundwater and migration to an accessible location such as a groundwater well. These two mechanisms are addressed in this EIS to determine the impacts on off-site members of the general public following closure of the disposal facility.

Release of particulates by wind erosion is not considered to be a viable pathway, given the depth of the disposal facility cover and use of good engineering practices during closure of the disposal facility, which would include measures to minimize erosion of the cover material. That is, it is assumed in this EIS that the disposed-of wastes would always be overlain by some clean soil cover. The only airborne emissions would be radioactive gases (such as radon) that could migrate through the facility cover and be released to the atmosphere.

The second release mechanism listed above (surface runoff) is also considered not relevant to the analysis conducted for this EIS. This mechanism addresses the loss of surficial contamination by precipitation that flows along the slope of the ground surface to the surrounding area. Since it is assumed in this EIS that there would always be some clean soil over the disposed-of wastes, this pathway is also not relevant to this assessment.

The most significant exposure pathway would be from groundwater contamination, and it is assumed that the resident farmer would install a drinking water well for use at his or her farm. The annual radiation doses within the first 10,000 years would range from zero to 2,300 mrem/yr for the three land disposal methods. The use of the resident farmer scenario is intended to provide estimates for comparing the various sites evaluated; however, this scenario may not be consistent with the reasonably foreseeable future scenario at some of the sites evaluated (e.g., Hanford Site). Subsequent NEPA review would use additional site-specific information, if available, for the evaluation of potential impacts should a site be selected for a GTCC disposal facility.

Because the radionuclide mix for each waste type (i.e., activated metals, sealed sources, and Other Waste) is different, the peak doses and LCF risks for each waste type do not necessarily occur at the same time. In addition, the peak doses and LCF risks for the entire GTCC LLRW and GTCC-like waste inventory considered as a whole could be different from those for the individual waste types. The results presented in the main body of the EIS are for the entire GTCC LLRW and GTCC-like waste inventory, and the contributions of the individual waste types given in these tables are those that occur at the time of the peak doses and LCF risks for the entire inventory.

The estimated doses and LCF risks for the hypothetical resident farmer scenario evaluated to assess the long-term impacts for GTCC LLRW and GTCC-like waste disposal using a borehole, trench, or vault disposal facility are presented in two ways in this EIS. The first presents the peak doses and LCF risks when disposal of the entire GTCC LLRW and GTCC-like waste inventory is considered. These are provided in tables in the site-specific chapters and are summarized in Table 2.7-3. The second way presents the peak doses and LCF risks for each waste type considered on its own. These results are presented in Appendix E to provide additional information on a waste-type basis.

In evaluating the performance of the three land disposal methods at the various sites in this EIS, it is assumed that the waste inventory contained in the land disposal facilities would be available for leaching into groundwater 500 years after closure. The calculations assume that the GTCC LLRW Other Waste and GTCC-like Other Waste would be stabilized (such as with grout or another similar material) prior to being placed in the disposal facility. It is assumed that stabilization with grout material would be effective for 500 years after closure of the disposal facility. Use of such a stabilizing agent is not assumed for the activated metal waste and sealed sources. Most of the radiation dose and LCF risk associated with the groundwater pathway is attributable to leaching from the Other Waste type, and use of a stabilizing agent such as grout would tend to reduce leaching of radionuclides from these wastes.

The long-term calculations conservatively assume that the receptor (a hypothetical resident farmer) is located 100 m (330 ft) downgradient from the edge of the disposal facility. This distance was selected because it is the nominal distance identified in the DOE *Radioactive Waste Management Manual*, DOE M 435.1-1 (DOE 1999), as the point of compliance for LLRW performance assessments. The distance to the nearest existing population from the edge of all reference locations evaluated in this EIS is much greater than 100 m (330 ft). Use of the actual (greater) distance would significantly lower the estimated doses (see Appendix E).

A number of engineering measures were included in the conceptual facility designs to minimize the likelihood of contaminants migrating from the disposal units. To account for these measures, the water infiltration rate into the waste disposal area was reduced to 20% of the natural rate for the surrounding area after 500 years following facility closure. This reduced rate is assumed to be effective for the entire remaining period of analysis. This reduced rate is limited to the waste disposal area; outside the area of the waste disposal units, the natural background infiltration rate was used. This method is assumed to be a reasonable way to model the use of an improved cover over the waste disposal units.

In this analysis, the same land disposal facility concepts and designs were used at each of the various sites. That is, the designs were not adjusted to account for site-specific environmental factors. The results given here indicate that the geologic repository (WIPP) and land disposal facilities located in arid regions of the country perform better than land disposal facilities located in more humid regions. This should not be interpreted as implying that a site in a humid environment could not be used to dispose of GTCC LLRW and GTCC-like waste in an acceptable manner. Rather, this means that more engineering and administrative controls may be necessary for such a site to meet the necessary performance objectives. Factors such as the infiltration rate, soil adsorption coefficients, engineered barriers, and stabilization techniques appear to make a difference and should be considered when making a decision on how to dispose of GTCC LLRW and GTCC-like waste. Using robust engineering designs and redundant measures to contain the radionuclides in the disposal facility could delay the potential releases of radionuclides and could reduce them to very low levels, thereby minimizing future potential groundwater contamination and its associated human health impacts.

The primary exposure pathway of concern for the borehole, trench, and vault disposal methods is leaching of radionuclides from the GTCC LLRW and GTCC-like waste to the groundwater. The radionuclides are assumed to move downgradient with the water and subsequently be withdrawn in a well located 100 m (330 ft) from the disposal facility and used by a hypothetical resident farmer. The key input parameters that influenced the long-term human health results are the precipitation rates and the soil distribution coefficients (K_ds) assumed in the calculations.

On the basis of site-specific precipitation rates that were assumed, it is estimated that the federal sites located in the arid regions of the country (Hanford Site, LANL, NNSS, and WIPP Vicinity) would generally have lower long-term human health impacts from the groundwater pathway than would the sites located in more humid regions (such as SRS). The exception is the INL Site, which is shown in Table 2.7-3 to have the highest dose and LCF risk estimates. The INL Site results are primarily due to using conservative parameters to represent a previously unanalyzed location. Conservative input parameters were assumed for the calculations for the INL Site because of the range of heterogeneity in geologic, hydraulic, and geochemical conditions observed across the 230,000 ha (580,000 ac) area spanned by the INL Site. Conservatively estimated parameters include distribution coefficients (K_ds) of zero for the radionuclides identified in the waste inventory, low aquifer flow velocities, and higher-than-average infiltration rates.

Zero K_ds were conservatively assigned to account for basalt layers that are present in some parts of the INL Site. Essentially, this assumption allows radionuclides to be released to the full extent once the basalt layers have been penetrated, and it neglects the presence of laterally continuous sedimentary interbeds known to exist across the GTCC reference location. Dense basalt units are associated with low aquifer velocities, which, combined with high infiltration rates, were assumed to conservatively limit the dilution of radionuclides in the aquifer. Estimates of long-term human health impacts from the groundwater pathway for the No Action Alternative also indicate that the arid regions would result in lower doses and LCF risks.

Site- and radionuclide-specific K_ds were assumed in the long-term human health calculations and can vary significantly between sites. K_ds provide an indication of the degree to which the radionuclide would adhere to soil and not move with the percolating water. The higher the K_d for a specific radionuclide, the more that radionuclide would adhere to soil particles. Sites that have high K_ds would generally result in lower groundwater radionuclide concentrations than those with lower K_ds.

SRS was estimated to have the second-highest potential dose and LCF risks after the INL Site. The peak annual dose to the hypothetical farmer receptor at SRS was estimated to be about 1,700 mrem/yr, with C-14, Tc-99, and I-129 as the major radionuclide contributors to the dose. The K_ds assumed for these three radionuclides are very low and generally the same as those used for all the federal sites evaluated in the EIS. As a result, these three radionuclides are also the major dose and risk contributors to the hypothetical resident farmer for the groundwater pathway for the federal sites in the western part of the country. However, the low precipitation rates for these sites resulted in generally lower peak annual doses and LCF risks than those for SRS, which is located in a more humid region.

Finally, of the three waste types, the activated metals and sealed sources would result in lower peak annual doses and LCF risks than the Other Waste. This would occur because the Other Waste type is physically the most leachable of the three waste types. In this EIS, it is assumed that the Other Waste would be stabilized with grout to minimize degradation over time. This would also reduce leaching of radionuclides. The activated metal and sealed source wastes are much more durable than the stabilized Other Waste, and leaching from these two waste types would be much lower over the long term.

The estimated doses to the hypothetical resident farmer provided in Table 2.7-3 are intended to serve as indicators of the performance or effectiveness of each of the land disposal methods at each of the sites evaluated and are expected to provide a metric for comparing the relative performance of the land disposal methods at these sites. When considering which GTCC disposal alternative to select, DOE will consider the potential dose to the hypothetical resident farmer as well as other factors described in Section 2.9.

2.7.4.3 Analysis of Intentional Destructive Acts

The EIS addressed the impacts of intentional destructive acts (IDAs) to provide perspective on the risks that the GTCC LLRW and GTCC-like waste could pose should such an act occur. An IDA could occur during waste handling, transportation, and disposal activities for the various alternatives. Since DOE has already considered the potential impacts of IDAs at WIPP (see Section 4.3.4.4), this EIS focuses on the three land disposal alternatives.

There would be no unpackaged GTCC LLRW and GTCC-like waste or bulk hazardous chemicals at the GTCC reference locations since it is assumed that no waste processing activities would be conducted there. All GTCC LLRW and GTCC-like waste would be shipped to the GTCC disposal facilities at the reference locations in approved waste packages, and the activated metal wastes would be transported in heavily shielded casks. The only time that the wastes would be a target for an IDA would be before they were placed in the disposal facility and before the facility closed. After facility closure, the GTCC LLRW and GTCC-like waste would be well-isolated from any potential IDA.

Since the GTCC reference locations addressed at this EIS are at secured federal sites, it would be very difficult for terrorists to gain access to the wastes, and even if they did, the generally remote locations would make these sites generally unattractive targets. The sealed source and activated metal wastes are very robust, and it would be difficult to disperse the radionuclides in them. In addition, the Other Waste is assumed to be stabilized with grout or some other similar material, which reduces the likelihood for dispersion. The impacts from any attempts to disperse these materials (such as those from an explosive blast) would likely be greater than those from the released radionuclides.

However, should a terrorist successfully obtain access to these wastes and disperse them, the potential impacts could be significant. Potential acute fatalities could be on the order of 10 to 50 people, with potential LCFs being in the hundreds. The economic impacts could reach billions of dollars (see Section 5.3.4.4). The extent of the impacts would depend on the exact location of the release, density of the surrounding population, local meteorology, and emergency response capabilities of individuals in the affected area. Appropriate security measures would be taken during all phases of waste handling and disposal activities to ensure that such events would not occur.

2.7.5 Ecology

Potential impacts on ecological resources are discussed in Sections 3.5, 4.3.5, 5.3.5, 6.2.5, 7.2.5, 8.2.5, 9.2.5, 10.2.5, and 11.2.5. There would be minimal ecological impacts associated with Alternatives 1 and 2. Under Alternative 1, no additional activities other than continued storage would occur. Under Alternative 2, no surface support structures in addition to those already in place at the WIPP facility would be needed. Hence, no additional land surface would be affected from the construction of the additional underground rooms at WIPP to emplace the GTCC LLRW and GTCC-like wastes, except for the small increased amount of land within the existing footprint of the WIPP site needed to store excavated material (salt) from the repository. Since construction activities under this alternative would be minimal, and since the ecological impacts associated with operations would be low, the ecological impacts associated with implementing this alternative would be minimal.

Under Alternatives 3 to 5, loss of habitat (specific to each site), followed by the eventual establishment of low-growth vegetation, would affect species that depend on these habitats at the candidate sites. However, population-level impacts on species are not expected. Reestablishing habitat after closure of the disposal facility could take up to 20 years or more. Although there are no natural aquatic habitats on any of the candidate sites under these alternatives, certain aquatic species (e.g., invertebrates, waterfowl, shorebirds, amphibians, and mammals) could become established in stormwater retention ponds, depending on the amount of water and the length of the retention time.

There are no federally listed or state-listed threatened or endangered species reported to be in the GTCC project areas at the INL Site or the WIPP Vicinity. Construction activities could affect federal or state candidate species or species under review for federal listing at the INL Site or the WIPP Vicinity. Impacts on these species would likely be small, since the area of habitat disturbance would be small relative to the overall size of such habitat in the area. Several federally listed or state-listed bird and mammal species occur within the GTCC project areas at the Hanford Site, SRS, LANL, and NNSS. Impacts on these species would likely be small, since the area of habitat disturbance would be small relative to the overall size of such habitat in the area. Adverse impacts would be minimized by conducting biological surveys in the project area and using good engineering practices to minimize impacts on the environment.

2.7.6 Socioeconomics

Potential impacts on socioeconomics are discussed in Sections 3.5, 4.3.6, 6.2.6, 7.2.6, 8.2.6, 9.2.6, 10.2.6, and 11.2.6. There would be minimal socioeconomic impacts associated with Alternatives 1 and 2. Under Alternative 1, the approach currently used for storing the wastes would continue and require the same workforce. Under Alternative 2, the construction activities necessary to expand the disposal capacity at WIPP to accommodate the incremental waste volume could be done with the same workforce employed at the site. The same holds true for operational activities. Since there would be no significant influx of new workers to implement this alternative, the socioeconomic impacts are expected to be very low.

Although it is expected that the potential socioeconomic impacts under Alternatives 3 to 5 would be larger than those under Alternatives 1 and 2, they would still be small. For Alternatives 3 to 5, construction and operations of a GTCC LLRW and GTCC-like waste disposal facility at the various sites considered in this EIS would increase the annual average employment growth rate by less than 0.1% in the region of interest (ROI). The amount of income that would be produced in the peak construction year would range from about $4 to $8 million (borehole and trench methods) to $11 to $13 million (vault method) (see Table 2.7-4 for the values for each method at each site).

The estimated in-migration to the ROI during peak construction ranges from a low of 10 individuals (borehole method at NNSS) to a high of 127 (vault method at the WIPP Vicinity) as a result of employment at the GTCC LLRW and GTCC-like waste disposal site. This in-migration would have only a marginal effect on population growth and require less than about 1% of vacant rental housing in the peak year at all of the candidate sites. Operations would create about 40 to 50 direct jobs and approximately the same number of indirect jobs in the ROI. The annual income during operations is estimated to be about $4 to $5 million per year.

2.7.7 Environmental Justice

Potential environmental justice issues are discussed in Sections 3.5, 4.3.7, 6.2.7, 7.2.7, 8.2.7, 9.2.7, 10.2.7, and 11.2.7. Under Alternative 1, the approach currently used for storing these wastes would continue, and environmental justice issues, if any, should remain similar to current conditions. Under Alternative 2, there would be no incremental impacts beyond those that have already occurred.

Under Alternatives 3 to 5, construction, operations, and post-closure of the land disposal facilities would not result in the potential for disproportionate and adverse impacts on minority and low-income populations in the vicinity of the federal sites evaluated in this EIS. However, subsequent NEPA review to support any GTCC implementation would have to consider any unique exposure pathways (such as subsistence fish, vegetation or wildlife consumption, and well water use) to determine any additional potential health and environmental impacts. DOE recognizes that concerns have been expressed by the American Indian tribes at the various federal sites involved, as discussed in Section 1.8 and in the tribal narratives in Chapters 6, 8, and 9 and Appendix G. DOE will continue to consult and coordinate with tribal governments to ensure that their concerns are considered in the decision-making process for selecting and implementing (a) disposal alternative(s) for GTCC LLRW and GTCC-like waste.

2.7.8 Land Use

Potential land use impacts are discussed in Sections 3.5, 4.3.8, 6.2.8, 7.2.8, 8.2.8, 9.2.8, 10.2.8, and 11.2.8. There would be no incremental land use impacts associated with Alternatives 1 and 2. No additional land would be affected by Alternative 1, since this alternative involves the continuation of the current storage of these wastes for the indefinite future. Under Alternative 2, no additional land surface within the existing footprint of the WIPP site would be affected by the construction of the additional underground rooms at WIPP to emplace the GTCC LLRW and GTCC-like wastes, except for the small increased amount of land within the existing facility boundary needed to store excavated material (salt) from the repository. The land use impacts associated with use of the WIPP facility for disposal of GTCC LLRW and GTCC-like waste were already incurred when the current WIPP facility was constructed.

Under Alternatives 3 to 5, it is estimated that the amount of land required for the various disposal methods would be 20 ha (50 ac) for the trench method, 24 ha (60 ac) for the vault method, and 44 ha (110 ac) for the borehole method. Reference locations were identified for the various federal sites for purposes of analysis in this EIS on the basis of site characteristics (e.g., depth to groundwater, consistency with current land use plans). The use of reference locations for the EIS is considered to be an acceptable approach to meet the objective of identifying the site and technology combination that could provide the most suitable option for GTCC LLRW and GTCC-like waste disposal. While institutional knowledge was used to select the reference locations evaluated in this EIS, more in-depth, site-specific, follow-on studies and appropriate NEPA reviews would be needed to ensure proper land use planning, assure protection of local ecological and cultural resources, and account for local variations in hydrology and geology to minimize potential waste migration.

At three of the six federal sites considered for the land disposal methods (Hanford Site, INL Site, and NNSS), no conflicts with the current land use designation are expected. Locating the GTCC facility within LANL's TA-54, which is currently designated as a reserve or experimental science area, would require that the reference locations be reclassified as waste management areas. Locating the GTCC facility at the WIPP Vicinity Section 35, which is designated for multiple uses, would require up to 44 ha (110 ac) to be reclassified as a waste management area and could result in the loss of about 0.2% of a 22,000-ha (56,000-ac) grazing allotment. The SRS GTCC reference location would also likely require reclassification; marketable timber on the site would have to be removed.

2.7.9 Transportation

Potential impacts on transportation are discussed in Sections 3.5, 4.3.9, 5.3.9, 6.2.9, 7.2.9, 8.2.9, 9.2.9, 10.2.9, and 11.2.9. The impacts associated with transporting the GTCC LLRW and GTCC-like wastes to the various disposal sites are evaluated for the truck and rail transport modes as separate options in this EIS. The higher number of estimated shipments to the WIPP repository as compared to the other three action alternatives is primarily due to the assumption that activated metals and RH wastes with higher external dose rates would be packaged in shielded canisters prior to being loaded onto the transport vehicles for disposal at WIPP. The impacts cover radiological impacts on the transport crew and general public and nonradiological impacts associated with both routine conditions and accidents. There would be no transportation impacts under Alternative 1, because this alternative does not involve the shipment of wastes to potential disposal sites. The wastes are assumed to be stored indefinitely at their current locations under the No Action Alternative.

Radiological impacts on transportation crew members and the general public would be small under Alternatives 2 to 5. No LCFs in the general public or the transportation crew are estimated for truck or rail transport under these alternatives. Because the estimated doses in these cases would be spread over thousands of individuals, the risk to any single member of the public would be small.

Care would be taken to limit the doses to crew members by controlling the number of shipments that individual workers would be involved with, so that the doses to these individuals would not exceed regulatory health-based dose limits and would be ALARA. The transport crew would consist of radiation workers, and doses to individual workers would not exceed the annual limit of 5 rem/yr, as specified in Subpart C of 10 CFR Part 20. Since transportation of GTCC LLRW and GTCC-like waste is expected to be done in vehicles consigned for exclusive use, the dose limits specified in 49 CFR 173.441 would be followed for all shipments. There are two dose limit requirements in these transportation regulations: a dose limit of 2 mrem/h in any normally occupied position in the vehicle (to limit worker doses), and a limit of 10 mrem/h at 2 m (6.6 ft) from the sides of the transport vehicle (to limit doses to members of the general public). By adhering to these requirements, it is expected that the radiation doses and LCF risks to workers and members of the general public would be small.

Under Alternatives 2 to 5, the estimated nonradiological impacts (accident fatalities) are expected to be small. Up to one fatality from accidents is estimated from all rail transport, with Alternative 2 having a bit higher number of estimated fatalities than Alternatives 3 to 5. Similarly for truck transport, up to two fatalities resulting from accidents are estimated, with Alternative 2 having a higher number of estimated fatalities than Alternative 3, 4, or 5. Alternative 2 has a slightly higher number of estimated fatalities for truck and rail transport because of the larger number of shipments associated with the different waste packages evaluated for disposal at WIPP. The results of these analyses are summarized in Tables 2.7-5 and 2.7-6 for truck and rail transport, respectively.

2.7.10 Cultural Resources

Potential impacts on cultural resources are discussed in Sections 3.5, 4.3.10, 5.3.10, 6.2.10, 7.2.10, 8.2.10, 9.2.10, 10.2.10, and 11.2.10. For the No Action Alternative (Alternative 1), there would be no incremental impacts on cultural resources at the potential disposal sites evaluated in this GTCC EIS because no construction activities related to GTCC LLRW and GTCC-like waste disposal would occur at these sites. Under Alternative 2, no additional impacts would occur from the construction of the additional underground rooms to emplace the GTCC LLRW at WIPP beyond those that were already incurred when the current WIPP facility was constructed.

Cultural resources are known or likely to occur at five of the sites considered for the land disposal methods: (1) the Hanford Site (traditional cultural properties, including Rattlesnake Mountain, portions of which have been determined eligible for listing on the *National Register of Historic Places* [NRHP], and isolated artifacts were found in the area), (2) the INL Site (prehistoric sites and historic homestead sites are possible), (3) LANL (18 cultural sites were found, some of which are eligible for listing on the NRHP), (4) SRS (seven archeological sites were identified), and (5) the WIPP Vicinity site (prehistoric artifact was found). A handful of very small lithic scatters are located within the GTCC reference location at NNSS, but none of them are eligible for listing on the NRHP. Local tribes would be consulted to identify appropriate mitigations to address potential adverse effects on historic properties and sensitive cultural resources that might occur as a result of a GTCC LLRW and GTCC-like waste disposal facility.

Because the borehole method requires the most land, it has the greatest potential to affect cultural resources, especially during the construction phase. Impacts that would occur at the locations that would provide the soil needed for backfill and cover material (the most of which is required for the vault method) would also be considered.

2.7.11 Waste Management

Potential impacts on waste management programs evaluated are discussed in Sections 3.5, 4.3.11, 5.3.11, 6.2.11, 7.2.11, 8.2.11, 9.2.11, 10.2.11, and 11.2.11. The potential waste management impacts discussed in the various chapters are intended to address potential waste generated from the construction and operational activities associated with the disposal facilities being proposed rather than impacts from the GTCC LLRW and GTCC-like waste inventory itself. Under the No Action Alternative, no waste from construction or operations of a waste disposal facility would be generated because these activities would not be conducted. Under Alternative 2, current waste management practices at WIPP would continue to manage any waste generated from the construction of additional underground rooms and the emplacement of GTCC LLRW and GTCC-like waste at the repository. It is expected that the waste volumes generated would not affect current waste management capacities.

Under Alternatives 3 to 5, the types of waste generated during the construction and operations of the land disposal facilities would be typical of those generated by large industrial projects (e.g., sanitary wastes, hazardous wastes, concrete, and steel spoilage). These waste types are routinely handled at the sites evaluated in this EIS. In addition, it is expected that the volumes generated would be small increments when added to the much larger quantities already produced at those sites, so these additional wastes would not affect waste management resources at these sites. Wastes generated from the proposed GTCC LLRW and GTCC-like waste disposal facility at the WIPP Vicinity reference locations would likely be disposed of off-site at permitted facilities, as necessary.

2.7.12 Cumulative Impacts

Potential impacts of the GTCC proposed action are considered in combination with the impacts of past, present, and reasonably foreseeable future actions. Cumulative impacts are discussed in Section 4.5 for Alternative 2 and in Sections 6.4, 7.4, etc., to 11.4 for Alternatives 3 to 5. DOE did not evaluate the cumulative impacts of the No Action Alternative at the many privately-owned and operated locations, since such an evaluation would involve making speculative assumptions about environmental conditions and future activities at those locations where GTCC LLRW could be stored.

For Alternative 2, the low potential impacts (discussed in Sections 2.7.1 to 2.7.11 and Section 4.3) of that alternative indicate that the cumulative impacts from the construction, operations, and post-closure phases of the proposed action at the WIPP site would be small and would not exceed regulatory requirements established for the WIPP facility. The post-closure performance analysis performed for emplacement of all GTCC LLRW and GTCC-like waste at WIPP demonstrates that disposal of these wastes would result in WIPP still being in compliance with existing regulatory requirements (see Section 4.3.4.3).

For Alternatives 3 to 5 at the federal sites, the estimated impacts from the GTCC proposed action are not expected to contribute substantially to cumulative impacts for the various resource areas evaluated (see Sections 2.7.1 to 2.7.11 and Sections 6.2, 7.2, etc., to 11.2), with the likely exception of potential human health impacts in the long term. That is, during the post-closure phase of the proposed action, potential leaching of radionuclides from the GTCC LLRW and GTCC-like waste inventory into groundwater could contribute to doses and LCF risks to a hypothetical resident farmer located about 100 m (330 ft) from the edge of the borehole, trench, or vault disposal facility at the federal reference locations (i.e., at the Hanford Site, INL Site, LANL, and SRS). For the Hanford Site, as stated in the Hanford TC&WM EIS (DOE 2009), when the impacts of technetium-99 from past leaks and cribs and trenches (ditches) are combined, DOE believes it may not be prudent to add significant additional technetium-99 to the existing environment. Therefore, one means of mitigating this impact would be for DOE to limit disposal of off-site waste streams containing iodine-129 or technetium-99 at Hanford. The post-closure doses and LCF risks are summarized in Table 2.7-3. The resident farmer scenario is assumed to be conservative (i.e., one that overestimates the expected dose and LCF risk) because it assumes a total loss of institutional control and institutional memory with regard to the disposal facility. (The sites evaluated for Chapters 6 to 11 are on federal land and would most likely continue to be managed by the federal government for a long time.) In addition, land use designations for these sites might be incompatible with or would not allow a resident farmer scenario. Follow-on NEPA evaluations to support further considerations of siting a new borehole, trench, or vault disposal facility at the sites evaluated in this EIS would provide more detailed analyses of site-specific issues relative to cumulative impacts.

TABLE 2.7-1 Comparison of Potential Impacts from Alternatives 1 through 5 on Air Quality and Noise

Alternative	Air Quality	Noise
1: No Action	No incremental air quality impacts due to construction activities for a disposal facility would occur because none would be undertaken. Procedures being used to store wastes would continue. It is assumed that the facility operations in the storage sites would continue and result in minimal impacts.	No incremental impacts due to construction activities for a disposal facility are expected because none would be undertaken. It is assumed that the facility operations in the storage sites would continue and result in minimal impacts.
2: WIPP	Emissions from construction and operational activities would not contribute significantly to concentrations at the site boundary or nearest residence. Concentration levels during operation are expected to remain below National Ambient Air Quality Standards/State Ambient Air Quality Standards (NAAQS/SAAQS). The average-year emissions would be about one-third of peak-year emissions.	No significant vibration impacts are anticipated because most activities would occur underground and because no major equipment that could cause ground vibration would be used. The noise from operational activities would be barely discernable or completely inaudible at the site boundaries and the nearest residences. Incremental impacts would extend the time frame of the impacts and not the magnitude of annual or single events.
3: Borehole method		
Hanford Site	Potential impacts of construction and operations would be low but higher than for Alternatives 1 and 2. Construction and operational activities would be well within the site boundaries, and emissions would contribute little to concentrations at or beyond the site boundaries. The total peak-year emissions of criteria pollutants, VOCs, and CO_2 would be very small. O_3 levels are currently in attainment, and O_3 precursor emissions levels are much lower than are those for the regional air shed. Activities would not contribute significantly to particulate matter (PM) concentrations at the boundary or nearest residence.	During construction, the highest composite noise would be about 92 dBA at 15 m (50 ft) from the source, and levels at 690 m (2,300 ft) would be below the EPA guideline of 55 dBA. The nearest off-site residences are 6 km (4 mi) from the Hanford GTCC reference location. No ground-borne vibration impacts are anticipated. The impacts during operations would be less than those during the construction phase.
INL Site	Same as the potential impacts discussed for the Hanford Site for this method (borehole).	Same as the potential impacts discussed for the Hanford Site for this method (borehole). The nearest off-site residences are >11 km (7 mi) from the INL Site GTCC reference location.

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TABLE 2.7-1 (Cont.)

Alternative	Air Quality	Noise
LANL	Same as the potential impacts discussed for the Hanford Site for this method (borehole).	Same as the potential impacts discussed for the Hanford Site for this method (borehole). The nearest off-site residences are approximately 3.5 km (2.2 mi) from the LANL GTCC reference location.
NNSS	Same as the potential impacts discussed for the Hanford Site for this method (borehole).	Same as the potential impacts discussed for the Hanford Site for this method (borehole). The nearest off-site residences are >6 km (4 mi) from the NNSS GTCC reference location.
WIPP Vicinity	Same as the potential impacts discussed for the Hanford Site for this method (borehole).	Same as the potential impacts discussed for the Hanford Site for this method (borehole). The nearest off-site residences are >5 km (3 mi) from the WIPP Vicinity reference locations.
4: Trench method		
Hanford Site	Potential impacts from construction and operations would be low but higher than for Alternatives 1 to 3. Construction and operational activities would be well within the site boundaries, and emissions would contribute little to concentrations at or beyond the site boundaries. The total peak-year emissions of criteria pollutants, VOCs, and CO_2 would be small. O_3 levels are currently in attainment, and O_3 precursor emission levels are much lower than those for the regional air shed. Activities would not contribute significantly to PM concentrations at the boundary or nearest residence. The emission levels for the trench method are slightly lower than those for the vault method.	Same as for Alternative 3.
INL Site	Same as the potential impacts discussed for the Hanford Site for this method (trench).	Same as for Alternative 3.
LANL	Same as the potential impacts discussed for the Hanford Site for this method (trench).	Same as for Alternative 3.

TABLE 2.7-1 (Cont.)

Alternative	Air Quality	Noise
NNSS	Same as the potential impacts discussed for the Hanford Site for this method (trench).	Same as for Alternative 3.
SRS	Same as the potential impacts discussed for the Hanford Site for this method (trench).	Same as for Alternative 3, except the highest composite noise would be about 90 dBA at 15 m (50 ft) from the source, and levels at 610 m (2,000 ft) would be below the EPA guideline of 55 dBA. The nearest off-site residences are >14 km (9 mi) from the SRS reference location.
WIPP Vicinity	Same as the potential impacts discussed for the Hanford Site for this method (trench).	During construction, the highest composite noise would be about 92 dBA at 15 m (50 ft) from the source, and levels at 690 m (2,300 ft) would be below the EPA guideline of 55 dBA. No ground-borne vibration impacts are anticipated. The impacts during operations would be less than those during the construction phase. The nearest off-site residences are >5 km (3 mi) at the WIPP Vicinity GTCC reference locations.
5: Vault method		
Hanford Site	Potential impacts from construction and operations would be low but higher than for Alternatives 1 to 4. Construction and operational activities would be well within the site boundaries, and emissions would contribute little to concentrations at or beyond the site boundaries. The total peak-year emissions of criteria pollutants, VOCs, and CO_2 would be very small. O_3 levels are currently in attainment, and O_3 precursor emission levels are much lower than those for the regional air shed. Activities would not contribute significantly to PM concentrations at the boundary or nearest residence. The emission level for the vault method is almost the same as that for the trench method, and it is the highest of those for the three land disposal methods.	Same as Alternative 3.

TABLE 2.7-1 (Cont.)

Alternative	Air Quality	Noise
INL Site	Same as the potential impacts discussed for the Hanford Site for this method (vault).	Same as Alternative 3.
LANL	Same as the potential impacts discussed for the Hanford Site for this method (vault).	Same as Alternative 3.
NNSS	Same as the potential impacts discussed for the Hanford Site for this method (vault).	Same as Alternative 3.
SRS	Same as the potential impacts discussed for the Hanford Site for this method (vault).	Same as Alternative 3.
WIPP Vicinity	Same as the potential impacts discussed for the Hanford Site for this method (vault).	Same as Alternative 3.

TABLE 2.7-2 Comparison of Potential Impacts from Alternatives 1 through 5 on Geology, Water Resources, Ecological Resources, and Cultural Resources

Alternative	Geology	Water Resources	Ecological Resources	Cultural Resources
1: No Action	No incremental impacts are expected because construction activities for a disposal facility would not be undertaken. It is assumed that the facility operations in the storage sites would continue and result in minimal impacts.	No incremental impacts are expected to occur. Continued monitoring procedures would ensure that discharges to surface waters would not exceed regulatory limits.	No incremental impacts are expected because construction activities for a disposal facility would not be undertaken. It is assumed that the facility operations in the storage sites would continue and result in minimal impacts.	No incremental impacts are expected because continued waste storage activities would not require disruption of additional areas not already affected.
2: WIPP	No incremental impacts are expected because construction, operational, and post-closure activities would not involve additional land disturbance beyond that already occupied by the existing footprint of the WIPP site.	The incremental impacts would be minor when added to those already associated with operations at the WIPP facility. Surface water and groundwater resources would not be affected because no land surfaces would be disturbed.	The incremental impacts on habitat and wildlife would be localized and are not expected to result in adverse population-level impacts.	No incremental impacts are expected because construction, operational, and post-closure activities would not involve additional land disturbance beyond that already occupied by the existing footprint of the WIPP site.

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TABLE 2.7-2 (Cont.)

Alternative	Geology	Water Resources	Ecological Resources	Cultural Resources
3: Borehole method				
Hanford Site	Impacts due to land disturbance would be proportional to the total land area affected. The borehole method would disturb the most land of the three land disposal methods. The boreholes would be completed in unconsolidated material, and there would be no adverse impacts from extraction and use of geologic and soil resources. No significant changes in surface topography or natural drainages are expected. The soil erosion potential is low and would be further reduced by use of best management practices.	The borehole method requires the least water of the three land disposal methods. The maximum increase in annual water use (from the Columbia River) would be as high as 0.31% during normal operations. Surface water and groundwater resources could be impacted by surficial spills. Wastewater discharges to drainage fields and evaporation ponds would have a small impact on groundwater resources. The GTCC reference location is not within a 100-yr floodplain. In addition, groundwater could become contaminated with radionuclides from GTCC LLRW and GTCC-like waste disposal, as indicated by estimates from the post-closure performance of a borehole disposal facility.	Impacts are expected to be small because of the small amount of land that would be affected. The loss of sagebrush habitat, followed by eventual establishment of low-growth vegetation, would affect sagebrush-dependent species. Loss of sagebrush would be compensated for by restoration elsewhere. Ground disturbance during the nesting season could destroy eggs and affect birds that use these areas for nests. There are no natural aquatic habitats within the immediate vicinity of the GTCC reference location. No federally listed species have been reported in the GTCC reference location. However, construction could affect federal and state candidate species that depend on sagebrush habitat.	There are no known historic properties within the GTCC reference location, although isolated prehistoric artifacts have been found in the area. Section 106 of the NHPA would be followed to determine the effect(s) on any historic properties and to develop appropriate mitigation measures. Consultation requirements associated with the NHPA and DOE American Indian & Alaska Native Tribal Government Policy would also be followed. Of the three land disposal methods, the borehole method has the greatest potential to affect cultural resources because it requires the most land.

TABLE 2.7-2 (Cont.)

Alternative	Geology	Water Resources	Ecological Resources	Cultural Resources
INL Site	Same as the potential impacts discussed for the Hanford Site for this method (borehole).	Same as the potential impacts discussed for the Hanford Site for this method (borehole), except the maximum increase in annual water use (from on-site wells) would be as high as 0.05% during normal operations.	Same as the potential impacts discussed for the Hanford Site for this method (borehole).	There are no known cultural resources within the GTCC reference location, although prehistoric archaeological sites and a substantial number of historic homestead sites are possible. Section 106 of NHPA would be followed to determine the impact on cultural resources and to develop appropriate mitigation measures. Local tribes would be consulted to ensure that no traditional cultural properties were impacted. Of the three land disposal methods, the borehole method has the greatest potential to affect cultural resources because it requires the most land.

TABLE 2.7-2 (Cont.)

Alternative	Geology	Water Resources	Ecological Resources	Cultural Resources
LANL	Same as the potential impacts discussed for the Hanford Site for this method (borehole), except that the boreholes would be in unconsolidated mesa top alluvium and tuff. The facility would have to be sited away from a mesa cliff edge.	Same as the potential impacts discussed for the Hanford Site for this method (borehole), except the maximum increase in annual water use (from on-site wells) would be as high as 0.18% during operations. The GTCC reference location is not within the 100-year floodplain.	Impacts are expected to be minor because of the small amount of land that would be affected. The loss of pinyon-juniper woodland habitat, followed by eventual establishment of low-growth vegetation, would affect some species. Ground disturbance during the nesting season could destroy eggs and affect birds that use these areas for nests. There are no natural aquatic habitats within the immediate vicinity of the GTCC reference location. Construction activities could affect wildlife species, but small mammals, ground-nesting birds, and reptiles would eventually recolonize. Larger mammals would likely avoid the area. Foragers and hunters would be excluded by fencing during the institutional control/monitored post-closure period. Several federally or state-listed species occur within the GTCC reference location. Construction could affect federal and state candidate species that depend on pinyon-juniper woodland habitat.	Eighteen cultural resources are reported to be in and near the project area, and some of the sites in the GTCC reference location are considered eligible for listing under the NHPA. Section 106 of NHPA would be followed to determine the impact on cultural resources and to develop appropriate mitigation measures. Local tribes would be consulted to ensure no traditional cultural properties were affected. Of the three land disposal methods, the borehole method has the greatest potential to affect cultural resources because it requires the most land.

TABLE 2.7-2 (Cont.)

Alternative	Geology	Water Resources	Ecological Resources	Cultural Resources
NNSS	Same as the potential impacts discussed for the Hanford Site for this method (borehole).	Same as the potential impacts discussed for the Hanford Site for this method (borehole), except the maximum increase in annual water use (from on-site wells) would be as high as 0.23% during normal operations. Nearby streams are ephemeral, and the GTCC reference location is not within any known floodplains.	Same as the potential impacts discussed for LANL for this method (borehole), except the existing habitat is creosote bush/white bursage. The desert tortoise is the only federally listed animal species resident on NNSS. It inhabits the southern third of the site at low estimated densities. However, since the Radioactive Waste Management Site (RWMS) is not considered a suitable habitat for the tortoise, the area is not subject to the requirements of the U.S. Fish and Wildlife Service's (USFWS's) 1996 Biological Opinion. Construction activities might destroy western burrowing owl burrows or directly kill owls. Adverse impacts would be minimized by conducting biological surveys in the GTCC reference location and using appropriate mitigation measures.	A handful of very small lithic scatters are located within the GTCC reference location at NNSS, but none of them are eligible for inclusion in the NRHP. Section 106 of NHPA would be followed to determine the impact on cultural resources and to develop appropriate mitigation measures. Local tribes would be consulted to ensure no traditional cultural properties were affected. Of the three land disposal methods, the borehole method has the greatest potential to affect cultural resources because it requires the most land.

TABLE 2.7-2 (Cont.)

Alternative	Geology	Water Resources	Ecological Resources	Cultural Resources
WIPP Vicinity	Same as the potential impacts discussed for the Hanford Site for this method (borehole). In addition, oil production and gas production currently occur at Section 35, and potash mining occurs at other sections. Disposal activities in Section 35 would not have adverse impacts on the extraction of economic minerals in the surrounding region (an area known to be rich in potash ore), but they would preclude mining within the section. Section 27, which is within the WIPP Land Withdrawal Boundary (LWB), is closed to commercial mineral development.	Same as the potential impacts discussed for the Hanford Site for this method (borehole), except the maximum increase in annual water use would be as high as 26% of what is used at the nearby WIPP repository during normal operations. The increased demand on Carlsbad's Double Eagle South Well Field water supply system would be about 0.39% of its capacity. The GTCC reference location is not within a 100-year floodplain, and there are no surface water bodies in the immediate vicinity.	Impacts are expected to be minor because only a small amount of land would be affected. Loss of shrub-dominated sand dune habitat, followed by eventual establishment of low-growth vegetation, would not create a long-term reduction in the local or regional ecological diversity. DOE's wildlife management goals for WIPP include protection and maintenance of crucial habitats for certain species; wildlife management goals at the WIPP Vicinity would likely be similar. There are no natural aquatic habitats within the immediate vicinity of the GTCC reference location. No endangered, threatened, or other special-status species have been reported in the GTCC reference location; however, the site provides favorable habitat for the lesser prairie-chicken, a federal candidate species. Impacts on this species would likely be small, since the area of disturbance would be relatively small.	Some isolated prehistoric artifacts and possibly some larger prehistoric cultural resources would be found in the project area. One known prehistoric site is within the WIPP Vicinity reference location (Section 35) and has yet to be evaluated for listing on the NRHP. If additional archaeological sites were identified, they would require evaluation for listing on the NRHP. Section 106 of the NHPA would be followed to determine the impacts of disposal facility activities on significant cultural resources, as needed. Local tribes would be consulted to ensure that no traditional cultural properties were impacted.

TABLE 2.7-2 (Cont.)

Alternative	Geology	Water Resources	Ecological Resources	Cultural Resources
4: Trench method				
Hanford Site	Same impacts as those under Alternative 3, except there would be less land disturbed.	Water needs would be greater for the trench method than for the borehole method. The maximum increase in annual water use would be as high as 0.65% during normal operations for the trench method. Surface water and groundwater resources could be affected by surficial spills. Wastewater discharges to drainage fields and evaporation ponds would have a negligible impact on groundwater resources. The GTCC reference location is not within a floodplain for a probable maximum flood. Same as for the borehole method with regard to the potential for radionuclide contamination in groundwater from the proposed trench facility during the post-closure phase.	Same as for Alternative 3.	Same as for Alternative 3.

TABLE 2.7-2 (Cont.)

Alternative	Geology	Water Resources	Ecological Resources	Cultural Resources
INL Site	Same as Alternative 3, except there would be less land disturbed and the bottom of the trench could penetrate the top basalt layer.	Same as the potential impacts discussed for the Hanford Site for this method (trench) (the potential impact would be greater than Alternative 3 relative to the increase in annual water use). The maximum increase in annual water use would be as high as 0.13% during normal operations for the trench method.	Same as for Alternative 3.	The potential for impacts is less than that for Alternative 3 because less land would be affected.
LANL	Same as Alternative 3, except there would be less land disturbed and the bottom of the trench could penetrate the tuff.	Same as the potential impacts discussed for the Hanford Site for this method (trench) (the potential impact would be greater than Alternative 3 relative to the increase in annual water use). The maximum increase in annual water use would be as high as 0.39% during normal operations for the trench method. The GTCC reference location is not within the 100-year floodplain.	Same as for Alternative 3.	Same as for Alternative 3.
NNSS	Same as Alternative 3, except there would be less land disturbed.	Same as the potential impacts discussed for the Hanford Site for this method (trench) (the potential impact would be greater than Alternative 3 relative to the increase in annual water use). The maximum increase in annual water use would be as high as 0.48% during normal operations for the trench method. Nearby streams are ephemeral, and the GTCC reference location is not within any known floodplains.	Same as for Alternative 3.	Same as for Alternative 3.

TABLE 2.7-2 (Cont.)

Alternative	Geology	Water Resources	Ecological Resources	Cultural Resources
SRS	Same as Alternative 3, except there would be less land disturbed. There would be no changes in the natural drainages.	Same as the potential impacts discussed for the Hanford Site for this method (trench) (the potential impact would be greater than Alternative 3 relative to the increase in annual water use). The maximum increase in annual water use would be as high as 0.1% during normal operations for the trench method. The GTCC reference location is not within the 100-year floodplain.	Similar to Alternative 3 for other sites, except mostly upland pine and some hardwood forest habitats would be lost. Several state-listed or special-status species occur within the GTCC reference location. Impacts on these species would likely be small, since the area of disturbance would be relatively small. Forest removal during construction would eliminate a small portion of about 0.1% of the Supplemental Red-Cockaded Woodpecker Management Area; population-level impacts are not expected.	There are seven archaeological sites within the GTCC reference location. These sites would require evaluation for listing on the NRHP. Mitigation for eligible sites would be determined through consultation with the South Carolina State Historic Preservation Office (SHPO) and appropriate tribes. The potential for impacts is greater for the vault method because it would affect more land than would the trench method.
WIPP Vicinity	Same as Alternative 3, except there would be less land disturbed.	Same as the potential impacts discussed for the Hanford Site for this method (trench), except the maximum increase in annual water use would be as high as 26% of what is used at the nearby WIPP repository during normal operations. The increased demand on Carlsbad's Double Eagle South Well Field water supply system would be about 0.39% of its capacity. The GTCC reference location is not within a 100-year floodplain, and there are no surface water bodies in the immediate vicinity.	Same as for Alternative 3.	Same as for Alternative 3.

TABLE 2.7-2 (Cont.)

Alternative	Geology	Water Resources	Ecological Resources	Cultural Resources
5: Vault method				
Hanford Site	Same impacts as those under Alternative 3, except there would be less land disturbed. Associated land disturbance would be greater than for Alternative 4.	Water needs would be greater than those for Alternative 3 but about the same as those for Alternative 4. Surface water and groundwater resources could be affected by surficial spills. Wastewater discharges to drainage fields and evaporation ponds would have a small impact on groundwater resources. The GTCC reference location is not within a floodplain for a probable maximum flood.	Same as for Alternatives 3 and 4.	Same as for Alternatives 3 and 4, except that the vault method could have a greater potential for impacts because it would affect more land than would the trench method.
INL Site	Same impacts as those under Alternative 3, except there would be less land disturbed. Associated land disturbance would be greater than for Alternative 4.	Water needs would be greater than those for Alternative 3 but about the same as those for Alternative 4.	Same as for Alternatives 3 and 4.	Same as for Alternative 3, except that the vault method could have a greater potential for impacts because it would affect more land than would the trench method.
LANL	Same impacts as those under Alternative 3, except there would be less land disturbed. Associated land disturbance would be greater than for Alternative 4.	Water needs would be greater than those for Alternative 3 but about the same as those for Alternative 4.	Same as for Alternatives 3 and 4.	Same as for Alternatives 3 and 4
NNSS	Same impacts as those under Alternative 3, except there would be less land disturbed. Associated land disturbance would be greater than for Alternative 4.	Water needs would be greater than those for Alternative 3 but about the same as those for Alternative 4.	Same as for Alternatives 3 and 4.	Same as for Alternatives 3 and 4.

TABLE 2.7-2 (Cont.)

Alternative	Geology	Water Resources	Ecological Resources	Cultural Resources
SRS	Same impacts as those under Alternative 3, except there would be less land disturbed. Associated land disturbance would be greater than for Alternative 4. There would be no changes in the natural drainages.	Same as for Alternative 4.	Same as for Alternative 4.	Same as for Alternative 4.
WIPP Vicinity	Same as the potential impacts discussed for the Hanford Site for this method (vault).	Water needs would be greater than those for Alternative 3 but about the same as those for Alternative 4.	Same as for Alternatives 3 and 4.	Same as for Alternatives 3 and 4.

1
2

TABLE 2.7-3 Comparison of Potential Impacts from Alternatives 1 through 5 on Human Health[a]

Alternative	Annual Collective Worker Dose (person-rem)[b]	Annual Collective Worker LCF Risk	Annual No. of Physical Injuries to Workers[c]	Highest Annual Dose to a Hypothetical Resident Farmer (mrem/yr)[d]	Highest Annual LCF Risk to Resident Farmer[d]	Highest Individual Dose from Waste Handling Accident (rem)[e]	Highest Individual LCF Risk from Waste Handling Accident[e]	Highest Population Dose from Waste Handling Accident (person-rem)[e]	Highest Population LCF Risk from Waste Handling Accident[e]
1: No Action	4[f]	0.002	NA			NA	NA	NA	NA
Region I				470,000	0.3				
Region II				860	0.0005				
Region III				120	0.00007				
Region IV				0[g]	0				
2: WIPP	0.29	0.0002	3	0[h]	[h]	7.5[i]	0.005[i]	1.7[j]	0.001[j]
3: Borehole method									
Hanford Site	2.6	0.002	1	4.8 0	0.000003	16	0.009	95	0.06
INL Site	2.6		1	820	0.0005	11	0.007	13	0.008
LANL	2.6	0.002	1	160	0.00009	12	0.007	160	0.1
NNSS	2.6	0.002	1	0	0	2.4	0.001	0.47	0.0003
WIPP Vicinity	2.6 0.002	0.002		0	0	7.5	0.005	7.0	0.004
Generic Commercial Region IV	2.6	0.002	1	0	0	NA[k]	[k]	[k]	NA[k]
4: Trench method		1							
Hanford Site	4.6	0.003	2	48	0.00003	NA	0.009	95	0.06
INL Site	4.6		2	2,100	0.001	11	0.007 NA	13	0.008
LANL	4.6	0.003	2	380	0.0002	12	0.007	160	0.1
NNSS	4.6	0.003	2	0	0	2.4	0.001	0.47	0.0003
SRS	4.6 0.003	0.003	2	1,700	0.001 16	4.3	0.003	45	0.03
WIPP Vicinity	4.6	0.003	2	0	0	7.5	0.005	7.0	0.004
Generic Commercial Region II	4.6	0.003	2	1,200	0.0007	NA[k]	[k]	[k]	NA[k]
Generic Commercial Region IV	4.6	0.003	2	0	0	NA[k]	NA[k]	NA[k]	NA[k]
5: Vault method						NA			
Hanford Site	5.2	0.003	2	49	0.00003		0.009	95	0.06
INL Site	5.2		2	2,300	0.001	11	0.007 NA	13	0.008
LANL	5.2	0.003	2	430	0.0003	12	0.007	160	0.1

0.003 16

TABLE 2.7-3 (Cont.)

Alternative	Annual Collective Worker Dose (person-rem)[b]	Annual Collective Worker LCF Risk	Annual No. of Physical Injuries to Workers[c]	Highest Annual Dose to a Hypothetical Resident Farmer (mrem/yr)[d]	Highest Annual LCF Risk to Resident Farmer[d]	Highest Individual Dose from Waste Handling Accident (rem)[e]	Highest Individual LCF Risk from Waste Handling Accident[e]	Highest Population Dose from Waste Handling Accident (person-rem)[e]	Highest Population LCF Risk from Waste Handling Accident[e]
5: Vault method (Cont.)									
NNSS	5.2	0.003	2	0	0	2.4	0.001	0.47	0.0003
SRS	5.2	0.003	2	1,300	0.0008	4.3	0.003	45	0.03
WIPP Vicinity	5.2	0.003	2	0	0	7.5	0.005	7.0	0.004
Generic Commercial Region I	5.2	0.003	2	12,000	0.007	NA[k]	NA[k]	NA[k]	NA[k]
Generic Commercial Region II	5.2	0.003	2	1,200	0.0007	NA[k]	NA[k]	NA[k]	NA[k]
Generic Commercial Region III	5.2	0.003	2	530	0.0003	NA[k]	NA[k]	NA[k]	NA[k]
Generic Commercial Region IV	5.2	0.003	2	0	0	NA[k]	NA[k]	NA[k]	NA[k]

[a] Radiation doses are given to two significant figures, and LCF risks and physical injuries are given to one significant figure. NA means not analyzed, and a value of 0 for long-term human health impacts means that the radioactive contamination does not reach the well of the hypothetical receptor (for Alternatives 1, 3, 4, and 5) or the Culebra Dolomite at WIPP for Alternative 2.

[b] The annual occupational doses for Alternatives 3, 4, and 5 were based on an average annual dose rate of 0.2 rem per full-time equivalent (FTE) worker and the number of FTE workers estimated for waste disposal. An "FTE worker" for waste disposal purposes would not actually be one worker but would likely consist of several individually badged workers, since the workers would perform other tasks in addition to waste disposal. The worker dose estimates for Alternative 2 were based on actual doses that have occurred during defense-generated TRU waste disposal operations.

[c] Physical injuries to workers are given as number of lost workdays. The estimate for Alternative 2 was based on actual data from operations at WIPP and generic accident rates were used for Alternatives 3, 4, and 5.

[d] For Alternatives 1, 3, 4, and 5, these impacts are the peak long-term annual radiation doses and LCF risks estimated to occur within the first 10,000 years after closure of the waste disposal facility to a hypothetical resident farmer 100 m (330 ft) downgradient from the edge of the disposal facility. For Alternative 2, there would be no releases to the accessible environment and therefore no radiation doses and LCF risks during the first 10,000 years following closure of the WIPP repository, as noted in Section 5.1.12.1 of DOE (1997).

[e] The highest individual dose and LCF risk is for an individual assumed to be located 100 m (330 ft) from an accident involving a fire to a standard waste box (SWB). This individual is expected to be a noninvolved worker. The highest exposed population is that group of people in the sector downwind from the site resulting in the highest population dose.

Footnotes continue on next page.

TABLE 2.7-3 (Cont.)

[f] Estimate is based on outdoor storage of spent nuclear fuel at several locations and is assumed to be conservative. For the No Action Alternative, GTCC LLRW and GTCC-like waste would continue to be stored at facilities licensed by the NRC and Agreement States (GTCC LLRW) and at DOE facilities (GTCC-like waste) in accordance with all applicable requirements.

[g] Radionuclides are not expected to reach groundwater within 10,000 years for a number of sites and disposal methods. The radiation doses and LCF risks are reported as zero in these cases.

[h] The disposal of defense-generated TRU waste at WIPP is conducted in accordance with the standards and criteria in 40 CFR Part 191 and 40 CFR Part 194. As noted in footnote d, there would be no radionuclide releases to the accessible environment in the first 10,000 years following closure of WIPP, and the corresponding annual dose and LCF risk are both reported as 0.

[i] The impacts from a waste handling accident to an individual from storage activities were not re-analyzed in this EIS as analysis was performed in Chapter 5 of “The WIPP Disposal Phase Final Supplement EIS (EIS-0026-S-2, September 1997); the accident analysis in the EIS has been reviewed by EM and is still representative and bounding. The highest individual dose and LCF risk from this accident would be expected to be very similar to those reported for disposal at the WIPP Vicinity site. These values are given here for these impacts.

[j] The impacts from a waste handling accident to an individual from storage activities were not re-analyzed in this EIS as analysis was performed in Chapter 5 of “The WIPP Disposal Phase Final Supplement EIS (EIS-0026-S-2, September 1997); the accident analysis in the EIS has been reviewed by EM and is still representative and bounding. The nearby population dose and LCF risk from this accident would be expected to be very similar to those reported for disposal at the WIPP Vicinity site. These values are given here for these impacts.

[k] The impacts from a waste handling accident associated with the use of a commercial GTCC LLRW and GTCC-like waste disposal facility are dependent on the local meteorology and location of nearby individuals. While these cannot be calculated lacking a specific site, these impacts would be expected to be comparable to those given for the federal sites in this table.

TABLE 2.7-4 Comparison of Potential Impacts from Alternatives 1 through 5 on Socioeconomics, Environmental Justice, Land Use, and Waste Management

Alternatives	Socioeconomics	Environmental Justice	Land Use	Waste Management
1: No Action	No incremental impacts due to construction activities for a disposal facility are expected because none would be undertaken. It is assumed that the facility operations in the storage sites would continue and result in minimal impacts.	No incremental impacts due to construction activities for a disposal facility are expected because none would be undertaken. It is assumed that the facility operations in the storage sites would continue and result in minimal impacts.	No incremental impacts due to construction activities for a disposal facility are expected because none would be undertaken. It is assumed that the facility operations in the storage sites would continue and result in minimal impacts.	No incremental impacts due to construction activities for a disposal facility are expected because none would be undertaken. It is assumed that the facility operations in the storage sites would continue and result in minimal impacts.
2: WIPP	Overall impacts would be small. Construction for expanding the disposal capacity to accommodate the increased waste volume could be done by the current workforce at the site. The duration of facility operations would be extended to accommodate the schedule for disposal of the wastes.	There would be no incremental impacts beyond those that have already occurred on the minority and low-income population near the facility.	No changes in land use at the WIPP site or surrounding area would occur. Other uses within the site (e.g., oil and gas leases and livestock grazing) would not be affected. No additional land surface within the existing footprint of the WIPP site would be affected by the construction of the additional underground rooms at WIPP to emplace the GTCC LLRW and GTCC-like wastes, except for the small increased amount of land within the existing facility boundary needed to store excavated material (salt) from the repository.	Small quantities of nonradioactive hazardous and nonhazardous and radioactive solid and liquid wastes would be produced during construction and waste disposal operations. These would be managed in the same manner as other such wastes produced by operations at the site.

1

TABLE 2.7-4 (Cont.)

Alternatives	Socioeconomics	Environmental Justice	Land Use	Waste Management
3: Borehole method				
Hanford Site	The overall impacts would be small. The annual average employment growth rate would increase by less than 0.1%, and about $4.2 million in income would be produced in the peak construction year. An estimated 21 people would in-migrate to the ROI as a result of employment on-site; in-migration would have only a marginal effect on population growth and require less than 1% of vacant rental housing in the peak year. Operating a borehole facility would create 38 direct jobs annually and an additional 36 indirect jobs in the ROI. A borehole facility would produce $3.9 million in annual income during operations.	Potential impacts on the minority and low-income population are not expected from Alternative 3. Subsequent NEPA review to support any GTCC LLRW and GTCC-like waste disposal facility implementation would consider any unique exposure pathways (such as subsistence fish, vegetation or wildlife consumption, and well water use) to determine any additional potential human health and environmental impacts.	Land use impacts are expected to be relatively small. About 44 ha (110 ac) of land would be altered to accommodate the necessary facilities. The GTCC reference location would be near the 200 Area complex, and there would be no conflicts with current land use designations or patterns.	Small quantities of nonradioactive hazardous and nonhazardous and radioactive solid and liquid wastes would be produced during construction and GTCC LLRW and GTCC-like waste disposal operations. These would be managed in the same manner as other such wastes produced by current operations at the site. Alternative 3 would generate the least (between Alternatives 3 and 5) hazardous and nonhazardous waste during construction and operations, with the exception of nonhazardous solids that could be generated during construction.

TABLE 2.7-4 (Cont.)

Alternatives	Socioeconomics	Environmental Justice	Land Use	Waste Management
INL Site	Same as the potential impacts discussed for the Hanford Site for this method (borehole), except about $8.8 million in income would be produced in the peak construction year. An estimated 32 people would in-migrate to the ROI as a result of employment on-site. Disposal operations would create 38 direct jobs annually and an additional 42 indirect jobs in the ROI and produce $3.9 million in annual income.	Same as the potential impacts discussed for the Hanford Site for this method (borehole).	Same as the potential impacts discussed for the Hanford Site for this method (borehole), except the GTCC reference location is not within existing major complex areas.	Same as the potential impacts discussed for the Hanford Site for this method (borehole).
LANL	Same as the potential impacts discussed for the Hanford Site for this method (borehole), except about $5.4 million in income would be produced in the peak construction year. An estimated 21 people would in-migrate to the ROI as a result of employment on-site. Disposal operations would create 38 direct jobs annually and an additional 41 indirect jobs in the ROI and produce $4.0 million in annual income.	Same as the potential impacts discussed for the Hanford Site for this method (borehole).	Same as the potential impacts discussed for the Hanford Site for this method (borehole), except the GTCC reference location is within TA-54. Land use at the reference location might have to be reclassified as waste management areas. The addition of a GTCC LLRW and GTCC-like waste disposal facility would expand the area of T-54 currently used for waste disposal.	Same as the potential impacts discussed for the Hanford Site for this method (borehole).
NNSS	Same as the potential impacts discussed for the Hanford Site for this method (borehole), except about $4.3 million in income would be produced in the peak construction year. An estimated 10 people would in-migrate to the ROI as a result of employment on-site. Disposal operations would create 38 direct jobs annually and an additional 31 indirect jobs in the ROI and produce $4.1 million in annual income.	Same as the potential impacts discussed for the Hanford Site for this method (borehole).	Same as the potential impacts discussed for the Hanford Site for this method (borehole), except the GTCC reference location would be integrated into the radioactive waste management zone of the Area 5 RWMC, an area where defense-related activities are conducted.	Same as the potential impacts discussed for the Hanford Site for this method (borehole).

TABLE 2.7-4 (Cont.)

Alternatives	Socioeconomics	Environmental Justice	Land Use	Waste Management
WIPP Vicinity	Same as the potential impacts discussed for the Hanford Site for this method (borehole), except about $5.2 million in income would be produced in the peak construction year. An estimated 41 people would in-migrate to the ROI as a result of employment on-site. Disposal operations would create 38 direct jobs annually and an additional 32 indirect jobs in the ROI and produce $3.8 million in annual income.	Same as the potential impacts discussed for the Hanford Site for this method (borehole).	Same as the potential impacts discussed for the Hanford Site for this method (borehole), except the current land use at the GTCC reference location would have to be altered from a multiple-use area to a waste management area. A loss of about 0.2% of a 22,000-ha (56,000-ac) grazing allotment would result. Management of withdrawn land would be transferred to DOE.	Same as the potential impacts discussed for the Hanford Site for this method (borehole), except specific waste management plans would have to be prepared as necessary to address these wastes because there are currently no waste operations ongoing at the WIPP Vicinity.
4: Trench method				
Hanford Site	Same as for Alternative 3 except about $4.5 million in income would be produced in the peak construction year. An estimated 27 people would in-migrate to the ROI as a result of employment on-site. Disposal operations would create 48 direct jobs annually and an additional 42 indirect jobs in the ROI and produce up to $4.7 million in annual income.	Same as for Alternative 3.	Same as for Alternative 3, except about 20 ha (50 ac) of land would be required for the trench method.	Small quantities of nonradioactive hazardous and nonhazardous and radioactive solid and liquid wastes would be produced during construction and GTCC LLRW and GTCC-like waste disposal operations. These would be managed in the same manner as other such wastes produced by current operations at the site. In general, Alternative 4 would generate more waste than Alternative 3 but less than Alternative 5.

TABLE 2.7-4 (Cont.)

Alternatives	Socioeconomics	Environmental Justice	Land Use	Waste Management
INL Site	Same as for Alternative 3, except about $4.6 million in income would be produced in the peak construction year. An estimated 27 people would in-migrate to the ROI as a result of employment on-site. Disposal operations would create 48 direct jobs annually and an additional 48 indirect jobs in the ROI and produce up to $4.7 million in annual income.	Same as for Alternative 3.	Same as for Alternative 3, except about 20 ha (50 ac) of land would be required for the trench method.	Same as the potential impacts discussed for the Hanford Site for this method (trench).
LANL	Same as for Alternative 3 except about $4.6 million in income would be produced in the peak construction year. An estimated 27 people would in-migrate to the ROI as a result of employment on-site. Disposal operations would create 48 direct jobs annually and an additional 46 indirect jobs in the ROI and produce up to $4.8 million in annual income.	Same as for Alternative 3.	Same as for Alternative 3, except about 20 ha (50 ac) of land would be required for the trench method.	Same as the potential impacts discussed for the Hanford Site for this method (trench).
NNSS	Same as for Alternative 3 except about $4.6 million in income would be produced in the peak construction year. An estimated 14 people would in-migrate to the ROI as a result of employment on-site. Disposal operations would create 48 direct jobs annually and an additional 35 indirect jobs in the ROI and produce up to $4.8 million in annual income.	Same as for Alternative 3.	Same as for Alternative 3, except about 20 ha (50 ac) of land would be required for the trench method.	Same as the potential impacts discussed for the Hanford Site for this method (trench).

TABLE 2.7-4 (Cont.)

Alternatives	Socioeconomics	Environmental Justice	Land Use	Waste Management
SRS	About $4.8 million in income would be produced in the peak construction year. An estimated 27 people would in-migrate to the ROI as a result of employment on-site. Disposal operations would create 48 direct jobs annually and an additional 43 indirect jobs in the ROI and produce up to $4.8 million in annual income.	No potential impacts on the minority and low-income population are expected from Alternative 4.	Land use impacts are expected to be relatively small. The GTCC reference location is within an area designated as a forest timber unit. Marketable timber would be removed and sold, and the area would likely be reclassified to accommodate the proposed GTCC LLRW and GTCC-like waste disposal facility.	Same as the potential impacts discussed for the Hanford Site for this method (trench).
WIPP Vicinity	Same as for Alternative 3, except about $4.4 million in income would be produced in the peak construction year. An estimated 55 people would in-migrate to the ROI as a result of employment on-site. Disposal operations would create 48 direct jobs annually and an additional 37 indirect jobs in the ROI and produce up to $4.5 million in annual income.	Same as for Alternative 3.	Same as for Alternative 3, except about 20 ha (50 ac) of land would be required for the trench method.	Same as the potential impacts discussed for the Hanford Site for this method (trench), except specific waste management plans would have to be prepared as necessary to address these wastes because there are currently no waste operations ongoing at the WIPP Vicinity.

TABLE 2.7-4 (Cont.)

Alternatives	Socioeconomics	Environmental Justice	Land Use	Waste Management
5: Vault method				
Hanford Site	Same as for Alternatives 3 and 4, except about $12.3 million in income would be produced in the peak construction year. An estimated 64 people would in-migrate to the ROI as a result of employment on-site. Disposal operations would create 51 direct jobs annually and an additional 43 indirect jobs in the ROI and produce up to $5.0 million in annual income.	Same as for Alternatives 3 and 4.	Same as for Alternatives 3 and 4, except about 24 ha (60 ac) would be required for the vault method.	Alternative 5 would generally generate more waste than Alternatives 3 and 4.
INL Site	Same as for Alternatives 3 and 4, except about $12.1 million in income would be produced in the peak construction year. An estimated 64 people would in-migrate to the ROI as a result of employment on-site. Disposal operations would create 51 direct jobs annually and an additional 50 indirect jobs in the ROI and produce up to $4.9 million in annual income.	Same as for Alternatives 3 and 4.	Same as for Alternatives 3 and 4, except about 24 ha (60 ac) would be required for the vault method.	Same as the potential impacts discussed for the Hanford Site for this method (vault).

TABLE 2.7-4 (Cont.)

Alternatives	Socioeconomics	Environmental Justice	Land Use	Waste Management
LANL	Same as for Alternatives 3 and 4, except about $12.2 million in income would be produced in the peak construction year. An estimated 64 people would in-migrate to the ROI as a result of employment on-site. Disposal operations would create 51 direct jobs annually and an additional 48 indirect jobs in the ROI and produce up to $5.0 million in annual income.	Same as for Alternatives 3 and 4.	Same as for Alternatives 3 and 4, except about 24 ha (60 ac) would be required for the vault method.	Same as the potential impacts discussed for the Hanford Site for this method (vault).
NNSS	Same as for Alternatives 3 and 4, except about $12.8 million in income would be produced in the peak construction year. An estimated 32 people would in-migrate to the ROI as a result of employment on-site. Disposal operations would create 51 direct jobs annually and an additional 36 indirect jobs in the ROI and produce up to $5.1 million in annual income.	Same as for Alternatives 3 and 4.	Same as for Alternatives 3 and 4, except about 24 ha (60 ac) would be required for the vault method.	Same as the potential impacts discussed for the Hanford Site for this method (vault).

TABLE 2.7-4 (Cont.)

Alternatives	Socioeconomics	Environmental Justice	Land Use	Waste Management
SRS	Same as for Alternative 4, except about $12.7 million in income would be produced in the peak construction year. An estimated 64 people would in-migrate to the ROI as a result of employment on-site. Disposal operations would create 51 direct jobs annually and an additional 45 indirect jobs in the ROI and produce up to $5.0 million in annual income.	Same as for Alternative 4.	Land use impacts are expected to be relatively small. About 24 ha (60 ac) would be altered to accommodate the necessary facilities for the vault method. The GTCC reference location is within an area designated as a forest timber unit. Marketable timber would be removed and sold, and the area would likely be reclassified to accommodate the proposed GTCC LLRW and GTCC-like waste disposal facility.	Same as the potential impacts discussed for the Hanford Site for this method (vault).
WIPP Vicinity	Same as for Alternatives 3 and 4, except about $11.7 million in income would be produced in the peak construction year. An estimated 127 people would in-migrate to the ROI as a result of employment on-site. Disposal operations would create 51 direct jobs annually and an additional 38 indirect jobs in the ROI and produce up to $4.8 million in annual income.	Same as for Alternatives 3 and 4.	Same as for Alternatives 3 and 4, except about 24 ha (60 ac) would be required for the vault method.	Same as the potential impacts discussed for the Hanford Site for this method (vault), except specific waste management plans would have to be prepared as necessary to address these wastes because there are currently no waste operations ongoing at the WIPP Vicinity.

TABLE 2.7-5 Comparison of Potential Impacts from Alternatives 1 through 5 on Truck Transportation

	Truck Transportation						
Alternative	Number of Shipments	Total Distance Travelled (km)	Collective Population Dose (person-rem)	Collective Population LCFs	Collective Transportation Crew Dose (person-rem)	Collective Transportation Crew LCFs	Accident Fatalities
1: No Action	–[a]	–	–	–	–	–	–
2: WIPP	33,700	89,700,000	68	0.04	180	0.1	2
3: Borehole method							
Hanford Site	12,600	50,300,000	170	0.1	500	0.3	1
INL Site	12,600	42,000,000	150	0.09	410	0.2	0.8
LANL	12,600	35,500,000	130	0.08	350	0.2	0.8
NNSS	12,600	47,800,000	160	0.1	470	0.3	0.9
WIPP Vicinity	12,600	35,600,000	130	0.08	350	0.2	0.8
4: Trench method							
Hanford Site	12,600	50,300,000	170	0.1	500	0.3	1
INL Site	12,600	42,000,000	150	0.09	410	0.2	0.8
LANL	12,600	35,500,000	130	0.08	350	0.2	0.8
NNSS	12,600	47,800,000	160	0.1	470	0.3	0.9
SRS	12,600	17,800,000	69	0.04	170	0.1	0.6
WIPP Vicinity	12,600	35,600,000	130	0.08	350	0.2	0.8
5: Vault method							
Hanford Site	12,600	50,300,000	170	0.1	500	0.3	1
INL Site	12,600	42,000,000	150	0.09	410	0.2	0.8
LANL	12,600	35,500,000	130	0.08	350	0.2	0.8
NNSS	12,600	47,800,000	160	0.1	470	0.3	0.9
SRS	12,600	17,800,000	69	0.04	170	0.1	0.6
WIPP Vicinity	12,600	35,600,000	130	0.08	350	0.2	0.8

[a] A dash means not applicable.

TABLE 2.7-6 Comparison of Potential Impacts from Alternatives 1 through 5 on Rail Transportation

	Rail Transportation						
Alternative	Number of Shipments	Total Distance Travelled (km)	Collective Population Dose (person-rem)	Collective Population LCFs	Collective Transportation Crew Dose (person-rem)	Collective Transportation Crew LCFs	Accident Fatalities
1: No Action	–[a]	–	–	–	–	–	–
2: WIPP	11,800	32,100,000	42	0.03	54	0.03	1
3: Borehole method							
Hanford Site	5,010	20,600,000	110	0.07	150	0.09	0.7
INL Site	4,980	17,000,000	100	0.06	130	0.08	0.5
LANL	5,010	14,000,000	94	0.07	110	0.07	0.5
NNSS	5,010	21,200,000	110	0.06	150	0.09	0.6
WIPP Vicinity	5,010	14,000,000	94	0.06	110	0.07	0.5
4: Trench method							
Hanford Site	5,010	20,600,000	110	0.07	150	0.09	0.7
INL Site	4,980	17,000,000	100	0.06	130	0.08	0.5
LANL	5,010	14,000,000	94	0.07	110	0.07	0.5
NNSS	5,010	21,200,000	110	0.06	150	0.09	0.6
SRS	5,010	8,320,000	70	0.04		0.05	0.6
WIPP Vicinity	5,010	14,000,000	94	0.06	110	0.07	0.5
5: Vault method							
Hanford Site	5,010	20,600,000	110	0.07	150	0.09	0.7
INL Site	4,980	17,000,000	100	0.06	130	0.08	0.5
LANL	5,010	14,000,000	94	0.07	110	0.07	0.5
NNSS	5,010	21,200,000	110	0.06	150	0.09	0.6
SRS	5,010	8,320,000	70	0.04		0.05	0.6
WIPP Vicinity	5,010	14,000,000	94	0.06	110	0.07	0.5

[a] A dash means not applicable.

2.8 UNCERTAINTIES ASSOCIATED WITH THE EVALUATIONS IN THIS EIS

The impact analyses conducted for this EIS used methodologies and approaches consistent with CEQ recommendations and DOE guidelines for preparing an EIS. As such, any uncertainties associated with the various environmental resource areas evaluated in this EIS are not unique to this EIS and should not differ from those in other EISs in general. Also, the results of the impact analyses for the action alternatives (as summarized and compared in Section 2.7) indicate that the impacts on the various resource areas from the proposed action would probably be small and also that they would not vary much among the sites evaluated, with the possible exception of potential post-closure impacts on human health.

The results from the analysis of human health impacts in the post-closure phase indicate that potential future doses and LCF risks to a hypothetical resident farmer could vary significantly by site. Hence, the discussion on uncertainties presented in the remainder of this section focuses on this aspect of the analysis because it provides information useful in identifying a preferred alternative.

A number of uncertainties are associated with the human health evaluations, and those that are considered most significant are discussed below. The major assumptions used to assess these impacts are described in Section 5.2.4. Several factors could alter the estimated human health impacts associated with disposal of these wastes, including changes in (1) the waste volume and radionuclide inventory, (2) the assumptions about the design and layout of the facilities, (3) the assumptions used to simulate how long the integrity of the engineered barriers and waste stabilizing agents would stay intact, and (4) the assumptions about site characteristics used as input for the calculations.

As noted previously, the results given here in terms of the long-term doses and LCF risks to a hypothetical resident farmer are to be used in a comparative manner to aid in identifying those parameters that influence the selection of a disposal method for these wastes. These results are not based on an actual facility design for use at a specific location. With proper engineering design and construction, an acceptable disposal facility could likely be built at any of the sites addressed in this EIS. The sites having the higher doses and LCF risks are those that would require the most effort in terms of design and licensing features to ensure the long-term effectiveness of the disposal facility.

2.8.1 Waste Volume and Radionuclide Inventory Uncertainties

Values for the waste volumes and radionuclide activities used for the analysis of impacts on human health in this EIS were developed by using the most recent information available, including information from published reports and databases and information that resulted from a call to DOE field offices for data. To support this analysis, wastes were placed in one of two groups, as discussed in Section 1.4.1. The uncertainty associated with the Group 1 inventory is low, because these wastes either were already generated and are in storage or are projected to be generated from facilities already in operation. The uncertainty associated with the Group 2 wastes is higher than that associated with Group 1 wastes, because the generation of such wastes is contingent upon facilities not yet constructed or in operation.

The radiological impacts on human health would depend mostly on the total radioactivity and the mix of radionuclides that would make up the waste. That is, if the waste volumes doubled but total activity remained the same, there would be no major change in the potential radiological impacts. Increasing the total radionuclide activity by a factor of two with the same mix of radionuclides, however, would essentially double the potential radiological impacts. Because the uncertainty with regard to the waste inventory is generally low to moderate, the inventory does not represent a major source of uncertainty in the human health impact analysis.

2.8.2 Assumptions about the Facility Design and Layout (for input to RESRAD-OFFSITE)

In addition to the direct effect that the uncertainties about the waste inventory could have on the estimated results in this EIS, several indirect effects could also affect the results. The waste volumes presented in this EIS were used in developing the conceptual designs of the disposal facilities addressed in this EIS (i.e., the volumes were used to determine the number of disposal boreholes, trenches, and vaults needed and the resultant size of the disposal area). The determined total disposal area was then used to estimate the dimensions of the source term, which is a primary input (along with the radionuclide activity in the wastes) for determining the source concentrations used in the RESRAD-OFFSITE computer code. Changes in the waste volumes and radionuclide activities could change both the geometry and the magnitude of the source term. In this EIS, the estimated human health impacts were calculated by assuming that all of the Group 1 and 2 wastes would be disposed of in a single location. If any of the waste streams were to be excluded (by not being generated or by being disposed of elsewhere), the potential human health impacts would be correspondingly lower at the specific site addressed.

Changes in the design and layout of the disposal facility could also change the potential human health impacts. For purposes of analysis in the EIS, the depth intervals available for waste disposal placement are assumed to be at about 4.3 to 5.5 m (14 to 18 ft) above ground surface for vaults, at 5 to 10 m (15 to 30 ft) below ground for trenches, and from 30 to 40 m (100 to 130 ft) below ground for boreholes. Changes in the design and layout of the disposal facility could result in changes in the total area and the subsequent depths of the waste disposal horizon in the EIS analyses. The footprint of the disposal facility, along with the distance from the edge of the facility to an off-site hypothetical well where potential radiation exposures are assumed to occur, determines the total distance that the radionuclides need to travel in the groundwater aquifer to cause a radiation dose. A decrease in the footprint of the disposal facility would shorten the distance from the midpoint of the waste zone to the off-site well. This shorter distance would increase the radionuclide concentrations in the groundwater because there would be less dilution and less decay in transit, and it would result in somewhat higher doses from the use of this groundwater.

An important parameter in the modeling analysis is the actual area assumed to be occupied by the waste itself relative to the entire footprint occupied by the waste disposal facility. This area affects the amount of water that could infiltrate into the disposal units and leach radionuclides from the waste containers. Changes to the design of the disposal facility could result in changes to the area potentially exposed to infiltrating water. A larger disposal area would allow more water infiltration and result in more radionuclides leaching out to deeper soils. Alternatively, a smaller area (with a subsequent greater depth of waste disposal) would result in a shorter soil column beneath the disposal units through which radionuclides leaching from the disposal area would need to travel to reach the groundwater table. The overall effect that could result from changes in the geometrical configuration of the disposal cells needs to be assessed with regard to the time frame used to evaluate the potential impacts and the specific site in question. However, these changes would not add a significant amount of uncertainty to the results, unless major changes were made to the current conceptual facility designs used in these analyses.

2.8.3 Assumptions Used to Simulate the Integrity of Engineered Barriers and Waste Stabilizing Practices

The amount of data on the performance of waste packages, engineering controls (e.g., facility covers), and stabilizing processes (e.g., grouting) over an extended time period is limited. Even when data are available, it is difficult to predict the release rates of radionuclides over a very long time period by using these data. The potential impacts on groundwater are evaluated over a very long time period in this EIS (10,000 years or longer to obtain peak doses and LCF risks and the times they would occur). How and when the waste packages, engineering controls, and stabilization agents would begin to degrade and how this degradation would progress over time are very difficult to determine.

For this EIS, it is assumed that the engineered controls would remain intact for the first 500 years after closure of the disposal facility and that during this time, essentially no infiltrating water would reach the wastes from the top of the disposal facility. It is assumed that after 500 years, the amount of infiltrating water that would contact the wastes would represent 20% of the site-specific natural infiltration rate for each of the sites evaluated, and that the water infiltration rate around and beneath the disposal facilities would be 100% of the natural rate of the site area. It is also assumed that the Other Waste would be stabilized with grout or other material and that this stabilizing agent would be effective for 500 years. It is assumed that after 500 years, radionuclide releases from the Other Waste would be controlled by the surrounding soil (i.e., the distribution coefficients or K_ds were revised from those reflecting cementitious systems to those for unsaturated soil at the sites).

The radionuclides in the disposed-of wastes would be available for leaching by infiltrating water. Many of the radionuclides in the GTCC LLRW and GTCC-like wastes have very long half-lives, so the 500-year period assumed for purposes of analysis in this EIS would not result in an appreciable reduction in the total hazard associated with these wastes as a result of radioactive decay, especially when the time it would take for these radionuclides to reach the hypothetical off-site receptor is considered. So although it is assumed that the effectiveness of the engineered controls and stabilizing agent would last 500 years, this time period is not sufficiently long enough to adequately reduce the hazards that the GTCC LLRW and GTCC-like waste would impose at some of the sites evaluated. The uncertainty is related to how much longer the engineered controls and stabilization process would remain effective for the sites at which the potential impacts are expected to be high.

In addition, global climate change impacts might add another aspect of uncertainty with regard to the long-term performance of the borehole, trench, and vault waste disposal facilities at the sites evaluated in this EIS. Since 1990, the average annual precipitation over the United States has increased by about 5%, but there were regional differences, e.g., increases mostly in the Northeast, Midwest, and southern Great Plains and a mix of increases and decreases in much of the Southeast and Southwest (Melillo et al. 2014). The global climate change model predictions indicate that in the Southwestern United States, drier or prolonged drought conditions could arise notably in the spring, whereas Northern areas could become wetter.

Although the global climate change impacts are modeled only to the year 2100, these initial indications can be used to provide a perspective on what impacts global climate change might have on the proposed borehole, trench, and vault waste disposal facilities at the various reference locations or regions evaluated in this EIS. As discussed previously, the water infiltration rate is one of the key input parameters that affect how much radioactivity could leach from waste in the disposal facility. On the basis of the global climate change predictions under a higher (i.e., worst-case) emission scenario (Melillo et al. 2014), average annual infiltration rates at the sites located in the Southwest (e.g., LANL, NNSS, WIPP Vicinity, and the generic commercial location in the southern part of NRC Region IV) are expected to decrease slightly or remain the same, while rates at the sites located in the Northwest (e.g., Hanford and INL Sites) and in the Southeast (e.g., SRS), would increase slightly.

On the basis of Melillo et al. (2014), it can be said that the maximum increase or decrease in precipitation under a higher emission scenario would be up to 20% depending on the season. Under a lower emission scenario, these percentages would be lower, and thus climate changes would probably not have any significant impacts on GTCC LLRW and GTCC-like waste disposal operations. This is because slight increases in precipitation are expected in humid sites such as SRS. For sites located in drier areas, such as Hanford, INL, LANL, NNSS, and WIPP/WIPP Vicinity, changes of up to about 20% by season would be expected under a higher emission scenario but these changes are not significant due to its lower annual precipitation. However, because the post-closure human health estimates presented in this EIS are for 10,000 years or more, and because current global climate change model projections extend only to the year 2100, it is uncertain whether the indications discussed here would continue for the 10,000-year post-closure period analyzed in this EIS.

As described in Section 1.4.1, the GTCC LLRW and GTCC-like waste encompass three waste types for purposes of analysis in this EIS: activated metals, sealed sources, and Other Waste. The radionuclide release rate for activated metal is assumed to be 1.19×10^{-5}/yr in this analysis. This value is assumed to be conservative on the basis of experiments that were conducted on metal wastes (see further discussion in Appendix E). The release rates of radionuclides in the sealed sources were estimated by using the distribution coefficients (K_ds) for the unsaturated soil at the various sites.

In performing the long-term calculations, it was assumed that the Other Waste would be stabilized (e.g., by using grout or another similar material) prior to being placed in the disposal units. The release rates for this solidified Other Waste were assumed to be the same as those for cementitious systems. The use of solidification agents such as grout is consistent with current disposal practices for such wastes, which include a wide variety of materials that could compact or degrade without such measures.

The grout material assumed here to last 500 years might not last that long, or it might last longer. If the stabilizing agent lasted for a longer time, the estimated potential impacts on groundwater from the radionuclides leaching from the waste could be lower than the impacts presented in this EIS. Use of such a stabilizing agent was not assumed for the activated metal wastes and sealed sources, although such a practice would reduce the doses from these materials as well. Most of the long-term radiation doses and LCF risks associated with the groundwater pathway would be attributable to leaching of the Other Waste. The approach used in this EIS is assumed to be conservative and adds some uncertainty to the estimated doses.

2.8.4 Assumptions about Site Characteristics

The best available information was used for the other RESRAD-OFFSITE input parameters. These were determined on a site-specific basis, and most were obtained from previous analyses performed at these sites.

The modeling simulation conducted for this EIS is a simplified representation of more complex soil and groundwater processes, and this simplification adds uncertainty to the results. The release rates of radionuclides in sealed sources and in Other Waste were simulated with distribution coefficients assumed to be the same as those for the unsaturated soil at the various sites (for sealed sources) and cementitious systems (for Other Waste). The release rates for activated metal wastes were based on a conservative rate, as described above.

Because backfill soil would surround the waste containers in the disposal units, radionuclides released from the waste materials would have to travel through the surrounding soils before leaving the disposal area. Because the soil distribution coefficients are used to calculate the radionuclide release rates for sealed sources, it is assumed that the radionuclides would be released to the surrounding soil immediately upon contact with water. This approach is assumed to be conservative, and it adds a large uncertainty to the results presented in this EIS. In addition, the distribution coefficients used as input into the model calculations have inherent uncertainties associated with them, and it is difficult to assign values for the level and direction of uncertainty that exist in the distribution coefficients for each site and from site to site.

It is assumed in this EIS that a resident farmer would be located 100 m (330 ft) downgradient from the edge of the disposal facility and would develop a well as a source of drinking water. This assumption is considered to be conservative on the basis of current land use patterns at the sites evaluated in the EIS. At these sites, the distance from the edge of the disposal facility to such an individual (given the current configurations of the alternative sites evaluated in this EIS) would likely be much longer. Use of a more realistic distance would result in much lower doses than those presented in this EIS. This distance adds a great deal of uncertainty and conservatism to the results presented in this EIS.

Finally, the human health impacts (doses and LCF risks) on a hypothetical resident farmer are meant to serve only for comparison purposes in evaluating the relative effectiveness of the various disposal methods and sites. Further design considerations and site-specific modeling would be performed when implementation decisions were made. By using robust engineering designs and redundant measures to contain the radionuclides in the disposal unit, the potential releases of radionuclides would be delayed and reduced to very low levels, thereby minimizing the potential groundwater contamination and its associated human health impacts in the future.

2.9 FACTORS CONSIDERED IN DEVELOPING A PREFERRED ALTERNATIVE

> The preferred alternative is based on the characteristics of the waste, its availability for disposal, and other key factors.

DOE developed a preferred alternative for inclusion in this Final GTCC EIS. Consistent with CEQ guidance, DOE's preferred alternative fulfills DOE's statutory mission and responsibilities and considers (1) public comments received on the Draft GTCC EIS; (2) NRC's regulatory requirements for the disposal of LLRW as found in 10 CFR Part 61, DOE Orders, and other applicable requirements; and (3) environmental, technical, economic, and other findings presented in the GTCC EIS. This EIS considers the public scoping comments on the NOI that were received, and it evaluates the conceptual designs for enhanced land disposal methods as alternatives to the geologic repository disposal method, which the NRC currently considers to be an acceptable method for disposing of GTCC LLRW. A summary of the public comments is included in Appendix J, and DOE has considered this summary in developing the preferred alternative.

In 10 CFR Part 61, "Licensing Requirements for Land Disposal of Radioactive Waste," the NRC classifies LLRW into four classes (Classes A, B, and C, and GTCC LLRW) on the basis of the concentrations of short-lived and long-lived radionuclides (10 CFR 61.55). By controlling isotope concentrations in each class, the NRC regulations seek to control potential radiation exposures to future receptors, including inadvertent human intruders (e.g., a water well driller) after the period of active institutional control has ended. The NRC states in 10 CFR 61.7(b)(5) that GTCC LLRW is "generally unacceptable" for near-surface disposal but also recognizes that "there may be some instances where waste with concentrations greater than permitted for Class C waste would be acceptable for near surface disposal with special processing or design."

The NRC regulations state that GTCC LLRW is to be disposed of in a geologic repository as defined in 10 CFR 60 or 63, unless proposals for an alternative method are approved by NRC under 10 CFR 61.55(a)(2)(iv). The NRC regulations identify one approved method for the disposal of GTCC LLRW and GTCC-like waste (a geologic repository), but they acknowledge that other methods could be approved.

In addition to protecting individuals from inadvertent intrusion, the preferred disposal alternative must protect the general population and involved workers from potential releases of radioactivity during facility construction and disposal operations. Long-term impacts after completion of the disposal operations and closure of the disposal facility also need to be considered. DOE developed the preferred alternative by considering these aspects along with the various other environmental resource areas discussed in this EIS. DOE structured this EIS so that the preferred alternative could be identified on the basis of a waste type, site, and disposal method. The preferred alternative is discussed in Section 2.10.

Sections 2.9.1 to 2.9.4 summarize key considerations related to the alternatives analyzed in this EIS. These considerations include (1) public comments (Section 2.9.1), waste type characteristics (Section 2.9.2), (2) disposal method considerations (Section 2.9.3), and (3) disposal location considerations (2.9.4).

2.9.1 Public Comments

A 120-day public comment period on the Draft GTCC EIS began with the publication of the EPA Notice of Availability in the Federal Register on February 25, 2011. DOE conducted public hearings at nine locations during April and May of 2011. Although the public comment period closed on June 27, 2011, DOE considered all comments, as covered in Appendix J, in identifying the preferred alternative that is presented in Section 2.10.

2.9.2 Waste Type Characteristics

The three types of GTCC LLRW and GTCC-like waste (activated metals, sealed sources, and Other Waste) come from different sources and have different physical, chemical, and radiological characteristics. In addition, some waste types differ in terms of when they would be available for disposal (see Section B.4 for discussion on assumed GTCC LLRW and GTCC-like waste generation rates). Thus, it might be appropriate to use different disposal methods for different waste types. Four key factors related to the three GTCC LLRW and GTCC-like waste types that might determine whether one disposal method would be more appropriate than another include the following:

1. *Radionuclide inventory.* The GTCC LLRW and GTCC-like waste include a wide range of radionuclides. Sealed sources generally consist of one (or possibly a few) radionuclides, whereas activated metal waste and the Other Waste type contain a large number of radionuclides. Some of these radionuclides have relatively short half-lives (such as Sr-90 and Cs-137 that have half-lives of about 30 years), whereas others (such as Pu-239) have half-lives of more than 10,000 years. Both the total inventory and mix of radionuclides are important to consider when selecting an appropriate disposal method for a particular waste type.

A number of TRU radionuclides decay to radioactive progeny, and the presence of these in-growth radionuclides needs to be addressed. Also, some radionuclides emit significant amounts of gamma radiation (such as Co-60 and Cs-137), whereas others emit very little or no such radiation. The activated metals are expected to have the highest gamma exposure rates of the three waste types, and the sealed sources are expected to have the lowest exposure rates. The Other Waste is divided into CH and RH wastes, because some of the Other Waste could contain significant concentrations of fission products and neutron activation products that could decay and release significant amounts of gamma radiation, whereas others might have very little of these products.

The concentrations of long-lived radionuclides in waste determine how long it will remain hazardous. Many of the GTCC-like wastes have long-lived TRU radionuclides, and so they will remain hazardous for many thousands of years. Similar wastes are currently being disposed of in a geologic repository (WIPP) because of this concern. Also, the relative mobility of the radionuclides in groundwater systems varies widely; some radionuclides (such as Tc-99 and I-129) are quite mobile, while radioactive metals tend to bind with the soil particles and move more slowly in the environment.

2. *Waste form stability.* While all of the GTCC LLRW and GTCC-like waste are solids, some are much more durable than others. Even though corrosion of the activated metal waste begins as soon as it comes in contact with water, these metals are assumed to retain their structural shape. The Other Waste would be stabilized in a grout matrix to improve its stability for a longer period of time. Sealed sources are also very robust and are expected to retain their form for long time periods. Waste form stability influences the ability of the disposal facility to contain the radioactive contaminants from leaching to the environment, with forms that could degrade more quickly being a long-term concern.

3. *Size.* Some GTCC activated metal wastes are large metallic items that can be disposed of more readily in a near-surface trench or vault than in a borehole or geologic repository (WIPP). Use of boreholes or a geologic repository might require more waste handling to make the physical size of the waste manageable than use of trenches or vaults. The need for treatment could result in greater worker doses.

4. *Availability for disposal.* While some GTCC LLRW and GTCC-like waste are currently in storage and available for disposal, much of the GTCC LLRW and GTCC-like waste will not be generated for several decades. The activated metal wastes are mainly associated with commercial nuclear power plants, and most of them are expected to operate for 20 years or more. Sealed sources represent a national security concern, so their disposal is a high priority.

On the basis of the above four factors, it is important to take into account the characteristics of a specific waste type with the site and disposal method under consideration to ensure the timely, cost-effective, and safe disposal of GTCC LLRW and GTCC-like waste. Sealed sources (which are generally small and durable) might be good candidates for borehole disposal, whereas other large wastes (such as activated metal waste) might be better suited for trenches and vaults. Many of the sealed sources recovered by GMS/OSRP for national security or public health and safety reasons meet the criteria for disposal at existing DOE facilities. (When GMS/OSRP recovers sealed sources, DOE typically takes ownership of the sources, and it may dispose of them at DOE facilities if they meet waste acceptance criteria for such facilities.) The long-term hazards associated with these wastes might preclude the use of certain disposal sites and methods, especially those that could result in groundwater contamination.

2.9.3 Disposal Methods

Key factors considered in identifying a preferred disposal method for GTCC LLRW and GTCC-like waste include (1) protecting the inadvertent human intruder, (2) leveraging operational experience, (3) minimizing institutional controls, and (4) achieving cost-effective disposal. Each of these factors is discussed here.

2.9.3.1 Inadvertent Human Intrusion

An inadvertent intruder is a person who might occupy the disposal site after closure and engage in normal activities, such as agricultural activities or the construction of buildings, or other pursuits in which the person might be unknowingly exposed to radiation from the waste (10 CFR 61.2). Human intrusion impacts might be mitigated by the waste form and packaging, institutional controls, and engineered and natural barriers (e.g., grouting and depth of disposal) (NRC 1981). All four disposal methods analyzed in this EIS include a combination of some or all these mitigation features, as discussed in Chapters 4 and 5 and Appendix D.

Disposal Method Considerations

Factor	Criterion
Inadvertent human intrusion	Favors methods that minimize the potential for inadvertent human intrusion
Construction and operational experience	Favors methods that have been successfully used in the past to manage similar wastes
Post-closure care	Favors methods that minimize the potential need for long-term maintenance after the facility has closed
Cost	Favors methods that result in cost-effective waste disposal

2.9.3.2 Construction and Operational Experience

All four disposal methods have been used to some degree in the United States or other countries to dispose of radioactive waste similar to the three waste types analyzed in the GTCC EIS.

- *Deep geologic disposal.* The DOE WIPP facility is currently the only operating deep geologic repository in the United States. Since it began operations in 1999, the facility has successfully received more than 64,000 m^3 (2,300,000 ft^3) of CH and RH TRU waste generated by DOE atomic energy defense activities. This waste includes radioactive sealed sources, debris, and other waste similar to GTCC LLRW and GTCC-like waste. Most of the GTCC-like waste is similar to waste currently being disposed of at WIPP, except that it may not have been generated by atomic energy defense activities and therefore may not be authorized for disposal at WIPP under the WIPP LWA as amended (P.L. 102-579 as amended by P.L. 104-201).

- *Boreholes.* DOE demonstrated the use of borehole facilities to dispose of radioactive waste at NNSS (formerly NTS) during 1981–1989. The boreholes operated from 1984 through 1989 and received DOE waste similar to GTCC LLRW. Borehole disposal is receiving increased attention from the International Atomic Energy Agency as an option for disposal of disused sealed sources (IAEA 2005). Currently, there are no NRC-licensed borehole facilities in the United States. The advantages of the borehole method include these: (1) it may be amenable to receiving intermittent or low-volume waste like GTCC LLRW and GTCC-like waste, (2) it is visually unobtrusive, (3) it has the potential for robust long-term isolation of wastes, and (4) no workers need to enter the disposal shafts, which thereby minimizes worker hazards. Boreholes also provide the greatest amount of natural shielding (the surrounding soil) of any of the three land disposal methods. A disadvantage of the borehole method is the low volume capacity of the borehole and the much higher volume of unused space surrounding each borehole. Consequently, a very large number of boreholes (approximately 930 boreholes) would be required to manage the entire GTCC LLRW and GTCC-like waste volume. As mentioned above, the method might be better suited to specific waste types (e.g., sealed sources), for which fewer boreholes would be required. Also, use of boreholes may be limited by underground injection control regulations or other requirements, such as the Safe Drinking Water Act.

- *Trenches.* Trenches are used for the disposal of LLRW in the United States and at a number of sites around the world. Commercial facilities dispose of Class A, B, and C LLRW in trenches and vaults. In addition, DOE uses trenches to dispose of its LLRW, including LLRW comparable to GTCC LLRW (e.g., Sr-90 radioisotope thermoelectric generators) on the basis of performance assessment analyses.[2] SRS currently disposes of large equipment

[2] A performance assessment is a systematic analysis of the potential risks posed by waste management systems to the public and the environment and the comparison of those risks to established performance objectives (e.g., protection against radiation exposure and release of radioactive material). The performance assessment is used to estimate (1) potential future doses to human receptors that consider transport pathways through which radionuclides might reach the environment and (2) the effectiveness of the engineered barrier system used to limit the influx of water, thereby reducing the resultant radionuclide doses.

(e.g., large cesium sources and other LLRW) in trenches using the components-in-grout technique. This technique allows for large equipment to be disposed in trenches and the waste form is surrounded with grout on all sides (bottom, sides, top). This approach will limit future subsidence and the release of radionuclides. The conceptual design for the trench that is evaluated in this EIS employs a deeper (11-m or 35-ft deep) and narrower (3-m or 10-ft wide) design than conventional belowground, near-surface radioactive waste disposal facilities in order to protect the facility from inadvertent human intrusion. Potential operational advantages of the trench include (1) its visual unobtrusiveness, (2) its ease of construction, and (3) the relative ease with which the wastes can be disposed of. Potential disadvantages include (1) the increased possibility of exposing workers to radiation hazards (i.e., more than that presented by boreholes), unless temporary covers or shields would be used, and (2) the possibility that this method might provide less protection from future intrusion into the wastes, as compared to boreholes and deep geologic disposal.

- *Vaults*. Vaults similar to the design presented in the GTCC EIS have been operated by DOE at SRS and other DOE facilities for the disposal of LLRW. This disposal method is more commonly used in humid environments, where belowground disposal methods might be limited by shallow groundwater. The conceptual design for the vault includes thick reinforced concrete walls, floors, and ceilings. To further isolate the waste, an engineered cover system is included in the design. Potential advantages of the vault include these: (1) it can be inspected visually and be more easily monitored than the other alternative land disposal methods; (2) because of its high visibility, inadvertent human intrusion is unlikely; and (3) it does not rely on waste packages for structural support (i.e., structural support is provided by the concrete cells). Potential disadvantages of the vault include these: (1) its active maintenance requirements (including active institutional controls) are likely to be more extensive than those of the other methods because of its visibility and exposure to the elements; (2) the costs to construct and operate it are higher than those of the other alternative land disposal methods; (3) it has a higher potential for exposing workers to radiation hazards than the other land disposal methods, unless temporary shielding or waste covers are used; and (4) it could attract intentional intruders because of its visibility.

2.9.3.3 Post-Closure Care Requirements

Some disposal methods might need to rely more on post-closure care than others. Because an above-grade vault is exposed to the elements, it might require more active institutional controls than the trench, borehole, and deep geologic disposal methods, extending to times beyond the period of institutional control normally considered when evaluating the safety of waste management facilities (NCRP 2005). If post-closure care is not maintained, vaults could pose a greater potential for radiological exposures to the public (Rao et al. 1992;

Kozak et al. 1993). Consequently, maintenance of institutional controls is considered particularly important for this technology to achieve post-closure safety. Long term post-closure care requirements for the trench, borehole, and deep geologic methods should be less than those for an above-grade vault (USACE Waterways Experiment Station 1984).

2.9.3.4 Construction and Operating Costs

The estimated cost to construct and operate a GTCC LLRW and GTCC-like waste disposal facility ranges from $250 million for disposal at a new trench facility to $570 million for disposal at the WIPP geologic repository, as shown in Table 2.9.3-1 and Appendix D. The cost estimates for each disposal method are based on the assumption that all GTCC LLRW would be disposed of by that method, although different combinations of disposal methods could be used for the different waste types. Costs for facility permits, licenses, transportation, packaging, and post-closure activities are not included in the estimates.

TABLE 2.9.3-1 Costs of GTCC LLRW and GTCC-Like Waste Disposal Alternatives[a]

Disposal Method	Cost to Construct Facility (in millions of $)[b]	Cost to Operate Facility (in millions of $)[c]	Total Cost to Construct and Operate Facility (in millions of $)
WIPP	14	560	570
Borehole	210	120	330
Trench	88	160	250
Vault	360	160	520

[a] Costs are rounded to two significant figures.

[b] Construction costs for the WIPP facility are for 26 new rooms. Construction costs for the borehole, trench, and vault disposal facilities are for 930 boreholes, 29 trenches, and 12 vaults (consisting of 130 total vault cells), respectively, and the supporting infrastructure.

[c] The operational cost for WIPP is based on the actual per-shipment cost for fiscal year 2008. Operational costs assume 20 years of facility operations for the borehole, trench, and vault disposal methods. On the basis of the assumed receipt rates, the majority of the wastes would be available for emplacement during the first 15 years of operations. The actual start date for operations is uncertain at this time and dependent upon, among other things, the alternative or alternatives selected, additional NEPA review as required, characterization studies, and other actions necessary to initiate and complete construction and operation of a GTCC LLRW and GTCC-like waste disposal facility. For purposes of analysis in the EIS, DOE assumed a start date of disposal operations in 2019. However, given these uncertainties, the actual start date could vary.

2.9.4 Disposal Location Considerations

The GTCC EIS evaluates six federal sites for the potential disposal of GTCC LLRW and GTCC-like waste, of which one is in a humid environment (SRS) and five are in semi-arid or arid environments (Hanford, INL, LANL, NNSS, WIPP/WIPP Vicinity). In addition, the GTCC EIS evaluates generic commercial locations in four regions of the United States.

Disposal Location Considerations

Factor	Criterion
Human health risk	Favors alternatives that reduce human health risk to both workers and the public.
Cultural resources	Favors alternatives that avoid adverse impacts to known cultural sites.
Laws, regulations, and other requirements	Favors alternatives that would not be inconsistent with current laws and other requirements.

On the basis of the results presented in this EIS, key factors to be considered in identifying a preferred disposal location for GTCC LLRW are potential human health risks for the post-closure long-term phase (including potential cumulative human health impacts from the post-closure phase); cultural resources and tribal concerns; and existing laws, regulations, and other requirements.

2.9.4.1 Human Health Impacts

Human health impacts include: (1) potential exposure of workers and the general public to radiation during routine conditions and accidents and (2) direct impacts on workers and the public from industrial and transportation accidents. All potential impacts were considered in developing the preferred alternative. A primary consideration is the potential long-term (post-closure) impacts on members of the general public who might be exposed to radioactive contaminants released from the waste packages that are transported in groundwater and migrate to an accessible location, such as a groundwater well. Consequently, potential cumulative long-term human health impacts at each of the sites evaluated would likewise be of primary consideration. For example, the long-term doses and LCF risks estimated for the GTCC proposed action for the Hanford Site should be considered relative to the findings presented in the *Final Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington* (TC&WM EIS) (DOE 2012). According to the TC&WM EIS, receipt of off-site waste streams that contain specific amounts of certain isotopes, specifically I-129 and Tc-99, could cause an adverse impact on the environment. The TC-99 inventory from off-site waste streams evaluated in the TC&WM EIS shows impacts that are less significant than those of I-129. However, when the impacts of Tc-99 from past leaks and cribs and trenches (ditches) are combined, DOE believes it may not be prudent to add significant additional technetium-99 to the existing environment. Therefore, one means of mitigating this impact would be for DOE to limit disposal of off-site waste streams containing I-129 or Tc-99 at Hanford.

With regard to transportation impacts, the optimal location would be one that is close to the waste-generating sources. This location would minimize the overall transportation distance and would have the lowest potential impacts on human health. However, most of the waste generators are located in the eastern half of the United States, and these areas have more humid climates than do sites in the western part of the country. The more humid sites (SRS and generic Regions I and II) were shown to generally have greater long-term impacts from the groundwater pathway, and this concern is a major consideration in identifying an acceptable location for a GTCC LLRW and GTCC-like waste disposal facility. Engineered controls would have to be used more at a disposal site in a humid environment than at one in an arid environment in order to minimize the long-term hazards to human health.

The natural site conditions are a very important factor in selecting a disposal location, and the post-closure results for the federal sites and generic (commercial) disposal locations indicate that conditions in arid regions of the country are more favorable for the conceptual land disposal designs evaluated in this EIS than those in other parts of the country. This does not mean that a site in a humid region could not be used for such a facility. Rather, a facility in a humid environment would have to rely more on engineering measures and institutional controls to ensure that the long-term hazards were maintained at acceptable levels. Results of the modeling calculations of the radiation doses and LCF risks are presented in Appendix E and Chapters 6 through 12 by waste type, disposal method, and location.

2.9.4.2 Cultural Resources and Tribal Concerns

Cultural resources include, among other things, definitive locations of traditional cultural or religious importance to specified social or cultural groups, such as American Indian tribes ("traditional cultural properties"). DOE consulted with participating tribes who have cultural or historical ties to DOE sites being analyzed in this EIS. Tribal perspectives, comments, and concerns (e.g., environmental justice issues) identified during the consultation process was considered by DOE in selecting and implementing a disposal alternative(s) for GTCC LLRW and GTCC-like waste. Tribal perspectives, comments, and concerns are summarized in Section 1.8 and included in Chapters 6, 8, and 9 and Appendices G and J.

2.9.4.3 Laws, Regulations, and Other Requirements

A number of laws, regulations, and requirements (including state permits) apply to the disposal alternatives considered in this EIS, as identified in Chapter 13 and the site-specific chapters (4 and 6 through 12). These include requirements that generally apply to all proposed disposal locations (e.g., Archaeological and Historic Preservation Act) and requirements that apply to a specific site (e.g., WIPP LWA as amended [P.L. 102-579 as amended by P.L. 104-201] and other required state permits). DOE considered all applicable requirements in developing the preferred alternative.

2.10 PREFERRED ALTERNATIVE IDENTIFIED

In developing the preferred alternative for the disposal of GTCC LLRW and GTCC-like wastes, DOE considered national security concerns, the projected timing of waste generation and the potential long-term impacts on human health and the environment at the various disposal locations evaluated in the GTCC EIS. DOE also took into consideration applicable laws and requirements (e.g., WIPP LWA as amended [P.L. 102-579 as amended by P.L. 104-201], the LLRWPAA [P.L. 99-240]; other required state permits), costs, compliance with agreements, public input on the Draft EIS, national and state priorities, and other appropriate information.

Given the diverse characteristics (e.g., different radionuclide inventories, range of physical conditions, and derived from both commercial and DOE sources) of GTCC and GTCC-like waste analyzed in this EIS, the preferred alternative selected is not limited to one disposal technology. The preferred alternative for the disposal of GTCC and GTCC-like waste is the WIPP geologic repository (Alternative 2) and/or land disposal at generic commercial facilities (Alternatives 3-5). These land disposal conceptual designs could be altered or enhanced, as necessary, to provide the optimal application at a given location. The preferred alternative does not include land disposal at DOE sites. In addition, there is presently no preference among the three land disposal technologies at the generic commercial sites. The factors considered during the development of the preferred alternative include those discussed in Section 2.9: public comment provided on the draft GTCC EIS; disposal site impacts including potential human health impacts, cultural resources and tribal concerns; waste types impacts including radionuclide inventory and characteristics and availability for disposal; and disposal method impacts including inadvertent human intrusion, construction and operation and cost. The analysis in this Final GTCC EIS has provided the Department with the integrated insight needed to identify a preferred alternative with the potential to enable the disposal of the entire waste inventory analyzed in this EIS. Due to the uncertainty regarding the need for legislative changes and/or licensing or permitting changes, further analysis will be needed before a Record of Decision is announced. The Department has determined the preferred alternative would satisfy the needs of the Department for the disposal of GTCC and GTCC-like waste.

As required by NEPA, DOE will not issue a ROD sooner than 30 days after the issuance of the Final EIS. Prior to issuing a ROD regarding which disposal alternative to implement, DOE must submit a Report to Congress to fulfill the requirement of Section 631(b)(1)(B)(i) of the Energy Policy Act of 2005 (P.L. 109-58) and await action by Congress. Section 631(b)(1)(B)(i) requires that the report include all alternatives under consideration and all the information required in the comprehensive report to ensure safe disposal of GTCC LLRW that was submitted by the Secretary to Congress in February 1987.[3]

[3] In accordance with the requirements in section 3(b)(3) of the LLRWPAA, the 1987 report (http://www.gtcceis.anl.gov/documents/docs/DOE_NE-0077.pdf) included: (1) an identification of the radioactive waste involved, including the source of such waste, and the volume, concentration, and other relevant characteristics of the waste; (2) an identification of the federal and nonfederal options for disposal of the waste; (3) a description of actions proposed to ensure the safe disposal of the waste; (4) a description of the projected costs of undertaking such actions; (5) an identification of the options for ensuring that the beneficiaries of the activities resulting in the generation of the waste bear all reasonable costs of disposing of such wastes; and (6) an identification of any statutory authority required for disposal of the waste.

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3 ALTERNATIVE 1: NO ACTION

The Council on Environmental Quality's NEPA-implementing regulations require an analysis of the No Action Alternative to provide a baseline for comparison with the action alternatives (Alternatives 2 through 5). The No Action Alternative would not be responsive to the national security concerns related to management of disused or unwanted sealed sources.

Under the No Action Alternative for this EIS, DOE would take no further action to develop disposal capability for the GTCC LLRW. For the GTCC-like waste, DOE could, under its existing authorities, pursue other disposition paths. Therefore, under the No Action Alternative, there would be no environmental and human health consequences at any of the potential federal sites or facilities or at the generic commercial sites either from the construction of a GTCC LLRW disposal facility or facilities or from waste disposal operations (such as those evaluated for the action alternatives), since such waste-disposal-related activities would not be conducted. Under the No Action Alternative, it is assumed that any new GTCC LLRW and GTCC-like waste would continue to be stored at the various locations where the wastes were either already being stored or at the locations where they would be generated.

Potential environmental consequences under the No Action Alternative would result from the continuation of the practices currently used to manage these wastes for both the short term and the long term. DOE did not evaluate the cumulative impacts of the No Action Alternative, since such an evaluation would involve making speculative assumptions about environmental conditions and future activities at the many locations where the GTCC LLRW and GTCC-like waste could be stored.

A description of the No Action Alternative is provided in Section 3.1 to establish the basis for identifying the potential environmental consequences discussed in Section 3.5. Section 3.2 provides a detailed description of current practices used to store the different types of waste that make up the GTCC LLRW, and Section 3.3 does the same for the GTCC-like waste. The waste generation times and locations are discussed in Section 3.4.

3.1 DESCRIPTION OF THE NO ACTION ALTERNATIVE

Under the No Action Alternative, current practices for storing GTCC LLRW and GTCC-like waste would continue. The GTCC LLRW generated by commercial nuclear reactors (mainly activated metal waste) would continue to be stored at the various nuclear reactor sites that generate this waste. Figure 3.1-1 shows the general locations of the currently operating commercial nuclear reactors in the United States.

The second type of GTCC LLRW — sealed sources — would continue to be stored at licensee locations. Sources recovered by GMS/OSRP for national security or public health and safety reasons would continue to be staged at LANL or off-site contractor facilities pending disposal, and if they meet disposal criteria for DOE facilities, would continue to be disposed of in those facilities. The inventory of GTCC-like sealed sources in storage includes only those

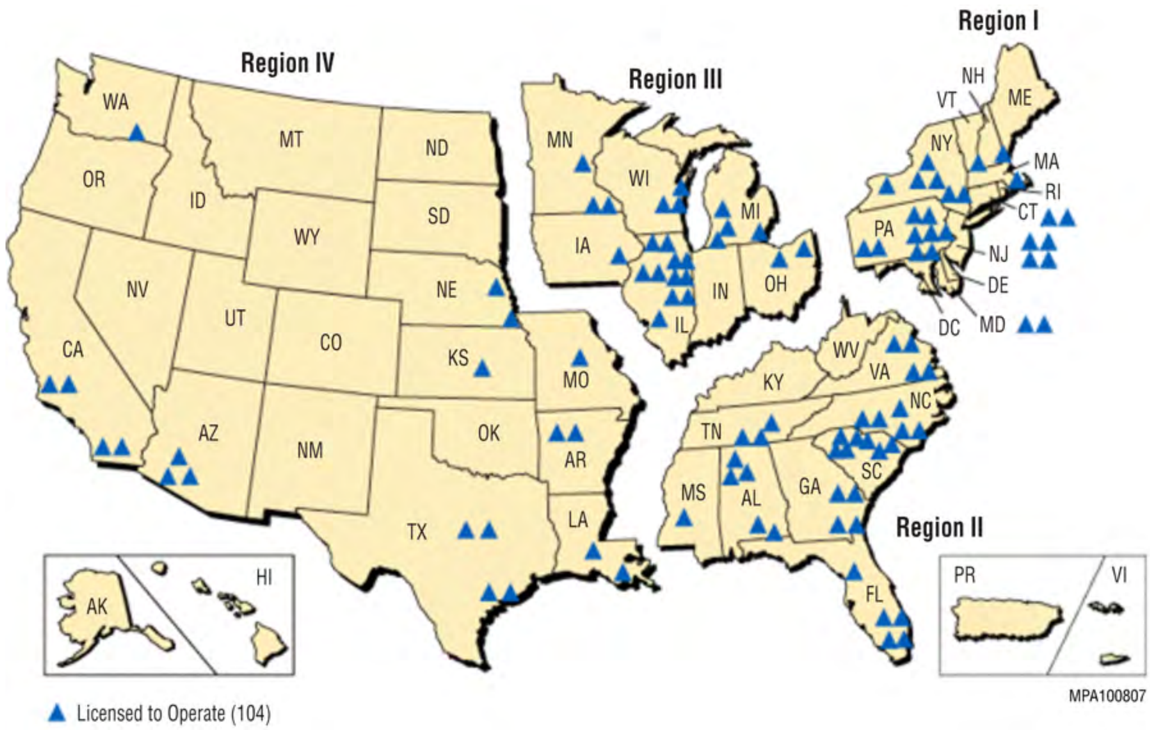

FIGURE 3.1-1 Map Showing Locations of Nuclear Reactors in Four NRC Regions

sealed sources that may not have an identified disposal path. The projected inventory for GTCC-like sealed sources does not include sources that may, in the future, be recovered by GMS/OSRP. Any such sources are the responsibility of the licensees until the point at which they are recovered by GMS/OSRP; therefore, they are included in the projected inventory for commercial GTCC sealed sources.

The third type of waste — Other Waste — would also remain stored and managed at the generator or other interim storage sites.

In a similar manner, all stored waste and projected GTCC-like waste (activated metals, sealed sources, and Other Waste) would remain at current DOE storage and generator locations until DOE developed other disposal paths. It is further assumed that the stored waste would be actively managed for 100 years after all the waste was generated and placed in storage. This 100-year time frame is assumed for the analysis of short-term impacts. This time frame is consistent with that typically implemented as an active institutional control period for similar facilities (i.e., as discussed in 10 CFR 61.59).

3.2 CURRENT PRACTICES FOR MANAGING GTCC LLRW

Current practices for managing the three GTCC LLRW waste types — activated metals, sealed sources, and Other Waste — are described in Sections 3.2.1 through 3.2.3. In this EIS, GTCC LLRW and GTCC-like wastes are presented as being in one of two groups, as described in Section 1.4.1. Group 1 consists of wastes that are either already in storage and awaiting disposal or projected to be generated by currently operating facilities. Group 2 consists of wastes that might be generated in the future at facilities that might or might not exist now or from actions that might or might not take place. A much greater level of uncertainty is associated with the estimated volumes and radionuclide activities of Group 2 wastes.

3.2.1 GTCC LLRW Activated Metal Waste

Wastes from a number of decommissioned reactors have already been generated and are currently being stored by the nuclear utilities that own the reactors, generally at the site at which the wastes were generated or at other reactor sites owned by the same utility. The activated metal wastes are stored in spent fuel storage pools or in heavily shielded containers, including dual-purpose canister systems at several decommissioned reactor sites (e.g., Maine Yankee, Connecticut Yankee), in the same manner as SNF is currently being stored in independent spent fuel storage installations (ISFSIs).

Three major ISFSI design configurations exist. The canisters are housed (1) vertically in below-ground-level, reinforced concrete vaults; (2) vertically in reinforced concrete casks resting on concrete storage pads; or (3) horizontally within reinforced concrete vaults. In all cases, the SNF or activated metal is contained in large stainless-steel canisters that are welded shut. These storage units are generally located inside a fenced area within the restricted access area at the reactor site, in accordance with conditions specified in the existing NRC license (see Figure 3.2.1-1). Under the No Action Alternative for this EIS, this practice would continue to be used to store these wastes.

Most of the GTCC LLRW activated metals would be generated in the future when the currently operating reactors (as well as those planned to be built in the near future) were decommissioned. Under the No Action Alternative, DOE assumed that if there was no disposal facility, wastes would be stored indefinitely at either the reactor site or at another nearby secured facility.

3.2.2 GTCC LLRW Sealed Source Waste

The possession and the use of radioactive materials in sealed sources in the commercial sector are regulated under licenses issued by the NRC and NRC Agreement States. Some sealed sources (those not considered GTCC LLRW) can be disposed of at commercial LLRW disposal facilities when no longer needed. For sources meeting the definition of GTCC LLRW, however, there is no commercial disposal path available. Therefore, sealed sources in the commercial sector that are classified as GTCC LLRW and that have no beneficial future use would continue to be stored. It is assumed this practice would continue indefinitely under the No Action Alternative.

FIGURE 3.2.1-1 Activated Metal Waste in Storage

NNSA Global Threat Reduction Initiative's Off-Site Source Recovery Project (GMS/OSRP)

The Global Threat Reduction Initiative's Off-Site Source Recovery Project (GMS/OSRP) grew out of early efforts at LANL to recover and disposition excess Pu-239 sealed sources that were distributed in the 1960s and 1970s under the Atoms for Peace Program. After the terrorist attacks of 2001, the interagency community began to recognize the threat posed by excess and unwanted radiological materials, particularly those that could not be disposed of at the end of their useful life. Because of their high activity and portability, these sources can be used in radiological dispersal devices (RDDs) commonly referred to as "dirty bombs," resulting in economic impacts amounting to billions of dollars and significant social disruption. GMS/OSRP's mission expanded to include recovery of material based on national security considerations. DOE has a Memorandum of Understanding (MOU) with the NRC that provides for coordination between the two agencies regarding management of sealed sources. Under this MOU, the NRC notifies GMS/OSRP when it learns of orphan sources, and GMS/OSRP expedites the recovery of these sources. GMS/OSRP also recovers non-orphan disused sources on the basis of recovery prioritization criteria developed in coordination with the NRC.

In addition, under the GMS/OSRP, DOE recovers, stages, and disposes of, as appropriate, unwanted or excess sealed sources in response to national security or public health and safety threats. This program would continue under the No Action Alternative. Sources recovered by the GMS/OSRP that were not eligible for disposal at a DOE facility would continue to be stored.

Finally, some sealed sources requiring management as GTCC LLRW would be recycled. In some cases, owners of Cs-137 irradiators would have the option of returning them to the manufacturers. However, some irradiator manufacturers are out of business. Moreover, the return of irradiators to manufacturers that would still be in business and interested in recycling the material could be cost-prohibitive for some licensees. In other cases, if the irradiators were still usable, they might be put to use elsewhere. Similarly, isotope shortages have resulted in some large Am-241 sealed sources being remanufactured and reused by industry.

3.2.3 GTCC LLRW Other Waste

The Other Waste type consists of GTCC LLRW that does not fall into one of the other two types (i.e., Other Waste is not activated metal or a sealed source) (see Section 1.4.1.3). There is generally little commercially generated GTCC LLRW in the Group 1 Other Waste type, and such waste is generally stored at the point of generation or sent to a waste broker for consolidation and storage with other similar wastes. Two sites, one in Virginia and one in Texas, are currently storing GTCC LLRW Other Waste. Under the No Action Alternative, this waste would continue to be stored.

Most of the Group 2 waste in this waste type would be associated with the possible exhumation of two disposal areas at the West Valley Site in New York as part of future decommissioning actions at the site. In addition, Group 2 Other Waste would be generated by future Mo-99 production activities. For purposes of this EIS, it is assumed that this waste would be generated and stored at the sites that generated the waste. Since much of the Group 2 waste would be associated with the West Valley Site and if a decision was made to exhume the waste, it is likely that additional waste storage facilities would need to be provided at that site to manage these wastes.

3.3 CURRENT PRACTICES FOR MANAGING GTCC-LIKE WASTE

As described in Section 1.4.1, GTCC-like waste is waste that is similar to GTCC LLRW but is owned or generated by DOE. Most of this waste meets the DOE definition of TRU waste and may not have originated from defense activities, such that it may not be authorized for disposal at WIPP under current legislation and has no other currently identified path to disposal. The current approach for managing the three types of GTCC-like waste is described as follows.

3.3.1 GTCC-Like Activated Metal Waste

GTCC-like activated metal waste has characteristics similar to those of commercially generated GTCC LLRW activated metal waste. It is produced in reactors and other types of facilities that use high-energy neutrons. There is a relatively small volume of this waste type that is GTCC-like waste when compared with the volume that is generated in the commercial sector by the nuclear utility industry. This waste is being stored at the DOE sites (INL and ORNL) where it is generated, and it is expected that this practice would continue under the No Action Alternative. Wastes generated from new facilities constructed in the future would be stored in a similar manner under the No Action Alternative.

3.3.2 GTCC-Like Sealed Source Waste

As is the case for the activated metal waste, there is much less GTCC-like sealed source waste than GTCC LLRW sealed source waste. Waste in this category that is not eligible for disposal at a DOE facility is generally stored at the site where it was used. Under the No Action Alternative, it is assumed that this approach for storing these wastes would continue indefinitely.

3.3.3 GTCC-Like Other Waste

Most of the GTCC-like Other Waste consists of waste associated with the decontamination and decommissioning of facilities at the West Valley Site (Group 1 and Group 2 wastes) and waste associated with the planned DOE Pu-238 production project (Group 2 wastes). Some of the West Valley waste has already been generated and is in storage at the site, while the rest would be generated in the future. Much of the waste from these two projects would be DOE non-defense-generated TRU waste. Under the No Action Alternative, the GTCC-like Other Waste from the West Valley Site, Pu-238 production project, and any additional wastes from existing facilities or new facilities that would be constructed in the future would be stored indefinitely at the site at which it was generated.

3.4 WASTE GENERATOR LOCATIONS AND GENERATION TIMES

3.4.1 Waste Generator Locations

The GTCC LLRW and the GTCC-like waste that make up the inventory evaluated in this EIS are generated at various locations. The volumes of GTCC LLRW and GTCC-like wastes are summarized in Table 1.4.1-2. Under the No Action Alternative, it would be necessary to store these wastes indefinitely after they were generated.

Table 3.4-1 lists the currently licensed commercial nuclear power reactors that are the source of most of the GTCC LLRW activated metal discussed above in Sections 3.1 and 3.2. Sealed sources are being used and stored throughout the country at medical facilities and hospitals, industrial facilities, and universities, and some of these sources that are no longer

TABLE 3.4-1 Locations of Operating, Shut-Down, and Proposed Commercial Reactors[a]

Reactor Name	Approximate Location	No. Operating	No. Shut Down	No. Proposed
BWRs				
Browns Ferry	Decatur, AL	3		
Brunswick	Southport, NC	2		
Clinton	Clinton, IL	1		
Columbia Generating Station	Richland, WA	1		
Cooper	Nebraska City, NE	1		
Dresden	Morris, IL	2	1	
Duane Arnold	Cedar Rapids, IA	1		
Edwin I. Hatch	Baxley, GA	2		
Fermi-2	Newport City, MI	1		1
Grand Gulf-1	Vicksburg, MS	1		1
Hope Creek-1	Wilmington, DE	1		
James Fitzpatrick	Oswego, NY	1		
LaSalle County	Ottawa, IL	2		
Limerick	Philadelphia, PA	2		
Monticello	Minneapolis, MN	1		
Nine Mile Point	Oswego, NY	2		1[b]
Oyster Creek-1	Toms River, NJ	1		
Peach Bottom	Lancaster, PA	2		
Perry-1	Painesville, OH	1		
Pilgrim-1	Plymouth, MA	1		
Quad Cities	Moline, IL	2		
River Bend-1	Baton Rouge, LA	1		1
Susquehanna	Berwick, PA	2		
Vermont Yankee-1	Brattleboro, VT	1		
Big Rock Point	Charlevoix, MI		1	
GE VBWR	Sunol, CA		1	
Humboldt Bay-3	Eureka, CA		1	
La Crosse	Genoa, WI		1	
Pathfinder	Sioux Falls, SD		1	
Victoria County Station	Victoria City, TX			2[c]
PWRs				
Arkansas Nuclear	Russellville, AR	2		
Beaver Valley	McCandless, PA	2		
Braidwood	Joliet, IL	2		
Byron	Rockford, IL	2		
Callaway	Fulton, MO	1		1
Calvert Cliffs	Annapolis, MD	2		1
Catawba	Rock Hill, SC	2		
Comanche Peak	Glen Rose, TX	2		2
Crystal River-3	Crystal River, FL	1		
D.C. Cook	Benton Harbor, MI	2		
Davis-Besse	Toledo, OH	1		
Diablo Canyon	San Luis Obispo, CA	2		
Fort Calhoun	Omaha, NE	1		
Ginna	Rochester, NY	1		
H.B. Robinson-2	Florence, SC	1		
Indian Point	New York City, NY	2	1	

TABLE 3.4-1 (Cont.)

Reactor Name	Approximate Location	No. Operating	No. Shut Down	No. Proposed
PWRs (Cont.)				
Joseph M. Farley	Dothan, AL	2		
Kewaunee	Green Bay, WI	1		
McGuire	Charlotte, NC	2		
Millstone	New London, CT	2	1[d]	
North Anna	Richmond, VA	2		1[e]
Oconee	Greenville, SC	3		
Palisades	South Haven, MI	1		
Palo Verde	Phoenix, AZ	3		
Point Beach	Manitowoc, WI	2		
Prairie Island	Minneapolis, MN	2		
Salem	Wilmington, DE	2		
San Onofre	San Clemente, CA	2	1	
Seabrook-1	Portsmouth, NH	1		
Sequoyah	Chattanooga, TN	2		
Shearon Harris-1	Raleigh, NC	1		2
South Texas Project	Bay City, TX	2		2[f]
St Lucie	Ft. Pierce, FL	2		
Summer	Columbia, SC	1		2
Surry-1	Newport News, VA	2		
Three Mile Island-1	Harrisburg, PA	1		
Turkey Point	Miami, FL	2		2
Vogtle	Augusta, GA	2		2
Waterford-3	New Orleans, LA	1		
Watts Bar-1	Spring City, TN	1		
Wolf Creek-1	Burlington, KS	1		
Haddam Neck	East Hampton, CT		1	
Maine Yankee	Wiscasset, ME		1	
Rancho Seco	Herald, CA		1	
Saxton	Saxton, PA		1	
Yankee-Rowe	Rowe, MA		1	
Zion	Warrenville, IL		2	
Alternate Energy Holdings	Bruneau, ID			1
Amarillo Power	Amarillo, TX			2
William Lee (Duke)	Charlotte, SC			2
MidAmerican	Payette County, ID			1
Bellefonte	Scottsboro, AL			2
PPL Generation	Berwick, PA			1
Levy	Levy County, FL			2
Unannounced	Unknown			1
Total		104	16	33

[a] Status as of February 2013.

[b] Proposed reactor is a pressurized water reactor (PWR).

[c] License application was withdrawn on June 11, 2010.

[d] Shut-down reactor is a boiling water reactor (BWR).

[e] Proposed reactor is a BWR.

[f] Proposed reactors are BWRs.

needed are being stored at commercial storage and staging locations. It is not possible to identify the specific locations where the sealed sources are being used or stored. Most of these sources are probably close to the larger population centers in the country. GTCC-like activated metal wastes, sealed sources, and Other Waste are generated and/or stored at the INL Site, LANL, ORR, the West Valley Site, and a commercial facility in Lynchburg, Virginia (see Appendix B, Table B-2).

Most of the Other Waste is associated with the West Valley Site or located at other DOE sites (ORR and the INL Site). Two commercial facilities (in Virginia and Texas) are being used to store GTCC LLRW Other Waste. In addition, Other Waste would be generated in the planned Mo-99 production projects (GTCC LLRW) and the planned Pu-238 production project (GTCC-like waste). The wastes from these planned projects are included in Group 2, and it is assumed that they would be stored at the facilities that generated them until a disposal facility becomes available.

3.4.2 Waste Generation Times

GTCC LLRW and GTCC-like waste have been and are continuing to be generated. Figure 3.4.2-1 shows the assumed timeline for the receipt of waste for disposal (see Section B.4 for additional discussion). The actual start date for operations is uncertain at this time and dependent upon, among other things, the alternative or alternatives selected, additional NEPA review as needed, characterization studies, and other actions necessary to initiate and complete construction and operation of a GTCC LLRW and GTCC-like waste disposal facility. For purposes of analysis in the EIS, DOE assumed a start date of disposal operations in 2019. However, given these uncertainties, the actual start date could vary. The GTCC LLRW and GTCC-like waste are stored as they are generated, since there is no licensed facility that can accept GTCC LLRW for disposal and since there is currently no disposal path for the GTCC-like waste. This practice would continue indefinitely under the No Action Alternative.

Disused sealed sources would continue to be generated and stored by commercial licensees. Although some GTCC LLRW activated metal waste from decommissioning nuclear reactors is currently in storage, most of this waste type will not be generated and available for disposal for several decades. In the future, if no disposal facility was available to accept the waste, utilities would have to continue storing this waste in a manner consistent with their NRC licenses. The Other Waste (such as that from the West Valley Site) would continue to be managed at the generator site or at some other location.

GTCC-like waste at the DOE sites would continue to be stored in accordance with the *Radioactive Waste Management Manual*, DOE M 435.1-1 (DOE 1999) and other DOE requirements.

3.5 POTENTIAL CONSEQUENCES OF THE NO ACTION ALTERNATIVE

This section focuses on potential short- and long-term impacts on human health from continued management of the GTCC LLRW and GTCC-like waste at current storage and

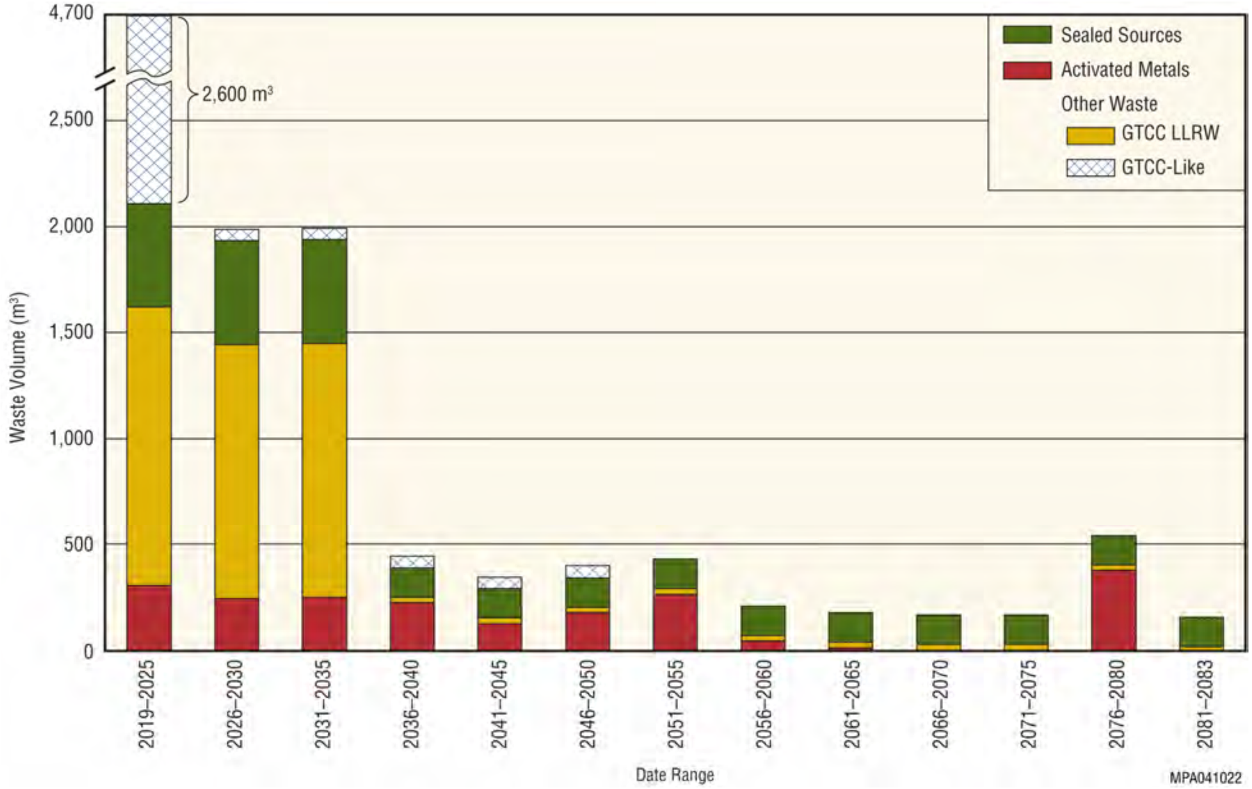

FIGURE 3.4.2-1 Assumed Timeline for Receipt of Waste for Disposal

generator sites. Under the No Action Alternative, it is assumed that the current facility operations at the storage and generator sites would continue for the short term and result in minimal impacts on most resource areas (e.g., air quality, geology, water resources, ecological resources, socioeconomics, land use, transportation, and cultural resources). The main concerns are associated with the human health impacts that could occur from storage of this waste.

Short-term impacts are assumed to be the impacts that would last for 100 years after the wastes were generated and placed in storage. This time frame is consistent with the typical active institutional control period assumed for such facilities. Long-term impacts are those assumed to last for a period from 100 to 10,000 years after generation and placement in storage. The short-term impacts are expected to be mainly occupational doses from maintenance and monitoring activities. No off-site releases are expected for the short term, because the waste packages would contain the radioactive materials and because monitoring of the site and nearby vicinity would identify any needs for corrective action. It is possible that the public could be exposed to external gamma radiation from the stored wastes if individuals were to venture close enough to the stored wastes, but it is expected that such exposures would be low and not result in any significant LCF risk.

Long-term impacts are those associated with the potential release of contaminants to the environment and with the subsequent exposure to nearby individuals. Because it is assumed that the site would not be monitored for the long term, there would be no worker doses during this time period. Also, although airborne releases from degraded containers could occur, it is expected that the dispersion of any released radionuclides by the wind would greatly decrease the air concentrations. The highest doses would therefore probably be those associated with the migration of radionuclides to groundwater that would subsequently be used by members of the general public. For this assessment, the exposed individual is assumed to be a hypothetical resident farmer located 100 m (330 ft) downgradient from the storage facility.

For evaluating long-term impacts, no credit is taken for maintenance of the stored wastes beyond 100 years. That is, it is assumed for analysis purposes in this EIS that after 100 years, water could contact the radioactive contaminants in the waste packages and leach radionuclides from the wastes, and that these radionuclides could then move toward the underlying groundwater system. For this EIS, it is assumed that the activated metals and Other Waste would stay within the NRC region in which the facility that generated the wastes was located, and the sealed sources would be divided in the four NRC regions in proportion to the number of NRC-licensed facilities within each region.

For purposes of analysis of the long-term impacts, wastes from the GTCC inventory that are assumed to be generated within a given NRC region are assumed to be stored at a single facility in that region, and this storage facility is assumed to have a footprint of 300 × 300 m (1,000 × 1,000 ft). It is recognized that these simplifying assumptions do not represent the current situation, and GTCC LLRW and GTCC-like waste are currently stored throughout the region at a number of locations. However, this approach is assumed to be reasonable for estimating the potential radiation doses and LCF risks to address the long-term impacts associated with the No Action Alternative. It needs to be emphasized that the approach used for analysis of the No Action Alternative differs from that used for the action alternatives, in which the entire GTCC LLRW and GTCC-like waste inventory is assumed to be disposed of at each site by using one of the disposal methods (i.e., for the No Action Alternative, only portions of the inventory are assumed to be stored in each region).

The results of the long-term assessment for the No Action Alternative for the first 10,000 years following the 100-year institutional control period are presented in Tables 3.5-1 and 3.5-2. Figures 3.5-1 through 3.5-7 illustrate the results for a time period extending to 100,000 years. The tables provide the radiation doses and LCF risk in the four NRC regions for the various waste types, and the figures illustrate the radionuclides expected to be the significant dose contributors. In some figures, the time and dose scales are linear, and in others, they are logarithmic, in order to better illustrate the results.

The results presented in these two tables and seven figures reflect the doses that could occur from the groundwater pathway after the 100-year institutional control period assumed. During the institutional control period, the site would be monitored, and corrective actions would be taken if off-site releases were detected. However, it is assumed that after this time period, all monitoring activities would cease, and any releases could thus be undetected.

Because the radionuclide mix for each waste type (i.e., activated metals, sealed sources, and Other Waste) is different, the peak doses and LCF risks for each waste type do not necessarily occur at the same time. In addition, the peak doses and LCF risks for the entire

TABLE 3.5-1 Estimated Peak Annual Doses (in mrem/yr) from the Use of Contaminated Groundwater within 10,000 Years after the Institutional Control Period for the No Action Alternative[a,b]

	GTCC LLRW				GTCC-Like Waste				
NRC Region[c]/ Waste Group	Activated Metals	Sealed Sources	Other Waste - CH	Other Waste - RH	Activated Metals	Sealed Sources	Other Waste - CH	Other Waste - RH	Peak Annual Dose
Region I	120	73,000	3,800	26,000	0.0	0.0	97,000	270,000	470,000
Region II	7.5	0.0	0.0	850	0.052	0.0	0.0	0.0	860
Region III	5.4	120	0.0	0.0	0.0	0.0	0.0	0.0	120
Region IV	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

[a] These doses are associated with the use of contaminated groundwater by a resident farmer located 100 m (330 ft) from the edge of the storage facility. All values are given to two significant figures. The times for the peak annual doses for NRC Regions I, II, and III were calculated to be about 3,700, 98, and 1,100 years, respectively, after the assumed institutional control period of 100 years. No doses from the groundwater pathway were calculated to occur within 10,000 years in Region IV for the No Action Alternative. The primary contributors to the dose are GTCC LLRW sealed sources, GTCC LLRW Other Waste - RH, and GTCC-like Other Waste - RH. The primary radionuclides contributing to the dose are C-14, I-129, Np-237, and isotopes of uranium, plutonium, and americium.

[b] The values given in this table represent the maximum or peak annual dose to the hypothetical resident farmer when the assumed entire GTCC LLRW and GTCC-like waste inventory for a particular region is considered. The values in the waste-type-specific columns provide the doses associated with each waste type at the time of the maximum or peak annual dose for the entire inventory. These contributions do not necessarily represent the maximum or peak dose that could result from each of these waste types separately. Because of the different radionuclide mixes and activities for each of the waste types, the maximum or peak annual dose that could result from each waste type individually could occur at a different time. The peak annual doses that could result from each of the waste types when considered separately are presented in Table E-21. This information is discussed in Sections 3.5.1 through 3.5.6.

[c] Region I includes the states of Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, and Washington, D.C. Region II includes the states of Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, Tennessee, Virginia, and West Virginia. Region III includes the states of Illinois, Indiana, Iowa, Michigan, Minnesota, Ohio, and Wisconsin. Region IV includes Alaska, Arizona, Arkansas, California, Colorado, Hawaii, Idaho, Kansas, Louisiana, Missouri, Montana, Nebraska, Nevada, New Mexico, North Dakota, Oklahoma, Oregon, South Dakota, Texas, Utah, Washington, and Wyoming.

TABLE 3.5-2 Estimated Annual LCF Risks from the Use of Contaminated Groundwater within 10,000 Years after the Institutional Control Period for the No Action Alternative[a,b]

NRC Region[c]/ Waste Group	GTCC LLRW				GTCC-Like Waste				Peak Annual LCF Risks
	Activated Metals	Sealed Sources	Other Waste – CH	Other Waste - RH	Activated Metals	Sealed Sources	Other Waste - CH	Other Waste - RH	
Region I	7E-05	4E-02	2E-03	2E-02	0E+00	0E+00	6E-02	2E-01	3E-01
Region II	4E-06	0E+00	0E+00	5E-04	6E-08	0E+00	0E+00	0E+00	5E-04
Region III	3E-06	7E-05	0E+00	0E+00	0E+00	0E+00	0E+00	0E+00	7E-05
Region IV	0E+00	0E+00	0E+00	0E+00	0E+00	0E+00	0E+00	0E+00	0E+00

[a] All values are given to one significant figure. The times for the peak annual LCF risks for NRC Regions I, II, and III were calculated to be about 3,700, 98, and 1,100 years, respectively, after the assumed institutional control period of 100 years. No LCFs from the groundwater pathway were calculated to occur within 10,000 years in Region IV for the No Action Alternative. The primary contributors to the LCF risk are GTCC LLRW sealed sources, GTCC LLRW Other Waste - RH, and GTCC-like Other Waste - RH. The primary radionuclides contributing to the LCF risk are C-14, I-129, Np-237, and isotopes of uranium, plutonium, and americium.

[b] The values given in this table represent the maximum or peak annual LCF risk to the hypothetical resident farmer when the assumed entire GTCC LLRW and GTCC-like waste inventory for a particular region is considered. The values in the waste-type-specific columns provide the risks associated with each waste type at the time of maximum or peak annual LCF risk for the entire inventory. These contributions do not necessarily represent the maximum or peak LCF risk that could result from each of these waste types separately. Because of the different radionuclide mixes and activities for different the waste types, the maximum or peak LCF risk that could result from each waste type individually could occur at a different time. This information is discussed in Sections 3.5.1 through 3.5.6.

[c] Region I includes the states of Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, and Washington, D.C. Region II includes the states of Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, Tennessee, Virginia, and West Virginia. Region III includes the states of Illinois, Indiana, Iowa, Michigan, Minnesota, Ohio, and Wisconsin. Region IV includes Alaska, Arizona, Arkansas, California, Colorado, Hawaii, Idaho, Kansas, Louisiana, Missouri, Montana, Nebraska, Nevada, New Mexico, North Dakota, Oklahoma, Oregon, South Dakota, Texas, Utah, Washington, and Wyoming.

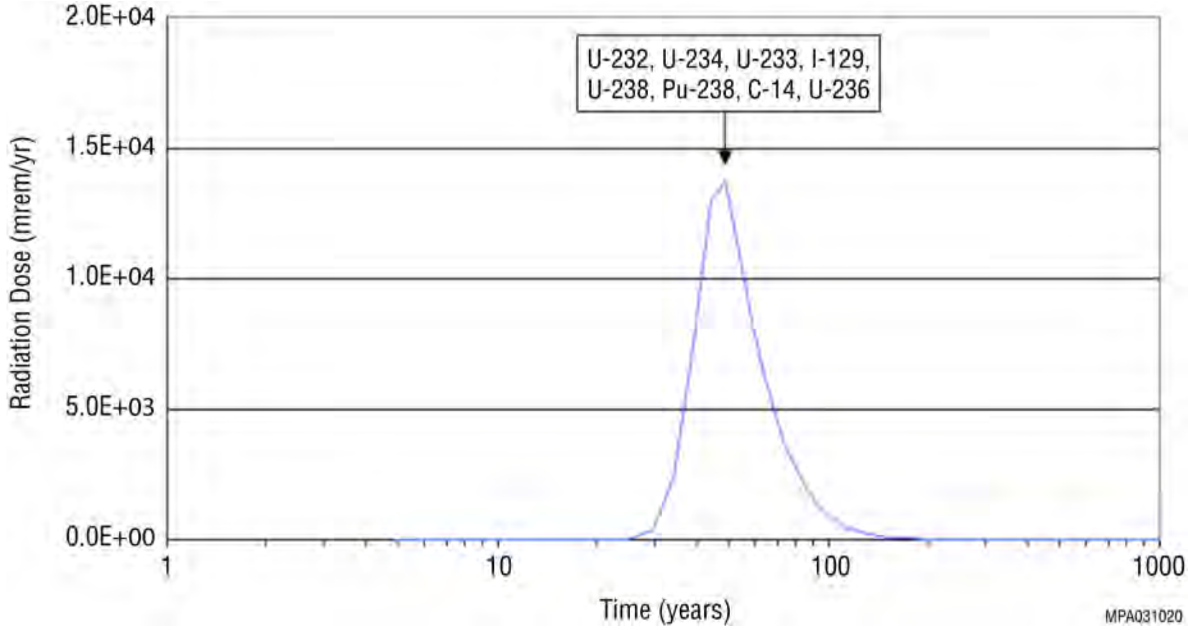

FIGURE 3.5-1 Temporal Plot of Radiation Doses Associated with the Use of Contaminated Groundwater within 1,000 Years after the Institutional Control Period in NRC Region I for the No Action Alternative

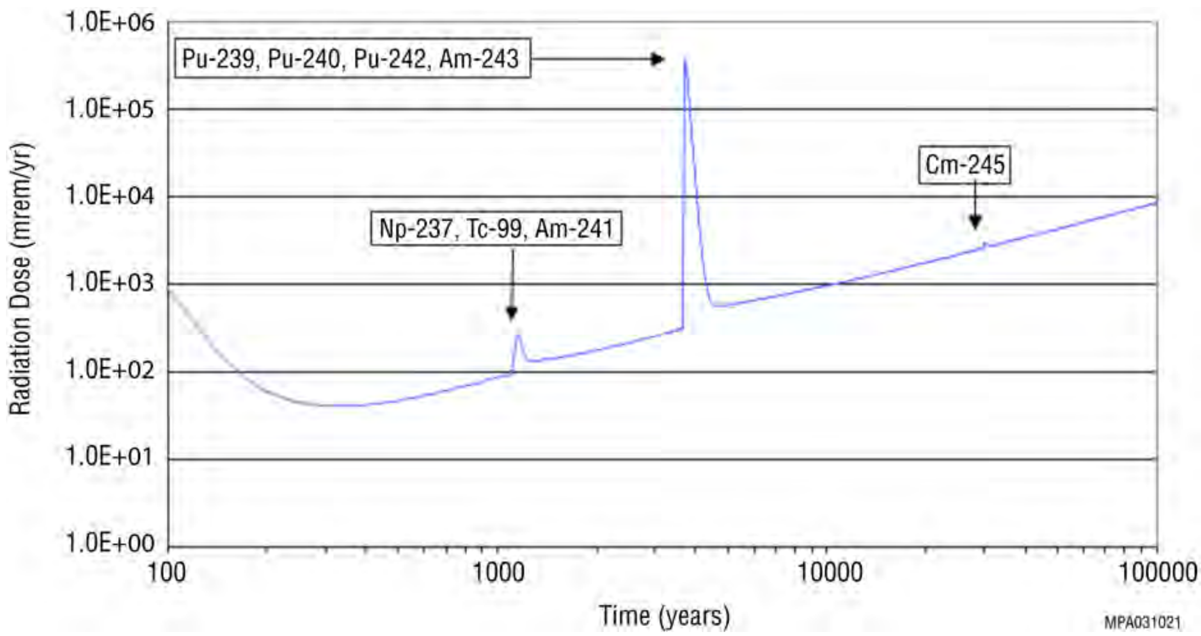

FIGURE 3.5-2 Temporal Plot of Radiation Doses Associated with the Use of Contaminated Groundwater within 100,000 Years after the Institutional Control Period in NRC Region I for the No Action Alternative

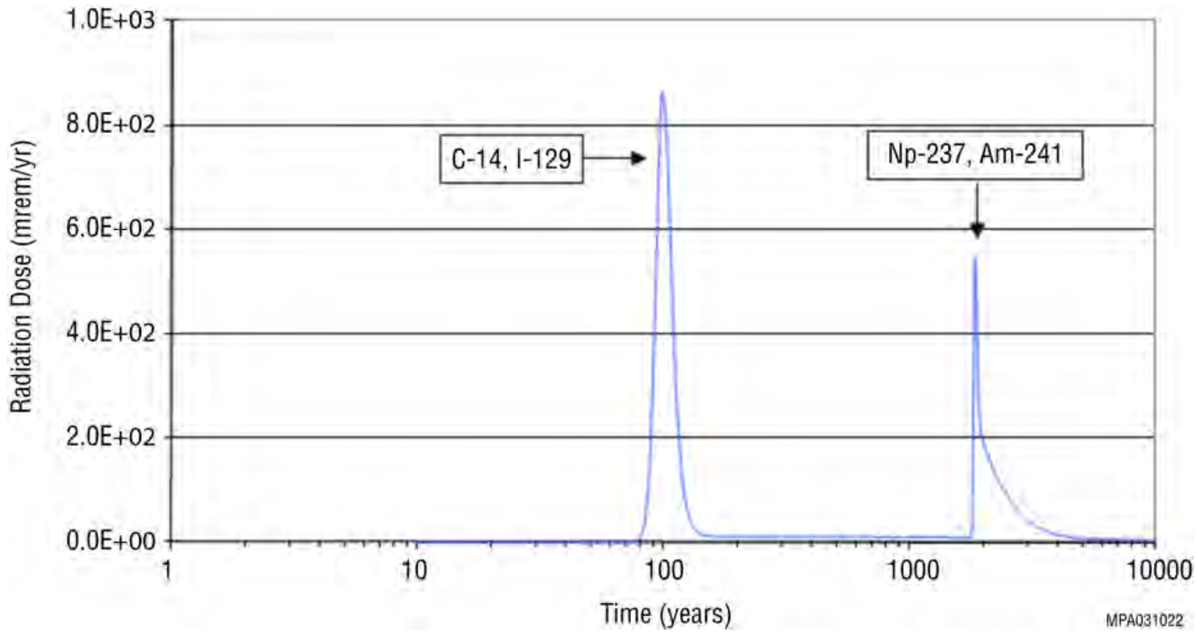

FIGURE 3.5-3 Temporal Plot of Radiation Doses Associated with the Use of Contaminated Groundwater within 10,000 Years after the Institutional Control Period in NRC Region II for the No Action Alternative

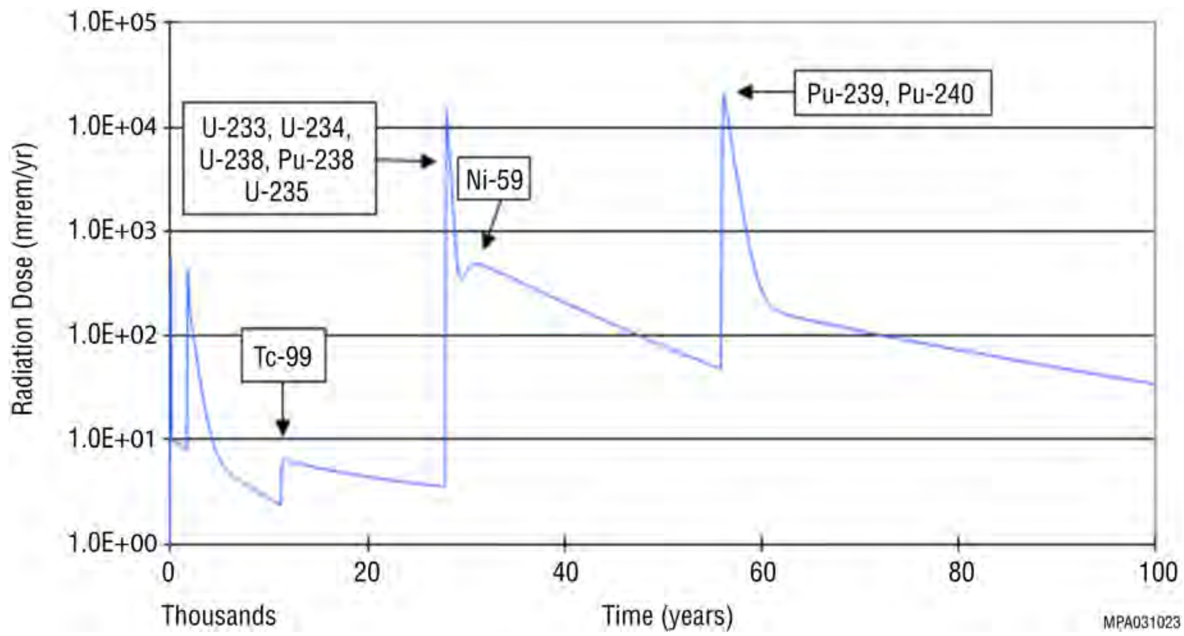

FIGURE 3.5-4 Temporal Plot of Radiation Doses Associated with the Use of Contaminated Groundwater within 100,000 Years after the Institutional Control Period in NRC Region II for the No Action Alternative

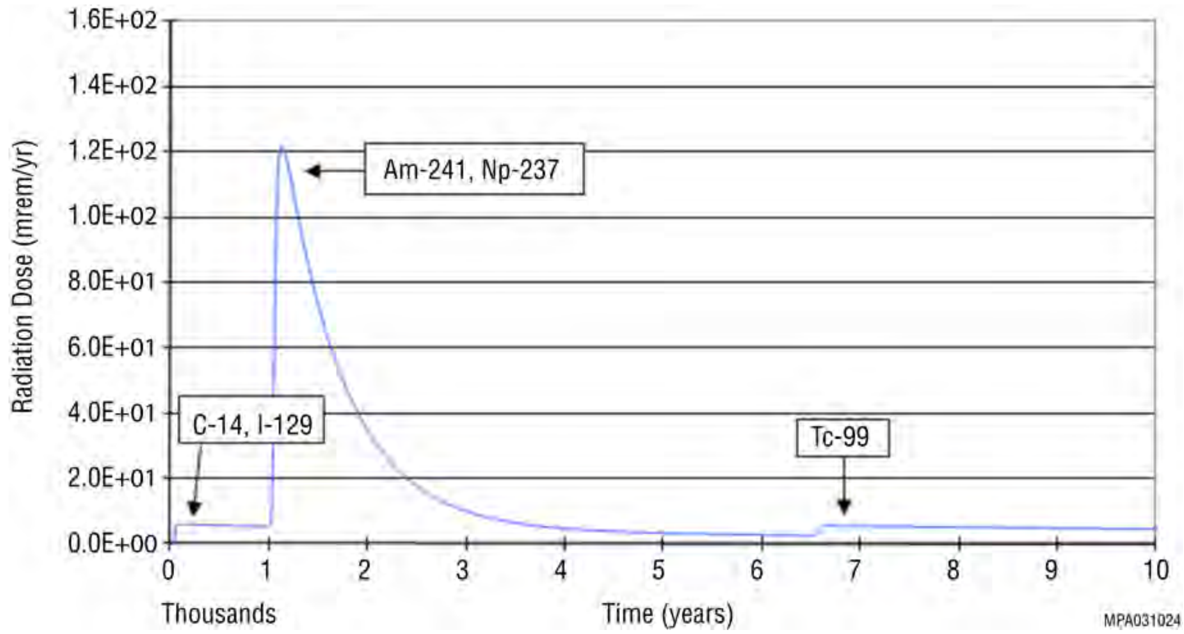

FIGURE 3.5-5 Temporal Plot of Radiation Doses Associated with the Use of Contaminated Groundwater within 10,000 Years after the Institutional Control Period in NRC Region III for the No Action Alternative

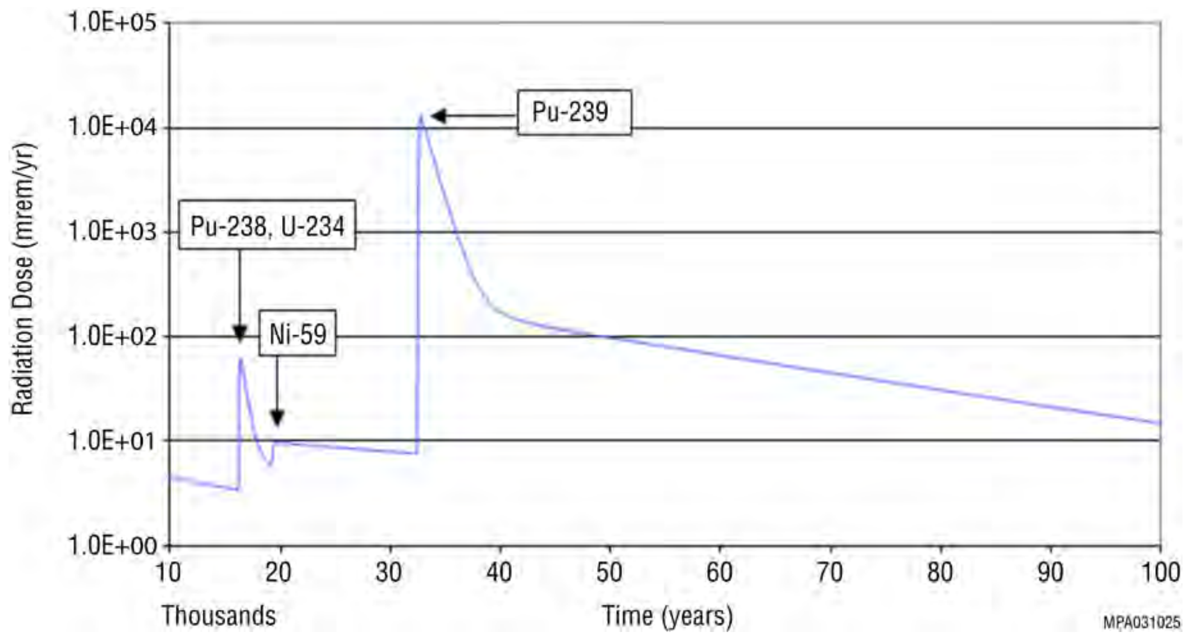

FIGURE 3.5-6 Temporal Plot of Radiation Doses Associated with the Use of Contaminated Groundwater within 100,000 Years after the Institutional Control Period in NRC Region III for the No Action Alternative

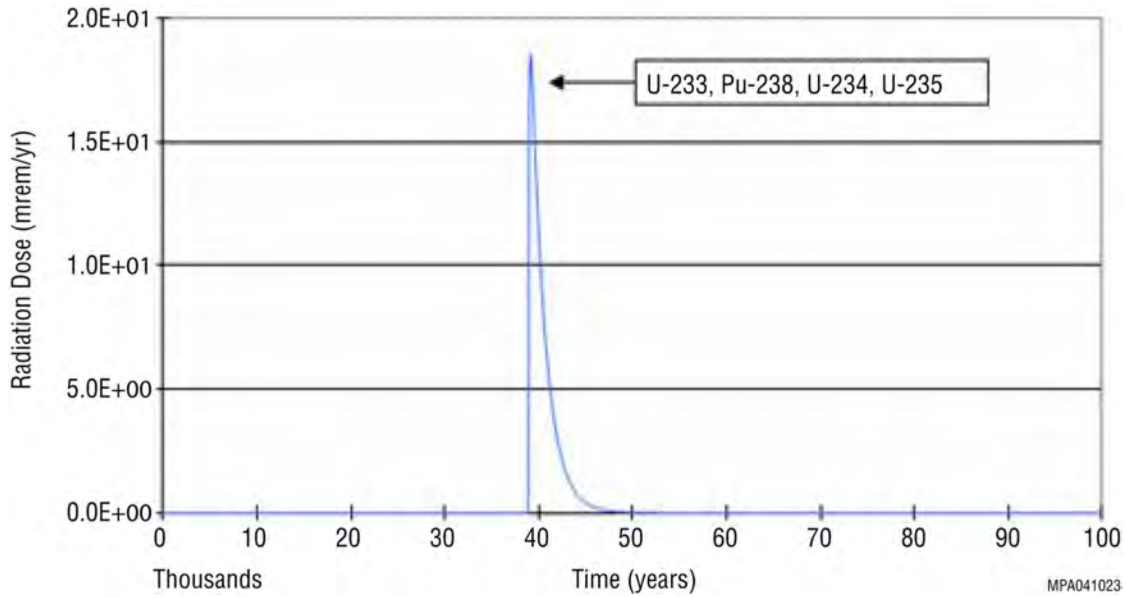

FIGURE 3.5-7 Temporal Plot of Radiation Doses Associated with the Use of Contaminated Groundwater within 100,000 Years after the Institutional Control Period in NRC Region IV for the No Action Alternative

GTCC LLRW and GTCC-like waste inventory considered as a whole could be different than those for the individual waste types. The results presented in Tables 3.5-1 and 3.5-2 are for the entire GTCC LLRW and GTCC-like waste inventory assumed for that region, and the contributions of the individual waste types given in these tables are those that occur at the time of peak doses and LCF risks for the given inventory. The peak annual doses that could result from each of the waste types when considered separately are presented in Table E-21.

The estimated doses and LCF risks for the hypothetical resident farmer scenario evaluated to assess the long-term impacts for the No Action Alternative are presented in two ways in this EIS. The first presents the peak dose and LCF risk when long-term storage of the entire GTCC LLRW and GTCC-like waste inventory is considered. These are provided in Tables 3.5-1 and 3.5-2. The second presents the peak dose and LCF risk for each waste type considered on its own. These results are presented in Sections 3.5.1 through 3.5.6, which focus on those waste types that have peak doses and LCF risks at different times than those presented in the two tables.

It was calculated that radionuclides would not reach the groundwater table in NRC Region IV within 10,000 years, so the results presented in Tables 3.5-1 and 3.5-2 have zeroes for this region for all waste types. Radionuclides were calculated to reach the groundwater table and a well located 100 m (330 ft) downgradient at about 40,000 years in NRC Region IV (see Figure 3.5-7). The peak annual dose in this region was determined to be about 19 mrem/yr, largely due to uranium and plutonium isotopes and their radioactive decay products. There is a high degree of uncertainty with regard to estimates that extend so far into the future.

The highest radiation doses and LCF risks for the four regions evaluated are associated with NRC Region I. This region has the largest portion of the GTCC LLRW and GTCC-like waste inventory assumed (due to the presence of the waste from the West Valley Site). The West Valley Site accounts for about 56% of the entire GTCC EIS waste inventory, and much of this waste meets the DOE definition of TRU waste. The total estimated volume of GTCC LLRW at the West Valley Site is about 4,300 m^3 (150,000 ft^3), and the volume of GTCC-like waste is estimated to be about 2,200 m^3 (78,000 ft^3).

Another reason for the higher doses and LCF risk in NRC Region I is because a disposal facility in that region would likely be in a generally humid environment with a relatively short distance to the groundwater table. These properties would probably result in higher radiation doses and LCF risks, especially when compared with the more arid sites expected in NRC Region IV.

The peak annual dose in NRC Region I within 10,000 years was calculated to be 470,000 mrem/yr, and this dose would occur about 3,700 years after termination of the institutional control period (assumed to be 100 years). This dose is assumed to result if an exposure pathway to the contaminated groundwater is possible and if the resident farmer scenario realistically represents this exposure. This dose would be largely attributable to plutonium isotopes and Am-243 (which decays to Pu-239) and would result from the long-term storage of GTCC LLRW sealed sources containing plutonium and Am-243 and from the Other Waste. The Other Waste would contribute about 84% to this peak annual dose and be associated mainly with the West Valley Site. In addition to this peak annual dose at 3,700 years in the future, there would be a high dose (about 14,000 mrem/yr) in the very near term from C-14, I-129, Pu-238, and uranium isotopes, because it is assumed in this analysis that C-14, I-129, and uranium would dissolve completely in water. It was calculated that this dose would occur about 50 years following the institutional control period.

The peak annual doses in NRC Regions II and III would be lower than that for Region I, but they would exceed 100 mrem/yr. The peak annual dose within 10,000 years in NRC Region II was calculated to be 860 mrem/yr and to occur about 98 years following the institutional control period. This peak dose would be largely attributable to C-14 and I-129, with GTCC LLRW Other Waste - RH being the main contributor. The peak annual dose within 10,000 years in NRC Region III was calculated to be 120 mrem/yr and to occur about 1,100 years in the future. This dose would be largely attributable to Np-237 and Am-241 (which decays to Np-237), with GTCC LLRW sealed sources being the main contributor to this dose. Much larger doses were calculated to occur in these two NRC regions in the very long term (see Figures 3.5-4 and 3.5-6), largely due to uranium and plutonium isotopes. There is a very large degree of uncertainty in estimates that range this far into the future.

An additional discussion of these short-term and long-term impacts in terms of the specific types of wastes being addressed in this EIS is provided here, as follows.

3.5.1 GTCC LLRW Activated Metal Waste

As shown in Table 3.4-1 and Figure 3.1-1, the activated metal waste would be retained for storage at some or all of the 84 locations having commercial nuclear reactors. This total would include the 33 assumed new, yet-to-be-licensed reactors. It is assumed that the wastes would be stored in secure locations at these sites in accordance with NRC licenses for an indefinite period of time.

3.5.1.1 Short-Term Impacts

Under the No Action Alternative, it is expected that short-term impacts would be the same as those at sites with ISFSIs having stored wastes and that storage practices would be protective of human health and the environment. Monitoring and maintenance of these waste storage areas would continue, and any required maintenance would be performed in a manner consistent with the existing NRC licenses. These wastes could also be stored at other NRC-approved facilities, and it is expected that this option would also have minimal impacts on the environment. Because the activated metals would be in closed (welded shut) stainless-steel canisters, no releases of radioactive material to the air, ground, or water are anticipated for the short term. Should an accidental release occur, best management practices and site operating procedures would ensure that any contaminant releases to the air would be minimal and comply with NRC licensing requirements.

Minimal adverse impacts on the health of the workers and the general public are expected. The short-term human health impacts would be a result of the low levels of radiation from the stored activated metals in their shielded canisters. Since the activated metals would come from a decommissioned reactor, most ISFSIs with activated metal canisters would be at decommissioned reactor sites, unless the waste had been shipped elsewhere for interim storage. Therefore, most human exposure at these locations would result primarily from stored SNF rather than stored activated metals, because the number of activated metal canisters might only be about 10% or less of the number of SNF canisters in ISFSIs. Annual occupational involved worker collective doses from surveillance and maintenance activities at a single ISFSI are estimated to be on the order of 1 to 4 person-rem per year (Pacific Gas and Electric Company 2001; Prairie Island 2008; Surry Power Station 2002). Such doses would depend on the size and type of the ISFSI. In addition, the actual impact from activated metal storage would likely be less and would depend on the number of activated metal canisters and their locations and external dose rates relative to those of the SNF canisters present.

Some reactor sites have more than one reactor, with one or more having been decommissioned and one or more still in operation. Thus, impacts would also occur to nearby worker populations at an active reactor site with an ISFSI. Such noninvolved worker exposures would depend on the size of the ISFSI, the relative locations (i.e., distance) and shielding afforded by the nearby work area(s), and the number of nearby noninvolved workers. Potential annual collective doses to noninvolved workers at a reactor site from a collocated ISFSI have been estimated to reach as high as about 10 person-rem (Prairie Island 2008).

While the radiation field from an ISFSI is generally low, potential public exposure is possible, depending on distance and the local site characteristics (e.g., elevation contours, vegetation). The annual collective external dose to the public from an ISFSI could exceed 1 person-rem (Prairie Island 2008) if a sufficiently large local population was located close enough to the site. Again, most exposure would result from SNF rather than from any GTCC activated metals present at the ISFSI. None of these doses is expected to result in an LCF.

3.5.1.2 Long-Term Impacts

As discussed previously, the NRC license requires storage facilities or areas to be maintained in a manner that is safe for the environment and the general public until a path to disposal is identified. Continued storage of activated metal waste at the 84 reactor (generator) sites would entail a continued risk of intruder access (i.e., both inadvertent human intruder and intentional acts such as sabotage) at each of the sites.

For the long-term evaluation of the No Action Alternative in this EIS, the following assumptions apply: (1) maintenance activities at these storage facilities would not be conducted after the active institutional control period (i.e., after 100 years), (2) the storage containers would start to degrade to the extent that potential radionuclide releases could occur, (3) these radionuclides would then reach the groundwater and move downgradient off-site, and (4) a hypothetical individual would use and consume this contaminated groundwater in the future. These assumptions were made to allow for an assessment of the potential human health impacts in the future; they do not imply that such a situation is reasonable or likely to occur.

Once the containers would begin to degrade, other exposure pathways could also be relevant, including exposures from airborne releases and releases to surface waters in the site vicinity. There is a large amount of uncertainty with regard to these pathways and the likelihood of future exposures to nearby individuals. This analysis was limited to the groundwater pathway to allow for a comparison with the action alternatives in this EIS. Because releases are limited to a single environmental medium (groundwater), the estimate of the potential radiation doses and LCF risks is expected to be conservative, since the amount of radionuclides released to groundwater is maximized, and since there would probably be much less dilution in groundwater than in a nearby surface water feature, such as a stream, river, or lake, due to the smaller impacted volume. Any releases to the air would be dispersed quickly by wind, resulting in generally low concentrations.

To address the impacts associated with long-term storage of GTCC LLRW activated metals, an analysis was performed by using the RESRAD-OFFSITE computer code. This was done to allow for a comparison of the potential impacts (future radiation doses and LCF risks) under the No Action Alternative with those under the action alternatives. This approach involves calculating the future dose to a resident located 100 m (330 ft) downgradient of the perimeter of the storage area in the next 10,000 years (see also Section 5.3.4.3).

Radionuclides would not be released to the environment from the stored wastes until the waste containers degraded to the point that precipitation would be infiltrating into the containers, leaching the radionuclides for subsequent migration to groundwater. The maximum annual radiation dose to the highest exposed individual that could result from using and ingesting contaminated groundwater associated with the long-term storage of GTCC LLRW activated metal waste would range from 6.3 mrem/yr at 73 years following the assumed 100-year institutional control period in NRC Region III to 130 mrem/yr at 3,800 years in the future in NRC Region I. These doses are the peak doses for the LLRW activated metal waste type and are about 10% to 20% higher than those given in Table 3.5-1, which presents doses from the activated metal waste type but at the time of the peak dose for the entire waste inventory (i.e., doses are for a different time). Much of the radiation doses and LCF risks associated with the activated metals would be attributable to C-14 and plutonium isotopes and their radioactive decay products.

High doses and LCF risks could occur in the long term if these wastes remained in storage at these reactor sites for the indefinite future and no action was taken. The results given here are conservative but provide a perspective on the doses that could occur under this alternative.

3.5.2 GTCC LLRW Sealed Source Waste

Currently, disused sealed sources are stored at licensee locations (e.g., hospitals, laboratories, and industrial facilities) throughout the country pending the availability of a disposal path. As discussed in Section 3.1, the sources recovered by GMS/OSRP are not included in the GTCC EIS inventory.

Disused or Unwanted Sealed Sources Present a National Security and Public Health Threat

<u>According to the National Nuclear Security Administration:</u>

“Every year, thousands of sources become disused and unwanted in the United States. While secure storage is a temporary measure, the longer sources remain disused or unwanted, the greater the chance that they will become unsecured or abandoned. Due to their high activity and portability, radioactive sealed sources … could be used in a radiological dispersal device (RDD), commonly referred to as ‘dirty bombs.’ An attack using an RDD could result in extensive economic loss, significant social disruption, and potential serious public health problems.” (Source: NNSA News 2010, www.nnsa.energy.gov/mediaroom/pressreleases/01.14.10a)

An accidental release of cesium-chloride from a radioactive sealed source in Goiania, Brazil, in 1987 demonstrates the dangers that can result from unsecured or abandoned sources. An abandoned Cs-137 teletherapy unit (formerly used by a private radiography institute to treat cancer) was found by scrap metal scavengers in Goiania and sold to a junkyard. Believing the source material to be valuable, the junkyard owner distributed small pieces of the highly dispersible material to friends and family. Four people died within 2 months of the accident, approximately 250 people were contaminated, and more than 112,000 people were surveyed for contamination. The environment, including eighty-five houses, was also severely contaminated. (Sources: GAO 2003, www.gao.gov/new.items/d03638.pdf; National Research Council 2008, www.nap.edu/catalog/11976.html)

3.5.2.1 Short-Term Impacts

Sources awaiting disposition in the short term could pose an external radiation hazard that would have to be properly addressed. At facilities that routinely handle sealed sources with a strong gamma component, average annual dose rates to occupational workers range from tens to hundreds of millirem per person (NRC 2008). When the waste would be in storage (and not being handled), it is expected that occupational exposure values would be lower than these values would be when waste is handled for monitoring and surveillance purposes. Average worker doses would depend on the number and type of sources and the characteristics of the storage areas and monitoring program. Exposure to noninvolved workers might occur if their work areas were close to stored sources. These doses are not expected to result in an LCF.

3.5.2.2 Long-Term Impacts

For sealed sources stored at licensed locations, an assessment similar to that conducted for activated metal wastes (i.e., a regional storage concept) was done for their long-term storage under the No Action Alternative. The inventory of sealed sources is assumed to be divided among the four NRC regions in proportion to the number of licenses in each region. The RESRAD-OFFSITE computer code was used to calculate the future dose to a resident located 100 m (330 ft) downgradient of the storage area perimeter.

The maximum annual radiation dose to a hypothetical individual having the highest impacts from using and ingesting contaminated groundwater is estimated to be 120 mrem/yr at 1,100 years following the institutional control period in NRC Region III and 73,000 mrem/yr at 3,700 years in the future in NRC Region I. These values are the same as those presented in Table 3.5-1. The radionuclides that would result in most of the dose would be Np 237, Am-241, and plutonium isotopes and their radioactive decay products.

Very high doses and LCF risks could occur in the long term (after 10,000 years) if these wastes remained in storage at these sites indefinitely and no action was taken. The results given here are based on the following assumptions: (1) maintenance activities at these storage facilities would end at 100 years, (2) the storage containers would degrade to the extent that radionuclide releases would occur, (3) these radionuclides would then reach groundwater and move downgradient off-site, and (4) an individual would consume this contaminated groundwater in the future. This set of circumstances is very unlikely, but the results given here help provide a perspective on the doses that could occur under this alternative.

The estimated doses for the sealed sources are much larger than the doses for the activated metal wastes mainly because of the assumed higher leach rates. Should it be necessary to store sealed sources for a very long period of time, measures (such as the use of grout or other stabilizing material) would be taken to minimize the leachability of these wastes and thereby minimize the likelihood of these releases occurring. It is expected that such procedures would reduce the peak annual doses significantly (by a factor of 100 or more), such that the values would be comparable to those given above for the activated metal wastes. The No Action Alternative would not address potential national security concerns presented by the current lack of disposal capability for disused GTCC sealed sources (NRC 2006).

3.5.3 GTCC LLRW Other Waste

Most of the waste in this waste type category would be associated with the possible exhumation of two disposal areas (i.e., NDA and SDA) at the West Valley Site. These wastes are included in Group 2 and would be generated only if a decision was made under NEPA to remove these wastes as part of decommissioning the West Valley Site. Under the No Action Alternative in this EIS, a disposal facility would not be made available for these wastes; hence, it would be necessary to store this GTCC LLRW in a secured facility at the site for an indefinite period of time. These wastes at the West Valley Site are addressed only for NRC Region I, which is the NRC region in which this site is located. Note that the input parameters for site characteristics are based on the regionalized input values in Tables E-20 and E-21 and may not necessarily be the same as site-specific values applicable to the West Valley Site.

The total volume of GTCC Other Waste in these two disposal areas is estimated to be about 3,500 m^3 (120,000 ft^3). Most of this waste is GTCC LLRW, with 31 m^3 (1,100 ft^3) (from the NDA) being GTCC-like waste. The GTCC LLRW and GTCC-like waste associated with the NDA and SDA are a result of previous commercial nuclear fuel processing activities and the disposal of radioactive waste from a number of commercial and government programs. These two areas are located adjacent to each other on the south plateau portion of the West Valley Site.

In addition to these wastes from the West Valley Site, a smaller volume of waste would be associated with two planned Mo-99 production projects. The total volume of GTCC LLRW associated with these two Mo-99 production projects would be 390 m^3 (14,000 ft^3).[1] It is expected that these wastes would be stored at the production facilities until disposal capability would become available.

3.5.3.1 Short-Term Impacts

The short-term impacts are expected to be comparable to those from the storage of the activated metal waste but lower because the external gamma exposure rates associated with the GTCC LLRW Other Waste are generally lower than those associated with the activated metal waste. The annual radiation doses to involved workers performing surveillance and maintenance activities would probably not exceed 1 person-rem/yr (based on the information provided for storage of activated metal waste in Section 3.5.1.1). The annual collective external dose to the public is also not expected to exceed 1 person-rem. Most of these impacts are expected to occur within NRC Region I because the West Valley Site is there. None of these doses are expected to result in an LCF.

[1] Waste from Mo-99 production will be generated by NRC and Agreement State licensees and is therefore, for purposes of analysis in this EIS, considered to be GTCC LLRW. In the event Mo-99 producers enter into a uranium lease agreement with DOE pursuant to applicable provisions in the American Medical Isotopes Production Act of 2012 (Title XXXI, Subtitle F, National Defense Authorization Act for Fiscal Year 2013, Public Law 112-239), it is possible that waste resulting from Mo-99 production included in the current estimates of GTCC LLRW may be determined to be waste for which DOE is responsible for final disposition.

3.5.3.2 Long-Term Impacts

To address the impacts associated with long-term storage of GTCC LLRW Other Waste, an analysis was performed by using the RESRAD-OFFSITE computer code. This was done to allow for a comparison of the potential impacts (future radiation doses and LCF risks) under the No Action Alternative with those under the action alternatives. This approach involves calculating the future dose to a resident located 100 m (330 ft) downgradient of the perimeter of the storage area in the next 10,000 years (see also Section 5.3.4.3). The approach used for this analysis is generally the same as that described for the activated metal wastes (see Section 3.5.1.2).

Radionuclides would not be released to the environment from the stored wastes until the waste containers degraded to the point that precipitation would be infiltrating into the containers, leaching the radionuclides for subsequent migration to groundwater. The maximum annual radiation dose to an individual from the use and ingestion of contaminated groundwater from the long-term storage of GTCC LLRW Other Waste in NRC Region I was calculated to be 30,000 mrem/yr and to occur about 3,700 years in the future. A much lower peak dose was calculated for NRC Region II; the maximum annual dose in this NRC region was calculated to be 850 mrem/yr and to occur 98 years after termination of institutional controls. These values are the same as those given in Table 3.5-1. These doses and LCF risks would be largely attributable to uranium and plutonium isotopes and their radioactive decay products.

High doses and LCF risks could occur in the long term if no action was taken and these wastes remained in storage at these sites for the indefinite future. The results given here are conservative but provide a perspective on the doses that could occur under this alternative.

3.5.4 GTCC-Like Activated Metal Waste

The total volume of GTCC-like activated metal waste is estimated to be about 13 m^3 (460 ft^3). Under the No Action Alternative, this small volume of waste and other GTCC-like activated metal waste would continue to be securely stored at the DOE sites where the waste was generated. The impacts under the No Action Alternative for these wastes are expected to be much smaller than those for GTCC LLRW activated metal waste described in Section 3.5.1.1 for the short term and Section 3.5.1.2 for the long term because the volume of waste would be much lower. It is estimated that there would be a small radiation dose of 0.14 mrem/yr to the hypothetical resident farmer in NRC Region II at 120 years after termination of institutional controls. This peak dose is solely attributable to this waste type and is about three times higher than that given in Table 3.5-1, which represents the peak dose for the entire GTCC LLRW and GTCC-like waste inventory.

3.5.5 GTCC-Like Sealed Source Waste

There would be a very small amount of GTCC-like sealed source waste in the EIS inventory (0.83 m^3 [29 ft^3]). In contrast, the estimated total volume of GTCC LLRW sealed source waste would be about 2,900 m^3 (100,000 ft^3). The impacts under the No Action Alternative for the GTCC-like sealed sources are expected to be much smaller than those for GTCC LLRW sealed sources discussed in Section 3.5.2.1 for the short term and Section 3.5.2.2 for the long term because the volume of waste would be much lower.

3.5.6 GTCC-Like Other Waste

Most of the waste in this waste type category would be associated with decontamination and decommissioning the West Valley Site. Some of this waste would be in Group 1, and some would be in Group 2. The total volume of GTCC-like Other Waste is estimated to be about 2,800 m^3 (99,000 ft^3), and all but 590 m^3 (21,000 ft^3) would be associated with cleanup of the West Valley Site. The remaining amount would be associated with the planned DOE Pu-238 production project (380 m^3 or 13,000 ft^3 in Group 2) and wastes from several DOE sites (210 m^3 or 7,400 ft^3 in Group 1).

Under the No Action Alternative in this EIS, a disposal facility would not be made available for these wastes; hence, it would be necessary to store this GTCC-like Other Waste in a secured facility at the generating site for an indefinite period of time. Most of this waste is in NRC Region I, which is the NRC region in which the West Valley Site is located. The same approach as that used for GTCC LLRW Other Waste was used for the GTCC-like Other Waste.

3.5.6.1 Short-Term Impacts

The short-term impacts are expected to be comparable to those from storage of the activated metal waste, but lower because of the generally lower external gamma exposure rates associated with Other Waste than with activated metal waste. The annual radiation doses to involved workers performing surveillance and maintenance activities would probably not exceed 1 person-rem/yr (based on the information provided for storage of activated metal waste in Section 3.5.1.1). In addition, the annual collective external dose to the public would not exceed 1 person-rem/yr. It is expected that these impacts would occur largely within NRC Region I because the West Valley Site is there. None of these doses are expected to result in an LCF.

3.5.6.2 Long-Term Impacts

To address the impacts associated with long-term storage of GTCC-like Other Waste, an analysis was performed by using the RESRAD-OFFSITE computer code. This was done to allow for a comparison of the potential impacts (future radiation doses and LCF risks) under the No Action Alternative with those under the action alternatives. This approach involves calculating the future dose to a resident located 100 m (330 ft) downgradient of the perimeter of the storage area in the next 10,000 years (see also Section 5.3.4.3). The approach used for this analysis is generally the same as that described for the activated metal waste (see Section 3.5.1.2).

Radionuclides would not be released to the environment from the stored wastes until the waste containers degraded to the point that precipitation would be infiltrating into the containers, leaching the radionuclides for subsequent migration to groundwater. The maximum annual radiation dose to an individual that could result from using and ingesting contaminated groundwater associated with the long-term storage of GTCC-like Other Waste in NRC Region I was calculated to be about 370,000 mrem/yr and to occur about 3,700 years in the future. In NRC Region II, the maximum annual dose was calculated to be 380 mrem/yr and to occur 1,800 years in the future. These doses are the peak doses for the GTCC-like Other Waste type. The value for NRC Region II differs from that given in Table 3.5-1, which presents doses from the GTCC-like Other Waste type but at the time of the peak dose for the entire GTCC LLRW and GTCC-like waste inventory (i.e., doses are for a different time). The value for NRC Region I is the same as that given in Table 3.5-1. The doses and LCF risks would be largely attributable to Np-237, Am-243, and uranium and plutonium isotopes and their radioactive decay products.

High doses could occur in the long term if these wastes remained in storage at these sites for the indefinite future and no action was taken. The results given here are conservative but provide a perspective on the doses that could occur under this alternative.

3.6 REFERENCES FOR CHAPTER 3

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4 ALTERNATIVE 2: DISPOSAL IN A GEOLOGIC REPOSITORY AT THE WASTE ISOLATION PILOT PLANT

This chapter provides an evaluation of the affected environment, environmental and human health consequences, and cumulative impacts from disposal of GTCC LLRW and GTCC-like waste at WIPP. Section 4.1 describes the WIPP alternative (Alternative 2). The affected environments for various environmental resource areas evaluated for this alternative are discussed in Section 4.2. The potential environmental and human health consequences from the construction of the additional underground rooms and from the operations associated with emplacing the waste containers in these rooms are discussed in Section 4.3. A summary of the potential impacts at the WIPP site area from the proposed action is presented in Section 4.4; Section 4.5 deals with cumulative impacts. Section 4.6 describes the irreversible and irretrievable commitment of resources associated with this alternative. Statutory and regulatory requirements specific to WIPP are discussed in Section 4.7. Federal and state statutes and regulations and DOE Orders relevant to WIPP are discussed in Chapter 13 of this EIS. Impact assessment methodologies used for this EIS are described in Appendix C.

It should be noted that waste disposal operations at WIPP were suspended on February 5, 2014, following a fire involving an underground vehicle. Nine days later, on February 14, 2014, a radiological event occurred underground at WIPP, contaminating a portion of the mine primarily along the ventilation path from the location of the incident and releasing a small amount of contamination into the environment.

On February 5, 2014, at approximately 10:45 am, an underground fire occurred involving a salt haul truck, a diesel-powered vehicle used to move mined salt from the underground. There were 86 people in the underground at the onset of the fire; all exited the mine safely. Six personnel were evaluated for smoke inhalation and released from a local hospital the day of the underground fire. The Department appointed an Accident Investigation Board (AIB) to determine the cause of the accident and to develop recommendations for corrective actions to prevent recurrence. The AIB is an independent entity that performs a rigorous accident investigation and prepares associated investigation reports in accordance with established Department requirements, i.e., DOE Order 225.1B, *Accident Investigations*. The results of the fire accident investigation were released in an extensive report issued March 13, 2014[1]. Corrective actions have been incorporated into the recovery baseline schedule.

On February 14, 2014, at 11:14 pm, a continuous air monitor detected a radiological release in the underground. The underground ventilation system automatically switched to HEPA filtration and the damper was manually opened and adjusted to achieve designated airflow. The airflow was reduced from 425,000 cubic feet per minute (cfm) to 60,000 cfm. No employees were in the underground at the time. The continuous air monitor was located immediately outside Panel 7. Redirecting the ventilation through the HEPA filters is designed to protect aboveground workers at the site and the public in the surrounding areas by minimizing radiation releases to the environment. The automatic switch to HEPA ventilation operated as designed, thereby minimizing the external radiological release. Slightly elevated levels of airborne

[1] AIB fire report available at: http://www.wipp.energy.gov/Special/AIB%20Report.pdf.

radioactive concentrations were detected outside the WIPP facility after the release occurred due to leakage through closed ventilation filter bypass dampers.

The Department appointed a second AIB to determine the cause of the radiological release and to develop recommendations for corrective actions. This second AIB is using a two-phased approach. The first phase focused on the response to the radioactive material release, including related exposure to aboveground workers and the response actions, while the second phase evaluated the cause of the underground radiological release event.

The first phase results are documented in the comprehensive report issued April 24, 2014[2]. According to the Phase 1 report, the cumulative effect of inadequacies in ventilation system design and operability compounded by degradation of key safety management programs and safety culture resulted in the release of a minimal amount of radioactive material from the underground to the environment. The Phase 2 AIB report, covering the cause of the radiological release, was issued April 16, 2015. Similar to the fire incident, the key elements of the corrective action plans are included in recovery planning activities.

DOE will resume disposal operations at WIPP when it is safe to do so. The schedule for restart of limited operations is currently under review. DOE is continuing to characterize and certify TRU waste at the Idaho National Laboratory, Oak Ridge National Laboratory, Savannah River Site, and Argonne National Laboratory for eventual shipment to WIPP. TRU waste continues to be generated at the Hanford site and Lawrence Livermore National Laboratory. DOE is carefully evaluating and analyzing the impacts on storage requirements and commitments with state regulators at the generator sites. These efforts will inform decisions related to the availability of storage for certified TRU waste until waste shipments to WIPP can resume. Detailed information on the status of recovery activities at WIPP can be found at http://www.wipp.energy.gov/wipprecovery/recovery.html.

4.1 DESCRIPTION OF ALTERNATIVE 2

Under Alternative 2, it is assumed that GTCC LLRW and GTCC-like wastes would be received at WIPP and be disposed of by using the same technologies and methods currently used there for the disposal of defense-generated TRU waste. The exception is emplacement of activated metal and Other Waste that are RH wastes. These wastes are assumed to be managed as CH waste and would be emplaced in room floors instead of in wall spaces. It is assumed that all of the surface (aboveground) facilities at WIPP would be available for managing these wastes, and no additional surface facilities would need to be constructed. On the basis of current mining experience in the area, it is assumed that the existing mine shafts, shaft stations, and underground haul routes and tunnels would be functional during the period projected for the disposal of GTCC LLRW and GTCC-like waste. The incremental impacts on the environment and human health from the construction of additional underground rooms and from the operations involved with disposing of the GTCC LLRW and GTCC-like waste at WIPP are evaluated in this EIS to allow for comparison with other alternatives. Should WIPP be identified as the preferred option

[2] AIB radiological release Phase 1 report available at: http://www.wipp.energy.gov/Special/AIB_Final_WIPP_ Rad_Release_Phase1_04_22_2014.pdf.

for disposal of these wastes, further evaluation and analysis of alternative technologies and methods to optimize the transport, handling, and emplacement of the wastes would be conducted to identify those technologies and methods that would minimize to the extent possible any potential impacts on human health or the environment. Follow-on WIPP-specific NEPA evaluation and documentation, as appropriate, would be conducted to examine in greater detail the potential impacts associated with the disposal of GTCC LLRW and GTCC-like wastes at WIPP.

4.1.1 Facility Location and Background

WIPP is the nation's only underground repository for the permanent disposal of defense-generated TRU waste. DOE issued an EIS for WIPP in 1980 (DOE 1980), and this was followed by two supplemental EISs. The first supplement issued in 1990 (DOE 1990) and the second supplement issued in 1997 (DOE 1997) focused on impacts from waste disposal operations. Impacts from operations are periodically re-evaluated as required by DOE NEPA regulations. This re-evaluation occurs at least every five years and utilizes the supplemental analysis process to consider whether any significant new circumstances or changes to the WIPP program could cause substantial changes to the environmental impacts predicted in the second supplement. The latest re-evaluation was completed in 2009 (DOE 2009a). Construction of WIPP began in the 1980s. A site and preliminary design validation study that was initiated in 1981 provides the foundation for the mine plan design and construction (DOE 1983). The first shipment of CH TRU waste was received at WIPP on March 26, 1999, and the first shipment of RH TRU waste was received on January 23, 2007. The total capacity for disposal of TRU waste established under the WIPP LWA as amended (P.L. 102-579 as amended by P.L. 104-201) is 175,675 m^3 (6.2 million ft^3). The Consultation and Cooperative Agreement with the State of New Mexico (1981) established a total RH capacity of 7,080 m^3 (250,000 ft^3), with the remaining capacity for CH TRU at 168,500 m^3 (5.95 million ft^3). In addition, the WIPP LWA as amended limits the total radioactivity of RH waste to 5.1 million curies. Current plans include receipt and emplacement of TRU waste in 10 waste disposal panels through FY 2030.

The WIPP site is located in Eddy County in the Chihuahuan Desert of southeastern New Mexico (Figure 4.1.1-1). The site is about 42 km (26 mi) east of Carlsbad in a region known as Los Medaños, a relatively flat, sparsely inhabited plateau with little surface water. The WIPP site encompasses approximately 41 km^2 (16 mi^2) under the jurisdiction of DOE pursuant to the WIPP LWA as amended (P.L. 102-579 as amended by P.L. 104-201), which was signed into law on October 30, 1992. This law transferred responsibility of the WIPP withdrawal area from the Secretary of the Interior to the Secretary of Energy. The land is permanently withdrawn from all forms of entry, appropriation, and disposal under the public land laws and is reserved for uses associated with the purposes of WIPP.

The WIPP site covers 16 sections (each section is one square mile) of federal land in Township 22 South, Range 31 East, and is divided into four areas under DOE control (Figure 1.4.3-2). A chain-link fence surrounds the innermost "Property Protection Area," which includes all of the surface facilities. Surrounding this inner area is the "Exclusive Use Area," which is surrounded by a barbed-wire fence. Enclosing these two areas is the "Off-Limits Area,"

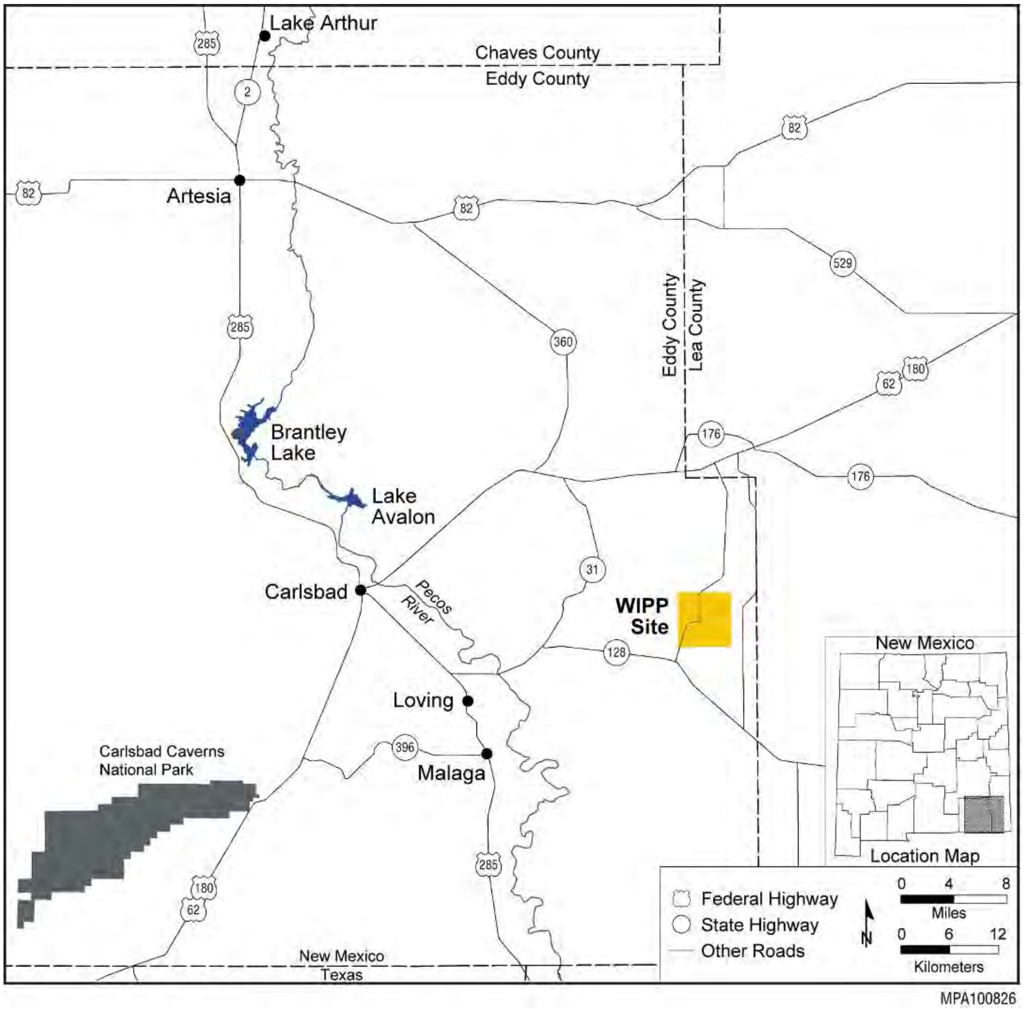

FIGURE 4.1.1-1 Location of WIPP in Eddy County, New Mexico (Source: DOE 2006a)

which is unfenced to allow livestock grazing but, like the other two areas, is patrolled and posted against trespassing or other land uses. Beyond the Off-Limits Area, the land is managed under the traditional public land use concept of multiple uses, but mining and drilling are restricted. The boundary of WIPP was set to extend at least 1.6 km (1 mi) beyond any underground development (Sandia 2008a). WIPP includes all of the necessary surface and subsurface facilities to manage waste handling and disposal operations.

4.1.2 Surface Support Facilities

A map of surface structures at WIPP is shown in Figure 4.1.2-1. There are 50 permanent buildings, several trailers, and various structures used for storage. The site buildings provide a total of 31,060 m^2 (334,400 ft^2) of office and industrial space. There are three basic types of structures at WIPP: surface structures, shafts, and underground structures. The surface facilities at WIPP are used to accommodate the personnel, equipment, and support services required for

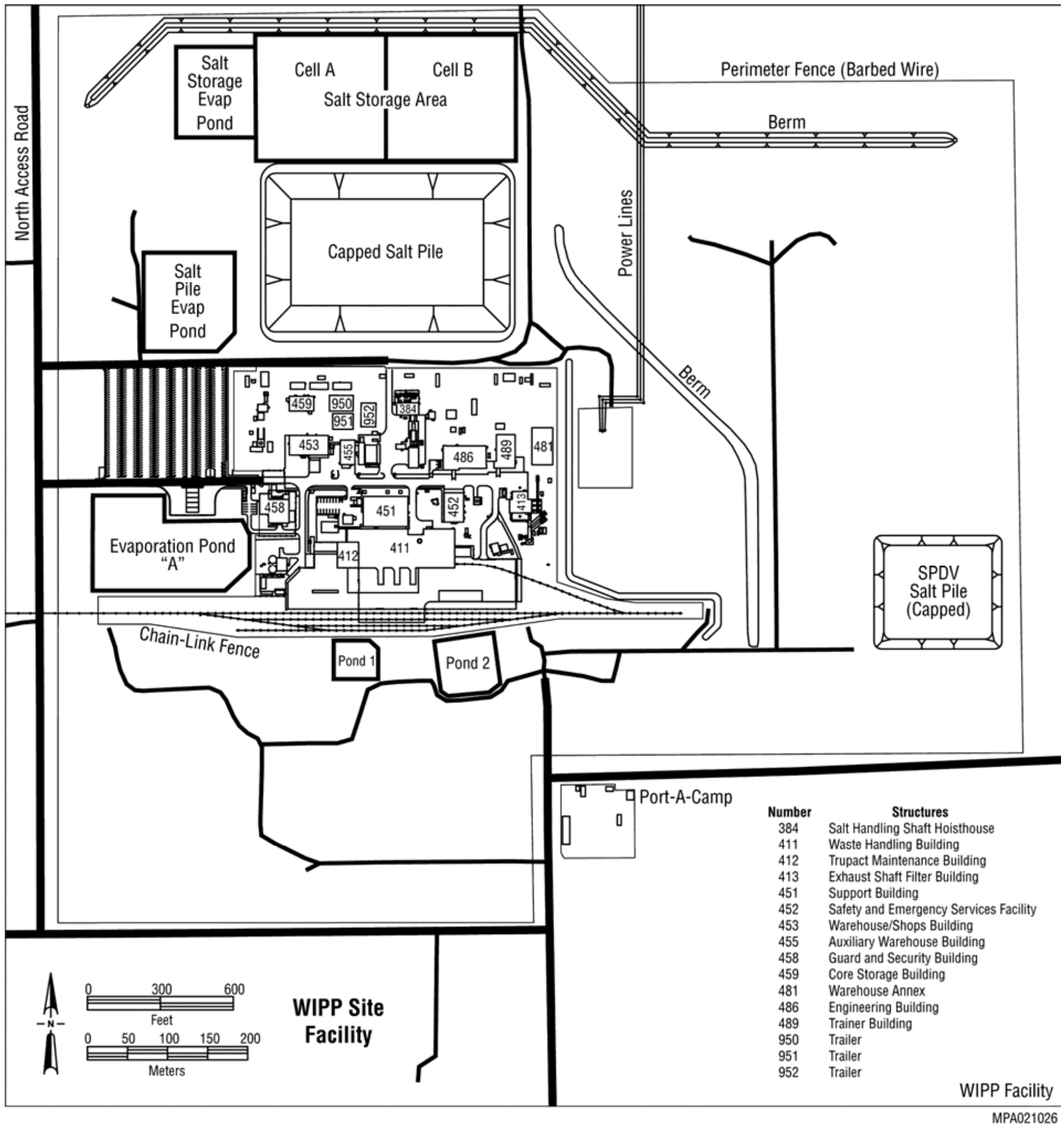

FIGURE 4.1.2-1 Map of Aboveground Infrastructure and Major Surface Structures at WIPP

the receipt, preparation, and transfer of TRU waste from the surface to the underground disposal area. The primary surface structure is the Waste Handling Building (WHB), which is divided into the CH-TRU waste handling area, RH-TRU waste handling area, and support areas.

There are two surface locations where TRU waste is being managed and stored, as shown in Figure 4.1.2-2. The first area is the Waste Handling Building Container Storage Unit (WHB Unit) for TRU radioactive mixed waste management and storage. The WHB Unit consists of the WHB CH Bay and the RH Complex. The second area designated for managing and storing TRU

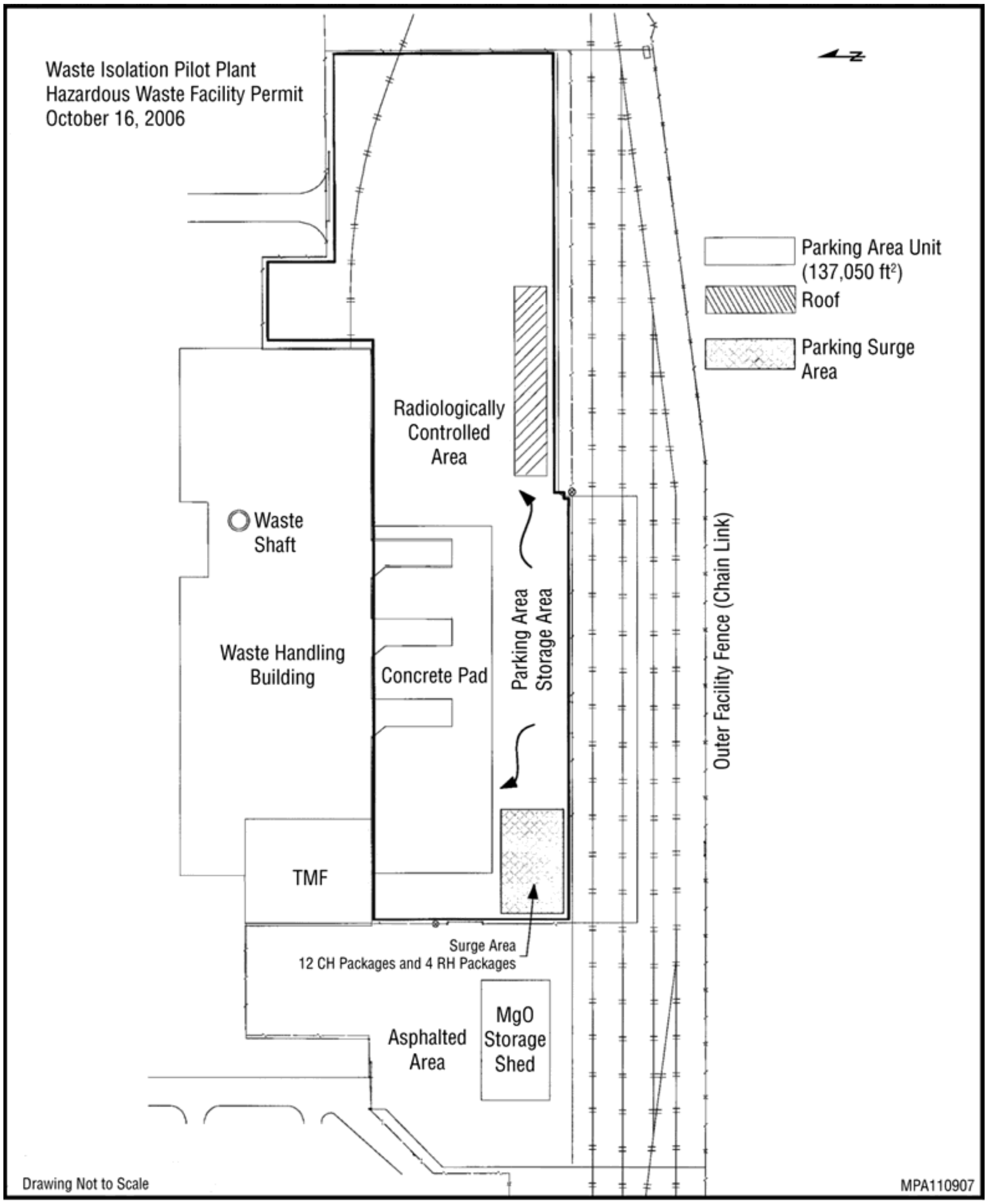

FIGURE 4.1.2-2 Container Storage Areas at the Waste Handling Building and Parking Area at WIPP (Source: DOE 2006b)

waste is the Parking Area Container Storage Unit (Parking Area Unit), an outside container storage area that extends south from the WHB to the rail siding. The Parking Area Unit provides storage space for up to 50 loaded CH packages and 8 loaded RH packages on an asphalt and concrete surface. It is assumed that the surface structures currently at the WIPP would be used for the disposal of GTCC LLRW and GTCC-like waste and that construction of new surface structures would not be needed.

Other major WIPP buildings or structures include the (1) Exhaust Shaft Filter Building, which houses the high-efficiency particulate air (HEPA) filters, building filtration units, exhaust fans, supply-air handling units, motor control centers, and air lock; (2) Water Pump House, which contains water pumps and space for water chlorination equipment and chemical storage; (3) Support Building, which houses general support services; (4) Salt Storage Area or "salt pile," which consists of a 12-ha (30-ac) area north of the property protection area that houses salt excavated from the repository; and (5) detention basins and sewage treatment ponds.

4.1.3 WIPP Underground

The WIPP disposal area is located in a salt formation about 655 m (2,150 ft) beneath the ground surface. Figures 4.1.3-1 and 4.1.3-2 illustrate the subsurface layout of WIPP. These underground facilities include the waste disposal area, access tunnels, and associated support facilities. The waste disposal area is composed of a series of panels containing disposal rooms. Each waste panel consists of seven rooms. Each room is about 91-m (300-ft) long, 10-m (33-ft) wide, and 4-m (13-ft) high. Pillars between rooms are 30-m (100-ft) thick. Eight waste panels are separated from each other and from the main entries by nominally six 61-m (200-ft) pillars. In addition to the eight panels, the main north-south and east-west access drifts in the panel regions are available for waste disposal. These have been designated as Panels 9 and 10 for permitting and modeling purposes.

The underground is connected to the surface by four vertical shafts: the waste shaft, salt handling shaft, exhaust shaft, and air intake shaft. The waste, salt handling, and air intake shafts have permanently installed hoists capable of moving personnel, equipment, and waste between the surface and the underground repository.

Mining of the shafts and underground passages within the repository gives rise to a disturbed rock zone (DRZ) that is important to repository performance. The DRZ forms as a consequence of unloading the rock in the vicinity of the excavation. Increased permeability is created by microfractures along grain boundaries and by bed separation along lateral seams. The DRZ development begins immediately after excavation and continues as salt creeps into the opening. The plastic property of the salt allows the DRZ to heal when a back-stress is applied. Continued creep closure will allow the salt to come in contact with the waste that is applying the back-stress, thereby healing the salt fractures and returning the properties of the salt to properties that are similar to those of the original, intact salt.

In addition to the natural barriers provided by the geology of the WIPP repository, engineered barriers are included in the design to provide additional confidence that the repository will isolate the waste. EPA regulations required both natural and engineered barriers to be used at WIPP. Four features that meet the definition of an engineered barrier are incorporated at WIPP: shaft seals, panel closures, backfill, and borehole plugs. Shaft seals and borehole plugs will limit migration of liquid and gases in the WIPP shafts and boreholes. Panel closures will limit the communication of brine and gases among the waste panels and to the accessible environment. The designs of the shaft seals, borehole plugs, and panel closures use common engineering materials that have low permeability, appropriate mechanical properties, and durability, with the intent to reduce the movement of water and radionuclides toward the accessible environment after WIPP closure.

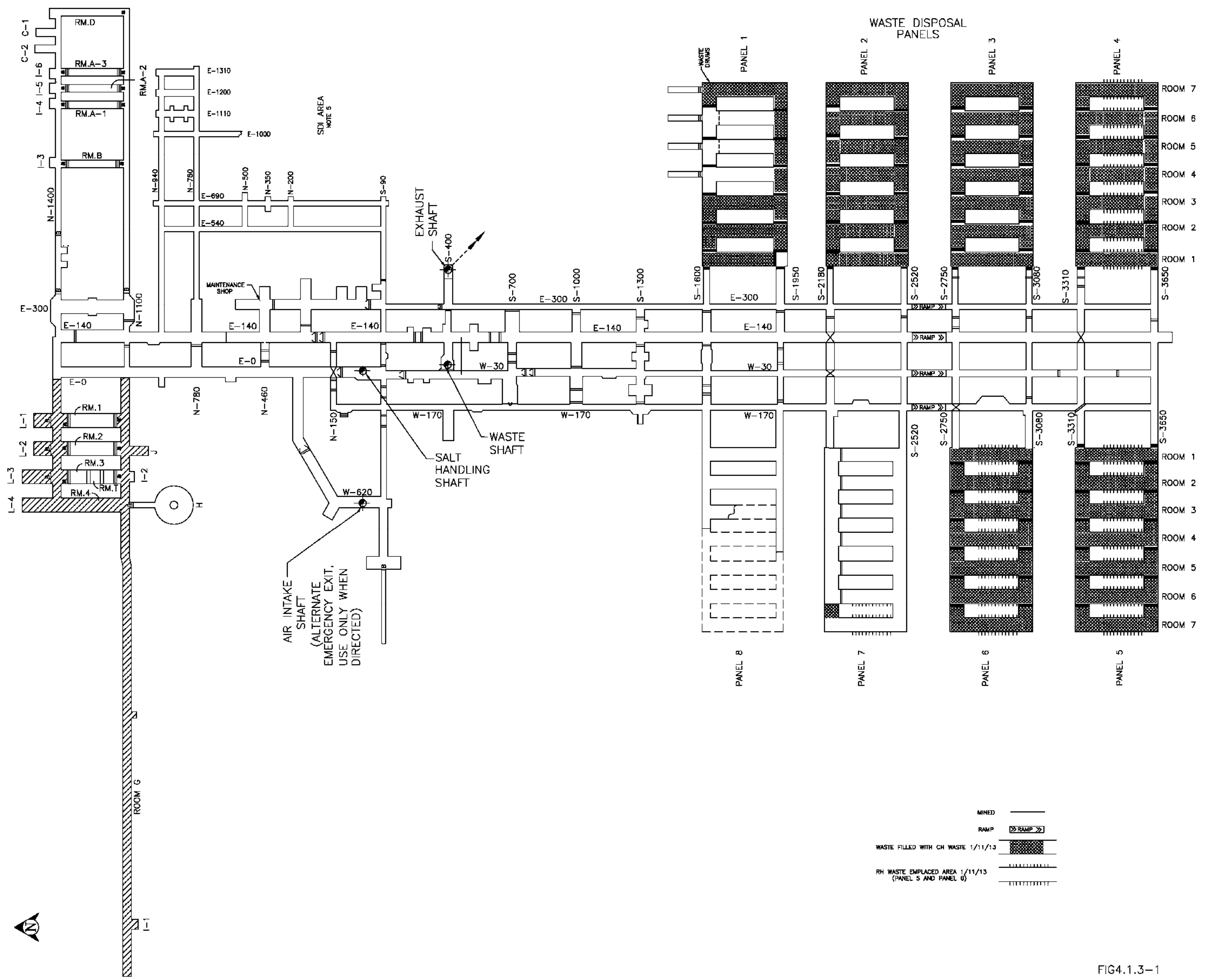

FIGURE 4.1.3-1 Layout of the Current (2014) Waste Disposal Region at WIPP

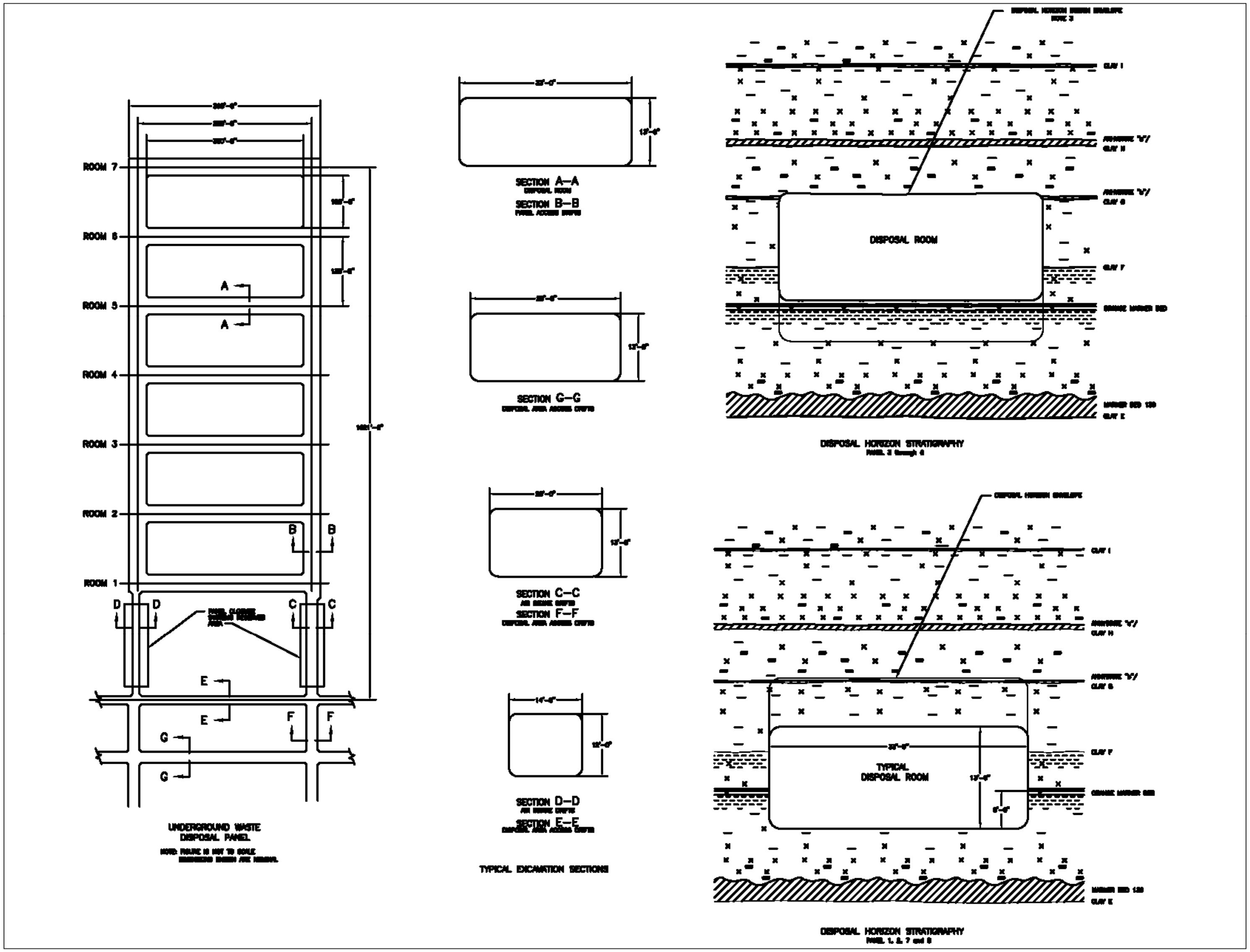

FIGURE 4.1.3-2 Individual Panel Layout and Dimensions (Source: DOE 2009b)

The October 2014 EPA Final Rule on the DOE proposed panel closure redesign was documented in the federal register notice (Volume 79, No. 195, Wednesday October 8, 2014) and based on the EPA technical review of the proposed panel closure redesign, EPA concluded that WIPP would continue to comply with the long term (i.e., 10,000 year compliance time frame after final facility closure) radioactive release standards. However, the primary purpose of a panel closure design is to meet the NMED, WIPP Hazardous Waste Facility Permit closure requirements for the operational period (prior to final facility closure). A panel closure is designed to provide assurance in terms of Resource Conservation Recovery Act (40 CFR 264.110 Subpart G – Closure and Post Closure), that the limit for the migration of hazardous constituents, volatile organic compounds (VOCs), during the operational time frame will be met at the point of compliance, which is the WIPP Land Withdrawal boundary. NMED will have to determine, through a well-defined regulatory review process (i.e., 40 CFR 270.42), the adequacy of a panel closure redesign to meet the primary panel closure design criteria which is to prevent the migration of hazardous VOCs in the air pathway in concentrations above health-based levels beyond the WIPP Land Withdrawal boundary during the operational time frame. NMED will first need to approve the adequacy of the panel closure redesign prior to implementation.

4.1.4 Construction and Disposal Operations for GTCC LLRW and GTCC-Like Waste at WIPP

Discussions on the construction of additional rooms and disposal operations at WIPP are provided in Sections 4.1.4.1 and 4.1.4.2, respectively.

4.1.4.1 Construction

DOE has submitted a planned change request to use shielded containers for safe emplacement of selected RH TRU waste streams on the floor of the repository. The use of the shielded containers will enable DOE to significantly increase the efficiency of transportation and disposal operations for RH TRU waste at WIPP. Consistent with this planned change request, this EIS assumes that all RH waste would be placed in shielded containers and managed as if it was CH waste by being emplaced on floor space (instead of wall space, as is currently practiced at WIPP). This approach would be taken in order to minimize the number of additional rooms that would be needed for emplacement of the GTCC waste inventory. It is estimated that about 26 additional rooms would be needed to emplace the GTCC LLRW and GTCC-like waste (Group 1 and 2 volumes totaling 12,000 m^3 [420,000 ft^3]). Underground rooms are constructed by conventional mining techniques that use an electric-powered continuous miner rather than blasting. The mined salt is transported underground by haul trucks; once there, the salt is placed on the salt hoist and lifted to the surface. The exact locations and orientations of these rooms would be determined on the basis of mining engineering, safety, and other factors. Refer to Section 4.1.4.1 in the EIS for additional information on construction (Sandia 2008a,b, 2012).

Underground rooms are constructed by conventional mining techniques that use an electric-powered continuous miner rather than blasting. The mined salt is transported underground by haul trucks; once there, the salt is placed on the salt hoist and lifted to the surface. It is estimated that about 560,000,000 kg (or 560,000 t) of salt would be generated in the process of mining the underground rooms needed to emplace the GTCC LLRW and GTCC-like waste. The salt generated would be stored at the Salt Storage Area (Sandia 2008a).

The exact locations and orientations of these rooms would be determined on the basis of mining engineering, safety, and other factors. Therefore, an updated figure of a conceptual location of the 26 additional waste disposal rooms will be developed after those factors are determined.

For the purpose of this EIS, the number of years of construction is assumed to be 20 years. Information on the number of workers needed for construction, the amount of water used, the amount of waste generated, and the cost to construct the additional underground disposal rooms is provided in the appropriate topic areas of Section 4.3. Additional details on this information can be found in Sandia (2008a). Supplemental information on air emissions during construction is presented in Appendix D, Section D.9. These estimates were used to make the evaluations presented in Section 4.3 for the various environmental resource areas.

4.1.4.2 Disposal Operations

The GTCC waste inventory in Groups 1 and 2 would result in approximately 63,000 waste disposal containers (Sandia 2012). The types of containers used would depend on the types of waste in the inventory. A stack of waste emplaced at WIPP is typically composed of three assemblies of various combinations; for example, three 7-packs in a stack or one SWB and two 7-packs in a stack.

Table 4.1.4-1 shows the various types of waste, the types of containers, the number of disposal containers, the number of stacks, and the number of rooms that would be needed. These estimates (and the supporting assumptions discussed in this section) are intended as input for the evaluations in this EIS only; the amounts could vary during actual implementation. In addition, random emplacement of GTCC LLRW and GTCC-like waste at WIPP rooms is assumed.

For GTCC LLRW and GTCC-like waste, it is assumed that activated metals would be managed as CH waste and would be packaged and emplaced in yet-to-be-developed, half-shielded activated metal canisters (h-SAMCs). The h-SAMCs would be designed to provide sufficient radiation shielding to allow for safe handling during waste disposal operations. These containers are also assumed to be emplaced in a 7-pack configuration. These 7-packs would be heavy assemblies and therefore would not be stacked on top of each other. It is also assumed that no waste would be placed on top of these 7-pack assemblies. It is expected that the current WIPP waste handling system (e.g., waste hoist and underground forklift) could accommodate GTCC LLRW and GTCC-like waste packages, but they could be modified, if necessary. The WIPP waste hoist is rated to 45 tons, significantly more than the maximum weight of the shielded container packages, which weigh approximately 30,000 kg (66,000 lb). The RH underground forklift is rated at 41 tons. It may be assumed that the current WIPP waste handling system can accommodate the GTCC packages, but it is likely that some minor modification would be necessary.

TABLE 4.1.4-1 Number of Containers, Stacks, and Rooms for GTCC LLRW and GTCC-Like Waste Emplacement at WIPP[a]

Description	Container Type	No. of Containers	Containers per Stack	No. of Stacks	No. of Rooms
Group 1					
GTCC LLRW					
Activated metals - RH					
Past/present commercial reactors	h-SAMC	12,595	7	1,800	4.5
Sealed sources - CH					
Small	55-gal drum	8,702	21	410	0.8
Cesium irradiators	Self-contained	1,435	4	360	0.7
Other Waste - CH	55-gal drum	203	21	9.7	0.02
Other Waste - RH	h-SAMC	172	7	25	0.1
GTCC-like waste					
Activated metals - RH	h-SAMC	70	7	10	0.02
Sealed sources - CH					
Small	55-gal drum	4	21	0.2	0.05
Other Waste - CH	55-gal drum	173	21	8.2	0.02
Other Waste - CH	SWB	381	3	130	0.2
Other Waste - RH	h-SAMC	3,654	7	520	1.3
Group 1 total		27,389	7	3,300	7.6
Group 2					
GTCC LLRW					
Activated metals - RH					
New BWRs	h-SAMC	956	7	140	0.3
New PWRs	h-SAMC	4,789	7	680	1.7
Additional commercial waste	h-SAMC	3,736	7	530	1.3
Other Waste - CH	SWB	829	3	280	0.5
Other Waste - RH	Shielded container	20,348	3	6,800	12
Other Waste - RH	h-SAMC	323	7	46	0.1
GTCC-like waste					
Other Waste - CH	SWB	261	3	87	0.2
Other Waste - RH	h-SAMC	4,441	7	630	1.6
Group 2 total		35,683		9,200	18
Total Groups 1 and 2		63,072		13,000	26

[a] CH = contact handled, h-SAMC = half-shielded activated metal canister, RH = remote handled, SWB = standard waste box. Number of containers was obtained from Sandia (2012). All values except those in the "No. of Containers" column have been rounded to two significant figures.

For sealed sources, it is assumed that this type of waste would be contained in 208-L (55-gal) drums, except for the Cs-137 irradiators. A large number of containers could be generated if sources were not consolidated to the maximum extent allowable under the WIPP waste acceptance criteria (WAC) assumed in this EIS. The waste containers would be emplaced at WIPP as 7-packs similar to the configuration used for the activated metal h-SAMCs. These 7-packs would then be stacked three high. Figure 4.1.4-1 shows this configuration. The Cs-137 irradiators would be emplaced at WIPP in bundles of four as 4-packs. The weight of these 4-pack assemblies would not allow them to be stacked on top of one another. Although bagged magnesium oxide (MgO) is currently placed on top of each stack at WIPP, it is expected that this practice would not be needed for GTCC LLRW and GTCC-like waste disposal at WIPP. The placement of bagged MgO is related to potential carbon dioxide (CO_2) generation caused by the degradation of cellulosic, plastic, and rubber materials. TRU waste is mostly debris waste that contains large quantities of cellulosic, plastic, and rubber materials. Cellulosic, plastic, and rubber materials are not expected to be a large component of the GTCC LLRW and GTCC-like waste. There may be small amounts of plastic and rubber in GTCC packaging materials. However, plastic and rubber degradation is very uncertain and is modeled to occur in only 25% of the WIPP performance assessment vectors (less of an impact on performance). Anoxic corrosion of steel generates hydrogen, and MgO does not sequester hydrogen. In addition, MgO addresses a specific 40 CFR Part 191 engineered barrier requirement (assurance requirement) for WIPP. 10 CFR Part 61 does not address multiple assurance requirements as specifically as do 40 CFR Parts 191 and 194. It states that a sufficient depth or an engineered structure (engineered barrier) lasting 500 years can be used to inhibit an inadvertent intruder (in addition to the need for 100-year active institutional controls).

With regard to the category referred to as Other Waste, Other Waste - CH would be contained either in 208-L (55-gal) drums or in SWBs. The SWBs would be stacked three high

FIGURE 4.1.4-1 Disposal of Contact-Handled Transuranic Waste in Typical 208-L (55-gal) Drum 7-Packs at WIPP (bagged magnesium oxide chemical buffer is on top of each stack) (Source: DOE 2007)

for final disposal. Other Waste - RH would be contained either in h-SAMCs or lead-shielded containers.

DOE Order 231.1A, "Environmental Safety and Health Reporting," Order 450.1, "Environmental Protection Program," and DOE/EH 0173T, "Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance," will require any GTCC disposal facility to monitor environmental factors, such as potential hazardous material releases, radioactive releases, and the environmental impacts of facility operations.

The number of workers needed for the disposal operations, water usage, waste generated, and cost to complete the emplacement of waste in the underground disposal rooms can be found in Sandia (2008a). Supplemental information on air emissions during operations is presented in Appendix D, Section D.9. These estimates are used in the evaluations presented in Section 4.3 for the various disciplines.

4.2 AFFECTED ENVIRONMENT

This section describes the affected environment for the various environmental resource areas evaluated for the disposal of GTCC LLRW and GTCC-like waste at WIPP.

4.2.1 Climate, Air Quality, and Noise

4.2.1.1 Climate

Located in Eddy County in the Chihuahuan Desert of southeastern New Mexico, the regional climate around the WIPP site is semiarid, characterized by warm temperatures, low precipitation and humidity, and a high rate of evaporation (DOE 1997).

A wind rose for 2006 at the 10-m (33-ft) level of the WIPP on-site meteorological station, which is located about 600 m (2,000 ft) northeast of the WHB, is presented in Figure 4.2.1-1. About 40% of the time, winds blew inclusively from the east-southeast to south-southeast, with the highest winds from the southeast (DOE 2007). Wind speeds categorized as calm (less than 0.5 m/s [1.1 mph]) occurred less than 0.5% in 2006. Winds of 3.71 to 6.30 m/s (8.30 to 14.1 mph) were the most prevalent, occurring about 36% of the time.

For the 1986–2007 period, the annual average temperature at the WIPP site was 17.9°C (64.3°F) (WRCC 2008). December was the coldest month, averaging 7.2°C (44.9°F) and ranging from –1.3°C to 15.6°C (29.6°F to 60.1°F), and July was the warmest month, averaging 28.4°C (83.2°F) and ranging from 20.6°C to 36.4°C (69.1°F to 97.5°F). For the same period, the highest temperatures reached 50.0°C (122°F) and the lowest reached –17.2°C (1°F). Days with a maximum temperature of higher than or equal to 32.2°C (90°F) occurred about one-third of the time, while those with a minimum temperature of less than or equal to 0°C (32°F) occurred about 20% of the time.

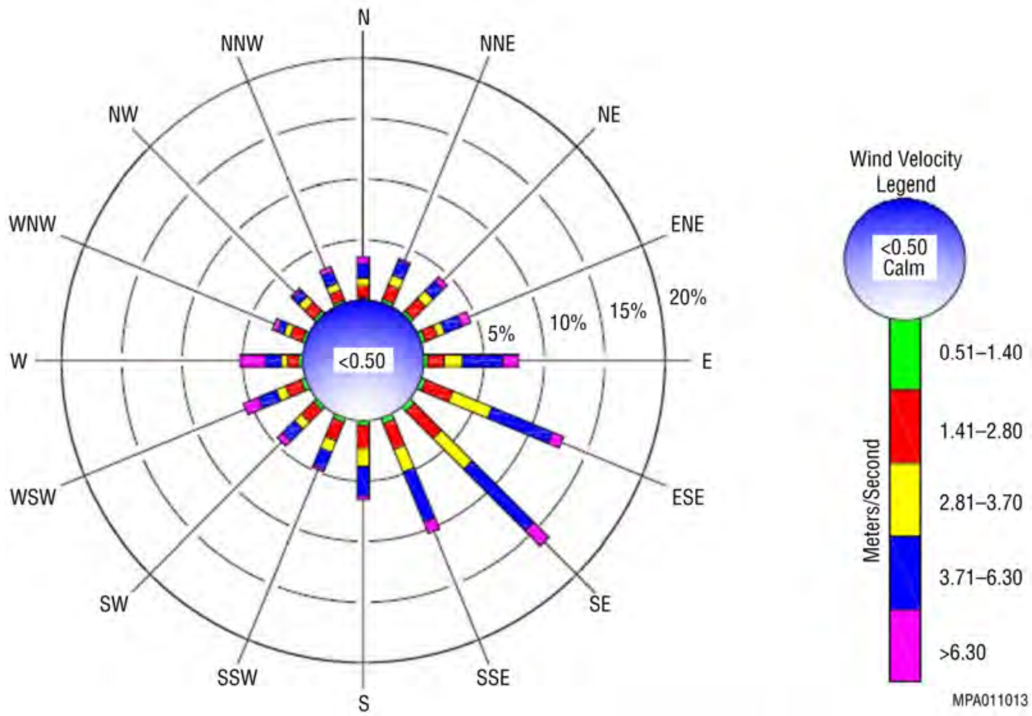

FIGURE 4.2.1-1 Wind Rose at the 10-m (33-ft) Level for the WIPP Site in 2006 (Source: DOE 2007)

Annual precipitation at the WIPP site averages about 33.8 cm (13.32 in.) (WRCC 2008). Precipitation is the highest in summer and tapers off markedly in winter. About 60% of the precipitation from June through September is in the form of high-intensity, short-duration thunderstorms, sometimes accompanied by hail (DOE 2004). Rains are brief but occasionally intense and can result in flash flooding in arroyos and along the floodplains. Measurable snow is rare and, if it occurs, remains on the ground for only a short time. Light snow typically occurs from December to January, and the annual average snowfall in the area is about 2.3 cm (0.9 in.).

Strong winds are common and can blow from any direction, creating potentially violent windstorms that carry large volumes of dust and sand (DOE 2004b). In late winter and spring, there are strong west winds and dust storms. On rare occasions, a tropical hurricane may cause heavy rain in eastern and central New Mexico as it moves inland from the western part of the Gulf of Mexico, but there is no record of serious wind damage from these storms (WRCC 2008).

Tornadoes in the area surrounding the WIPP site, which is located on the edge of the tornado alley in the central United States, are common but less frequent and destructive than those in the tornado alley. For the period 1950–2008, 512 tornadoes were reported in New Mexico (an average of about 9 tornadoes per year; they occurred mostly at lower

Fujita Scale of Tornado Intensities

• F0	Gale	18–32 m/s	40–72 mph
• F1	Moderate	33–50 m/s	73–112 mph
• F2	Significant	51–70 m/s	113–157 mph
• F3	Severe	71–92 m/s	158–206 mph
• F4	Devastating	93–116 m/s	207–260 mph
• F5	Incredible	117–142 m/s	261–318 mph

elevations in eastern New Mexico next to Texas (NCDC 2008). For the same period, a total of 52 tornadoes (an average of about 1 tornado per year) were reported in Eddy County, which includes the WIPP site. However, most tornadoes occurring in Eddy County were relatively weak (i.e., 49 were F0 or F1, and three were F2 on the Fujita tornado scale). No deaths and 29 injuries were associated with these tornadoes.

4.2.1.2 Air Quality and Existing Air Emissions

The Clean Air Act Amendments (CAAA) of 1990 provides for the preservation, protection, and enhancement of air quality. Both the State of New Mexico and the EPA have authority for regulating compliance with portions of the CAAA. On the basis of an initial 1993 air emissions inventory, the WIPP site is not required to obtain CAA permits (DOE 2007). WIPP was required to obtain a New Mexico Air Quality Control Regulation 702 operating permit (recodified in 2001 as 20.2.72 *New Mexico Administrative Code* [NMAC], "Construction Permits") for two backup diesel generators at the site in 1993. There have been no activities or modifications to the operating conditions of the diesel generators that would require reporting under the conditions of the permit in 2006.

Annual emissions for major facility sources and total point and area sources for 2002 for criteria pollutants and VOCs in Eddy County, New Mexico, including the WIPP site, are presented in Table 4.2.1-1 (EPA 2008a). Data for 2002 are the most recent emission inventory data available on the EPA website. Area sources consist of nonpoint and mobile sources. Point sources account for most total sulfur dioxide (SO_2) and nitrogen oxides (NO_x) emissions in the county; SO_2 is emitted equally from industrial fuel combustion and from petroleum and related industries, and NO_x is emitted mostly from industrial fuel combustion. For carbon monoxide (CO) and particulate matter with a diameter of 10 μm or less (PM_{10}), area sources account for most of total emissions in the county; for VOCs and PM with a diameter of 2.5 μm or less ($PM_{2.5}$), emissions from area sources are higher than those from point sources. CO is emitted from on-road sources. PM_{10}/$PM_{2.5}$ are emitted from miscellaneous sources, and VOCs are omitted from many different activities, with the highest contribution coming from petroleum and related industries.

Among criteria pollutants (SO_2, nitrogen dioxide [NO_2], CO, O_3, PM_{10} and $PM_{2.5}$, and lead), the New Mexico SAAQS are identical to the NAAQS for NO_2 (EPA 2008b; 20.2.3 NMAC), as shown in Table 4.2.1-2. The State of New Mexico has established more stringent standards for SO_2 and CO but has no standards for O_3, PM, and lead. In addition, the State has adopted standards for hydrogen sulfide (H_2S) and total reduced sulfur and has still retained the standard for total suspended particulates (TSP), which used to be one of the criteria pollutants but was replaced by PM_{10} in 1987.

The WIPP site is located in Eddy County. Currently, the entire county, including the WIPP site, is designated as being in attainment for all criteria pollutants (40 CFR 81.332). The whole state is designated as an attainment area, except for a small portion in the south-central part of the state, Anthony (adjacent to El Paso, Texas), which is not in attainment for PM_{10}.

TABLE 4.2.1-1 Annual Emissions of Criteria Pollutants and Volatile Organic Compounds from Selected Major Facilities and Total Point and Area Source Emissions in Eddy County Encompassing the WIPP Site[a]

	Emission Rates (tons/yr)					
Emission Category	SO_2	NO_x	CO	VOCs	PM_{10}	$PM_{2.5}$
Eddy County						
Agave Gas Plant[b]	*2,099*	*2.0*	*0.6*	*20.2*	*0.0*	*0.0*
Artesia Gas Plant	*838*	*919*	*301*	*52.6*	*1.9*	*1.9*
Empire Abo Plant	*0.0*	*29.1*	*1.0*	*2.2*	*1,307*	*1,143*
Indian Basin Gas Plant	*2,040*	*361*	*396*	*60.4*	*2.4*	*2.2*
Navajo Refining Co.–Artesia	*1,975*	*387*	*394*	*1,204*	*187*	*112*
Total point sources	7,515	6,661	5,399	3,444	1,847	1,569
Total area sources	268	1,776	20,326	4,778	25,479	3,175
County total	7,783	8,437	25,725	8,222	27,326[b]	4,744

[a] Emissions for selected major facilities are total point and area sources for 2002. CO = carbon monoxide, NO_x = nitrogen oxides, $PM_{2.5}$ = particulate matter ≤2.5 μm, PM_{10} = particulate matter ≤10 μm, SO_2 = sulfur dioxide, VOCs = volatile organic compounds.

[b] Data in italics are not added to yield total.

Source: EPA (2009)

Seven classes of EPA-regulated pollutants have been monitored at WIPP since August 1986. Monitoring results indicated that air quality around the WIPP site usually met state and federal standards, except for occasional exceedances of TSP during periods of high wind and blowing sands and infrequent exceedances of SO_2 (DOE 1997). On October 30, 1994, DOE, after notifying the EPA, terminated on-site monitoring of criteria pollutants at the WIPP site because there was no longer a regulatory requirement to do so. Currently, VOC monitoring is performed to comply with the provisions of the WIPP Hazardous Waste Facility Permit. In 2006, three of the nine target compounds were detected above the method reporting limit (DOE 2007). The most substantial results were at least three orders of magnitude below the lower action level as described by the Hazardous Waste Facility Permit.

To establish representative background concentrations for the WIPP site, nearby urban or suburban measurements were used. The highest concentration levels for SO_2, NO_2, PM_{10}, and $PM_{2.5}$ around the WIPP site are less than or equal to 59% of their respective standards in Table 4.2.1-2 (EPA 2008b). However, the highest O_3 concentrations are a little higher than the applicable standards in the area. No measurement data for CO and lead around the WIPP site are available, but those values are expected to be lower. They would be lower for CO because of the distance from urban areas and major highways, and they would be lower for lead because of the distance from industrial processes, such as smelters.

TABLE 4.2.1-2 National Ambient Air Quality Standards (NAAQS) or New Mexico State Ambient Air Quality Standards (SAAQS) and Highest Background Levels Representative of the WIPP Area, 2003–2007

			Highest Background Levels	
Pollutant[a]	Averaging Time	NAAQS/ SAAQS[b]	Concentration[c,d]	Location (Year)
SO_2	1-hour	75 ppb	–[e]	–
	3-hour	0.50 ppm	0.017 ppm (3.4%)	Artesia, Eddy Co. (2006)
	24-hour	0.10 ppm	0.004 ppm (4.0%)	Artesia, Eddy Co. (2006)
	Annual	0.02 ppm	0.001 ppm (5.0%)	Artesia, Eddy Co. (2007)
NO_2	1-hour	0.100 ppm	–	–
	24-hour	0.10 ppm	–	–
	Annual	0.05 ppm	0.006 ppm (12%)	Artesia, Eddy Co. (2003)
CO	1-hour	13.1 ppm	9.6 ppm (73%)	Albuquerque, Bernalillo Co. (2003)[f]
	8-hour	8.7 ppm	3.5 ppm (40%)	Albuquerque, Bernalillo Co. (2004)[f]
O_3	1-hour	0.12 ppm[g,h]	0.086 ppm (72%)	Carlsbad, Eddy Co. (2006)
	8-hour	0.075 ppm[h]	0.076 ppm (101%)	Carlsbad, Eddy Co. (2006)
TSP	24 hours	150 µg/m^3	–	–
	7 days	110 µg/m^3	–	–
	30 days	90 µg/m^3	–	–
	Annual geometric mean	60 µg/m^3	–	–
PM_{10}	24-hour	150 µg/m^3 [h]	88 µg/m^3 (59%)	Hobbs, Lea Co. (2003)
$PM_{2.5}$	24-hour	35 µg/m^3 [h]	18 µg/m^3 (51%)	Hobbs, Lea Co. (2005)
	Annual	15.0 µg/m^3 [h]	7.3 µg/m^3 (49%)	Hobbs, Lea Co. (2007)
Lead[i]	Calendar quarter	1.5 µg/m^3 [h]	0.03 µg/m^3 (2.0%)	Bernalillo Co. (2003)[f]
	Rolling 3-month	0.15 µg/m^3 [h]	–	–
H_2S	1 hour	0.010 ppm	–	–
Total reduced sulfur	1/2 hour	0.003 ppm	–	–

a CO = carbon monoxide, H_2S = hydrogen sulfide, NO_2 = nitrogen dioxide, O_3 = ozone, $PM_{2.5}$ = particulate matter ≤2.5 µm, PM_{10} = particulate matter ≤10 µm, SO_2 = sulfur dioxide, TSP = total suspended particulates.

b The more stringent standard between the NAAQS and the SAAQS is listed when both are available.

c Monitored concentrations are the highest arithmetic mean for calendar-quarter lead; second-highest for 1-hour, 3-hour, and 24-hour SO_2, 1-hour and 8-hour CO, 1-hour O_3, and 24-hour PM_{10}; fourth-highest for 8-hour O_3; 98th percentile for 24-hour $PM_{2.5}$; arithmetic mean for annual SO_2, NO_2, PM_{10}, and $PM_{2.5}$.

d Values in parentheses are monitored concentrations as a percentage of SAAQS or NAAQS.

e A dash indicates that no measurement is available.

f These locations with highest observed concentrations in the state of New Mexico are not representative of the WIPP site but are presented to show that these pollutants are not a concern over the state of New Mexico.

Footnotes continue on next page.

TABLE 4.2.1-2 (Cont.)

[g] On June 15, 2005, the EPA revoked the 1-hour O_3 standard for all areas except the 8-hour O_3 nonattainment Early Action Compact (EAC) areas. (Those do not yet have an effective date for their 8-hour designations.) The 1-hour standard will be revoked for these areas 1 year after the effective date of their designation as attainment or nonattainment for the 8-hour O_3 standard.

[h] Values are NAAQS. No SAAQS exists.

[i] Used old standard because no data in the new standard format are available.

Sources: EPA (2008a, 2009); 20.2.3 NMAC (refer to http://www.nmcpr.state.nm.us/nmac/parts/title20/20.002.0003.pdf)

The WIPP site and its vicinity are classified as Prevention of Significant Deterioration (PSD) Class II areas. The nearest Class I area is Carlsbad Caverns National Park, about 61 km (38 mi) west-southwest of WIPP (40 CFR 81.421). Guadalupe Mountains National Park in Texas is about 100 km (62 mi) west-southwest of WIPP (40 CFR 81.429). There are no facilities currently operating at the WIPP site that are subject to PSD regulations.

4.2.1.3 Existing Noise Environment

The State of New Mexico and Eddy County have established no quantitative noise-level regulations.

The major noise sources associated with disposal operations at WIPP include traffic noise from site workforce vehicles, salt haulage vehicles, and waste transport vehicles; from the WHB during normal operations; and from infrequent emergency diesel generator testing. The Final EIS for WIPP reported that an overall sound pressure level of 50 dBA might occur 120 m (400 ft) away as a result of normal operations. Because the WIPP facility is more than 2.4 km (1.5 mi) from the fence line, generator noise is inaudible at the fence line and hence at any nearby residence.

The ambient noise level in the WIPP area before construction was 26 to 28 dBA, similar to wilderness natural background noise levels (DOE 1997). For the general area surrounding the WIPP site, the countywide day-night sound level (L_{dn}) based on population density is estimated to be 33 dBA for Eddy County, typical of the lower end of the range for rural areas (33–47 dBA) (Eldred 1982).

4.2.2 Geology and Soils

The WIPP repository is located in the Salado Formation, a massive bedded salt unit, about 655 m (2,150 ft) below the ground surface. The following sections provide an overview of the regional geologic setting and stratigraphy, with an emphasis on the Salado Formation and the formations directly above and below it.

4.2.2.1 Geology

4.2.2.1.1 Physiography. WIPP is located in southeastern New Mexico, in the Pecos Valley Section of the Great Plains physiographic province (Figure 4.2.2-1). The terrain throughout the province varies from plains and lowlands to rugged canyons. In the immediate vicinity of WIPP, numerous small mounds formed by wind-blown sand characterize the land surface. A 410,000- to 510,000-year-old layer enriched in calcium carbonate material, the Mescalero caliche, is typically present beneath the surface layer of sand. The caliche layer overlies a 600,000-year-old volcanic ash layer (DOE 1996b). The Mescalero caliche can be found over large portions of the Pecos River drainage area and is generally considered to be an indicator of surface stability (DOE 1980).

A high plains desert environment characterizes the area. Because of the seasonal nature of the rainfall, most surface drainage is intermittent. The Pecos River, 16 km (10 mi) southwest of the WIPP boundary, is a perennial river and the master drainage for the region. A natural

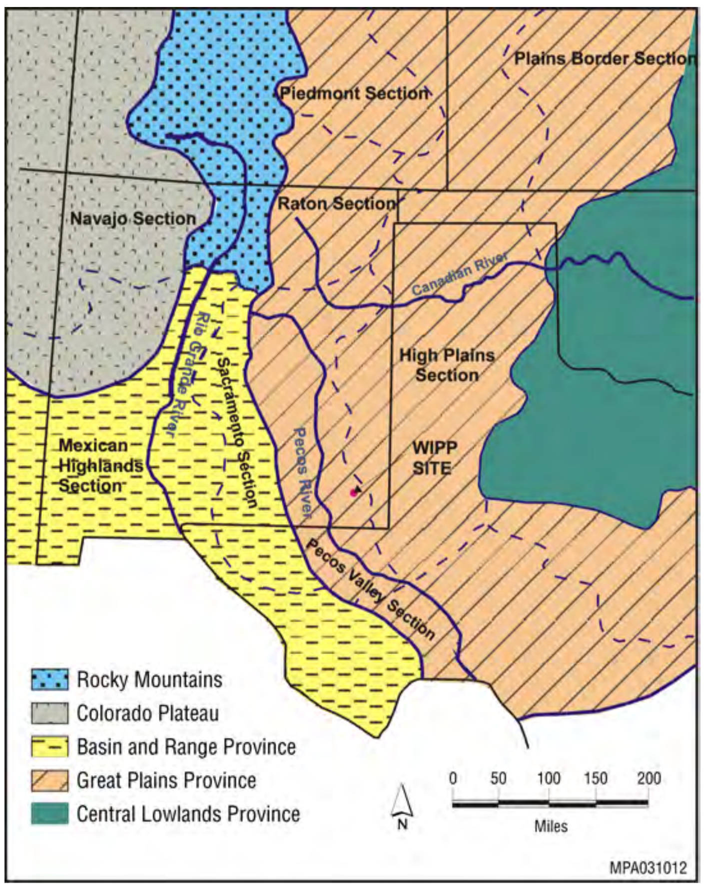

FIGURE 4.2.2-1 Location of the WIPP Site within the Great Plains Province in Southeastern New Mexico (Source: DOE 1997)

divide lies between the Pecos River and the WIPP site. As a result, the Pecos drainage system does not currently affect the site. Local surface drainage features include Nash Draw and the San Simon Swale.

4.2.2.1.2 Topography. The topography of the Pecos Valley section ranges from flat plains and lowlands to rugged canyon lands, with elevations of 1,830 m (6,000 ft) mean sea level (MSL) in the northwest, 1,520 m (5,000 ft) MSL in the north, 1,220 m (4,000 ft) MSL in the east, and 610 m (2,000 ft) MSL in the south. The valley has an uneven rock floor, resulting from differential weathering of limestones, sandstones, shales, and gypsums. The Pecos Valley section is drained mainly by the Pecos River, the only perennial stream in the region. The Pecos drainage system flows to the southeast; its closest point is about 16 km (10 mi) from the WIPP site. The Pecos River Valley shows characteristic lowland topography marked by widespread karst topography, with solution-subsidence features (e.g., sinkholes) resulting from dissolution of Permian rocks from the Ochoan Series (Powers et al. 1978; Mercer 1983).

The land surface of the WIPP site is hummocky, with numerous eolian sand ridges and dunes, and it slopes gently from an elevation of about 1,090 m (3,570 ft) MSL at its eastern boundary to about 990 m (3,250 ft) MSL along its western boundary. An extensive layer of hard caliche (the Mescalero caliche) lies between the surficial sand deposits and the underlying Gatuña Formation. It ranges in age from about 510,000 years at its base to 410,000 years at the top (Powers et al. 1978; DOE 1997).

4.2.2.1.3 Site Geology and Stratigraphy. The WIPP site is located in the northern portion of the Delaware Basin, a structural basin underlying present-day southeastern New Mexico and western Texas that contains a thick sequence of sandstones, shales, carbonates, and evaporites. The WIPP repository is located at a depth of approximately 655 m (2,150 ft) in rocks of Permian age. The sediments accumulated during the Permian period represent the thickest portion of the sequence in the northern Delaware Basin and are divided into four series (Figure 4.2.2-2). From oldest to youngest, these series are the Wolfcampian, Leonardian, Guadalupian, and Ochoan. The Ochoan Series consists of extensive evaporite deposits; the series is divided into four formations. From oldest to youngest, these formations are Castile, Salado (the lower part of which contains the WIPP repository), Rustler, and Dewey Lake.

The following sections describe the geologic formations important to understanding the long-term performance of WIPP, starting with the host rock for the WIPP repository (the Salado Formation), the formations below the Salado (the Castile and Bell Canyon Formations), and the formations above the Salado (the Rustler, Dewey Lake, Santa Rosa, and Gatuña Formations).

Salado Formation. The Permian Salado Formation is a massive bedded salt formation that is predominantly halite (sodium chloride) and is thick and laterally extensive. DOE selected the Salado Formation as the site of the WIPP repository for several geologically related reasons (DOE 1980, 1990): (1) the Salado halite units have very low permeability to fluid flow, which impedes groundwater flow into and out of the repository; (2) the Salado is regionally

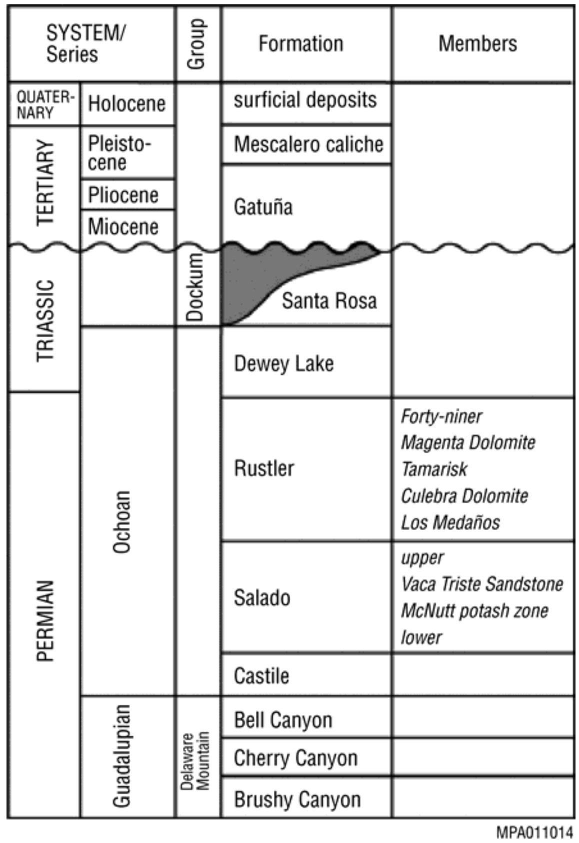

FIGURE 4.2.2-2 Stratigraphic Column for the WIPP Site and Surrounding Area (Source: EPA 2006)

widespread; (3) the Salado includes continuous halite beds without complicated structure; (4) the Salado is deep with little potential for dissolution; (5) the Salado is near enough to the surface that access is reasonable; and (6) the Salado is largely free of mobile groundwater, when compared with existing mines and other potential repository sites.

The Salado Formation ranges in thickness from approximately 540 to 646 m (1,770 to 2,120 ft). The Salado is composed of four members. From oldest to youngest, they are the Lower Member, the McNutt Potash Member, the Vaca Triste Sandstone, and the Upper Member. The WIPP repository is located in the Lower Member and in the thickest part of the Salado Formation.

Although the most common Delaware Basin evaporite mineral is halite, there are less soluble layers or interbeds (dominantly anhydrite, polyhalite, and claystone) and more soluble admixtures (e.g., sylvite, glauberite, kainite) within the formation. These other minerals result in chemical and physical properties of the bulk Salado that are different from those of pure halite layers contained within it. In particular, the McNutt Potash Zone is locally explored and mined for potassium-bearing minerals of economic interest. As shown in Figure 4.2.2-3, the

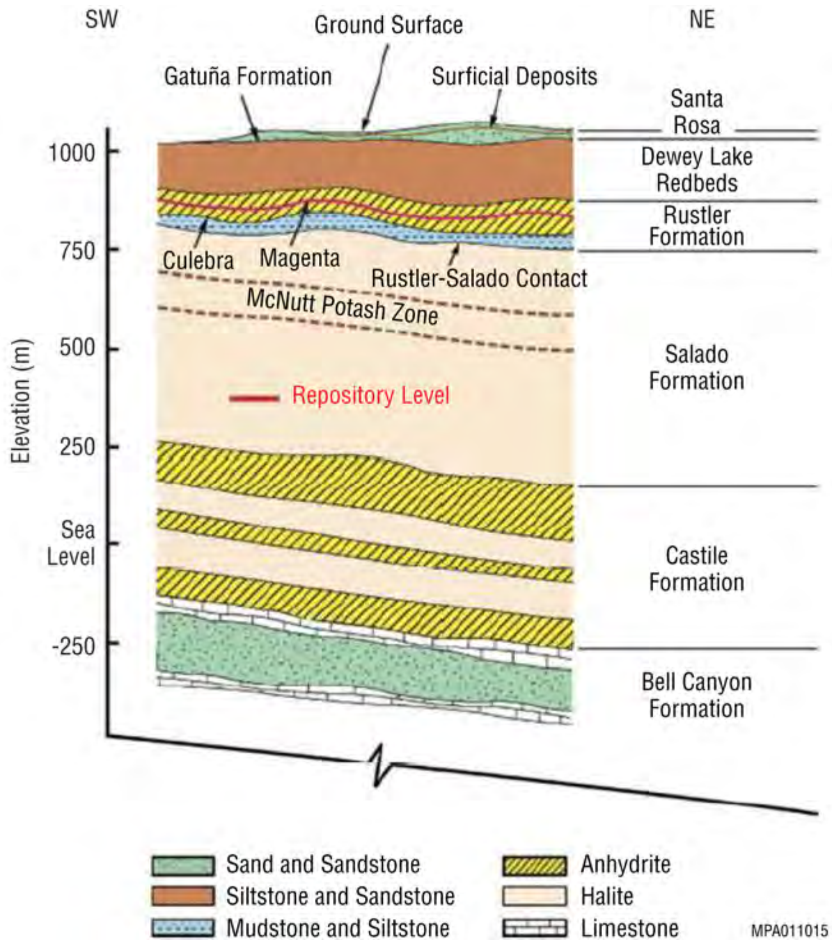

FIGURE 4.2.2-3 Stratigraphy of Aquifer Units at the WIPP Site (DOE 2008b)

potash in the McNutt Potash Zone is generally located near the upper portion of the Salado formation above the repository.

Castile Formation. The Permian Castile Formation directly underlies the Salado Formation and typically consists of three relatively thick anhydrite/carbonate units and two thick halite units in the WIPP area. It is approximately 390-m (1,280-ft) thick and is present from approximately 810 to 1,200 m (2,660 to 3,940 ft) bgs at the site, which is approximately 155 m (509 ft) below the level of the repository. The more brittle anhydrite units of the Castile are locally fractured, and the fracture zones are relatively permeable and act as zones for accumulation of brine trapped in the Castile since the Permian (DOE 1997).

Bell Canyon Formation. The Permian Bell Canyon Formation underlies the Castile Formation and is composed of a layered sequence of sandstones, shales, siltstones, and limestones near the WIPP site. It is also the uppermost target of hydrocarbon exploration in the local area. It is approximately 350-m (1,150-ft) thick and is present from approximately 1,200 to 1,550 m (3,940 to 5,090 ft) bgs at the site. The top of the Bell Canyon is approximately 545 m (1,790 ft) below the level of the repository.

Rustler Formation. The upper Permian Rustler Formation lies above the WIPP repository and directly overlies the Salado Formation. It is divided into five members. From the base of the Rustler Formation, these members are the Los Medaños, the Culebra Dolomite, the Tamarisk, the Magenta Dolomite, and the Forty-niner. The Culebra consists of locally argillaceous and arenaceous, well to poorly indurated dolomicrite with numerous cavities (vugs), fractures, and silty zones. The Magenta is a silty, gypsiferous, laminated dolomite. The other three members contain layers of claystone or mudstone sandwiched between layers of anhydrite/gypsum. In the southeast corner of the WIPP site and farther to the east, halite beds are also present in the non-dolomite members of the Rustler Formation. The Rustler Formation is approximately 94-m (310-ft) thick and is present from approximately 164 to 257 m (538 to 843 ft) bgs at the WIPP site. The top of the formation dips to the east-northeast across much of the WIPP site (Powers 2009). Its base is approximately 400 m (1,312 ft) above the level of the repository. The Rustler Formation contains the most extensive water-bearing units in the WIPP site area.

Dewey Lake Formation. The Dewey Lake Formation overlies the Rustler Formation at WIPP and is Permo-Triassic in age. It consists largely of reddish-brown siltstones and claystones, with lesser amounts of very fine to fine sandstone. Sediments are typically cemented with sulfates (gypsum and anhydrite). The formation generally thickens across the WIPP site from west to east to a maximum thickness of more than 183 m (600 ft) in the eastern part of the Delaware Basin east of the site. At the WIPP site, it is approximately 146-m (480-ft) thick and occurs from approximately 16 to 162 m (52 to 532 ft) bgs. The base of the Dewey Lake is approximately 495 m (1,623 ft) above the level of the repository. The surface water from Dewey Lake is primarily used for livestock watering and irrigation (Powers 2009).

Santa Rosa Formation. The Triassic Santa Rosa Formation, the basal formation of the Dockum Group, overlies the Dewey Lake Formation and consists of light reddish-brown sandstones and conglomerates, siltstone, and claystone. The Santa Rosa Formation is several hundred feet thick east of the WIPP site, but it thins to the west. It is about 12-m (40-ft) thick near the center of the WIPP site and is absent in the western third of the site as a result of erosion. The Santa Rosa is used as a source of groundwater to the east of the WIPP site (DOE 1996b; Powers 2009).

Gatuña Formation. The Miocene-Pleistocene Gatuña Formation overlies the Santa Rosa Formation and is somewhat similar in lithology and color, although the Gatuña is also characterized by a wide range of lithologies (coarse conglomerates to gypsum-bearing claystones). The upper Gatuña contains a 600,000-year-old volcanic ash layer (DOE 1996b). The formation is generally less than 15-m (50-ft) thick across the WIPP site and occurs at depths of

4.6 to 6.1 m (15 to 20 ft) bgs. The Gatuña Formation is in turn overlain by the Mescalero caliche and surficial sand deposits (Powers 2009).

Mescalero Caliche and Other Surface Deposits. The Mescalero caliche is a pedogenic carbonate unit that is continuous across the WIPP site, with thicknesses of up to 1.8 m (6 ft). The unit is exposed in places but may also underlie dune sand (to depths of up to 6.1 m [20 ft]). The continuity of the Mescalero is disrupted by erosion and solution and by plant growth. Funnel-like features called "flowerpots" can be seen throughout areas where the unit is well-exposed; mesquite and creosote bush root systems are found in some of these features. The presence of the Mescalero caliche indicates general stability across the land surface, since it took about 100,000 years to form and developed about 500,000 years ago (Powers 2009).

Above the Mescalero is the Berino soil, a thick, reddish, semiconsolidated sand containing little carbonate, ranging in thickness from centimeters (inches) to 0.30 to 0.61 m (1 to 2 ft). The Berino soil is likely derived from wind-blown material modified by pedogenic processes. It is often found in flowerpots and as a thin soil veneer on the surface of the Mescalero caliche (Powers 2009).

4.2.2.1.4 Seismicity. No surface displacement or faulting younger than early Permian has been reported, indicating that tectonic movement since then, if any, has not been noteworthy. No mapped Quaternary (last 1.9 million years) or Holocene (last 10,000 years) faults exist closer to the site than the western escarpment of the Guadalupe Mountains, about 100 km (60 mi) to the west-southwest (DOE 1997).

The strongest earthquake on record within 290 km (180 mi) of the site was the Valentine, Texas, earthquake of August 16, 1931 (DOE 1997), with an estimated Richter magnitude of 6.4. A modified Mercalli intensity of V was estimated for this earthquake's ground shaking at WIPP. At Intensity V, ground shaking is felt by nearly everyone; a few instances of cracked plaster occur; and unstable objects are overturned. This is the strongest ground-shaking intensity known for the WIPP site.

From November 1974 to August 2006, the largest earthquake within 300 km (184 mi) of the WIPP site occurred on April 14, 1995 (based on a search of the U.S. Geological Survey [USGS] National Earthquake Information Center data). It was located 32 km (20 mi) east-southeast of Alpine, Texas (approximately 240 km [150 mi] south of the site) and was assigned a Richter magnitude of 5.7. It was the largest event within 300 km (184 mi) of the site since the Valentine, Texas, earthquake, and had no effect on any structures at WIPP (Sanford et al. 1995). From 1974 to 2006, recorded earthquakes within a 300-km (184-mi) radius of WIPP have ranged from magnitude 2.3 to 5.7 (USGS 2010).

4.2.2.1.5 Volcanic Activity. The nearest potentially active volcanoes are in the Zuni-Bandera volcanic field in northwestern New Mexico. Volcanoes in this area are of the cinder cone (basaltic) type. They have not been active in at least 2,000 years and are considered to be dormant (New Mexico Bureau of Geology and Mineral Resources 2008).

4.2.2.2 Mineral and Energy Resources

4.2.2.2.1 Hydrocarbons. Prior to 1970, most commercially related drilling in the WIPP area targeted shallow oil (1,200 to 1,400 m [3,940 to 4,590 ft] in depth) in the Bell Canyon Formation. From 1970 to the mid-1980s, most drilling near WIPP focused on gas exploration in the deeper Morrow and Atoka Formations (approximately 4,000 m [13,100 ft]). During the late 1980s and early 1990s, commercial oil was discovered in the Permian Cherry Canyon and Brushy Canyon Formations, which lie below the Bell Canyon Formation described above. These discoveries were made at locations adjacent to the eastern and northeastern boundary of WIPP, at a depth of approximately 2,100 to 2,400 m (6,890 to 7,870 ft). These formations are the primary exploration and development targets in the Permian Basin, one of the most actively explored areas in the United States (Broadhead et al. 1995).

Oil and gas exploration drilling activities in the New Mexico portion of the Permian Basin (in which the WIPP site is located) have fluctuated considerably since 1997. As many as 57 rigs were working in the basin in late 1997, but the maximum number dropped to about 15 in 2000. The maximum rig count increased to approximately 65 in 2001, dropped to the low 30s in 2002, and then steadily increased to approximately 60 in 2005. It is assumed that hydrocarbon exploration drilling activities in the region of the WIPP site will continue for the foreseeable future (*Crossroads* 2005).

Within a 1-mi strip adjacent to WIPP, in-place oil reserves are estimated at 35.3×10^6 bbl, and in-place gas reserves are estimated at 28,870 Mcf (million cubic feet) in the Morrow and Atoka Formations and in shallower Bell Canyon and Cherry Canyon Formation reservoirs (Broadhead et al. 1995).

4.2.2.2.2 Potash. Bedded potash (a mixture of several soluble oxide, sulfate, and chloride compounds containing potassium, used chiefly in fertilizers) was discovered in Eddy County, New Mexico, in 1925. By 1944, New Mexico was the largest domestic potash producer, representing 85% of consumption. Development continued through the 1950s and 1960s, reversed in the 1970s, and had declined by the mid 1990s.

Since 1997, potash mining activities in the region of the WIPP site have continued. Approximately 1,500,000 tons of potash were produced in 1997, and production has slowly declined since that time. In 2005, approximately 1,000,000 tons were produced (NMEMNRD 2006).

The majority of actively mined and potential resources of potash ore are found in the 37-m-thick (120-ft-thick) McNutt Member of the Salado Formation, which is the host for 11 ore zones.

4.2.3 Water Resources

4.2.3.1 Surface Water

There are no natural surface water bodies within the boundaries of the WIPP site. Widespread eolian (sand dune) deposits that are of Holocene age or older indicate that little surface drainage has developed within and around the site. The nearest significant surface water body, Laguna Grande de la Sal, is located about 13 km (8 mi) west-southwest of the site in Nash Draw,[3] where there are shallow brine ponds. Small, man-made earthen livestock watering holes (called "tanks") occur around the WIPP site, particularly to the south, but are not hydrologically connected to the formations overlying the WIPP repository. The watering holes are constructed to hold runoff and not allow it to infiltrate. There may be minor leakage through the unsaturated zone beneath them that eventually reaches a Dewey Lake water table. The predominant use of surface water in the region is for livestock watering and irrigation (DOE 1997, 2008a; Powers 2009).

The Pecos River is the only perennial stream in the region (Figure 4.1.1-1). The river flows to the south-southeast and is, at its closest point (the Malaga Bend), about 16 km (10 mi) west of the WIPP site. The WIPP site is within the Pecos River drainage basin, although a natural divide lies between the Pecos River and the WIPP site. As a result, the Pecos drainage system does not currently affect the site. At least 90% of the mean annual precipitation at the WIPP site (30 cm [12 in.]) is lost by evapotranspiration, although precipitation rates may exceed evapotranspiration during intense thunderstorms that produce runoff and percolation. The average annual streamflow of the Pecos River at Malaga Bend (from 1938 through 2008) was 4.6 m^3/s or cms (164.5 ft^3/s or cfs) (USGS 2009). The maximum recorded streamflow (with a monthly mean of 119 cms [4,200 cfs]) occurred in August 1996 at the Malaga Bend; its maximum elevation was 90 m (300 ft) below the surface elevation of the WIPP site (USGS 2009; DOE 1997, 2006a).

Surface water samples collected along the Pecos River and from various tanks around the WIPP site are routinely analyzed for radionuclides, including U, Pu, Am, K-40, Co-60, Cs-137, and Sr-90. In 2007, uranium and plutonium concentrations were compared to baseline levels observed between 1985 and 1989. The highest concentrations of U-234, U-235, and U-238 detected in the Pecos River and surrounding tanks were found to fall within the ranges of baseline levels. Pu-238, Pu-239, and Pu-240 were not detected. Am-241 was found in water (at 1.14×10^{-3} Bq/L) from Tut tank, northwest of the border of the WIPP site (but no baseline data were available for comparison). The only other radionuclide exceeding its baseline value was K-40, found in a sample from an on-site sewage lagoon at 148 Bq/L (the baseline value for K-40 was 76 Bq/L) (DOE 2008a).

[3] Nash Draw is a surface depression, about 32-km (20-mi) long and 8- to 19-km (5- to 12-mi) wide, located about 6 km (3.7 mi) to the west of the WIPP site (Lorenz 2006). The valley is notable for its karst features and for exposures of some of the geologic units underlying the WIPP region.

4.2.3.2 Groundwater

4.2.3.2.1 Water-Bearing Units. Several water-bearing zones have been identified and extensively studied at and near the WIPP site. Limited amounts of potable water are found in the middle Dewey Lake Formation and the overlying Triassic Dockum Group (Santa Rosa Sandstone) in the southern part within the WIPP LWB. Two water-bearing units in the Rustler Formation, the Culebra and Magenta Dolomite Members, produce brackish to saline water at the WIPP site and surrounding locations. Another very-low-transmissivity, saline water-bearing zone occurs along the contact between the Rustler and Salado Formations (DOE 2008a). Mercer (1983) reports no evidence of water in the Gatuña Formation or surficial materials at the WIPP site. Figure 4.2.2-3 shows the stratigraphic relationships of these aquifer units.

Lower Water-Bearing Horizons (below Salado Formation). The Castile Formation is the basal unit of the Ochoan series and represents the oldest of the water-bearing units at the WIPP site. The term “water-bearing horizons” is used in this discussion because nothing below the Salado can properly be termed an aquifer. The formation is about 390-m (1,280-ft) thick and lies about 244 m (800 ft) below the level of the repository. It consists of three thick anhydrite units interbedded with halite and acts as an aquitard between the overlying Salado Formation and the underlying water-bearing sandstones, shales, and limestones of the Bell Canyon Formation (Guadalupian series). No regional groundwater flow system appears to be present in the Castile Formation in the WIPP site area. Fracturing within an anhydrite layer of the upper Castile has created isolated, high-permeability regions (brine reservoirs) that contain brine at higher-than-hydrostatic pressure (Popielak et al. 1983; DOE 1996a, 1999, 2008a).

Salado Formation (WIPP Repository Horizon). The WIPP repository lies entirely within the massive halite beds of the Salado Formation, a regional aquiclude.[4] Estimated hydraulic conductivities range from 10^{-16} to 10^{-11} m/s for impure halite intervals and from 10^{-13} to 10^{-10} m/s in anhydrite (Roberts et al. 1999; Beauheim and Roberts 2002). Although the hydraulic conductivity of the Salado Formation is extremely low, it is not dry. Brine content within the Salado is estimated at 1–2% by weight, and thin clay seams have been observed to contain up to 25% brine by volume (DOE 1999).

Occurrence of groundwater in the Salado Formation is restricted because halite does not have primary porosity, solution channels, or open fractures. No evidence of circulating water has been found in the unit; however, small pockets of brine (e.g., in Marker Bed 139, which is an anhydrite rather than a halite) and nonflammable gas have been found. Inflow of brine into the repository excavation has been observed in boreholes and from “weeps,” which are localized brine seeps issuing from the surfaces of the repository walls, floors, and roofs. The volumes of brine observed from these occurrences have been small, and flow into the repository ceased within three years of initial observation. Nevertheless, for the long term, it is reasonable and

[4] An aquiclude is a hydrologic unit that contains groundwater but does not transmit it.

conservative to consider that there may be brine near the repository that would flow toward and into the repository, albeit at a low rate (DOE 1996a, 2008a).

Brine inflow is a concern for the repository in that the brine would provide necessary moisture for the degradation of certain waste material components and gas generation.

Upper Water-Bearing Horizons (above the Salado Formation). Directly above the Salado Formation in Nash Draw is a zone of dissolution residue capable of transmitting water. The transmissivity of this interval, referred to as the Rustler-Salado contact, decreases from Nash Draw eastward to the WIPP site area. Small quantities of brine were found in this zone in WIPP site test holes (DOE 2008a).

The 95-m (310-ft) thick Rustler Formation, which directly overlies the Salado Formation, ranges in depth from 164 to 257 m (538 to 843 ft) at the WIPP site. Its base is about 398 m (1,310 ft) above the level of the repository. The five members of the Rustler Formation are described in Section 4.2.2.1.3. In ascending order, these members are the Los Medaños Member, Culebra Dolomite Member, Tamarisk Member, Magenta Dolomite Member, and Forty-niner Member. Only the Culebra and Magenta Dolomite Members have enough transmissivity to produce water to wells. The other three members act as aquitards (DOE 1996a).

The Culebra Dolomite Member of the Rustler Formation is composed predominantly of fractured, microcrystalline dolomite and ranges in thickness from 5.8 to 12.5 m (19 to 41 ft) in the WIPP site region. It is the first significant water-bearing unit above the Salado Formation at the WIPP site. Regional flow of groundwater in the Culebra Dolomite is generally to the south. Because of its lateral continuity and high transmissivity (as high as 10^{-3} m^2/s [DOE 2008b]), it is considered to be the most likely pathway for radionuclide releases from the repository to the accessible environment. Estimates of hydraulic conductivity in the Culebra Dolomite vary widely, but in general, they decrease from 10^{-4} m/s in Nash Draw to 10^{-14} m/s east of the WIPP site (DOE 1999). These conductivity variations are believed to be controlled by the relative abundance of pore-filling cements, stress-relief fracturing, and fracturing related to dissolution of the upper Salado Formation rather than by primary depositional features of the unit. Porosities measured in core samples from the Culebra range from 0.03 to 0.30 (Kelley and Saulnier 1990; TerraTek, Inc. 1996). Although the dolomite matrix provides most of the unit's storage capacity, fluid movement occurs mainly through fractures and vugs. Recent studies of the Culebra show that it is a heterogeneous system with anisotropic characteristics, suggesting variability of fracture orientations on a local scale, especially in the WIPP site area (DOE 2008a; Lorenz 2006). These studies support the interpretation that the Culebra Dolomite and other members of the Rustler Formation are unkarsted strata (Lorenz 2006; DOE 2008b).

The Magenta Dolomite Member of the Rustler Formation is above the Culebra Dolomite and is separated from it by the Tamarisk Member. The Magenta is about 8-m (26-ft) thick and consists of fine-grained gypsiferous dolomite. The Magenta Dolomite is less transmissive (about 10^{-7} m^2/s [DOE 2008b]) than the Culebra Dolomite, having hydraulic conductivities one to two orders of magnitude less than those of the Culebra in most locations (from 10^{-9} to 10^{-3} m/s). Like those of the Culebra Dolomite, its hydraulic conductivities increase to the west toward Nash

Draw. The hydraulic gradient of the Magenta also increases toward the west, ranging from 0.003 to 0.0038 on the east side of the WIPP site to 0.0061 along its west side (DOE 1997, 1999).

The reddish-brown fine sandstone, siltstone, and silty claystone of the Dewey Lake Red Beds Formation overlie the Rustler Formation. The formation is about 150-m (490-ft) thick at the center of the WIPP site, thinning to the west. The upper portion of the Dewey Lake consists of a fairly thick (up to 80 m [164 ft]) unsaturated zone. Just below this zone is a saturated zone perched above a cementation change from carbonate (above) to sulfate (below). The saturated zone, which makes up the middle portion of the Dewey Lake, occurs at depths of about 50 to 80 m (164 to 262 ft). In this zone, water is transmitted through open fractures. Below it, fractures tend to be completely filled with gypsum (DOE 1999, 2008a).

The Santa Rosa Formation thins from being 66-m (217-ft) thick along the eastern WIPP site boundary to zero near the center of the WIPP site. Anthropogenic water (e.g., irrigation water) has been found in the formation in the center part of the WIPP site. The Gatuña Formation unconformably overlies the Santa Rosa. It ranges in thickness from about 6 to 9 m (19 to 31 ft) and consists of silt, sand, and clay, with deposits formed in localized depressions. Saturation in the Gatuña occurs in discontinuous perched zones. This water may also have an anthropogenic source (DOE 1999, 2008a).

4.2.3.2.2 Groundwater Quality. Groundwater samples from monitoring wells in the Culebra Member of the Rustler Formation have been characterized as saline to brine, with total dissolved solid concentrations ranging from 4,000 to 360,000 mg/L. Water from the Culebra has been classified as Class III water by EPA guidelines and is not acceptable for human consumption or for agricultural purposes (Richey et al. 1985; DOE 2007). DOE (2007) reports there is no WIPP-related contamination in groundwater from the Culebra Member.

Groundwater in the overlying Dewey Lake Formation is of better quality, with an average total dissolved solids value of 3,350 mg/L. This water has been classified as Class II water by EPA guidelines and is suitable for livestock consumption (DOE 2007).

4.2.3.3 Water Use

The WIPP site water supply is categorized as a nontransient, noncommunity system for reporting and testing requirements. Water service for the WIPP facility is furnished by the City of Carlsbad from a City-owned waterline that originates at the Double Eagle South Well Field 31 mi (50 km) north of the facility. The volume capacity of the waterline is such that it meets all water requirements for the operation of the WIPP facility. As specified in a bill of sale transferring this waterline from DOE to the City in June of 2009, Carlsbad will provide up to 25 million L/yr (6.6 million gal/yr) water to the WIPP facility free of charge for the next 100 years. Annual water use at the WIPP site is approximately 20 million L/yr (5.4 million gal/yr) (Sandia 2008a).

The City of Carlsbad is serviced by two separate well fields: Sheep's Draw and Double Eagle. Approximately 98% of Carlsbad's water is supplied by groundwater pumped from nine wells located 11 km (7 mi) southwest of Carlsbad in an area called Sheep's Draw in the foothills of the Guadalupe Mountains. The other 2% comes from the Double Eagle water system. The Double Eagle well system is located near Maljamar, New Mexico. It serves the Ridgecrest Subdivision, Connie Road, Blackfoot Road, Hobbs Highway Industrial Park Area, Brantley Lake State Park, and the WIPP site. In 2007, the city of Carlsbad's water supply system pumped 9.5 billion L (2.5 billion gal) of water (Carlsbad 2008a).

The Double Eagle system that supplies water to the WIPP site has 29 wells in two well fields (north and south). Twelve of the wells are operational in the north well field; two are operational in the south well field. The south well field is the main source of water for the WIPP site and a handful of other users. Double Eagle water is withdrawn from the Ogallala Aquifer (Carlsbad 2008a,b). The Double Eagle system has a total capacity of approximately 9.5 billion L/yr (2.5 billion gal/yr). Existing storage facilities include a 11.4 million L (3 million gal) reservoir, a 1.6 million L (0.42 million gal) reservoir, and a 3.8 million L (1 million gal) reservoir. A 7.6 million L (2 million gal) reservoir has also been added to the South Well Field. In 2004, the reservoir capacity was too small to meet the system demands. In order to maintain pressure and flow requirements, the wells were operated continuously (Tully 2004). If operated at capacity, the two south well field wells would produce about 1.4 billion L (360 million gal) of water annually. There is a recommendation to install six new large-diameter wells, three in each well field, once well design is completed (Carlsbad 2008b).

4.2.4 Human Health

The dose limit for WIPP operations is given in 40 CFR Part 191, Subpart A, and requires that the combined annual dose equivalent to any member of the general public in the vicinity of the site not exceed 25 mrem/yr to the whole body and 75 mrem/yr to any critical organ. Potential radiation exposures of the off-site general public can occur as a result of three pathways: (1) air transport, (2) water ingestion, and (3) ingestion of game animals. Of these three pathways, only the air pathway is considered to be credible. Elevated concentrations of radionuclides have not been detected in groundwater or game animals in the site vicinity.

The estimated highest dose to an individual receptor from airborne releases was estimated to be less than 1.8×10^{-5} mrem/yr effective dose equivalent in 2011 (DOE 2012). This individual receptor is assumed to reside 7.5 km (4.7 mi) west-northwest of the site. This dose is well below the standard of 10 mrem/yr given in 40 CFR Part 61, Subpart H. A hypothetical individual residing at the site fence line in the northwest sector is estimated to receive a dose of less than 1.3×10^{-3} mrem/yr for the whole body and 1.9×10^{-3} mrem/yr to the critical organ. These values are well below the dose limits for WIPP operations given in 40 CFR Part 191, Subpart A.

The potential collective dose to the 92,600 people living within 80 km (50 mi) of WIPP was calculated to be 2.7×10^{-5} person-rem/yr in 2011 (DOE 2012). Assuming this dose was distributed uniformly to all individuals living within 80 km (50 mi) of the site, the average dose to each person would be about 2.9 × 10^{-7} mrem/yr. This is an extremely small fraction of the average dose to members of the general public of 620 mrem/yr from all natural background and man-made sources of radiation exposure (NCRP 2009).

Before operations started at WIPP for receipt and disposal of TRU waste, estimates were developed for the doses that could be expected to occur to workers (Bradley et al. 1993). The estimated doses for each worker during normal CH waste handling operations at WIPP were estimated to be as follows: Waste handlers receive 0.70 rem/yr, radiation control technicians receive 0.60 rem/yr, and an average individual receives 0.68 rem/yr. The estimated annual doses to these three categories of workers for handling all TRU (CH and RH) waste are given as 0.79 rem/yr, 0.87 rem/yr, and 0.81 rem/yr, respectively. The average individual represents the dose associated with the range of activities at WIPP and is thus a composite (or average) worker. The WAC for WIPP limits the contact dose rate to 200 mrem/h for CH wastes and 1,000 rem/h for RH wastes. The project has a self-imposed limit of 1 rem/yr for worker exposure at WIPP, which is lower than the occupational exposure limit of 5 rem/yr given in DOE Order 458.1 (DOE 2011a).

Data on actual operations at WIPP indicate that workers are receiving very low doses from external gamma radiation (Jierree 2009; McCauslin 2010b). The total annual worker dose commitment for the years 1999 through 2009 was 12.4 person-rem (or an average of about 1.1 person-rem/yr) and ranged from a low of 0.331 person-rem/yr to a maximum of 2.298 person-rem/yr. Of the more than 1,100 workers who were monitored for radiation exposure in 2009, 68 had reportable doses. Most of the individuals who had reportable doses were waste handlers and radiological control technicians.

These occupational doses are lower than the preoperational estimates noted above. These low occupational doses reflect both the good radiation control practices at WIPP and the safe design of the waste handling equipment and remote handling processes for RH wastes. In addition, most of the waste disposed of at WIPP has been CH waste having low contact dose rates. For purposes of analysis in this EIS, all of the GTCC LLRW and GTCC-like waste would be managed in the same manner as CH waste for disposal at WIPP.

4.2.5 Ecology

4.2.5.1 Terrestrial Resources

The WIPP site area is characterized by large, stabilized sand dunes. It is located within a transition area between the northern extension of the Chihuahuan Desert (desert grassland) and the southern Great Plains (short-grass prairie) and shares the vegetative characteristics of both areas (DOE 1980). More than 100 species of plants have been identified within the WIPP LWB (DOE 1993). Numerous species of forbs and perennial grasses are present. The dominant shrubs include shinnery oak (*Quercus havardii*), mesquite (*Prosopis glandulosa*), sand sagebrush (*Artemisia filifolia*), dune yucca (*Yucca campestris*), and smallhead snakeweed (*Gutierrezia* *microcephala*) (DOE 1980, 1997). Russian thistle (*Salsola kali*) is a nonnative species that is commonly established in disturbed areas (DOE 1980).

More than 45 mammal species (including 15 bat species) occur within Lea and Eddy counties, with 39 species occurring in the WIPP site area (DOE 1980). Mule deer (*Odocoileus hemionus*), pronghorn (*Antilocapra americana*), and coyote (*Canis latrans*) are among the larger mammals found in the area (DOE 1980, 1997).

More than 120 species of birds have been documented on or near the WIPP site (DOE 1980). Common bird species include the loggerhead shrike (*Lanius ludovicianus*), pyrrhuloxia (*Cardinalis sinatus*), and black-throated sparrow (*Amphispiza bilineata*) (DOE 1997). The availability of nesting sites may limit bird populations in the project area (DOE 1980).

Twenty-three reptile and 10 amphibian species occur in the area (DOE 1980, 1993). Most desert amphibians are generally seen only following spring or summer rains (DOE 1993).

4.2.5.2 Wetlands

No wetlands occur on the WIPP site or in the immediate vicinity of the site.

4.2.5.3 Aquatic Resources

The two-county region lies within the drainage basin of the Pecos River. However, the only permanent aquatic habitats near the WIPP site include earthen watering ponds for livestock (DOE 1997). These man-made livestock watering holes, which are not hydrologically connected to the formations overlying the WIPP site, are located several miles way (DOE 2007). Two salt pile evaporation ponds, a detention basin, and two man-made ponds occur within the developed portions of the WIPP site. However, these ponds do not provide productive aquatic habitats.

4.2.5.4 Threatened and Endangered Species

The endangered, threatened, and other special status species reported from the area of Eddy and Lea counties, including the WIPP Vicinity reference locations, are listed in Table 4.2.5-1. (Special status aquatic species and species that primarily occur near major aquatic habitats are not included because no aquatic habitats in which those species occur are located near the WIPP site.) None of the species listed in Table 4.2.5-1 were observed within the WIPP LWB in 1996, and there is no designated critical habitat for federally listed species at the WIPP site (DOE 1997). Critical habitat for the gypsum wild-buckwheat (*Eriogonom gypsophilum*) is more than 48 km (30 mi) from the WIPP site. Favorable habitat for the lesser prairie-chicken (*Tympanuchus pallidicinctus*), a Federal candidate species, does occur within the WIPP LWB and other surrounding areas (DOE 2007). WIPP employees have instituted measures, in consultation with BLM, to protect the lesser prairie-chicken and its habitat. These measures

TABLE 4.2.5-1 Federally and State-Listed Species Potentially Occurring at the WIPP Site

Common Name	Scientific Name	Federal Status	State Status
Plants			
Gypsum wild-buckwheat	*Eriogonom gypsophilum*	Threatened	Endangered
Hershey's cliff daisy	*Chaetopappa hersheyi*		Species of Concern
Kuenzler hedgehog cactus	*Echinocereus fendleri* var. *kuenzleri*	Endangered	Endangered
Lee's pincushion cactus	*Escobaria sneedii* var. *leei*	Threatened	Endangered
Glass Mountain coral-root	Hexalectris nitida		Endangered
Sneed pincushion cactus	*Coryphantha sneedii* var. *sneedii*	Threatened	Endangered
Guadalupe jewelflower	*Streptanthus sparsiflorus*		Species of Concern
Wright's water-willow	*Justicia wrightii*		Species of Concern
Birds			
American peregrine falcon	*Falco peregrinus anatum*		Threatened
Arctic peregrine falcon	*Falco peregrinus tundrius*		Threatened
Baird's sparrow	*Ammodramus bairdi*		Threatened
Least tern (interior population)	*Sterna antillarum athalassos*	Endangered	Endangered
Lesser prairie-chicken	*Tympanuchus pallidicinctus*	Candidate	
Southwestern willow flycatcher	*Empidonax traillii extimus*	Endangered	Endangered
Sprague's pipit	*Anthus spragueii*	Candidate	
Mammals			
Black-footed ferret	*Mustela nigripes*	Endangered	

Source: BISON (2012); NMRPTC (2012); USFWS (2012)

include the establishment of periods during which off-site field activities may not be performed during the species' breeding season (DOE 2007).

4.2.6 Socioeconomics

Socioeconomic data for WIPP describe an ROI surrounding the site composed of two counties: Eddy County and Lea County, New Mexico. The majority of WIPP workers reside in these counties (DOE 1997).

4.2.6.1 Employment

In 2011, total employment in the ROI stood at 55,331 (U.S. Department of Labor 2012). Employment grew at an annual average rate of 2.4% between 2002 and 2011. The economy of the ROI is dominated by the mining, trade, and service industries, with employment in these activities currently contributing almost 72% of all employment (see Table 4.2.6-1). The WIPP annual budget accounts for 1,095 full-time employees (Sandia 2008a).

TABLE 4.2.6-1 WIPP: County and ROI Employment by Industry in 2009

	New Mexico			
Sector	Eddy County	Lea County	ROI Total	% of ROI Total
Agriculture[a]	1,009	664	1,673	4.0
Mining	3,305	3,295	6,600	15.8
Construction	1,544	2,526	4,070	9.7
Manufacturing	1,297	750	2,047	4.9
Transportation and public utilities	1,046	1,030	2,076	5.0
Trade	3,170	3,824	6,994	16.7
Finance, insurance, and real estate	758	928	1,686	4.0
Services	8,400	8,296	16,696	39.3
Other	10	10	20	0.0
Total	20,475	21,437	41,912	

[a] Source: USDA (2008).

Source: U.S. Bureau of the Census (2012a)

4.2.6.2 Unemployment

Unemployment rates have varied across the counties in the ROI (Table 4.2.6-2). Over the 10-year period 2002–2011, the average rate in Eddy County was 4.7%, with a slightly higher rate of 4.8% in Lea County. The average rate in the ROI over this period was 4.7%, slightly lower than the average rate for the state of 5.7%. Unemployment rates for 2010 were consistently higher than rates for 2011; in Lea County, the unemployment rate fell from 7.3% to 5.2%, while in Eddy County, the rate fell from 5.7% to 4.5%. The unemployment rate for the state also declined during this period, from 7.9% to 7.4%.

TABLE 4.2.6-2 WIPP: Average County, ROI, and State Unemployment Rates (%) in Selected Years

Location	2002–2011	2010	2011
Eddy County	4.7	5.7	4.5
Lea County	4.8	7.3	5.2
ROI	4.7	6.5	4.9`
New Mexico	5.7	7.9	7.4

Source: U.S. Department of Labor (2012)

4.2.6.3 Personal Income

Total personal income in the ROI stood at almost $4.3 billion in 2009, growing at an annual average rate of growth of 4.6% over the period 2000 to 2009 (Table 4.2.6-3). ROI personal income per capita also rose over the same period, reaching $38,507 in 2009, compared to $27,118 in 2000. Per-capita incomes were higher in Eddy County ($40,609 in 2009) than elsewhere in the ROI.

TABLE 4.2.6-3 WIPP: County, ROI, and State Personal Income in Selected Years

Location	2000	2009	Average Annual Growth Rate (%), 2000–2009
Eddy County			
Total personal income (2011 $ in billions)	1.4	2.1	4.5
Personal income per capita (2011 $)	27,892	40,609	4.3
Lea County			
Total personal income (2011 $ in billions)	1.5	2.2	4.7
Personal income per capita (2011 $)	26,398	36,667	3.7
ROI total			
Total personal income (2011 $ in billions)	2.9	4.3	4.6
Personal income per capita (2011 $)	27,118	38,507	4.0
New Mexico			
Total personal income (2011 $ in billions)	54.1	70.1	2.9
Personal income per capita (2011 $)	29,748	34,880	1.8

Source: DOC (2012)

4.2.6.4 Population

The population of the ROI was 118,556 in 2010 (U.S. Bureau of the Census 2012b) and was expected to reach 121,020 by 2012 (Table 4.2.6-4). In 2010, 64,727 people were living in Lea County (55% of the ROI total). Over the period 2000 to 2010, the population in the ROI as a whole grew slightly, with an average growth rate of 1.0%, while the population in New Mexico as a whole grew at a rate of 1.2% over the same period.

4.2.6.5 Housing

Housing stock in the ROI as a whole grew at an annual rate of 0.4% over the period 2000 to 2010 (Table 4.2.6-5), with 47,504 housing units in the ROI in 2010. A total of 1,850 new units were added to the existing housing stock in the ROI between 2000 and 2010. In 2010, 4,857 vacant housing units were available in the ROI, of which 1,409 were rental units that could be available to construction workers at the GTCC proposed facility.

4.2.6.6 Fiscal Conditions

Further construction and operations at WIPP for GTCC LLRW and GTCC-like waste disposal would result in continued expenditures for local government jurisdictions, including counties, cities, and school districts. Table 4.2.6-6 presents information on expenditures by the various local government jurisdictions and school districts in the ROI.

TABLE 4.2.6-4 WIPP: County, ROI, and State Population in Selected Years

Location	1990	2000	2010	Average Annual Growth Rate (%), 2000–2010	2012[a]
Eddy County	48,605	51,658	53,829	0.4	54,274
Lea County	55,765	55,511	64,727	1.5	66,746
ROI total	104,370	107,169	118,556	1.0	121,020
New Mexico	1,521,574	1,818,046	2,059,179	1.2	2,110,883

[a] Argonne National Laboratory projections.

Source: U.S. Bureau of the Census (2012b)

TABLE 4.2.6-5 WIPP: County and ROI Housing Characteristics in Selected Years

Type of Housing	2000	2010
Eddy County		
Owner occupied	14,391	14,844
Rental	4,988	5,567
Vacant units	2,870	2,174
Total units	22,249	22,585
Lea County		
Owner occupied	14,301	15,434
Rental	5,398	6,802
Vacant units	3,706	2,683
Total units	23,405	24,919
ROI		
Owner occupied	28,692	30,278
Rental	10,386	12,369
Vacant units	6,576	4,857
Total units	45,654	47,504

Source: U.S. Bureau of the Census (2012b)

TABLE 4.2.6-6 WIPP: County, ROI, and State Public Service Expenditures in 2006 ($ 2011 in millions)[a]

Location	Local Government	School Districts
Eddy County	33.6	53.0
Lea County	76.0	54.0
ROI	109.6	107.0
New Mexico	7,536	2,789

[a] Argonne National Laboratory projections.

4.2.6.7 Public Services

Further construction and operations at WIPP would continue the demand for employment to provide public safety, fire protection, and community and educational services in the counties, cities, and school districts likely to host relocating construction workers and operations employees. Demands would also continue on local physician services. Table 4.2.6-7 presents data on employment and levels of service (number of employees per 1,000 population) for public safety and general local government services. Table 4.2.6-8 provides staffing and level-of-service data for school districts. Table 4.2.6-9 provides data on medical employment.

4.2.7 Environmental Justice

Figures 4.2.7-1 and 4.2.7-2 and Table 4.2.7-1 show the minority and low-income compositions of the total population located in the 80-km (50-mi) buffer around WIPP from Census data for the year 2010 and CEQ guidelines (CEQ 1997). Persons whose incomes fall below the federal poverty threshold are designated as low income. Minority persons are those who identify themselves as Hispanic or Latino, Asian, Black or African American, American Indian or Alaska Native, Native Hawaiian or other Pacific Islander, or multi-racial (with at least one race designated as a minority race under CEQ). Individuals identifying themselves as Hispanic or Latino are included in the table as a separate entry. However, because Hispanics can be of any race, this number also includes individuals who also identify themselves as being part of one or more of the population groups listed in the table.

A large number of minority and low-income individuals are located in the 50-mi (80-km) area around the boundary of the reference location. Within the 50-mi (80-km) radius in New Mexico, 53.0% of the population is classified as minority, while 15.5% is classified as low income. Although the number of minority individuals does not exceed the state average by 20 percentage points or more, the number of minority individuals exceeds 50% of the total population in the area; that is, there is a minority population in the New Mexico portion of the 50-mi (80-km) area based on 2010 Census data and CEQ guidelines. The number of low-income

TABLE 4.2.6-7 WIPP: County, ROI, and State Public Service Employment in 2009

	Eddy County		Lea County	
Service	No.	Level of Service[a]	No.	Level of Service[a]
Police protection	46	0.9	43	0.7
Fire protection[b]	64	1.2	90	1.5

	ROI		New Mexico[c]	
Service	No.	Level of Service[a]	No.	Level of Service[a]
Police protection	89	0.8	3,882	2.0
Fire protection	154	1.4	2,121	1.1

a Level of service represents the number of employees per 1,000 persons.

b Does not include volunteers.

c 2006 data.

Sources: U.S. Bureau of the Census (2008a,b, 2012b,c); FBI (2012); Fire Departments Network (2012)

TABLE 4.2.6-8 WIPP: County, ROI, and State Education Employment in 2011

County	No. of Teachers	Level of Service[a]
Eddy County	663	15.5
Lea County	820	15.7
ROI total	1,483	15.6
New Mexico	22,457	14.8

a Level of service represents the number of teachers per 1,000 persons in each county.

Sources: National Center for Educational Statistics (2012); U.S. Bureau of the Census (2012a,b)

TABLE 4.2.6-9 WIPP: County, ROI, and State Medical Employment in 2010

County	No. of Physicians	Level of Service[a]
Eddy County	77	1.4
Lea County	69	1.1
ROI total	146	1.2
New Mexico	4,421	2.3

a Level of service represents the number of physicians per 1,000 persons in each county.

Sources: AMA (2012); U.S. Bureau of the Census (2008b, 2012b)

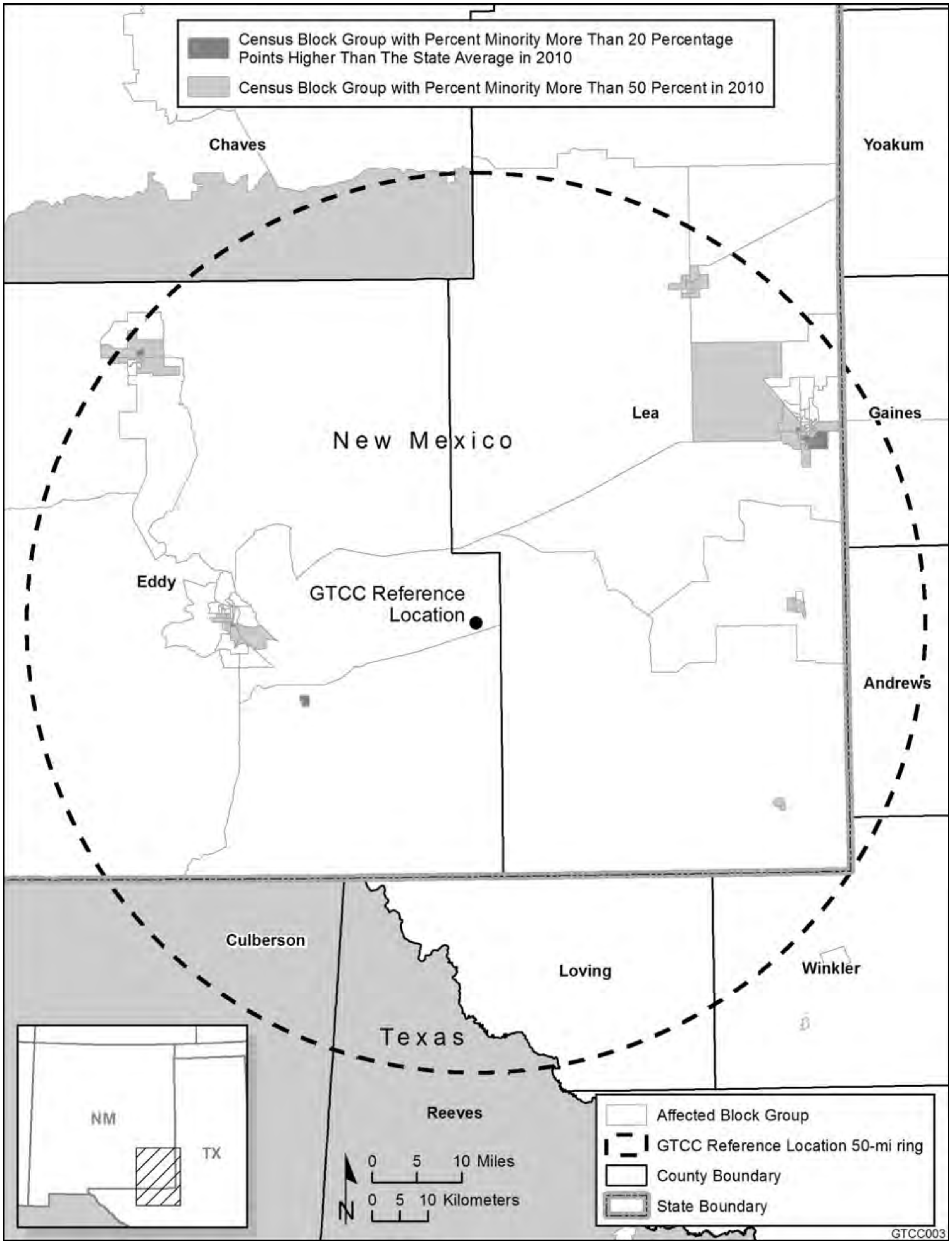

FIGURE 4.2.7-1 Minority Population Concentrations in Census Block Groups within an 80-km (50-mi) Radius of the WIPP Site (Source: U.S. Bureau of the Census 2012b)

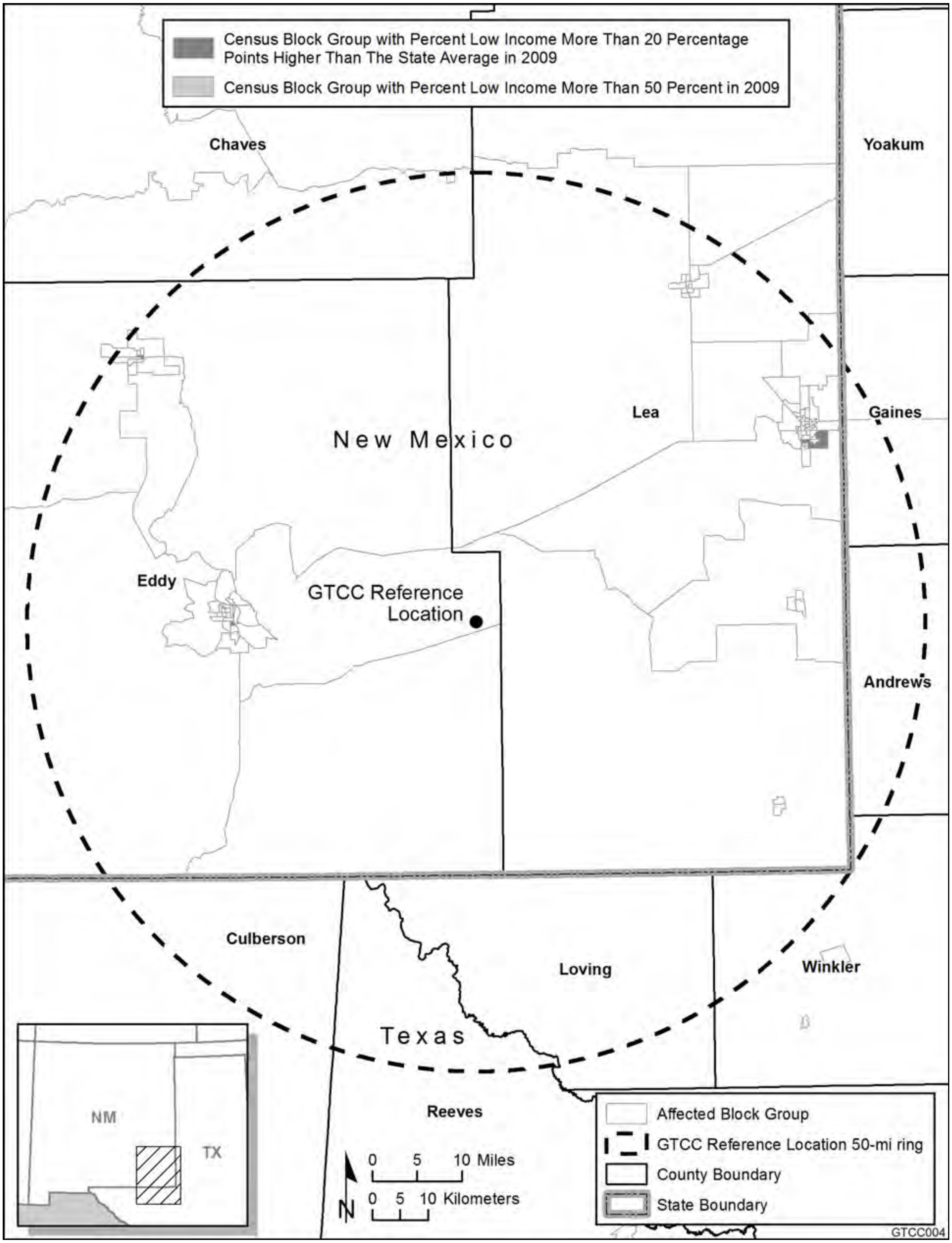

FIGURE 4.2.7-2 Low-Income Population Concentrations in Census Block Groups within an 80-km (50-mi) Radius of the WIPP Site (Source: U.S. Bureau of the Census 2012b)

TABLE 4.2.7-1 Minority and Low-Income Populations in an 80-km (50-mi) Radius of WIPP

Population	New Mexico Block Groups	Texas Block Groups
Total population	119,260	12,723
White, Non-Hispanic	56,083	6,955
Hispanic or Latino	57,355	5,025
Non-Hispanic or Latino minorities	5,822	743
One race	4,664	683
Black or African American	2,983	554
American Indian or Alaskan Native	907	31
Asian	624	69
Native Hawaiian or other Pacific Islander	33	1
Some other race	117	28
Two or more races	1,158	60
Total minority	63,177	5,768
Percent minority	53.0%	45.3%
Low-income	6,299	349
Percent low-income	15.5%	15.4%
State percent minority	59.5%	54.7%
State percent low-income	18.0%	17.2%

Source: U.S. Bureau of the Census (2012b)

individuals does not exceed the state average by 20 percentage points or more and does not exceed 50% of the total population in the area; that is, there are no low-income populations in the New Mexico portion of the 50-mi (80-km) area around the reference location as a whole.

Within the 50-mi (80-km) radius in Texas, 45.3% of the population is classified as minority, while 15.4% is classified as low income. The number of minority individuals does not exceed the state average by 20 percentage points or more, and the number of minority individuals does not exceed 50% of the total population in the area; that is, there is no minority population in the Texas portion of the 50-mi (80-km) area as a whole area based on 2010 Census data and CEQ guidelines. The number of low-income individuals does not exceed the state average by 20 percentage points or more and does not exceed 50% of the total population in the area; that is, there are no low-income populations in the Texas portion of the 50-mi (80-km) area around the reference location as a whole.

4.2.8 Land Use

There are four property areas defined within the 4,146-ha (10,240-ac) WIPP site (Figure 4.2.8-1):

- *Property Protection Area*. This is the 14-ha (35-ac) interior core of the site that is surrounded by a chain-link fence. It is under tight, 24-hour security.

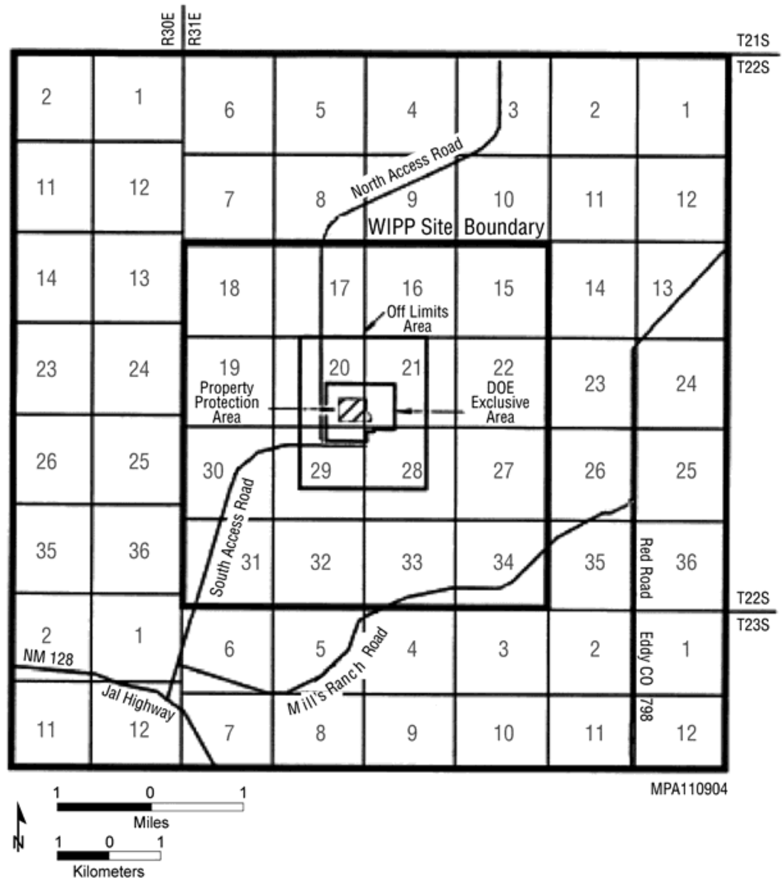

FIGURE 4.2.8-1 Four Property Areas within the WIPP Boundary (Source: DOE 1997)

- *Exclusive Use Area*. This 112-ha (277-ac) area is surrounded by a barbed-wire fence and restricted for the exclusive use of DOE and its contractors and subcontractors in support of the project. The area is marked with "no trespassing" signs and is patrolled by WIPP security personnel.

- *Off-Limits Area*. This is a 588-ha (1,454-ac) area where unauthorized entry and introduction of weapons and/or dangerous materials are prohibited. Prohibition signs are posted at consistent intervals along its perimeter. Unless they pose a threat to security, safety, or the environmental quality of the WIPP site, grazing and public thoroughfares can occur in this area. This area is patrolled by WIPP security personnel to prevent unauthorized activities or use.

- *WIPP LWB*. This 4,146-ha (10,240-ac) area delineates the perimeter of the WIPP site. This boundary was established to extend at least 1.6 km (1.0 mi) beyond any WIPP underground development.

Except for the facilities within the boundaries of the posted 112-ha (277-ac) Exclusive Use Area, surface land use remains largely unchanged from its pre-1992 multiple land use designation. Those who wish to conduct activities that might affect lands that are under the jurisdiction of WIPP but outside the Property Protection Area are required by the WIPP Land Management Plan (LMP) to prepare a land use request (DOE 2007). Mining and drilling for reasons other than to support WIPP activities are prohibited within the WIPP site except at two 129-ha (320-ac) tracts of land within the WIPP LWB that are leased for oil and gas development. These adjoining lease tracts occupy Section 31 in the far southwest corner of the WIPP site (DOE 1993).

Portions of two grazing allotments administered by BLM (DOE 1993) occur within the WIPP site boundary. Nearly 5.2% of one 22,493-ha (55,581-ac) allotment overlaps the WIPP site but does not include areas that are posted “no trespassing.” About 9.5% of the other 31,393-ha (77,574-ac) grazing allotment overlaps the remainder of the WIPP site boundary, including the Exclusive Use Area that is posted against trespassing and fenced to prevent grazing (DOE 1993).

The WIPP LMP focuses on management protocols for the following: administration of the plan, environmental compliance, wildlife, cultural resources, grazing, recreation, energy and mineral sources, land and realty, reclamation, security, industrial safety, emergency management, maintenance, and work control (DOE 1993).

Most land in the vicinity of the WIPP site is managed by BLM. Land use in the surrounding area includes livestock grazing, potash mining, oil and gas development, and recreation (e.g., hunting, camping, hiking, off-highway vehicle operation, horseback riding, and bird watching) (DOE 1993, 2007). The dominant land use in the WIPP vicinity is for cattle grazing; smaller amounts of land are used for oil and gas extraction and potash mining. There is little privately owned land near WIPP, although two ranches are located within 16 km (10 mi) of the site (DOE 1997). The only agricultural land within 48 km (30 mi) is irrigated farmland along the Pecos River, near the municipalities of Carlsbad and Loving. Little, if any, dry-land farming takes place near WIPP (DOE 1980).

The region is popular for recreation, providing opportunities for hunting, camping, hiking, and bird watching. The area has a very low population density, and there are approximately 25 residents at various locations within 16 km (10 mi) of the site. The nearest community is the village of Loving, New Mexico, which is located 29 km (18 mi) west-southwest of WIPP. This community has an estimated population of about 1,300 residents.

4.2.9 Transportation

The WIPP site can be reached by rail or highway. Rail access to WIPP is provided by a rail line connecting with a spur of the Burlington Northern Santa Fe (BNSF) Railroad near the Mosaic Potash Nash Draw Mine, 9.6 km (6 mi) southwest of the site. The rail line includes an adjacent service road. The railroad and service road were constructed on an easement width of 46 m (150 ft).

The WIPP site can also be accessed by the North and South Access Roads constructed for the WIPP project (Figure 4.2.9-1). The WIPP LMP (DOE 1993) gives information about the aboveground infrastructure at WIPP. Realty components originally constructed and currently maintained and/or utilized in the operation of WIPP that are under custodial right-of-way (ROW) reservations include, but are not limited to, the North Access Road, South Access Road, and the Access Railroad (DOE 2002). The ROWs, corridors, and realty components are shown in Figure 4.2.9-1.

4.2.9.1 North Access Road

The North Access Road is a private road granted, for perpetuity, under ROW Reservation NM 55676 on August 24, 1983. The North Access Road is approximately 21 km (13 mi) in length, with an easement width of 37 m (120 ft). Use of this road is restricted to DOE personnel, agents, and contractors of DOE on official business related to the WIPP project or to BLM personnel, permittees, licensees, or lessees. Signs are placed and maintained at the turnout of US 62/180 stating the restrictions on access. Persons desiring access to Highway 128 can use Lea County Line Road immediately to the east. ROW Reservation NM 55676 was amended on April 22, 1988, to facilitate the construction of livestock fencing along either side of the subject road.

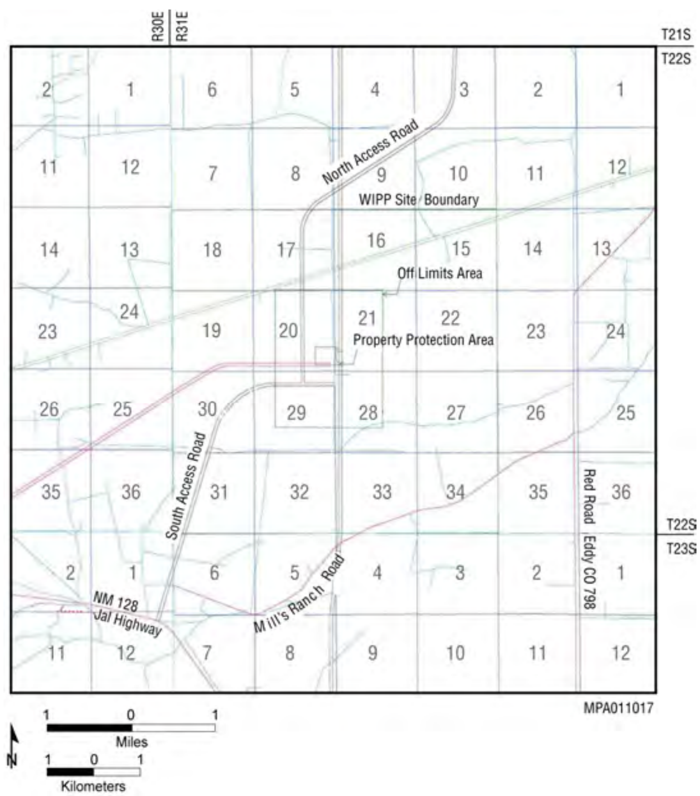

FIGURE 4.2.9-1 Access and Rights-of-Way for the WIPP Site (Source: DOE 2002)

4.2.9.2 South Access Road

The South Access Road, formerly Eddy County Road 802, is a private road granted under ROW Reservation NM 123703. Terms for the ROW expire on December 31, 2039, and terms are subject to renewal. The South Access Road is approximately 6.4 km (4 mi) in length, with an easement width of 43 m (140 ft). On January 27, 2010, Eddy County relinquished ROW NM 46130 that was held by the County for Eddy County Road 802. Multiple-use access for the South Access Road will be allowed unless it is determined that access by industry or the general public represents a significant safety risk to WIPP personnel or to the public. Upon determination, general access of the South Access Road may be restricted at the boundary of the 580-ha (1,450-ac) Off-Limits Area in accordance with DOE Manual 470.4-2, "Physical Protection" (DOE 2005).

4.2.9.3 Access Railroad

Rail access to the WIPP site is possible by a rail line connecting with a spur of the BNSF Railroad near the Mosaic Nash Draw Mine 9.7 km (6 mi) southwest of the site. This section of rail, which was constructed under the auspices of ROW Reservation NM 55699 granted on September 27, 1983, is approximately 8 km (5 mi) in length. It consists of an adjacent frontage road in addition to the rail. Both the railroad and service road were constructed on an easement width of 46 m (150 ft).

4.2.10 Cultural Resources

From about 10,000 B.C. to the late 1800s, southeastern New Mexico was inhabited by aboriginal hunters and gatherers who subsisted on various wild plants and animals. In the late 1800s, the region was settled by ranchers and farmers. Known archeological sites in the vicinity of WIPP are primarily the remains of prehistoric camps and short-term settlements. These areas are generally marked by hearth features, scattered burned rock, flaked stone projectile points, and cutting and scraping tools, pottery fragments, and ground stone implements. Locations generally represent short-term, seasonal occupations by small, nomadic groups of hunters and gatherers who used the plants and animals in the dune lands east of the Pecos River. In a few cases, sites with evidence of structures have been reported, probably associated with occupations of several weeks to months.

Historic remains or features (more than 50 years old) are rare but have occasionally been identified. These include features and debris related to yearly ranching in the twentieth century, including fences that may still be in use. The majority of historic sites identified to date include elements that could contribute to their eligibility for the NRHP.

With few exceptions, cultural resources known or anticipated in the area covered by the WIPP LWB are significant; they must be identified, recorded, assessed through an inventory, and considered in any plan of development for the area. When compared with most other portions of southeastern New Mexico, the locations (and nature) of cultural resources within the WIPP LWB can be described relatively well on the basis of an intensive inventory of portions of the area, limited excavation, and other investigative work on some sites.

Several surveys have been completed in the WIPP LWB, and 59 archeological sites and 91 isolated occurrences (single artifact or only a few artifacts, or isolated features that can be fully recorded in the field) have been identified to date. The sites and isolates identified are almost exclusively prehistoric. Only one site with both prehistoric and historic components was noted. Approximately 37% of the area within the WIPP LWB has been inventoried for cultural resources. Extrapolating the current number of resources located to date to the rest of the (unsurveyed) area indicates that about 99 additional sites and 153 isolates could be present at the site. The land within the WIPP LWB appears to represent a potentially significant contributor of cultural resources and should be regarded as such when land management decisions are made (DOE 2002).

4.2.11 Waste Management

Support structures at the WIPP facility used to manage waste generated from facility operations include a sewage treatment system. The sewage treatment system at WIPP is a zero-discharge facility consisting of two primary settling lagoons, two polishing lagoons, a chlorination system, and four evaporation basins. The facility is designed to dispose of domestic sewage and site-generated brine waters from observation well pumping and from underground dewatering activities at WIPP (Sandia 2008a).

4.3 ENVIRONMENTAL AND HUMAN HEALTH CONSEQUENCES

As described previously, this alternative involves the construction of up to 26 additional underground rooms for emplacement of GTCC LLRW and GTCC-like waste at WIPP. This activity is the focus of the evaluation of potential consequences discussed here in Section 4.3.

4.3.1 Air Quality and Noise

This section describes potential air quality and noise impacts from the construction of additional rooms and waste disposal operations at WIPP. It is assumed that all the current aboveground facilities would be adequate for the surface handling and waste packaging that would be needed to prepare the wastes for transfer underground (Sandia 2008a). Thus, the only additional construction that would be needed to accommodate wastes would be to create the underground disposal space at WIPP. Construction and operational equipment and resources currently in use at WIPP would be employed.

4.3.1.1 Air Quality

4.3.1.1.1 Construction. There are two potential sources of air pollutant emissions from construction: (1) aboveground activities (e.g., emissions from haul trucks; from stockpiling at the Salt Storage Area; and from commuter, delivery, and support vehicles) and (2) underground activities (e.g., emissions from haul trucks and salt mining that would be released through the exhaust shaft). No air emissions are expected from electric-driven equipment, such as the continuous miner, salt hoist, and ventilation fans. Sources of emissions of criteria pollutants (e.g., SO_2, NO_x, CO, PM_{10}, and $PM_{2.5}$), VOCs, and the primary greenhouse gas CO_2 during the construction period would include fugitive dust and engine exhaust emissions from these activities.

Air emissions of criteria pollutants, VOCs, and CO_2 from construction activities are estimated for the average year, as shown in Table 4.3.1-1. Detailed information on emission factors, assumptions, and emission inventories is given in Appendix D. As shown in the table, total average yearly emission rates would be small when compared with emission totals for Eddy County, which encompasses WIPP. In terms of contribution to the total emissions, the highest average yearly emissions of $PM_{2.5}$ would be from salt mining activities, at about 0.030% of the total emissions.

Background concentration levels for PM_{10} and $PM_{2.5}$ at the WIPP site are well below the standards, less than 59% of NAAQS and SAAQS; PM_{10} and $PM_{2.5}$ estimates include diesel particulate emissions (see Table 4.2.1-2). All construction activities would occur about 3 km (2 mi) from the site boundary and thus would not contribute much to concentrations at the site boundary or the nearest residence. Construction activities would be conducted so as to minimize potential impacts of construction-related emissions on ambient air quality. Also, construction permits typically require fugitive dust control by established standard dust control practices (primarily by watering unpaved roads, disturbed surfaces, and temporary stockpiles); and by implementing other recognized practices (e.g., temporary wind breaks, slowing down or stopping construction during high wind events).

Although O_3 levels in Carlsbad (about 42 km [26 mi] west of the WIPP site) exceeded the standard (see Table 4.2.1-2), Eddy County, including the WIPP site, is currently in attainment for O_3 (40 CFR 81.332). The WIPP site is located far from any major cities, and O_3 precursor emissions from waste disposal at WIPP would be relatively small, less than 0.017% and 0.005% of county total NO_x and VOC emissions, respectively. These emissions would be much lower than those for the regional air shed in which emitted precursors are transported and formed into O_3. Accordingly, potential impacts of O_3 precursor releases from construction on regional O_3 would not be of concern.

The major air quality concern with respect to emissions of CO_2 is that it is a greenhouse gas, which traps solar radiation reflected from the earth, keeping it in the atmosphere. The combustion of fossil fuels makes CO_2 the most widely emitted greenhouse gas worldwide. CO_2 concentrations in the atmosphere continuously increased from approximately 280 parts per

TABLE 4.3.1-1 Average Annual Emissions of Criteria Pollutants, Volatile Organic Compounds, and Carbon Dioxide from Construction under Alternative 2

Pollutant	Total Emissions (tons/yr)[a]	Construction Emissions (tons/yr)	
SO_2	7,783	0.23	(0.003)[b]
NO_x	8,437	1.4	(0.017)
CO	25,725	0.97	(0.004)
VOCs	8,222	0.14	(0.002)
PM_{10}[c]	27,327	1.8	(0.007)
$PM_{2.5}$[c]	4,744	1.4	(0.03)
CO_2		190	
County[d]	1.85×10^6		(0.010)
New Mexico[e]	6.50×10^7		(0.0003)
U.S.[e]	6.54×10^9		(0.000003)
Worldwide[e]	3.10×10^{10}		(0.000001)

[a] Total emissions in 2002 for Eddy County, in which WIPP is located. See Table 4.2.1-1 for criteria pollutants and VOCs.

[b] As percent of total emissions.

[c] Estimates for GTCC construction include diesel particulate emissions.

[d] Emission data for the year 2005. Currently, data on CO_2 emissions at the county level are not available, so county-level emissions were estimated from available state total CO_2 emissions on the basis of population distribution.

[e] Annual CO_2 emissions in New Mexico, the United States, and worldwide in 2005.

Sources: EIA (2008); EPA (2008b, 2009)

million (ppm) in preindustrial times to 379 ppm in 2005, a 35% increase. Most of this increase has occurred in the last 100 years (IPCC 2007).

Because CO_2 is stable in the atmosphere and is essentially uniformly mixed, its climatic impact does not depend on the geographic location of sources; that is, the global total is the important factor with respect to global warming. Therefore, a comparison between U.S. and global emissions and the total emissions from the construction of a disposal facility is useful in understanding whether CO_2 emissions from the site are significant with respect to global warming. As shown in Table 4.3.1-1, CO_2 emissions from construction would be less than 0.010%, 0.0003%, and 0.000003%, respectively, of 2005 county, state, and U.S. CO_2 emissions. In 2005, CO_2 emissions in the United States were about 21% of worldwide emissions

(EIA 2008). The potential impacts from construction emissions on climate change would be small.

Construction activities would occur only during daytime hours when air dispersion is most favorable. Accordingly, potential impacts from construction activities on ambient air quality would be minor and intermittent in nature.

General conformity applies to federal actions taking place in nonattainment or maintenance areas and would not be applicable to the disposal of GTCC LLRW and GTCC-like wastes at the WIPP site because the area is classified as being in attainment for all criteria pollutants (40 CFR 81.332).

4.3.1.1.2 Operations. As was the case for construction, criteria pollutants, VOCs, and CO_2 would be released into the atmosphere during operations. These emissions would result primarily from exhaust emissions from heavy equipment, such as forklifts and the waste transporter, both aboveground and underground. Estimated peak-year emissions of criteria pollutants, VOCs, and CO_2 for the WIPP alternative are presented in Table 4.3.1-2. Detailed information on emission factors, assumptions, and emission inventories is available in Appendix D. As shown in the table, annual emissions from operations are estimated to be higher than those from construction, except for PM_{10}, $PM_{2.5}$, and NO_x emissions. Compared with annual emissions for Eddy County, the peak-year emissions of NO_x are the highest, about 0.031% of the total emission.

Because of the distance from the source to the boundary (about 3 km [2 mi]), emissions (including diesel particulate emissions) from operational activities would not contribute much to concentrations at the site boundary or the nearest residence. Therefore, it is expected that, except for O_3, concentration levels from operational activities would remain well below the NAAQS.

With regard to regional O_3, precursor emissions of NO_x and VOCs would be lower from operations than from construction (0.031% and 0.003% of the total county emissions, respectively). It is not anticipated that they would contribute much to regional O_3 levels. CO_2 emissions would be about 0.016% of the Eddy County emissions; thus, the potential impact on climate change would also be negligible.

PSD regulations are not applicable to waste disposal at WIPP because WIPP is not a major stationary source. In addition, general conformity, which applies only to federal actions taking place in a nonattainment or maintenance area, is also not applicable to the proposed action.

4.3.1.2 Noise

4.3.1.2.1 Construction. The only construction activities at WIPP would involve salt mining, and no site clearing and building construction are anticipated, as discussed in

TABLE 4.3.1-2 Peak-Year Emissions of Criteria Pollutants, Volatile Organic Compounds, and Carbon Dioxide from Operations under Alternative 2

Pollutant	Total Emissions (tons/yr)[a]	Operation Emissions (tons/yr)	
SO_2	7,783	0.48	(0.006)[b]
NO_x	8,437	2.6	(0.031)
CO	25,725	0.56	(0.002)
VOCs	8,222	0.23	(0.003)
PM_{10}[c]	27,327	0.24	(0.001)
$PM_{2.5}$[c]	4,744	0.22	(0.005)
CO_2		290	
County[d]	1.85×10^6		(0.016)
New Mexico[e]	6.50×10^7		(0.001)
U.S.[e]	6.54×10^9		(1×10^{-5})
Worldwide[e]	3.10×10^{10}		(2×10^{-6})

[a] Total emissions in 2002 for Eddy County, within which the WIPP is located. See Table 4.2.1-1 for criteria pollutants and VOCs.

[b] As percent of total emissions.

[c] Estimates for GTCC operations include diesel particulate emissions.

[d] Emission data for the year 2005. Currently, CO_2 emissions at county level are not available, so county-level emissions were estimated from available state-total CO_2 emissions on the basis of population distribution.

[e] Annual CO_2 emissions in New Mexico, the United States, and worldwide in 2005.

Source: EIA (2008); EPA (2008b,2009)

Section 4.3.1.1. For Alternative 2, the primary construction activities would include underground salt mining and stockpiling aboveground at the Salt Storage Area. Noise sources from construction activities would include those from the continuous miner, salt hoist, ventilation fans, and diesel-powered haul trucks operating aboveground and underground. The types of construction equipment and their noise levels are presented in Table 4.3.1-3.

With regard to a noise impact analysis, when a known noise-sensitive receptor (e.g., school or hospital) is adjacent to a construction project and/or stringent local ordinances or specifications apply, a detailed impact analysis is warranted. However, for a general assessment of construction, it is adequate to assume that only the two noisiest pieces of equipment would operate simultaneously in order to estimate noise levels at the nearest receptor (Hanson et al. 2006). Note that most of the activities would occur underground and would thus have a minimal

TABLE 4.3.1-3 Types of Construction Equipment and Their Typical Noise Levels at WIPP

Type of Construction Equipment	Capacity (hp)	Power	Typical Level at 15 m (50 ft) from a Source (dBA)
Continuous miner	720	Electric	74
Surface haul trucks	525	Diesel	88
Underground haul trucks	185	Diesel	84
Salt hoist	2,200	Electric	70
Ventilation fans	600	Electric	87

Sources: Barnes et al. (1977); Miller et al. (1984); Sandia (2008a); Vér and Beranek (2006); Yantek (2003)

impact on ambient noise levels. It is estimated that the highest composite noise levels from aboveground construction activities (e.g., a truck and three ventilation fans operating continuously) would be about 93 dBA at 15 m (50 ft) from the source. Considering geometric spreading only, and assuming a 10-hour daytime shift, the noise levels at a distance of 780 m (2,500 ft) from noise sources would be below the EPA guideline of 55 dBA as the L_{dn} for residential zones. This distance is well within the WIPP boundary, which is at least 3 km (2 mi) from the WIPP surface facilities, and no residential dwellings exist within this distance. The EPA guideline was established to protect against interference and annoyance due to outdoor activity (EPA 1974). Actual sound levels would be much lower because of air absorption and ground effects due to terrain and vegetation. Accordingly, noise from construction activities would be barely discernible or completely inaudible at the site boundaries and the nearest residences.

Most of these construction activities would occur during the day, when noise is tolerated better than at night because of the masking effects of background noise. Nighttime noise levels would drop to the background levels of a rural environment because construction activities would cease at night.

Construction activity could result in various degrees of ground vibration, depending on the equipment and construction methods used. Activities that typically generate the most severe vibrations are the detonation of high explosives and impact pile driving. All construction equipment causes ground vibration to some degree, but the vibration diminishes in strength with distance. For example, the vibration level at receptors beyond 70 m (230 ft) from a vibratory roller (94 VdB at 7.6 m [25 ft]) would diminish below the threshold of perception for humans and interference with vibration-sensitive activities, which is around 65 VdB (Hanson et al. 2006). During the construction phase, no major construction equipment that could cause ground vibration would be used, and no sensitive structures are located nearby. Therefore, there would be no adverse vibration impacts from construction activities at the WIPP site.

4.3.1.2.2 Operations. During the operations phase, noise-generating activities within the WIPP site would include those from the primary activities of receiving, handling, and emplacing waste packages, and many of the activities would occur underground.

During facility operation, the operation of heavy equipment (e.g., a 41-ton forklift and three ventilation fans running continuously) would generate a combined noise level of about 92 dBA at a distance of 15 m (50 ft) from noise sources. This level would be 1 dB lower than the level during construction. On the basis of the same assumptions for construction, the noise level at a distance of 700 m (2,300 ft) from noise sources would be below the EPA guideline of 55 dBA as the L_{dn} for residential zones. This distance is well within the WIPP boundary, which is at least 3 km (2 mi) from the WIPP surface facilities, and no residential locations exist within this distance. Accordingly, noise from operational activities would be barely discernable or completely inaudible at the site boundaries and the nearest residences.

4.3.2 Geology and Soils

To emplace GTCC LLRW and GTCC-like waste at WIPP, additional underground disposal rooms would be needed. It is assumed that the GTCC LLRW and GTCC-like waste would be disposed of in underground waste disposal rooms similar (if not identical) to those currently used for the disposal of TRU waste, and that this waste would be emplaced in disposal rooms adjacent to those currently planned for the WIPP repository. Because the room construction would involve the same techniques as those employed to develop the existing repository, geologic impacts would be the same as the impacts produced by historical construction activities, which were small.

4.3.3 Water Resources

Direct and indirect impacts on water resources at the WIPP repository could result from the construction of the additional rooms and the waste disposal operations carried out to emplace the GTCC LLRW and GTCC-like waste inventory. Impacts from post-closure would not differ from any current impacts associated with the repository.

4.3.3.1 Construction

Construction of the additional 26 rooms at the WIPP repository would require about 460,000 L/yr (120,000 gal/yr) of water, assuming that water usage is 65,000 L (17,000 gal) per allocated WIPP disposal room and that about seven rooms or one panel can be constructed in a given year (Sandia 2008a). At the WIPP site, all water needs are met by using groundwater piped from the city of Carlsbad's water supply system. The Carlsbad Double Eagle South Well Field, which supplies water to WIPP, has an annual water production of about 1.4 billion L (360 million gal). Construction activities to accommodate GTCC LLRW and GTCC-like waste disposal at the WIPP repository would increase the site's annual water use (20 million L or 5.4 million gal) by about 2% and increase production at the South Well Field by about 0.03%.

Although construction water would be obtained from the Double Eagle water system, which was operating continuously in 2004, the increased demand would be easily accommodated. Similarly, the 61-cm (24-in.) pipeline that carries water from the Double Eagle water system to WIPP would be able to transport the increased water effectively. Increased water demand could slightly lower the existing water table below the Double Eagle South Well Field. However, because the increased water demand would be very small, impacts on the water table's elevation and the direction of groundwater flow would be negligible.

Construction activities for the additional rooms at the WIPP repository would not disturb the ground surface. Because no land surfaces would be disturbed during construction, there would be no impacts on either surface water or groundwater resources. Similarly, there would be no impacts on surface water or groundwater quality during construction because there would be no liquid wastes produced, and underground spills would be limited to the interior of the repository, where timely and effective cleanup would occur.

4.3.3.2 Operations

In the peak operational year, GTCC LLRW and GTCC-like waste shipments would be equivalent to the entire annual level of waste shipments that are currently handled at WIPP; as such, it is assumed that the quantity of water is the same amount used currently for WIPP operations, which is approximately 20 million L/yr (5.4 million gal/yr). Because the amount of water that would be used annually would be the same as the amount that is currently used, there would be no net increase in water use at the site and no additional water demand on the Double Eagle water supply system.

Nonhazardous liquids generated during waste disposal operations would be disposed of at on-site sanitary lagoons. Because of the dry climate, high rate of evaporation, size of the ponds (on the order of acres), and small volume of discharged water, impacts on groundwater resources would be negligible.

4.3.4 Human Health

The human health impacts assessed in this EIS for the disposal of GTCC LLRW and GTCC-like wastes at WIPP are the incremental impacts from use of this facility to dispose of these wastes. WIPP is currently being used to dispose of defense TRU wastes, and this activity is expected to continue. The human health impacts associated with current WIPP disposal operations are not included here but are addressed under cumulative impacts and in NEPA documents (e.g., DOE 1997, 1980) specifically prepared to address the construction and operation of WIPP.

For this EIS, WIPP is assumed to remain in operation for the number of years necessary to dispose of the entire volume of GTCC LLRW and GTCC-like wastes. Human health impacts are assessed for the construction, operations, and post-closure phases of this activity. Different types of hazards and potentially impacted individuals are addressed in these various phases. For this EIS, the assessment of impacts from using WIPP is limited to those associated with normal operations. The impacts from accidents at WIPP have been extensively evaluated and documented in safety analysis reports for CH and RH TRU wastes (DOE 2006c,d). The impacts from accidents involving much of the GTCC LLRW and essentially all of the GTCC-like waste (most of which meets the DOE definition of TRU waste) are addressed by those analyses. The GTCC LLRW and GTCC-like waste types that may not be explicitly covered by the two safety analysis reports are the activated metal waste from decommissioning commercial nuclear reactors and the Cs-137 sealed sources. These two waste types are LLRW and not TRU wastes. The impacts from transportation of GTCC LLRW and GTCC-like wastes to WIPP are discussed separately in Section 4.3.9.

Some of the activated metal wastes from decommissioning commercial nuclear reactors would have contact dose rates near (or possibly above) 1,000 rem/h and thus could exceed the radiation dose limits currently allowable for disposal at WIPP. Additional shielding might be required in the waste packages for certain wastes to meet the current waste disposal requirements at WIPP. It is assumed that the Cs-137 sealed sources would be disposed of in their original shielded devices, which are very robust.

Even though some of the GTCC LLRW and GTCC-like wastes may have radiation dose rates above those for the TRU wastes currently being disposed of at WIPP, the safety envelope established for CH and RH wastes in the documented safety analysis reports (DOE 2006c,d) should be adequate for disposal of this waste at WIPP. The two safety analysis reports address a number of accidents, and appropriate engineering procedures, equipment, and controls are in place to mitigate the impact of these accidents to workers and members of the general public. These accidents address those that could occur from operational errors, equipment malfunctions, severe natural phenomena, and events external to the facility. Should WIPP be identified as the preferred alternative for disposal of GTCC LLRW and GTCC-like wastes, additional analyses would be performed as appropriate to address all aspects of waste disposal operations, including those associated with potential accidents.

The most significant human health impacts during normal operations would be the radiation doses and associated health risks to workers handling the wastes. The radiation doses to off-site individuals would be very low, because the actions taken to protect workers (e.g., use of shielding and remote handling equipment) would also serve to protect any nearby members of the public. The remote setting of the facility would limit the radiological impacts on nearby off-site individuals, and many of the operations occur underground. Hence, this assessment is limited to those impacts expected to be incurred by workers.

The physical hazards to workers are considered during the construction, operations, and post-closure phases of the project. The only significant impact during the post-closure phase would be from the potential release of radioactive contaminants from the disposed-of wastes, which could reach individuals living near the site. These impacts are addressed in Section 4.3.4.3. During the operational phase, the radiation exposures of workers are considered in addition to the physical hazards associated with emplacement of the GTCC LLRW and GTCC-like wastes at WIPP.

Two types of workers are addressed in the EIS: involved workers (those directly involved in handling and disposing of the wastes at the disposal sites) and noninvolved workers (those present at the site but not directly involved in waste disposal activities). Given the physical form of the wastes, the only pathway of concern for workers during normal operations would be external gamma irradiation. This is consistent with operations to date at WIPP. It is assumed that all of the wastes would arrive at the site as solid materials that could be placed directly into the disposal facility. Any necessary waste treatment would have already occurred at the generating site or during staging of the wastes prior to their shipment, and the impacts associated with these activities are not covered in this EIS.

4.3.4.1 Construction and Operations

4.3.4.1.1 Radiological Impacts. The involved workers would incur radiation doses when they were in the general proximity of the waste containers during handling and disposal activities. The external gamma exposure rates from the GTCC LLRW and GTCC-like waste packages would cover a very wide range. The wastes addressed in this EIS would range from those that could be managed directly because they have very low exposure rates to wastes that would have to be managed by using a large amount of shielding or remote handling equipment. For purposes of analysis in this EIS, it is assumed that all wastes would be placed in shielded containers (as necessary) to allow for their disposal as WIPP CH wastes (Sandia 2008a).

Because the procedures to be used to manage these wastes at WIPP and the exact activities that would be conducted by each involved worker (and their proximity to the waste containers) are not known at this time, it is difficult to calculate the dose to the workforce. For purposes of this EIS, information on the actual doses incurred by workers at WIPP as given in Section 4.2.4 was used. This is a reasonable approach because all of the GTCC LLRW and GTCC-like wastes will be managed as CH wastes at WIPP.

Worker doses at WIPP must be kept below 5 rem/yr, as given in 10 CFR Part 835. In addition, an administrative control limit has been set at 1 rem/yr for the project. The radiation exposures of the involved workers would be monitored for the duration of disposal activities. It is assumed that the current WIPP practices for keeping worker doses ALARA would remain in place for the duration of the disposal campaign. This practice would ensure that worker doses were kept low and that they would comply with all applicable DOE standards and policies.

A total of 90,983 m^3 (3,213,034 ft^3) of TRU waste was disposed of at WIPP as of February 2014. Of this total volume, 90,627 m^3 (3,200,462 ft^3) was CH waste, and the remainder was RH waste. A total of 171,064 containers were used to dispose of this waste. In contrast, the total volume of GTCC LLRW and GTCC-like waste requiring disposal is about 12,000 m^3 (420,000 ft^3), and an estimated 63,072 containers will be needed for this purpose (see Table 4.1.4-1). The occupational dose to dispose of this waste was estimated to be 5.8 person-rem by using the total occupational worker doses for disposal of defense-generated TRU waste at WIPP through 2009 (12.4 person-rem) and pro-rating this value by the number of containers required for disposal of the GTCC LLRW and GTCC-like wastes. This worker dose commitment would result in less than 1 LCF when a risk factor of 0.0006 LCF per person-rem is used (see Section 5.2.4.3).

The dose commitment to the workforce would be distributed among all workers involved in managing the wastes at WIPP over the entire time period that the facility was receiving and disposing of GTCC LLRW and GTCC-like wastes. Workers would likely be rotated so that different ones would perform these activities over time, so the maximum dose to any individual worker over the duration of the project would likely be no more than several hundred mrem. Wastes might be received intermittently over the operational time period. The dose to the highest-exposed worker in any given year would be well below the administrative limit set for WIPP of 1 rem/yr.

The dose to noninvolved workers would be much less than the dose to involved workers. The noninvolved workers (such as those in the administration building) would be some distance away from the waste packages. The external gamma dose rate from a waste package decreases rapidly with distance, a situation that minimizes the likelihood that noninvolved workers would incur a measurable dose. Also, there would likely be significantly fewer noninvolved workers than involved workers when wastes were being processed at the site to ensure compliance with the DOE ALARA requirement. The total dose to the uninvolved workforce is conservatively estimated to be less than 0.1 person-rem over the duration of the project and is not expected to result in any LCFs.

4.3.4.1.2 Nonradiological Impacts. The nonradiological human health impacts from accidents that could occur during construction and operational activities are assessed in this EIS. The physical consequences of these accidents are given here in terms of injuries and illnesses (as lost workdays) as well as the likelihood of worker fatalities. These impacts were estimated by using information compiled by DOE for TRU waste disposal activities at WIPP and estimates of the number of workers needed for all phases of this project.

DOE has maintained a record of all accidents and injuries that have resulted in lost workdays since TRU waste disposal operations were initiated at WIPP. In 2009, a total of 83 lost workdays occurred as a result of injuries at the site, and the average number of employees at the site was reported to be 1,330 (McCauslin 2010a). The workplace nonfatal injury rate (as lost workdays) can be calculated by dividing these two values; this rate is 6.2 per 100 FTE workers. This rate was used for the construction and operations phases of the project. No fatalities have occurred at WIPP as a result of accidents.

Worker fatality and injury risks are calculated as the product of the incidence rate (given above) and the number of FTE workers needed for constructing the rooms and panels at WIPP to dispose of the GTCC LLRW and GTCC-like wastes. These results are summarized in Table 4.3.4-1. The number of FTEs needed to develop the necessary disposal capacity at WIPP for the GTCC LLRW and GTCC-like wastes was based on information in Sandia (2008a,b). It is estimated that a total of 70 FTE workers would be needed during the construction phase at WIPP. The number of lost workdays due to injuries was calculated to be 4.3, and no fatalities are expected to occur during the construction activities at WIPP. Construction activities at WIPP

TABLE 4.3.4-1 Estimated Number of Full-Time Equivalent (FTE) Involved Workers, Nonfatal Injuries and Illnesses, and Fatalities Associated with Construction and Operations at WIPP

Workers, Injuries and Illnesses, and Deaths per Phase	Number
Construction	
Total FTEs[a]	70
Nonfatal injuries and illnesses[b]	4.3
Fatalities[c]	0
Operations	
Total FTEs[d]	1,000
Nonfatal injuries and illnesses[e]	62
Fatalities[f]	0

[a] The total number of FTE workers needed during construction was based on Sandia (2008a,b). These estimates provide the worker requirements for constructing the panels and rooms needed to dispose of the expected volume of GTCC LLRW and GTCC-like wastes.

[b] The number of nonfatal injuries and illnesses is given in terms of lost workdays and was estimated on the basis of data compiled by DOE for TRU waste disposal activities at WIPP in 2009 (McCauslin 2010a). The nonfatal injury and illness rate for involved workers was 6.2 per 100 FTEs.

[c] No fatalities occurred from all construction activities at the WIPP repository as of August 2010 (McCauslin 2010a). On the basis of this experience, no worker fatalities are anticipated for GTCC LLRW and GTCC-like waste disposal activities at the WIPP repository.

[d] The total number of FTE workers during the operational phase is the estimated value for operators and technicians needed to dispose of GTCC LLRW and GTCC-like wastes at WIPP based on Sandia (2008a,b).

[e] The number of nonfatal injuries and illnesses is given in terms of lost workdays and was estimated on the basis of data compiled by DOE for TRU waste disposal activities at WIPP in 2009 (McCauslin 2010a). The nonfatal injury and illness rate for involved workers was 6.2 per 100 FTEs.

[f] No fatalities occurred from all waste disposal activities at the WIPP repository as of August 2010 (McCauslin 2010a). On the basis of this experience, no worker fatalities are anticipated for GTCC LLRW and GTCC-like waste disposal activities at the WIPP repository.

include mining of new panels. Since there have been no fatalities during WIPP operations, these data were used to derive the future construction fatality risks for GTCC. In 1981, there was a construction-related death. Using operations-derived data for construction risks in this EIS is more appropriate than using past WIPP construction data from 1981.

The same approach was used for the operations period, using the site-specific accident rate given above. The estimated number of FTE workers necessary to dispose of these wastes at WIPP is based on Sandia (2008a,b). For this assessment, the involved workers are considered to be the operators and technicians required to conduct the disposal operations. About 1,000 FTEs are estimated to be necessary to dispose of the total volume of GTCC LLRW and GTCC-like wastes (Sandia 2010). The total number of lost workdays due to nonfatal injuries is calculated to be 62, and no fatalities are expected to occur (see Table 4.3.4-1).

The total recordable rate of work-related injuries over the past several years at WIPP has ranged from zero to 1.0 per 100 employees per year (Dotson 2009). The rate in 2009 was 0.48 per 100 employees per year, and there have been no occupational fatalities at the site from waste disposal operations. The recordable rate of work-related injuries at WIPP is lower than that for all DOE sites combined of 1.2 per 100 workers per year (McCauslin 2010a). It is assumed that the current WIPP practices for keeping worker injuries at very low levels would remain in place for the duration of the disposal campaign. This practice would ensure that worker health and safety were not compromised by using this facility to dispose of GTCC LLRW and GTCC-like wastes.

4.3.4.2 Accidents

The health consequences that might result from exposure to radioactive materials from postulated facility accident scenarios during disposal of GTCC LLRW and GTCC-like waste would be bound by accidents evaluated for WIPP (DOE 1997, 2006c,d). Any waste shipped to WIPP would be required to meet the WAC for disposal. The radionuclide activity limits set forth in the WAC are met by the GTCC LLRW and the GTCC-like waste containers assumed to be disposed of at the WIPP in this EIS. Therefore, the impacts estimated previously for WIPP, which are similar to the accident impacts assessed for the land disposal options in Chapters 6 through 12, are expected to be representative of what could occur during disposal operations for the GTCC LLRW and the GTCC-like waste at WIPP.

4.3.4.3 Post-Closure

The post-closure impacts of disposing of the GTCC LLRW and GTCC-like wastes were evaluated in the EIS in the same manner as was done for TRU wastes (i.e., by developing complementary cumulative distribution functions (CCDFs) based on performance assessments) (Sandia 2008c,d; 2012). The post-closure impacts are limited to the potential radiation doses from the release of radionuclides from waste packages at WIPP and from their subsequent migration to groundwater. Once the radionuclides are in the groundwater, it is possible for members of the general public to be exposed to them by various ingestion pathways. The WIPP is a deep geologic disposal facility, and it would be sealed during decommissioning activities. This closure process precludes the release of radionuclides to the atmosphere.

Post-closure compliance of WIPP with regulatory limits is based on the cumulative releases of radionuclides to the accessible environment over a 10,000-year time horizon. The WIPP-related environmental standards for disposal are given in 40 CFR Part 191, Subpart B; environmental standards for groundwater protection are found in 40 CFR Part 191, Subpart C. The criteria for certification of compliance with the disposal standard are given in 40 CFR Part 194. The regulations set limits on the radiation doses to a member of the public in the accessible environment for 10,000 years of undisturbed performance, and they also set limits on the radioactive contamination of certain sources of groundwater for 10,000 years after disposal. Compliance with these requirements is demonstrated by presenting the results from long-term performance as CCDFs. The CCDFs represent the probability of exceeding various levels of cumulative releases caused by all significant processes and events (examples include the impacts from the potential for resource extraction due to potash mining above the WIPP, for inadvertent human intrusion due to boreholes from oil and gas exploration, and for a pressurized brine reservoir below the repository).

The CCDF of total releases for the latest recertification of WIPP is given in Figure 4.3.4-1. The release limits (as stated in 40 CFR 191.13) are represented by the dotted line on the right in this figure. The solid line in Figure 4.3.4-1 shows the mean probability of the total cumulative releases, after the likelihood of different futures occurring at WIPP and the uncertainty in the calculation parameters have been addressed by using computer models that estimate the radionuclide release for each future. WIPP is in compliance when the total release (solid line) is to the left of the release limits (dotted line). If the mean total release line crosses the release limits line, then WIPP is not in compliance (Sandia 2008c). As seen in this figure, WIPP is in compliance with its regulatory limits for TRU waste disposal, as indicated by its recent recertification.

The CCDF for Group 1 GTCC LLRW and GTCC-like wastes is shown in Figure 4.3.4-2, along with the CCDF for the latest recertification of WIPP. The CCDF for Group 2 wastes is shown in Figure 4.3.4-3, and the CCDF for the sum of Group 1 and Group 2 GTCC LLRW and GTCC-like wastes is shown in Figure 4.3.4-4. As these figures illustrate, adding the GTCC LLRW and GTCC-like wastes to the WIPP inventory would increase the potential for radionuclide release from the repository (the curves move to the right), but in no case does the curve cross over the release limit line (Sandia 2012).

Based on a performance assessment that was modified to account for the addition of the GTCC LLRW and GTCC-like waste, CCDFs were generated. Although this analysis was based on the WIPP performance assessment methodology, it is assumed that continued compliance with the WIPP disposal regulations is an appropriate indicator that compliance could be demonstrated for a yet-to-be-determined regulation for GTCC LLRW and GTCC-like waste disposal. Although the most important elements that influence the results of the CCDFs were modeled to account for the GTCC LLRW and GTCC-like wastes, simplifying assumptions were made in the analysis such that not all potential impacts are captured in the analysis.

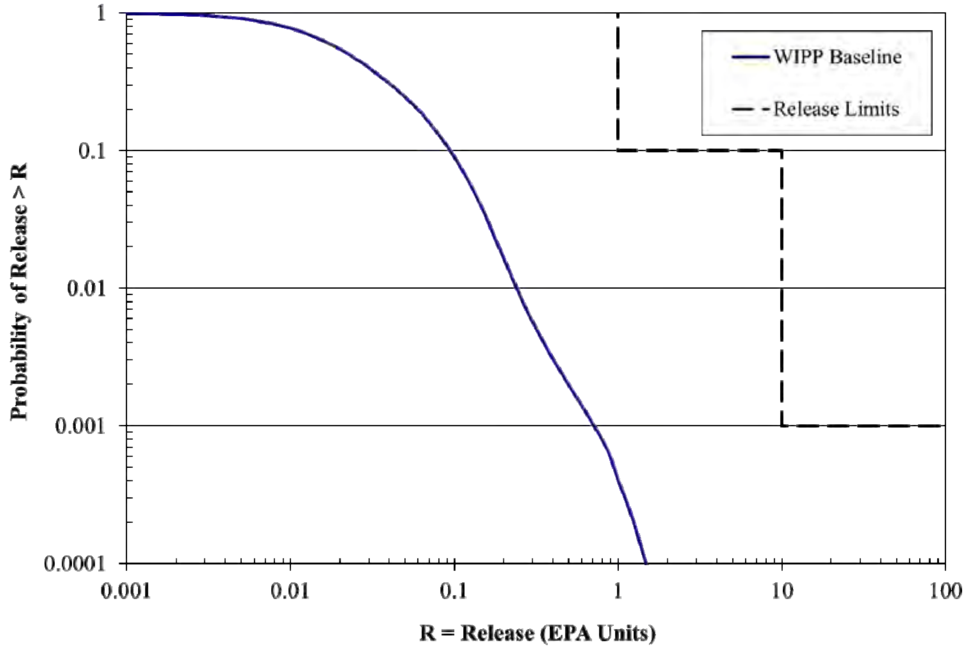

FIGURE 4.3.4-1 Mean Total Release CCDF for WIPP Recertification (Sources: Sandia 2012, DOE 2009b)

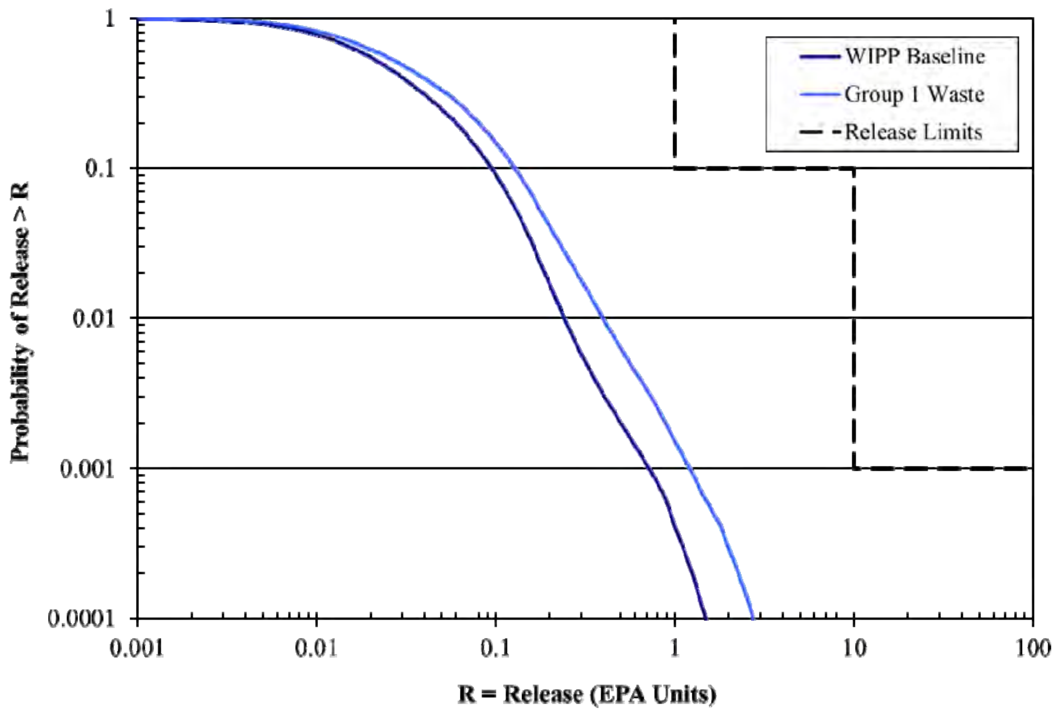

FIGURE 4.3.4-2 Mean Total Release CCDF for Group 1 Wastes (Sources: Sandia 2012, DOE 2009b)

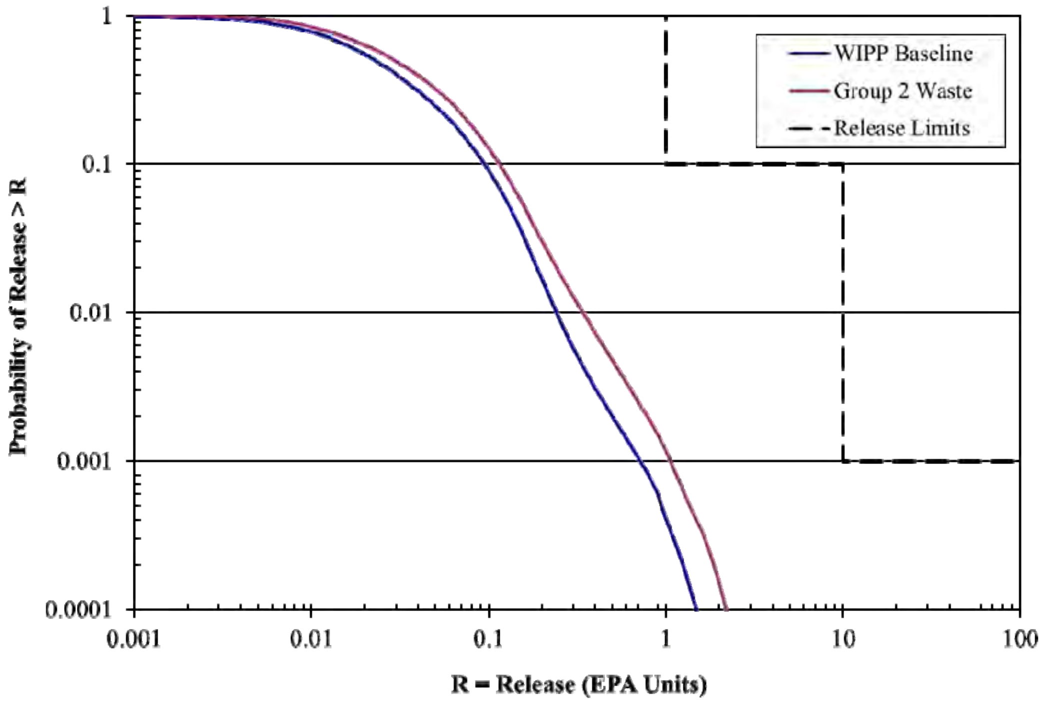

FIGURE 4.3.4-3 Mean Total Release CCDF for Group 2 Wastes (Sources: Sandia 2012, DOE 2009b)

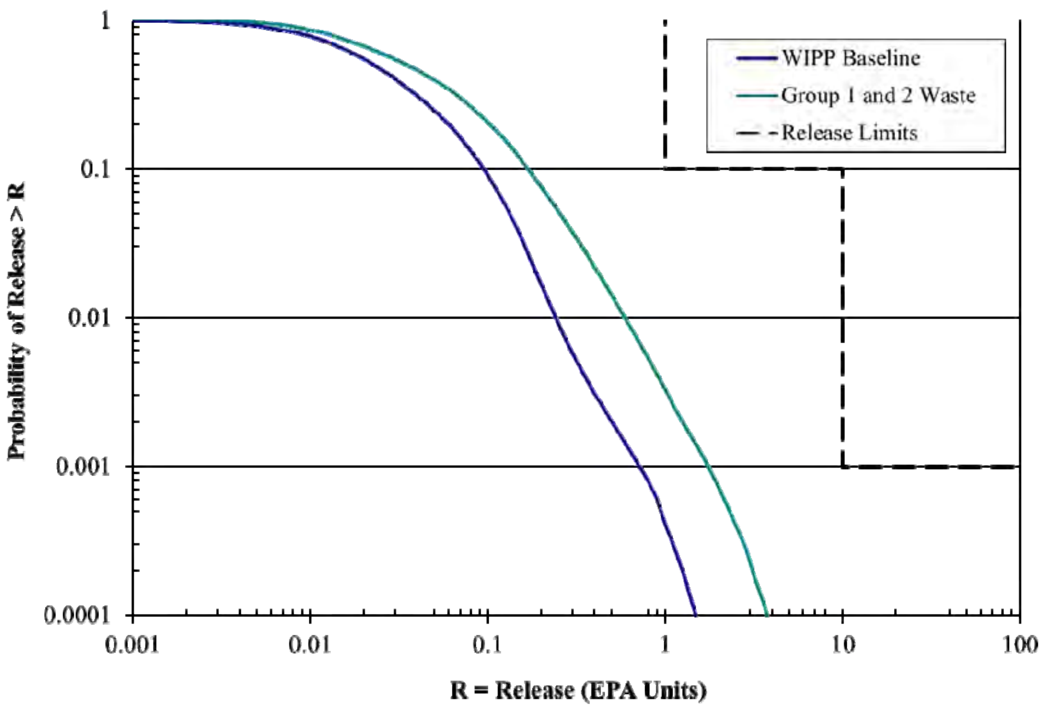

FIGURE 4.3.4-4 Mean Total Release CCDF for Groups 1 and 2 Wastes Combined (Sources: Sandia 2012, DOE 2009b)

4.3.4.4 Intentional Destructive Acts

GTCC LLRW and GTCC-like waste pose a potential terrorist threat because of their higher radioactivity in a given volume when compared with other LLRW. Such material could be incorporated into an RDD intended to cause societal disruption, including significant negative economic impacts. The consequences of an IDA involving hazardous material depend on the material's packaging, chemical composition, radioactive and physical properties, accessibility, quantity, and ease of dispersion, and on the surrounding environment, including the number of people who are close to the event.

With regard to the deep geologic disposal of similar waste at WIPP, DOE had previously considered the potential impacts of IDAs (i.e., acts of sabotage or terrorism). The previous impacts estimated for WIPP would be no greater than the impacts of an accident as analyzed in the supplemental EIS (DOE 1997) and supplement analysis (DOE 2009a) because the initiating forces and resulting quantities of radioactive or hazardous material that could be released by an IDA would be similar to those for the severe accident scenarios.

4.3.5 Ecology

The disposal of GTCC LLRW and GTCC-like waste would not require modifications to any WIPP surface facilities or the aboveground infrastructure. The existing facilities are assumed to be adequate to facilitate waste handling, storage, and transport to the underground rooms. WIPP can receive standard truck shipments and has a rail spur adjacent to the WHB. Current parking areas may be used for temporary storage or overflow of transport trailers within the property protection area. Additional paved areas not currently used for parking exist within the property protection area. There are also aboveground waste container storage areas within the WIPP CH and RH waste handling facilities. On the basis of the presence and type of existing facilities, it is assumed that no additional construction would be needed to accept, handle, or store GTCC LLRW and GTCC-like waste or transport them to the underground facility. Therefore, the impacts on ecological resources from disposal of GTCC LLRW and GTCC-like waste at the WIPP site would be very small potential increases in disturbance to wildlife habitat or wildlife injuries or deaths from collisions with vehicles. Both impacts would be localized and are not expected to result in adverse population-level impacts.

4.3.6 Socioeconomics

The potential socioeconomic impacts from constructing additional underground rooms at WIPP to accommodate the GTCC LLRW and GTCC-like waste would be small. Construction activities would involve 58 employees in the peak construction year and an additional 72 indirect jobs in the ROI (Table 4.3.6-1). Because construction would be accomplished by using the existing workforce, no in-migration of workers or their families would occur during the construction period, so no impacts on housing, public finances, public service employment, or traffic would result.

TABLE 4.3.6-1 Effects of Construction and Operations on Socioeconomics at the ROI for WIPP[a]

Impact Category	Construction of Rooms	Operation
Employment (number of jobs)		
Direct	58	1,123
Indirect	72	1,218
Total	130	2,341
Income ($ in millions)		
Direct	1.6	64
Indirect	3.0	40
Total	4.6	104
Population (number of new residents)	None	None
Housing (number of units required)	None	None
Public finances (% impact on expenditures)		
Cities and counties[b]	None	None
Schools[c]	None	None
Public service employment (number of new employees)		
Local government employees[d]	None	None
Teachers	None	None
Traffic (impact on current levels of service)	None	None

[a] Impacts shown are for peak year of construction and operations.

[b] Includes impacts that would occur in the cities of Artesia, Carlsbad, Loving, Eunice, Hobbs, Jal, Lovington, and Tatum and in Eddy and Lea Counties.

[c] Includes impacts that would occur in the Artesia, Carlsbad, Loving, Eunice, Hobbs, Jal, Lovington, and Tatum school districts.

[d] Includes police officers, paid firefighters, and general government employees.

The potential socioeconomic impacts from disposal operations to emplace GTCC LLRW and GTCC-like waste in underground rooms could be relatively large in the peak years of operations. Operational activities would require the same workforce as that currently employed at WIPP (i.e., about 1,123 direct jobs annually and an additional 1,218 indirect jobs in the ROI) (Table 4.3.6-1). It is estimated that operations associated with the disposal of GTCC LLRW and GTCC-like waste at WIPP would produce $104 million in income annually (the same amount as the current annual budget for WIPP). Because the waste disposal operations would be accomplished largely by using only the existing workforce, there would be no significant in-migration of workers or their families during the construction period; thus there would not be any impacts on housing, public finances, public service employment, or traffic.

4.3.7 Environmental Justice

4.3.7.1 Construction

No radiological risks and only very low chemical exposure and risk are expected during construction of the additional underground rooms at WIPP. Because the health impacts of the construction activities on the general population within the 80-km (50-mi) assessment area during construction would be negligible, impacts from construction on the minority and low-income population would not be significant.

4.3.7.2 Operations

Consistent with the assumption that incoming GTCC LLRW and GTCC-like waste containers would only be consolidated for placement and that no repackaging would be necessary, there would be no measurable radiological impacts on the general public during operations and no adverse health effects on the general population. In addition, no surface releases that might enter local streams or interfere with subsistence activities by low-income or minority populations would occur. Because the health impacts of routine operations on the general public would be negligible, there would be no disproportionately high and adverse impact on minority and low-income population groups within the 80-km (50-mi) assessment area.

4.3.7.3 Accidents

A release of GTCC LLRW and GTCC-like waste at WIPP could cause minor impacts in the surrounding area. However, it is highly unlikely that such an accident would occur. Therefore, the risk to any population, including low-income and minority communities, is considered to be low. In the unlikely event of a GTCC release, the communities most likely to be affected would be minority or low-income, given the demographics within 80 km (50 mi) of WIPP.

If an accident producing significant contamination occurred, appropriate measures would be taken to ensure that the impacts on low-income and minority populations would be minimized. The extent to which low-income and minority population groups would be affected would depend on the amount of material released and the direction and speed at which airborne material was dispersed by the wind. Although the overall risk would be very small, the greatest risk of exposure following an airborne release would be to the population groups residing to the northwest of the site.

4.3.8 Land Use

Use of WIPP for disposal of GTCC LLRW and GTCC-like wastes would not change the multiple-use management of the surface area of the site. In general, the inclusion of GTCC LLRW and GTCC-like waste would not require modifications to any WIPP surface facilities or the aboveground infrastructure. It is assumed that the existing facilities would be adequate to facilitate waste handling, storage, and transport to the underground storage area at WIPP. WIPP can receive standard truck shipments and has a rail spur adjacent to the WHB. There are aboveground waste container storage areas within the WIPP CH and RH waste handling facilities. Current parking areas could be used for temporary storage or overflow of transport trailers within the property protection area. Additional paved areas that are not currently used for parking exist within the property protection area. Because the WIPP site is a designated waste disposal site, there would be no change in land use at the site that would result from the inclusion of GTCC LLRW and GTCC-like wastes. The oil and gas leases and livestock grazing that occur within the WIPP site would not be affected. Land use on areas surrounding the WIPP site would not be affected. Future land use activities that would be permitted within or immediately adjacent to WIPP would be limited to those currently allowable, which would not jeopardize the integrity of the facility, create a security risk, or create worker or public safety risks.

4.3.9 Transportation

The transportation of GTCC LLRW and GTCC-like waste necessary for the disposal of all such waste at WIPP was evaluated. Transportation of all cargo is considered for both truck and rail modes of transport as separate options for the purposes of this EIS. As discussed in Appendix C, Section C.9, the impacts of transportation were calculated in three areas: (1) collective population risks during routine conditions and accidents (Section 4.3.9.1), (2) radiological risks to individuals receiving the highest impacts during routine conditions (Section 4.3.9.2), and (3) consequences to individuals and populations after the most severe accidents involving a release of radioactive or hazardous chemical material (Section 4.3.9.3).

Radiological impacts during routine conditions are a result of human exposure to the low levels of radiation near the shipment. The regulatory limit established in 49 CFR 173.441 (Radiation Level Limitations) and 10 CFR 71.47 (External Radiation Standards for All Packages) to protect the public is 0.1 mSv/h (10 mrem/h) at 2 m (6 ft) from the outer lateral sides of the transport vehicle. This dose rate corresponds roughly to 14 mrem/h at 1 m (3 ft). As discussed in Appendix C, Section C.9.4.4, the external dose rate for all shipments to the WIPP repository was assumed to be 0.5 and 1.0 mrem/h at 1 m (3 ft) for truck and rail shipments, respectively, based on shipments of similar types of waste. Dose rates for rail shipments are approximately double those for truck shipments because rail shipments are assumed to have twice the number of waste packages as corresponding truck shipments. The assignment of these dose rates is also based on the assumption that all of the GTCC LLRW and GTCC-like waste would be packaged in containers so as to meet contact-handling requirements. Impacts from accidents are dependent on the amount of radioactive material in a shipment and what fraction is released should an accident occur. The parameters used in the accident consequence analysis are described further in Appendix C, Section C.9.4.3.

4.3.9.1 Collective Population Risk

The collective population risk is a measure of the total risk posed to society as a whole by the actions being considered. For a collective population risk assessment, the persons exposed are considered as a group, without specifying individual receptors. Exposures to four different groups were considered: (1) persons living and working along the transportation routes, (2) persons sharing the route, (3) persons at stops, and (4) transportation crew members. The collective population risk is used as the primary means of comparing various options. Collective population risks are calculated for cargo-related causes for routine transportation and accidents. Vehicle-related risks are independent of the cargo in the shipment and are calculated only for traffic accidents (fatalities caused by physical trauma).

Estimated impacts from the truck and rail options are summarized in Tables 4.3.9-1 and 4.3.9-2, respectively. For the truck option, it is estimated that approximately 33,700 shipments resulting in about 90 million km (56 million mi) of travel would occur but not be expected to cause any LCFs to truck crew members or to the general public. About two accident fatalities are estimated to occur. One accident fatality and no LCFs are estimated for the rail option, in which approximately 11,800 railcar shipments would result in about 32 million km (20 million mi) of travel. The estimated total truck distance travelled of 90 million km (56 million mi) is approximately 0.05% of the total vehicle miles travelled (173,130 million km or 107,602 million mi) by heavy-duty trucks (gross vehicle weight of more than 11,800 kg or 26,000 lb) in the United States in one year (2002) (DOT 2005).

4.3.9.2 Highest Exposed Individuals during Routine Conditions

During the routine transportation of radioactive material, specific individuals may be exposed to radiation in the vicinity of a shipment. Risks to these individuals for a number of hypothetical exposure-causing events were estimated. The receptors include transportation workers, inspectors, and members of the public exposed during traffic delays, while working at a service station, or while living and/or working near a destination site. The assumptions about exposure are given in Appendix C, and transportation impacts for CH shipments are provided in Section 5.3.9. The scenarios for exposure are not meant to be exhaustive; they were selected to provide a range of representative potential exposures. On a site-specific basis, if someone was living or working near the entrance to the WIPP site and present for all 33,700 truck or 11,800 rail shipments projected, that individual's estimated dose would be approximately 0.5 or 1.0 mrem, respectively, over the course of more than 50 years. The individual's associated lifetime LCF risk would then be 3×10^{-7} or 6×10^{-7} for truck or rail shipments, respectively.

4.3.9.3 Accident Consequence Assessment

Whereas the collective accident risk assessment considers the entire range of accident severities and their related probabilities, the accident consequence assessment assumes that an accident of the highest severity category has occurred. The consequences, in terms of committed dose (rem) and LCFs for radiological impacts, were calculated for both exposed populations and

TABLE 4.3.9-1 Estimated Collective Population Transportation Risks for Shipment of GTCC LLRW and GTCC-Like Waste by Truck for Disposal at WIPP[a]

			Cargo-Related[b] Radiological Impacts								Vehicle-Related Impacts[c]
			Dose Risk (person-rem)						Latent Cancer Fatalities[d]		
				Routine Public							
Waste	Number of Shipments	Total Distance (km)	Routine Crew	Off-link	On-link	Stops	Total	Accident[e]	Crew	Public	Physical Accident Fatalities
Group 1											
GTCC LLRW											
Activated metals - RH											
Past BWRs	12	39,600	0.082	0.0035	0.013	0.015	0.031	<0.0001	<0.0001	<0.0001	0.00092
Past PWRs	85	242,000	0.5	0.02	0.076	0.089	0.18	0.00013	0.0003	0.0001	0.0055
Operating BWRs	2,670	7,260,000	15	0.53	2.2	2.7	5.4	0.0031	0.009	0.003	0.17
Operating PWRs	9,830	23,800,000	50	1.7	7.3	8.8	18	0.01	0.03	0.01	0.54
Sealed sources - CH											
Small	209	360,000	0.15	0.031	0.2	0.26	0.49	0.017	<0.0001	0.0003	0.0091
Cesium irradiators	240	413,000	0.17	0.036		0.3	0.56	0.0028	0.0001	0.0003	0.01
Other Waste - CH	5	603	0.00025	<0.0001	0.00032	0.00043	0.00077	<0.0001	<0.0001	<0.0001	<0.0001
Other Waste - RH	172	477,000	0.98	0.23	0.15	0.18	0.56	<0.0001		0.0002	0.011
GTCC-like waste			0.04								
Activated metals - RH	70	158,000	0.33	0.0074	0.046	0.058	0.11	0.0006	0.0002	<0.0001	0.0039
Sealed sources - CH	1	1,720	0.00072	0.00015	0.00096	0.0012	0.0023	<0.0001	<0.0001	<0.0001	<0.0001
Other Waste - CH	69	211,000	0.088	0.029	0.12	0.15	0.3	0.00097	<0.0001	0.0002	0.0044
Other Waste - RH	3,650	10,700,000	22	0.75	3.2	3.9	7.9	0.0022	<0.0001	0.005	0.22
									0.01		

TABLE 4.3.9-1 (Cont.)

			Cargo-Related[b] Radiological Impacts								Vehicle-Related Impacts[c]
			Dose Risk (person-rem)						Latent Cancer Fatalities[d]		
				Routine Public							
Waste	Number of Shipments	Total Distance (km)	Routine Crew	Off-link	On-link	Stops	Total	Accident[e]	Crew	Public	Physical Accident Fatalities
Group 2											
GTCC LLRW											
Activated metals - RH											
New BWRs	956	1,650,000	3.4	0.094	0.48	0.61	1.2	0.00063	0.002	0.0007	0.039
New PWRs	4,790	11,100,000	23	0.8	3.4	4.1	8.3	0.0048	0.01	0.005	0.25
Additional commercial waste	3,740	11,600,000	24	0.82	3.5	4.3	8.6	<0.0001	0.01	0.005	0.24
Other Waste - CH	139	433,000	0.18	0.06	0.26	0.31	0.63	0.003	0.0001	0.0004	0.009
Other Waste - RH	2,590	7,730,000	16	0.55	2.3	2.8	5.7	0.0008	0.01	0.003	0.16
GTCC-like waste											
Other Waste - CH	44	117,000	0.049	0.016	0.069	0.084	0.17	0.0004	<0.0001	0.0001	0.0025
Other Waste - RH	4,440	13,300,000	27	0.94	4	4.9	9.9	0.0022	0.02	0.006	0.28
Total Groups 1 and 2	33,700	89,700,000	180	6.5	28	34	68	0.049	0.1	0.04	2

[a] BWR = boiling water reactor, PWR = pressurized water reactor, CH = contact-handled, RH = remote-handled.

[b] Cargo-related impacts are impacts attributable to the radioactive nature of the material being transported.

[c] Vehicle-related impacts are impacts independent of the cargo in the shipment. Vehicle-related impacts were assessed for round-trip travel.

[d] LCFs were calculated by multiplying the dose by the health risk conversion factor of 6×10^{-4} fatal cancer per person-rem (see Section 5.2.4.3).

[e] Dose risk is a societal risk and is the product of accident probability and accident consequence.

TABLE 4.3.9-2 Estimated Collective Population Transportation Risks for Shipment of GTCC LLRW and GTCC-Like Waste by Rail for Disposal at WIPP[a]

			Cargo-Related[b] Radiological Impacts								Vehicle-Related Impacts[c]
			Dose Risk (person-rem)						Latent Cancer Fatalities[d]		Physical Accident Fatalities
				Routine Public							
Waste	Number of Shipments	Total Distance (km)	Routine Crew	Off-link	On-link	Stops	Total	Accident[e]	Crew	Public	
Group 1											
GTCC LLRW											
Activated metals - RH											
Past BWRs	7	21,300	0.034	0.011	0.00066	0.015	0.027	<0.0001	<0.0001	<0.0001	0.0017
Past PWRs	31	84,300	0.14	0.045	0.0027	0.065	0.11	0.00017	<0.0001	<0.0001	0.005
Operating BWRs	900	2,480,000	4.1	1.3	0.073	1.9	3.3	0.0019	0.002	0.002	0.1
Operating PWRs	3,300	8,620,000	15	4.8	0.25	6.9	12	0.0074	0.009	0.007	0.39
Sealed sources - CH											
Small	105	169,000	0.5	0.15	0.0075	0.37	0.53	0.00092	0.0003	0.0003	0.0059
Cesium irradiators	120	194,000	0.57	0.17	0.0085	0.42	0.6	0.00013	0.0003	0.0004	0.0068
Other Waste - CH	3	2,920	0.011	0.0023	0.00012	0.0085	0.011	<0.0001	<0.0001	<0.0001	0.00011
Other Waste - RH	58	181,000	0.29	0.12	0.0047	0.13	0.25	<0.0001	0.0002	0.0002	0.007
GTCC-like waste											
Activated metals - RH	24	59,300	0.1	0.024	0.0013	0.047	0.072	<0.0001	<0.0001	<0.0001	0.0028
Sealed sources - CH	1	1,610	0.0047	0.0014	<0.0001	0.0035	0.005	<0.0001	<0.0001	<0.0001	<0.0001
Other Waste - CH	35	103,000	0.25	0.12	0.0068	0.18	0.3	0.00011	0.0001	0.0002	0.0042
Other Waste - RH	1,220	3,550,000	5.8	1.9	0.11	2.8	4.8	0.00025	0.003	0.003	0.14

TABLE 4.3.9-2 (Cont.)

			Cargo-Related[b] Radiological Impacts								Vehicle-Related Impacts[c]
			Dose Risk (person-rem)						Latent Cancer Fatalities[d]		Physical Accident Fatalities
				Routine Public							
Waste	Number of Shipments	Total Distance (km)	Routine Crew	Off-link	On-link	Stops	Total	Accident[e]	Crew	Public	
Group 2											
GTCC LLRW											
Activated metals - RH											
New BWRs	320	670,000	1.2	0.38	0.02	0.6	1	0.00044	0.0007	0.0006	0.03
New PWRs	1,610	4,050,000	6.9	2.4	0.11	3.3	5.8	0.003	0.004	0.003	0.18
Additional commercial waste	1,250	3,690,000	6	2	0.12	2.9	5	<0.0001	0.004	0.003	0.16
Other Waste - CH	70	207,000	0.49	0.24	0.014	0.36	0.61	0.00036	0.0003	0.0004	0.0087
Other Waste - RH	1,240	3,630,000	5.9	2	0.11	2.9	5	<0.0001	0.004	0.003	0.15
GTCC-like waste											
Other Waste - CH	22	62,500	0.15	0.078	0.0038	0.1	0.18	<0.0001	<0.0001	0.0001	0.0025
Other Waste - RH	1,480	4,340,000	7.1	2.4	0.13	3.4	2.8	0.00023	0.004	0.002	0.18
Total Groups 1 and 2	11,800	32,100,000	54	18	0.98	26	42	0.015	0.03	0.03	1.4

[a] BWR = boiling water reactor, PWR = pressurized water reactor, CH = contact-handled, RH = remote-handled.

[b] Cargo-related impacts are impacts attributable to the radioactive nature of the material being transported.

[c] Vehicle-related impacts are impacts independent of the cargo in the shipment. Vehicle-related impacts were assessed for round-trip travel.

[d] LCFs were calculated by multiplying the dose by the health risk conversion factor of 6×10^{-4} fatal cancer per person-rem (see Section 5.2.4.3).

[e] Dose risk is a societal risk and is the product of accident probability and accident consequence.

individuals in the vicinity of an accident. Because the exact location of such a transportation accident is impossible to predict and thus is not specific to any one site, generic impacts were assessed, as presented in Section 5.3.9.

4.3.10 Cultural Resources

No potential impacts on cultural resources are expected because construction, operations, and post-closure activities from GTCC LLRW and GTCC-like waste disposal would not involve any additional disturbance of land surface areas beyond the land already occupied by the existing footprint of the WIPP site.

4.3.11 Waste Management

Waste from emplacement of GTCC LLRW and GTCC-like waste at WIPP would primarily be from disposal operations and include liquid and solid nonhazardous waste (primarily sanitary), solid hazardous waste, and sludge waste. Nonhazardous or sanitary waste flows by gravity to the facultative lagoon system. Nonhazardous solid or sludge waste is disposed of at a commercial sanitary landfill (Sandia 2008a). Solid hazardous waste is characterized, packaged, labeled, and manifested to off-site treatment, storage, and disposal facilities in accordance with the requirements of 40 CFR Part 262 (DOE 2002). Table 4.3.11-1 presents data on the waste that is generated from the construction of underground rooms and from waste disposal operations.

4.4 SUMMARY OF POTENTIAL ENVIRONMENTAL CONSEQUENCES AND HUMAN HEALTH IMPACTS

The potential environmental consequences from the construction of additional rooms, disposal operations, and post-closure facility performance discussed in Section 4.3 are summarized here, as follows.

Air quality. Because of the distance of the emission sources from the WIPP site boundary (about 3 km [2 mi]), emissions from construction and operational activities would not contribute much to concentrations at the boundary and the nearest residence. Therefore, it is expected that concentration levels from operational activities would remain well below the NAAQS and SAAQS.

Noise. During the construction phase, most of the activities would occur underground. No major construction equipment that could cause ground vibration would be used, and no sensitive structures would be in close proximity. Therefore, there would be no adverse vibration impacts from construction activities at the WIPP site. Noise from operational activities would be barely discernable or completely inaudible at the site boundary and the nearest residence.

TABLE 4.3.11-1 Waste That Is Generated from Construction and Operations under Alternative 2

Waste	Construction	Operations[a]
Liquid nonhazardous (sanitary) (L/yr)	NA[b]	830,000
Solid nonhazardous (sanitary) (tons/yr)	NA	23
Solid hazardous (including sludge) (tons/yr)	NA	8.6

[a] Assumed a total of 8,669 hoist trips and 20 years of operation, which is when the majority of GTCC LLRW and GTCC-like waste would be received. Estimates were based on Sandia (2008a).

[b] NA means not applicable.

Geology. It is assumed that the GTCC LLRW and GTCC-like waste would be disposed of in underground waste disposal rooms similar to those currently used for the disposal of TRU waste and that they would be mined adjacent to the panels currently planned for the repository. Because the techniques used for room construction would be the same as those employed for developing the existing repository, geologic impacts would be the same as those produced by historical construction activities and would be negligible.

Water resources. Construction activities to allow for the disposal of GTCC LLRW and GTCC-like waste in the WIPP repository would increase the site's annual water use of 15 million L (4 million gal) by about 2% and would increase production at the Carlsbad Double Eagle South Well Field by about 0.03%. Construction of the additional rooms at the WIPP repository would not disturb the ground surface. Because no land surfaces would be disturbed during construction, there would be no impacts on either surface water or groundwater resources. Similarly, there would be no impacts on surface water or groundwater quality during construction because there would be no liquid wastes produced and because underground spills would be limited to the interior of the repository, where timely and effective cleanup would occur. The waste disposal operations to emplace the GTCC LLRW and GTCC-like waste inventory at the WIPP repository would require approximately 20 million L (5.4 million gal) of water. This quantity of water is the same as the amount used currently for WIPP operations because in the peak operational year, GTCC LLRW and GTCC-like waste shipments would be emplaced at a level similar to the level for waste shipments currently being handled at WIPP. Because the quantity of water used annually would be the same as the amount that is currently used, there would be no net increase in water use at the site. Similarly, there would be no additional water demand on the Double Eagle water supply system.

Human health. It is estimated that the radiation dose commitment to the workforce would be 5.8 person-rem and would not produce any LCFs. The maximum dose to any individual worker would not exceed the administrative limit for waste disposal at WIPP of 1 rem/yr and would likely be no more than several hundred mrem over the entire duration of the disposal activities. A total of about 62 lost workdays due to occupational injuries and no fatalities are projected for the workforce who would be disposing of GTCC LLRW and GTCC-like wastes under this alternative. These injuries would not be associated with the radioactive nature of the wastes but would simply be those that are expected to occur in any project of this size. No measurable radiation doses or LCFs are expected to occur to members of the general public residing near the site during or after site operations, according to the same modeling approach as that used in the recent recertification of WIPP.

Ecological resources. The only potential impacts on ecological resources from disposal of GTCC LLRW and GTCC-like waste at the WIPP site would result from minor increases in land disturbance and from collisions of animals with vehicles. Both would have only a localized impact on wildlife and are not expected to result in adverse population-level impacts.

Socioeconomics. Potential impacts from the construction of additional underground rooms at WIPP to accommodate the GTCC LLRW and GTCC-like waste would be relatively small. Construction activities would involve direct employment of 58 people in the peak construction year and an additional 72 indirect jobs in the ROI. Construction would also produce approximately $4.6 million in income in the peak construction year. Potential impacts from disposal operations could be relatively large. Operational activities would involve about 1,123 direct jobs annually and an additional 1,218 indirect jobs in the ROI. The operations at WIPP for emplacement of GTCC LLRW and GTCC-like waste would also produce $104 million in income annually. Because these operations at WIPP would be accomplished by using the existing workforce, no significant in-migration of workers or their families would occur; thus, there would be no resulting impacts on housing, public finances, public service employment, or traffic.

Environmental justice. Health impacts on the general population within the 80-km (50-mi) assessment area during construction and operations would be negligible, and no impacts on minority and low-income populations as a result of the construction and operations of a GTCC LLRW and GTCC-like waste disposal facility are expected. If analyses that accounted for any unique exposure pathways (such as subsistence fish, vegetation, or wildlife consumption or well-water consumption) determined that health and environmental impacts would not be significant, then there would be no high and adverse impacts on minority and low-income populations. If impacts were found to be significant, disproportionality would be determined by comparing the proximity of high and adverse impacts to the location of low-income and minority populations.

Land use. There would be no change in the land use at the WIPP site and its surrounding area from the inclusion of GTCC LLRW and GTCC-like wastes. The oil and gas leases and livestock grazing that occur within the WIPP site would not be affected.

Transportation. Shipment of all waste to WIPP by truck would result in approximately 33,700 shipments involving a total distance of 90 million km (56 million mi). No LCFs are expected to occur to truck crew members or the general public, but two accident fatalities could occur. For shipment of all waste by rail, 11,800 railcar shipments totaling 32 million km (20 million mi) of travel would be required. One accident fatality is estimated for rail shipment to WIPP, and no LCFs would result.

Cultural resources. No potential impacts on cultural resources are expected from the disposal of GTCC LLRW and GTCC-like waste at WIPP, since the construction, operations, and post-closure activities associated with GTCC LLRW and GTCC-like waste disposal would not involve disturbance to land beyond that already occupied by the existing footprint of the WIPP site.

Waste management. Waste from GTCC LLRW and GTCC-like waste emplacement at WIPP would primarily be from operations and include small quantities of nonhazardous solid and liquid waste and solid hazardous waste. The waste generated would not affect current waste management protocols at WIPP.

4.5 CUMULATIVE IMPACTS

> **Cumulative Impacts**
>
> Cumulative impacts are the total impacts on a given resource resulting from the incremental environmental effects of an action or actions added to those from other past, present, and reasonably foreseeable future actions.

Consistent with 40 CFR 1508.7, in this EIS, a cumulative impact is the impact on the environment that results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (federal or nonfederal) or person undertakes such actions. A cumulative impacts assessment accounts for both geographic (spatial) and time (temporal) considerations of past, present, and reasonably foreseeable actions. Geographic boundaries can vary by resource area, depending on the amount of time an impact remains in the environment, the extent to which such an impact can migrate, and the magnitude of the potential impact. The primary factor considered for the purpose of cumulative impacts analysis for this EIS is if the other actions would have some influence on the resources in the same time and space as those affected by the implementation of this alternative (construction of additional underground disposal rooms and the conduct of disposal operations for emplacement of the GTCC LLRW and GTCC-like waste) at WIPP.

The primary use of land within 16 km (10 mi) of the WIPP site is grazing, with lesser amounts of land used for oil and gas extraction and potash mining. Most of this land is managed and owned by BLM. Two ranches are located within 16 km (10 mi) of the WIPP site; the closest town, Loving, New Mexico, is about 29 km (18 mi) away. Most of the land within 50 km (30 mi) of the site is owned by either the federal government or the State of New Mexico. Within 80 km (50 mi) of the site, there is dry land farming and there is irrigated farming along the Pecos River; also, some forest, wetlands, and urban land can be found. At the time of the preparation of this EIS, no known large actions were being planned on BLM land.

The land use described above, in combination with the low potential impacts discussed in Section 4.3 for Alternative 2, indicate that cumulative impacts from the construction, operations, and post-closure phases of the proposed action at the WIPP site would be small and would not have a significant cumulative impact on area air quality, geology and soils, water resources, ecology, socioeconomics, environmental justice, cultural resources, and land use. Potential radionuclide concentrations that could be released from the facility are expected to be negligible. The post-closure performance analysis performed for emplacement of all GTCC LLRW and GTCC-like waste at WIPP demonstrates that disposal of these wastes would not result in human health impacts (see Section 4.3.4.3). Potential combined effects of transportation of GTCC LLRW and GTCC-like waste to WIPP would likewise not have a significant cumulative impact on transportation (see Section 4.3.9).

On June 15, 2005, the NRC staff issued the *Environmental Impact Statement for the Proposed National Enrichment Facility in Lea County, New Mexico* (NRC 2005). This facility was constructed and is in operation. It is located about 59 km (37 mi) east of the WIPP site (town of Eunice). The distance from the WIPP site — combined with NRC staff findings as reported in NRC (2005), which stated that environmental impacts from this enrichment facility would be small to moderate — indicate that cumulative impacts from the possible GTCC LLRW and GTCC-like waste disposal activities at WIPP in combination with the enrichment facility operations would likewise not result in a significant cumulative impact (including human health and transportation impacts).

On June 5, 2012 (*Federal Register*, Vol. 77, No. 108/Tuesday, June 5, 2012), DOE proposed to evaluate two additional locations for a long-term mercury storage facility. These two locations are both near WIPP, but the first one is located within and the second is located outside the land subject to the WIPP LWA as amended (P.L. No. 102-579 as amended by P.L. 104-201). The first is located in Section 20, Township 22 South, Range 31 East (across the WIPP access road from the WIPP facility), and the second is located in Section 10, Township 22 South, Range 31 East, approximately 3.5 mi (5.6 km) north of the WIPP facility. In response to comments received during public scoping, DOE has decided to analyze a third location near WIPP, Section 35 in Township 22 South, Range 31 East, Section 35 is the same section being analyzed in this GTCC EIS. The analysis of impacts on the various resource areas from construction and operation of a long-term mercury storage facility at locations considered in the *Final Long-Term Management and Storage of Elemental Mercury Environmental Impact Statement* (DOE/EIS-0423; DOE 2011b) and in the *Final Long-Term Management and Storage of Elemental Mercury Supplemental Environmental Impact Statement* (DOE/EIS-0423-S1; DOE 2013) indicated that the impacts would range from none to minor, including impacts on land use and visual resources, surface water or groundwater resources, air emissions, engine exhaust emissions from transporting mercury, noise levels, ecological resources, cultural and paleontological resources, the site's waste management infrastructure, human health, socioeconomics, and vehicle trips during construction. There would be minor, short-term (6-month) air quality impacts involving construction of a new storage facility. There would be no disproportionately high and adverse effects on minority or low-income populations. Transportation accidents are predicted to pose a negligible to low risk to human health. The impacts from the proposed construction and operation of a long-term mercury storage facility discussed above, in combination with the potential impacts summarized in Section 4.4 for the GTCC proposed action, would not have a significant cumulative impact on any of the resource areas evaluated for WIPP and the WIPP Vicinity. Disposal or storage of mercury at WIPP may require amending the WIPP LWA as amended.

4.6 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENT OF RESOURCES

The resources that would be irreversibly and irretrievably committed for the disposal of GTCC LLRW and GTCC-like waste at WIPP would include the underground space, energy, raw materials, and other natural and man-made resources used to construct the additional rooms needed. The impacts from such a commitment of resources would be small, since the WIPP facility is already in place.

Energy expended would be in the form of fuel for equipment and vehicles and electricity for facility operation. Construction and operations would consume approximately 1.9 million L (490,000 gal) of diesel fuel. The electrical energy requirement would represent a small increase in the electrical energy demand of the area. Resources that would be committed irreversibly or irretrievably for GTCC LLRW and GTCC-like waste disposal at WIPP would include materials that could not be recovered or recycled and materials that would be consumed or reduced to unrecoverable forms. It is expected that about 520,000 kg (510 tons) of steel would be committed to the construction of the additional disposal rooms. During operations, the proposed action would generate a small amount of nonrecyclable waste streams, such as hazardous wastes that would be subject to RCRA regulations. Generation of these waste streams would represent an irreversible and irretrievable commitment of material resources.

4.7 STATUTORY AND REGULATORY PROVISIONS RELEVANT TO THIS GTCC EIS

The WIPP LWA as amended (P.L. 102-579 as amended by P.L. 104-201) limits the use of WIPP to the disposal of TRU waste generated by atomic energy defense activities. In addition, the WIPP LWA as amended establishes certain limits on the surface dose rate, total volume, total radioactivity (curies), and maximum activity level (curies per liter averaged over the volume of the canister) for waste received at WIPP. The implementation of the WIPP alternative for GTCC LLRW and GTCC-like waste would require a change in laws to allow receipt of non-defense TRU and non-TRU waste and modification of the disposal capacity limits stipulated by the WIPP LWA as amended to authorize an increase in the total volume of all TRU waste and total curies of RH TRU waste received at WIPP. In addition, (1) a corresponding modification to the facility's RCRA permit with the New Mexico Environment Department (NMED); (2) a modification to the *Agreement for Consultation and Cooperation between Department of Energy and the State of New Mexico for the Waste Isolation Pilot Plant* (updated April 18, 1988), which sets limits on the total volume of RH TRU received at WIPP; and (3) compliance certification with the EPA might be required. Remote-handled GTCC LLRW and GTCC-like waste would be packaged in shielded containers and would not exceed the surface dose and curie-per-liter limits for RH waste in the WIPP LWA as amended.

Implementation of the WIPP alternative would also require legislative changes for WIPP to be utilized as a disposal facility for GTCC LLRW consistent with the LLRWPAA (P.L. 99-240) direction that such a facility be licensed by the NRC. DOE plans to highlight these issues in the Report to Congress that will be submitted. The report will include a description of disposal alternatives evaluated in the GTCC EIS.

The total capacity for disposal of TRU waste established under the WIPP LWA as amended (P.L. 102-579 as amended by P.L. 104-201) is 175,675 m^3 (6.2 million ft^3). The Consultation and Cooperative Agreement with the State of New Mexico (1981) established a total RH capacity of 7,080 m^3 (250,000 ft^3), with the remaining capacity for CH TRU at 168,500 m^3 (5.95 million ft^3). In addition, the WIPP LWA as amended limits the total radioactivity of RH waste to 5.1 million curies. For comparison, the GTCC LLRW and GTCC-like CH volume, RH volume, and RH total radioactivity are approximately 6,650 m^3 (235,000 ft^3), 5,050 m^3 (178,000 ft^3), and 157 million curies, respectively. On the basis of emplaced and anticipated waste volumes, the disposal of all GTCC LLRW and GTCC-like waste at WIPP would exceed the limits for RH volume and RH total activity. The majority of the GTCC LLRW and GTCC-like RH volume is from the Other Waste category (e.g., DOE non-defense TRU), and activated metal waste contributes to most of the RH activity. The WIPP LWA as amended also limits disposal in WIPP to defense-generated TRU waste. Therefore, the implementation of the WIPP alternative for all GTCC LLRW and GTCC-like waste would require a change in law to allow receipt of non-defense wastes on non-transuranic (non-TRU) waste at WIPP, an increase in the disposal capacity limit for RH total curies, and a change to the Consultation and Cooperative Agreement to authorize an increase in the total volume of all RH TRU waste. In addition, a corresponding modification of the facility's RCRA permit with the NMED, a modification to the Agreement for Consultation and Cooperation between the U.S. Department of Energy and the State of New Mexico for the Waste Isolation Pilot Plant (updated April 18, 1988), which sets limits (identified above) on the total volume of RH TRU received at WIPP, and compliance certification with the EPA might be required. RH GTCC LLRW and GTCC-like waste would be packaged in shielded containers and would not exceed the surface dose and curies-per-liter limits for RH waste in the WIPP LWA as amended.

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5 EVALUATION ELEMENTS COMMON TO ALTERNATIVES 3, 4, AND 5

This chapter presents information that is applicable to the three land disposal alternatives: Alternative 3 (borehole disposal), Alternative 4 (trench disposal), and Alternative 5 (vault disposal). Section 5.1 describes Alternatives 3 to 5 and the general approach and assumptions that were incorporated in developing the conceptual facility designs evaluated in this EIS. Section 5.2 summarizes the assessment approach and assumptions for developing the affected environment and consequence analyses for each environmental resource area. Section 5.3 discusses the potential environmental consequences and human health impacts that are common to all land disposal sites evaluated in Chapters 6 through 11. This chapter concludes with a discussion of the irreversible and irretrievable commitment of resources from construction and operations in Section 5.4, of the inadvertent human intruder scenario in Section 5.5, and of institutional controls in Section 5.6. These topics apply to all three disposal methods being evaluated under Alternatives 3 to 5, regardless of the site or disposal location.

5.1 DESCRIPTION OF ALTERNATIVES 3 TO 5

Sections 5.1.1 to 5.1.3 describe Alternatives 3 to 5, respectively. Details on the conceptual designs for the three land disposal facilities are presented in Section 5.1.4. At each of the six federal sites (Hanford Site, INL Site, LANL, NNSS, SRS, and WIPP Vicinity) to be evaluated under Alternatives 3 to 5, a parcel of land has been designated as the GTCC reference location for evaluation purposes in this EIS. These GTCC reference locations are generally near current waste disposal facilities at the sites. Figures showing the locations are provided in the site-specific chapters, Chapters 6 through 11. Figures that show the general footprints of the GTCC reference locations in order to provide perspective on where the locations are situated with regard to the sites as a whole are provided in Chapter 1 (Figures 1.4.3-4 through 1.4.3-9). Since no specific commercial disposal location has been identified for evaluation, no reference locations for the generic commercial disposal facilities at the four regions are presented in this EIS, and evaluations are hypothetical in nature.

The approximate size (44 ha or 110 ac) of the GTCC reference locations at the Hanford Site, the INL Site, LANL, NNSS, and WIPP Vicinity was based on the space required for the borehole method because it requires the most space of the three land disposal methods evaluated for those sites (see Table 5.1-1 and Table 1.4.3-1). The approximate size (24 ha or 60 ac) of the GTCC reference location at SRS was based on the space required for the vault disposal method, because it is larger than the space required for the trench method and because the borehole method is not being considered for this site.

The size of the GTCC reference location depends primarily on the number of disposal units (i.e., the number of boreholes, trenches, or vaults) required to accommodate the total volume of waste. Less space would be required if only a portion of the GTCC LLRW and GTCC-like waste inventory was disposed of by using a particular method. Table 5.1-2 summarizes the capacity of a single borehole, trench, or vault (each vault is made up of 11 vault cells) for emplacing the disposal containers assumed in this EIS. The numbers of disposal units

TABLE 5.1-1 Number of Disposal Units and Land Area Required for Land Disposal Methods

Land Disposal Facility	No. of CH Waste Disposal Units	No. of RH Waste Disposal Units	Total No. of Disposal Units[a]	Facility Size (ac)[b]
Borehole	420	510	930	110
Trench	7	22	29	50
Vault	34 cells[a]	92 cells	12	60

[a] For the vault method, there would be 12 vaults, each containing 11 disposal cells. Values presented were rounded to two significant figures.

[b] Required acreage presented for the borehole, trench, and vault disposal facility were rounded from 110.4, 46, and 63 acres, respectively.

TABLE 5.1-2 Number of Each Type of Disposal Container That Can Be Accommodated by One Disposal Unit[a]

Type of Container	Borehole	Trench	Vault Cell[b]
CH 55-gal drums	56	3,000	630
SWB	8	500	100
Cs irradiator	20	1,700	300
RH 55-gal drums	54[c]	1,200	290
AMCs	36	910	220

[a] Values presented were rounded to two significant figures.

[b] There are 11 vault cells per vault disposal unit.

[c] It is assumed that three RH drums would be packaged in an RH canister for borehole disposal, with 18 RH canisters per borehole.

(i.e., number of boreholes, trenches, or cells in a vault) needed for each land disposal method and for each waste group and container type are summarized in Table 5.1-3. Details on disposal containers and packing arrangements in the disposal units are also provided in Sections 5.1.1 to 5.1.3 and in Appendix D.

5.1.1 Alternative 3: Disposal in a New Borehole Disposal Facility

Alternative 3 would involve the construction, operations, and post-closure of a new borehole facility for disposal of the GTCC LLRW and GTCC-like waste inventory. GTCC

TABLE 5.1-3 Number of Disposal Units Required for Each Waste Type and Disposal Container[a]

Waste Type	Container Type	Containers Stored	Containers Projected	Containers Total	Boreholes Stored	Boreholes Projected	Boreholes Total	Vault Cells Stored	Vault Cells Projected	Vault Cells Total	Trenches Stored	Trenches Projected	Trenches Total
Group 1													
GTCC LLRW													
Activated metals - RH													
Past/present commercial reactors	AMC		2,300	2,500	4.6	64	68	0.8	11	11	0.2	2.5	2.7
Sealed sources - CH	55-gal[b] drum	0	8,700	8,700	0	160	160	0	14	14	0	2.9	2.9
Cesium irradiators - CH	Self-contained	0	1,400	1,400	0	72	72	0	4.8	4.8	0	0.9	0.9
Other Waste - CH	55-gal drum	200	0	200	3.6	0	3.6	0.3	0	0.3	< 0.1	0	< 0.1
Other Waste - RH	55-gal170um	160	5	160	2.9	< 0.1	3	0.5	< 0.1	0.6	0.1	< 0.1	0.1
GTCC-like waste													
Activated metals - RH	AMC	20	18	38	0.6	0.5	1.1	< 0.1	< 0.1	0.2	< 0.1	< 0.1	< 0.1
Sealed sources - CH	55-gal drum	1	3	4	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Cesium irradiators - CH	Self-contained	0	0	0	0 0	0	0	0 0	0	0	0	0	0
Other Waste - CH	55-gal drum	170	0	170	3.1	0	3.1	0.3	0	0.3	< 0.1	0	< 0.1
Other Waste - CH	SWB	220	170	380	27	21	48	2.2	1.7	3.8	0.4	0.3	0.8
Other Waste - RH	55-gal drum	2,500	950	3,500	47	18	64	8.7	3.3	12	2.1	0.8	2.9
Group 2													
GTCC LLRW													
Activated metals - RH													
New BWRs	AMC	0	200	200	0	5.6	5.6	0	0.9	0.9	0	0.2	0.2
New PWRs	AMC	0	830	830	0	23	23	0	3.9	3.9	0	0.9	0.9
Additional commercial waste	AMC	0	2,000	2,000	0	55	55	0	9.2	9.2	0	2.2	2.2
Other Waste - CH	SWB	0	830	830	0	100	100	0	8.3	8.3	0	1.7	1.7
Other Waste - RH	55-gal drum	0	11,000	11,000	0	210	210	0	39	39	0	9.4	9.4
GTCC-like waste													
Other Waste - CH	SWB	0	260	260	0	33	33	0	2.6	2.6	0	0.5	0.5
Other Waste - RH	55-gal drum	0	4,200	4,200	0	78	78	0	15	15	0	3.5	3.5
Total Groups 1 and 2		3,400	33,000	37,000	89	840	930	13	110	130[c]	3	26	29

TABLE 5.1-3 (Cont.)

		Number of Containers			Number of Boreholes			Number of Vault Cells			Number of Trenches		
Waste Type	Container Type	Stored	Projected	Total	Stored	Projected	Total	Stored	Projected	Total	Stored	Projected	Total
Breakdown by Container Type for Groups 1 and 2													
	CH drum	380	8,700	9,100	6.7	160	160	0.6	14	14	0.1	2.9	3
	SWB	220	1,300	1,500	27	160	180	2.2	13	15	0.4	2.5	2.9
	Self-contained	0	1,400	1,400	0	72	72	0	4.8	4.8	0	0.9	0.9
	RH drum	2,700	17,000	19,000	49	310	360	9.3	57	67	2.2	14	16
	AMC	190	5,300	5,500	5.2	150	150	0.9	25	26	0.2	5.9	6.1
	Total	3,400	33,000	37,000	89	840	930	13	110	130	3	26	29

[a] All values have been rounded to two significant figures. Some totals may not equal sum of individual components because of independent rounding. AMC = activated metal canister, BWR = boiling water reactor, CH = contact handled, PWR = pressurized water reactor, RH = remote handled, SWB = standard waste box.

[b] 55 gal = 208 L.

[c] There are 11 vault cells per vault; therefore, 130 vault cells would require 12 vaults.

reference locations at five of the six sites are evaluated for this alternative: Hanford Site, INL Site, LANL, NNSS, and WIPP Vicinity. Alternative 3 is not evaluated for SRS because the depth required (i.e., about 40 m or 130 ft) for the borehole disposal method is incompatible with the shallow groundwater table present at this site. Borehole disposal is also evaluated for one of the generic commercial regional locations (in Region IV).

About 44 ha (110 ac) of land would be required to accommodate the approximately 930 boreholes needed to dispose of the waste packages containing the 12,000 m^3 (420,000 ft^3) of GTCC LLRW and GTCC-like waste. Fewer boreholes and less space would be required if only a portion of the inventory was disposed of by using boreholes. This acreage would include land required for support infrastructure (e.g., facilities or buildings for receipt and handling of waste packages or containers) and space for a retention pond to collect stormwater runoff and truck washdown water. Borehole disposal entails emplacement of waste in boreholes at depths deeper than 30 m (100 ft) but above 300 m (1,000 ft) bgs. Boreholes can vary widely in diameter (from 0.3 to 3.7 m [1 to 12 ft]), and the proximity of one borehole to another can vary depending on the design of the facility. The technology for drilling larger-diameter boreholes is simple and widely available. The current conceptual design employs boreholes that are 2.4 m (8 ft) in diameter and 40-m (130-ft) deep in unconsolidated to semiconsolidated soils, as shown here in Figure 5.1.1-1 and in Figure 1.4.2-1, with the spacing between boreholes being 30 m (100 ft).

A bucket auger would be used to drill the large-diameter borehole (see Figure 5.1.1-2), and a smooth steel casing would be advanced to the depth of the borehole during the drilling and construction of the borehole. The casing would provide stability to the borehole walls and ensure that waste packages would not snag or plug the borehole as they were lowered and that they would sit in an upright position when they reached the bottom. The upper 30 m (100 ft) of smooth steel casing would be removed upon closure of the borehole. In some cases where consolidated materials might be encountered, a more robust drilling technology, such as drilling a series of smaller boreholes next to each other with equipment designed to drill into rock formations, would be required. A casing would also be used in this latter case as an aid in placing the waste packages.

For a borehole, the packing arrangements assumed for CH waste are eight intervals (levels) of 208-L (55-gal) drum 7-packs, five intervals of Cs irradiator 4-packs, or eight intervals of one SWB. For RH waste, three intervals of two 3-packs of RH canisters or six intervals of two 3-packs of activated metal canisters (AMCs) are assumed. The waste packages would be placed into the borehole, and then a fine-grained, cohesionless fill (sand) would be used to backfill around the waste containers to fill voids. After the borehole was filled with the waste containers and backfill, a reinforced concrete layer would be placed over the waste packages to help mitigate any future inadvertent intrusion. It is anticipated that clean fill from construction would be used to backfill the borehole above the concrete layer. Each borehole could be capped with a cover system consisting of a geotextile membrane overlain by gravel, sand, and topsoil layers, similar to the cover system for trench disposal discussed in Section 5.1.3 and shown later for vault disposal in Figure 5.1.3-4. In the case of the borehole, the top of the cover system would be flush with or slightly elevated above the surrounding ground surface, depending on the final design. Details on borehole facility construction, operations, and facility integrity are provided in Section 5.1.4.

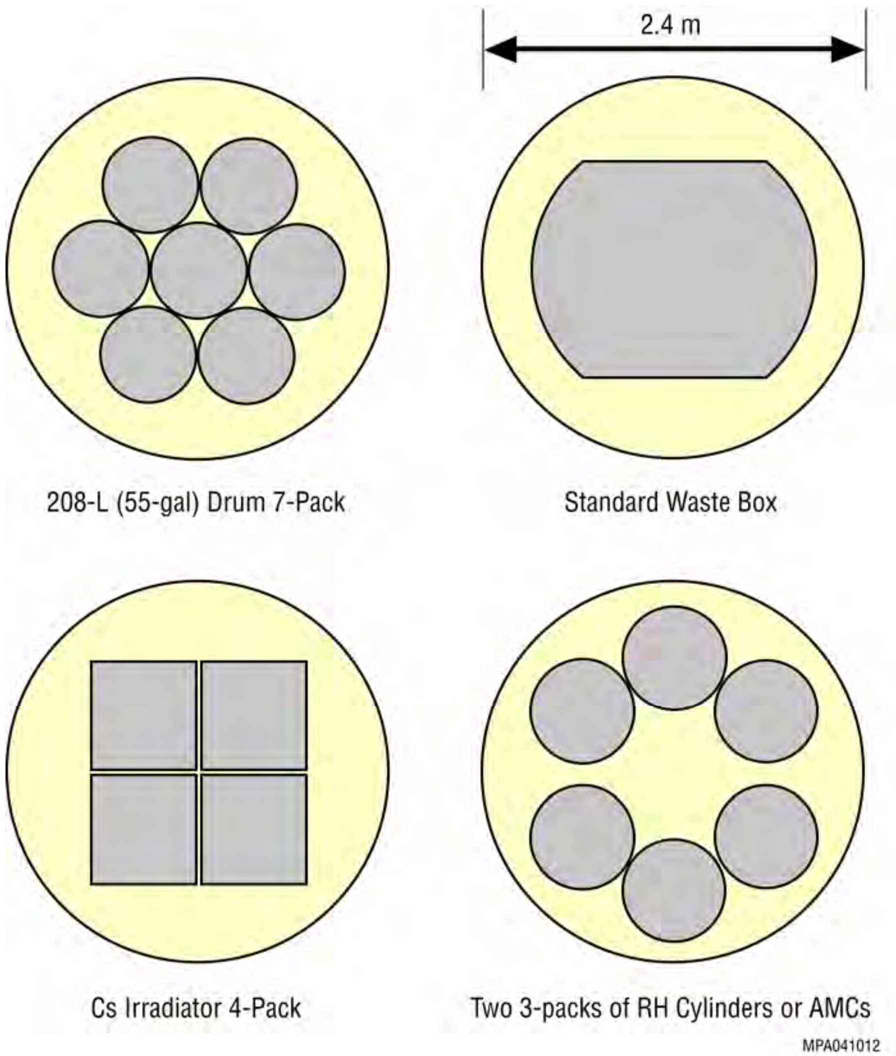

FIGURE 5.1.1-1 Top View of Single-Interval Packing Arrangements in 2.4-m-Diameter (8-ft-Diameter) Boreholes for Different Container Types

5.1.2 Alternative 4: Disposal in a New Enhanced Trench Disposal Facility

Alternative 4 would involve construction, operations, and post-closure of a new trench facility for disposal of the GTCC LLRW and GTCC-like waste included in Groups 1 and 2 of the inventory. GTCC reference locations at the six federal sites (Hanford Site, INL Site, LANL, NNSS, SRS, and WIPP Vicinity) and at the four generic regional locations for the hypothetical commercial disposal facilities are evaluated for this alternative.

To dispose of the entire 12,000 m^3 (420,000 ft^3) of GTCC LLRW and GTCC-like waste, the conceptual design would include 29 trenches occupying a footprint of about 20 ha (50 ac) (see Table 5.1-1). Fewer trenches and less space would be required if only a portion of the GTCC LLRW and GTCC-like waste inventory was disposed of by using this method. The

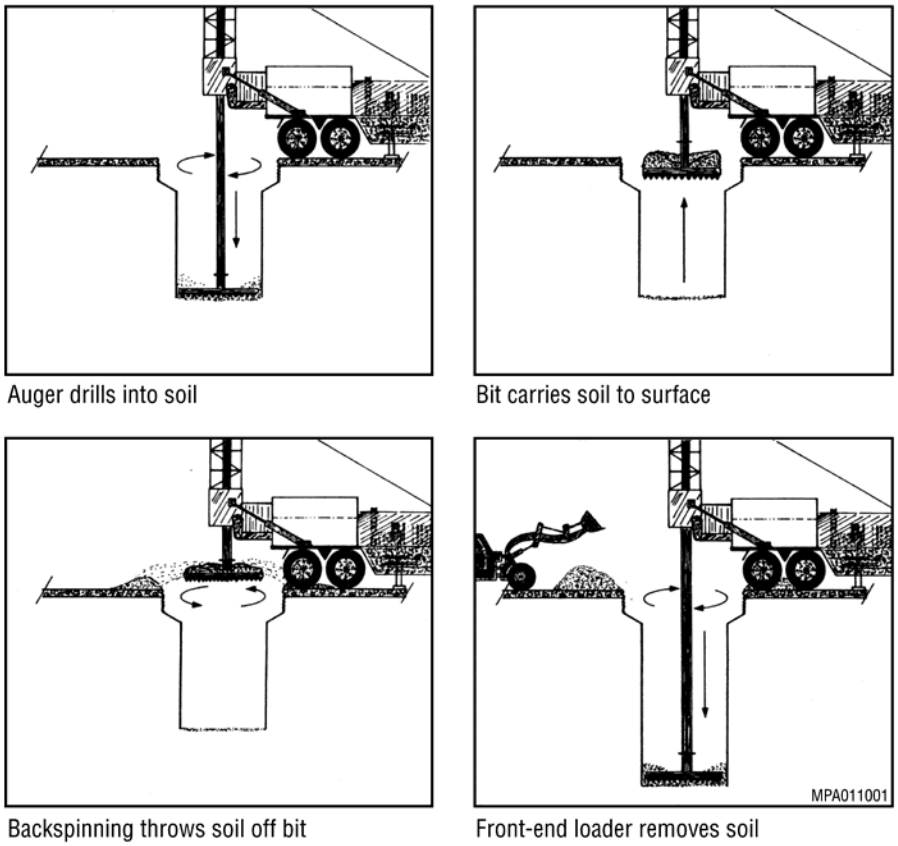

FIGURE 5.1.1-2 Process Schematic for Drilling a Large-Diameter Borehole by Using a Bucket Auger (Source: Sandia 2007)

assumed 20-ha (50 ac) area would include land needed for supporting infrastructure (e.g., facilities or buildings for receipt and handling of waste packages or containers) and space for a retention pond to collect stormwater runoff and truck washdown water. Each trench would be approximately 3-m (10-ft) wide, 11-m (36-ft) deep, and 100-m (330-ft) long. The number of packages that would be needed to contain the waste inventory is given in Table 5.1-3. The information is presented on a waste type basis. After placement of wastes in the trench, an engineered barrier (a reinforced concrete layer) would be placed on top, and then backfill would be added to just below the surface level. Each trench could be capped with a cover system consisting of a geotextile membrane overlain by gravel, sand, and topsoil layers, similar to that shown for the vault design final cover system later in Figure 5.1.3-4. In the case of the trench, the top of the cover system would be flush with or slightly elevated above the surrounding ground surface, depending on the final design. The additional concrete layer would serve to deter inadvertent intrusion into the buried waste during the post-closure period.

During disposal operations for CH waste, one end of a trench would have a ramp to the surface to allow entry by a forklift carrying CH waste packages (a pallet of four drums, four Cs irradiators, or a single SWB) for emplacement. The assumed packing arrangement for 208-L (55-gal) drums and SWBs in a 10-m (33-ft) section of trench is shown in Figure 5.1.2-1.

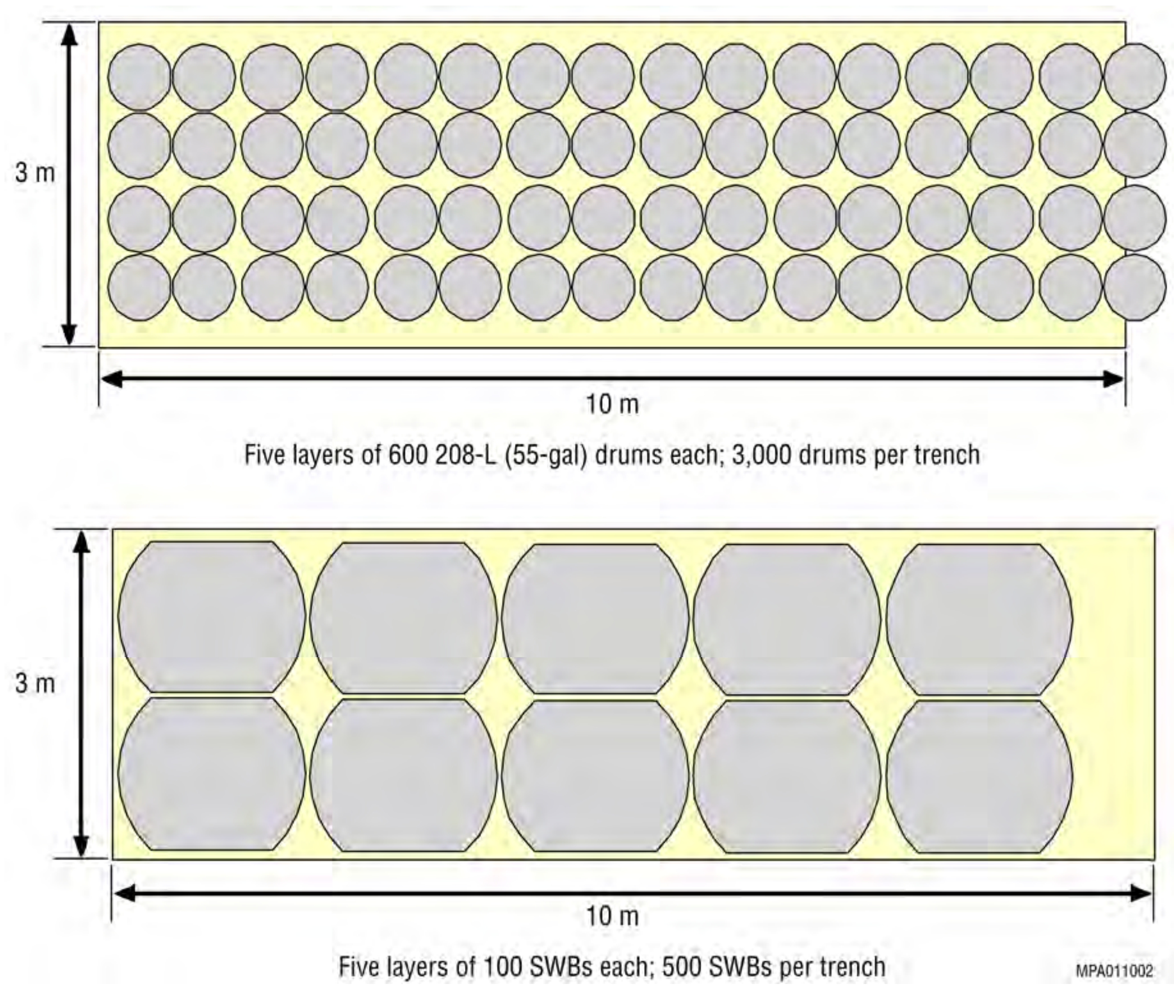

FIGURE 5.1.2-1 Top View of a 10-m (33-ft) Section of a Trench Packed with Contact-Handled Waste

Additional features would be necessary in the trenches where RH waste would be buried to provide shielding for the workers once the waste was in place. The RH waste packages (AMCs, drums, and RH canisters containing drums) would be disposed of in vertical reinforced concrete cylinders with concrete shield plugs on the top of each cylinder. A mating flange would enable coupling of the bottom-loading transfer cask to a given cylinder for transfer of the waste package into the disposal unit. The transfer cask would be moved off of an on-site transport truck and into position by an overhead crane. Figure 5.1.2-2 shows a top view of a 10-m (33-ft) section of an RH waste disposal trench. Each cylinder would be able to hold up to three AMCs, four individual 208-L (55-gal) drums, or one RH canister. During trench closure, the engineered barrier would be placed directly on top of the concrete shield plugs.

Facility construction, operations, and post-closure activities assumed for the evaluation of the trench disposal method are discussed in Section 5.1.4 and Appendix D.

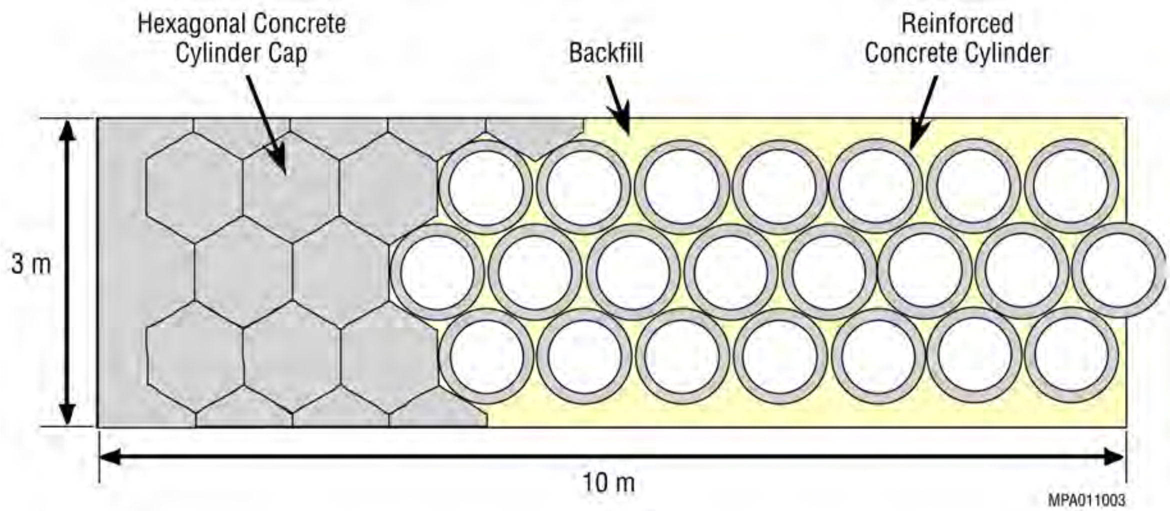

FIGURE 5.1.2-2 Top View of a 10-m (33-ft) Section of a Trench for Disposal of Remote-Handled Waste

5.1.3 Alternative 5: Disposal in a New Vault Disposal Facility

Alternative 5 would involve the construction, operations, and post-closure of a new vault facility for disposal of GTCC LLRW and GTCC-like waste included in Groups 1 and 2 of the inventory. GTCC locations at all six federal sites (Hanford Site, INL Site, LANL, NNSS, SRS, and WIPP Vicinity) and at the generic commercial sites for the four regions are evaluated for this alternative.

In the conceptual design for vault disposal of GTCC LLRW and GTCC-like waste, a reinforced concrete vault would be constructed near grade level, with the footings and floors of the vault situated in a slight excavation just below grade. The design is a modification of a disposal concept proposed by Henry (1993) for GTCC LLRW, and it is similar to a belowground vault LLRW disposal method (Denson et al. 1987) previously investigated by the USACE. A similar concrete vault structure is currently in use (mostly below grade) for the disposal of higher-activity LLRW at SRS (MMES et al. 1994).

The vault disposal facility would occupy a footprint of about 24 ha (60 ac) (see Table 5.1-1) to accommodate the 12 vaults required to dispose of the entire 12,000 m^3 (420,000 ft^3) of GTCC LLRW and GTCC-like waste. Each vault (excluding the interim and final cover) would be about 11-m (36-ft) wide, 94-m (310-ft) long, and 7.9-m (26-ft) tall, with 11 disposal cells situated in a linear array. Interior cell dimensions would be about 8.2-m (27-ft) wide, 7.5-m (25-ft) long, and 5.5-m (18-ft) high, with an internal volume of 340 m^3 (12,000 ft^3) per cell. Double interior reinforced concrete walls with an expansion joint would be included after every second cell. Figure 1.4.2-4 in Chapter 1 shows a schematic cross section of a vault cell.

The packing arrangement to be used for CH 208-L (55-gal) drums in a cell assumes the placement of 7-drum packs as received at the facility in a Transuranic Package Transporter-II (TRUPACT-II) Type B transportation package. Figure 5.1.3-1 shows the arrangement for the CH drums, with 18 7-drum packs per layer. If five layers were used, 630 drums could be accommodated in each cell. For SWBs, 20 SWBs could be arranged in one layer (Figure 5.1.3-2), with five layers for 100 SWBs in one vault cell. In addition, it is assumed that about 300 Cs irradiators (three layers of 10 by 10) could fit in one cell. SWBs, 7-drum packs, and 4-packs of irradiators would be taken off an on-site transport truck and loaded into the cell by an overhead crane.

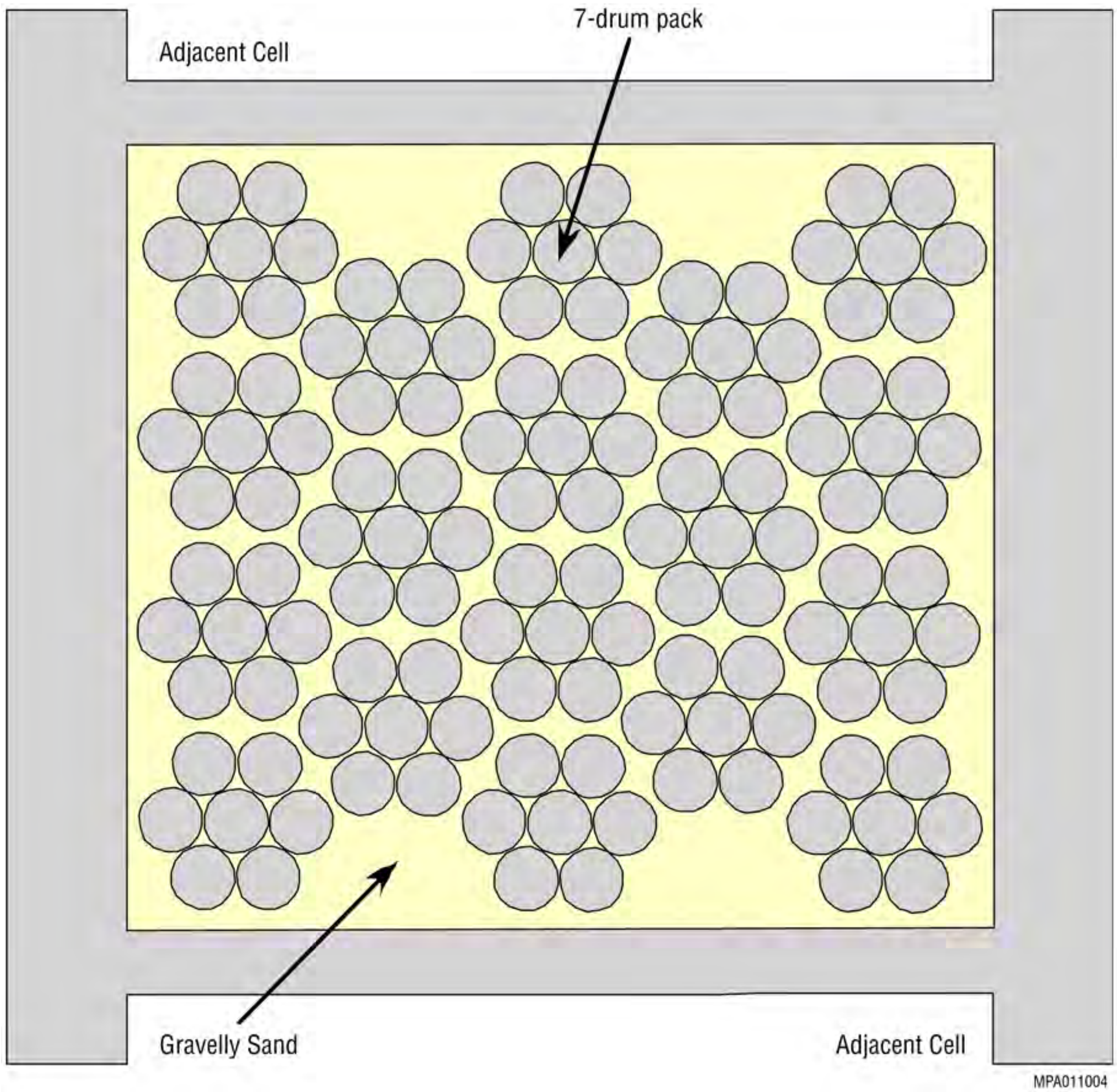

FIGURE 5.1.3-1 Single-Layer Packing Arrangement of Contact-Handled Waste in 208-L (55-gal) 7-Drum Packs in Vault Cells

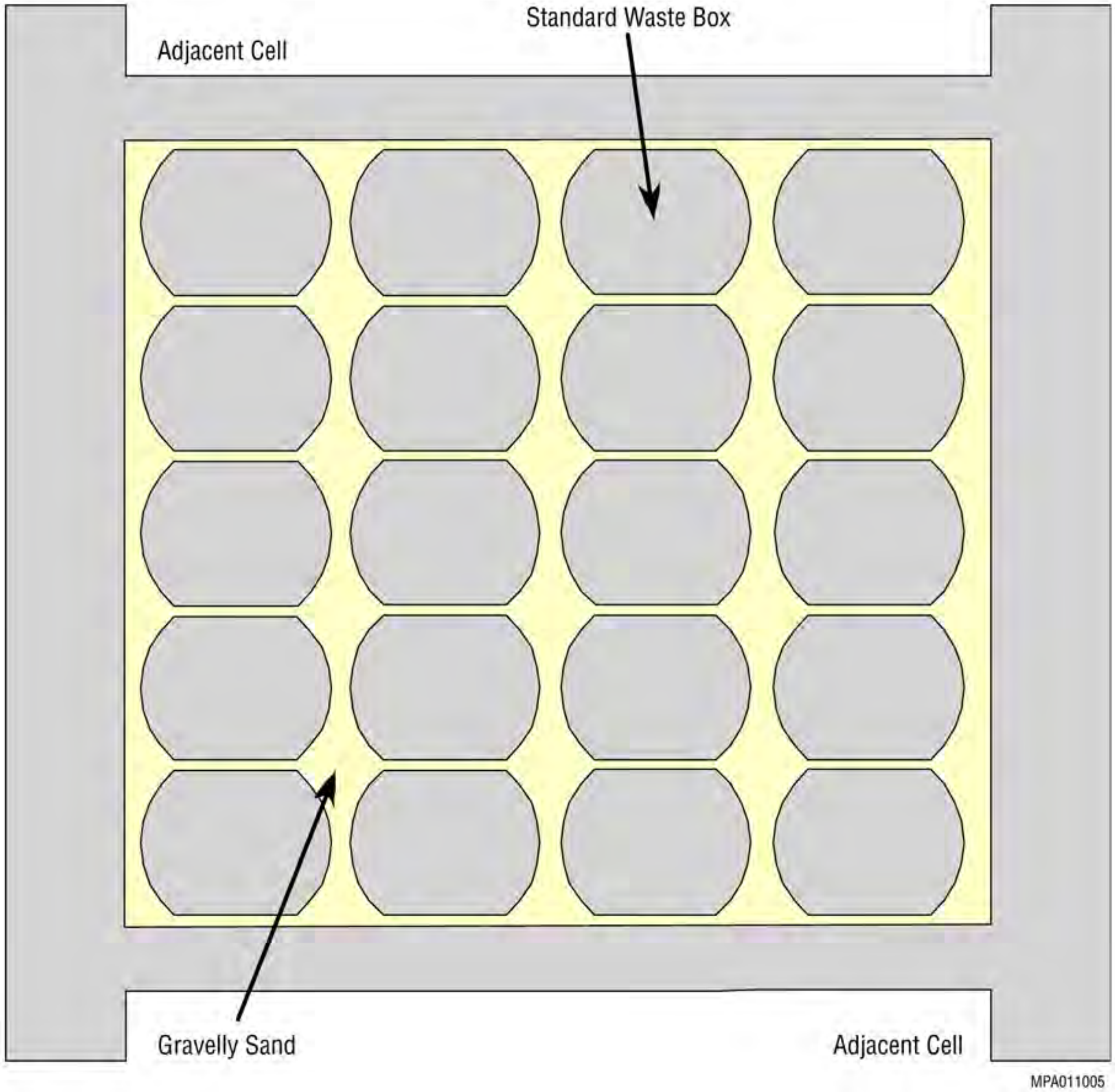

FIGURE 5.1.3-2 Single-Layer Packing Arrangement of Contact-Handled Waste in Standard Waste Boxes in Vault Cells

The vault cell design for disposal of RH waste would be similar to the trench design, as discussed in Section 5.1.2. RH AMCs, 208-L (55-gal) drums, or canisters would be loaded from a bottom-loading transfer cask into vertical concrete cylinders with thick concrete shield plugs within each cell. Figure 5.1.3-3 shows a view from the top of a vault cell. The cylinder loading would be the same as that for a trench: three AMCs, four 208-L (55-gal) drums, or one RH canister per cylinder.

Two engineered cover systems would be used for the vaults. Figure 5.1.3-4 provides a cross-sectional view of each. The first cover would either be installed after each vault was filled with waste and permanently closed, or it would be installed incrementally as the vault was being

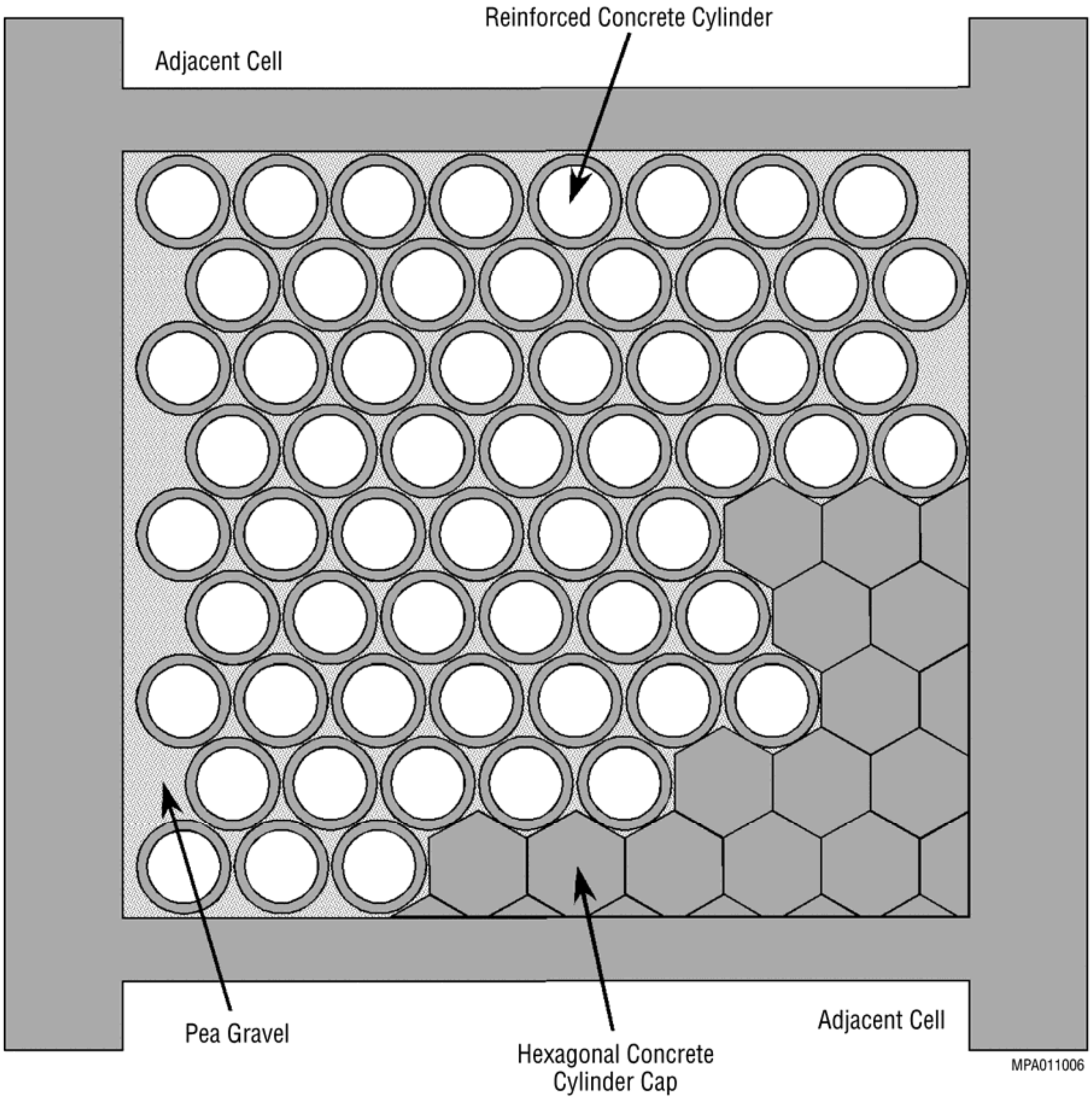

FIGURE 5.1.3-3 Top View of a Vault Cell for Disposal of Remote-Handled Waste

filled (this would be the interim cover with a rise-to-run of 1:3 from the vault edge to ground level). The second cover system would partially replace the interim cover prior to closure of the disposal facility (this would be the final cover with a rise-to-run of 1:5 from the vault edge to ground level). The final cover would span all of the vaults in the facility to preclude runoff from settling between vaults. As depicted in Figure 5.1.3-4, approximately the top 1.2 m (4 ft) of the interim cover would be removed (another option would be to leave it in place); the native soil that was removed would be used as fill between the vaults, along with additional soil; and the engineered cover, consisting of the geotextile, gravel, sand, and topsoil, would be placed on top.

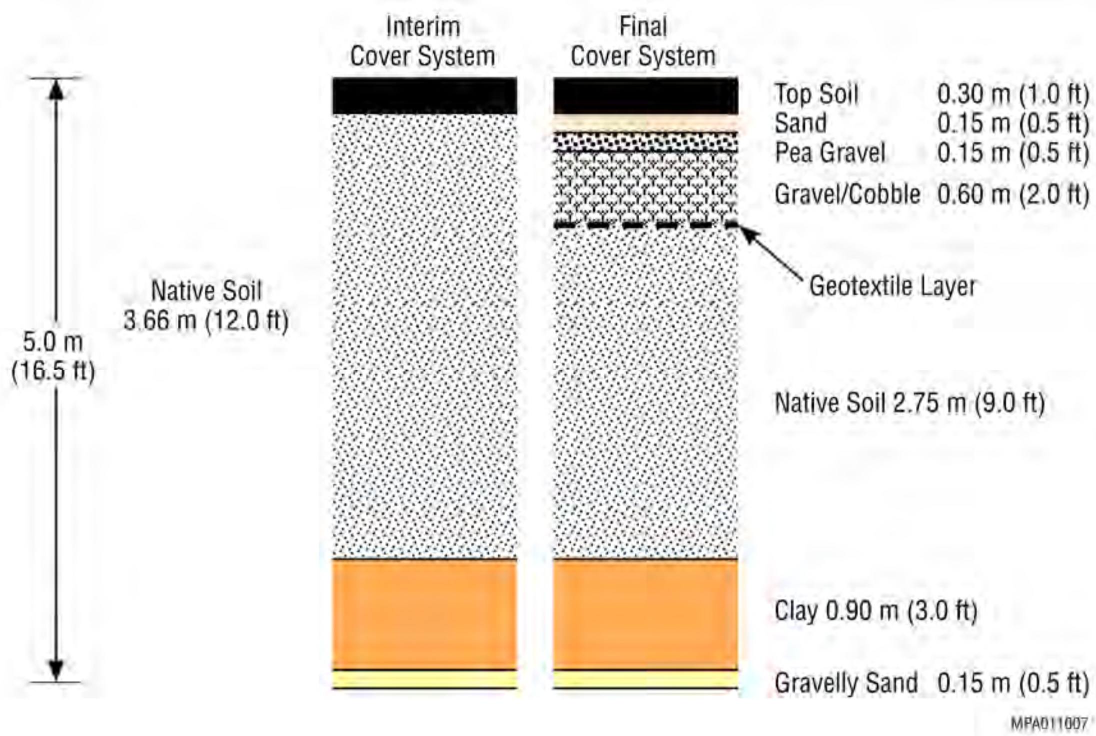

FIGURE 5.1.3-4 Conceptual Cover Systems for a Vault Disposal Facility (Source: Modified from Henry 1993)

A graded slope of 3% would be used over the top of the vaults. Both covers would have a minimum depth of 5 m (16 ft) over any portion of the vault, with a 15-cm (0.5-ft) layer of gravelly sand over the vault followed by a layer of clay that was 0.9-m (3-ft) thick, as shown in Figure 5.1.3-4. The next layer in the interim cover would consist of 3.7 m (12 ft) of native soil followed by 0.3 m (1 ft) of topsoil. In the final cover, the next layer over the clay layer would have 2.8 m (9 ft) of native soil, followed by a geotextile layer, 0.6 m (2 ft) of gravel, 15 cm (0.5 ft) of pea gravel, 15 cm (0.5 ft) of sand, and 0.3 m (1 ft) of topsoil (Henry 1993). If needed, rock armor could also be incorporated into the final cover to further protect against erosion. The total height of the vault system (i.e., vault and final cover system) would be 13 m (43 ft).

Construction, operations, and post-closure activities for the vault are also discussed next in Section 5.1.4 and in Appendix D.

5.1.4 Conceptual Facility Construction, Operations, and Integrity and Estimated Cost for the Borehole, Trench, and Vault Disposal Methods

A conceptual design for each of the three land disposal methods (borehole, trench, and vault) was developed to conduct an evaluation consistent with the objective of this EIS: to provide a comparative analysis of the general performance of these generic conceptual waste disposal facilities at the various GTCC reference locations evaluated.

The conceptual designs for the land disposal facilities were selected on the basis of current practices or concepts associated with the disposal of similar types of radioactive waste, as discussed in Section 1.4.2. It is assumed that the land disposal methods discussed in this chapter would accommodate the entire waste inventory. Thus, the estimated impacts of any given land disposal method and site are expected to bound other potential scenarios in which a disposal facility might be used to accommodate one or two of the waste types considered (e.g., activated metals, sealed sources, or Other Waste). Table 5.1-1 summarizes the estimated facility size for each disposal method. Figures 5.1.4-1, 5.1.4-2, and 5.1.4-3 provide conceptual full facility layouts for the borehole, trench, and vault methods, respectively. Figure 5.1.4-4 illustrates a cross section of the conceptual vault final cover system. A final cover system similar to that shown in Figure 5.1.4-4 for the vault design could be employed for the trench and borehole designs, depending on the local topology of the disposal area. In addition to the separate cover for each borehole or trench, a cover system that would span multiple boreholes or trenches could be added to maximize water runoff from the disposal area.

5.1.4.1 Disposal Facility Construction

Current industry construction practices were used as guidelines for assumptions about construction. It is assumed that initial site construction would take about 820 workdays spread over 3.4 years (240 workdays per year). The construction period would cover the time necessary

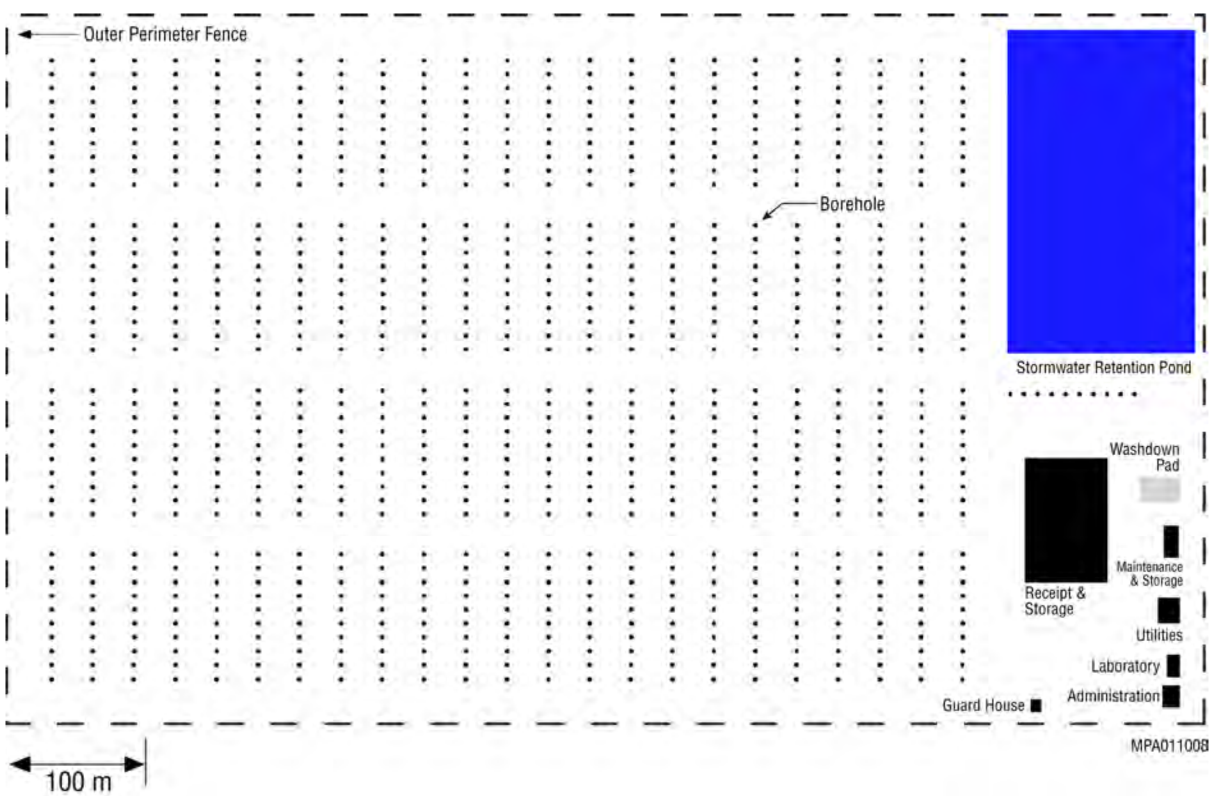

FIGURE 5.1.4-1 Layout of a Conceptual Borehole Disposal Facility

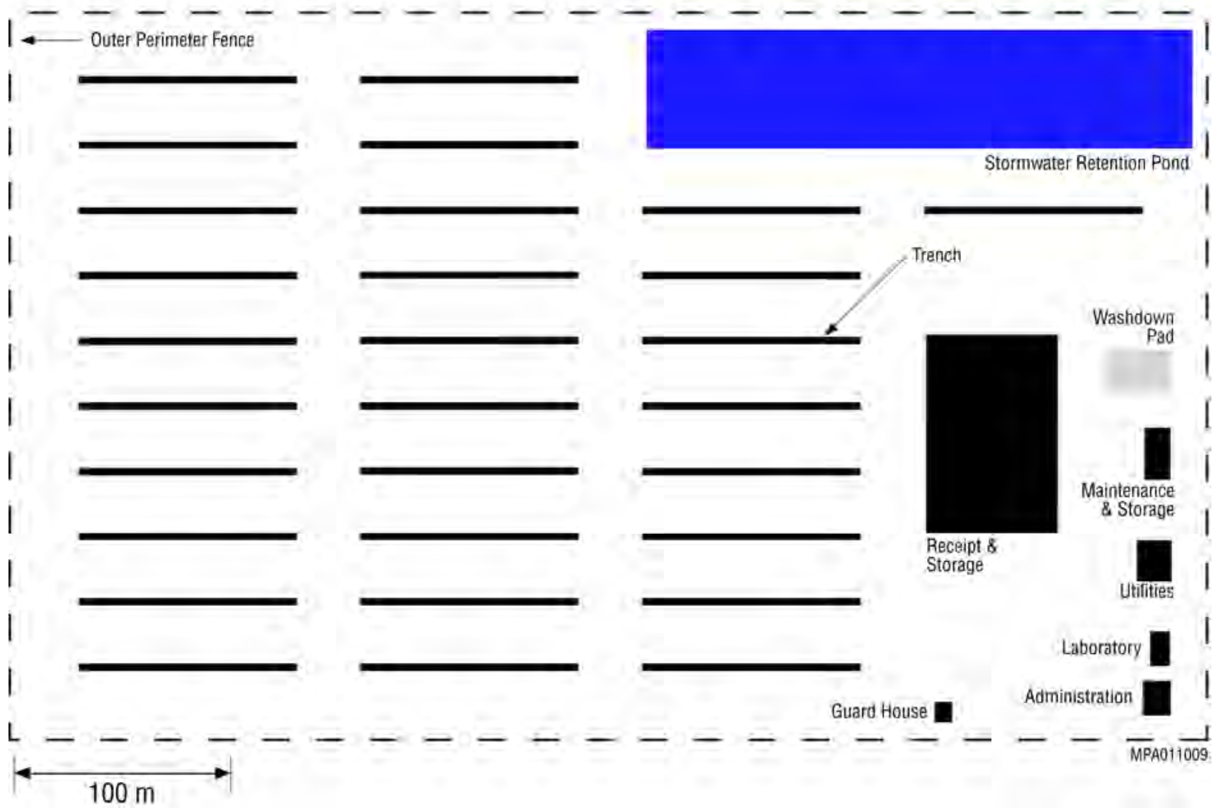

FIGURE 5.1.4-2 Layout of a Conceptual Trench Disposal Facility

for initial site preparation, infrastructure emplacement, and support structure construction. It is assumed that construction of the disposal units (borehole, trench, or vault) would occur in parallel with their operations over a 20-year period, when the majority of the waste is expected to be received. A period of 20 years is assumed for the construction of all disposal units. Assuming an average annual rate of construction, the estimated 20-year period would be slightly more than that necessary to accommodate the assumed receipt rate of the GTCC LLRW and GTCC-like waste for at least the first 15 years of disposal operations. Thus, the annual impacts from construction as presented in this EIS are considered to be slightly conservative but not unrealistic, because waste receipt rates could vary from year to year. In addition, it is expected that the majority of the waste (approximately 75% of the total waste) would be received for disposal within the first 20 years of operations.

5.1.4.2 Disposal Facility Operations

Disposal operations, including the number of workers required, are contingent on the availability and receipt of waste. Additional information about assumed GTCC LLRW and GTCC-like waste generation rates or when waste would be received for disposal is provided in Section B.4. As a conservative approach, it is assumed that the disposal facilities would be standalone facilities operated on a continuous basis. In other words, they would not open

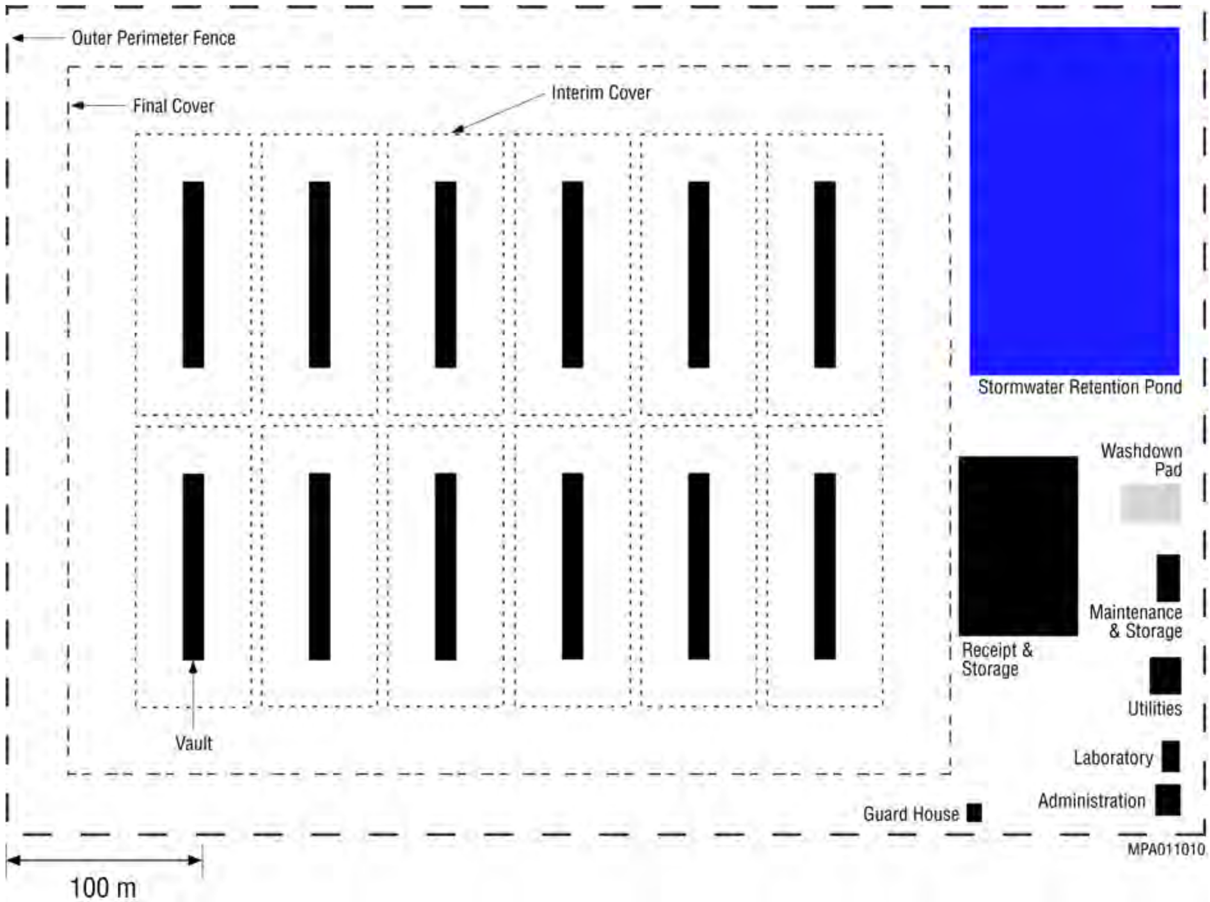

FIGURE 5.1.4-3 Layout of a Conceptual Vault Disposal Facility

periodically to receive a short shipping campaign. Thus, the impacts assessed are considered to represent reasonable maximum values, because such a disposal facility could be collocated with another facility, and personnel, equipment, and supplies could be shared. If the collocation of facilities was selected in the future, impacts from the GTCC LLRW and GTCC-like waste disposal facility would be correspondingly lower depending on the number of employees and costs associated with the overlapping of facilities. The minimum number of personnel assumed for continuous operation of the facility was determined on the basis of a time-motion analysis of operations associated with receiving and disposing of shipping containers (Argonne 2010).

It is assumed that disposal operations at the borehole, trench, or vault facilities would start in 2019 for the purposes of this EIS. On the basis of this starting point and assumptions about the availability of stored and projected waste, about shipping and packaging, and about on-site operations, the number of workers required for the land disposal methods was estimated. The actual start date for operations is uncertain at this time and dependent upon, among other things, the alternative or alternatives selected, additional NEPA review as required, characterization studies, and other actions necessary to initiate and complete construction and operation of a GTCC LLRW and GTCC-like waste disposal facility. For purposes of analysis in the EIS, DOE assumed a start date of disposal operations in 2019. However, given these

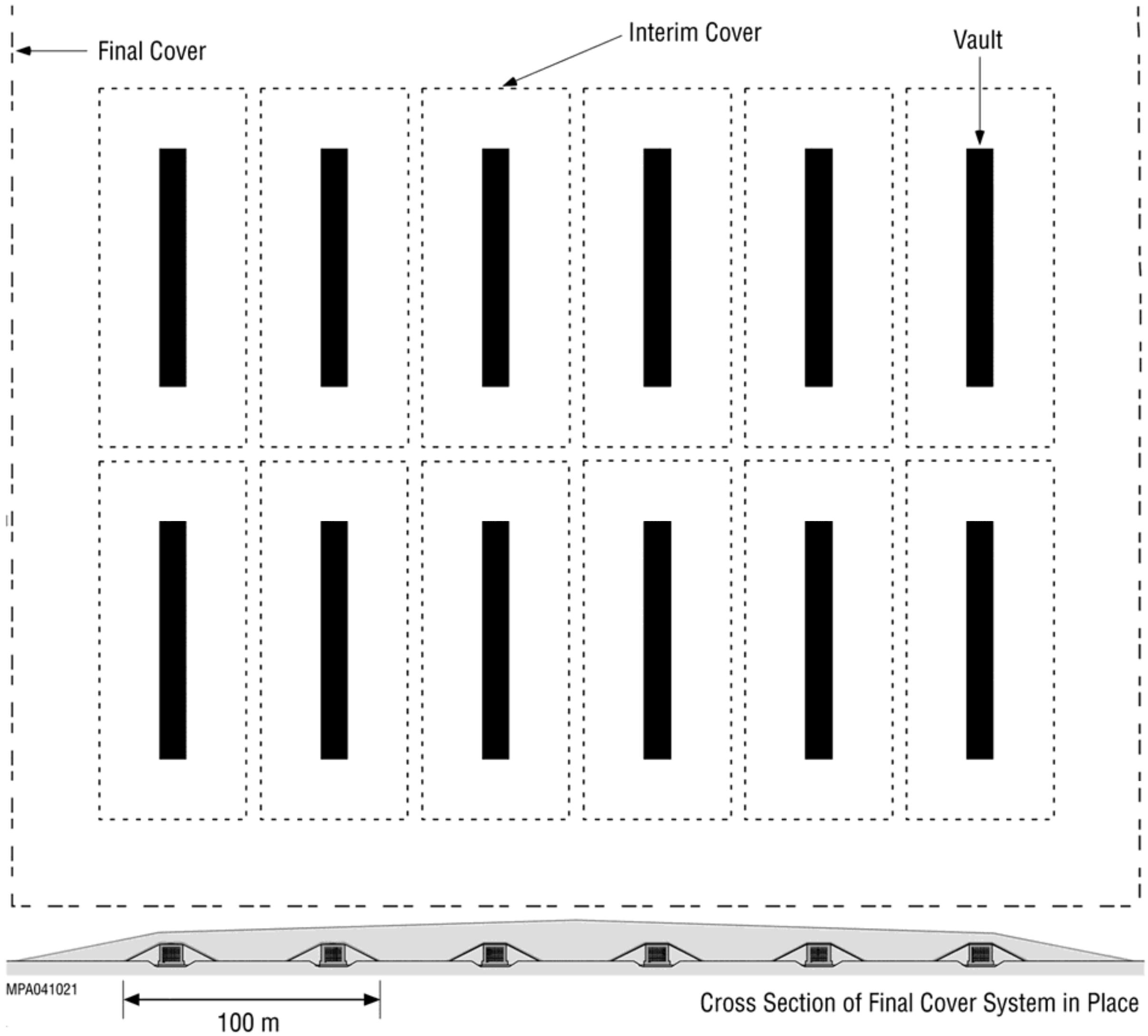

FIGURE 5.1.4-4 Cross Section of Vault Final Cover System (bottom) below Top View of Vault Disposal Area (both images are drawn to the same scale)

uncertainties, the actual start date could vary. In each case, it was estimated that approximately 570 shipments would be received annually through 2035, at which time fewer shipments would be expected on an annual basis. The number of waste containers for disposal of GTCC LLRW and GTCC-like waste at the land disposal (borehole, trench, and vault) facility is estimated to be about 37,000, as shown in Table 5.1-3.

If a GTCC LLRW and GTCC-like waste disposal facility operated in conjunction with another facility and if supporting infrastructure could be shared and economies of scale could be realized, the actual impacts would be less than those presented in this chapter and in the site-specific chapters (Chapters 6 through 12) for the land disposal alternatives. This would be the case for the potential disposal of waste at WIPP (deep geologic disposal) that is being evaluated, for which additional workers and support facilities are not expected to be required; only additional time and disposal space would be needed if GTCC LLRW and GTCC-like waste were disposed of at WIPP while it was already operating.

5.1.4.3 Disposal Facility Integrity

For the purposes of the EIS, the integrity of the land disposal facilities is assumed to be the same for the borehole, trench, and vault methods for the impact analyses. This approach allows for a comparison of the disposal methods on the basis of the general geophysical conditions at each site. All disposal methods incorporate an engineered cover to reduce water infiltration in the post-closure phase. (The Hanford Site is required to use lined disposal facilities. A GTCC LLRW and GTCC-like waste facility, if implemented at Hanford, would thus include a liner or leachate collection system in its design.)

Consideration of additional engineered features, such as internal grouting of the waste in its disposal containers or grouting of the space between disposal containers in the disposal units, might reduce the leach rates of radionuclides into the groundwater and thereby reduce the potential peak impacts in the long term. An assumption that the third waste type, the Other Waste, would be grouted in disposal containers was incorporated into the post-closure analysis. For wastes like activated metals and sealed sources, which mostly contain radionuclides with shorter half-lives, this EIS does not assume grouting would be required because of the waste form.

5.1.4.4 Estimated Costs of Constructing and Operating the Borehole, Trench, and Vault Disposal Facilities

The estimated costs for the initial construction of the land disposal facilities and for their operation are discussed in detail in Appendix D. The same support functions would be necessary for all three disposal methods because the GTCC LLRW and GTCC-like waste would arrive at the disposal facility in the same packaging and disposal containers. The primary differences would be found in the actual waste disposal units themselves and the equipment used to emplace the waste. Thus, the primary difference in cost among the three methods would be in the cost of constructing the disposal units; similar costs are expected for operations. Construction of a vault facility is expected to have the highest cost because of the amount of material and labor involved in its construction. The estimated cost for operations is based on 20 years of operations, as discussed in Section 5.1.4.1 (approximately 75% of the total inventory is assumed to be received for disposal within the first 20 years of operation). Table 5.1.4-1 presents a summary of these estimates.

5.2 ASSESSMENT APPROACH AND ASSUMPTIONS

This section provides assessment approaches and assumptions for the environmental resource areas evaluated for Alternatives 3 to 5. Appendix C provides additional details on methodologies used for the impact analyses presented in this EIS. The generic commercial disposal locations are not evaluated for the environmental resource areas discussed in this section

TABLE 5.1.4-1 Estimated Costs to Construct and Operate the Land Disposal Facilities[a]

Disposal Method	Cost to Construct Facility (in millions of $)[b]	Cost to Operate Facility (in millions of $)[c]	Total Cost to Construct and Operate Facility (in millions of $)
Borehole	210	120	330
Trench	86	160	250
Vault	360	160	520

[a] Costs are rounded to two significant figures.

[b] Construction costs for the borehole, trench, and vault disposal facilities are for 930 boreholes, 29 trenches, and 12 vaults (consisting of 132 total vault cells) and the supporting infrastructure.

[c] Operational costs assume 20 years of facility operations for the borehole, trench, and vault disposal methods. On the basis of the assumed receipt rates, the majority of the wastes would be available for emplacement during the first 15 years of operations (assumed to start in 2019). The actual start date for operations is uncertain at this time and dependent upon, among other things, the alternative or alternatives selected, additional NEPA review as required, characterization studies, and other actions necessary to initiate and complete construction and operation of a GTCC LLRW and GTCC-like waste disposal facility. For purposes of analysis in the EIS, DOE assumed a start date of disposal operations in 2019. However, given these uncertainties, the actual start date could vary.

because each of the four regions encompasses a very large area for which a meaningful evaluation of the resource area is not possible. However, human health impacts for the long term are estimated by using region-specific input parameters. This estimate was done in order to provide information that could be used to distinguish the four regions from one another.

5.2.1 Climate, Air Quality, and Noise

5.2.1.1 Climate and Air Quality

This section provides general descriptions for the following federally based air quality programs likely to affect construction and operations of a disposal facility for GTCC LLRW and GTCC-like waste:

- National Ambient Air Quality Standards (NAAQS),
- Prevention of Significant Deterioration (PSD),
- Visibility protection,

- General conformity, and
- National Emissions Standards for Hazardous Air Pollutants (NESHAPs).

Specific details (such as state air standards) that differ among the GTCC reference locations are presented in the site-specific discussions of the affected environment (Chapters 6 through 12).

5.2.1.1.1 NAAQS. The EPA has set NAAQS for six criteria pollutants — including SO_2, NO_2, CO, O_3, PM (PM_{10} and $PM_{2.5}$), and lead — as shown in Table 5.2.1-1. Primary NAAQS specify maximum ambient (outdoor air) concentration levels of the criteria pollutants with the aim of protecting public health with an adequate margin of safety. Secondary NAAQS specify maximum concentration levels with the aim of protecting public welfare. The NAAQS specify different averaging times as well as maximum concentrations. Some of the NAAQS for averaging times of 24 hours or less allow the standard values to be exceeded a limited number of times per year. States can have SAAQS. SAAQS must be at least as stringent as the NAAQS, and they can include standards for additional pollutants. If a state has no standard corresponding to one of the NAAQS, the NAAQS apply.

Particulate Matter

Particulate matter (PM) is dust, smoke, and other solid particles and liquid droplets in the air. The size of the particulate is important and is measured in micrometers (μm). A micrometer is 1 millionth of a meter (0.000039 in.). PM_{10} is PM with an aerodynamic diameter that is less than or equal to 10 μm, and $PM_{2.5}$ is PM with an aerodynamic diameter that is less than or equal to 2.5 μm.

An area in which the measured air quality is above the NAAQS/SAAQS maximum concentration is called a nonattainment area. Nonattainment areas in which air quality has improved and is demonstrated to be below an NAAQS/SAAQS concentration can be redesignated as a maintenance area. These areas are required to adopt a maintenance plan that ensures air quality will not degrade in the area.

5.2.1.1.2 PSD. While the NAAQS (and SAAQS) place upper limits on the levels of air pollution, PSD regulations that apply to attainment areas place limits on the total increase in ambient pollution levels above established baseline levels for SO_2, NO_2, and PM_{10}, thus preventing "polluting up to the standard" (see Table 5.2.1-1). These allowable increases are smallest in Class I areas such as national parks and wilderness areas. The rest of the country is subject to larger Class II increments. States can choose a less stringent set of Class III increments, but none have done so. Major (large) new and modified stationary sources must meet the requirements for the area in which they are located and for any areas they impact. Thus, a source located in a Class II area that is near a Class I area would need to meet the more stringent Class I increment in the Class I area and the Class II increment elsewhere, as well as any other applicable requirements.

In addition to capping increases in criteria pollutant concentrations below the levels set by the NAAQS, the PSD program mandates stringent control technology requirements for new

TABLE 5.2.1-1 National Ambient Air Quality Standards and Maximum Allowable Increments for Prevention of Significant Deterioration

		NAAQS[b]		PSD Increments[d] (μg/m^3)	
Pollutant[a]	Averaging Time	Value	Type[c]	Class I	Class II
SO_2	1-hour	75 ppb	P	–[e]	–
	3-hour	0.5 ppm (1,300 μg/m^3)	S	25	512
	24-hour	0.14 ppm	P	5	91
	Annual	0.03 ppm	P	2	20
NO_2	1-hour	0.100 ppm	P	–	–
	Annual	0.053 ppm (100 μg/m^3)	P, S	2.5	25
CO	1-hour	35 ppm (40 mg/m^3)	P	–	–
	8-hour	9 ppm (10 mg/m^3)	P	–	–
O_3	1-hour	0.12 ppm[f]	P, S	–	–
	8-hour	0.075 ppm	P, S	–	–
PM_{10}	24-hour	150 μg/m^3	P, S	8	30
	Annual	–	–	4	17
$PM_{2.5}$	24-hour	35 μg/m^3	P, S	–	–
	Annual	15.0 μg/m^3	P, S	–	–
Lead[g]	Calendar quarter	1.5 μg/m^3	P, S	–	–
	Rolling 3-month	0.15 μg/m^3	P, S	–	–

[a] CO = carbon monoxide, NO_2 = nitrogen dioxide, O_3 = ozone, $PM_{2.5}$ = particulate matter ≤ 2.5 μm, PM_{10} = particulate matter ≤ 10 μm, SO_2 = sulfur dioxide, ppm = part(s) per million.

[b] Refer to 40 CFR Part 50 for detailed information on attainment determination and the reference method for monitoring.

[c] P = primary standard whose limits were set to protect public health; S = secondary standard whose limits were set to protect public welfare.

[d] Class I areas are specifically designated areas in which degradation of air quality is severely restricted under the CAA; they include national parks, wilderness areas, monuments, and other areas of special national and cultural significance. Class II areas have a somewhat less stringent set of allowable emissions.

[e] A dash indicates that no standard exists.

[f] On June 15, 2005, the 1-hour O_3 standard was revoked for all areas except the 8-hour O_3 nonattainment Early Action Compact (EAC) areas (those do not yet have an effective date for their 8-hour designations). The 1-hour standard will be revoked for these areas 1 year after the effective date of their designation as attainment or nonattainment for the 8-hour O_3 standard.

[g] On October 15, 2008, the EPA revised the lead standard from a calendar-quarter average of 1.5 μg/m^3 to a rolling 3-month average of 0.15 μg/m^3.

Sources: 40 CFR 52.21; EPA (2008)

and modified major sources. In Class I areas, federal land managers are responsible for protecting the areas' air-quality-related values (AQRVs), such as scenic, cultural, biological, and recreational resources. As stated in the CAA, the AQRV test requires the federal land manager to evaluate whether the proposed project will have an adverse impact on the AQRVs, including visibility. Even if PSD increments are met, if the federal land manager determines that there is an impact on an AQRV, the permit may not be issued.

5.2.1.1.3 Visibility Protection. Visibility was singled out for particular emphasis in the CAAA. Visibility in a Class I area is protected under two sections of the Act. Section 165 provides for the PSD program (described above) for new sources. Section 169(A), for older sources, describes requirements for reasonably attributable single sources and regional haze requirements, which address multiple sources. Federal land managers have a particular responsibility to protect visibility in Class I areas. Even sources locating outside a Class I area may need to obtain a permit that assures no adverse impact on visibility within the Class I area, and existing sources may need to retrofit controls. EPA's 1999 Regional Haze Rule set goals of preventing future impairment and remedying existing impairment to visibility in Class I areas. States had to revise their State Implementation Plans to establish emission reduction strategies to meet a goal of natural conditions by 2064.

5.2.1.1.4 General Conformity. Under EPA's general conformity regulations (40 CFR Parts 51 and 93, April 5, 2010), federal departments and agencies are prohibited from taking actions in nonattainment and maintenance areas unless they first demonstrate that the actions would conform to the State Implementation Plan as it applies to criteria pollutants. Transportation-related projects are subject to requirements for transportation conformity. General conformity requirements apply to stationary sources. Conformity addresses only those criteria pollutants for which the area is in nonattainment or maintenance (for example, VOCs and NO_X for O_3). If annual source emissions are below specified threshold levels, no conformity determination is required. If the emissions exceed the threshold, a conformity determination must be undertaken to demonstrate that the action conforms to the State Implementation Plan. The demonstration process includes public notification and response and may require extensive analysis.

Volatile Organic Compounds

Volatile organic compounds (VOCs) are organic vapors in the air that can react with other substances, principally nitrogen oxides (NO_x), to form ozone (O_3) in the presence of sunlight.

Given the low emissions, general conformity is unlikely to affect management options for GTCC LLRW and GTCC-like waste.

5.2.1.1.5 NESHAPs. In addition to the criteria pollutants, the EPA regulates hazardous or toxic air pollutants specifically listed in the CAA, such as beryllium, cadmium, and radionuclides. These NESHAPs generally regulate emissions rather than ambient concentrations. The most important NESHAP for a GTCC LLRW and GTCC-like waste disposal facility is for radionuclides (40 CFR Part 61, Subpart H), and it requires a demonstration that radionuclides other than radon released to the air from a DOE facility do not result in a dose to the public of more than 10 mrem/yr. Emissions from both traditional stacks and diffuse sources must be considered when demonstrating compliance.

5.2.1.2 Noise

This section provides general descriptions of noise and vibration associated with construction and operation of a GTCC LLRW and GTCC-like waste disposal facility.

Any pressure variation that the human ear can detect is considered sound; noise is unwanted sound. Sound is described in terms of amplitude (perceived as loudness) and frequency (perceived as pitch). Sound pressure levels are typically measured with logarithmic decibel (dB) scale. To account for human sensitivity to frequencies of sound (i.e., humans are less sensitive to lower and higher frequencies and most sensitive to sounds between 1 and 5 kHz), A-weighting (denoted by dBA) is widely used and is correlated with a human's subjective reaction to sound (Acoustical Society of America 1983, 1985). To account for variations of sound with time, the equivalent-continuous sound level (L_{eq}) is used. L_{eq} is the continuous sound level during a specific time period that would contain the same total energy as the actual time-varying sound. For example, L_{eq} (1-h) is the 1-hour equivalent-continuous sound level. In addition, human responses to noise differ depending on the time of the day (e.g., there is more annoyance over noise during nighttime hours). The day-night average sound level (L_{dn}) provides an average of the level over a 24-hour period after the addition of 10 dB to sound levels from 10 p.m. to 7 a.m. to account for the greater sensitivity of most people to nighttime noise. Generally, a 3-dB change is considered a just noticeable difference, and a 10-dB increase is subjectively perceived as a doubling in loudness and almost always causes an adverse community response.

The Noise Control Act of 1972, along with its subsequent amendments (Quiet Communities Act of 1978, 42 USC, Parts 4901–4918), delegates to the states the authority to regulate environmental noise and directs government agencies to comply with local community noise statutes and regulations. Many local noise ordinances are qualitative, prohibiting excessive noise or noise that results in a public nuisance. Because of the subjective nature of such ordinances, they are often difficult to enforce. However, a handful of states and counties have established quantitative noise-level regulations, which typically specify environmental noise limits based on the land use of the property receiving the noise.

The EPA has a noise guideline that recommends an L_{dn} of 55 dBA, which is sufficient to protect the public from the effect of broadband environmental noise in typically quiet outdoor and residential areas (EPA 1974). These levels are not regulatory goals, but they are "intentionally conservative to protect the most sensitive portion of the American population" with "an additional margin of safety." For protection against hearing loss in the general population from nonimpulsive noise, the EPA guideline recommends an L_{eq} of 70 dBA or less over a 40-year period.

Construction activities can result in varying degrees of ground vibration, depending on the equipment and methods employed. Construction activities that typically generate the most severe vibrations are blasting and impact pile-driving.

Three ground-borne vibration impacts are of general concern: human annoyance, interference with vibration-sensitive activities, and damage to buildings. In evaluating ground-borne vibration, two descriptors are widely used.

- *Peak particle velocity (PPV).* Measured as distance per time (such as inches per second), PPV is the maximum peak velocity of the vibration and correlates with the stresses experienced by buildings.

- *Vibration velocity level (L_V).* This represents a 1-second average amplitude of the vibration velocity. It is typically expressed on a log scale in decibels (VdB), just as noise is measured in dB. This descriptor is suitable for evaluating human annoyance because the human body responds to average vibration amplitude.

A background vibration velocity level in residential areas is usually 50 VdB or lower, well below the threshold of perception for humans, which is around 65 VdB (Hanson et al. 2006). However, human response is not usually significant unless the vibration exceeds 70 VdB. For evaluating interference with vibration-sensitive activities, the vibration impact criterion for general assessment is 65 VdB. For residential and institutional land use (primarily only daytime use, such as at a school or church), the criteria range from 72 to 80 VdB and from 75 to 83 VdB, respectively (depending on event frequency). For potential structural damage effects, guideline vibration damage criteria for various structural categories are provided in Hanson et al. (2006), but damage to buildings would occur at much higher levels (0.30 cm/s [0.12 in./s] or higher, or approximately 90 VdB) than human annoyance and interference with vibration-sensitive activities.

5.2.2 Geology and Soils

The main elements in assessing impacts on geologic and soil resources at the GTCC reference locations being evaluated are the location and extent of the land being disturbed during construction and operations. Geologic and soil conditions at each of the GTCC reference locations are described in the affected environment sections for each site (Chapters 6 through 11). Surveys in the vicinity of these locations, including soil surveys, topographic surveys, and geologic and seismic hazard maps, were reviewed. Well log data from on-site (or near-site) wells and boreholes were also reviewed.

The EIS analysis evaluates impacts on critical geologic attributes, including access to mineral or energy resources, destruction of unique geologic features, and mass movement induced by construction. The impact analysis also evaluates regional geologic conditions, such as the earthquake potential. The analysis for soil resources evaluates impacts on specific soil attributes, including the potential for soil erosion and compaction by construction activities. Last, the determination of the relative magnitude of an impact for each of the reference locations is based on an analysis of both the context of the action and the intensity of the impact on a particular resource.

5.2.3 Water Resources

Hydrologic resources potentially affected by the proposed action include rivers, streams, and groundwater. Hydrologic conditions in the vicinity of each of the GTCC reference locations are described in the affected environment section for each of these locations. Impacts on surface water are presented as changes in runoff by comparing runoff areas with and without the GTCC LLRW and GTCC-like waste disposal facility. The potential for surface water quality impacts is assessed on the basis of the disposal facility's location relative to rivers and streams, local runoff rates, and groundwater discharge.

Potential impacts on groundwater resources are evaluated as impacts on underlying aquifers relative to changes in groundwater depth, direction of groundwater flow, groundwater quality, and recharge rates. Impacts on groundwater depth and the direction of flow are assessed by comparing the existing use of water with the projected demand for water to operate the GTCC LLRW and GTCC-like waste disposal facility.

5.2.4 Human Health

5.2.4.1 Affected Environment Assessment

Human health impacts discussed under the affected environment sections summarize the current radiation doses to on-site workers and the nearby off-site general public for each of the sites evaluated. Potential radiation exposures can result from environmental releases of radionuclides to groundwater and from airborne emissions that occur during the transport, storage, and disposal of radioactive wastes. For most sites, the radiation doses are reported for the highest-exposed individual for affected workers and members of the general public. In some cases, the average individual dose instead of the dose to the highest-exposed individual was reported by the site. Collective doses over the affected populations are also presented whenever data are available. These reported radiation doses are compared to radiation dose limits set by DOE or promulgated by regulatory agencies, and the expected radiation dose from natural background and man-made sources. The reported doses were estimated by using generally conservative exposure assumptions; in general, an individual is expected to receive a dose much lower than that reported in these site-specific documents.

Potential radiation doses reported in the human health portions of the affected environment sections for each site were estimated from environmental monitoring data or by using computer models that simulate environmental transport, dispersion, and distribution of radionuclides. The primary sources for the monitoring data and estimated doses were the annual environmental reports for each site. In addition to these reports, published site-specific EISs and DOE reports concerning radiation worker exposures were also referenced.

5.2.4.2 Assessment of Impacts on Human Health

The human health impacts associated with the waste handling, transportation, and disposal of GTCC LLRW and GTCC-like wastes are analyzed for all aspects associated with managing these wastes, from the point of generation, to the transportation of wastes to the disposal site, to the placement of wastes in the disposal facility, and to the long-term management of the closed facility. That is, this evaluation includes an assessment of potential environmental impacts for both the operational phase and post-closure phase of actions at the disposal sites. For purposes of analysis in the EIS, the wastes are assumed to be in a form that will allow for transportation and disposal with no additional treatment being required, consistent with the defined scope of the EIS.

The human health impacts are addressed for the three phases of the waste disposal site in this EIS: construction, operations, and post-closure. During the first two phases, the impacts consist of those from radiation exposure as well as nonradiation impacts. During the post-closure period, the impacts are limited to those associated with long-term releases from the disposal facilities. Direct physical intrusion, such as by a future inadvertent intruder into the disposal facilities after site closure, is not analyzed quantitatively in this EIS. The actual facility design would include barriers and other engineered features to preclude the likelihood of high impacts on future inadvertent intruders (see related discussion in Sections 5.5 and 5.6). The human health impacts include both those associated with routine activities and those from potential accidents.

The analysis does not address potential toxic chemical releases from the wastes; it is limited to radioactive constituents only. The radioactive hazards of these wastes are expected to exceed those associated with any toxic chemicals that might be present in the GTCC LLRW and GTCC-like waste. The impacts presented for the radioactive contaminants are expected to bound those that could occur from any hazardous chemicals in the wastes. The impacts associated with waste transportation are addressed separately in this EIS; see Section 5.2.9 for a discussion of the approach used to address these impacts.

5.2.4.3 Radiological Impacts

Management of the GTCC LLRW and GTCC-like waste involves the handling, transportation, and disposal of these radioactive wastes. Following completion of the useful life of the disposal facility, it would be decommissioned in accordance with applicable requirements at the time. A long-term monitoring and maintenance period would follow site decommissioning to ensure that the disposal facility was adequately containing the disposed wastes. These activities might result in workers and members of the general public being exposed to radiation and radioactive

> **Radiation**
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> Radiation consists of energy, generally in the form of subatomic particles (neutrons, alpha particles, beta particles) or photons (x-rays and gamma rays) given off by unstable, radioactive atoms as they decay to reach a more stable configuration. Radiation can be classified as being in one of two categories: ionizing and non-ionizing (such as from a laser). The radiation from GTCC LLRW and GTCC-like waste is ionizing radiation. This type of radiation has sufficient energy to displace electrons from atoms or molecules when it interacts with matter (including the human body), creating ion pairs. Ionizing radiation can cause cell damage; this damage can be repaired by the cell, or the cell may die, or the cell may reproduce other altered cells that can lead to cancer.

materials. Radiation, either man-made or naturally occurring, is released when an unstable atom of an element (an isotope) transforms (decays) into a more stable configuration. The radiation that is released can be in the form of particles (e.g., neutrons, alpha particles, beta particles) or waves of pure energy (e.g., gamma rays and x-rays).

Radiation can be broadly classified into two categories: ionizing and non-ionizing radiation. Ionizing radiation is generally more energetic than non-ionizing radiation and can knock electrons out of molecules with which the particles or gamma rays and x-rays interact, creating ion pairs. Non-ionizing radiation, such as that emitted by a laser, is different in that it does not create ions when it interacts with matter but generally dissipates its energy in the form of heat. The radiation associated with GTCC LLRW and GTCC-like waste is ionizing radiation.

Key Concepts in Estimating Risks from Radiation

The health effect of concern from exposure to radiation at the levels expected from management of the GTCC LLRW and GTCC-like wastes is the induction of cancer. Radiation-induced cancers may take many years to develop following exposure and are generally indistinguishable from cancers caused by other sources. Current radiation protection standards and practices are based on the premise that any radiation dose, no matter how small, can result in detrimental health effects such as cancer, and that the number of effects produced is in direct proportion to the radiation dose. This concept is referred to as the "linear-no-threshold hypothesis" and is generally considered to result in conservative estimates (i.e., overestimates) of the health effects from low doses of radiation.

Ionizing radiation is a known human carcinogen, and the relationship between radiation dose and health effects is relatively well characterized for high doses of most types of radiation. Some of these cancers can be fatal, and this is referred to as LCF because the cancer may take many years to develop and cause death. Lower levels of exposure might constitute a health risk, but it is difficult to establish a direct cause-and-effect relationship because a particular effect in a specific individual can be produced by different processes. The features of cancers resulting from radiation are not distinct from those of cancers produced by other causes. Hence, the risk of cancer from chronic exposures of ionizing radiation must be extrapolated from data for increased rates of cancer observed at much higher dose rates. Chronic doses of low-level radiation have not been directly shown to cause cancer, although this assumption has been made in order to be protective.

The amount of energy deposited in ionizing radiation per unit mass of any material is the absorbed dose and is generally expressed in the unit of rad (for radiation absorbed dose). Certain types of radiation are more effective at producing ionizations than others. For the same amount of absorbed dose, alpha particles will produce significantly more biological harm than will beta particles or gamma rays. The dose equivalent approach was developed to normalize the unequal biological effects produced by different types of radiation. The dose equivalent is the product of the absorbed dose (in rad) and a quality factor that accounts for the relative biological effectiveness of the radiation. The dose equivalent is typically expressed in a unit called a rem (for roentgen equivalent man).

The dose delivered to internal organs as a result of radionuclides being systemically incorporated into the body may continue long after intake of the radionuclide has ceased. After being taken into the body, some radionuclides are eliminated fairly quickly, while others are incorporated into tissues or ultimately deposited in bones and can be retained for many years. This process is in contrast to external doses, which occur only when a radiation field is present. The committed dose equivalent was developed to account for doses to internal organs from radionuclides taken into the body. The committed dose equivalent is the integrated dose equivalent to specific organs for 50 years following intake.

The International Commission on Radiological Protection (ICRP) developed the concepts of effective dose equivalent (EDE) and committed effective dose equivalent (CEDE) to account for the differing cancer rates from chronic exposures to radiation by different organs and tissues in the body. The EDE and CEDE are weighted sums of the organ-specific dose equivalents and committed dose equivalents. The weighting factors used in these calculations are based on selected stochastic risk factors and are used to average organ-specific dose equivalents. The total effective dose equivalent (TEDE) is the sum of the EDE for external radiation and the 50-year CEDE for internal radiation. The calculated doses given in this EIS are the TEDEs, as defined here.

The most common forms of radiation associated with GTCC LLRW and GTCC-like waste are neutrons, alpha and beta particles, and electromagnetic radiation in the form of gamma rays and x-rays. Neutrons are one of the two components of an atom's nucleus (the other being the proton) and are often emitted by unstable TRU radionuclides, such as isotopes of plutonium, americium, and curium. An alpha particle consists of two protons and two neutrons and is identical to the nucleus of a helium atom. Beta particles can be either positive (positron) or negative (negatron); a negatron is identical to an electron. Gamma rays and x-rays have no electrical charge or mass and can travel long distances in air, body tissues, or other materials.

Ionizing radiation can impart sufficient localized energy to living cells to cause cell damage. This damage may be repaired by the cell, or the cell may die, or the cell may reproduce other altered cells, sometimes leading to the induction of cancer. An individual may be exposed to radiation from outside the body (external exposure) or, if the radioactive material has entered the body through inhalation or ingestion, from inside the body (internal exposure).

Everyone is exposed to radiation on a daily basis, primarily from naturally occurring cosmic rays, radioactive elements in the soil, and radioactive elements incorporated into the body (such as potassium-40 [K-40]). Man-made sources of radiation include medical x-rays and fallout from previous aboveground nuclear weapons tests and nuclear reactor accidents (such as the accident involving the Chernobyl nuclear reactor in the Soviet Union in 1986). Ionizing radiation causes biological damage only when the energy released during radioactive decay is absorbed by tissue.

Radiation exposures associated with management of GTCC LLRW and GTCC-like waste are generally expected to be limited to chronic effects. The main health concern associated with chronic exposure to radiation is an increased likelihood of developing cancer, and this impact is assessed in the EIS. Relatively large doses are required to cause acute effects, and potential mechanisms for such exposures include direct intrusion into the disposal units or workers being in the immediate vicinity of a large accidental release during operations. Acute doses above

25 rad delivered over a short time period can induce a number of deleterious effects, including nausea and vomiting, malaise and fatigue, increased body temperature, blood changes, epilation (hair loss), and temporary sterility; bone marrow changes have not been identified until the acute doses reach 200 rad (Cember 1983). Such exposures are highly unlikely for managing these wastes.

> **Dose Conversion Factors**
>
> Dose conversion factors (DCFs) represent the total effective dose equivalent (TEDE) per unit intake of radionuclide (internal exposure) or exposure to a unit concentration of radioactive material external to the body (external exposure). The DCFs are used — along with estimates of the amount of radioactive material taken into the body by inhalation and ingestion (for internal exposures) or estimates of the exposure to radioactive material that emits gamma rays or x-rays (for external exposures) — to estimate the TEDE. Updated DCFs have been developed by the ICRP and are used in this EIS to estimate radiation doses to workers and members of the general public.

The EPA has developed dose conversion factors (DCFs) for internal and external exposures, and these factors are given in Federal Guidance Report (FGR) 11 (EPA 1988) and FGR 12 (EPA 1993). For internal exposures, the DCF represents the 50-year CEDE per unit intake of radionuclide, and for external exposures, the DCF represents the EDE per unit of time at 1 m (3 ft) above the ground surface per unit of activity concentration of the specified radionuclide. These DCFs given in the two EPA documents are based on the dosimetry models and results given in ICRP 26 (ICRP 1977) and ICRP 30 (ICRP 1979, 1980, 1981). These DCFs were developed on the metabolic and anatomical model of an adult male, the ICRP reference man weighing 70 kg (150 lb).

The ICRP updated its radiation dosimetry models for members of the general public (spanning a range of ages, including adults) in ICRP 72 (ICRP 1996), and the concepts and models included in ICRP 72 are gaining wide acceptance in the scientific community. For this EIS, the DCFs given in ICRP 72 for adults are used to calculate the doses to workers and members of the general public (ICRP 1996). These are the most recent values and provide a reasonable estimate of doses for comparing the various alternatives evaluated in this EIS. Note that the EPA included the DCFs based on ICRP 72 in its compact disc supplement to Federal Guidance Report No. 13 (EPA 2002).

For the EIS, the radiological impacts were estimated by calculating the radiation doses to workers and members of the general public from the anticipated activities required under each alternative. These activities include those during the operations period, long-term monitoring and surveillance period, and long-term post-closure period. Doses were estimated for internal and external exposures that might occur during normal (or routine) operations and following hypothetical accidents. The analysis considered three groups of people: (1) involved workers, (2) noninvolved workers, and (3) members of the general public. These three cohorts are defined as follows:

- *Involved workers*. These are individuals working at the site (and transportation drivers) who are directly involved with the handling of the wastes. The main exposure mechanism would be from external gamma radiation.

- *Noninvolved workers*. These are individuals working at a disposal site who are not directly involved with the handling of the wastes. The main exposure pathway is also external gamma radiation (but at a greater distance).

- *Members of the general public*. These are persons living near the site. These individuals could receive a small external gamma radiation dose during the operation period, and they could be exposed to radioactive materials over the long term via the airborne and groundwater pathways.

For each of these groups, doses were estimated for the group as a whole (population or collective dose). For the noninvolved workers and general public, doses were also calculated for the highest-exposed individual (i.e., a hypothetical individual who could receive the greatest possible dose). In accordance with DOE policies, all radiation exposures and releases of radioactive material to the environment are required to be kept ALARA, a practice that has as its objective the attainment of dose levels as far below applicable limits as possible.

In addition to estimating the radiation doses (TEDE) for potentially impacted individuals, estimates were developed for the number of potential LCFs by using a health risk conversion factor. This factor relates the radiation dose to the potential number of expected LCFs on the basis of comprehensive studies of groups of people historically exposed to large doses of radiation, such as the Japanese atomic bomb survivors. For this EIS, a health risk conversion factor of 0.0006 LCF/person-rem was used. This value was identified by the Interagency Steering Committee on Radiation Standards as a reasonable factor to use in the calculation of potential LCFs associated with radiation doses as given in DOE guidance and recommendations (DOE 2003b, 2004c). This conversion factor is used to calculate the number of LCFs for the general population and for workers from the estimated radiation doses in this EIS.

This factor means that if a population of workers receives a total dose of 10,000 person-rem, on average, 6 additional LCFs will occur among the workers. In many situations, the estimated number of LCFs is less than 1. For example, if each of 100,000 people in the general public was exposed to 1 mrem (or 0.001 rem), the total dose would be 100 person-rem, and the estimated number of LCFs would be 0.06. This estimate of 0.06 needs to be interpreted statistically (i.e., as the average number of deaths if the same radiation exposure was applied to many groups of 100,000 people). In most groups, no one would incur an LCF from a dose of 1 mrem. In a very small percentage of groups (about 6%), 1 LCF would occur. In an extremely small percentage of groups, 2 or possibly more LCFs would occur. An LCF value of 0.06 can also be viewed as a 6% chance of 1 radiation-induced LCF in the exposed population.

These LCF estimates provided in the EIS are in addition to those from other causes. In 2008, the American Cancer Society estimated 566,000 people would die of cancer in the United States, and about three times that number (1,440,000) would be diagnosed with cancer (ACS 2008). Also, the likelihood of developing an LCF from background radiation is about 0.03, based on an average background radiation dose rate of 620 mrem/yr as given by the National Council on Radiation Protection and Measurements (NCRP 2009), a 70-year lifetime, and an LCF factor of 0.0006/rem. The 620 mrem/yr background radiation estimate given in NCRP (2009) includes about 310 mrem/yr from natural sources and 310 mrem/yr from man-made sources, including medical procedures and consumer products. This value is significantly larger than the previous NCRP estimate of 360 mrem/yr primarily because of the increased use of ionizing radiation in diagnostic and interventional medical procedures (NCRP 2009). In this EIS, estimates of LCFs are given to one significant figure.

A number of radionuclides present in GTCC LLRW and GTCC-like wastes occur naturally in the environment, including isotopes of uranium, thorium, and radium and their radioactive decay products. The radiological impacts given in this EIS are incremental to those from natural and man-made sources of radiation; that is, the impacts are those that an average individual would incur in addition to the 620 mrem/yr noted above. A decision on the disposal of GTCC LLRW and GTCC-like waste can thus be made on the basis of the radiological impacts from this activity, without considering the background radiation contribution.

One of the major sources of the dose from natural background radiation is indoor radon gas, largely because of its short-lived decay products. Most of this dose is due to radon-222, which has a 3.8-day half-life (see Table B-7). Radon-222 is a decay product of radium-226. The doses from the other two naturally occurring isotopes of radon (radon-219 and radon-220) are much lower than the dose from radon-222. The annual radiation dose from the decay products of radon-222 (referred to as radon progeny in this EIS) is estimated to be about 200 mrem/yr (NCRP 2009). This dose is from naturally occurring radon gas in soil, rock, and water that infiltrates into houses; in the houses, the gas's decay products (which are charged particles) can build up and attach to dust particles in the air.

Radium-226 is present in some GTCC LLRW and GTCC-like waste; thus, incremental releases of radon gas from the waste packages could occur following their disposal. This gas would not be released from the packages while they were intact but would instead decay to solid radionuclides. However, following disposal, the packages would eventually degrade, and radon gas in the packages could be released to the environment. This incremental radiation dose from radon gas is included in the post-closure impacts presented in the EIS.

5.2.4.4 Nonradiological Impacts

The nonradiological impacts are those that would result from similar activities being conducted for projects that do not involve radioactive materials. These impacts are not related to the radioactive characteristics of the wastes; they result from the physical hazards associated with these activities and are given in terms of the number of on-the-job fatalities and injuries that could occur to workers under the various alternatives. These workers include construction workers building the disposal facilities, transportation drivers, and workers moving the wastes from the transport vehicles and placing the packages in the disposal facility. The approach used to estimate the impacts on transportation is given separately in Section 5.2.9. These impacts were calculated by using industry-specific statistics from the Bureau of Labor Statistics (BLS), as reported by the National Safety Council. The injury incidence rates were for injuries involving lost workdays (excluding the day of injury).

The analysis calculated the predicted number of annual worker fatalities and injuries as the product of the appropriate annual incidence rate and the number of FTE employees required to implement the activities for the various alternatives. Estimates for the construction phase of the project were developed separately from those for the operations phase, since the types of activities that would occur are expected to be different. Construction would involve the use of large earth-moving equipment and could entail a number of construction activities, whereas the operations phase would be expected to use more specialized material-handling equipment, such as forklifts. Data for the construction industry in 2006 were used for the former, and data for the transportation and warehousing industry (excluding highway accidents) in 2006 were used for the latter.

The calculation of fatalities and injuries from industrial accidents was based solely on historical industry-wide statistics and therefore did not consider a threshold (i.e., any activity would result in some estimated risk of fatality and injury). The selected alternative for managing these wastes would be implemented in accordance with DOE and industry best management practices, thereby reducing fatality and injury incidence rates. For the construction phase, the number of lost workdays due to nonfatal injuries and illnesses was estimated by using a value of 6.0 per 100 FTE workers (BLS 2007a), and the estimated number of fatalities was estimated by using a value of 13.2 per 100,000 FTE workers (BLS 2007b); information was from the construction industry. For the operations phase, the number of lost workdays due to nonfatal injuries and illnesses was estimated by using a value of 8.0 per 100 FTE workers (BLS 2007a), and the number of fatalities was estimated by using a value of 7.4 per 100,000 FTE workers (BLS 2007b); information was from the transportation and warehousing (excluding highway accidents) industry.

5.2.5 Ecological Resources

> **Ecological Resources**
>
> Ecological resources include plant and animal species and the habitats on which they depend (e.g., forests, fields, wetlands, streams, and ponds).

This section provides an overview of the considerations and data used to describe the ecological resources at the alternative sites. The evaluation of the potential impacts from construction, operations, and post-closure of the GTCC LLRW and GTCC-like waste disposal facility at each site depends on an adequate understanding of the ecological resources that exist at each alternative site. The ecological resources are described in the affected environment subsections for each alternative site. These descriptions cover the vegetation, wildlife, aquatic biota, special status species, and habitats at the DOE sites in general and within the areas designated for the GTCC LLRW and GTCC-like waste disposal facility. The affected environment subsections address past activities and current species and habitat management actions that have influenced the ecological resources at each alternative site. The information presented for each site was primarily obtained from previous NEPA documents and from various environmental studies and resource and management documents prepared for the alternative sites.

The GTCC reference locations are found in five states (Idaho, New Mexico, Nevada, South Carolina, and Washington) across the continental United States. A wide variety of terrestrial habitats and, to a lesser extent, aquatic and wetland habitats occur in the vicinity of the alternative GTCC reference locations. General descriptions of terrestrial habitats throughout the conterminous United States are included in ecoregion descriptions. An ecoregion describes a broad landscape in which the ecosystems have a general similarity. It can be characterized by the spatial pattern and composition of biotic and abiotic features, such as vegetation, wildlife, physiography, climate, soils, and hydrology (EPA 2007). Level III ecoregions (EPA 2007) are used to describe ecosystems at a general level for each alternative site and are discussed in the ecological resource section provided for each alternative site in Chapters 6 through 11.

As a federal land manager, DOE is responsible for managing and conserving biota and their habitats on all the alternative sites. Compliance with a number of federal laws, regulations, and Executive Orders would help protect ecological resources at the GTCC reference locations (see Chapter 13). In addition, state regulations could be applicable at the various potential disposal sites. The Endangered Species Act of 1973 (ESA), as amended, is among the major laws and regulations that would be applicable to ecological resources. The ESA is federal legislation intended to provide a means to conserve the ecosystems upon which endangered and threatened species depend and provide programs for conserving those species, thus preventing extinction of plants and animals. The ESA sections that would apply to a GTCC LLRW and GTCC-like waste disposal facility are Section 7 and Section 10(a)(1)(B).

Section 7 of the ESA requires all federal agencies, in consultation with the USFWS or the National Marine Fisheries Service (NMFS), to use their authorities to further the purpose of the ESA and to ensure that their actions are not likely to jeopardize the continued existence of listed species or result in destruction or adverse modification of critical habitat. The following definitions are applicable to the species listing categories under the ESA:

- *Endangered*. Any species that is in danger of extinction throughout all or a significant portion of its range.

- *Threatened*. Any species that is likely to become endangered within the foreseeable future throughout all or a significant part of its range.

- *Proposed for listing*. Species that have been formally proposed for listing as threatened or endangered by the USFWS or NMFS by notice in the *Federal Register*.

- *Candidate*. Species for which the USFWS or NMFS has sufficient information on their biological status and threats to propose them as threatened or endangered under the ESA, but for which development of a proposed listing regulation is precluded by other higher-priority listing actions.

- *Critical habitat*. Specific areas within the geographical area occupied by the species at the time it is listed, on which are found physical or biological

> features essential to the conservation of the species and which may require special management considerations or protection. Except when designated, critical habitat does not include the entire geographical area that can be occupied by the threatened, endangered, or other special status species.

Section 10(a)(1)(B) of the ESA allows for permits for incidental taking of threatened or endangered species. Such permits would be required, for example, where the potential exists for individuals of a listed species to be accidentally destroyed by land disturbance or by vehicular traffic, or when a nest of a listed species may need to be relocated.

Each state also identifies species that are of concern within its borders. Each state differs in the listing status designations that it uses and in its regulations for protecting these species. Some of these species are listed under the ESA. Project-specific assessments would consider impacts on these species prior to project development.

Five of the DOE sites (Hanford Site, INL Site, LANL, NNSS, and SRS) evaluated in this EIS serve to preserve regional biodiversity by providing a refuge for species that have been reduced by human activities in the surrounding region. Off-road driving, public access, and livestock grazing are prohibited at most of the alternative sites, thus providing additional protection to ecological resources.

The same six DOE sites are National Environmental Research Parks (NERPs) and also have other natural resource designations (Table 5.2.5-1). NERPs are outdoor laboratories that provide opportunities for environmental studies on protected lands that act as buffers around DOE facilities. These studies are used to (1) evaluate the environmental consequences of energy use and development and mitigation of these effects and (2) demonstrate possible environmental and land-use options (DOE 2007a).

5.2.6 Socioeconomics

Socioeconomic data for each site describe an ROI surrounding the site, which is made up of multiple counties. The ROI is used to assess the impacts of site activities on employment, unemployment, income, population, housing, community fiscal conditions, and community service employment. The ROI at each site is based on the residential locations of government workers directly related to site activities, and it encompasses the area in which these workers spend their wages and salaries.

5.2.7 Environmental Justice

Executive Order 12898 (February 16, 1994) formally requires federal agencies to incorporate environmental justice as part of their missions. Specifically, it directs them to address, as appropriate, any disproportionately high and adverse human health or environmental effects of their actions, programs, or policies on minority and low-income populations.

TABLE 5.2.5-1 National Environmental Research Parks and Other Natural Management Resource Areas within the Alternative Sites Proposed for a GTCC LLRW and GTCC-Like Waste Disposal Facility

DOE Site	National Environmental Research Park	Other Natural Resource Areas
Hanford Site	Established in 1983, 366,000 acres.[a] Allows for comparative studies of ecological processes in sagebrush-steppe ecosystems.	Hanford Reach National Monument: Approximately 200,000 acres divided into six administrative units: • Fitzner-Eberhardt Arid Land Ecology Reserve: 77,000 acres • McGee Ranch-Riverlands Unit: 9,100 acres • Vernita Bridge Recreation Area: 800 acres • River Corridor Unit: 25,000 acres • Saddle Mountain Unit/Saddle Mountain National Wildlife Refuge: 32,000 acres • Wahluke Unit: 57,000 acres
Idaho National Laboratory (INL Site)	Established in 1975, 568,300 acres. Allows for comparative studies of ecological processes in sagebrush-steppe ecosystems to demonstrate the compatibility of energy technology development and a quality environment.	INL Sagebrush Steppe Ecosystem Reserve: 74,000 acres
Los Alamos National Laboratory (LANL)	Established in 1973, 28,400 acres. Allows for research in arid pinyon-juniper communities and their interface with coniferous forests and mountain meadows and valleys under various levels of stress and for the development of technology to resolve regulatory and compliance-related problems.	White Rock Reserve: Approximately 1,000 acres at TA-70 and TA-71
Nevada National Security Site (NNSS)	Established in 1992, 865,000 acres. Allows for investigations of environmental restoration and waste management activities.	NE[b]

TABLE 5.2.5-1 (Cont.)

DOE Site	National Environmental Research Park	Other Natural Resource Areas
Savannah River Site (SRS)	Established in 1972, 198,000 acres. Allows for ecological research of cypress swamp and southeastern pine and hardwood forests and for protection from public intrusion and most site-related activities. Includes 30 DOE Research Set-Aside Areas that are representative habitats on SRS.	• Crackerneck Wildlife Management Area and Ecological Reserve: 11,200 acres • Red-Cockaded Woodpecker Management Area: 87,200 acres • Supplemental Red-Cockaded Woodpecker Management Area: 47,100 acres • Savannah River Swamp Management Area: 10,000 acres • Lower Three Runs Corridor Management Area: 4,400 acres
Waste Isolation Pilot Plant (WIPP)	NE	NE
WIPP Vicinity	NE	NE

[a] To convert to hectares, multiply the acreage by 0.405.

[b] NE = not established. No NERP or other natural resource area designation has been established at the WIPP or WIPP Vicinity. No other natural resource area designation has been established for NNSS.

Sources: DOE (2000, 2007a); Evans et al. (2003); The Nature Conservancy (2003); USFS (2005)

The analysis of the impacts of a GTCC LLRW and GTCC-like waste disposal facility on environmental justice issues follows guidelines described in *Environmental Justice Guidance under the National Environmental Policy Act* (CEQ 1997). The analysis method has three parts: (1) the geographic distribution of low-income and minority populations in the affected area is described; (2) an assessment is made of whether the impacts from construction and operations would be high and adverse; and (3) if the impacts would be high and adverse, a determination is made of whether these impacts would disproportionately affect minority and low-income populations.

Construction and operations of a GTCC LLRW and GTCC-like waste disposal facility could affect environmental justice if any adverse health and environmental impacts resulting from either phase of development were significantly high and if these impacts disproportionately affected minority and low-income populations. If an analysis that accounted for any unique exposure pathways (such as subsistence fish, vegetation or wildlife consumption, or well-water consumption) determined that health and environmental impacts would not be significant, there could be no high and adverse impacts on minority and low-income populations. If impacts were found to be significant, disproportionality would be determined by comparing the proximity of high and adverse impacts to the location of low-income and minority populations. Information needed to conduct the analysis would be collected and developed to support future evaluations that would be included in follow-on documents for the selected alternatives.

The analysis of environmental justice issues considered impacts in an 80-km (50-mi) buffer around the GTCC reference location in order to include any potential adverse human health or socioeconomic impacts related to the construction and operations that might occur. Accidental radiological releases, for example, have the potential to affect minority and low-income population groups located some distance from the site, depending on the size and nature of potential releases and on meteorological conditions. Any accidental release to the environment also has the potential to affect fish and other natural resources that might be used for subsistence by low-income and minority population groups located some distance from the site. The extent would depend on the size and nature of any potential release at the site.

The description of the geographic distribution of minority and low-income groups was based on demographic data from the 2010 Census (U.S. Bureau of the Census 2012). The following definitions were used to define minority and low-income population groups.

- *Minority.* Persons are included in the minority category if they identify themselves as belonging to any of the following racial groups: (1) Hispanic, (2) Black (not of Hispanic origin) or African American, (3) American Indian or Alaska Native, (4) Asian, or (5) Native Hawaiian or other Pacific Islander.

  Beginning with the 2010 Census, where appropriate, the census form allows individuals to designate multiple population group categories to reflect their ethnic or racial origin. In addition, persons who classify themselves as being of multiple racial origins may choose up to six racial groups. The term "minority" includes all persons, including those classifying themselves in multiple racial categories, except those who classify themselves as "White" (U.S. Bureau of the Census 2012).

  The CEQ guidance proposed that minority populations should be identified where either (1) the minority population of the affected area exceeds 50% or (2) the minority population percentage of the affected area is meaningfully greater than the minority population percentage in the general population or other appropriate unit of geographic analysis.

  The EIS applies both criteria in using the Census Bureau data for census block groups, wherein consideration is given to the minority population that is both more than 50% and 20 percentage points higher in the block than it is in the state (the reference geographic unit).

- *Low-income.* Individuals who fall below the poverty line. The poverty line takes into account family size and age of individuals in the family. The poverty threshold for 2009 for a family of five with three children below the age of 18 was $25,603. For any given family below the poverty line, all family members are considered as being below the poverty line for the purposes of analysis in the EIS. Although the poverty line is estimated annually, the data are not available at the census block group level used in the EIS analysis.

5.2.8 Land Use

> **Land Use**
>
> Land use is a classification of parcels of land relative to the presence of human activities (e.g., industry, agriculture, and recreation) and natural areas.

Land use is a classification of parcels of land relative to the presence of human activities (e.g., industry, agriculture, recreation) and natural areas. This section provides an overview of the considerations and data used to describe land use at the alternative sites. The evaluation of the potential impacts on land use from construction, operations, and post-closure of a GTCC LLRW and GTCC-like waste disposal facility at each site depends on an adequate understanding of the existing land use at each alternative site and of whether the proposed GTCC LLRW and GTCC-like waste disposal facility would be consistent with existing land use designations. The descriptions of land use for each alternative site cover the current land uses (1) at the DOE sites and WIPP Vicinity (including Section 35 that is administered by BLM), (2) in the areas surrounding the sites, and (3) within the GTCC reference location. The affected environment sections address past and current land uses that have influenced the GTCC reference location at each alternative site. The information presented for each site was obtained primarily from previous environmental studies and from various documents prepared for the alternative sites. The land use descriptions for each alternative site pay particular attention to special land uses both within and surrounding the alternative sites. These include national parks, designated wilderness areas, state lands (e.g., recreation areas and parks), NERPs or other natural resource designations, designated waste management areas, and so forth. Such land use attributes could be important considerations in determining which alternative sites are more suitable for locating the GTCC LLRW and GTCC-like waste disposal facility.

5.2.9 Transportation

The transportation risk analysis estimated both radiological and nonradiological impacts associated with the shipment of GTCC LLRW and GTCC-like waste during disposal facility operations from their points of origin to the disposal sites considered in this EIS. Further details on the risk methodology and input data are provided in Section C.9 of Appendix C.

5.2.9.1 General Approach and Assumptions

Transportation impacts from both truck and rail shipments were estimated for each waste type considered. In either case, the shipment configurations and the number of shipments required were the same for each of the land disposal methods considered.

This EIS evaluates the total number of shipments expected over the life of the disposal facility. Shipment of waste is not presented on an annual basis because of the uncertainty associated with the time of future waste generation and disposal facility operations. Appropriate shipment schedules would be proposed in the future as part of a further analysis once a disposal site and a disposal method were selected.

The transportation risk assessment considers human health risks from routine transport (normal, incident-free conditions) of radiological materials and from potential accidents. In both cases, risks associated with the nature of the cargo itself, called “cargo-related” impacts, are considered. Risks related to the transportation vehicle (regardless of type of cargo), called “vehicle-related” impacts, are considered for potential accidents (see Figure 5.2.9-1 for an image of waste being loaded onto a transport vehicle). The transportation of hazardous chemicals is not part of this analysis because hazardous chemicals have not been identified as part of the waste inventory.

5.2.9.2 Routine Transportation Risk

The radiological risk associated with routine transportation is cargo-related and results from the potential exposure of people (including workers and the public) to low levels of external radiation near a loaded shipment. No direct physical exposure to radioactive material would occur during routine transport because these materials would be in packages designed and

FIGURE 5.2.9-1 Transport of Radioactive Waste Containers

maintained to ensure that they would contain and shield their contents during normal transport. Any leakage or unintended release would be considered under accident risks.

Collective population radiological risks were estimated for persons living in the vicinity of the shipment routes (off-link population), persons in all vehicles sharing the transportation route (on-link population), and persons who might be exposed while a shipment was stopped en route (persons at stops). For truck transportation, these stops include those for refueling, food, and rest. For rail transportation, stops were assumed to occur for purposes of classification.

Collective doses were also calculated for truck transportation crew members involved in the actual shipment of material and for railroad inspectors of rail shipments. Workers involved in loading or unloading were not considered. The doses calculated for the first three population groups were added together to yield the collective dose to the public; the dose calculated for the fourth group represents the collective dose to workers.

In addition to assessing the routine collective population risk, the radiological risks to individuals were estimated for a number of hypothetical exposure scenarios. Receptors included transportation crew members, departure inspectors, and members of the public exposed during traffic delays, while working at a service station, or while living near a facility.

5.2.9.3 Accident Transportation Risk

The cargo-related radiological risk from transportation-related accidents lies in the potential release and dispersal of radioactive material into the environment during an accident and the subsequent exposure of people through multiple exposure pathways, such as exposure to contaminated soil, inhalation of airborne contaminants, or ingestion of contaminated food. The radiological transportation accident risk assessment estimated collective population risks as well as individual and population consequences.

The risk analysis for potential accidents differs fundamentally from the risk analysis for routine transportation because occurrences of accidents are statistical in nature. Accident risk is defined as the product of the accident consequence and the probability of the accident occurring. In this respect, the collective accident risk to populations is estimated by considering a spectrum of transportation-related accidents. The spectrum of accidents was designed to encompass a range of possible accidents, including low-probability accidents that have high consequences and high-probability accidents that have low consequences (e.g., “fender benders”). For radiological risk, the results for collective accident risk can be compared directly to the results for routine collective risk, because the latter results implicitly incorporate a probability of occurrence of 1 if the shipment takes place.

The calculation of the collective population dose following the release and dispersal of radioactive material includes the following exposure pathways:

- External exposure to the passing radioactive cloud,

- External exposure to contaminated ground,

- Internal exposure from inhalation of airborne contaminants, and

- Internal exposure from the ingestion of contaminated food (rural areas only).

Because predicting the exact location of a severe transportation-related accident is impossible when estimating population impacts, separate accident consequences were calculated for accidents occurring in three population density zones: rural, suburban, and urban. Moreover, to address the effects of the atmospheric conditions existing at the time of an accident, two atmospheric conditions were considered: neutral and stable. The highest-exposed individual for severe transportation accidents was considered to be located at the point of highest hazardous material concentration that would be accessible to the general public.

The vehicle-related accident risk refers to the potential for transportation accidents that could result directly in fatalities not related to the nature of the cargo in the shipment. This risk represents fatalities from physical trauma. State-average rates for transportation fatalities are used in the assessment. Vehicle-related accident risks are calculated by multiplying the total distance traveled by the transportation fatality rates. In all cases, the vehicle-related accident risks are calculated on the basis of distances for round-trip shipments, since the presence or absence of cargo would not be a factor in accident frequency.

5.2.10 Cultural Resources

Cultural resources include archaeological and historic architectural sites and structures, as well as places from the past having important public and scientific uses, and may include definite locations (sites or places) of traditional cultural or religious importance to specified social or cultural groups, such as American Indian tribes ("traditional cultural properties"). Cultural resources can be either man-made or natural physical features associated with human activity and, in most cases, are unique, fragile, and nonrenewable. Cultural resources that meet the eligibility criteria for listing on the NRHP are termed "historic properties" under the NHPA.

NHPA is a comprehensive law that creates a framework for managing cultural resources in the United States. It expands the NRHP; establishes SHPOs, Tribal Historic Preservation Offices, and the Advisory Council on Historic Preservation (ACHP); and provides a number of mandates for federal agencies. Section 106 of NHPA directs all federal agencies to take into account the effects of their undertakings (actions and authorizations) on historic properties included in or eligible for the NRHP. Section 106 of the Act is implemented by regulations of the ACHP (36 CFR Part 800). Section 106 regulations permit agencies to integrate compliance with the NEPA process. This EIS represents the first phase of the Section 106 process, and compliance focuses on consultation and the programmatic definitions of resources that might be affected; the types of effects that might be anticipated; and recommendations to agencies on avoiding, minimizing, or mitigating adverse effects if development of a GTCC LLRW and GTCC-like waste disposal facility does occur at the indicated site. Full compliance with Section 106 would occur when specific proposals were acted upon. A compilation of laws and regulations pertinent to cultural resources is presented in Table 5.2.10-1.

1 **TABLE 5.2.10-1 Cultural Resource Laws and Regulations**

Law or Order Name	Intent of Law or Order
Antiquities Act of 1906	This was the first law to protect and preserve cultural resources on federal lands. It makes it illegal to remove cultural resources from federal land without a permit, establishes penalties for illegal excavation and looting, and allows the President to establish historical monuments and landmarks.
National Historic Preservation Act (1966) (NHPA)	This law created the legal framework for considering the effects of federal undertakings on historic properties in the United States. The law expands the NRHP and establishes the ACHP, SHPOs, and Tribal Historic Preservation Offices. Section 106 and its accompanying regulations direct all agencies to take into account the effects of their actions on properties included in or eligible for the NRHP, and they establish the process for doing so.
Executive Order 11593, *Protection and Enhancement of the Cultural Environment* (1971)	Executive Order 11593 requires federal agencies to inventory their cultural resources and to meet professional standards for recording any cultural resource that may have been altered or destroyed.
Archaeological and Historic Preservation Act (1974) (AHPA)	The AHPA addresses impacts on cultural resources resulting from federal activities and provides a funding mechanism to recover, preserve, and protect archaeological and historical data.
Archaeological Resources Protection Act of 1979 (ARPA)	ARPA establishes civil and criminal penalties for the unauthorized excavation, removal, damage, alteration, or defacement of archaeological resources; prohibits trafficking in resources from public lands; and directs federal agencies to establish educational programs on the importance of archaeology.
American Indian Religious Freedom Act of 1978 (AIRFA)	AIRFA protects First Amendment guarantees to religious freedom for American Indians. It requires federal agencies to consult when a proposed land use might conflict with traditional Indian religious beliefs or practices and to avoid interference to the extent possible. It also requires that American Indians be allowed access to locations of religious importance on federal land.
Native American Graves Protection and Repatriation Act of 1990 (NAGPRA)	NAGPRA establishes the rights of Indian tribes to claim ownership of certain “cultural items,” including human remains, funerary objects, sacred objects, and objects of cultural patrimony. It requires federal agencies and museums to identify holdings of such remains and work toward their repatriation. Excavation or removal of such cultural items requires consultation with groups showing cultural affinity with the items, as does discovery of these items during land use activities.
Executive Order 13007, *Indian Sacred Sites* (1996)	Executive Order 13007 defines sacred sites and directs agencies to accommodate Indian religious practitioners’ access to and use of sacred sites, avoid adverse effects, and maintain confidentiality. It does not create new rights but strongly affirms those that do exist.

TABLE 5.2.10-1 (Cont.)

Law or Order Name	Intent of Law or Order
Executive Order 13287, *Preserve America* (2003)	Executive Order 13287 encourages the federal government to take a leadership role in the protection, enhancement, and contemporary use of historic properties and establishes new accountability for agencies with regard to inventories and stewardship.
National Environmental Policy Act (NEPA) (1969)	This law requires federal agencies to analyze the impacts of an action on the human environment in order to ensure that federal decision makers are aware of the environmental consequences of a project before implementation.

5.2.11 Waste Management

Wastes generated from the three land disposal methods were estimated to determine if the waste types and volumes could affect waste management programs at each of the sites being evaluated under Alternatives 3 to 5. Potential impacts were determined by identifying whether current site waste handling programs (or capacities, if information is available) include the types of waste generated by the construction and operation of the land disposal facilities under Alternatives 3 to 5. It is also assumed that no prior contamination would be encountered during construction of the land disposal facilities.

5.3 ENVIRONMENTAL CONSEQUENCES COMMON TO ALL SITES UNDER ALTERNATIVES 3 TO 5

Environmental consequences from Alternatives 3 to 5 that are not site-specific are summarized below and are not repeated in the discussions presented in Chapters 6 through 11 for each of the alternative land disposal sites. Because the proposed disposal facilities are expected to be available to contain the waste for a very long time (for the next hundreds of years), the decommissioning phase of the proposed action could be better evaluated at the time the disposal facility would be ready to be decommissioned. Hence, evaluations for the decommissioning phase are not included in this EIS; instead, subsequent NEPA documentation would be prepared at a later time to address the decommissioning phase.

Post-closure activities would include minimal activities, such as periodic visits for site inspection and monitoring, that would involve light- or medium-duty vehicle traffic and infrequent repair or maintenance activities, as needed. There would be no water demands during the post-closure period. However, given enough time (on the order of thousands of years), it is possible that groundwater at the various sites could become contaminated with some highly soluble radionuclides (e.g., C-14, Tc-99, and I-129). Indirect impacts on surface water (except at NNSS) could also result from aquifer discharges (of contaminated groundwater) to seeps, springs, and rivers. There would be no impact on geologic and soil resources, land use, and cultural resources during the post-closure phase, because there would not likely be any additional land disturbance and because no additional geologic materials or soil would be used. Monitoring activities during post-closure are also not expected to have adverse impacts on these resources. It is expected that potential impacts from the post-closure phase on all the resource areas evaluated (i.e., the resource areas discussed above in addition to ecological resources, socioeconomics, environmental justice, transportation, and waste management) would be less than those from the construction and operations phases as presented in the site-specific chapters. Potential human health impacts for the post-closure phase are presented in the site-specific chapters.

5.3.1 Climate, Air Quality, and Noise

The analysis for air quality and noise examined the potential impacts resulting from construction, operations, and post-closure activities of the three land disposal facilities being evaluated. Activities associated with these phases can have impacts both at the site of activity and away from it, as air emissions are dispersed and noise is propagated from the point of generation to other locations. Potential consequences on climate and air quality from Alternatives 3 to 5 are site dependent and are discussed in Chapters 6 through 11 for the Hanford Site, the INL Site, LANL, NNSS, SRS, and WIPP Vicinity, respectively. Noise impacts during construction and operations are discussed in Section 5.3.1.1. Section 5.3.1.2 provides a qualitative discussion regarding global climate impacts.

5.3.1.1 Noise

5.3.1.1.1 Construction. During construction, the commuter and delivery vehicles moving around the facilities and along the traffic routes would generate intermittent noise. However, the contribution to noise from these intermittent sources would be limited to the immediate vicinity of the traffic route and would be minor in comparison with the contribution from continuous noise sources, such as compressors or bulldozers, during construction. Sources of noise during construction of the GTCC LLRW and GTCC-like waste disposal facility would include standard construction activities involved with moving earth and erecting concrete and steel structures. Noise levels from these activities would be comparable to those from other construction sites of similar size. The noise levels would be highest during the early phases of construction, when heavy equipment would be used to clear the site. Typically, this early phase of construction would last for a few months of the entire construction period.

In general, the dominant noise source for most construction equipment is an insufficiently muffled diesel engine. However, noise from pile driving or pavement breaking would dominate in cases where these activities were involved. During construction, a variety of heavy equipment would be used. Average noise levels for typical construction equipment range from 74 dBA for a roller to 101 dBA for a pile driver (impact) at a distance of 15 m (50 ft) from a source (Hanson et al. 2006). Data on the typical noise from a bucket auger, which would be heavily used for borehole drilling, are not available, but data on noise from typical diesel-powered equipment indicate that the noise would range from 84 to 89 dBA (Barnes et al. 1977).

Accordingly, except for pile drivers and rock drills, most construction equipment has noise levels of 75 to 90 dBA at a distance of 15 m (50 ft) from the source. The types and amounts of construction equipment noise levels on a peak day under the three land disposal methods are presented in Table 5.3.1-1.

With regard to noise, when a known noise-sensitive receptor (e.g., school, hospital) is adjacent to a construction project and/or stringent local ordinances or specifications apply, a detailed impact analysis is warranted. However, for a general assessment of construction, it is adequate to assume that only the two noisiest pieces of equipment would operate simultaneously in order to estimate noise levels at the nearest receptor (Hanson et al. 2006). The highest composite noise levels from construction activities (e.g., two drill rigs) are estimated to be about 92 dBA at 15 m (50 ft) from the source. Considering geometric spreading only, and assuming a 10-hour daytime shift, the noise levels at a distance of 690 m (2,300 ft) from noise sources would be below the EPA guideline of 55 dBA as the L_{dn} for residential zones. This distance is smaller than the distance between the GTCC reference locations and the respective nearest known off-site residence. Estimated distances of the GTCC reference locations from the respective nearest known off-site residences are as follows: >6 km (4 mi) at Hanford; >11 km (7 mi) at the INL Site; approximately 3.5 km (2.2 mi) at LANL (nearest residence in White Rock); >6 km (4 mi) at NNSS; >14 km (9 mi) at SRS; and >5 km (3 mi) at the WIPP Vicinity. The EPA guideline was established to protect against interference and annoyance due to outdoor activity (EPA 1974). Actual sound levels would be much lower as a result of air absorption and ground effects due to terrain and vegetation. Accordingly, noise from construction activities would be barely discernible or completely inaudible at the site boundaries and the nearest residences.

Most of these construction activities would occur during the day, when noise is tolerated better than at night because of the masking effects of background noise. Nighttime noise levels would drop to the background levels of a rural environment because construction activities would cease at night.

Construction activity can result in various degrees of ground vibration, depending on the equipment and construction methods used. Activities that typically generate the most severe vibrations are the detonation of high explosives and impact pile driving. All construction equipment causes ground vibration to some degree, but the vibration diminishes in strength with distance. For example, the vibration level at receptors beyond 70 m (230 ft) from a vibratory roller (94 VdB at 7.6 m [25 ft]) would diminish below the threshold of perception for humans and of interference with vibration-sensitive activities, which is around 65 VdB. During the construction phase, no major construction equipment that could cause ground vibration would be used. No sensitive structures would be located nearby. Therefore, there would be no adverse vibration impacts from construction activities.

5.3.1.1.2 Operations. During the operations phase, noise-generating activities would include those from the primary activities of receiving, handling, and emplacing waste packages and attendant noise sources from heavy equipment and vehicle traffic, similar to those at any other industrial site. It is estimated that between 2019 and 2035, there would be an annual

TABLE 5.3.1-1 Peak-Day Construction Equipment Usage by the Disposal Methods and Typical Noise Levels

Type of Construction Equipment	No.	Typical Level at 15 m (50 ft) from a Source (dBA)
Trench		
Loader	1	85
Dozer	1	85
Grader	1	85
Water truck	2	88
Vibratory roller	1	74
Dump truck	2	88
Borehole		
Loader	3	85
Dozer	1	85
Grader	1	85
Water truck	3	88
Vibratory roller	1	74
Dump truck	2	88
Drill rig	2	89
Vault		
Loader	3	85
Dozer	2	85
Grader	1	85
Water truck	1	88
Vibratory roller	1	74
Dump truck	3	88

Sources: Barnes et al. (1977); Hanson et al. (2006)

average of 570 truck shipments (Appendix D). Assuming 240 workdays per year, a daily average of slightly more than two shipments is anticipated.

When emplacement would take place at the disposal area, the operation of heavy equipment (e.g., a trailer tractor and a front-end loader) would generate a combined noise level of about 90 dBA at a distance of 15 m (50 ft) from the noise sources, a little lower than the level during construction. The noise levels at a distance of 530 m (1,700 ft) from noise sources would be below the EPA guideline of 55 dBA as the L_{dn} for residential zones. This distance is within the site boundaries evaluated for the land disposal methods, as discussed previously in Section 5.3.1.1.1. No residential locations exist within this distance. When other types of attenuation and the intermittency of operational activities are taken into account, these levels would be much lower. Accordingly, noise from operational activities would be barely discernible or completely inaudible at the site boundaries and the nearest residences.

As was the case for construction activities, no major heavy equipment that could cause ground vibration would be operating during operational activities, and no sensitive structures would be located nearby. Therefore, there would be no adverse vibration impacts from operations at the land disposal sites.

5.3.1.2 Climate Change Impacts

Climate changes are underway in the United States and globally, and they are projected to grow substantially over the next several decades unless immediate measures are taken to reverse this trend. Climate-related changes include rising temperature and sea level; increased frequency and intensity of extreme weather conditions (e.g., heavy downpours, floods, and droughts); earlier snowmelts and associated frequent wildfires; and reduced snow cover, glaciers, permafrost, and sea ice. After a thorough examination of the scientific evidence and careful consideration of public comments, the EPA announced on December 7, 2009, that greenhouse gases threaten the public health and welfare of the American people and should be considered within the Clean Air Act definition of air pollutants.

Greenhouse gases include those gases, such as water vapor (H_2O), carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons, and perfluorocarbons, that are transparent to incoming solar (short-wave) radiation but opaque to long-wave (infrared) radiation and are thus capable of preventing long-wave thermal radiant energy discharged from the earth's surface from leaving earth's atmosphere. The net effect over time is a trapping of absorbed radiation and a tendency to warm the planet's surface and the boundary layer of the earth's atmosphere, which constitute the "greenhouse effect." Some greenhouse gases (CO_2, CH_4, and N_2O) are both naturally occurring and the product of industrial activities, while others (such as the hydrofluorocarbons) are man-made and are present in the atmosphere exclusively as a result of human activities. Each greenhouse gas has a different radiative forcing potential (the ability to affect a change in climatic conditions in the troposphere, expressed as the amount of thermal energy [in watts] trapped by the gas per square meter of the earth's surface). The radiative efficiency of a greenhouse gas is directly related to its concentration in the atmosphere.

This EIS presents an assessment comparing the CO_2 emissions estimated for the three land disposal methods with the CO_2 emissions for the states associated with the federal sites evaluated in Chapters 6 through 12 (i.e., Hanford Site, INL Site, LANL, NNSS, SRS, and the WIPP Vicinity). The assessment indicates that estimated CO_2 emissions from the borehole, trench, and vault disposal methods would be negligible. In addition, this Section 5.3.1.2 provides a qualitative assessment of the potential effects of global climate change on the proposed land disposal (borehole, trench, and vault) facilities for the long term, as discussed below.

Since 1990, the average annual precipitation over the United States has increased by about 5%, but there were regional differences, e.g., increases mostly in the Northeast, Midwest, and southern Great Plains and a mix of increases and decreases in much of the Southeast and Southwest (Melillo et al. 2014). The global climate change model predictions indicate that in the Southwestern United States, drier or prolonged drought conditions could arise notably in the spring, whereas Northern areas could become wetter.

Although the global climate change impacts are modeled only to the year 2100, these initial indications can be used to determine what impacts global climate change might have on the proposed borehole, trench, and vault waste disposal facilities at the various reference locations or regions evaluated in this EIS. On the basis of the global climate change predictions under a higher (i.e., worst-case) emission scenario (Melillo et al. 2014), average annual infiltration rates for the long term at sites located in the Southwest (e.g., LANL, NNSS, WIPP Vicinity, and the generic commercial location in the southern part of NRC Region IV) are expected to decrease slightly or remain the same, while sites located in the Northwest would increase slightly (e.g., Hanford and INL Sites). On the basis of Melillo et al. (2014), it can be said that the maximum increase or decrease in precipitation under a higher emission scenario would be up to 20% depending on the season. Under a lower emission scenario, these percentages would be lower, and thus climate changes would probably not have any significant impacts on the GTCC LLRW and GTCC-like waste disposal operations and facilities. This is because slight increases in precipitation are expected in humid sites such as SRS. For sites located in drier areas, such as Hanford, INL, LANL, NNSS, and WIPP Vicinity, changes of up to about 20% by season are expected under a higher emission scenario but these changes are not significant due to its lower annual precipitation. However, because current global climate change model projections extend only to the year 2100, it is uncertain whether the indications discussed here would continue for the 10,000-year period of interest for this EIS (i.e., human health estimates are carried out to 10,000 years and longer for post-closure performance of the borehole, trench, and vault disposal methods; see Section 5.3.4.3).

In addition to the potential increase or decrease in annualized precipitation rates, it is also predicted that global climate change impacts would result in more intense precipitation events (e.g., rainfall), which could affect the physical stability of the land disposal facilities. Global climate change impacts predicted also include temperature increases and a rise in the sea level. The modeled temperature increase of 2 to 11°F is not expected to impact the structural integrity of the facilities themselves or the waste contained in the facilities. The GTCC reference locations are not located in coastal areas and so are not likely be impacted by the rise in sea level.

5.3.2 Geology and Soils

Data on the geologic and soil material requirements for the borehole, trench, and vault disposal methods are provided in Table 5.3.2-1. Potential impacts on geology and soils from Alternatives 3 to 5 are site dependent and are discussed in Chapters 6 through 11 for the Hanford Site, the INL Site, LANL, NNSS, SRS, and WIPP Vicinity, respectively.

5.3.3 Water Resources

Impacts on water resources include direct and indirect impacts on surface waters and groundwater (unsaturated and saturated). Direct impacts are impacts that would occur at the place of origin. Indirect impacts would occur away from the point of origin. Direct and indirect impacts could occur during the construction, operations, and post-closure. Impacts could result from any of the three land disposal methods.

TABLE 5.3.2-1 Geologic and Soil Resource Requirements for Constructing a New GTCC LLRW and GTCC-Like Waste Disposal Facility, by Disposal Method[a]

	Amount Required (yd^3), by Method		
Material	Trench	Borehole	Vault
Concrete	25,600	18,600	88,200
Gravel	36,100	25,300	156,400
Sand	3,600	27,900	198,300
Clay	12,900	–[b]	56,000
Soil (from off-site)	–	–	254,000

[a] The values presented in this table are for facility construction only.

[b] A dash indicates “not required.”

Direct and indirect impacts on surface water resources could include changes in surface water flow rates, depths, and quality. Direct and indirect impacts on groundwater could include changes in the rate of groundwater recharge, the depth to groundwater, its flow direction and velocity, and quality. Table 5.3.3-1 provides an estimate of the water needs for the three land disposal methods under consideration in this EIS. These estimates are the same for all sites. In addition, stormwater, truck washdown water, and sanitary waste water generated from the construction and operations of the three land disposal methods could be discharged at the various sites evaluated (see Table 5.3.11-1 for the estimated amounts). Tables 5.3.3-2 and 5.3.3-3 summarize direct and indirect impacts from the construction and operations, respectively, at all sites.

Site-dependent potential consequences on water resources under Alternatives 3 to 5 are discussed in Chapters 6 through 11 for the Hanford Site, the INL Site, LANL, NNSS, SRS, and WIPP Vicinity, respectively.

5.3.4 Human Health

The human health impacts associated with the disposal of GTCC LLRW and GTCC-like wastes are analyzed in this EIS for the construction, operations, and post-closure phases of the project. Different types of hazards and potentially impacted individuals were addressed for these three phases. The assessment of impacts was divided into those from normal operations and those from potential accidents. The impacts from transportation are discussed separately in Section 5.3.9.

The human health impacts during the construction and operations are expected to be about the same for the three land disposal methods. The post-closure impacts are site dependent,

TABLE 5.3.3-1 Water Consumption for the Three Land Disposal Methods

	Amount Consumed or Involved[a]		
Activity/ Resource	Trench	Borehole	Vault
Construction			
Total utility water for 20 yr (gal)	5,300,000	2,800,000	17,100,000
Annual utility water (gal/yr)	270,000	140,000	860,000
Operations			
Annual potable water (gal/yr)	310,000	240,000	310,000
Annual raw water (gal/yr)	1,100,000	410,000	1,100,000

[a] To convert to liters, multiply by 3.78.

TABLE 5.3.3-2 Summary of Water Use Impacts from Construction of a Land Disposal Facility at the GTCC Reference Locations

Proposed Site	Water Source	Current Annual Site Water Use or Capacity (gal)[a]	Maximum Proposed Annual GTCC Facility Water Use (gal)[b]	Percent Increase
Hanford Site	Surface water (Columbia River)	216 million	855,000	0.40
INL Site	Groundwater (on-site wells)	1.1 billion	855,000	0.078
LANL	Groundwater (on-site wells)	359 million (in 2005)	855,000	0.24
NNSS	Groundwater (on-site wells)	293 million	855,000	0.29
SRS	Groundwater (on-site wells)	1.42 billion (in 2006)	855,000	0.060
WIPP Vicinity	Groundwater (Double Eagle South Well Field system)	5.4 million	855,000	0.24[c]

[a] Sources for current annual site water use are as follows: Hanford Site (DOE 2009), INL Site (DOE 2005b), LANL (LANL 2008), NNSS (USGS 2007), SRS (Mamatay 2007), and WIPP Vicinity (Sandia 2008).

[b] The maximum annual water use for the construction period would be 855,000 gal for the vault method.

[c] Although the water demand for the proposed GTCC LLRW and GTCC-like waste disposal facility at the WIPP Vicinity site would increase WIPP's water use by 16% per year (i.e., 855,000 gal ÷ 5.4 million gal), it would increase the use of groundwater from the Double Eagle South Well Field system (which has a capacity of 360 million gal/yr) by only 0.24% per year (i.e., 855,000 gal ÷ 360 million gal).

TABLE 5.3.3-3 Summary of Water Use Impacts from Operations at a Land Disposal Facility at the GTCC Reference Locations

Proposed Site	Water Source	Current Annual Site Water Use or Capacity (gal)[a]	Maximum Proposed Annual GTCC Facility Water Use (gal)[b]	Percent Change
Hanford Site	Surface water (Columbia River)	216 million	1.4 million	0.65
INL Site	Groundwater (on-site wells)	1.1 billion	1.4 million	0.13
LANL	Groundwater (on-site wells)	359 million (in 2005)	1.4 million	0.39
NNSS	Groundwater (on-site wells)	293 million	1.4 million	0.48
SRS	Groundwater (on-site wells)	1.42 billion (in 2006)	1.4 million	0.099
WIPP Vicinity	Groundwater (Double Eagle South Well Field system)	5.4 million	1.4 million	0.39[c]

[a] Sources for current annual site water use are as follows: Hanford Site (DOE 2009), INL Site (DOE 2005b), LANL (LANL (2008), NNSS (USGS 2007), SRS (Mamatay 2007), and WIPP Vicinity (Sandia 2008).

[b] The maximum annual water use for the operational period would be about 1.4 million gal for the trench and vault methods.

[c] Although the water demand for the proposed GTCC LLRW and GTCC-like waste disposal facility at the WIPP Vicinity site would increase WIPP's water use by 26% per year (i.e., 1.4 million gal ÷ 5.4 million gal), it would increase the use of groundwater from the Double Eagle South Well Field system (which has a capacity of 360 million gal/yr) by only 0.39% per year (i.e., 1.4 million gal ÷ 360 million gal).

and these are addressed for each of the sites in Chapters 6 through 11 for the Hanford Site, the INL Site, LANL, NNSS, SRS, and WIPP Vicinity, respectively. A summary of these results is provided in Section 5.3.4.3, and the results are discussed in more detail in the appropriate sections of Chapters 6 through 11. Post-closure human health impacts are also estimated on a regional basis for the generic commercial disposal locations; these are presented in Chapter 12.

The greatest risk to human health during normal operations would result from radiation doses and associated health risks to workers handling the wastes. The radiation doses to off-site individuals would be very low, since the actions taken to protect workers, such as use of shielding and remote handling equipment, would also serve to protect any nearby members of the public. However, it is possible that waste-handling accidents could occur and result in loss of shielding and possibly the release of radioactive contaminants that could become airborne and affect nearby off-site members of the general public.

The physical hazards to workers were considered during the construction and operations phases of the project. The only significant impact during the post-closure phase would be from the potential release of radioactive contaminants from the disposed wastes, which could reach individuals living near the site. During the operations phase, the radiation exposures of workers were considered in addition to the physical hazards associated with emplacement of the wastes into the disposal facility.

5.3.4.1 Operations

During operations, the wastes would arrive at the disposal facility, be unloaded from the transport vehicle, proceed through on-site staging activities, and be placed in the disposal facility. Many of these activities would require shielding to keep worker doses in compliance with DOE limits and ALARA. Remote handling equipment would be used as necessary to further reduce these exposures. All of these activities would keep the doses to members of the general public at very low levels, generally indistinguishable from those associated with exposure to normal background radiation. However, it is expected that workers would incur measurable radiation doses during waste disposal activities.

5.3.4.1.1 Workers. Two types of workers are addressed in the EIS: involved workers (those directly involved in handling and disposing of the wastes at the disposal sites) and noninvolved workers (those present at the site but not directly involved in waste disposal activities). Given the physical form of the wastes, the only pathway of concern for workers during normal operations would be external gamma irradiation. It is assumed that all of the wastes would arrive at the site as solid materials that could be placed directly into the disposal facility. Any necessary waste treatment would have already occurred at the site that generated or staged the wastes prior to shipment, and the impacts associated with these activities are outside the scope of this EIS.

The involved workers would incur radiation doses when they were in the general proximity of the waste containers during waste handling and disposal activities. The external gamma exposure rates of the GTCC LLRW and GTCC-like waste packages would cover a very wide range of values; wastes would range from those that could be managed directly because they had very low exposure rates to those that would have to be managed by using a large amount of shielding and remote handling equipment.

The external gamma dose rates associated with packages containing activated metal wastes were modeled by using the computer code MicroShield (Grove Software, Inc. 2005). The gamma exposure rates on the surfaces of these containers, assuming there would be no additional shielding, could exceed 1,000 roentgen/hour (R/h). These dose rates are somewhat smaller than, but generally comparable to, those associated with SNF and high-level radioactive wastes. However, these exposure rates would decrease quite quickly with distance. The external gamma dose rate would be about 1% of the surface dose rate at a distance of 5 m (16 ft) from the source and 0.01% of the surface dose rate at a distance of 50 m (160 ft). Shielding would be used to protect both the involved and noninvolved workers. Use of remote-handling equipment would also be necessary for these very-high-exposure-rate containers.

In addition to this direct gamma radiation, worker exposures could occur from secondary (or air-scattered) radiation. The computer code MicroSkyshine (Grove Software, Inc. 2008) was used to evaluate this component, again focusing on the activated metal waste containers by using the conceptual geometric configurations of the vault, trench, and borehole. This computer code was developed to address radiation exposures from secondary radiation when there is shielding between the radiation source (waste packages) and a potentially exposed individual (nearby worker). The shielding would greatly reduce the dose from direct (unscattered) radiation, but the dose from air-scattered radiation could be significant. This dose could result from waste packages in an open vault, trench, or borehole partially filled with waste. In this situation, the gamma radiation would be emitted from the waste packages to the air above the disposal unit and be scattered by air molecules in the atmosphere, and then a small fraction of the scattered radiation would be directed toward a nearby worker. MicroSkyshine is a standard computer code used for analyzing situations like this one that is relevant to disposal of GTCC LLRW and GTCC-like waste.

Although this dose component is significantly lower than the direct (unshielded) exposure associated with the activated metal waste containers, the exposure rates from skyshine radiation could exceed 10 mR/h and approach 100 mR/h close to the disposal facility if several waste containers were grouped together, such as in a trench, vault, or borehole prior to placement of the overlying cover. These exposure rates further indicate the need to use shielding to protect individuals working at the site.

Because the procedures to be used to manage these wastes at the site and the exact activities that would be conducted by each involved worker (and the worker's proximity to the waste containers) are not known at this time, it is difficult to calculate the dose to the workforce implementing the various alternatives. For purposes of this EIS, data on the radiation exposures of workers at existing DOE facilities were used to estimate the total dose that could be incurred by workers in disposing of these wastes. Worker doses are required to be kept below 5 rem/yr, as mandated in 10 CFR Part 835. In addition, administrative control limits would be set below this limit, and radiation exposures of the involved workers would be monitored for the duration of the project.

DOE has established an agency-wide administrative control limit of 2 rem/yr in its *Radiological Control Manual* (DOE 1994). This manual also requires that any contractors working on DOE projects (such as those who would be expected to work on disposing of GTCC LLRW and GTCC-like waste) establish a lower administrative control limit, on the order of 0.5 to 1.5 rem/yr. A project-specific administrative control limit would be set in accordance with these requirements before any waste disposal activities would be implemented, and this limit would be based on the specific conditions of the selected alternative. In addition, extensive use would be made of remote-handling equipment and shielding to reduce potential exposures of the workers, in accordance with DOE's ALARA requirement.

The average dose received by workers at DOE waste processing and management facilities was 56 to 60 mrem/yr between 2004 and 2006. In 2006, 7,687 workers were monitored for radiation exposure, and 2,457 of them (about one-third) had measurable doses. With regard to the workers who had measurable doses, most (2,032 persons) received a dose of less than 100 mrem, 324 received a dose between 100 and 250 mrem, 91 received a dose between 250 and 500 mrem, 9 received a dose between 500 and 750 mrem, and only one received a dose between 750 and 1,000 mrem. No worker received a dose greater than 1 rem in 2006 (DOE 2007b).

For this EIS, the dose to the workforce was calculated by using an average annual dose to an FTE involved worker and the estimated number of FTE operators and technicians during the operations phase as given in Appendix D. The concept of an FTE worker was largely used to estimate costs for the various disposal options (see Appendix D). An annual FTE is simply the number of person-hours required for a given task divided by the number of working hours in a year; that is, it is the number of full-time workers necessary to complete the task. This work can be divided among a relatively large workforce. For example, if each of 100 individuals worked 3 months on a task (like waste disposal) over the course of a year, a total of 25 FTEs would be associated with this task during that year. The annual dose to an FTE worker would thus be larger than the dose to any individual worker. In this example, it could be four times greater.

It is expected that the GTCC LLRW and GTCC-like waste would be received at a disposal site intermittently (see Section 3.4.2). There might be only a few waste disposal campaigns in any week or month over the course of a year. Because of this, several crews might be used to dispose of these wastes. These crews would perform other functions when wastes were not available for disposal. So it is likely that a larger number of individuals than the number of FTEs given in Appendix D would actually be involved with waste disposal activities.

As noted above, the doses to workers at DOE facilities are a very low percentage of the limit given in 10 CFR Part 835. For this assessment, the average annual dose for an FTE involved worker is taken to be 0.2 rem/yr, which is about three times greater than the average dose to a badged worker for comparable activities at DOE sites in 2006. A higher dose rate was assumed for this analysis, since the dose rates for some of the waste containers (specifically those for activated metal wastes, which constitute about 17% of the GTCC LLRW and GTCC-like waste volume) are expected to be significantly higher than those for the containers processed and disposed of at DOE sites in 2006. In addition, many of the occupationally exposed workers at DOE sites (such as those included in the data provided for 2006) likely spend much of their time in nonradioactive areas, and the calculation given here is based on the number of FTEs that would be needed to manage the wastes.

The number of operators and technicians necessary to receive, transfer, and dispose of the expected number of GTCC LLRW and GTCC-like waste packages is estimated to be 23 for waste disposal in trenches, 13 for boreholes, and 26 for vaults (Appendix D). Although it is assumed for purposes of analysis in this EIS that disposal operations would occur over a period lasting up to 64 years, the actual length of the operational period would depend on the actual wastes that were being disposed of and the times when these wastes were being generated.

On the basis of these estimates and the assumption of an average annual dose rate of 0.2 rem/yr per involved worker FTE, the annual worker doses would be 4.6 person-rem for trenches, 2.6 person-rem for boreholes, and 5.2 person-rem for vaults. Note that these annual worker doses are somewhat higher than but generally comparable to those associated with the storage of SNF at commercial nuclear power plants (see Section 3.5.1.1). These annual worker doses would result in annual LCF risks of 0.003, 0.002, and 0.003 for these three disposal methods, respectively. These LCF estimates were obtained by using a risk factor of 0.0006 LCF per person-rem, as identified in Section 5.2.4. The average annual dose rate of 0.2 rem/yr per involved worker FTE could be spread over a number of workers who make up the FTE. The average dose rate to any given individual worker is expected to be similar to the values given above for DOE waste processing and management activities, depending on the actual number of workers involved in these activities.

It should be noted that this dose to the workforce would be distributed among all workers involved in managing the wastes at the alternative sites over the entire time period that the facility would be receiving and disposing of wastes. Different workers would likely be rotated into these activities over time, so the maximum dose to any given worker over the entire duration of the project would likely be no more than a few rem. Wastes would be received intermittently over the operational time period. The annual dose to the highest-exposed worker would be no more than the DOE administrative control limit (2 rem/yr) for site operations.

The dose to noninvolved workers would be much less than the dose to involved workers. The noninvolved workers (such as those constructing additional facilities or working in the administration building) would be some distance away from the waste packages. As noted previously, the external gamma dose rate at 50 m (160 ft) from the waste package is only about 0.01% of the surface dose rate. Also, there would likely be significantly fewer noninvolved workers than involved workers when wastes would be processed at the site to ensure compliance with the DOE ALARA requirement. The annual collective dose to the noninvolved workforce is conservatively estimated to be less than 0.1 person-rem/yr for each of these three disposal methods. No LCFs would be expected to result from these doses to noninvolved workers.

5.3.4.1.2 General Public. The only exposures to members of the general public at off-site locations near the disposal site during normal operations would be from the external gamma radiation emitted by the waste containers at off-site locations near the disposal site. Access to the site would be restricted during this time frame. These doses are expected to be very small, since procedures to protect on-site workers handling the wastes would also serve to reduce the off-site doses to levels that would be indistinguishable from background.

The scattered (skyshine) dose at a distance of 100 m (330 ft) from the activated metal waste containers in the trench was calculated by MicroSkyshine to be about 0.050 mrem/h. This dose could occur from a waste container placed in the trench prior to placement of the cover (or interim shielding to reduce the overall skyshine dose in the vicinity). The exposure rates for the borehole and vault were calculated to be lower.

The actual dose received by an off-site individual would depend on the location of the disposal facility at a given site, the specific design used for the facility, procedures used to manage the wastes at the site (including the use of temporary shielding), the extent of the buffer zone, and the length of an individual's exposure. However, the dose to the highest-exposed member of the general public is not expected to exceed a few millirem over the duration of waste disposal activities and would likely be indistinguishable from that associated with natural background radiation.

5.3.4.2 Accidents

This EIS addresses the human health impacts on workers and members of the general public from a range of potential accidents at a disposal facility that could occur under the three land disposal methods. The impacts of these accidents are expected to be comparable for all three methods. An accident is an event or series of unexpected or undesirable events leading to a loss of waste containment or shielding that results in exposures to workers or members of the general public. The two important elements considered in the assessment of risks from potential accidents are the consequences of the accident and the expected frequency (or probability) of the accident. As noted earlier, all of the wastes received at the disposal facility are assumed to be in a solid form that can be disposed of directly. As such, very little material is expected to become airborne from an accident involving waste containers.

5.3.4.2.1 Accidents Involving Radioactive Releases of Material. A wide range of different types of accidents was evaluated for the land disposal methods. The accidents included those initiated by operational events, such as equipment or operator failure, and natural phenomena, such as earthquakes. Because the disposal methods involve similar operations and the same waste packages, the accidents evaluated are applicable to all three land disposal methods. Because of differences in the local weather patterns and the location of the potential receptors, the radiological impacts for Alternatives 3 to 5 are site-dependent and are discussed in Chapters 6 through 11 for the Hanford Site, the INL Site, LANL, NNSS, SRS, and WIPP Vicinity, respectively. These impacts for accidents are not addressed for the generic commercial disposal locations in this EIS.

No repackaging of waste is anticipated at the disposal facility. Thus, the only way a release of radioactive material to the environment from operational events could occur would be if a disposal container ruptured during handling operations. Handling operations would include the (1) transfer of disposal containers from their Type B packages as received at the Waste Receipt and Storage Building for temporary storage, (2) transfer from temporary storage to an on-site transport vehicle, and (3) transfer from the transport vehicle into the disposal unit. All such operations are expected to involve the use of forklifts and/or cranes. Table 5.3.4-1 summarizes the accident scenarios analyzed. Further details on the scenario analysis can be found in Appendix C.

Physical damage to waste containers could result from low-speed vehicle collisions or from being dropped or crushed by falling objects. Only minor releases are expected at the facility

TABLE 5.3.4-1 Accidents Evaluated for the Land Disposal Facilities

			Frequency Range			
Scenario Number	Accident Scenario[a]	Accident Description	$>10^{-2}$/yr	10^{-4} to 10^{-2}/yr	10^{-6} to 10^{-4}/yr	$<10^{-6}$/yr
1	Single drum drops, lid failure in Waste Receipt and Storage Building	A single CH drum is damaged by a forklift and spills its contents onto the ground inside the Waste Receipt and Storage Building.	X			
2	Single SWB drops, lid failure in Waste Receipt and Storage Building	A single CH SWB is damaged by a forklift and spills its contents onto the ground inside the Waste Receipt and Storage Building.	X			
3	Three drums drop, puncture, lid failure in Waste Receipt and Storage Building	Three CH drums are damaged by a forklift and spill their contents onto the ground inside the Waste Receipt and Storage Building.	X			
4	Two SWBs drop, puncture, lid failure in Waste Receipt and Storage Building	Two CH SWBs are damaged by a forklift and spill their contents onto the ground inside the Waste Receipt and Storage Building.	X			
5	Single drum drops, lid failure outside	A single CH drum is damaged by a forklift and spills its contents outside.	X			
6	Single SWB drops, lid failure outside	A single CH SWB is damaged by a forklift and spills its contents outside.	X			
7	Three drums drop, puncture, lid failure outside	Three CH drums are damaged by a forklift and spill their contents outside.	X			
8	Two SWBs drop, puncture, lid failure outside	Two CH SWBs are damaged by a forklift and spill their contents outside.	X			

TABLE 5.3.4-1 (Cont.)

			Frequency Range			
Scenario Number	Accident Scenario[a]	Accident Description	$>10^{-2}$/yr	10^{-4} to 10^{-2}/yr	10^{-6} to 10^{-4}/yr	$<10^{-6}$/yr
9	Fire inside the Waste Receipt and Storage Building, one SWB assumed to be affected	A fire or explosion within the Waste Receipt and Storage Building affects the contents of a single CH SWB.			X	
10	Single RH waste canister breach	A single RH waste canister is breached during its fall in the Waste Receipt and Storage Building.			X	
11	Earthquake affects 18 pallets, each with four CH drums	The Waste Receipt and Storage Building is assumed to be damaged during a design basis earthquake, with failure of the structure and confinement systems resulting.			X	
12	Tornado, missile hits one CH-SWB, contents released	A major tornado and associated tornado missiles result in failure of the Waste Receipt and Storage Building structure and its confinement systems.			X	
13	Flood	It is assumed that the location of the facility would be sited such that it would preclude severe flooding.				X

[a] Details of the accident scenario evaluated are presented in Appendix C.

should such accidents happen. Accidents involving CH waste containers are expected to result in higher impacts because these Type A containers, although fairly robust, are not as sturdy as the RH canisters or AMCs and their shielding casks. As a consequence, the CH waste containers would be more prone to lose a portion of their contents, and, in addition, airborne radioactive contamination from such material as activated metals would be minimal compared with contamination from Other Waste because the contamination associated with activated metal waste is very immobile. CH drum and SWB radionuclide inventories that gave the highest impacts were used in this facility accident analysis for accident numbers 1 through 9, 11, and 12. Accident number 10 was also evaluated for perspective, should an RH canister fail during an accident.

Fire from internal or external causes would be another potential cause for release of radioactive contamination. Internal causes would be minimized by proper treatment of the waste before packaging prior to receipt at the facility. External causes would be primarily linked to equipment fires, which could be minimized through proper maintenance and use of equipment. Accident number 9 considers the impacts from a short-term fire in the Waste Receipt and Storage Building.

Potential releases of radioactive material could also occur as a result of natural hazards. Such releases are only anticipated prior to emplacement (i.e., they would occur while the waste was at the Waste Receipt and Storage Building). However, it is assumed that the disposal facility would be sited in an area that is not prone to flooding, and depending on the area of the country in which it was situated, the facility would be built to meet local standards for earthquakes. Other natural hazards (such as tornadoes) in certain areas of the country could cause releases. Accident numbers 11 and 12 look at potential scenarios involving earthquakes and tornadoes, respectively.

The consequences for the highest-exposed individuals and the collective general public were estimated by using air dispersion models to predict the downwind air concentrations following a release. These models consider a number of factors, including the characteristics of the material released, location of the release, and meteorological conditions. The air concentrations were used to estimate the radiation doses and the potential LCFs associated with these doses. The consequences were estimated on the basis of the assumption that the wind was blowing in the direction that would yield the greatest impacts. For accidents involving releases of radioactive material, the consequences are expressed in the same way as are those from routine operations (i.e., as radiation doses and LCFs for the individuals receiving the highest impacts and exposed population for all important exposure pathways).

As long as the dose to an individual from accidental exposure is less than 20 rem and the dose rate is less than 0.60 rem/h, the health risk conversion factors given previously would be applicable, and the only important health impact would be the LCF. In other words, at those doses and dose rates, other possible radiation effects (e.g., fatalities from acute radiation syndrome, reproductive impairment, or cataract formation) do not need to be considered. These doses and dose rates for limiting the evaluation of health risk to cancer are given in Federal Guidance Report No. 13 (EPA 1999).

Highest-Exposed Individuals. The risk to involved workers would be very sensitive to the specific circumstances of the accident and depend on how rapidly the accident developed, the exact location and response of workers, the direction and amount of the release, the physical and thermal forces causing or caused by the accident, meteorological conditions, and the characteristics of the building if the accident occurred indoors. The involved workers would be radiation workers, and their exposures would be monitored and controlled by appropriate management methods.

The accident analysis evaluated the potential exposure of a hypothetical individual located 100 m (330 ft) downwind of an accident (radiation doses and LCFs). The exposure estimates include potential doses from inhalation, groundshine, and cloudshine for 2 hours following a hypothetical accidental release of radioactive material, as discussed above. The hypothetical individual receiving the greatest impacts would likely be a noninvolved worker at the disposal facility. At all the land disposal sites, any potential dose to an individual member of the public from an accidental release of radioactive material is expected to be much lower than those estimated here for the noninvolved worker. The radiological impacts to a hypothetical individual located downwind from an accident for Alternatives 3 to 5 are site-dependent and are discussed in Chapters 6 through 11 for the Hanford Site, the INL Site, LANL, NNSS, SRS, and WIPP Vicinity, respectively.

General Public. The general public consists of the population living within 80 km (50 mi) of the GTCC LLRW and GTCC-like waste disposal facility at the reference locations evaluated. The exposure estimates include potential doses from inhalation, groundshine, cloudshine, and ingestion of contaminated crops for 1 year following a hypothetical accidental release of radioactive material as discussed above. More details on the analysis are provided in Appendix C. The radiological impacts on the general public for Alternatives 3 to 5 are site-dependent and are discussed in Chapters 6 through 11 for the Hanford Site, the INL Site, LANL, NNSS, SRS, and WIPP Vicinity, respectively.

5.3.4.2.2 Nonradiological Worker Impacts. The potential human health impacts from accidents include the physical consequences of accidents whether or not a release of radioactive material occurs. The physical consequences are given here in terms of injuries and illnesses (as lost workdays) as well as the likelihood of worker fatalities.

The human health impacts on noninvolved workers are assessed for the construction and operational phases. These impacts are expected to be the same for each land disposal site under consideration in this EIS but are disposal-technology-dependent, since the activities and workforce requirements differ for the various disposal methods. These impacts were estimated by using statistical data compiled for private industry and data on the number of workers estimated to be needed for all phases of the project.

The rates at which accidents and injuries occur during construction activities were obtained from information provided by the BLS, as reported by the National Safety Council (BLS 2007a,b). On the basis of 2006 statistical data for the construction industry, the number of lost workdays due to nonfatal injuries and illnesses was calculated by using a value of 6.0 per 100 FTE workers, while the work-related fatality rate was taken to be 13.2 per 100,000 FTE workers. The statistical rates for the past few years vary only slightly from these values. These rates were used for the construction phase of the project for the three disposal methods.

Worker fatality and injury risks are calculated as the product of the incidence rate (given above) and the number of FTE workers needed for constructing the land disposal GTCC LLRW and GTCC-like waste facilities. Table 5.3.4-2 shows the calculation results for the three land disposal methods. The number of lost workdays due to injuries was calculated for the borehole, trench, and vault methods to be 16, 49, and 150, respectively; the number of lost workdays is proportional to the number of workers needed for the methods. While the numbers of fatalities calculated for the three disposal methods are different, they are all less than one (1), meaning no fatality is expected to occur among the involved workers during these two phases of the project.

The same approach was used for the operational period, although different rates were used to better reflect the type of expected activities. In addition, the results were given on an annual basis. The total number of injuries and fatalities can be obtained by multiplying the annual values given here by the assumed length of the operational period.

For nonfatal injuries, the 2006 statistics pertaining to the warehousing and storage industry were used, since this information is the most representative of the workers being evaluated in this EIS. For work-related fatalities, the statistics pertaining to the transportation and warehousing industries were modified, because “warehousing and storage” was not included as a separate category in the BLS fatality data. Among the reported fatality cases for the transportation and warehousing industry, 54% were related to highway accidents. Since transportation risks associated with the disposal of GTCC LLRW and GTCC-like wastes are addressed separately in this EIS, the fatalities of highway accidents included in these values were excluded. Therefore, the fatality rate used in this EIS analysis was 46% of the fatality rate for the transportation and warehousing industries. The nonfatal injury and illness rate (as lost workdays) used for involved workers during the operational period is 8.0 per 100 FTE workers, and the fatality rate is 7.4 per 100,000 FTE workers.

The number of FTE workers necessary for the operational period for the three land disposal methods represents the number of operators and technicians required to operate the disposal facility (see Appendix D). Although it is assumed that disposal operations would occur over a period lasting up to 64 years, the actual length of the operational period would depend on the actual wastes that were being disposed of and the time when the wastes were being generated. As shown in Table 5.3.4-2, the expected numbers of lost workdays per year due to nonfatal injuries were calculated to be 1 for the borehole method and 2 for the trench and vault methods. The total numbers of fatalities are all significantly less than one (1); therefore, no fatalities are expected to occur to the involved workers during operations of the three land disposal methods.

TABLE 5.3.4-2 Estimated Number of FTE Involved Workers, Nonfatal Injuries and Illnesses, and Fatalities Associated with the Construction and Operations of the Land Disposal Facilities[a]

Phase	Borehole	Trench	Vault
Construction			
Total FTEs[b]	260	820	2,400
Nonfatal injuries and illnesses[c]	16	49	150
Fatalities[d]	0.034	0.11	0.32
Operations			
Annual FTEs[e]	13	23	26
Annual nonfatal injuries and illnesses[f]	1	2	2
Annual fatalities[g]	0.00096	0.0017	0.0019

[a] The results for the construction phase represent the total number of injuries and fatalities for the three land disposal methods evaluated in the EIS. The results for the operations phase represent annual values. The total number of injuries and fatalities during the operations phase can be obtained by multiplying these annual values by the assumed length of the operational period.

[b] The total numbers of FTE workers needed during the construction phase was obtained from Appendix D. The values given here are those reported for construction of the three facility designs.

[c] The numbers of nonfatal injuries and illnesses (as lost workdays) were estimated on the basis of statistical data for the construction industry in 2006 (BLS 2007a). The nonfatal injury and illness rate was 6.0 per 100 FTEs.

[d] The numbers of fatalities were estimated on the basis of national census data for the construction industry in 2006 (BLS 2007b). The fatality rate was 13.2 per 100,000 FTEs.

[e] The annual numbers of FTE workers during the operations phase represent the average number of operators and technicians needed to operate the disposal facilities (Appendix D).

[f] The annual numbers of nonfatal injuries and illnesses (as lost workdays) were estimated on the basis of statistical data for the warehousing and storage industry in 2006 (BLS 2007a). The nonfatal injury and illness rate was 8.0 per 100 FTEs.

[g] The annual numbers of fatalities were estimated on the basis of national census data for the transportation and warehousing industry, excluding the fatalities caused by highway accidents, in 2006 (BLS 2007b). The fatality rate was 7.4 per 100,000 FTEs.

5.3.4.3 Post-Closure

For this EIS, the post-closure human health impacts were evaluated by considering the impacts that could occur to the general public from radioactive contaminants released from the waste packages emplaced in the land disposal facilities over the long term. It is assumed that no worker impacts would occur once the disposal sites were closed. Direct intrusion into the waste disposal units is qualitatively addressed in this EIS (see Section 5.5).

The two mechanisms by which off-site members of the general public could be affected by the disposal of these wastes in land disposal facilities in the long term are from (1) airborne emissions and (2) leaching of radioactive contaminants from the waste packages, followed by their transport to groundwater and migration to an accessible location, such as a groundwater well. Airborne emissions could include gases (such as radon, CO_2, and water vapor) and particulates should the disposal facility cover be completely lost through erosion. Particulate radionuclide air emissions are not expected to be significant, since it is very unlikely that the entire disposal facility cover would be lost through erosion. In addition, any material removed from the facility surface cover by erosion or weathering would be replaced to some extent by nearby soil that had been similarly removed. Nevertheless, this pathway was assessed for completeness.

Standard engineering practices and measures would be taken in designing and constructing the disposal facility in order to ensure long-term stability and minimize the likelihood of contaminant migration from the wastes to the surrounding environment. The facility would be sited in a location consistent with the requirements specified by the NRC for LLRW disposal facilities given in 10 CFR Part 61 and the *Radioactive Waste Management Manual*, DOE M 435.1-1 (DOE 1999a), which include siting them in locations with geologic characteristics that would minimize events that could compromise the containment characteristics of the disposal facility in the long term. Use of engineering controls in concert with the natural features of the selected site should ensure the long-term viability of the disposal facility.

For analysis of the long-term impacts on human health after closure of the disposal facility, a hypothetical individual is assumed to move near the site and reside in a house located 100 m (330 ft) from the edge of the disposal facility. This location was selected because it is the minimum distance identified in Manual DOE M 435.1-1 (DOE 1999a) for the location of the buffer zone surrounding a DOE LLRW disposal site at which compliance with dose standards needs to be demonstrated. No additional buffer zone beyond the area necessary to operate the LLRW disposal facility is assumed in this analysis. This assumption is expected to be conservative, since the DOE sites considered in this EIS are very large, and a significant buffer zone of greater than 100 m (330 ft) would likely be employed for this disposal facility.

For this analysis, a hypothetical individual is assumed to move to this location and develop a farm. It is assumed that this resident farmer would develop a groundwater well as the source of drinking water and would obtain much of his or her food (fruits, vegetables, meat, and milk) from the farm. A resident farmer was selected for this evaluation because this scenario would involve relatively intensive use of the land and provides a conservative basis for comparison of different options.

The hypothetical resident farmer could be exposed to airborne contaminants, including radon gas and its short-lived decay products, as well as gaseous radionuclides such as carbon-14 (C-14 in the form of CO_2) and hydrogen-3 (H-3 or tritium in the form of water vapor). These gases could diffuse out of the waste containers and move through the disposal facility cover and then be transported by the wind to the off-site residence of the farmer. This individual could also incur a radiation dose through the use of groundwater contaminated from the leaching of radionuclides in the waste containers and their transport to the underlying groundwater table.

Secondary soil contamination at off-site locations would be possible if contaminated groundwater was used for irrigation and if this practice continued for an extended period of time. Potential exposure pathways related to the use of contaminated groundwater include external irradiation; inhalation of dust particulates, radon gas (and its short-lived decay products), H-3, and C-14; and ingestion of water, soil, plant foods, meat, and milk. Plant foods (fruits and vegetables) could become contaminated through foliar deposition as well as root uptake. Meat and milk could become contaminated if livestock ingested contaminated water (obtained from the well) and fodder contaminated by this groundwater.

The potential for radiation exposure to this hypothetical receptor in the future would exist only if radionuclides were released from the waste containers and disposal facility. The most likely mechanism for this scenario to occur would be contact with infiltrating water. Water (such as that from precipitation) could infiltrate into the disposal area and contact the waste containers. No releases would occur while the waste containers and engineering barriers (such as a cover system) remained intact. However, over time, it is likely that the waste packages and engineering barriers would lose their integrity. When this situation occurred, water could contact the waste materials within the packages and move downward to the groundwater table.

Data on the performance of waste packages and engineering barriers over an extended time period are limited. Even when the data are available, using such data to predict the release rates of radionuclides over a very long time period can be difficult to defend, especially in the context of a comparative analysis that is not intended to consider extensive details. The potential impacts on groundwater are evaluated over a very long period in this EIS (10,000 years or longer to peak dose). How and when the waste packages and engineering barriers would begin to degrade and how this degradation would progress over time are very difficult to determine.

It was assumed for purposes of analysis in the EIS that the Other Waste type (as opposed to activated metals and sealed sources) would be solidified (e.g., with grout or another similar material) prior to being placed in the disposal units. This is a reasonable assumption and consistent with current disposal practices for such wastes, which include a wide variety of materials that could compact or degrade without such measures. Use of such a stabilizing agent was not assumed for the activated metal waste and sealed sources because their waste form makes them less susceptible to leaching.

In performing these evaluations, a number of engineering measures (e.g., a cover system) were included in the conceptual facility designs to minimize the likelihood of contaminant migration from the disposal units. It was assumed that these measures would remain intact for 500 years after the disposal facility closed. After 500 years, the barriers would gradually fail. To account for these measures, it was assumed that the water infiltration rate to the top of the waste disposal area would be zero for the first 500 years and then 20% of the natural rate for the area of the remainder of the period of calculation (10,000 years). A water infiltration rate of 20% of the natural rate for the area was only used for the waste disposal area. The natural background infiltration rate was used at the perimeter of the waste disposal units. This method is assumed to be a reasonable way to model the use of an improved cover for the purposes of this analysis. A sensitivity analysis was performed to evaluate the significance of these assumptions, and this is presented in Appendix E.

To evaluate the uncertainties that the key assumptions might have on the long-term human health impacts presented in this EIS, a sensitivity analysis was performed and is provided in Section E.5 of Appendix E. In this sensitivity analysis, the RESRAD-OFFSITE calculations were repeated each time different values were used for each of the key assumptions (the values for the other parameters were kept at their base values).

Three key parameters were addressed in the sensitivity analysis: (1) the water infiltration rate to the top of the disposal facility cover, (2) the effectiveness of the stabilizing agent (grout) used for Other Waste, and (3) the distance to the assumed hypothetical receptor. These three parameters relate to disposal facility design, waste form stability, and site characteristics.

The results indicated that the peak annual dose would increase as the water infiltration rate increased, because when more water would enter the waste disposal horizon, more radionuclides would be leached and released from the disposal facility. The increase in the peak dose would be approximately proportional to the increase in the water infiltration rate. This result is not unexpected, and it indicates the need for a very effective cover to minimize the amount of infiltrating water that could contact the GTCC LLRW and GTCC-like waste.

With regard to the use of a stabilizing agent for Other Waste, the release rates of radionuclides from the waste disposal area would be reduced as long as the agent remained effective. The use of the agent would reduce the annual dose and LCF risk associated with groundwater contamination for the corresponding period. Hence, the peak annual dose after the effective period would be lower than it would be when there was no waste stabilization or when the effective period of the stabilizing agent was shorter. The extent of this reduction would be very dependent on the specific site being addressed and the mix of radionuclides in the wastes.

Finally, the radiation dose incurred by the hypothetical resident farmer would decrease with increasing exposure distance, as would be expected. This reduction would occur because additional dilution of radionuclide concentrations in groundwater would result from the additional transport distance toward the location of the off-site well. As the distance would increase from 100 m (330 ft) to 500 m (1,600 ft), the maximum annual radiation dose would decrease by more than 70%.

The results of this analysis are summarized in Table 5.3.4-3 for radiation doses and Table 5.3.4-4 for LCFs. These results are discussed further in the appropriate sections of Chapters 6 through 12 and Appendix E.

Because the radionuclide mix for each waste type (i.e., activated metals, sealed sources, and Other Waste) is different, the peak annual doses and LCF risks for each waste type do not necessarily occur at the same time. In addition, the peak annual doses and LCF risks for the entire GTCC LLRW and GTCC-like waste inventory considered as a whole could be different from those for the individual waste types. Hence, estimated annual doses and LCF risks for the hypothetical resident farmer scenario evaluated for the post-closure phase are presented in two ways in this EIS. The first presents the peak annual doses and LCF risks when disposal of the entire GTCC LLRW and GTCC-like waste inventory is considered. The second presents the peak annual doses and LCF risks when each waste type is considered on its own. Results are presented for each land disposal method as evaluated for each given site. The first set of results could be used as the basis for comparing the performance of each site and each land disposal method if the entire GTCC LLRW and GTCC-like waste inventory was going to be disposed of at one site by using one method. The second set could be used as the basis for comparing the performance of each site and each land disposal method when disposal of each of the three waste types was being considered.

The tables in Chapters 6 through 12 (e.g., Tables 6.2.4-2 and 6.2.4-3 in Chapter 6; Tables 7.2.4-2 and 7.2.4-3 in Chapter 7 etc. to Chapter 11; Chapter 12 tables are those shown in Section 12.2) present the peak annual doses and LCF risks to the hypothetical resident farmer when disposal of the entire GTCC LLRW and GTCC-like waste inventory at each site is being considered for the land disposal methods evaluated (the first set described above). In these tables, the doses contributed by each waste type to the peak annual dose reported (i.e., dose for each waste type at the time when the peak dose for the entire inventory is observed) are also tabulated. As discussed above, these doses (from the various waste types) do not represent the peak annual dose and LCF risk of the waste type itself when considered on its own.

The second set of results is presented in Tables E-22 through E-25 in Appendix E. Peak annual doses and LCF risks are reported for each waste type. Because these peak annual doses and LCF risks generally occur at different times, the results should not be summed to obtain total annual doses and LCF risks for comparison with those presented in Chapters 6 through 12 (although for some cases, these sums might be close to those presented in the site-specific chapters).

The human health impacts (annual doses and LCF risks) to the hypothetical resident farmer given in this EIS are intended to serve as indicators of the relative performance of each of the three land disposal methods at each of the sites evaluated. These can be considered to serve as a metric for comparing the relative performance of the land disposal methods at these sites. Further design considerations and site-specific modeling would be performed when implementation decisions were being made. By using robust engineering designs and redundant measures to contain the radionuclides in the disposal unit, the potential releases of radionuclides would be delayed and reduced to very low levels, thereby minimizing potential groundwater contamination and its associated human health impacts in the future.

TABLE 5.3.4-3 Comparison of Maximal Doses (mrem/yr) within 10,000 Years for the Resident Farmer Scenario Associated with the Use and Ingestion of Contaminated Groundwater at the Various GTCC Reference Locations Evaluated for the Land Disposal Methods[a,b]

Disposal Facility	Hanford Site	INL Site	LANL	NNSS	SRS	WIPP Vicinity
Borehole	4.8	820	160	0	NA[c]	0
Trench	48	2,100	380	0	1,700	0
Vault	49	2,300	430	0	1,300	0

[a] All values are given to two significant figures. The values are based on the entire inventory of GTCC LLRW and GTCC-like waste being disposed of in a borehole, trench, or vault facility at each site. These results do not address combinations of disposal methods, which could result in lower doses and LCF risks, depending on the waste types being disposed of.

[b] In addition to the dose associated with contaminated groundwater, there would be a small radiation dose from the airborne release of radioactive gases from the disposed-of wastes for the trench (<1.8 mrem/yr) and vault (<0.52 mrem/yr) disposal methods.

[c] NA = not applicable.

TABLE 5.3.4-4 Comparison of Maximal Latent Cancer Risks (LCF/yr) within 10,000 Years for the Resident Farmer Scenario Associated with the Use and Ingestion of Contaminated Groundwater at the Various GTCC Reference Locations Evaluated for the Land Disposal Methods[a]

Disposal Facility	Hanford Site	INL Site	LANL	NNSS	SRS	WIPP Vicinity
Borehole	0.000003	0.0005	0.00009	0	NA[b]	0
Trench	0.00003	0.001	0.0002	0	0.001	0
Vault	0.00003	0.001	0.0003	0	0.0008	0

[a] All values are given to one significant figure to reflect the uncertainties in these estimates. The values and are based on the entire inventory of GTCC LLRW and GTCC-like waste being disposed of in a borehole, trench, or vault facility at each site. These results do not address combinations of disposal methods, which could result in lower doses and LCF risks, depending on the waste types being disposed of.

[b] NA = not applicable.

In this analysis, the same land disposal facility concepts and designs were used at each of the various sites. As a result, some sites (specifically those in arid regions) performed better than those in more humid environments. This result should not be interpreted as implying that a site in a humid environment could not be used to dispose of GTCC LLRW and GTCC-like waste in an acceptable manner. Rather, this means that more engineering and administrative controls might be necessary. DOE has considered the potential doses to the hypothetical resident farmer as well as other factors discussed in Section 2.9 in identifying the preferred alternative as presented in Section 2.10.

5.3.4.4 Intentional Destructive Acts

DOE evaluated the consequences of scenarios involving IDAs, such as sabotage or terrorism events, associated with the GTCC LLRW and GTCC-like waste types and disposal methods analyzed in this EIS. Potential IDA scenarios involving the GTCC LLRW and GTCC-like waste under consideration could occur during transport of the waste to the disposal facility, while the waste containers are being handled at the facility (unloading, temporary storage, and emplacement), or after emplacement.

5.3.4.4.1 Approach. GTCC LLRW and GTCC-like waste pose a potential terrorist threat because of their higher radioactivity in a given volume when compared to other LLRW. Such material could be incorporated into an RDD intended to cause societal disruption, including significant negative economic impacts. The consequences of an IDA involving hazardous material depend on the material's chemical, radioactive, and physical properties, its accessibility, its quantity, its packaging, and its ease of dispersion, and also on the surrounding environment, including the number of persons in close proximity to an event. Because the characteristics of the activated metals, sealed sources, and Other Waste considered in this EIS (see Section 1.4.1) are different, the wastes are treated separately in this IDA analysis.

There are many detailed scenarios, ranging from minor incidents to widespread contamination, whereby this waste could be used in an IDA, Even though the likelihood of occurrence of any detailed scenario is speculative and cannot be determined, there are certain classes of events that may be identified and qualitatively analyzed to provide an upper range estimate of impacts.

In this analysis, generic IDA scenarios for transporting the waste to a disposal facility and for handling and disposing of the waste at the facility are evaluated and discussed separately. In the case of transportation, a limited amount of material is available in robust packaging, but it is more readily accessible to the public and could travel through areas of varying population density and land use. Initiating events could range from hijacking the transportation vehicle and its contents for future use in a single or multiple RDDs, causing an accident involving a transportation vehicle in an attempt to release radioactive material, or detonating explosives placed on or near the transportation vehicle (e.g., an improvised explosive device, rammed by a car or truck bomb) during transport. Regardless of the initiating event, the highest potential impacts would be similar to the severe transportation accident impacts discussed later in

Section 5.3.9.3 and discussed in detail soon in Section 5.3.4.4.5 for the various waste types. Such impacts were evaluated over a range of scenarios, from rural areas with few people to highly populated urban areas.

In a similar fashion, it is expected that generic IDA scenarios at a disposal facility could cause a range of impacts similar to those analyzed for facility accidents earlier in Section 5.3.4.2.1 and in Chapters 6 through 11 (Sections 6.2.4.1, 7.2.4.1, etc.) for facilities. Such scenarios could involve an overt or covert land or aerial attack on the facility involving any number of assailants, with or without explosives or incendiary devices, and with or without insider assistance. The upper range of potential impacts is discussed soon in Section 5.3.4.4.5 for the land disposal methods analyzed.

Therefore, this IDA analysis focuses on the land disposal methods because DOE already considered the potential impacts of IDAs (i.e., acts of sabotage or terrorism) at WIPP, the geologic repository (see Section 4.3.4.4).

5.3.4.4.2 Security Measures. Appropriate security measures would be instituted to ensure the safety of facility workers and the surrounding off-site public. DOE is responsible for safe disposition of the GTCC LLRW and GTCC-like waste, whether it is in an NRC-licensed disposal facility, a facility operated at a DOE or commercial site, or a facility operated by DOE or a commercial entity.

DOE has acted in a strong and proactive manner to understand and preclude or mitigate the threats posed by IDAs. In accordance with DOE Order 470.4A, "Safeguards and Security Program," and Order 470.3B, "Graded Security Protection Policy," DOE conducts vulnerability assessments and risk analyses of facilities and equipment under its jurisdiction to evaluate the physical protection elements, technologies, and administrative controls needed to protect DOE assets. DOE Order 470.4A establishes the roles and responsibilities for the conduct of DOE's Safeguards and Security Program. DOE Order 470.3B (a) specifies those national security assets that require protection; (b) outlines threat considerations for safeguards and security programs to provide a basis for planning, design, and construction of new facilities or modifications to existing facilities; and (c) provides an adversary threat basis for evaluating the performance of safeguards and security systems. DOE also protects against espionage, sabotage, and theft of radiological materials.

DOE would conduct in-depth, site-specific safeguards and security inspections of the GTCC LLRW and GTCC-like waste disposal facility to ensure that existing safeguards and security programs satisfied DOE requirements. Any issues identified would be resolved before the startup of the operations.

As part of the licensing requirements for a LLRW disposal facility, NRC regulations at 10 CFR 61.16 may require a physical security plan for the facility. Licensed LLRW disposal facilities also undergo periodic inspections. The primary purpose of the NRC inspection program for LLRW facilities is to verify that these facilities are operated and managed throughout their entire life cycle in a manner that provides protection from radioactivity to employees, members of the public, and the environment. Included in these inspections are reviews of site security and the security of handled radioactive materials.

5.3.4.4.3 Disposal Options. The three land disposal options (borehole, vault, and trench) share the same infrastructure, in that these three types of facilities are designed for receipt, secure temporary storage, and final disposal of the waste. No waste processing would be conducted at the facility, which would eliminate any potential for malevolent acts involving unpackaged waste or bulk hazardous chemicals. CH waste in 208-L (55-gal) drums or SWBs would be the most vulnerable to attack, either in temporary storage at the WHB or during on-site transport for final emplacement. The RH waste would pose a less desirable target for attack because of the added shielding required for handling, and, in the case of activated metals, because it would be in a form that is much less dispersible.

During transport to the disposal facility, waste materials would be in heavily shielded casks that would prevent the release of any radioactive material under any but the most severe conditions, as discussed in Section C.9.3.3 in Appendix C. Once at the facility, waste would be unloaded from the transport vehicle and placed in secure temporary storage. CH waste containers such as 208-L (55-gal) drums or SWBs would be taken out of the transport packaging, such as a TRUPACT-II container, and staged in a temporary storage area at the WHB prior to emplacement in a disposal unit. RH waste would either be stored in its Type B transport cask or be removed from its cask and temporarily stored in a heavily shielded room in the WHB before emplacement. Only limited numbers of waste containers would be in the WHB at any given time.

Emplacement of the waste would entail loading the CH containers by crane or forklift onto on-site transport vehicles, moving the waste to the disposal unit, and unloading the waste by crane or forklift into the disposal unit. CH waste might also be taken directly by forklift from the WHB to the disposal unit, depending on the final facility design and operating procedures. RH waste would be transferred to an on-site transfer cask. The cask would be loaded by crane onto an on-site transport vehicle, if it was not already on the vehicle during the waste transfer, and moved to the disposal unit, then unloaded by crane into the disposal unit.

Once emplaced in a closed disposal unit, the waste would be well-isolated from any potential IDA, thus significantly reducing the risk of contaminating the environment. The disposed-of waste would have a minimum cover of 5 m (17 ft). For the trench option, the 5-m (17-ft) cover would include the 1.1-m (3.8-ft)-thick, reinforced concrete, engineered barrier, whereas the vault option has a minimum cover of 5 m (17 ft) on top of its 1.1-m (3.8-ft)-thick reinforced concrete ceiling (see Section D.3 in Appendix D). Waste in the borehole would have a 30-m (100-ft) cover, including a 1.1-m (3.8-ft)-thick concrete layer. However, a large blast or excavation using typical earth-moving equipment could readily expose, at the least, the concrete cover on the trench or vault. Such an action would likely not initially disperse the waste but would make it easier to access. A borehole, with its 30-m cover and small cross section (smaller amount of waste per unit) precluding anything but specialized drilling equipment to reach the waste, would provide more security.

Compared to the vault and trench options, the borehole option would also provide the most security after emplacement before the disposal unit was closed. Because of the borehole's depth and smaller diameter, access to the waste in the borehole and the dispersion of the waste into the surrounding environment would be difficult. CH waste would be readily accessible in partially filled trenches or vault cells. RH waste would be less accessible in either case, lying beneath the 1.1 m (3.8 ft) of concrete of the radiation shield. Final covers on the trenches could be installed in sections as the waste was in place, thereby reducing the amount of material available to an IDA before closure of the entire trench.

5.3.4.4.4 Facility Location. The location of the disposal facility would affect how readily accessible the waste was and also the extent of human health impacts if an IDA occurred at the facility. The further a disposal site is from population centers, the less likely it is that the site would become a target, because terrorists would find it harder to blend in with the local population (i.e., they might be more easily detected while they were planning, preparing, and executing a potential IDA). In addition, an IDA at a location farther from potential victims would affect fewer individuals, and would likely be a less attractive option for terrorists. All specific disposal locations being considered are in relatively remote areas. Most locations under consideration for a disposal facility in this EIS are also within secure DOE areas, providing added protection for an operating facility or one that is still under institutional control.

5.3.4.4.5 Waste Types and Characteristics. Human health impacts of an IDA are directly related to what the characteristics of the radionuclide are (e.g., alpha or beta emitter and isotope half-life), how much radiological material is available for dispersal, how readily dispersible the material may be, and how the material is dispersed to the environment. For example, activated metals are highly radioactive gamma emitters that pose an external exposure threat, but they are not readily dispersible because of their solid metal form. Other Waste may consist of random pieces of maintenance, process, or demolition debris, such as contaminated metal, wood, cloth, plastic, or paper. Many of these items have loosely adhering radioactive contamination and/or are readily combustible, allowing the radioactive material to be more easily dispersed. Like activated metals, sealed sources contain highly radioactive gamma emitters. These materials are often doubly encapsulated in stainless steel and thus are not readily dispersible unless the source is first mechanically opened or somehow forcibly ruptured. The radioactive material in sealed sources can take on different forms that affect dispersibility. These include solid metals, ceramic or compressed disks, and powders.

Because of the physical and chemical characteristics of the different waste types as discussed above and in Section 1.4.1 and Appendix B, the IDA analysis of the GTCC LLRW and GTCC-like activated metals and Other Waste was conducted separately from the analysis of the sealed sources.

Activated Metals and Other Waste. For the activated metals and Other Waste considered for disposal, the initiating forces and resulting quantities of radioactive material that could be released by an IDA would be similar to those released in severe accidents, as analyzed in Section 5.3.9.3 for transportation and here in Section 5.3.4.2.1 and in Chapters 6 through 11 (Sections 6.2.4.1, 7.2.4.1, etc.) for facilities.

Unlike the evaluation of accidents, the evaluation of IDAs provides an estimate of the potential consequences of such events, without attempting to estimate the frequency or probability that an IDA would be attempted or would succeed. This is because there is no accepted basis for estimating the frequency of IDAs. Consequently, the evaluation does not account for security measures that might be implemented to help prevent such attacks. Final disposition of the waste in the types of disposal facilities considered in this EIS would greatly reduce the potential for diversion or theft associated with an IDA. The comparison of IDAs with accidents in the following sections is limited to the consequences that might result if an accident or IDA occurred, and it does not address the likelihood of either type of event.

Transportation impacts. It is expected that an IDA involving a shipment of activated metals or Other Waste would have impacts similar to those from a severe transportation accident. Because of high radionuclide inventories, most of the GTCC LLRW and GTCC-like waste is expected to require the use of Type B packaging for shipment, as discussed and described in Section C.9.4.2. The robust nature of these casks limits the potential release of radioactive material under the severest of accident conditions, as analyzed in Section 5.3.9.3. The severe accidents evaluated are generic in nature (i.e., there is no specific initiating event) but do involve extremes in mechanical and thermal (fire) forces.

The largest impacts were assessed for accidents involving fully loaded railcars (maximum amount of radioactive material available) in highly populated urban areas (largest affected population) under stable (calm) weather conditions (least amount of airborne dispersion, highest potential air concentrations of radioactive material). For these maximum reasonably foreseeable accidents, such an analysis is conservative in nature because any change in conditions would likely result in lower impacts. For this reason, it is not expected that during a single shipment, a terrorist attack could create conditions that would further increase impacts. For activated metal shipments, the largest impact would be a collective population dose of 60 person-rem, with no LCFs expected, as presented in Table 5.3.9-3. For the Other Waste category, a collective population dose of 3,200 person-rem, with the potential for two LCFs in the general population, is estimated for a railcar shipment of CH waste.

Facility impacts. Once received at a disposal facility, the GTCC LLRW and GTCC-like waste would be removed from their protective Type B shipping containers, stored temporarily in the WHB, and then transported on-site to a disposal unit, where they would be emplaced. An IDA committed at a disposal facility could occur during one of these phases; the largest potential impacts would likely occur during temporary storage of the waste in the WHB.

The on-site transportation of activated metal waste or Other Waste - RH would involve the use of a shielded on-site transfer cask to protect workers from the high radiation levels associated with these types of waste. The transfer cask would have properties similar to those of the Type B casks used for off-site transport and would limit dispersal if an accident or IDA occurred. Thus, IDA impacts involving the on-site transfer of activated metal or Other Waste - RH at the disposal facility are expected to be similar to those from a severe truck transportation accident involving one cask. Because all of the proposed disposal facility sites are in isolated rural areas, a collective population dose of 0.46 or 6.0 person-rem or less is expected, as given in Table 5.3.9-3 for a severe accident involving a truck carrying activated metal waste or Other Waste - RH, respectively, in a rural population zone.

The on-site transportation of Other Waste - CH would involve moving the waste in its disposal containers: either 208-L (55-gal) drums or SWBs. These Type A containers as described in Appendix B are not as robust as the Type B transportation casks and are more susceptible to dispersion of their contents as a result of an IDA event. The facility accident analyses described in 5.3.4.2.1 took this factor into account.

On-site movement of CH waste would involve either a single SWB or a 7-drum pack of 208-L (55-gal) drums. However, more waste can be contained by a direct-filled SWB than in seven 208-L (55-gal) drums. An SWB would be moved by forklift or similar conveyance from the WHB to the disposal unit. The facility accident with the largest impacts would be one that involved an SWB filled with Other Waste - CH in a fire (Accident No. 9). It is expected that an IDA event involving an SWB during on-site movement would have similar results, because it would provide maximum dispersion of the SWB contents to off-site locations. As seen in Chapters 6 through 12 (Sections 6.2.4.1, 7.2.4.1, etc.), the potential collective population consequences would range from 0.47 person-rem at the NNSS reference locations to 160 person-rem at LANL for Accident No. 9. Although Type A containers do not provide as much protection from dispersion after an IDA than do Type B containers, the impacts would still be less than or comparable to those from the off-site severe transportation accidents discussed above, because the population densities surrounding the sites would be low and because less material would be at risk. Impacts from site to site would vary, depending on the site meteorology and the surrounding population density and its distribution.

The IDA scenario that would encompass the most material at risk is the one that would occur during the temporary storage of the GTCC LLRW and GTCC-like waste after their receipt at a disposal facility. The conceptual facility designs used for this EIS do not include the amount of detail required to specify the total number of containers that could be stored at any one time, either physically or administratively. The amount of waste to be stored would be established during the implementation phase, limited to minimize worker risk, dependent on the security measures implemented, and dependent on the type of disposal units employed at the site. However, a rough estimate of potential consequences can be derived by scaling the CH waste facility (fire) accident by the number of SWBs that might be stored. For example, if 20 SWBs were in storage at the WHB and if all of them were involved in a serious fire, the collective off-site population consequence at the Hanford Site reference location would be about 1,500 person-rem or less, because it is likely that not all SWBs would have the maximum amount of radioactivity possible. The magnitude of such a consequence is about the same as that of the worst severe transportation accidents evaluated in urban areas.

Sealed Sources. With regard to the sealed sources being considered for disposal, the initiating forces and resulting quantities of radioactive material (from contents of sealed sources) that could be released by an IDA could be larger than the forces and quantities associated with severe accidents as analyzed in Section 5.3.9.3 for transportation and in Section 5.3.4.2.1 and Chapters 6 through 11 (6.2.4.1, 7.2.4.1, etc.) for facilities. Sealing the sources would reduce their potential to release radioactivity during facility accidents in which the waste containers in which the sources were packaged were punctured or dropped. Sealing, in addition to the shielding afforded by the massive Type B containers used for transportation, would limit the potential release of their contents during severe transportation accidents. In the case of an IDA, the entire contents of one or more sealed sources could be made available for dispersion. Unlike the Other Waste, the sealed sources at risk would be in a concentrated form that would make multiple sources more amenable to consolidation and covert movement before a potential IDA. Thus, an IDA involving sealed sources could be preceded by the theft or diversion of the sources and their consolidation to prepare an RDD.

The use of sealed sources in an RDD could lead to a mass contamination event (NAS 2008; GAO 2008). Fortunately, it is very difficult to cause deterministic human health effects in more than a handful of people (Musolino and Harper 2006). As shown in Table 5.3.9-3, estimates indicate that the sealed source transportation accidents that would involve the most material at risk and greatest potential consequences would result in fewer than 10 LCFs over the long term in highly populated urban areas. Consolidation of the contents of sealed sources and detonation in an RDD without the protective containment provided by a Type B transportation cask could increase the potential impact by more than two orders of magnitude. However, even among people who were suffering from health effects, few people, if any, would receive a dose that could result in acute lethality (GAO 2008). For the highest collective urban human health impact estimated in Table 5.3.9-3, the average risk to a member of the affected population of contracting cancer from exposure in his or her lifetime would be about 1 chance in 3.5 million. The primary impacts of such an event would be to raise the level of fear and anxiety in the general population and extract a large economic toll on the community (NAS 2008).

Human health impacts would depend on the location of the release, the surrounding population density, the area topology, and the local meteorology. Potential exposure to individuals would also depend highly on their actions immediately following the release (Dombrowski and Fishbeck 2006). Such impacts would be influenced to some extent by emergency response capabilities and training in the affected area (Musolino and Harper 2006; Harper et al. 2007).

Because the exact nature, time, and location of an IDA are impossible to predict, a range of scenarios involving radiological releases similar to events that could involve sealed sources considered in this EIS were investigated in the past. Depending on the amount of activity involved, contaminated locations (where individuals might receive more than the suggested U.S. Department of Homeland Security relocation guidelines of 2 rem/yr [73 FR 45029]) could range in the tens of square kilometers (Harper et al. 2007; GAO 2008). Potential acute fatalities could be on the order of 10 to 50 people, with potential LCFs being in the hundreds (Dombroski and Fishbeck 2006; Rosoff and von Winterfeldt 2007). The economic impacts (e.g., relocation, business loss, decontamination, demolition, and disposal) could reach billions of dollars.

5.3.5 Ecological Resources

This section describes the potential impacts on ecological resources associated with a GTCC LLRW and GTCC-like waste disposal facility regardless of the alternative site chosen. Both direct and indirect impacts on terrestrial vegetation and wetlands, wildlife, aquatic biota, and special status species are presented. Most impacts on ecological resources would occur during construction of the disposal facility, when most land disturbance would occur. Compliance with applicable environmental laws, regulations, and guidance (Chapter 13), coupled with use of mitigation measures, would minimize the adverse impacts described in this section (DOE 2003a).

5.3.5.1 Potential Impacts on Terrestrial Vegetation

Ground-disturbing activities during the construction of the GTCC LLRW and GTCC-like waste disposal facility (including excavation, grading, and clearing of vegetation) would have direct impacts on plant communities. The operation of heavy equipment would injure or destroy existing vegetation and compact and disturb soils. Soil aeration, infiltration rates, and moisture content could be affected. Deposition of fugitive dust from exposed soil surfaces or gravel roadways might result in reduced photosynthesis and primary production in adjacent terrestrial and wetland habitats. Impacts might include reduced growth and density of vegetation and changes in the plant community composition to more tolerant species. In areas where loose soils such as sand dunes occur, erosion might occur as a result of stormwater runoff, wind erosion, or sloughing of unstable slopes. Stabilization of slope margins might be difficult, and establishment of vegetative cover might be slow, possibly resulting in prolonged habitat losses near the construction area.

Removal of trees within or along forest or woodland areas could potentially result in an indirect disturbance to forest or woodland interior areas by changing the light and moisture conditions and by introducing nonforest or nonwoodland species, including potentially invasive species. In addition, trees remaining along the margin of the construction area might decline as a result of stress induced by altered conditions. Disturbance of surface soils near trees could also adversely affect trees along the margin. Root disturbance, soil compaction, topsoil loss, reduced soil moisture or reduced aeration, or altered drainage patterns might contribute to tree losses in addition to the loss of trees removed during land clearing.

Some plant species can benefit from land-disturbing activities because the activities create suitable habitat for them or create an opportunity to recruit seeds into new locations. Fencing (during the institutional control/monitored post-closure period), which would exclude larger herbivores, might also benefit some plant species. The species used to revegetate the GTCC reference location would be chosen in accordance with management policies at the site. As appropriate, regionally native plants would be used to landscape the disposal site. In arid regions, revegetation might be difficult.

Under Executive Order 13112, federal agencies are mandated, to the extent practicable, to prevent and control the spread of invasive species and to restore native species and habitat conditions. Even with judicious attempts to revegetate the GTCC reference location with native vegetation, site disturbance could facilitate the dispersal of invasive species by altering existing habitat conditions, stressing or removing native species, and allowing easier movement by wildlife or human vectors (Trombulak and Frissell 2000). Invasive plant species are present at all of the alternative DOE sites. Typically, seeds or other propagules of these species are easily dispersed, and they generally tolerate disturbed conditions. The introduction and spread of invasive plant species into disturbed areas represents a potential threat to biodiversity through displacement of native species, simplification of plant communities, and fragmentation of habitat (DOE 1999b). In addition, invasive species may alter ecological processes, such as fire regimes. Effects may include an increase in both the frequency and the intensity of wildfires, particularly as a result of the establishment of annual grasses (e.g., cheatgrass [*Bromus tectorum*] in the Western states), which produce large amounts of easily ignitable fuel over large contiguous areas. Native species, particularly shrubs, in habitats not adapted to frequent or intense fires might be adversely affected, and their populations could be greatly reduced in affected areas, creating opportunities for further increases in populations of invasive species. Vehicle traffic could also increase the potential for fires.

Contamination by compounds such as diesel fuel might result from accidental spills at the disposal site. Contaminants spilled onto ground surfaces could result in direct injury and mortality of plants, and migration through the soil could make recovery and restoration difficult. Habitats with highly permeable soils could experience rapid migration of contaminants through the root zone. Some contaminants might migrate to shallow groundwater and subsequently enter the root zone of nearby vegetation in the path of groundwater movement.

5.3.5.2 Potential Impacts on Wildlife

The construction and operations of the GTCC LLRW and GTCC-like waste disposal facility might adversely affect wildlife through (1) habitat reduction, alteration, or fragmentation; (2) introduction of invasive vegetation; (3) injury or mortality of wildlife; (4) erosion and runoff; (5) fugitive dust; (6) noise; and (7) exposure to contaminants. The overall impact on wildlife populations would depend on the (1) type and amount of wildlife habitat that would be disturbed, (2) spatial and temporal extent of the disturbance, (3) wildlife that occupy the project site and surrounding areas, and (4) timing of construction activities relative to crucial life stages of wildlife (e.g., breeding season).

5.3.5.2.1 Habitat Disturbance. Developed and fenced areas (during the institutional control/monitored post-closure period), could directly eliminate habitat, inhibit habitat use, or alter the dispersal and distribution patterns of wildlife. The amount of habitat that would be disturbed would be a function of the degree of disturbance already present in the project site area and the area disturbed for the disposal facility (i.e., up to 44 ha [110 ac] for boreholes, 24 ha [60 ac] for vaults, or 20 ha [50 ac] for trenches). The construction of a disposal facility would not only result in the direct reduction or alteration of wildlife habitat within the project footprint but could also affect the diversity and abundance of wildlife through the fragmentation of habitat.

Effects from habitat disturbance would be related to the type and abundance of the habitats affected and the wildlife species that occur in those habitats. For example, habitat disturbance could affect local wildlife populations, especially species whose habitats were uncommon and not well represented in the surrounding landscape. In contrast, few population-level impacts are expected for cases in which the GTCC LLRW and GTCC-like waste disposal facility would be located on currently disturbed or modified lands, such as rangelands. The wildlife species least likely to be affected would be habitat generalists. Also, many wildlife species can tolerate and adapt to a variety of habitats and can therefore be found in habitats other than those considered typical for the species (Giffen et al. 2007).

Although most fragmentation research has focused on forested areas, similar ecological impacts have been reported for the more arid and semiarid landscapes of the western United States, particularly shrub-steppe habitats that are dominated by sagebrush or salt desert scrub communities. For example, habitat fragmentation, combined with habitat loss and degradation, has been shown to be largely responsible for the decline in greater sage-grouse (*Centrocercus urophasianus*) throughout most of its range (Strittholt et al. 2000). Similar impacts could be expected for other species, such as the federally listed pygmy rabbit (*Brachylagus idahoensis*) and sagebrush lizard (*Sceloporus graciosus*).

The creation of edge habitat could (1) increase predation and parasitism of vulnerable forest interior animals in the vicinity of edges; (2) have negative consequences for wildlife by modifying their distribution and dispersal patterns; (3) be detrimental to species requiring large undisturbed areas, because increases in edges are generally associated with concomitant reductions in habitat size and possible isolation of habitat patches and corridors (habitat fragmentation); or (4) increase local wildlife diversity and abundance.

The ecological importance of the edge largely depends on how different it is from the regional landscape. For example, the influence of the edge would be less ecologically important where the landscape has a high degree of heterogeneity. Also, edge influence would be less ecologically important in a forest with a more open and diverse canopy (Harper et al. 2005). Landscapes with a patchy composition (e.g., tree-, shrub-, and grass-dominated cover) might already contain edge-adapted species that would make a created edge less likely to have any influence (Harper et al. 2005).

Although habitats adjacent to facilities might remain unaffected, wildlife tend to make less use of these areas. The combination of avoidance and stress reduces the capability of wildlife to use habitat effectively.

Long-term displacement of elk (*Cervus elaphus*), mule deer (*Odocoileus hemionus*), pronghorn (*Antilocapra americana*), or other species from critical (crucial) habitat or parturition areas as a result of habitat disturbance would be considered significant. For example, activities around parturition areas have the potential to decrease the usability of these areas for calving and fawning. A disposal facility located within a crucial winter area could directly reduce the amount of habitat available to the local population. This situation could force individuals to use suboptimal habitat, which could lead to debilitating stress and possibly to population-level effects.

While not an absolute barrier, the GTCC LLRW and GTCC-like waste disposal facility might limit travel by wildlife species between areas on either side of the facility. Habitat specificity, seasonal changes in microclimate, and population pressures could influence the extent and rate at which small mammals would cross a cleared area. The size of the disposal facility could present a barrier to the movement of some small animals (due to distance) and larger mammals (due to the fence during the institutional control/monitored post-closure period); human presence would also be a factor.

5.3.5.2.2 Introduction of Invasive Vegetation. Wildlife habitat could also be affected if invasive vegetation became established in the construction-disturbed areas and adjacent off-site habitats. The establishment of invasive vegetation could reduce habitat quality for wildlife and locally affect wildlife occurrence and abundance.

5.3.5.2.3 Wildlife Injury or Mortality. Construction activities would result in the direct injury or death of wildlife that (1) are not mobile enough to avoid construction activities (e.g., reptiles, small mammals), (2) utilize burrows (e.g., ground squirrels and burrowing owls [*Athene cunicularia*]), or (3) defend nest sites (such as ground-nesting birds). Although more mobile wildlife species, such as deer and adult birds, might avoid the initial clearing activity by moving into habitats in adjacent areas, it is conservatively assumed that adjacent habitats are at carrying capacity for the species that live there and could not support additional wildlife from the construction areas. The subsequent competition for resources in adjacent habitats would likely preclude the incorporation of the displaced individuals into the resident populations. Collision with vehicles could also be a source of wildlife mortality, especially in areas with concentrations of wildlife or in travel corridors. Wildlife might also be affected if increased access led to an increase in the legal and illegal taking of wildlife, which could affect local populations of some species.

5.3.5.2.4 Erosion and Runoff. Construction activities might result in increased erosion and runoff from freshly cleared and graded sites. This erosion and runoff could reduce water quality in nearby aquatic or wetland habitats used by amphibians and other wildlife. Potential impacts on wildlife could range from avoidance of the habitats to effects on reproduction, growth, and survival. The latter would occur primarily to amphibians that would inhabit these habitats. The potential for water quality impacts during construction would be short term for the duration of construction activities and post-construction soil stabilization (e.g., reestablishment of natural or man-made ground cover). Any impacts on amphibian populations would be localized to the surface waters or wetlands receiving site runoff. Although the potential for runoff would be temporary, pending the completion of construction activities and the stabilization of disturbed areas with vegetative cover, erosion could result in significant impacts on local amphibian populations if an entire recruitment class was eliminated (e.g., complete recruitment failure for a given year because of siltation of eggs or mortality of aquatic larvae).

5.3.5.2.5 Fugitive Dust. Little information is available regarding the effects of fugitive dust on wildlife; however, if exposure was of sufficient magnitude and duration, the effects could be similar to the respiratory effects identified for humans (e.g., breathing and respiratory symptoms). A more probable effect would be the dusting of plants, which could make forage less palatable. This effect would generally coincide with the area of displacement and stress to wildlife resulting from human activity. Fugitive dust generation during construction activities is expected to be short term and localized to the immediate construction area and is not expected to result in any long-term individual or population-level effects.

5.3.5.2.6 Noise. Principal sources of noise during construction activities would include truck traffic and the operation of heavy machinery. The most adverse impacts associated with construction noise could occur if critical life-cycle activities (e.g., mating and nesting) were disrupted. If birds were disturbed during the nesting season to the extent that they were displaced, then nest or brood abandonment might occur.

Much of the research on wildlife-related noise effects has focused on birds. This research has shown that noise may affect territory selection, territorial defense, dispersal, foraging success, fledging success, and song learning (e.g., Reijnen and Foppen 1994; Foppen and Reijnen 1994; Larkin 1996). Several studies (Foppen and Reijnen 1994; Reijnen and Foppen 1994, 1995; Reijnen et al. 1995, 1996, 1997) have shown reduced densities of some species adjacent to roads, with effects detectable from 20 to 3,530 m (66 to 11,600 ft) from the roads. On the basis of these studies, Reijnen et al. (1996) identified a threshold effect sound level of 47 dBA for all species combined and 42 dBA for the most sensitive species; the observed reductions in population density were attributed to a reduction in habitat quality caused by elevated noise levels. This threshold sound level of 42 to 47 dBA (which is somewhat below the EPA-recommended limit for residential areas) is at or below the sound levels generated by truck traffic that would likely occur at distances of 76 m (250 ft) from the construction area or access roads or the levels generated by typical construction equipment at distances of 760 m (2,500 ft) or more from the construction site.

Overall, the magnitude and duration of noise associated with trucks and construction equipment are expected to result in only minor annoyance to wildlife at the site and not result in any long-term adverse effects. The response of wildlife to this disturbance would vary by species; the individual animal’s physiological or reproductive condition; the distance from the noise source; and the type, intensity, and duration of the disturbance.

5.3.5.2.7 Exposure to Contaminants. The depth of disposal and cover materials associated with the disposal facilities is expected to prevent or minimize the exposure of wildlife to radionuclides. Wildlife might be exposed to accidental spills or releases of oil, herbicides, fuel, or other hazardous materials. Exposure to these materials could affect reproduction, growth, development, or survival of exposed individuals. Potential impacts on wildlife would vary according to the material spilled, the volume of the spill, the location of the spill, and the species being exposed. Spills could contaminate soils and surface water and could affect wildlife associated with these media. The use by wildlife of areas contaminated with hazardous constituents could result in the wildlife also becoming contaminated, and if individuals left the area, they could spread the contaminants to other locations. A spill would likely have a population-level adverse impact only if it was very large or it contaminated a crucial habitat area. The potential for either event is very unlikely. Because the amounts of fuels and hazardous materials used are expected to be small, an uncontained spill would affect only a limited area. In addition, wildlife use of the area during construction would be very minor or nonexistent, thus greatly reducing the potential for exposure. Spill response plans would be in place to address any accidental spills or releases.

5.3.5.3 Potential Impacts on Aquatic Biota

The overall impact of a project on aquatic resources would depend on the type and amount of aquatic habitat disturbed or contaminated, the nature of the disturbance or contamination, and the biota that occupied the areas aquatic habitats. Surface waters do not occur within any of the reference locations evaluated for the GTCC LLRW and GTCC-like waste disposal facility at any of the alternative DOE sites. Therefore, potential impacts on aquatic biota are limited to indirect impacts.

Characteristics of surface water runoff, such as flow direction and flow rates following rain events, are controlled, in part, by local topography and vegetation cover. As a consequence, any construction activities that affected the terrain and vegetation during construction of the GTCC LLRW and GTCC-like waste disposal facility could alter the water flow patterns. Impacts on aquatic ecosystems could result if these alterations affected the amount and timing of runoff entering a particular water body.

During construction, ground disturbance could result in increased suspended sediment loads. Turbidity and sedimentation from erosion are part of the natural cycle of physical processes in water bodies, and most populations of aquatic organisms have adapted to short-term changes in these parameters. However, if sediment loads were unusually high or lasted for extended periods of time compared with natural conditions, adverse impacts could occur (Waters 1995). Increased sediment loads could decrease the rate of photosynthesis in plants and phytoplankton; decrease fish feeding efficiency; decrease the levels of invertebrate prey; reduce fish spawning success; adversely affect the survival of incubating fish eggs, larvae, and fry; and adversely affect amphibians, their larval stage, and their eggs. In addition, some migratory fishes might avoid streams that contained excessive levels of suspended sediments (Waters 1995).

The level of effects from increased sediment loads would depend on the natural condition of the receiving waters and the timing of sediment inputs. Whereas most aquatic systems would probably be affected by large increases in the levels of suspended and deposited sediments, aquatic habitats in which waters are normally turbid might be less sensitive to small to moderate increases in suspended sediment loads than would habitats that normally have clear waters. Similarly, increased sedimentation during periods of the year in which sediment levels might naturally be elevated (e.g., during wet parts of the year) might have impacts smaller than the sediment impacts that occur during periods in which natural sediment levels are expected to be lower.

Appropriate soil and erosion control measures would be used to protect aquatic resources. During construction, the impacts from erosion and sedimentation would be minor to negligible, and once the site was stabilized and revegetated, erosion and sedimentation impacts on nearby water resources would probably not occur.

The potential exists for toxic materials (e.g., fuels and herbicides) to be introduced accidentally into waterways during construction and maintenance activities. The level of impacts from releases of toxicants would depend on the type and volume of chemicals entering the waterway, the location of the release, the nature of the water body (e.g., size, volume, and flow rates), and the types and life stages of organisms present in the waterway. Mitigation measures would be taken during the development and maintenance of the GTCC LLRW and GTCC-like waste disposal facility to restrict the use of machinery near waterways and to place restrictions on the application methods, quantities, and types of herbicides that are used in the vicinity of waterways in order to limit the potential for impacts on aquatic ecosystems. The GTCC LLRW and GTCC-like waste disposal facility stormwater retention pond is not expected to become a highly productive aquatic habitat.

5.3.5.4 Potential Impacts on Special-Status Species

Potential impacts on threatened, endangered, and other special-status species would be fundamentally similar to those on vegetation, wildlife, and aquatic biota discussed earlier in this section. However, threatened, endangered, and other special-status species are far more vulnerable to impacts because their population sizes are smaller than those of the more common and widespread species. This small population size makes them more vulnerable to the effects of habitat fragmentation, habitat alteration, habitat degradation, human disturbance and harassment, and mortality of individuals. Their vulnerability makes it very important to comply with applicable laws, regulations, and Executive Orders (Chapter 13) and to successfully implement mitigation measures.

5.3.6 Socioeconomics

The socioeconomic impacts of constructing and operating GTCC LLRW and GTCC-like waste disposal facilities were assessed for an ROI around each site, corresponding to the area in which construction and operational workers at the site would reside and spend their wages and salaries. The economic impacts of GTCC LLRW and GTCC-like waste disposal facility construction and operations were measured in terms of employment and income. Since an in-migrant labor force is expected during both construction and operations of a disposal facility, impacts of construction and operations on population, housing, public services, education expenditures, and employment were also assessed. Impacts on the local transportation network of GTCC LLRW facility employees who would commute were also assessed.

Any socioeconomic impacts that would result from the transportation of GTCC LLRW and GTCC-like waste, including impacts on property values, would be minimal. This is because it is likely that the current transportation of other hazardous materials and the risk of accidents involving these materials are already captured in housing values in the vicinity of transportation routes. An accident involving GTCC LLRW or GTCC-like waste might create additional impacts on the housing market only if residents were prevented from quickly returning to their homes.

Potential site-specific consequences relative to socioeconomics from Alternatives 3 to 5 are further discussed in Chapters 6 through 11 for the Hanford Site, the INL Site, LANL, NNSS, SRS, and WIPP Vicinity, respectively.

5.3.7 Environmental Justice

Potential consequences on environmental justice from Alternatives 3 to 5 would be site-dependent. They are discussed in Chapters 6 through 11 for the Hanford Site, the INL Site, LANL, NNSS, SRS, and WIPP Vicinity, respectively.

5.3.8 Land Use

Land use impacts focus on the net land area affected, the area's relationship to existing land uses in the project area, current growth trends and current and proposed land use designations, proximity to special use areas, and other factors pertaining to land use. The amount of land that would be cleared to construct a GTCC LLRW and GTCC-like waste disposal facility would be up to 44 ha (110 ac) for the borehole method, 24 ha (60 ac) for the vault method, and 20 ha (50 ac) for the trench method. Therefore, current land use of up to 44 ha (110 ac) (or use of up to 24 ha [60 ac] at SRS) would be altered to (or, in several cases, remain) the land use associated with a radioactive waste disposal site.

Current land use was taken into account in identifying the GTCC reference locations at each alternative site in order to minimize potential land use conflicts at the outset. Because of the small area in which land use would change as a result of the GTCC LLRW and GTCC-like waste disposal facility relative to the land use that currently exists in the area of the alternative sites, land use impacts would be considered moderate to minor. Potential consequences relative to land use from Alternatives 3 to 5 would be site-dependent and are discussed in Chapters 6 through 11 for the Hanford Site, the INL Site, LANL, NNSS, SRS, and WIPP Vicinity, respectively.

5.3.9 Transportation

Transportation impacts from the shipment of GTCC LLRW and GTCC-like waste were evaluated for each disposal site considered. The impacts from both routine and accident conditions were evaluated, as discussed in Appendix C, Section C.9. These impacts are presented in three subsections: (1) collective population risks during routine conditions and accidents,

(2) radiological risks to individuals receiving the highest impacts during routine conditions, and (3) consequences to individuals and populations after the most severe accidents involving a release of radioactive or hazardous chemical material.

Radiological impacts during routine conditions are a result of human exposure to the low levels of radiation near the shipment. The regulatory limit established in 49 CFR 173.441 (Radiation Level Limitations) and 10 CFR 71.47 (External Radiation Standards for All Packages) to protect the public is 0.1 mSv/h (10 mrem/h) at 2 m (6 ft) from the outer lateral sides of the transport vehicle. This dose rate corresponds roughly to 14 mrem/h at 1 m (3 ft). As discussed in Appendix C, Section C.9.4.4, the external dose rate for CH shipments to the land-disposal sites was set to 0.5 and 1.0 mrem/h at 1 m (3 ft) for truck and rail shipments, respectively. For shipments of RH waste, the external dose rate was set to 2.5 and 5.0 mrem/h for truck and rail shipments, respectively. These assignments were based on shipments of similar types of waste. Dose rates for rail shipments are approximately double those for truck shipments because rail shipments are assumed to have twice the number of waste packages as those on a corresponding truck shipment. Impacts from accidents are dependent on the amount of radioactive material in a shipment and on the fraction that is released if an accident occurs. The parameters used in the transportation accident analysis are described further in Appendix C, Section C.9.4.3.

5.3.9.1 Collective Population Risk

The collective population risk is a measure of the total risk posed to society as a whole by the actions being considered. For a collective population risk assessment, the persons exposed are considered as a group, without specifying individual receptors. Exposures to four different groups were considered: (1) persons living and working along the transport routes, (2) persons sharing the route, (3) persons at stops along the route, and (4) transportation crew members. The collective population risk is used as the primary means of comparing various methods, and it depends on the number and types of shipments as well as the origin and destination sites involved. These impacts are specific to the disposal site involved and are presented in conjunction with the site impacts given in Chapters 6 through 11.

5.3.9.2 Highest-Exposed Individuals during Routine Conditions

In addition to assessing the routine collective population risk, the risks to individuals for a number of hypothetical exposure scenarios were estimated as described further in Section C.9.2.2 in Appendix C. Receptors would include transportation workers, such as inspectors, and members of the public who would be exposed during traffic delays, while working at a service station, or while living or working near a facility. The distances and durations of exposure would be similar to those given in previous transportation risk assessments (DOE 1997a, 1999b, 2004a,b, 2008). The scenarios were not meant to be exhaustive but were selected to provide a range of potential exposure situations. The estimated doses and associated LCF estimates are provided in Tables 5.3.9-1 and 5.3.9-2, respectively.

TABLE 5.3.9-1 Estimated Routine Doses (rem) to the Highest-Exposed Individuals from Shipments of GTCC LLRW and GTCC-Like Waste, per Exposure Event

	Sealed Sources and Other Waste - CH		Other Waste - RH		Activated Metals - RH	
Receptor	Truck	Rail	Truck	Rail	Truck	Rail
Workers						
Inspector (truck and rail)	0.00072	0.0014	0.0044	0.0083	0.0044	0.0083
Railyard crew member	NA[a]	0.00024	NA	0.00064	NA	0.00064
Public						
Resident near route	1.6E-08	9.4E-08	4.1E-07	2.1E-07	4.1E-08	2.1E-07
Person in traffic	0.00064	NA	0.0037	NA	0.0037	NA
Person at service station	0.000014	NA	0.000037	NA	0.000037	NA
Resident near railyard	NA	3.2E-06	NA	7.2E-06	NA	7.2E-06

[a] NA = not applicable.

TABLE 5.3.9-2 Estimated Risk of Fatal Cancer (LCF) to the Highest-Exposed Individuals from Shipments of GTCC LLRW and GTCC-Like Waste, per Exposure Event

	Sealed Sources and Other Waste - CH		Other Waste - RH		Activated Metals - RH	
Receptor	Truck	Rail	Truck	Rail	Truck	Rail
Workers						
Inspector (truck and rail)	4E-07	9E-07	0.000003	0.000005	0.000003	0.000005
Railyard crew member	NA[a]	1E-07	NA	4E-07	NA	4E-07
Public						
Resident near route	1E-11	6E-11	2E-11	1E-10	2E-11	1E-10
Person in traffic	4E-07	NA	0.000002	NA	0.000002	NA
Person at service station	8E-09	NA	2E-08	NA	2E-08	NA
Resident near railyard	NA	2E-09	NA	4E-09	NA	4E-09

[a] NA = not applicable.

The highest potential routine radiological exposure to an individual, with an LCF risk of 5×10^{-6}, would be for truck and rail inspectors who could be exposed at a distance of 1 m (3 ft) from a shipment of RH waste for up to an hour. There is also the possibility for multiple exposures in some cases. For example, if an individual lived or worked near the disposal site, the person could receive a combined dose of as much as approximately 0.5 or 1.0 mrem if present for all truck or rail shipments, respectively, over the course of about 50 years. This dose is still very low, about 300 times lower than the amount an individual receives in a single year from natural background radiation (about 310 mrem/yr). (As noted in Section 5.2.4.3, the average radiation dose to an individual from natural background radiation and man-made sources of radiation is about 620 mrem/yr.)

5.3.9.3 Accident Consequence Assessment

Whereas the collective accident risk assessment considered the entire range of accident severities and their related probabilities, the accident consequence assessment assumes that an accident of the highest severity category has occurred. The consequences, in terms of committed dose (rem) and LCFs for radiological impacts, were calculated for both exposed populations and individuals in the vicinity of an accident. For perspective, impacts were assessed for shipments of each waste type (sealed sources, activated metals, Other Waste - CH, and Other Waste - RH) that would result in the highest potential impacts. Shipment inventories are provided in Appendix B.

Table 5.3.9-3 presents the radiological consequences to the population from severe accidents involving shipments of GTCC LLRW and GTCC-like waste to a near-surface disposal facility. Up to 9 LCFs were estimated for a severe urban rail accident involving sealed sources (1,470 Ci of Am-241 in six TRUPACT-II packages), while only 0.04 LCF was estimated for a similar accident involving activated metals (6.6 MCi of activity in four AMCs). A number of factors contributed to these differences, including the amount and type of activity per shipment, the shipment configuration, the number of packages assumed to be breached during the accident, and the amount released to the environment in an aerosol form.

The estimated population doses and associated LCFs were higher for the sealed sources and Other Waste - CH than for the activated metals and Other Waste - RH because they had higher amounts of alpha-emitting radionuclides, which are more of an inhalation (internal) hazard. The dominant exposure pathway for suburban and urban areas was from inhaling the aerosolized contaminant plume as it drifted downwind immediately after an accident. Exposure impacts from activated metal accidents were also lower because radionuclide activity is fixed in the outer layers of metal components and is not easily aerosolized, even under the extreme conditions assumed for the severe accidents.

Severe rail accidents could have higher consequences than truck accidents because each railcar would carry more material than would each truck. It is conservatively assumed that all truck shipments of sealed sources and CH waste would consist of three fully loaded TRUPACT-II packages and that each railcar shipment would consist of six fully loaded TRUPACT-II packages. Likewise, all truck shipments of activated metals and Other Waste - RH would consist of one Type B package capable of shielding an AMC (in the case of activated metals) or an RH72B package (in the case of the Other Waste - RH). Railcar shipments are assumed to consist of a suitable Type B rail cask, with four AMCs for activated metals or two RH72B packages for Other Waste - RH. The same shipment configurations for the TRUPACT-II and RH72B packages were used in similar studies (DOE 1997a,b, 1998).

TABLE 5.3.9-3 Potential Radiological Consequences to the Population from Severe Transportation Accidents[a]

Dose and Risk, per Type of Waste	Mode	Neutral Weather Conditions[b]			Stable Weather Conditions[b]		
		Rural	Suburban	Urban[c]	Rural	Suburban	Urban[c]
Dose (person-rem)							
Sealed sources - CH	Truck	930	2,000	4,400	1,600	3,400	7,600
	Rail	1,900	3,900	8,700	3,300	6,800	15,000
Activated metals - RH[d]	Truck	0.27	3.9	8.6	0.46	6.8	15
	Rail	1.1	16	35	1.9	27	60
Other Waste - CH	Truck	190	410	920	330	720	1,600
	Rail	380	830	1,800	650	1,400	3,200
Other Waste - RH[d]	Truck	3.0	9.6	21	6.0	120	270
	Rail	5.9	19	43	12	240	540
Risk (LCF)[e]							
Sealed sources - CH	Truck	0.6	1	3	1	2	5
	Rail	1	2	5	2	4	9
Activated metals - RH[d]	Truck	0.0002	0.002	0.005	0.0003	0.004	0.009
	Rail	0.0006	0.009	0.02	0.001	0.02	0.04
Other Waste - CH	Truck	0.1	0.2	0.6	0.2	0.4	1
	Rail	0.2	0.5	1	0.4	0.9	2
Other Waste - RH[d]	Truck	0.002	0.006	0.01	0.004	0.07	0.2
	Rail	0.004	0.01	0.03	0.007	0.1	0.3

[a] National average population densities were used for the accident consequence assessment, corresponding to densities of 6 persons/km^2, 719 persons/km^2, and 1,600 persons/km^2 for rural, suburban, and urban zones, respectively. Potential impacts were estimated for the population within a 80-km (50-mi) radius, assuming a uniform population density for each zone.

[b] Neutral weather conditions constitute the most frequently occurring atmospheric stability condition in the United States. They are represented by Pasquill stability Class D with a wind speed of 4 m/s (9 mi/h) in the air dispersion models used in this consequence assessment. Observations at National Weather Service surface meteorologic stations at more than 300 U.S. locations indicate that on a yearly average, neutral conditions (Pasquill Classes C and D) occur about half (50%) of the time, stable conditions (Classes E and F) occur about one-third (33%) of the time, and unstable conditions (Classes A and B) occur about one-sixth (17%) of the time (Doty et al. 1976). For the accident consequence assessment, doses were assessed under neutral atmospheric conditions (Class D with winds at 4 m/s [9 mi/h]) and under stable conditions (Class F with winds at 1 m/s [2.2 mi/h]). The results for neutral conditions represent the most likely consequences. The results for stable conditions represent weather in which the least amount of dilution is evident; the air has the highest concentrations of radioactive material, which leads to the highest doses.

[c] It is important to note that the urban population density generally applies to a relatively small urbanized area; very few, if any, urban areas have a population density as high as 1,600 persons/km^2 extending as far as 80 km (50 mi). The urban population density corresponds to approximately 32 million people within the 80-km (50-mi) radius, well in excess of the total populations along most of the routes considered in this assessment.

[d] As packaged for shipment to a near-surface disposal facility. If packaged for disposal at WIPP, potential impacts from a single accident would be about one-third less than those given here because the radionuclide shipment inventory would be that much smaller.

[e] LCFs were calculated by multiplying the dose by the health risk conversion factor of 6×10^{-4} fatal cancers per person-rem.

The severe accident consequence assessment assumed all packages in a shipment would become breached (DOE 1997a, 1998). However, it is unlikely that all six Type B packages, such as the TRUPACT-II packages, would become breached in one railcar accident and lead to a dose estimate of as much as 15,000 person-rem (9 LCFs) received by an urban population, as presented in Table 5.3.9-3. This dose is also spread over a footprint containing more than 1 million people, giving an average dose of less than 15 mrem per person. Such a dose is approximately 5% of the average annual dose received by an individual from natural background radiation.

Individuals in the vicinity of a severe accident could receive much higher doses, as shown in Table 5.3.9-4. A CEDE of up to 62 rem could be received by a nearby person downwind of the sealed source railcar accident. This dose would be from inhalation during passage of the aerosolized radioactive material (plume) after the accident. No deaths or symptoms of acute radiation syndrome are expected, but the increase in the lifetime risk of a fatal cancer would be 0.04. The dose received would be smaller if all of the TRUPACT-II packages were not breached, as might be expected, or if the contaminant material was released over a longer period of time (minutes), such as in a release involving a fire in which the person was not in the same location during passage of the entire plume.

Potential consequences relative to transportation from Alternatives 3 to 5 that would be site-dependent are discussed in Chapters 6 through 11 for the Hanford Site, the INL Site, LANL, NNSS, SRS, and WIPP Vicinity, respectively.

For activated metal and Other Waste - RH shipments to WIPP, estimated impacts would be about one-third of the values given in Tables 5.3.9-3 and 5.3.9-4 because the packages assumed for the WIPP shipments have about one-third of the capacity of the packages assumed for the near-surface facilities.

5.3.10 Cultural Resources

Potential impacts on cultural resources from Alternatives 3 to 5 would be site-dependent and are discussed in Chapters 6 through 11 for the Hanford Site, the INL Site, LANL, NNSS, SRS, and WIPP Vicinity, respectively.

5.3.11 Waste Management

Construction of the land disposal facilities would generate wastes typical of large construction projects. These wastes would include small quantities of hazardous solids, nonhazardous solids (e.g., concrete and steel spoilage, excavated materials), hazardous liquids (e.g., used motor oil and lubricants), and nonhazardous liquids (e.g., sanitary waste). Waste generated from operations would include small quantities of solid LLRW (e.g., spent HEPA filters) and nonhazardous solid waste (including recyclable wastes). Some liquid LLRW would also be generated from truck washdown water. Operations would also generate a small quantity of nonhazardous (sanitary) liquids.

TABLE 5.3.9-4 Potential Radiological Consequences to the Highest-Exposed Individual from Severe Transportation Accidents[a]

Type of Waste, per Mode	Neutral Weather Conditions[b]		Stable Weather Conditions[b]	
	Dose (rem)	Risk (LCF)[c]	Dose (rem)	Risk (LCF)[c]
Sealed sources - CH				
Truck	10	0.006	32	0.02
Rail	20	0.01	62	0.04
Activated metals - RH[d]				
Truck	0.00049	0.0000003	0.0016	0.0000009
Rail	0.0021	0.000001	0.0065	0.000004
Other Waste - CH				
Truck	2.1	0.001	6.6	0.004
Rail	4.1	0.002	13	0.008
Other Waste - RH[d]				
Truck	0.046	0.00003	0.14	0.00009
Rail	0.090	0.00005	0.29	0.0002

[a] The individuals receiving the highest doses and LCF risks were assumed to be at a downwind location that would maximize the short-term dose. These individuals were assumed to be about 140 to 150 m (460 to 490 ft) downwind for neutral weather conditions and 340 to 365 m (1,100 to 1,200 ft) downwind for stable weather conditions.

[b] Neutral meteorologic conditions constitute the most frequently occurring atmospheric stability condition in the United States. They are represented by Pasquill stability Class D with a wind speed of 4 m/s (9 mi/h) in the air dispersion models used in this consequence assessment. Observations at National Weather Service surface meteorologic stations at more than 300 U.S. locations indicate that on a yearly average, neutral conditions (Pasquill Classes C and D) occur about half (50%) of the time, stable conditions (Classes E and F) occur about one-third (33%) of the time, and unstable conditions (Classes A and B) occur about one-sixth (17%) of the time (Doty et al. 1976). For the accident consequence assessment, doses were assessed under neutral atmospheric conditions (Class D with winds at 4 m/s [9 mi/h]) and under stable conditions (Class F with winds at 1 m/s [2.2 mi/h]). The results for neutral conditions represent the most likely consequences. The results for stable conditions represent weather in which the least amount of dilution is evident; the air has the highest concentrations of radioactive material, which leads to the highest doses.

[c] When applied to individuals, the LCF risk is the increased lifetime probability of developing an LCF. LCFs were calculated by multiplying the dose by the health risk conversion factor of 6×10^{-4} fatal cancers per person-rem.

[d] As packaged for shipment to a near-surface disposal facility. If packaged for disposal at WIPP, potential impacts from a single accident would be about one-third less than those given here because the radionuclide shipment inventory would be that much smaller.

Table 5.3.11-1 presents the types and volumes of waste that would be generated from the construction and disposal operations associated with the land disposal methods evaluated for Alternatives 3 to 5. These waste types are similar to those currently handled at the various sites evaluated, except for the WIPP Vicinity reference location on BLM-administered land adjacent to the WIPP property boundary, where there are currently no ongoing operations. However, waste management resources available from the nearby WIPP repository could be used to manage any waste that might be generated by a land disposal facility at WIPP Vicinity.

Table 5.3.11-2 summarizes waste handling programs and capacities (when information was available) at the various sites evaluated for similar waste types. On the basis of the information provided in Table 5.3.11-2, the waste types and volumes that could be generated from the three land disposal methods would either be disposed of on-site or sent off-site for disposal. No impacts on waste management programs at the various sites are expected under Alternatives 3 to 5.

5.3.12 Cumulative Impacts

Consistent with 40 CFR 1508.7, in this EIS, a cumulative impact is "the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (federal or nonfederal) or

Cumulative Impacts

Cumulative impacts are the total impacts on a given resource resulting from the incremental environmental effects of an action or actions added to other past, present, and reasonably foreseeable future actions.

TABLE 5.3.11-1 Annual Waste Generated from the Construction and Operations of the Three Land Disposal Methods[a]

	Trench		Borehole		Vault	
Waste Type	Construction[b]	Operations[b]	Construction[b]	Operations[b]	Construction[b]	Operations[b]
Nonradioactive waste						
Hazardous solids (yd^3)	57	–[c]	18	–	168	–
Nonhazardous solids (yd^3)[d]	62,000	120	300,000	95	5,200	120
Hazardous liquids (gal)	23,000	–	7,300	–	68,000	–
Nonhazardous liquids (gal)	4,800,000	310,000	1,500,000	240,000	14,000,000	320,000
Radioactive waste						
Solid LLRW (yd^3)	–	16	–	10	–	16
Liquid LLRW (gal)	–	790,000	–	170,000	–	780,000

[a] Values given to two significant figures.

[b] The initial construction period is assumed to be 3.4 years; the operational period is assumed to be a 20-year period when most of the GTCC LLRW and GTCC-like waste are expected to be received for disposal.

[c] A dash indicates waste type is not generated.

[d] The volume reported for construction includes industrial waste and excavated soil material that could be used for the cover system; therefore, the inclusion here as waste would conservatively bound potential waste management impacts.

1 **TABLE 5.3.11-2 Waste Management Programs at the Various Sites Evaluated for the Land Disposal Methods**

Site	Nonhazardous Liquids	Nonhazardous Solids	Hazardous Liquids	Hazardous Solids	Solid LLRW	Liquid LLRW
Hanford Site[a]	Nonhazardous liquids are discharged to on-site treatment facilities, such as septic tanks, subsurface soil absorption systems, and wastewater treatment plants.	Nonhazardous solid wastes are sent to municipal or commercial solid waste facilities.	Hazardous liquids would be sent off-site for treatment, recycling, recovery, and disposal at RCRA-permitted commercial facilities.	Same as hazardous liquids.	Solid LLRW that meets disposal requirements is disposed of on-site at the mixed waste trenches or the Environmental Restoration Disposal Facility.	Liquid LLRW would be sent to the 200 Area Effluent Treatment Facility/Liquid Effluent Disposal Facility for treatment.
INL Site[b]	Sanitary wastes are treated and then discharged to impoundments, evaporation lagoons, or shallow subsurface drainage fields. Remaining sludge is placed in the on-site landfill.	When possible, nonhazardous wastes are recycled in accordance with waste minimization protocols. Those that cannot be recycled are disposed of in an on-site landfill complex (Central Facilities Area) or off-site.	Hazardous liquids are stored and then sent to off-site commercial disposal facilities.	Same as hazardous liquids.	Solid LLRW is treated and disposed of on-site and off-site. Storage capacity is 310 m^3 (403 yd^3).	Liquid LLRW is discharged to evaporation ponds in the Reactor Technology Complex (RTC). Liquid LLRW is solidified before disposal.
LANL[c]	Nonhazardous liquids are treated at the TA-46 Wastewater Treatment Plant and discharged to a permitted outfall.	Nonhazardous solids are processed at the TA-54 Material Recycling Facility. They are disposed of at the Los Alamos County Landfill, Rio Rancho Landfill, and/or recycling and scrap facilities.	Hazardous liquids produced by construction are handled at consolidated remote waste storage sites (CRWSSs) for off-site treatment and disposal.	Hazardous solids are treated at the CRWSSs and disposed of off-site.	Solid LLRW is treated at the TA-54 Solid Waste Operations Area G. The primary waste pathway is on-site treatment and disposal. Additional off-site disposal pathways are used as necessary.	Liquid LLRW is treated at theTA-50-1 Radioactive Liquid Waste Treatment Facility (RLWTF). The RLWTF generates effluent, which goes to a National Pollutant Discharge Elimination System (NPDES) outfall, and radioactive solid waste types, which are disposed of on-site.

2

TABLE 5.3.11-2 (Cont.)

Site	Nonhazardous Liquids	Nonhazardous Solids	Hazardous Liquids	Hazardous Solids	Solid LLRW	Liquid LLRW
NNSS[d]	Nonhazardous liquids are treated by using sewage lagoons or septic systems.	When possible, nonhazardous wastes are recycled in accordance with waste minimization protocols. Those that cannot be recycled are sent to appropriate permitted landfills.	Hazardous liquids are sent off-site to permitted treatment, storage, and disposal facilities.	Hazardous solids are shipped to commercial treatment and disposal facilities.	Solid LLRW is disposed of at the Area 5 Radioactive Waste Management Complex.	Liquid LLRW must be solidified to meet the NNSS waste acceptance criteria (and, if necessary, treated to meet RCRA Land Disposal Restrictions) before shipment to the NNSS.
SRS[e]	Sanitary and other nonhazardous liquids are treated at the Central Sanitary Wastewater Treatment Facility (CSWTF).	Nonsanitary nonhazardous solids are sent off-site for recycling or disposal. Sanitary nonhazardous solids are sent to the Three Rivers Landfill.	Hazardous liquids are sent off-site to permitted disposal facilities.	Hazardous solids are collected in containers and shipped off-site for treatment and disposal.	Solid LLRW is treated and disposed of on or off-site.	Same as solid LLRW.
WIPP Vicinity[f]	Nonhazardous liquids could be disposed of at on-site sanitary lagoons, as is done at the WIPP repository.	When possible, nonhazardous solids could be recycled in accordance with waste minimization protocols. Those that could not be recycled could be sent to appropriate disposal sites.	Hazardous liquids could be characterized, packaged, labeled, and manifested to off-site treatment, storage, and disposal facilities.	Nonmixed hazardous solids could be characterized, placed in containers, and stored until they could be transported off-site for treatment and/or disposal at a permitted facility.	Solid LLRW could be treated and disposed of off-site.	Same as solid LLRW.

[a] Source: DOE (2012).

[b] Source: DOE (2005a).

[c] Source: LANL (2010).

[d] Source: NNSA (2008).

[e] Sources: SRS (2005, 2010).

[f] Assumed waste operations would be similar to those conducted for WIPP.

persons undertakes such actions." A cumulative impact assessment accounts for both geographic (spatial) and time (temporal) considerations of past, present, and reasonably foreseeable actions. Geographic boundaries can vary by discipline, depending on the amount of time that the effects remain in the environment, the extent to which such effects can migrate, and the magnitude of the potential impact. The cumulative impacts are discussed in Chapters 6 through 11 for the Hanford Site, the INL Site, LANL, NNSS, SRS, and WIPP Vicinity, respectively.

The cumulative impacts section evaluates the impacts of constructing and operating a GTCC LLRW and GTCC-like waste disposal facility (proposed action) in combination with the impacts of past, present, and reasonably foreseeable future actions taking place within and around each of the candidate sites. For most resources, the impacts of past and present actions are generally accounted for in the affected environment section. For example, the current air quality reflects both past and present activities occurring in the region. Off-site activities might also contribute to cumulative impacts; these include clearing land for agriculture and urban development, grazing, water diversion and irrigation projects, power generation projects, waste management activities, industrial emissions, and the development of transportation and utility networks.

Reasonably foreseeable future actions at each of the candidate sites include those that are ongoing, under construction, or planned for future implementation. These are also described and, together with the proposed action, considered for each evaluation.

5.4 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENT OF RESOURCES

The resources that would be irreversibly or irretrievably committed during the disposal of GTCC LLRW and GTCC-like waste by using the land disposal methods evaluated under Alternatives 3 to 5 would include the land encompassed by the facility footprint, water, energy, raw materials, and other natural and man-made resources for construction of the disposal facility. The amount of resources consumed by the vault method would be the largest of those consumed by the three methods. Table 5.4-1 presents estimates of resources consumed for the construction of the three land disposal methods.

The operations of the land disposal methods would use up to 5.3 million L/yr (1.4 million gal/yr) of water resources. The water used would not be returned to its original source; however, the amount used would be small when compared with the annual production rates of the water source for the sites evaluated. Energy expended would be in the form of fuel for equipment and vehicles and electricity for facility operations. Each of the land disposal methods would consume up to approximately 800,000 L (210,000 gal) of diesel fuel annually to operate vehicles and emergency diesel generators during operations. The electrical energy requirement would be up to 1,160 MWh, which represents a small increase in electrical energy demand for the site areas. Table 5.4-2 presents estimates for annual utility consumption during disposal operations.

The resources that would be irreversibly or irretrievably committed during construction and operations of the land GTCC LLRW and GTCC-like waste disposal methods would include

TABLE 5.4-1 Estimates of the Materials and Resources Consumed during Construction of the Three Conceptual Land Disposal Facilities

Construction Materials and Resources	Total Consumption		
	Trench	Borehole	Vault
Utilities			
Water (gal)[a]	5,300,000	2,800,000	17,100,000
Electricity (MWh)[b,c]	34,000	10,800	101,000
Solids[b]			
Concrete (yd^3)	25,600	18,600	88,200
Steel (tons)	2,000	1,400	7,960
Gravel (yd^3)	32,900	25,000	156,000
Sand (yd^3)	3,600	28,000	198,000
Clay (yd^3)	NA[d]	NA	56,000
Soil (off-site) (yd^3)	NA	NA	254,000
Liquids			
Fuel (gal)[b]	580,000	3,030,000	3,400,000
Oil and grease (gal)	15,000	46,000	86,000
Gases			
Industrial gases (propane) (gal)[b]	5,400	4,300	13,600

[a] Water requirement is estimated on the basis of the assumptions that each FTE would require 20 gal/d and that cementation would require 25.1 lb of water per 100 lb of cement (see Appendix D).

[b] Methodology is described in Appendix D.

[c] Peak demand of 1.70, 0.51, or 4.57 MWh for the trench, borehole, and vault disposal facilities, respectively.

[d] NA = not applicable.

materials that could not be recovered or recycled and materials that would be consumed or reduced to unrecoverable forms. For example, it is estimated that up to 810,000 kg (800 tons) of steel and 68,000 m^3 (88,200 yd^3) of concrete would be committed to the construction of the vault facility (see Table 5.4-1). In addition, about 195,000 m^3 (254,000 yd^3) of off-site soil would be needed for construction of the vault method. During operations, the proposed action would generate a small amount of nonrecyclable waste types, such as hazardous wastes that would be subject to RCRA regulations. Generation of these waste types would represent an irreversible and irretrievable commitment of material resources.

TABLE 5.4-2 Annual Utility Consumption during Disposal Operations

	Annual Consumption[a]		
Utility	Trench	Borehole	Vault
Potable water (U.S. gal/d)	310,000	240,000	310,000
Raw water (U.S. gal/d)[b, c]	1,100,000	420,000	1,110,000
Sanitary sewer (U.S. gal/d)	310,000	240,000	320,000
Natural gas (10^6 ft^3)	11,200	11,200	11,200
Diesel fuel (U.S. gal/d)	210,000	80,000	210,000
Electricity (MWh)	1,160	970	1,150

[a] Based on 240 operation-days per year.

[b] Includes potable water and water used in truck washdown.

[c] Estimate is based on the assumption that, on average, 2,290 L (605 gal) are used to wash down the truck transporting the GTCC LLRW and GTCC-like waste (see Appendix D).

5.5 INADVERTENT HUMAN INTRUDER SCENARIO

The inadvertent human intruder scenario is not evaluated quantitatively for Alternatives 3 to 5 because the NRC had already incorporated the inadvertent human intruder protection concept in its classification system of LLRW as Class A, B, C, or GTCC. The NRC had already determined that for waste classified as GTCC, conventional near-surface land disposal is generally not protective of an inadvertent human intruder.

In promulgating 10 CFR Part 61, the NRC evaluated various scenarios by which an inadvertent human intruder might disrupt a waste trench (NRC 1981, 1982). This evaluation supported the development of the waste classification system in 10 CFR Part 61, which specifies radionuclide concentration limits for wastes that are appropriate for disposal near the surface. However, when 10 CFR Part 61 was promulgated, the NRC thought that the primary technology for disposing of LLRW would continue to be disposal in near-surface trenches, without engineered barriers.

The classification was also based on the concept that the number of inadvertent intrusion activities decreases with depth. Moreover, it is generally considered that for waste buried deeper than the normal residential intrusion zone (the normal zone being about 3 m [9 ft], which is generally required for residential dwellings with basements), the only potential for intrusion would occur during a drilling event, such as for the installation of a well. As the depth of a disposal facility gets deeper, it is generally considered that the likelihood of inadvertent intrusion also tends to decrease.

Although there is no consensus on the role of depth in protecting an inadvertent human intruder at intermediate depths, the International Atomic Energy Agency, in discussing intermediate-depth borehole designs, suggested that for boreholes at depths of 30 m (100 ft) or higher, the effects of intrusion should be managed by using institutional controls, but for boreholes below that depth, the effects do not need to be managed (IAEA 2003).

For the land disposal methods evaluated under Alternatives 3 to 5 in this EIS, it is expected that the protection of an inadvertent human intruder could be accomplished by incorporating one or more of the following waste disposal management activities or facility design features: institutional controls, disposal depth, control of waste concentrations, stabilization of the waste form, and intruder barriers. The designs considered for this EIS are suggested starting points for enhanced disposal facilities; if necessary, they could be fortified further, depending on-site-specific considerations and the actual waste characteristics once a final site(s) and disposal method(s) were selected.

The borehole conceptual design evaluated for Alternative 3 incorporates disposal depth and an intruder barrier (i.e., waste buried at a minimum depth of 30 m [100 ft] with a concrete barrier/cover to prevent or minimize the potential for a drilling intrusion). The trench and vault methods evaluated under Alternatives 4 and 5, respectively, also incorporate engineered barriers (i.e., a cover that is a minimum of 5-m [16-ft] thick with a concrete barrier for each) to prevent or minimize the probability of an inadvertent intrusion. Waste packaging activities would take into account the overall radionuclide concentrations or activity in the packages that would be emplaced. The activated metal waste from commercial reactors, which contains the majority of the radionuclide activity considered in this EIS, is already in a form that is resistive to drilling.

In summary, potential impacts could be minimized by mitigating either the probability of intrusion or its consequences if the intrusion occurred. Each combination of site and design addresses these two elements in different ways. Siting the disposal facility at a federal site could lower the likelihood of intrusion because it would increase the likelihood of retaining control. The remote locations of some of the federal sites evaluated in this EIS also help reduce the probability of intrusion into a waste disposal facility located at those sites. Design features could play a role in decreasing the consequences if an intrusion did occur. For instance, deep disposal might lead to a consideration of drilling intrusion only, whereas possibly for designs in which disposal is nearer the surface, more drastic types of intrusion would be considered. The form of the waste could also alter the consequences; for instance, activated metals cannot be broken up as easily as other waste forms. Considerations for institutional controls for Alternatives 3 to 5 are discussed in Section 5.6 below.

5.6 INSTITUTIONAL CONTROLS

As part of the long-term strategy for protecting human health and the environment, institutional controls would be incorporated in any facility used to dispose of GTCC LLRW and GTCC-like waste. Institutional controls refer to a set of measures, both active and passive in nature, to maintain the integrity and the protectiveness of a disposal facility. During the institutional control period (particularly during the period of active institutional controls), the potential for inadvertent human intruder would be minimized or eliminated. Institutional controls would also eliminate the potential for members of the public to be exposed to contaminants (e.g., by restricting the use of groundwater via deed restrictions).

Active institutional controls come in many forms (e.g., providing security guards to ensure that intrusion into a disposal facility does not occur, conducting routine inspections and monitoring, maintaining fences and other security infrastructures, and maintaining the integrity of the disposal facility itself). Passive institutional controls include fences, signs, and other markers that inform the public of the presence of a disposal facility long after active institutional controls have been completed. The passive institutional controls are expected to provide protection to the public in addition to the protection provided by engineering features that could be incorporated into the facility design, such as barriers and drill deflectors.

For the GTCC LLRW and GTCC-like waste disposal facility or facilities, it is expected that both active and passive institutional controls would be implemented and relied on to allow the facility to perform adequately with respect to protection from inadvertent human intruders. Because the GTCC reference locations are on federally owned land where disposal facilities currently exist, it is expected that passive institutional controls (including maintaining federal ownership of the facility and lands) would be continued after the active institutional control period. It is DOE's policy (DOE P 454.1) to use institutional controls as essential components of a defense-in-depth strategy that uses multiple, relatively independent layers of safety to protect human health and the environment (including natural and cultural resources). DOE would maintain the institutional controls as long as necessary to perform their intended protective purposes.

The active institutional control period for a GTCC LLRW and GTCC-like waste disposal facility would be determined as part of subsequent documentation (e.g., ROD) following this EIS. However, the long-lived nature of some of the radionuclides in the GTCC LLRW and GTCC-like waste should be taken into account in establishing the period of active institutional controls. The radionuclides in the GTCC LLRW and GTCC-like wastes are generally a combination of short-lived and very-long-lived radionuclides. A number of neutron activation products and fission products generally have short half lives (30 years or less), while the actinides and certain fission products, such as Tc-99 and I-129, have very long half-lives (more than 10,000 years). Hence, the total radioactivity and hazard of the wastes as a result of radioactive decay would not be significantly reduced after the first few hundred years. The short-lived radionuclides that would decay to inconsequential levels would have done so by then, and it would take several millennia for many of the long-lived radionuclides to decay to low levels. As a result, little would be gained by extending the length of the active institutional control period to much more than 100 years after closure.

5.7 REFERENCES FOR CHAPTER 5

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6 HANFORD SITE: AFFECTED ENVIRONMENT AND CONSEQUENCES OF ALTERNATIVES 3, 4, AND 5

This chapter provides an evaluation of the affected environment, environmental and human health consequences, and cumulative impacts from the disposal of GTCC LLRW and GTCC-like waste under Alternative 3 (in a new borehole disposal facility), Alternative 4 (in a new trench disposal facility), and Alternative 5 (in a new vault disposal facility) at the Hanford Site. Alternatives 3, 4, and 5 are described in Section 5.1. Environmental consequences that are common to the sites for which Alternatives 3, 4, and 5 are evaluated (including the Hanford Site) are discussed in Chapter 5 and not repeated in this chapter. Impact assessment methodologies used for this EIS are described in Appendix C. Federal and state statutes and regulations and DOE Orders relevant to the Hanford Site are discussed in Chapter 13 of this EIS.

This chapter also includes American Indian text (presented in text boxes in Sections 6.1 and 6.4) that reflects the views and perspectives of the Nez Perce, the Confederated Tribes of the Umatilla Indian Reservation, and the Wanapum People. Full narrative texts are provided in Appendix G. The perspectives and views presented are solely those of the tribes. When tribal neutral language is used (e.g., Indian People, Native People, Tribes) within the tribal text, it reflects the input from these tribes, unless otherwise noted. DOE recognizes that American Indians have concerns about protecting the traditions and spiritual integrity of the land in the Hanford Site region, and that these concerns extend to the propriety of the Proposed Action. Presenting tribal views and perspectives in this EIS does not represent DOE's agreement with or endorsement of such views. Rather, DOE respects the unique and special relationship between American Indian tribal governments and the Government of the United States, as established by treaty, statute, legal precedent, and the U.S. Constitution. For this reason, DOE has presented tribal views and perspectives in this EIS to ensure full and fair consideration of tribal rights and concerns before making decisions or implementing programs that could affect tribes.

6.1 AFFECTED ENVIRONMENT

This section discusses the affected environment for the various environmental resource areas evaluated for the GTCC reference location at Hanford. The GTCC reference location is south of the 200 East Area in the central portion of the Hanford Site (see Figure 6.1-1). The reference location was selected primarily for evaluation purposes for this EIS. The actual location would be identified on the basis of follow-on evaluations if and when it is decided to locate a land disposal facility at Hanford.

6.1.1 Climate, Air Quality, and Noise

6.1.1.1 Climate

The Hanford Site lies within the semiarid shrub-steppe Pasco Basin of the Columbia Plateau in south-central Washington state (Burk 2007), which is the lowest section in eastern

FIGURE 6.1-1 GTCC Reference Location at the Hanford Site

Washington. The region's climate is greatly influenced by the Pacific Ocean and the Cascade Mountain Range to the west and other mountain ranges to the north and east. The Pacific Ocean moderates temperatures throughout the Pacific Northwest, and the Cascade Range generates a rain shadow that limits rain and snowfall in the eastern half of Washington State. The Cascade Range also serves as a source of cold air drainage, which has a considerable effect on the wind regime at the Hanford Site. Mountain ranges to the north and east of the region shield the area from the severe winter storms and frigid air masses that move southward across Canada.

Climatological data for the Hanford Site are compiled at the Hanford Meteorology Station, which is located on the Hanford Site's Central Plateau, just outside the northeast corner of the 200 West Area and about 6 km (4 mi) northwest of the 200 East Area (Burk 2007). Because of the size and topographic features at Hanford, wind, precipitation, temperature, and other meteorological characteristics vary substantially.

The prevailing surface winds on Hanford's Central Plateau are from the northwest (Figure 6.1.1-1) and occur most often during winter and summer (Burk 2007). Winds from the southwest also occur frequently on the Central Plateau. During the spring and fall, there is an increase in the frequency of winds from the southwest and a corresponding decrease in winds from the northwest. In the southeastern portion of the Hanford Site, the prevailing wind direction near the surface is from the southwest during most months; winds from the northwest are much less common. Along the Columbia River, local winds are strongly influenced by the topography near the river. Stations that are relatively close together can exhibit significant differences in wind patterns. For example, Station 4 and Station 7 are only about 5 km (3 mi) apart, but the wind patterns at the two stations are very different (Figure 6.1.1-1).

At the Hanford Meteorology Station (HMS), about 6 km (4 mi) from the GTCC reference location, the prevailing wind direction is northwest; secondarily, it came from the west-northwest during the period from 1945 through 2004. The peak gusts are from the south-southwest, southwest, and west-southwest (Hoitink et al. 2005). The annual average wind speed at the 15-m (50-ft) level is about 3.4 m/s (7.6 mph). The fastest monthly average wind speeds, 4.1 m/s (9.1 mph), occur in June; the slowest, 2.7 m/s (6.0 mph), occur in December. The fastest wind speeds at the HMS are usually associated with flow from the southwest. However, the summertime drainage winds from the northwest frequently exceed 13 m/s (30 mph). The maximum speed of the drainage winds and their frequency of occurrence tend to decrease as one moves toward the southeast across the Hanford Site.

For the 1945–2004 period, the annual average temperature at the Hanford Site was 11.9°C (53.5°F) (Hoitink et al. 2005). January was the coldest month, averaging –0.5°C (31.1°F), and July was the warmest, averaging 24.8°C (76.6°F). During the last 60 years, the highest temperature was 45.0°C (113°F) and the lowest was –30.6°C (–23°F). The number of days with a maximum temperature of ≥32.2°C (90°F) was about 53, while the number of days with a minimum temperature of ≤0°C (32°F) was about 106.

The area around the Hanford Site is the driest section in eastern Washington. Annual precipitation at the Hanford Site averages about 17 cm (7 in.) (Hoitink et al. 2005). Precipitation is highest in the winter and the lowest in the summer, with spring and autumn being in between.

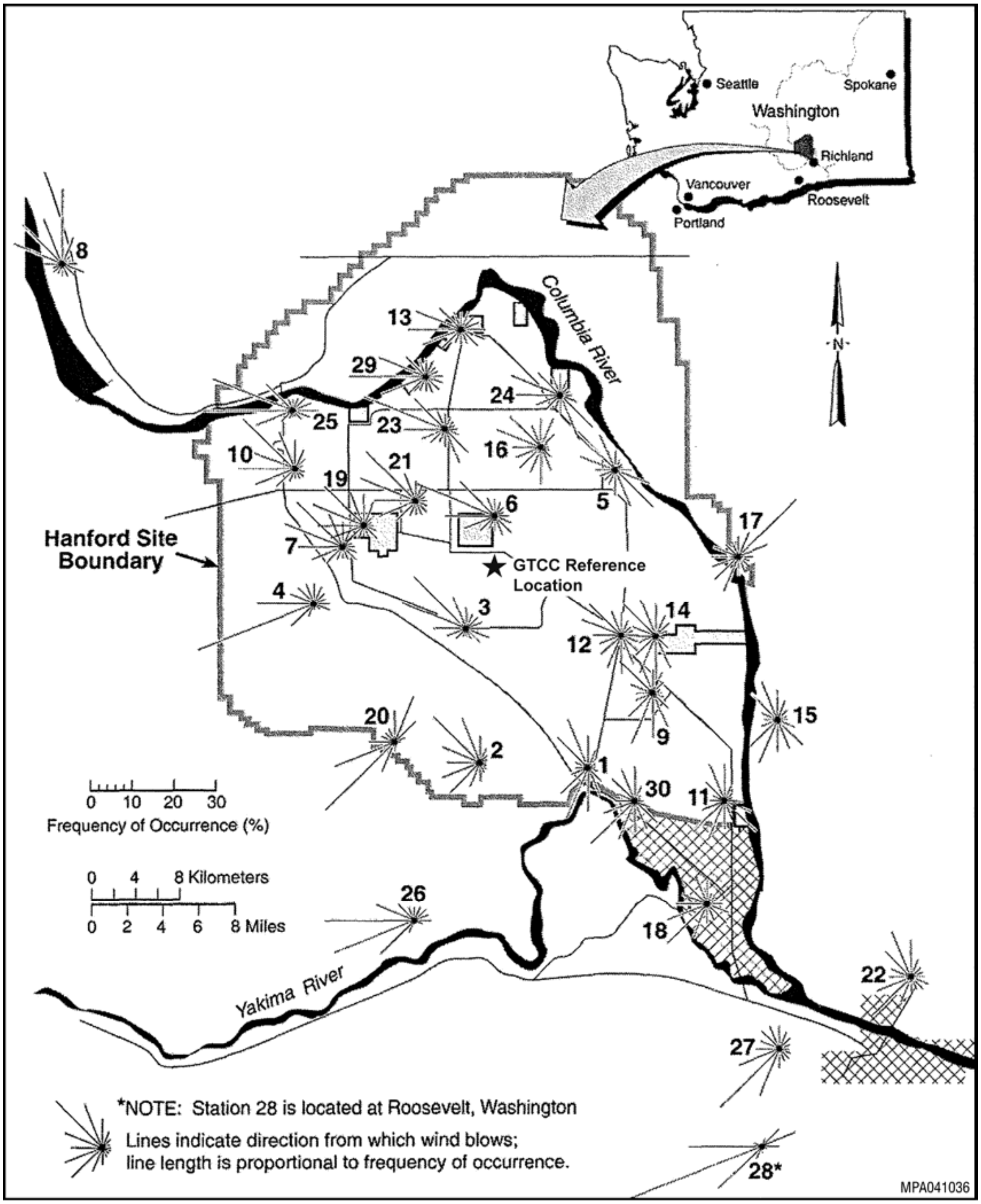

FIGURE 6.1.1-1 Wind Roses at the 9.1-m (30-ft) Level of the Hanford Meteorological Monitoring Network, Washington, 1982–2006 (Source: Burk 2007)

Measurable precipitation of 0.025 cm (0.01 in.) or more occurs an average of 68 days per year. Summer precipitation is usually associated with thunderstorms (Ruffner 1985). During July and August, it is not unusual for 4 to 6 weeks to pass without measurable rainfall. Measurable snow is a rarity, and, if it does occur, it remains on the ground for only a short time. Snow typically occurs from October through April. The annual average snowfall in the area is about 37.3 cm (14.7 in.), which peaks in December and January (Hoitink et al. 2005). The Central Basin is subject to Chinook winds that produce a rapid rise in temperature, and the snow partly melts and evaporates in the dry wind.

Severe weather usually includes thunderstorms, dust storms, glaze, and tornadoes. Thunderstorms occur in every month of the year except January and November (Hoitink et al. 2005). The thunderstorm season is essentially from April through September. For the period 1945 through 2004, there was an average of 10 thunderstorm days per year. The criterion for both dust and blowing dust is that horizontal visibility is reduced to 10 km (6 mi) or less. Dust is carried into the area from a distant source and may occur without strong winds. Blowing dust occurs when dust is picked up locally and occurs with stronger winds. There was an average number of five days per year with dust or blowing dust. Glaze is a coating of ice that forms when rain or drizzle freezes on contact with any surface having a temperature that is below freezing. There was an average number of six days per year with freezing rain or freezing drizzle. Washington does not experience hurricanes because of the cold waters off the Pacific Ocean.

Tornadoes in the northwestern portion of the United States, including the Hanford Site, are much less frequent and destructive than those in tornado alley in the central United States. For the period 1950–2006, 28 tornadoes were reported for 10 counties closest to the Hanford Site (Poston et al. 2007). For the same period, 11 tornadoes (an average of 0.2 tornado per year) were reported in the four counties that encompass the Hanford Site: Adams, Benton, Franklin, and Grant. However, most of these tornadoes were relatively weak; 10 were ranked less than or equal to F1 and one was F2 on the Fujita scale. No deaths or substantial property damage (in excess of $50,000) were associated with these tornadoes.

Fujita Scale of Tornado Intensities

• F0	Gale	40–72 mph	18–32 m/s
• F1	Moderate	73–112 mph	33–50 m/s
• F2	Significant	113–157 mph	51–70 m/s
• F3	Severe	158–206 mph	71–92 m/s
• F4	Devastating	207–260 mph	93–116 m/s
• F5	Incredible	261–318 mph	117–142 m/s

6.1.1.2 Existing Air Emissions

The Hanford Site is included in the CAA Title V air operating permit program because it is a “major source” as defined in the CAA and in *Washington Administrative Code* (WAC) 173-401-200(19). The Hanford Site operates under State License FF-01 for air emissions (Poston et al. 2007). Conditions specified in the license are incorporated into the Hanford Site Air Operating Permit, which was reissued by the Washington State Department of Ecology on December 29, 2006. The permit is intended to provide a compilation of applicable CAA requirements for both radioactive and nonradioactive (i.e., toxic and criteria pollutants)

American Indian Text

People have inhabited the Columbia Basin throughout the entire Younger Dryas era (from 10,000 years ago to the present). Several even earlier archaeological sites are known. Mammoth and bison harvest sites are found throughout the Columbia Plateau. As the temperatures rose throughout this period, the Pleistocene lakes began to shrink and wither away into alkali basins. The post-glacial grasslands of the Great Basin and Columbia Basin were replaced by desert grasses, juniper, and sage, and megafauna likewise decreased through ecological and hunting pressure. The glaciers in the Cascades, Wallowa and Steens mountains rapidly disappeared.

After about 5400 B.P. increasing precipitation and rising water tables were apparent again on both sides of the Cascades. Pollen history indicates continual short, sharp climatic shifts that, directly (e.g., soil moisture) or indirectly (e.g., fire and disease), produced rapid changes in the Northwest's vegetation. The plants and animals were now modern in form. Hunters switched to deer, elk, antelope and small game such as rabbits and birds. Fishing also became important along the coastal streams and in the Columbia River system, with an increasing emphasis on the annual runs of the salmon even though salmon runs date considerably farther back.

The human ethnohistory in the Columbia Basin is divided into cultural periods that parallel the climatic periods and represent cultural adaptations to changing environmental conditions. Throughout this entire period the oral history continually added information needed for survival and resiliency as the climate fluctuated. The oral history of local native people is consistent with contemporary scientific and historic knowledge of the region and validates the extreme climate changes that have occurred in the region over thousands of years. Cameron examined archaeological, ethnographic, paleoenvironmental, and oral historical studies from the Interior Plateau of British Columbia, Canada, from the Late Holocene period, and found correlations among all four sources of information.

Climate is one of the dominate issues of our time. Indian People have experience with volcanic periods when it seemed our world was on fire and times when our world was much colder. Distinct climatic periods have occurred during which Tribal life adapted to environmental changes and our oral history reflects these climate changes and adaptations. Scientific and historic knowledge validates tribal oral history for many thousands of years.

Columbia Plateau Tribes have stories about the world being transformed from a time considered prehistoric to what is known today. The Indian People remember volcanoes, great floods, and animals now extinct. Mammoth and bison harvest sites are found throughout the Columbia Plateau. They have memories of their world being destroyed by fire and water and believe it will happen again. Indian People on the Columbia Plateau have stories about the world being destroyed by fire and water. Some of these were directly experienced, for example, the Mazama eruption 6,800 years ago, and the last of the Missoula floods 13,000 years ago.

The Tribes know and remember about the weather and its changes because it was so important to forming their lives. Oral histories indicate that the climate was much wetter and supported vast forests in the region. Oral histories also recall a time when Gable

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Mountain or Nookshia, a major landscape feature on the Hanford Reservation, rose out of the Missoula floods. There is a story about Indian People who fought severe winds that were common a long time ago. One story tells of how a family trained their son by having him fight with the ice in the river until he became strong enough to fight the wind. He then beat the very strong winds of the past and now we do not have such winds.

Holocene is the term used to describe the climate since the last glaciers (11,700 years ago), covering much of the northwestern North America. This archaeological record confirms the prehistory that includes arctic foxes found with Marmes Rock Shelter. The Palynological data would be a good source for recreating climates that supported ecosystems of the past 10,000 years.

Climate change that will occur over the next 10,000 years will inevitably draw on knowledge from the past, whether the climate becomes wetter or drier. Evaluation of future climate scenarios will need to include as much variation as occurred in the last 10,000 years.

emissions at the Hanford Site and is implemented through federal and state programs. The Benton Clear Air Authority regulates open-air burning and oversees the site's compliance with asbestos regulations.

Annual emissions for major facility sources and total point and area sources of criteria pollutants and VOCs in Adams, Benton, Franklin, and Grant Counties for the year 2002 are presented in Table 6.1.1-1 (EPA 2009). Data for 2002 are the most recent emission inventory data available on the EPA website. Area sources consist of nonpoint and mobile sources. Because there are few major point sources in the area, area sources account for most of the emissions of criteria pollutants and VOCs. On-road sources are major contributors to total emissions of CO, NO_x, and VOCs; off-road sources to SO_2; and miscellaneous sources to PM_{10} and $PM_{2.5}$. Nonradiological emissions associated with any activities at the Hanford Site are less than 0.5% of those in Benton County and less than 0.2% of those in the four counties combined, as shown in the table.

Annual emissions for criteria air pollutants, VOCs, ammonia (NH_3), and toxic air pollutants during 2006 are presented in Table 6.1.1-2 (Poston et al. 2007). Nonradiological pollutants are primarily emitted from facilities in the 200 and 300 Areas on the Hanford Site. The 100, 400, and 600 Areas do not have any nonradiological emission sources of regulatory concern. In past years, gaseous NH_3 was emitted from the facilities, all located in both 200 Areas. During 2010, 200 Area tank farms produced reportable ammonia emissions. Emissions from carbon tetrachloride (CCl_4) vapor extraction work in the 200 West Area are categorized as "other toxic air pollutants" and do not need to be reported because they are below respective reportable quantities. On the basis of sitewide emissions in 2005, which were higher than those in 2006, air dispersion modeling indicates that concentrations from Hanford sources represent a small percentage of the ambient air quality standards (Poston et al. 2010; DOE 2012).

TABLE 6.1.1-1 Annual Emissions of Criteria Pollutants and Volatile Organic Compounds from Selected Major Facilities and Total Point and Area Source Emissions in Counties Encompassing the Hanford Site[a]

	Emission Rate (tons/yr)					
Emission Category	SO_2	NO_x	CO	VOCs	PM_{10}	$PM_{2.5}$
Adams County						
Point sources	0.0	0.0	0.0	0.0	0.0	0.0
Area sources	285	4,204	23,848	2,543	13,475	2,140
Total	285	4,204	23,848	2,543	13,475	2,140
Benton County						
Agrium U.S. Inc.[b]	*0.0*	*258*	*4.0*	*0.0*	*42.0*	*54.5*
DOE, Hanford Reservation	*3.0*	*12.0*	*27.0*	*9.0*	*2.6*	*1.7*
	0.48%[c]	*0.14%*	*0.04%*	*0.07%*	*0.03%*	*0.08%*
	0.18%	*0.05%*	*0.02%*	*0.03%*	*0.01%*	*0.02%*
Williams Pipeline	*0.1*	*117*	*17.4*	*0.3*	*0.01*	*0.01*
Point sources	3.2	388	49.4	10.2	44.7	56.4
Area sources	622	8,390	69,132	12,205	9,172	2,202
Total	626	8,778	69,182	12,215	9,217	2,258
Franklin County						
Point sources	0.0	0.0	0.0	0.0	0.0	0.0
Area sources	361	4,701	31,459	4,525	8,714	1,583
Total	361	4,701	31,459	4,525	8,714	1,583
Grant County						
Point sources	0.0	1.0	0.0	0.0	0.0	0.0
Area sources	383	5,366	45,981	6,647	15,985	2,682
Total	383	5,367	45,981	6,647	15,985	2,682
Four-county total	1,655	23,050	170,470	25,930	47,391	8,663

[a] Emission data for selected major facilities and for total point and area sources are for year 2002. CO = carbon monoxide, NO_x = nitrogen oxides, $PM_{2.5}$ = particulate matter ≤2.5 μm, PM_{10} = particulate matter ≤10 μm, SO_2 = sulfur dioxide, VOCs = volatile organic compounds.

[b] Data in italics are not added to yield totals.

[c] The top and bottom rows with % signs show emissions as percentages of Benton County total emissions and four-county total emissions, respectively.

Source: EPA (2009)

An agreement between DOE and EPA provides a plan and schedule to bring the Hanford Site into compliance with the NESHAP radionuclide requirements for continuous measurement of airborne emissions from applicable sources (Poston et al. 2007). In 2009, radiological emissions at the Hanford Site remained well below the levels that would cause off-site doses to exceed the standard of 10 mrem/yr.

TABLE 6.1.1-2 Annual Emissions of Criteria Pollutants, Volatile Organic Compounds, Ammonia, and Toxic Air Pollutants at the Hanford Site in 2006

	Emission Rate		
Pollutant	kg/yr	lb/yr	tons/yr
SO_x	2,900	6,400	3.2
NO_x	11,000	24,000	12.0
CO	13,000	28,000	14.0
VOCs	10,000	22,000	11.0
Total PM	3,700	8,200	4.1
PM_{10}	2,800	6,200	3.1
$PM_{2.5}$	1,000	2,200	1.1
Lead	0.44	0.97	4.85×10^{-4}
Ammonia	5,500	12,000	6.0
Other toxic air pollutants	4,500	9,900	4.95
Total criteria pollutants[a]	40,000	89,000	44.5

[a] Total criteria pollutants include SO_x, NO_x, CO, VOCs, total PM, and lead.

Source: Poston et al. (2007)

Radioactive constituents in air are monitored on the Hanford Site near facilities and operations, at site-wide locations away from facilities, and off-site around the site perimeter and in nearby and distant communities. In 2009, ambient air was monitored at site-wide locations away from facilities, and off-site around the site perimeter and in nearby and distant communities. In 2009, ambient air was monitored at 84 locations on the Hanford Site near facilities and operations. Samplers were located primarily at or within approximately 500 m (1,640 ft) of sites or facilities having the potential for, or a history of, environmental releases. Samples were collected biweekly and analyzed. The 2009 data indicate a large degree of variability by location. Samples collected from locations at or directly adjacent to Hanford Site facilities had higher radionuclide concentrations than samples collected farther away. In general, analytical results for most radionuclides were at or near Hanford Site background levels, which are much less than EPA concentration limits but greater than those measured off-site. The data also show that concentrations of certain radionuclides were higher and widely variable within different on-site operational areas. Naturally occurring beryllium-7 and potassium-40 were routinely identified (Poston et al. 2010).

Air sampling was conducted at 24 locations in the 200-West Area during 2009 (see Table 6.1.1-3). Generally, radionuclide levels measured in the 200-West Area were similar to results for previous years. Uranium-234 and uranium-238 were detected in approximately 90% of the samples. Plutonium-239/240 was detected in approximately 33% of the samples. The plutonium-239/240 concentrations at air-sampling locations N165 (near the 216-Z-9 Trench) and N987 (near the 241 TV Tank Farm) were greater than 10% of the EPA concentration value

TABLE 6.1.1-3 Concentrations of Selected Radionuclides (pCi/m^3) in Near-Facility Air Samples in 2009

Radionuclide	Site	No. of Samples	No. of Detections	Concentration (pCi/m^3) Average	Concentration (pCi/m^3) Maximum	Sample Number
Gross alpha	200-West	639	606	1.3E-03 ± 1.3E-03	6.9E-03 ± 1.4E-03	N433
	ERDF[a]	130	120	1.1E-03 ± 1.0E-03	2.9E-03 ± 8.4E-04	N518
Gross beta	200-West	639	638	1.8E-02 ± 1.7E-02	5.0E-02 ± 5.3E-03	N550
	ERDF	130	130	1.6E-02 ± 1.9E-02	5.0E-02 ± 5.3E-03	N550
Cobalt-60	200-West	50	0	4.7E-06 ± 9.1E-05	1.0E-04 ± 8.7E-05	N304
	ERDF	10	0	–3.0E-06 ± 5.1E-05	5.7E-05 ± 8.8E-05	N518
Strontium-90	200-West	50	1	–2.0E-04 ± 3.8E-04	2.1E-04 ± 1.9E-04	N449
	ERDF	10	0	–1.7E-04 ± 2.9E-04	6.8E-05 ± 1.5E-04	N517
Cesium-137	200-West	50	5	4.7E-05 ± 1.1E-04	2.0E-04 ± 1.4E-04	N974
	ERDF	10	3	1.2E-04 ± 2.1E-04	3.8E-04 ± 1.5E-04	N517
Uranium-234	200-West	50	45	1.2E-05 ± 9.5E-06	2.8E-05 ± 1.4E-05	N550
	ERDF	10	10	2.4E-05 ± 2.4E-05	5.3E-05 ± 2.4E-05	N517
Uranium-235	200-West	50	7	2.0E-06 ± 4.7E-06	9.7E-06 ± 7.1E-06	N550
	ERDF	10	3	3.3E-06 ± 5.3E-06	9.7E-06 ± 7.1E-06	N550
Plutonium-238	200-West	50	1	1.4E-06 ± 1.3E-05	2.6E-05 ± 3.3E-05	N165
	ERDF	10	1	4.2E-07 ± 1.6E-05	1.6E-05 ± 8.3E-06	N963
Uranium-238	200-West	50	43	1.0E-05 ± 8.6E-06	2.0E-05 ± 1.1E-05	N200
	ERDF	10	10	2.0E-05 ± 1.9E-05	3.8E-05 ± 1.8E-05	N517
Plutonium-239/240	200-West	50	17	1.7E-05 ± 1.0E-04	2.8E-04 ± 1.1E-04	N987
	ERDF	10	3	5.7E-06 ± 9.9E-06	1.5E-05 ± 8.7E-06	N517
Americium-241	200-West	2	2	3.6E-05 ± 1.5E-05	4.3E-05 ± 1.9E-05	N165
Plutonium-241	200-West	2	0	3.5E-04 ± 7.4E-04	7.2E-04 ± 7.5E-04	N165

[a] ERDF = Environmental Restoration Disposal Facility.

(40 CFR Part 61, Appendix E, Table 2) for the composite samples collected during the first half of 2009. Required notifications were made to the Washington State Department of Health. The elevated plutonium value at N165 is believed to originate from the nearby retired 216-ZP-9 Trench that received liquid waste from the plutonium finishing plant until 1995. No attributable cause was specifically identified for the elevated plutonium value at N987.

> American Indian Text
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> The importance of clean fresh air is often overlooked in NEPA analysis. For example, while wind and fire are part of the natural regime, an intact soil surface with a cryptogam crust in the desert reduces dust resuspension during wind events.
>
> The extensive cleanup and construction activities on Hanford contribute to blowing dust, increased traffic, diesel emissions, deposition or re-deposition of radionuclides, and generation of ozone, particulate matter, and other air pollutants with unknown human and environmental health effects.
>
> The Indian People believe that radioactivity is brought into the air by high winds – commonly blowing 40-45 miles per hour and intermittently much stronger (http://www.bces.wa.gov/windstorms.pdf). High winds over 150 mile per hour were recorded in 1972 on Rattlesnake Mountain and in 1990 winds on the mountain were recorded at 90 miles per hour. Dust devils can be massive in size, spin up to 60 miles per hour, and frequently occur at the site. Tornadoes have been observed in Benton County which is regionally famous for receiving strong winds.
>
> It gets so windy that the site managers at Environmental Restoration Disposal Facility (ERDF) occasionally send all workers home and close down the facility due to the degree of blowing dust making it unsafe to work. Air quality monitoring results, including radioactive dust, should be presented for ERDF, various plant operations, emission stacks, venting systems, and power generation sites. Also, fugitive dust can affect Viewshed and contribute to health affects during inversions.

6.1.1.3 Air Quality

With regard to the criteria pollutants (SO_2, NO_2, CO, O_3, PM_{10} and $PM_{2.5}$, and lead), the Washington SAAQS are identical to the NAAQS for NO_2, CO, and PM_{10} (EPA 2008a; WAC 173-470, 173-475), as shown in Table 6.1.1-4. The State of Washington has established more stringent standards for SO_2 (WAC 173-474). In addition, the State has adopted standards for gaseous fluorides (expressed as hydrogen fluoride [HF]) (WAC 173-481) and still retains standards for total suspended particulates (TSPs) (WAC 173-470), which used to be one of criteria pollutants but was replaced by PM_{10} in 1987.

The Hanford Site is located primarily in Benton County; the northern portion of the site is located in Grant, Franklin, and Adams Counties. The counties encompassing the Hanford Site are designated as being in attainment for all criteria pollutants (40 CFR 81.348).

A variety of air monitoring activities have been conducted on and around the Hanford Site to assess the effectiveness of emission treatment and control systems and pollution management practices and to determine compliance with state and federal regulatory requirements (Fritz 2007a). The air pollutant of primary concern at the Hanford Site is radiological contamination. PM_{10} concentrations are generally low in the region. However, there have been infrequent instances of high levels of PM_{10} concentrations in the region because of

TABLE 6.1.1-4 National Ambient Air Quality Standards (NAAQS) or Washington State Ambient Air Quality Standards (SAAQS) and Highest Background Levels Representative of the GTCC Reference Location at the Hanford Site, 2003–2007

			Highest Background Level	
Pollutant[a]	Averaging Time	NAAQS/ SAAQS[b]	Concentration[c,d]	Location (Year)
SO_2	1-hour	75 ppb	0.238 ppm (60%)	Anacortes, Skagit Co. (2003)[e]
	3-hour	0.5 ppm[f]	0.080 ppm (16%)	Anacortes, Skagit Co. (2003)[e]
	24-hour	0.1 ppm	0.029 ppm (29%)	Anacortes, Skagit Co. (2005)[e]
	Annual	0.02 ppm	0.004 ppm (20%)	Seattle, King Co. (2005)[e]
NO_2	1-hour	0.100 ppm	–[g]	–
	Annual	0.053 ppm	0.018 ppm (36%)	Seattle, King Co. (2006)[e]
CO	1-hour	35 ppm	4.6 ppm (13%)	Yakima, Yakima Co. (2003)
	8-hour	9 ppm	3.4 ppm (38%)	Yakima, Yakima Co. (2003)
O_3	1-hour	0.12 ppm[h]	0.080 ppm (67%)	Klickitat Co. (2003)
	8-hour	0.075 ppm[f]	0.070 ppm (93%)	Klickitat Co. (2003)
TSP	24 hours	150 $\mu g/m^3$	–	–
	Annual geometric mean	60 $\mu g/m^3$	–	–
PM_{10}	24-hour	150 $\mu g/m^3$	95 $\mu g/m^3$ (63%)	Kennewick, Benton Co. (2005)
	Annual	50 $\mu g/m^3$	24 $\mu g/m^3$ (48%)	Kennewick, Benton Co. (2003)
$PM_{2.5}$	24-hour	35 $\mu g/m^3$ [f]	42 $\mu g/m^3$ (120%)	Kennewick, Benton Co. (2004)
	Annual	15.0 $\mu g/m^3$ [f]	7.6 $\mu g/m^3$ (51%)	Kennewick, Benton Co. (2004)
Lead[i]	Calendar quarter	1.5 $\mu g/m^3$ [f]	0.03 $\mu g/m^3$ (2.0%)	Seattle, King Co. (2002)[e, j]
	Rolling 3-month	0.15 µg/m	–	–
Gaseous fluorides (as HF)	24 hours	2.9	–	–
	7 days	1.7	–	–
	30 days	0.84	–	–
	Growing season[k]	0.5	–	–

[a] CO = carbon monoxide; HF = hydrogen fluoride; NO_2 = nitrogen dioxide; O_3 = ozone; $PM_{2.5}$ = particulate matter ≤2.5 µm; PM_{10} = particulate matter ≤10 µm; SO_2 = sulfur dioxide; TSP = total suspended particulates.

[b] The more stringent standard between the NAAQS and the SAAQS is listed when both are available.

[c] Values in parentheses are monitored concentrations as a percentage of SAAQS or NAAQS.

[d] Monitored concentrations are the highest arithmetic mean for calendar-quarter lead; 2nd-highest for 1-hour, 3-hour, and 24-hour SO_2, 1-hour and 8-hour CO, and 1-hour O_3; 4th-highest for 8-hour O_3; 99th percentile for 24-hour PM_{10}; 98th percentile for 24-hour $PM_{2.5}$; and arithmetic mean for annual SO_2, NO_2, PM_{10}, and $PM_{2.5}$.

Footnotes continue on next page.

TABLE 6.1.1-4 (Cont.)

[e] These locations with the highest observed concentrations in the state of Washington are not representative of the Hanford Site but are presented to show that these pollutants are not a concern over the state of Washington.

[f] NAAQS. No SAAQS exists.

[g] A dash indicates that no measurement is available.

[h] On June 15, 2005, the EPA revoked the 1-hour O_3 standard for all areas except the 8-hour O_3 nonattainment Early Action Compact (EAC) areas (these do not yet have an effective date for their 8-hour designations). The 1-hour standard will be revoked for these areas 1 year after the effective date of their designation as attainment or nonattainment for the 8-hour O_3 standard.

[i] Used old standard because no data in the new standard format are available.

[j] Measurements of lead have been discontinued in Washington since 2003.

[k] Period from April 1 to September 30.

Sources: 40 CFR 52.21; EPA (2008a, 2009); WAC 173-470, 173-474, and 173-475 (refer to http://www.ecy.wa.gov/laws-rules/ecywac.html)

exceptional natural events, such as dust storms and large wildfires. Concentrations of other criteria pollutants are relatively low because of low regional concentrations; thus, these pollutants are generally of less concern.

Nearby urban or suburban measurements are typically used as being representative of background concentrations at the Hanford Site. The highest concentration levels of all criteria pollutants, except for O_3 and $PM_{2.5}$, around the Hanford Site are less than or equal to 63% of their respective standards in Table 6.1.1-4 (EPA 2009). The highest O_3 and $PM_{2.5}$ concentrations, which are primarily of regional concern, are about 93% and 120% of the applicable standards, respectively. These higher percentages are due in part to recent changes in their standards. Overall, the areas surrounding the Hanford Site and the entire state of Washington are in attainment for all criteria pollutants and have good air quality.

Particulate matter (PM_{10} and $PM_{2.5}$) has been measured at the HMS on the Hanford Site since 2001 (Poston et al. 2007). During 2006, annual average PM_{10} concentrations were 12.7 $\mu g/m^3$, which are typical of those measured in recent years, and the 24-hour PM_{10} concentration did not exceed the EPA standard. During 2006, the measured annual average $PM_{2.5}$ concentration was 4.5 $\mu g/m^3$, while the highest 24-hour $PM_{2.5}$ concentration was 8.1 $\mu g/m^3$.

The Hanford Site and its vicinity are classified as PSD Class II areas. No Class I areas are located within 100 km (62 mi) of the GTCC reference location. The nearest Class I areas are the Alpine Lake and Goat Rocks Wilderness Areas, which are about 137 km (85 mi) west and northwest of the GTCC reference location, respectively (40 CFR 81.434). Two PSD permits for NO_2 emissions were issued to facilities at the Hanford Site during 1980, but they were terminated after permanent shutdowns (Fritz 2007a). There are no facilities currently operating at the Hanford Site that are subject to PSD regulations. A final PSD permit for the WTP was issued by the Washington State Department of Ecology in November 2003.

6.1.1.4 Existing Noise Environment

The State of Washington has established maximum permissible environmental noise levels that are defined for the zoning of the area according to the Environmental Designation for Noise Abatement (EDNA). Maximum noise levels are presented in Table 6.1.1-5. They are based on the EDNA classification of receiving properties and source areas. The Hanford Site is classified as EDNA Class C because of its industrial activities.

The noise-producing activities at the Hanford Site are associated with construction and operational activities and local traffic, similar to those at any other typical industrial site. Numerous field activities performed routinely at the Hanford Site have the potential to generate noise at levels above typical background noise levels (Fritz 2007b). These activities could possibly disturb wildlife when performed in remote areas. Noise sources at the Hanford Site include various facilities, equipment, and machines (e.g., cooling systems, transformers, engines, pumps, boilers, steam vents, and material handling equipment). However, traffic is the primary noise source at the site and nearby residences (DOE 2012).

The Hanford Site is located in a rural setting, and no residences and sensitive receptors (e.g., schools, hospitals) are located in the immediate vicinity of the GTCC reference location. Noise studies at the Hanford Site have been concerned primarily with occupational noise at workplaces (Fritz 2007b). Most industrial activities at the Hanford Site are located far away from the site boundaries, so noise levels at the site boundaries are not measurable or are barely distinguishable from background noise levels. Environmental noise measurements at Hanford were conducted during a site characterization for the Skagit/Hanford Nuclear Power Plant Site in 1981 and for the Basalt Waste Isolation Project in 1987. In the 1981 study, noise levels ranged from 30 to 61 dBA (L_{eq}) at 15 sites. In the 1987 study, background noise levels measured at five locations in undeveloped areas around the Hanford Site ranged between 24 and 36 dBA as L_{eq} (24-hour), in which wind was identified as the major contributor to background noise levels. For the New Production Reactor EIS in 1991, noise levels associated with traffic were estimated at a receptor located 15 m (50 ft) from the road edge of State Route (SR) 24 and SR 240. Noise levels were estimated to range from 62 to 75 dBA as L_{eq} (1-hour) for the baseline condition and during construction and operational phases.

For the general area surrounding the Hanford Site, countywide L_{dn}'s based on population density are estimated to be 31 for Adams County (typical of wilderness natural background levels), and 36, 38, and 41 dBA for Grant, Franklin, and Benton Counties, respectively (typical of rural areas) (Miller 2002; Eldred 1982).

TABLE 6.1.1-5 Washington Maximum Permissible Environmental Noise Levels (dBA)[a]

EDNA of Noise Source	EDNA of Receiving Property[b]		
	Class A[c]	Class B	Class C
Class A	55	57	60
Class B	57	60	65
Class C	60	65	70

[a] At any hour of the day or night, these applicable noise limitations may be exceeded for any receiving property in any 1-hour period by no more than (1) 5 dBA for a total of 15 minutes, (2) 10 dBA for a total of 5 minutes, or (3) 15 dBA for a total of 1.5 minutes.

[b] The three Environmental Designations for Noise Abatement (EDNAs) are as follows:

Class A (Residential): Lands where human beings reside and sleep (e.g., residential, hospitals)

Class B (Commercial): Lands involving uses requiring protection from noise that interferes with speech (e.g., commercial living accommodations, theaters, stadiums)

Class C (Industrial): Lands involving economic activities of a nature such that higher noise levels than those experienced in other areas are normally anticipated (e.g., warehouses, industrial properties).

[c] Between the hours of 10:00 p.m. and 7:00 a.m., the noise limitations in the table shall be reduced by 10 dBA for a receiving property within Class A EDNAs.

Source: WAC 173-60, "Maximum Environmental Noise Levels," http://www.ecy.wa.gov/biblio/wac17360.html. Accessed Dec. 2007.

> American Indian Text
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> Native people understand that non-natural noise can be offensive while traditional ceremonies are being held. Traditional ceremonies have been held at the Hanford site in recent years. Some of the cultural use of the Hanford site by Tribes is being lost. Not all ceremonial sites are known to non-Indians. The noise generated by the Hanford facility may presently create noise interference for ceremonies held at sites like Gable Mountain and Rattlesnake Mountain. Noise generating projects, such as the GTCC proposed site, can interrupt the thoughts and focus and thus the spiritual balance and harmony of the community participants of a ceremony. The Tribes recommend that quiet zones and time periods should be identified for known Native American ceremonial locations on and near the Hanford Reservation. The general values or attributes provide solitude, quietness, darkness and wilderness-like or undegraded environments. These attributes provide unquantifiable value and are fragile.

6.1.2 Geology and Soils

6.1.2.1 Geology

6.1.2.1.1 Physiography. The Hanford Site is located in the Columbia Basin, an intermontane basin between the Cascade Range and the Rocky Mountains, in the Pacific Northwest. The basin forms the northern part of the Columbia Plateau physiographic province and the Columbia River flood-basalt province. It has four structural subprovinces, two of which are important to the Hanford Site: the Yakima Fold Belt and the Palouse Slope (Figure 6.1.2-1). The Yakima Fold Belt is a series of anticlinal ridges and synclinal valleys in the southwestern part of the Columbia Basin that has a predominant east-west structural trend. The Palouse Slope is the northeastern part of the Columbia Basin and shows little deformation, with only a few faults and low-amplitude, long-wavelength folds on an otherwise gently westward-dipping paleoslope (Chamness and Sweeney 2007).

The Hanford Site lies within the Pasco Basin, a smaller basin in the Yakima Fold Belt along the southwestern margin of the Palouse Slope (Figure 6.1.2-1). The Saddle Mountains form the northern boundary of the Pasco Basin; Rattlesnake Mountain forms part of its southern boundary. The 200 East Area lies in the Cold Creek syncline between Yakima Ridge and Umtanum Ridge in the central portion of the Pasco Basin (Figure 6.1.2-2) (Chamness and Sweeney 2007).

The synclinal valleys and basins between anticlinal ridges have been filled by river and stream sediments; as a result, the Hanford Site has relatively low relief. Catastrophic flood events (from glacial Lake Missoula and others) during the Late Pleistocene eroded sediments and scoured basalt bedrock, forming the scablands to the north of the Pasco Basin. The scablands are characterized by branching flood channels, giant current ripples, ice rafted erratics, and giant flood bars. These landforms can be readily seen on the Hanford Site. Since the end of the Pleistocene (about 10,000 years ago), winds have locally reworked flood sediments, depositing

> American Indian Text
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> The Indian People recommend that DOE pay more attention to landscape features and visual and aesthetic services that flow from the geologic formations at Hanford. Cultural and sacred landscapes may be invisible unless they are disclosed by the peoples to whom they are important. Tribal values lie embedded within the rich cultural landscape and are conveyed to the next generation through oral tradition by the depth of the Indian languages. Numerous landmarks are mnemonics to the events, stories, and cultural practices of native peoples. Oral histories impart basic beliefs, taught moral values and the land ethic, and helped explained the creation of the world, the origin of rituals and customs, the location of food, and the meaning of natural phenomena. The oral tradition provides accounts and descriptions of the region's flora, fauna, and geology. Within this landscape are songs associated with specific places; when access is denied a song may be lost.

> American Indian Text
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> The Yakima Fold Belt and the Palouse Slope play potentially very significant roles at Hanford both culturally and geologically. Rattlesnake and Gable Mountains are examples of folded basalt structures within the Yakima Fold Belt. These geological features have direct bearing on the ground water and groundwater flow direction. There are oral history accounts of these basalt features above the floodwaters of Lake Missoula. Many other topography features have oral history explanations such as the Mooli Mooli (flood ripples along the river terrace) and the sand dunes.

dune sands in the lower elevations and windblown silt around the margins of the Pasco Basin. Most sand dunes have been stabilized by vegetation, although there are active dunes in the Hanford Reach National Monument, to the north of the 300 Area (Chamness and Sweeney 2007; Normark and Reid 2003).

6.1.2.1.2 Topography. The 200 Areas are situated on a broad plateau (alluvial terrace) of relatively low relief. Elevations range from 229 m (750 ft) MSL on the plateau to about 119 m (390 ft) MSL at the Columbia River.

6.1.2.1.3 Site Geology and Stratigraphy. The GTCC reference location is situated immediately to the south of the Integrated Disposal Facility (IDF) 200 East Area in the central portion of the Hanford Site. The site lies about 11 km (7 mi) due south of the Columbia River. Surficial sediments in the 200 East Area consist of active and stabilized eolian sand dunes of Holocene age.

The stratigraphy consists of a sequence of Tertiary sediments overlying the basalt flows of the Columbia River Basalt Group on the north limb of the Cold Creek syncline (Figure 6.1.2-2). Sediments include the upper Miocene to Pliocene Ringold Formation;

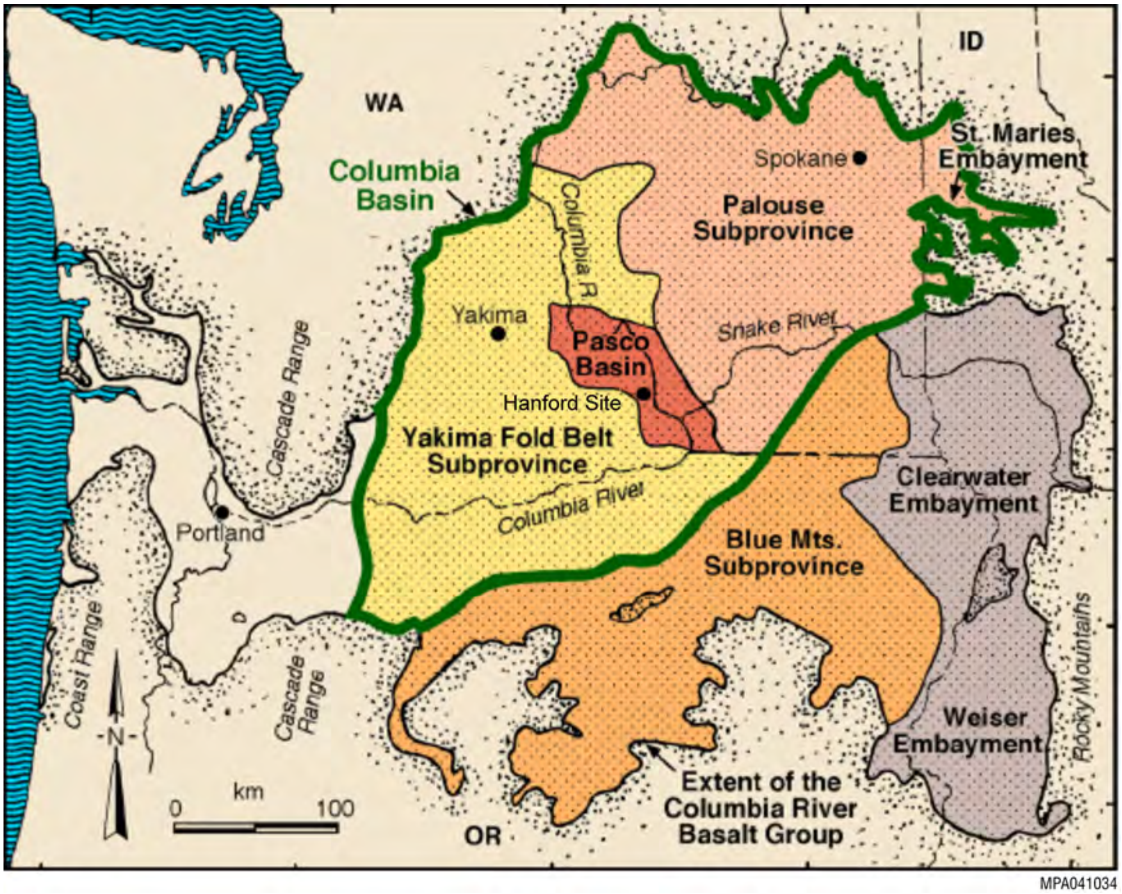


FIGURE 6.1.2-1 Location of the Hanford Site on the Columbia Plateau (Source: Modified from Chamness and Sweeney 2007)

Pleistocene flood gravels, sands, and silt of the Hanford Formation; and Holocene eolian deposits. The sedimentary sequence generally thickens toward the center of the syncline. The following summary of stratigraphy at the Hanford Site is based on Chamness and Sweeney (2007), Reidel and Fecht (2005), and Reidel (2005). Figure 6.1.2-3 presents a stratigraphic column for the Hanford Site and vicinity; Figure 6.1.2-4 shows the stratigraphy at the IDF site based on the work of Reidel (2005).

Columbia River Basalt Group. The Columbia River Basalt Group and interbedded sedimentary rocks (Ellensburg Formation) form the main bedrock of the Columbia Basin and the Hanford Site. The Columbia River Basalt Group consists of tholeiitic flood-basalt flows that erupted 17 and 6 million years ago (during the Miocene) and now cover an area of about 230,000 km^2 (88,000 mi^2) of eastern Washington and Oregon and western Idaho. At the IDF site, the Columbia River Basalt is encountered at depths of about 122 to 152 m (400 to 500 ft). The top of the basalt unit slopes gently to the south, following the dip of the Cold Creek syncline. There are at least 50 individual basalt flows beneath the Hanford Site with a total combined thickness of more than 3 km (1.9 mi). The Columbia River Basalt Group has been

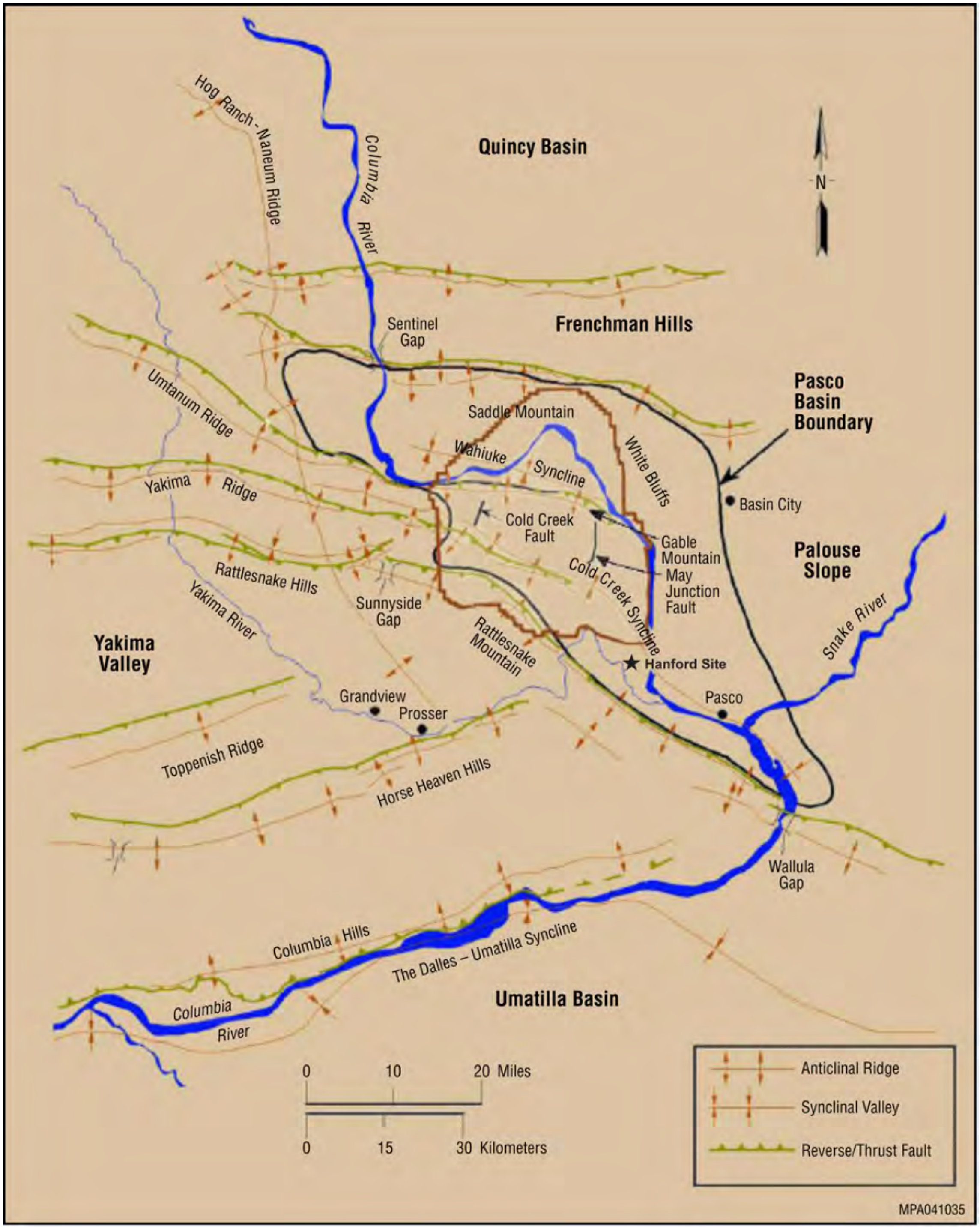


FIGURE 6.1.2-2 Physical Geology in the Vicinity of the Hanford Site (Source: Modified from Chamness and Sweeney 2007)

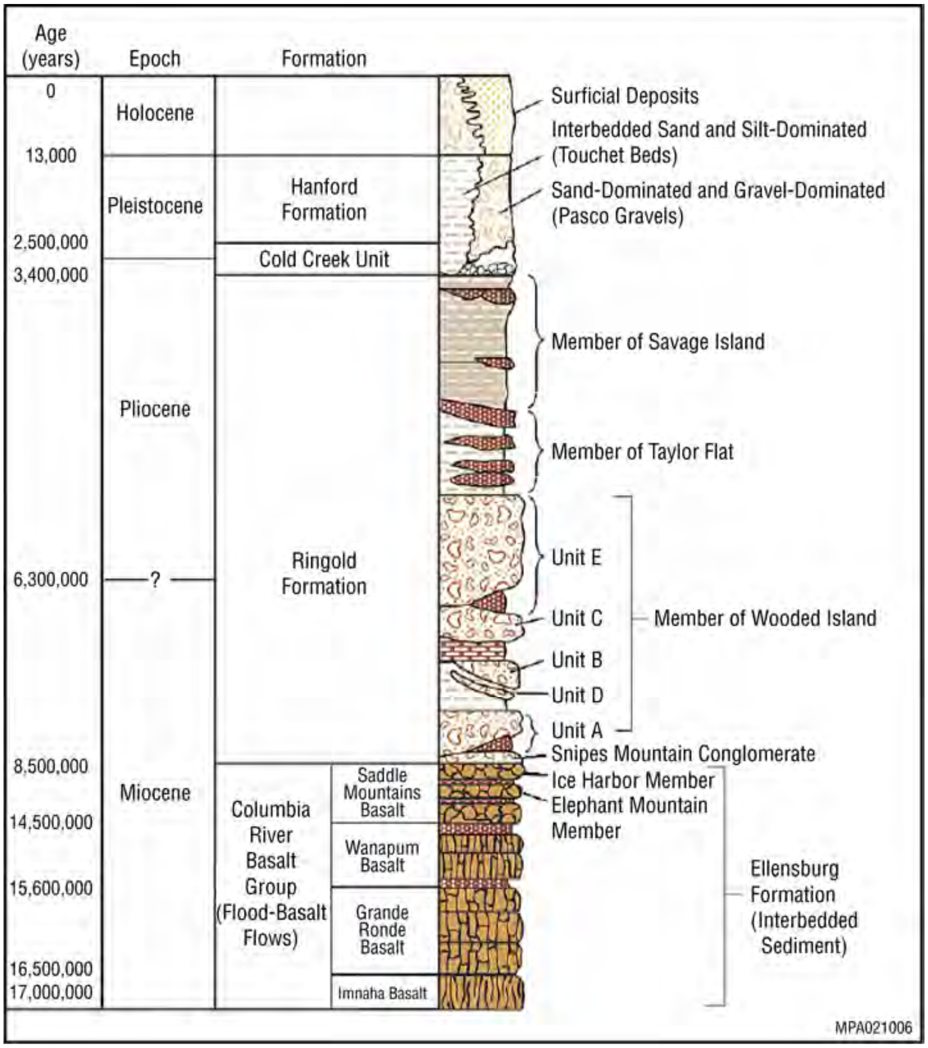


FIGURE 6.1.2-3 Generalized Stratigraphy of the Pasco Basin and Vicinity (Source: Chamness and Sweeney 2007)

divided into five formations; from oldest to youngest, they are Picture Gorge Basalt, Imnaha Basalt, Grande Ronde Basalt, Wanapum Basalt, and Saddle Mountains Basalt (Figure 6.1.2-3). Only the Grande Ronde Basalt, Wanapum Basalt, and Saddle Mountains Basalt are exposed at the Hanford Site.

The interbedded sedimentary rocks of the Ellensburg Formation consist predominantly of volcanic-derived sediment. Toward the central and eastern part of the basin, fluvial mainstream and overbank sediments of the ancestral Clearwater-Salmon and Columbia Rivers dominate.

Ringold Formation. The Ringold Formation is made up of fluvial and lacustrine sediments deposited by the ancestral Columbia and Clearwater-Salmon River systems between 3.4 and 8.5 million years ago (from the Miocene to the Pliocene). Only the member of Wooded

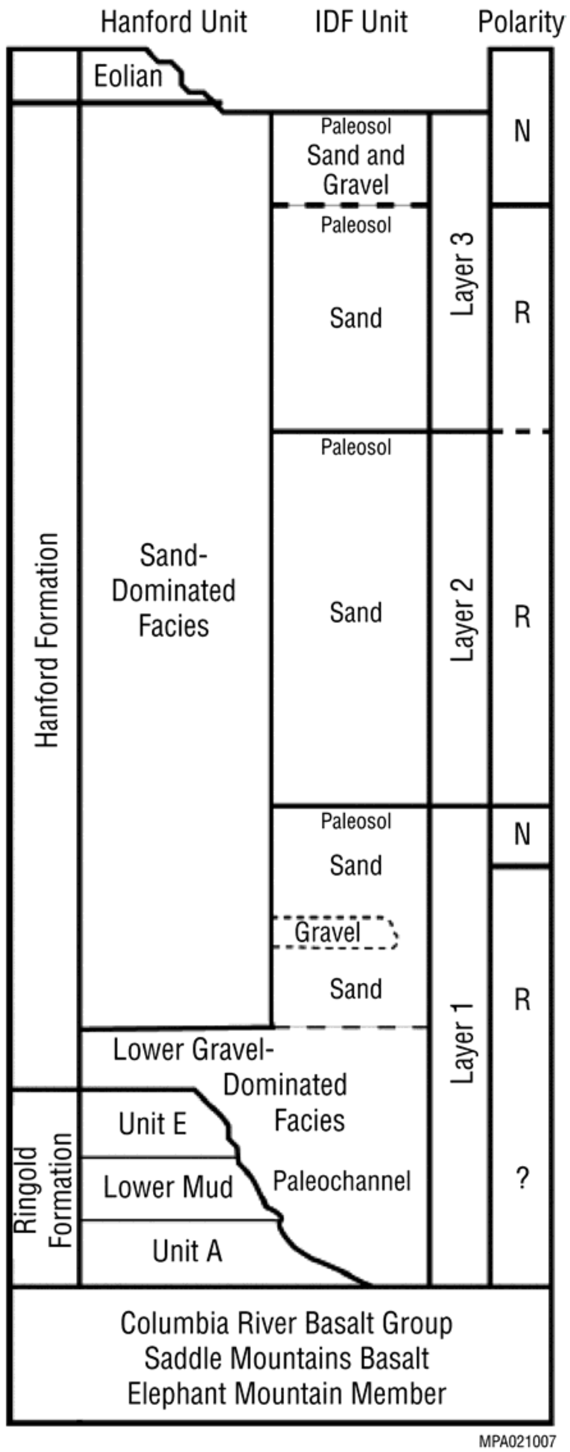


FIGURE 6.1.2-4 Stratigraphy at the IDF Site (Source: Reidel 2005)

Island is present beneath the 200 East Area. It consists of fluvial gravels separated by fine-grained deposits typical of overbank and lacustrine environments. The gravels are clast- and matrix-supported, pebble-to-cobble gravels with a fine to coarse sand matrix. The common lithologies are basalt, quartzite, and intermediate to felsic volcanics. Interbedded lenses of silt and sand are also common. The Ringold Formation reaches a maximum thickness of 87 m (285 ft) on the west side of the IDF site; it is entirely missing beneath the north and northeast parts of the 200 East Area.

Cold Creek Unit. The surface of the Ringold Formation was eroded extensively by the ancestral Columbia River and by catastrophic Pleistocene floodwaters. During this time, the Columbia River flowed through various channels between Umtanum Ridge and Gable Mountain (Figure 6.1.2-2) and eroded a wide channel to the south across the middle of the Hanford Site. The channel gradually shifted course to the east, where it continued to erode the eastern half of the site, removing the uppermost layers of the Ringold Formation. The eroded channel can be traced from Gable Gap across the eastern part of the 200 East Area and to the southeast. It is deepest below the northern portion of the IDF site. The channel is thought to be a smaller part of a much larger trough that underlies the 200 East Area.

Thin, laterally discontinuous alluvial deposits separate the Ringold Formation from the overlying Hanford Formation in some parts of the Hanford Site. These deposits are collectively referred to as the Cold Creek Unit and consist of a Plio-Pleistocene unit, pre-Missoula gravels, and early Palouse soil. The Plio-Pleistocene unit unconformably overlies the Ringold Formation in the western Cold Creek syncline in the vicinity of the 200 West Area. Depending on location, the Plio-Pleistocene unit is made up of interfingering carbonate-cemented silt, locally referred to as the “caliche layer,” sand and gravel, carbonate-poor silt, and sand; and/or basaltic detritus consisting of weathered and unweathered basaltic gravels deposited as locally derived slope wash, colluviums, and sidestream alluvium.

Pre-Missoula gravels are composed of quartzose to gneissic pebble-to-cobble gravel with a sand matrix. These gravels are up to 25-m (82-ft) thick, contain less basalt than underlying Ringold gravels and overlying Hanford deposits, have a distinctive white or bleached color, and sharply truncate underlying strata. The early Palouse soil consists of up to 20 m (66 ft) of silt and fine-grained sand. Deposits composing the early Palouse soil are massive, brownish-yellow, and compact.

Hanford Formation. The Hanford Formation rests unconformably atop the eroded surface of the Ringold Formation. It is as thick as 116 m (380 ft) in the vicinity of the IDF site. The unit is thickest in the northern part of the site where the erosional channel has cut into Ringold Formation; it thins to the southwest along the margin of the trough under the eastern portion of the IDF site. The sediments of the Hanford Formation were deposited between 2 million and 13,000 years ago by the catastrophic floodwaters from glacial Lake Missoula, glacial Lake Columbia, glacial Lake Bonneville, and ice-margin lakes.

The glaciofluvial sediments of the Hanford Formation consist of poorly sorted, pebble to cobble gravel and of fine- to coarse-grained sand, with lesser amounts of interstitial and interbedded silt and clay. They are divided into three facies (units): a lower gravel-dominated facies, an upper sand-dominated facies, and an interbedded sand- and silt-dominated facies (Figure 6.1.2-3). The gravel-dominated facies was deposited by high-energy floods and consists of coarse-grained, basaltic sand and granular to boulder gravel with an open framework texture, massive bedding, and large-scale planar cross bedding in outcrop. These deposits make up most of the Hanford Formation in the northern portion of the 200 Areas.

The sand-dominated facies were deposited adjacent to main flood channel courses during the waning stages of flooding and are most common in the central and southern parts of the 200 Areas. They consist of fine- to coarse-grained sand and granular gravel interlayered with deposits of Cascade ash. The sands have a high basalt content and are generally black, gray, or salt-and-pepper in color. The silt content of the sands varies and is lowest where the sands are well sorted. The interbedded sand- and silt-dominated facies were deposited in slack water conditions and in back-flooded areas. They consist of thin-bedded, plane-laminated, and ripple cross-laminated silt and fine- to coarse-grained sand. The beds are typically a few to several tens of inches or centimeters thick and have normally graded bedding. The interbedded sand- and silt-dominated unit tends to be absent in the vicinity of the IDF site.

Eolian Sand Dunes. Active and stabilized eolian sand dunes are a common feature across the Hanford Site. In the 200 East Area, the dunes have a parabolic form in plan view. Dune deposits include Mazama ash from an eruption that occurred 6,000 years ago. The dunes have massive cross bedding, which indicates eastward transport. Active blowouts are common. Most dunes and interdune areas at Hanford are stabilized by vegetation and have only local areas of active sand transport.

6.1.2.1.4 Seismicity. The seismicity of the Columbia Plateau is relatively low compared with other regions of the Pacific Northwest, the Puget Sound, and western Montana/eastern Idaho (DOE 2012). The largest known earthquake in the Columbia Plateau occurred in 1936 near Milton-Freewater, Oregon. It had a Richter magnitude of 5.75 and was followed by a number of aftershocks. The largest earthquakes near the Hanford Site occurred in 1918 and 1973. Both events had a magnitude of 4.4 and were located less than 16 km (10 mi) to the north of the Hanford Site near Othello (Chamness and Sweeney 2007).

Earthquakes in the central Columbia Plateau tend to occur in clusters or “swarms.” The areas north and east of the Hanford Site are regions of concentrated earthquake swarm activity. Earthquake swarms have also occurred at several locations within the Hanford Site. About 90% of the earthquakes occurring in swarms have magnitudes of 2 or less and have shallow focal depths (usually less than 4 km [2 mi]). Each swarm typically lasts several weeks to months and consists of several to a hundred or more earthquakes clustered in an area of 5 to 10 km (3 to 6 mi) in the lateral dimension, with the longest dimension in an east-west direction (Chamness and Sweeney 2007).

Seismic data from the Hanford Seismic Network and the Hanford Strong Motion Accelerometer Network located on and around the Hanford Site are reported in the site's annual seismic report. Seismograph stations and strong motion accelerometer sites are located throughout the site, including one (H2E) at the 200 East Area. A total of 117 earthquakes occurred at the Hanford Site between October 1, 2005, and September 30, 2006. Of these, the majority (78) were swarms with magnitudes usually less than 2; the remaining earthquakes (39) were considered random, occurring in prebasalt sediments or crystalline basement rocks. None of the earthquakes occurring in FY 2006 were thought to result from movement along faults associated with major anticlinal ridges in the Hanford Site area (Rohay et al. 2006).

Probabilistic seismic hazard analyses have determined that the design basis for facilities at the Hanford Site should be able to withstand peak horizontal accelerations of 0.10g from an earthquake with a return frequency of once in 500 years (annual probability of 0.002) and 0.20g from an earthquake with a return frequency of once in 2,500 years (annual probability of 0.0004) (Chamness and Sweeney 2007).

American Indian Text

Geologic structure of the Pacific Northwest includes a feature called the Olympic-Wallowa Lineament (the OWL). Surface and depth data have identified a structural "line" within the earth's crust that can be traced roughly from southeast of the Wallowa Mountains, under Hanford, through the Cascades and under Seattle and the Sound. Such lineaments are signals of crustal structure that are not yet well identified. Emerging research being reported through the USGS is highlighting the importance of Seattle area faults connecting under the Cascades into the Yakima Fold Belt and on along the OWL. The geologic stress on the surface of the earth in the local region have a north-south compressional force direction that has caused the surface to wrinkle in folds that trend approximately east-west, thus creating the Yakima Fold Belt. Fault movement along these folds occurs all the time, and studies have shown these to be considered active fault zones.

6.1.2.1.5 Volcanic Activity. Flood basalt volcanism associated with the Columbia River Basalt Group occurred during an 11-million-year episode between 17 and 6 million years ago. Most of the lava during this episode was extruded during the first 2 to 2.5 million years of that period. There has been no volcanic activity during the last 6 million years. The recurrence of Columbia River basalt volcanism is not considered to be a credible volcanic hazard (Tallman 1996).

Volcanism in the Cascade Range has been active since the Pleistocene (2 million years ago). Several volcanoes in this range are active today, including Mount Mazama (Crater Lake) and Mount Hood in Oregon and Mount St. Helens (the most active in the range), Mount Adams, and Mount Rainier in Washington state. They will likely remain active for the next 100 years. The three closest volcanoes to the Hanford Site are Mount Adams, 150 km (93 mi) to the west-southwest; Mount Rainier, 175 km (109 mi) to the northwest; and Mount St. Helens, 200 km (124 mi) to the west-southwest. Given these distances, the only volcanic hazard is ash accumulation following the eruption of a Cascade Range volcano (Tallman 1996).

Probabilistic volcanic hazard studies of the Cascade Range completed by the USGS calculated that the annual probability that the accumulation of volcanic ash in Washington would exceed 1 cm (0.39 in.) after an eruption is 0.001 (once every 1,000 years). The annual probability that the volcanic ash accumulation would exceed 10 cm (3.9 in.) is 0.00012 (once every 8,300 years). Design ashfall loads range from 14.6 kg/m^2 (2.99 lb/ft^2) for a hazard probability of 0.0021 (once every 476 years) to 146.5 kg/m^2 (30.0 lb/ft^2) for a hazard probability of 0.000043 (once every 23,256 years), assuming an uncompacted ash density of 769 kg/m^2 (158 lb/ft^2) and a 50% compaction ratio (Tallman 1996).

6.1.2.1.6 Slope Stability, Subsidence, and Liquefaction. No natural factors in the GTCC reference location that would affect the engineering aspects of slope stability or subsidence have been reported.

Liquefaction of saturated sediments is a potential hazard during or immediately following large earthquakes. Whether soils will liquefy depends on several factors, including the magnitude of the earthquake, peak ground velocity, liquefaction susceptibility of soils, and depth to groundwater. Given the deep water table in the 200 Areas, liquefaction is not likely to be a hazard. However, groundwater levels in the 200 Areas are changing as a result of changes in wastewater discharge practices in the area.

6.1.2.2 Soils

American Indian Text

Native Peoples understand the importance of soils and minerals. Oral history has suggested that soils have a medicinal purpose for healing wounds as well as used for building structures, creating mud baths, and filtering water. Material from the White Bluffs was used for cleaning hides, making paints, and whitewashing villages.

Soil characteristics: soil chemistry (ph, ion activity, micronutrients, microorganisms), lack of this knowledge is a data gap such as the influence of past tank leaks on soil chemistry and characteristics/properties. Sandy soils have high transmissivity. Soil integrity is important to tribes since the soils support plant life, which supports many other life forms, which are all important to tribes.

The undisturbed soils within the study area are predominantly sands and loamy sands. In the area of the GTCC reference location, the Rupert sand and Burbank loamy sand predominate. The Rupert sand is a brown to grayish brown, coarse-grained sand that grades to dark grayish brown at a depth of about 90 cm (35 in.). The sand has developed under grass, sagebrush, and hopsage in alluvial fan deposits mantled by wind-blown sand. It forms hummocky terraces and dune-like ridges. The Burbank loamy sand is a coarse-grained sand, very dark grayish brown in color, that ranges in thickness from 41 to 76 cm (16 to 30 in.) and is underlain by gravel (Hajek 1966).

6.1.2.3 Mineral and Energy Resources

The Hanford Site excavates borrow materials from existing borrow pits and quarries throughout the site, including the various parts of the 200 Area and the areas between them (but not in the area of the GTCC reference location). Historically, mineral resources, including gravel, sand, and basalt, have been used to make concrete, to construct roads, as cap material for closing waste sites, and in general construction (DOE 2001a).

No reported energy resources are being developed within the boundaries of the Hanford Site. Deep natural gas production from anticlines in the basalt of Pasco Basin has been tested by oil exploration companies without commercial success (DOE 1995).

6.1.3 Water Resources

American Indian Text

Water sustains all life. As with all resources, there is both a practical and a spiritual aspect to water. Water is sacred to the Indian People, and without it nothing would live. When having a feast, a sip of water is taken either first or after a bite of salmon, then a bit of salmon, then small bites of the four legged animals, then bites of roots and berries, and then all the other foods.

The quality of purity is very important for ceremonial use of water. The concept of sacred water or holy water is global, and often connects people, places, and religion; religions that are not land-connected may lose this concept. Additionally, concepts related to the flow of services from groundwater and the valuation of groundwater is receiving increased attention.

6.1.3.1 Surface Water

6.1.3.1.1 Rivers and Streams.

Columbia River. The Columbia River is the principal surface water body on the Hanford Site. It flows through the northern portion of the site and forms part of the site's eastern boundary. Flow in the river is from north to south across the site, with eventual discharge to the Pacific Ocean. The river is impounded by 11 dams within the United States; seven are upstream and four are downstream of the Hanford Site. The Hanford Reach is the last free-flowing, nontidal segment of the Columbia River in the United States. It extends from Priest Rapids Dam, immediately upstream of the Hanford Site about 82 km (51 mi) southeast, to Lake Wallula, 29 km (18 mi) downstream of the Hanford Site near Richland, Washington (Thorne and Last 2007). Figure 6.1.3-1 shows surface water features at Hanford.

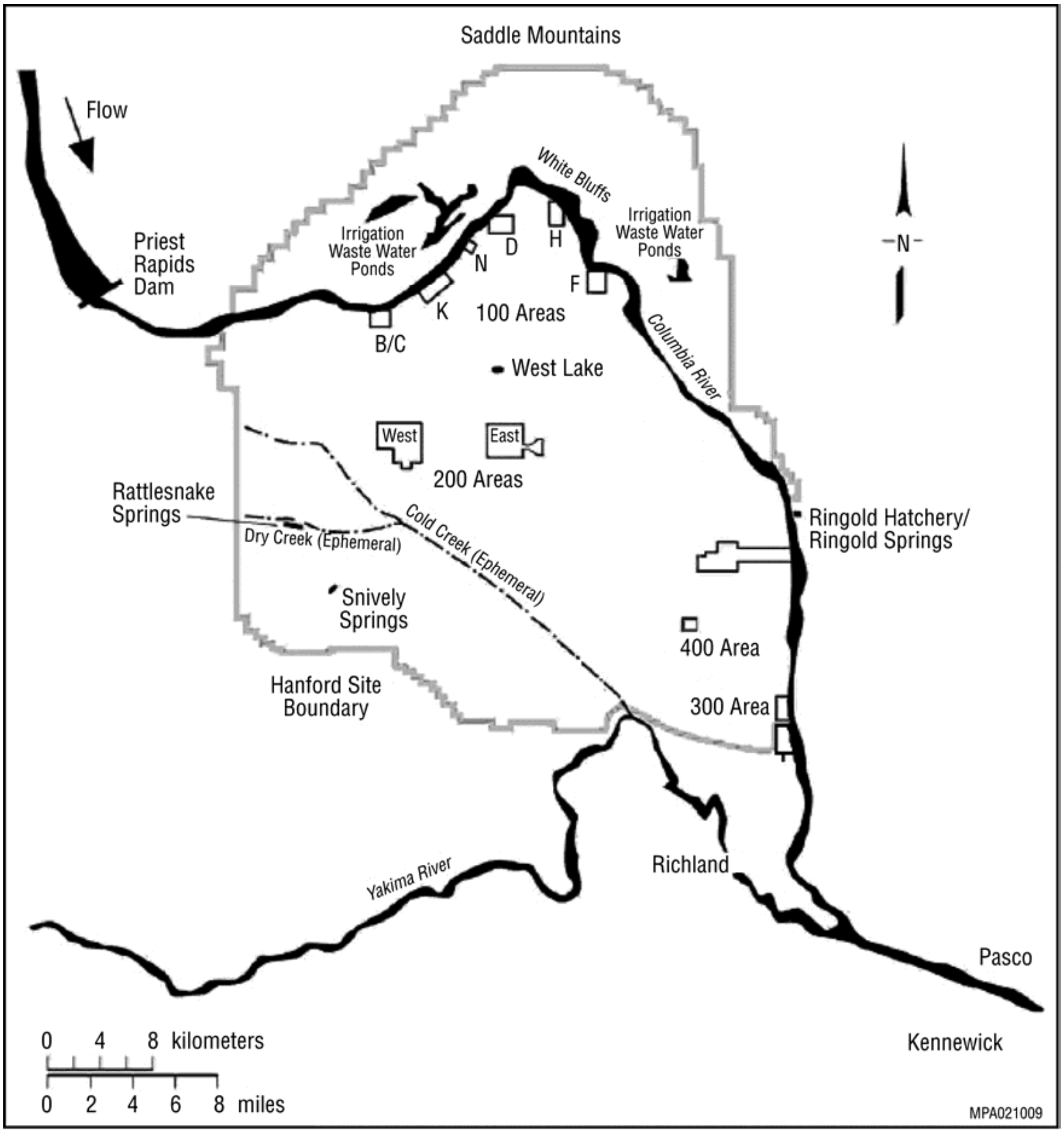


FIGURE 6.1.3-1 Surface Water Features on the Hanford Site (Source: Thorne and Last 2007)

Flows through the Hanford Reach fluctuate significantly and are controlled primarily by releases from three upstream storage dams: Grand Coulee in the United States and Mica and Keenleyside in Canada. Flows in the Hanford Reach are directly affected by releases from Priest Rapids Dam; however, Priest Rapids operates as a run-of-the-river dam rather than a storage dam. Flows are controlled to generate power and promote salmon egg and embryo survival. Columbia River flow rates near Priest Rapids during the 90-year period from 1917 to 2007 averaged about 3,330 cms (117,550 cfs). Daily average flows during this period ranged from 570 to 19,500 cms (20,000 to 690,000 cfs). The lowest and highest flows occurred before the construction of upstream dams. During the 10-year period from 1997 through 2006, the average flow rate was about 3,300 cms (116,500 cfs). Storage dams on tributaries of the Columbia River also affect flows (Thorne and Last 2007).

Peak daily average flow during 2006 was 7,731 cms (273,000 cfs). Columbia River flows typically peak from April through June during spring runoff from snowmelt, and they are lowest from September through October. As a result of daily discharge fluctuations from upstream dams, the depth of the river varies over a short time period. River stage changes of up to 3 m (10 ft) during a 24-hour period may occur along the Hanford Reach. The width of the river varies from approximately 300 to 1,000 m (1,000 to 3,300 ft) within the Hanford Reach (Thorne and Last 2007).

Major floods on the Columbia River are typically the result of rapid melting of the winter snowpack over a wide area during periods of high precipitation. The maximum historical flood on record occurred in 1894, with a peak discharge of 21,000 cms (724,000 cfs) at the Hanford Site. The largest recent flood took place in 1948, with an observed peak discharge of 20,000 cms (700,000 cfs) at the Hanford Site. Exceptionally high runoff in 1996 resulted in a maximum discharge of nearly 11,750 cms (415,000 cfs). Construction of several flood-control/water-storage dams upstream of the Hanford Site has increased control of the river’s flow and reduced the likelihood of flood recurrence (Thorne and Last 2007).

Flood potential on the Columbia River was evaluated by estimating the probable maximum flood, which takes into account the upper limit of precipitation falling on the drainage area and other hydrologic factors (e.g., antecedent moisture conditions, snowmelt, and tributary conditions) that could result in maximum runoff. The probable maximum flood for the Columbia River downstream of Priest Rapids Dam was calculated to be 40,000 cms (1.4 million cfs), which is greater than the 500-year flood (Figure 6.1.3-2). This flood would inundate parts of the 100 Areas adjacent to the Columbia River, but the central portion of the Hanford Site, including the 200 Areas, would remain unaffected. The USACE (1989) derived the standard project flood, giving both regulated and unregulated peak discharges for the Columbia River downstream of Priest Rapids Dam. Frequency curves for both 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 was given as 15,200 cms (540,000 cfs), and the 100-year regulated flood was given as 12,400 cms (440,000 cfs). Impacts on the Hanford Site would be negligible and less than the probable maximum flood (Thorne and Last 2007). According to 10 CFR Part 1022, a floodplain is defined as the lowlands adjoining inland and coastal waters and relatively flat areas and flood-prone areas of offshore islands, including, at a minimum, that area inundated by a ≥1%-chance flood in any given year (i.e., the “100-year floodplain” caused by the 100-year flood).

Upstream dam 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 USACE evaluated a number of scenarios on the effects from failures of Grand Coulee Dam, assuming flow conditions of 11,000 cms (400,000 cfs). For emergency planning, USACE hypothesized 25% and 50% breaches, that is, the “instantaneous” disappearance of 25% or 50% of the center section of the dam, resulting from the detonation of explosives. The discharge or flood wave

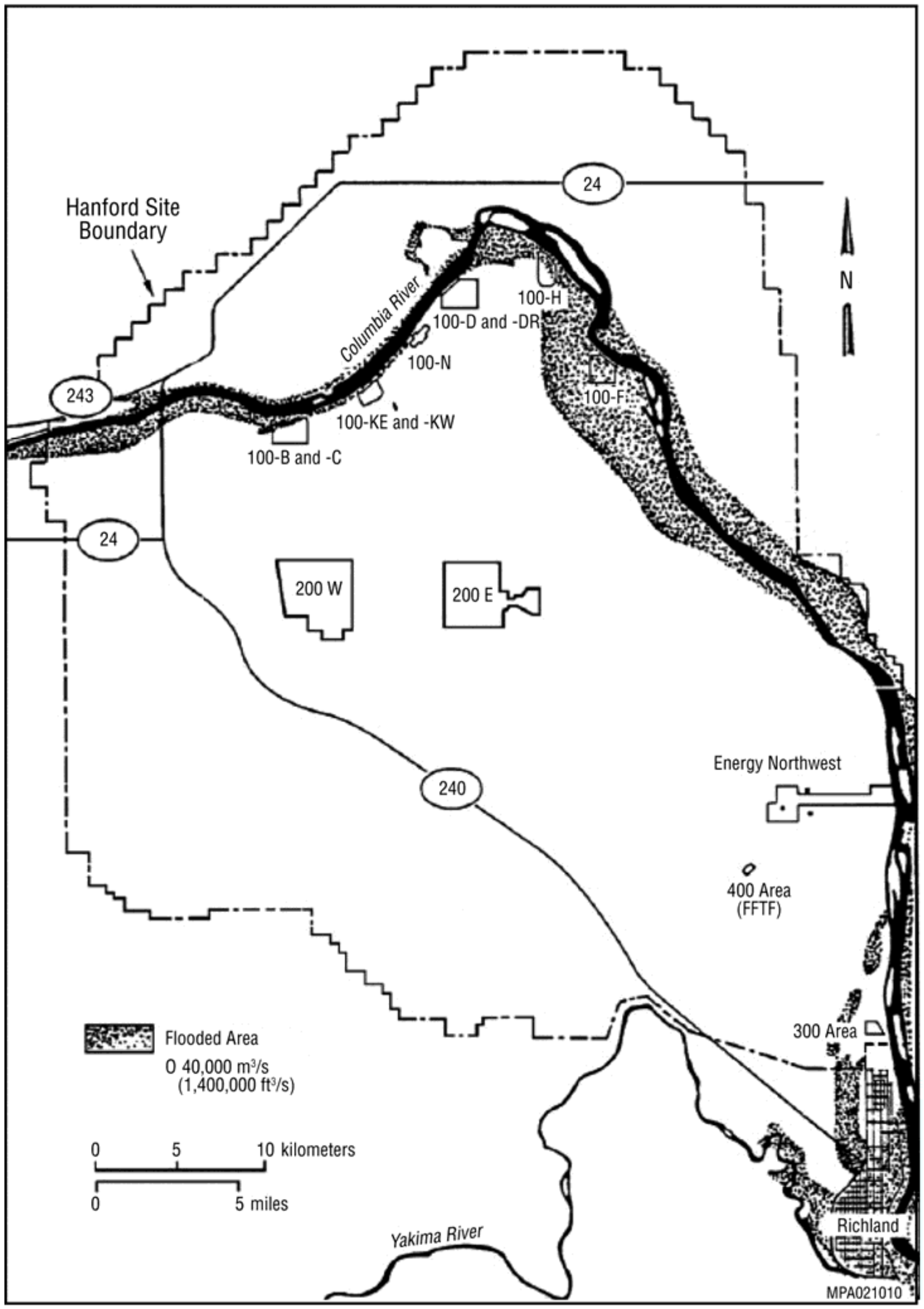


FIGURE 6.1.3-2 Flood Area for the Probable Maximum Flood on the Columbia River, Hanford Site (Source: Thorne and Last 2007)

resulting from such a breach at Grand Coulee Dam was determined to be 600,000 cms (21 million cfs) (Thorne and Last 2007).

In addition to the areas inundated by the probable maximum flood, shown in Figure 6.1.3-2, the remainder of the 100 Areas, the 300 Area, and nearly all of Richland would be flooded. No determinations were made regarding failures of dams upstream, associated failures downstream of Grand Coulee Dam, or breaches greater than 50% of Grand Coulee Dam. The 50% scenario was believed to represent the largest realistically conceivable flow resulting from either a natural or a human-induced breach.

The possibility of a landslide resulting in river blockage and flooding along the Columbia River was also examined for an area bordering the east side of the river upstream of Richland. The possible landslide area considered was the 75-m-high (250-ft-high) bluffs generally known as White Bluffs in the northern portion of the Hanford Site (and north of the river). Calculations were made for a 8×10^5 m^3 (1×10^6 yd^3) landslide volume, with a concurrent flood flow of 17,000 cms (600,000 cfs) and a 200-year flood, resulting in a flood-wave crest elevation of 122 m (400 ft) MSL. Areas inundated upstream of such a landslide event would be similar to those inundated during the probable maximum flood (Thorne and Last 2007).

The primary uses of the Columbia River include the production of hydroelectric power, irrigation of cropland in the Columbia Basin, and transportation of materials by barge. Several communities along the Columbia River rely on the river for drinking water. The Columbia River is also used as a source of both drinking water and industrial water for several Hanford Site

American Indian Text

The Columbia River is the lifeblood of the Indian People. It supports the salmon and every food or material that they rely on for subsistence. It is an essential human right to have clean water. If water is contaminated it then contaminates all living things. Tribal members that exercise a traditional lifestyle would also become contaminated. A perfect example is making a sweat lodge and sweating. It is a process of cleansing and purification. If water is contaminated then the sweat lodge materials and process of cleansing would actually contaminate the individual.

Indian People are well known for adopting technology if it were instituted wisely and did not sacrifice or threaten the survival of the group as a whole. This approach applies to tribal use of groundwater. Even though groundwater was not used except at springs, tribes would have potentially used technology for developing wells and would have used groundwater if seen to be an appropriate action. The existing contamination is considered an impact to tribal rights to utilize this valuable resource.

The hyporheic zone in the Columbia River needs to be more fully characterized to understand the location and potential of groundwater contaminants discharging to the Columbia River.

Contaminated groundwater plumes at Hanford are moving towards the Columbia River and some contaminants are already recharging to the river. It is the philosophy of the Indian People that groundwater restoration and protection be paramount to DOE’s management of Hanford. Institutional controls, such as preventing use of groundwater, should only be a temporary measure for the safety of people and animals. It will be questioned when DOE views institutional controls as a viable long-term management option to allow natural attenuation. The timeline of natural attenuation may not best represent a Tribal preference of a proactive corrective cleanup measure(s). for contamination plumes. Cleanup should be a priority before considering placement of additional waste like GTCC in the 200 area.

facilities. In addition, the river is used extensively for recreation (Thorne and Last 2007; Poston et al. 2007).

Yakima River. The Yakima River is located south of the Hanford Site and follows a portion of the southwestern boundary just to the west of the 300 Area. It drains surface runoff from about one-third of the Hanford Site. The Yakima River has much lower flows than the Columbia River, with an average daily flow of about 100 cms (3,530 cfs), according to 72 years of daily flow records kept by the USGS. The average monthly maximum and minimum are 497 cms (17,550 cfs) and 4.6 cms (165 cfs), respectively. Exceptionally high flows were observed during 1996 and 1997; the highest average daily flow rate during 1996 was nearly 1,300 cms (45,900 cfs). Average daily flow during 2000, a low water year, was 89.9 cms (3,176 cfs). The average daily flow during 2006 was 100 cms (3,530 cfs). The Yakima River is considered to be a losing river because the elevation of the river surface is higher than the local water table (Thorne and Last 2007).

There have been fewer than 20 major floods on the Yakima River since 1862. The most severe floods occurred during November 1906, December 1933, May 1948, and February 1996. During these events, discharge magnitudes at Kiona, Washington, were recorded at 1,870 cms (66,000 cfs), 1,900 cms (67,000 cfs), 1,050 cms (37,000 cfs), and 1,300 cms (45,900 cfs), respectively. The recurrence intervals for the 1933 and 1948 floods are estimated at 170 and 33 years, respectively. The development of irrigation reservoirs within the Yakima River Basin has considerably reduced the flood potential of the river. The southern border of the Hanford Site could be susceptible to a 100-year flood on the Yakima River (Thorne and Last 2007; Figure 6.1.3-3).

Cold Creek. Cold Creek and its tributary, Dry Creek, are ephemeral streams within the Yakima River drainage system in the southwestern portion of the Hanford Site (Figure 6.1.3-1). These streams drain areas to the west of the site and cross the southwestern part of the site toward the Yakima River (Figure 6.1.3-1). When surface flow occurs, it infiltrates rapidly and disappears into the surface sediments in the western part of the site.

The GTCC reference location at Hanford is situated about 16 km (10 mi) northeast of Cold Creek in the 200 East Area.

During 1980, a flood risk analysis of Cold Creek was conducted as part of the characterization of a basaltic geologic repository for high-level radioactive waste. Such design work is usually done according to the standard project flood criteria or probable maximum flood criteria 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 performed. It was based on a large rainfall or combined rainfall/snowmelt event in the Cold Creek and Dry Creek watershed. The probable maximum flood discharge rate for the lower Cold Creek Valley was 2,265 cms (80,000 cfs), compared with 564 cms (19,900 cfs) for the 100-year flood (Figure 6.1.3-4). Modeling indicated that SR 240 along the southwestern and western portions of the site would be unusable (Thorne and Last 2007).

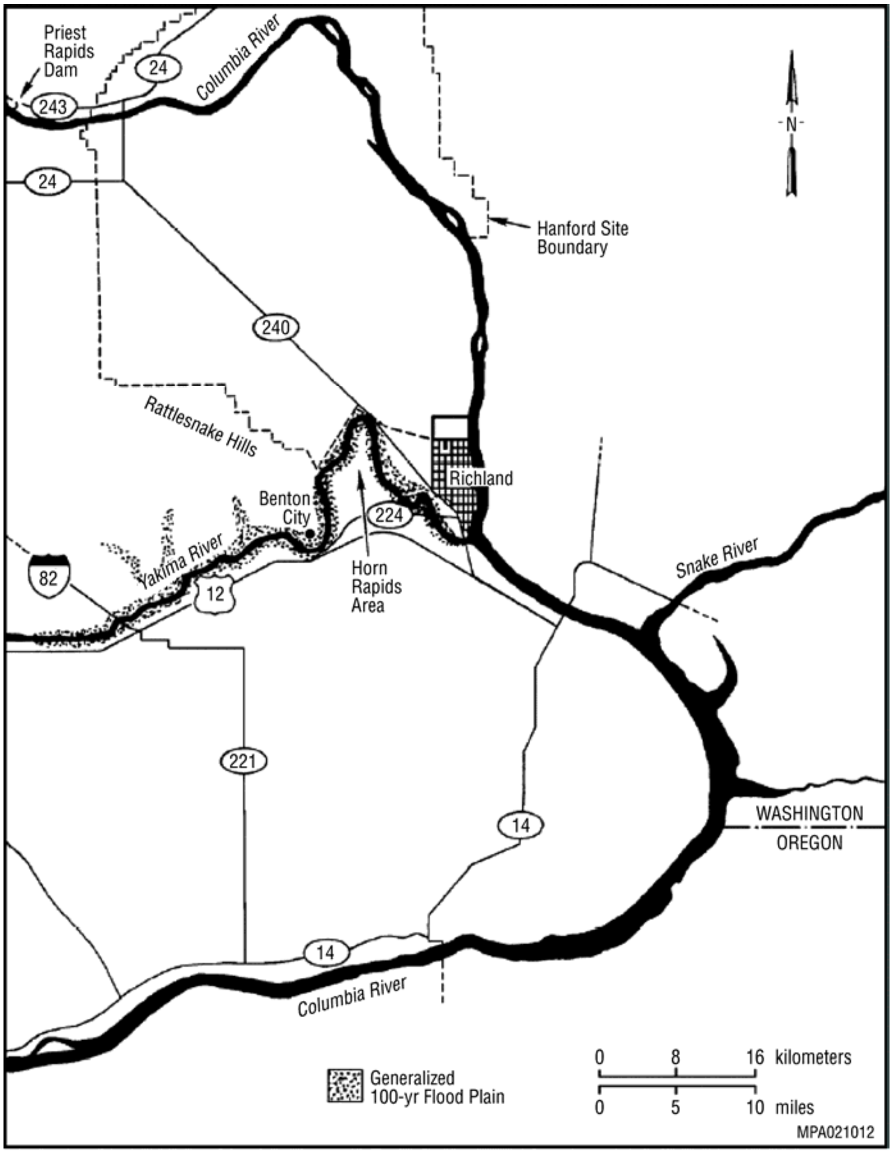


FIGURE 6.1.3-3 Flood Area from a 100-Year Flood of the Yakima River near the Hanford Site (Source: Thorne and Last 2007)

6.1.3.1.2 Other Surface Water.

Springs. Springs are found on the slopes of the Rattlesnake Hills along the western edge of the Hanford Site (Figure 6.1.3-1). There is also an alkaline spring at the east end of Umtanum Ridge. Rattlesnake and Snively Springs form small surface streams. Water discharged from Rattlesnake Springs flows into Dry Creek for about 3 km (1.9 mi) before disappearing into the ground (Thorne and Last 2007).

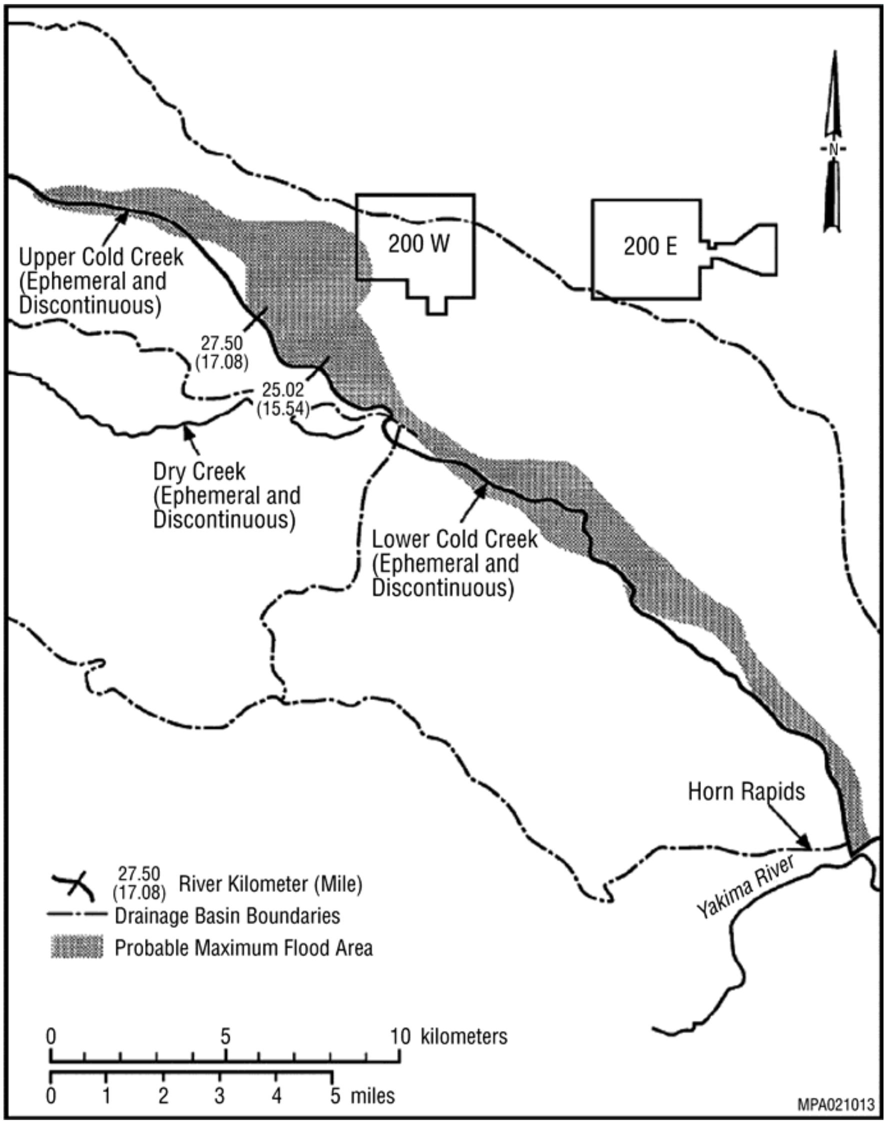


FIGURE 6.1.3-4 Extent of Probable Flood in Cold Creek Area, Hanford Site (Source: Thorne and Last 2007)

Riverbank springs were documented along the Hanford Reach long before Hanford operations began. During the early 1980s, researchers identified 115 springs along the Benton County shoreline of the Hanford Reach. The presence of shoreline springs varies with the river stage, which is controlled by upriver conditions and operations at upriver dams. Seepage occurs both below the river surface and on the exposed riverbank, particularly at a low river stage. Water flows into the aquifer (resulting in “bank storage”) as the river stage rises, then it discharges from the aquifer in the form of shoreline springs as the river stage falls. Following an extended period of low river flow, groundwater discharge zones located above the water level of the river may cease to exist once the level of the aquifer comes into equilibrium with the level of the river. Thus, springs are most readily identified immediately following a decline in the river stage. Bank storage of river water also affects the contaminant concentration of the springs.

Spring water discharged immediately following a river stage decline generally consists of river water or a mixture of river water and groundwater. The percentage of groundwater in the spring water discharge increases over time following a drop in the river stage (Thorne and Last 2007).

Ponds. West Lake is a natural alkaline lake that lies to the north of the 200 East Area (Figure 6.1.3-1). West Lake is about 1.4 ha (3.5 ac) and is located approximately 8 km (5 mi) northeast of the 200 West Area and about 3 km (1.9 mi) north of the 200 East Area. West Lake was considered to be an ephemeral lake before operations began at the Hanford Site, with water-level fluctuations depending on groundwater-level fluctuations. The lake sits in a topographically low area that intersects the water table and is recharged by groundwater. West Lake does not receive direct discharges of effluent from site facilities; however, wastewater discharges at other Hanford facilities influencing the water table indirectly affect water levels in the lake. The lake's water levels have been decreasing over the past several years because of reduced wastewater discharge at other facilities (Thorne and Last 2007).

The Treated Effluent Disposal Area is located to the east of the 200 East Area (Figure 6.1.3-1). It consists of two disposal ponds, each about 145 by 145 m (475 by 475 ft). The disposal ponds receive permitted industrial wastewater from the 200 East Area. Once in the ponds, wastewater is allowed to evaporate or infiltrate into the ground (Thorne and Last 2007).

Several naturally occurring vernal ponds are located on the Hanford Site, including 10 at the eastern end of Umtanum Ridge, seven in the central part of Gable Butte, and three at the eastern end of Gable Mountain. The ponds occur in depressions perched atop a shallowly buried basalt surface and are formed as water collects over the winter (they dry up by summer). The ponds range in size from about 6.1 by 6.1 m (20 by 20 ft) to 45.7 by 30 m (150 by 100 ft) and tend to occur in clusters (Thorne and Last 2007).

Wetlands. Wetlands on the Hanford Site occur in the riparian zone along the Columbia River (DOE 2012). Irrigation on the east and west sides of the Wahluke Slope and on White Bluffs has created two wetland areas just north of the Columbia River (Figure 6.1.3-1; Thorne and Last 2007).

6.1.3.1.3 Surface Water Quality. The water quality of the Columbia River from Grand Coulee Dam to the Washington-Oregon border, which includes the Hanford Reach, has been designated as Class A by Washington State (Poston et al. 2010). Class A waters are suitable for essentially all uses, including raw drinking water, recreation, and wildlife habitat. For the Columbia River downstream from Grand Coulee Dam, the aquatic life designation is "salmon and trout spawning, noncore rearing, and migration." (Noncore refers to areas in which physical, chemical, and biological conditions are not specifically good for mating, reproduction, rearing, feeding, migration, and/or avoidance of disturbances such as floods and fire.) This designation provides for the protection of the spawning, noncore rearing, and migration of salmon and trout and other associated aquatic life. The recreational use designation for the Columbia River downstream from Grand Coulee Dam is "primary contact," which provides for activities that may involve complete submersion by the participant. The entire Columbia River is designated for all water supply and miscellaneous uses by the State of Washington (Poston et al. 2010).

In 1999, members of the Washington congressional delegation renewed their effort to identify the 82-km (51-mi) Hanford Reach as a Wild and Scenic River. The Hanford Reach is the last free-flowing segment of the Columbia River and an important spawning habitat for far-north migrating Chinook salmon. In 2000, President Clinton signed an Executive Order creating the Hanford Reach National Monument. At 79,000 ha (195,000 ac), the Hanford Reach National Monument is the second largest nationally protected area in Washington, and it is the only national monument managed by the USFWS (Dicks 1999; Tate 2005).

Metals and anions in water from the Columbia River have been detected at locations upstream and downstream of the Hanford Site. Arsenic, antimony, cadmium, chromium, copper, lead, mercury, nickel, selenium, thallium, and zinc were detected in most samples, with similar concentrations at most locations. When taking into account total hardness (47 to 77 mg/L) as calcium carbonate ($CaCO_3$) from 1992 through 2008, all metal and anion concentrations in river water were less than the Washington ambient surface water quality criteria for the protection of aquatic life. Arsenic concentrations exceeded the EPA human health standard for the consumption of water and organisms; however, this value is 10,500 times lower than the state chronic toxicity value (Poston et al. 2010).

Columbia River samples collected along cross-river transects had slightly elevated concentrations of nitrate, chloride, and sulfate along both shorelines at the 100-North Area in 2009. They were also elevated at the city of Richland and the 300 Area. Elevated nitrate concentrations at the Hanford Site shoreline are from the contaminated groundwater plumes emanating from the 200 Area. Elevated concentrations of nitrate, chloride, and sulfate in other samples have been attributed to groundwater seepage associated with high fertilizer usage and extensive irrigation upstream of the Columbia River to the north and east (Poston et al. 2010).

Radionuclide concentrations monitored in Columbia River water were low throughout 2009. Tritium (H-3), U-234, U-238, and naturally occurring K-40 were consistently detected in filtered river water at levels greater than their reported minimum detectable concentrations. Sr-90, U-235, Pu-238, and Pu-239/240 were detected occasionally, but at levels near the minimum detectable concentrations. The concentrations of all other radionuclides were typically below the minimum detectable concentrations. Tritium, strontium, and plutonium are present in worldwide fallout from historical nuclear weapons testing as well as in effluent from Hanford Site facilities. Tritium and uranium are naturally occurring elements in the environment. The average gross alpha and gross beta concentrations in Columbia River water at Richland during 2009 were less than the Washington State criteria for ambient surface water quality of 15 and 50 pCi/L, respectively (Poston et al. 2010).

Surface water sampled across transects at various locations along the Columbia River shows a statistical increase in tritium and uranium between samples taken upstream of the site at Vernita Bridge and those taken downstream of the site at the Richland pump house. These constituents are known to be entering the river from contaminated groundwater beneath the

Hanford Site. For samples collected in 2009, the highest tritium concentration measured in cross-river transect water was 60 ± 7.0 pCi/L; the highest concentration in near-shore water was 180 ± 72 pCi/L (both samples were collected near the Hanford town site). Both tritium concentrations are far less than the Washington State ambient surface water quality criterion of 20,000 pCi/L. The highest uranium concentration, 0.67 ± 0.10 pCi/L, was measured for the sample from the Franklin County shore of the 300 Area transect. For comparison, the EPA drinking water standard for uranium is approximately 20 pCi/L. Elevated uranium in this location was likely the result of groundwater seepage and water from irrigation return canals that had elevated uranium levels from the use of phosphate fertilizers (Poston et al. 2009).

Measurements of Sr-90 at the Richland pump house were not statistically higher than those at the Vernita Bridge, even though Sr-90 is known to enter the river through groundwater inflow at the 100-North Area. The maximum Sr-90 concentration for 2009 was 0.056 ± 0.023 pCi/L for a near-shore sample collected at the Vernita Bridge transect location (Poston et al. 2010).

During 2009, samples of the surface layer of Columbia River sediment were collected from six locations that were permanently submerged. Samples were also collected from the Priest Rapids Dam Reservoir and from the McNary Dam Reservoir and were obtained from slack water areas along the Hanford Reach and at the City of Richland. Radionuclides consistently detected at low levels in Columbia River sediment in 2009 included K-40, Cs-137, U-234, U-235, U-238, Pu-238, Pu-239/240, and progeny products from naturally occurring radionuclides. Detectable amounts of most metals were found in all river sediment samples. Maximum and average concentrations of most metals were higher for samples collected upstream of Priest Rapids Dam than for samples from either the Hanford Reach or McNary Dam and may be associated with mining in the area. There are no Washington freshwater sediment quality criteria for comparison to the measured metal values (Poston et al. 2010).

Two on-site ponds, West Lake and the Fast Flux Test Facility (FFTF) Pond (Figure 6.1.3-1), were also sampled in 2009. Samples were obtained quarterly and included water from both ponds and sediment from West Lake. All water samples were analyzed for tritium, and samples from the FFTF pond were also analyzed for gross alpha, gross beta, and gamma-emitting radionuclides. All radionuclide concentrations in on-site pond water samples were less than the applicable DOE-derived concentration guides and Washington State ambient surface water quality criteria (Poston et al. 2010). Concentrations in West Lake sediment samples were similar to concentrations measured in prior years (i.e., detectable concentrations for gross alpha, gross beta, K-40, Sr-90, Cs-137, and uranium isotopes) (Posten et al. 2010).

6.1.3.2 Groundwater

6.1.3.2.1 Unsaturated Zone. Groundwater occurs in both the unsaturated (vadose) and saturated zones at Hanford. The unsaturated zone at Hanford consists of glacio-fluvial sands and gravels. The depth to saturated groundwater varies from about zero in the vicinity of the Columbia River to more than 100 m (330 ft) in the area of the central plateau (Chamness and

Sweeney 2007). In the vicinity of the GTCC reference location, the thickness of the vadose zone is about 100 m (330 ft) (DOE 2012). The lower part of the unsaturated zone also consists of fluvial-lacustrine sediments of the Ringold Formation (Thorne and Last 2007).

6.1.3.2.2 Aquifer Units.

Basalt-Confined Aquifer System. The relatively permeable sedimentary interbeds and the more porous interflow zones of the basalt flow layers compose the confined aquifers within the Columbia River Basalt Group. Groundwater in this aquifer system generally flows toward the Columbia River; however, vertical interaquifer flow also occurs between the unconfined aquifer system and the confined aquifer system. Water chemistry data indicate that interaquifer flow has occurred in an area north of the 200 East Area, near the Gable Mountain anticlinal structure (Thorne and Last 2007). Figure 6.1.2-3 shows a stratigraphic column for Hanford.

Unconfined (Suprabasalt) Aquifer System. The unconfined aquifer system in the 200 East Area is composed primarily of the unconsolidated glaciofluvial sands and gravels of the Hanford Formation and Unit A gravels of the Ringold Formation. In some areas, such as most of the 200 West Area and some portions of the 100 Area, the fluvial-lacustrine sediments (Unit E) of the Ringold Formation make up the lower portion of the unconfined aquifer system. The pre-Missoula gravels of the Cold Creek Unit lie between these formations and below the water table. The other subunits of the Cold Creek Unit are generally above the water table. Along the southern edge of the 200 East Area, the water table is in the Ringold Unit E gravels. The upper Ringold facies were eroded in most of the 200 East Area by the ancestral Columbia River and, in some places, by the Missoula floods that subsequently deposited Hanford gravels and sands on what was left of the Ringold Formation. On the north side of the 200 East Area, there is evidence of erosional channels that may allow interaquifer flow between the unconfined and uppermost basalt-confined aquifer. Depth to groundwater ranges from 0 m (0 ft) at the Columbia River to more than 100 m (330 ft) beneath parts of the central plateau (Thorne and Last 2007).

Horizontal hydraulic conductivities in the Hanford Formation sands and gravels and the coarse-grained multilithic facies of the Cold Creek Unit (pre-Missoula gravels) range from about 10 to 3,000 m/d (30 to 900 ft/d). Sediments in the underlying Ringold formation are more consolidated and partially cemented and are 10 to 100 times less permeable than the sediments of the Hanford Formation. Because the Hanford Formation and possibly the Cold Creek Unit sand and gravel deposits are much more permeable than the Ringold gravels, the water table is relatively flat in the 200 East Area, but groundwater flow velocities are higher (Thorne and Last 2007).

Slug tests at five monitoring wells in the vicinity of the GTCC reference location indicate permeabilities ranging from more than about 25 m/d (82 ft/d) to more than 45 m/d (148 ft/d) (Reidel 2005).

The hydrology of the 200 Area has been strongly influenced by the discharge of large quantities of wastewater to the ground over a 50-year period between the 1940s and 1990s. The discharges caused elevated groundwater levels across much of the Hanford Site, resulting in a large groundwater mound beneath the former U Pond in the 200 West Area and a smaller mound beneath the former B Pond, just to the northeast of the 200 East Area. The general increase in groundwater elevation caused the unconfined aquifer to extend upward into the Hanford Formation over a larger area, particularly near the 200 East Area. This resulted in an increase in groundwater velocity because of both the greater volume of groundwater and the higher permeability of the newly saturated Hanford Formation sediments (Thorne and Last 2007).

Discharges to the ground have greatly decreased since 1984 and currently contribute a volume of recharge to the unconfined aquifer system that is in the same range as the estimated natural recharge from precipitation. Decreases in the water table elevation in the past 20 years have been greatest at the 200 West Area and are estimated to be more than 8 m (26 ft). Water levels are expected to continue to decrease as the unconfined groundwater system reaches equilibrium with the new level of artificial recharge (Hartman et al. 2007; Thorne and Last 2007).

6.1.3.2.3 Groundwater Flow. Groundwater in the unconfined aquifer system flows from recharge areas in the elevated region near the western boundary of the Hanford Site toward the Columbia River on the eastern and northern boundaries (Figure 6.1.3-5). The Columbia River is the primary discharge area for the unconfined aquifer. The Yakima River borders the Hanford Site on the southwest and is generally regarded as a source of recharge. The rate of total discharge of groundwater from the Hanford Site aquifer to the Columbia River is in the range of 1.1 to 2.5 cms (39 to 88 ft^3/s), a very small rate relative to the river's average flow of 3,300 cms (116,500 ft^3/s) (Hartman et al. 2007; Thorne and Last 2007).

Along the Columbia River shoreline, daily river-level fluctuations may result in changes in the water table elevation of up to 3 m (10 ft). During the high-river-stage periods of 1996 and 1997, some wells near the Columbia River showed water-level changes of more than 3 m (10 ft). As the river stage rises, a pressure wave is transmitted inland through the groundwater. The longer the duration of the higher-river stage, the farther inland the effect is propagated. The pressure wave is observed farther inland than the water actually moves. For the river water to flow inland, the river level must be higher than the groundwater surface and must remain high long enough for the water to flow through the sediments. Typically, this inland flow of river water is restricted to within several hundred feet of the shoreline (Thorne and Last 2007).

Because precipitation at the Hanford Site is low (long-term average annual precipitation is 7 in. or approximately 17 cm) and because evapotranspiration is high (in an arid climate, potential evapotranspiration can exceed precipitation), recharge rates to underlying aquifers are low (Hoitink et al. 2005). In the vicinity of the GTCC reference location, annual recharge is estimated to be approximately 3.5 mm (0.14 in). (DOE 2005).

At the 200 East Area, the water table is relatively flat because of the highly permeable sediment of the Hanford Formation. The hydraulic gradient near B Pond in the 200 Area varies

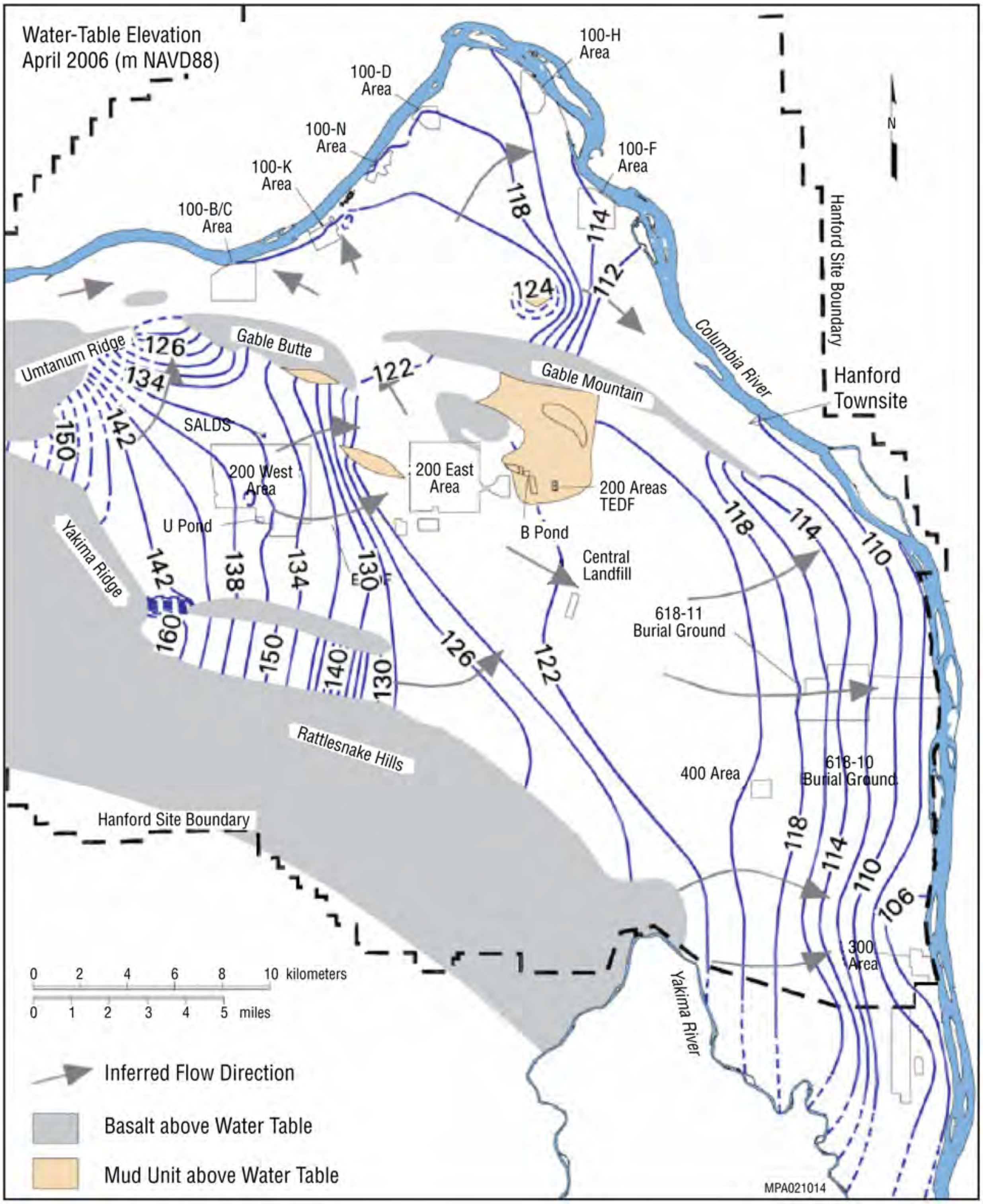


FIGURE 6.1.3-5 Water Table Elevations in Meters (1 m = 3.3 ft) and Inferred Groundwater Flow Directions for the Unconfined Aquifer at the Hanford Site in March 2006 (Source: Hartman et al. 2007)

from about 0.003 east of the mound apex to 0.006 west-southwest of the former location of the main pond (PNNL 2005). Groundwater enters the 200 East Area vicinity from the west and divides, with some migrating to the north through Gable Gap and some moving to the southeast toward the central part of the site. Groundwater flow in the unconfined aquifer is currently altered where extraction or injection wells are used for pump-and-treat systems (Hartman et al. 2007; Thorne and Last 2007).

Studies have indicated that the residence time of groundwater at the Hanford Site is on the order of thousands of years in the unconfined aquifer and more than 10,000 years for groundwater in the shallow confined aquifer, consistent with the recharge conditions expected for a semiarid climate. However, groundwater travel time from the 200 East Area to the Columbia River has been shown to be much faster, in a range of 10 to 30 years, because of the large volumes of wastewater discharged at the site in the past and the relatively high permeability of the Hanford Formation sediments. Travel times from the 200 Area to the Columbia River are expected to decrease because of the decrease in wastewater volume discharged in these areas and the reduced hydraulic gradient that will occur over time as a result (Thorne and Last 2007).

The subsurface hydrology of the 200 Areas has been strongly influenced by the discharge of large quantities of wastewater to the ground for more than 50 years. Those discharges have caused elevated water levels across much of Hanford, resulting in a groundwater mound beneath the former B Pond east of the 200-East Area and a larger groundwater mound beneath the former U Pond in the 200-West Area. Water table changes beneath the 200-West Area have been greatest because of the lower transmissivity of the aquifer in this area. After the beginning of Hanford operations during 1943, the water table rose about 27 m (89 ft) under the U Pond disposal area in the 200 West Area and about 9.1 m (30 ft) under disposal ponds near the 200 East Area. The volume of water that was discharged to the ground at the 200 West Area was actually less than that discharged at the 200 East Area. However, the lower hydraulic conductivity of the aquifer near the 200 West Area inhibited groundwater movement in this area, resulting in a higher groundwater mound. The presence of the groundwater mounds locally affected the direction of groundwater movement, causing radial flow from the discharge areas. Until about 1980, the edge of the mounds migrated outward from the sources over time. Groundwater levels have declined over most of the Hanford Site since 1984 because of decreased wastewater discharges; however, a residual groundwater mound beneath the 200 West Area is still shown by the curved water table contours near this location. A small groundwater mound near the wastewater disposal sites of the 200 Area Treated Effluent Disposal Facility (TEDF) (east of 200 East Area) and State-Approved Land Disposal Site (SALDS) (north of 200 West Area) is also still apparent (Thorne and Last 2007).

In recent years, discharges of water to the ground have been greatly reduced, and corresponding decreases in the water table elevation have been measured. The decline in part of the 200-West Area has been more than 8 m (26 ft). Water levels are expected to continue to decrease as the unconfined groundwater system reaches equilibrium with the new level of artificial recharge (Duncan 2007). Currently, the water table elevation is about 11 m (36 ft) above the estimated water table elevation prior to the start of Hanford operations. Computer simulations show that when equilibrium conditions are established in the aquifer after site closure, the water table may still be 5 to 7 m (16 to 23 ft) higher than the pre-Hanford water table because of modeling uncertainties, artificial recharge from off-site irrigation, or differences in current Columbia River conditions as compared with pre-Hanford times, such as dam construction (DOE 2010).

Across the 200-East Area, the depth to the water table varies from approximately 65 m (213 ft) to 100 m (328 ft), and the thickness of the saturated zone above the top of the basalt varies from 0 m in the north to about 80 m (262 ft) in the south. The depth to the water table in the 200-West Area varies from about 50 m (164 ft) to greater than 100 m (328 ft). Beneath the 200-West Area, the saturated thickness of the unconfined aquifer varies from about 65 m (213 ft) to greater than 150 m (492 ft) (Hartman 2000).

Groundwater beneath the 200-West Area generally flows from west to east across most of the area, but it is locally influenced by the 200-ZP-1 groundwater pump-and-treat remediation system. The decline in liquid effluent discharges to the soil in the 200-West Area and the resulting decline in the water table have changed the flow direction in the northern part of the area about 35 degrees over the past decade from a north-northeast to a more eastward direction. Flow in the central part of the 200-West Area (the south part of the 200-ZP-1 Operable Unit) is strongly influenced by the operation of the 200-ZP-1 groundwater pump-and-treat remediation system. This system extracts water from the vicinity of the 216-Z cribs and trenches (ditches), treats it to remove carbon tetrachloride and other volatile organic compounds, then reinjects the water into the aquifer west of the area (DOE 2010).

Recharge rates from precipitation across the Hanford Site are estimated to range from near zero to more than 100 mm/yr (3.94 in./yr). Between 1944 and the mid 1990s, the volume of artificial recharge from Hanford wastewater disposal was significantly greater than the natural recharge. An estimated 1.7×10^{12} L (4.44×10^{11} gal) of liquid was discharged to disposal ponds and cribs during this period. Because of the reduction in discharges, groundwater levels are falling, particularly around the operational areas (Chamness and Sweeney 2007). Vertical gradients between the basalt-confined aquifer and the unconfined aquifer are upward on most of the Hanford Site (Murray et al. 2003; Hartman et al. 2007; Thorne and Last 2007).

American Indian Text

Purity of water is very important to the Indian People, and thus DOE should be managing for an optimum condition considering Tribal cultural connection and direct use of water, rather than managing for a minimum water quality threshold. From the perspective of the Indian People, the greatest long-term threat at the Hanford site lies in the contaminated groundwater. There is insufficient characterization of the vadose zone and groundwater. There is a tremendous volume of radioactive and chemical contamination in the groundwater. The mechanisms of flow and transport of contaminants through the soil to the groundwater are still largely unknown. The volumes of contamination within the groundwater and direction of flow are still only speculative. Due to lack of knowledge and limited technical ability to remediate the vadose zone and groundwater puts the Columbia River at continual risk.

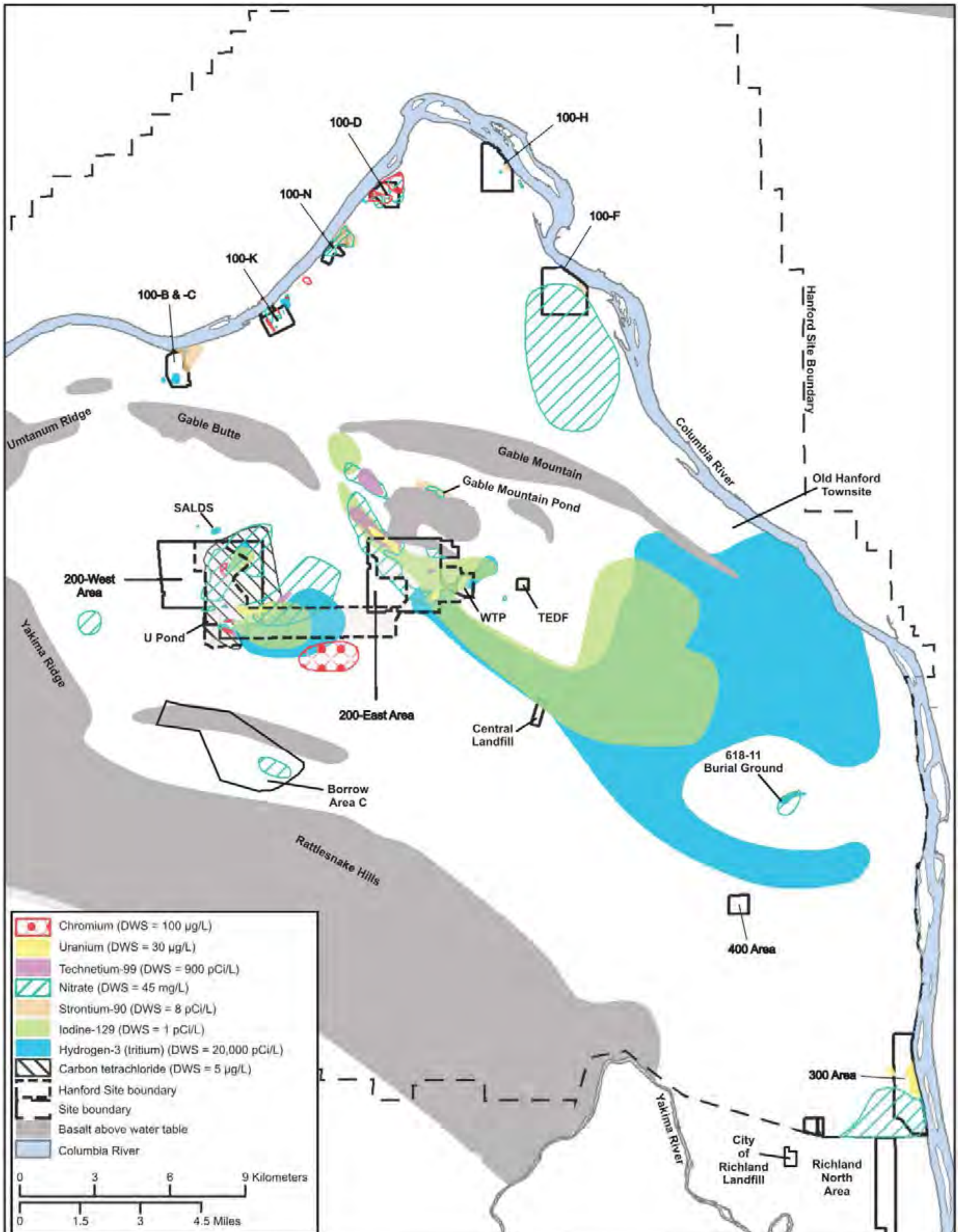
6.1.3.2.4 Groundwater Quality. The natural quality of groundwater at the Hanford Site varies depending on the aquifer system and depth, which are generally related to the residence time in the aquifer. Some of the shallower basalt-confined aquifers in the region (e.g., the Wanapum basalt aquifer) have exceptionally good water quality. Deeper basalt-confined aquifers, however, typically have a high dissolved solids content, and some have fluoride concentrations that exceed the drinking water standard of 4 mg/L (Thorne and Last 2007).

Groundwater in the unconfined aquifer beneath large areas of the Hanford Site has been contaminated by radiological and chemical constituents because of past site operations. These contaminants were primarily introduced through wastewater discharged to cribs, ditches, injection wells, trenches, and ponds. Additional contaminants from spills, leaking waste tanks, and burial grounds (landfills) have also entered groundwater in some areas. Contaminant plumes had sources in the 200 East Area and extend to the east and southeast; contaminant concentrations in these plumes are expected to decline through radioactive decay, mineral adsorption, chemical degradation, and dispersion. However, contaminants also exist within the vadose zone beneath waste sites as well as in waste storage and disposal facilities. These contaminants have the potential to continue to move downward into the aquifer (Hartman et al. 2007; Thorne and Last 2007).

Groundwater contamination is being actively remediated through pump-and-treat operations at the 200 West Area, 100-D Area, and 100-H Area. Extraction wells in the 100-K, 100-D, 100-H, and 200 West Areas capture contaminated water from the surrounding areas. These operations are summarized in Hartman et al. (2007). At the 100-N Area, pump-and-treat remediation has been terminated, and a passive treatment barrier is being used to reduce contaminant migration. Currently, no active groundwater remediation is occurring at the operable unit (200-PO-1) underlying the southern portion of the 200 East Area (Hartman et al. 2007).

Radiological and chemical constituents in groundwater at the Hanford Site are monitored to characterize physical and chemical trends in the flow system, establish groundwater quality baselines, assess groundwater remediation, and identify new or existing groundwater problems. Groundwater monitoring is also performed to verify compliance with applicable environmental laws and regulations. Samples were collected from 778 wells and 247 shoreline aquifer tubes during FY 2006 to determine the distributions of radiological and chemical constituents in Hanford Site groundwater. A total of 3,357 samples of Hanford groundwater were analyzed for chromium, 1,680 samples for nitrate, and 1,180 for tritium. Figure 6.1.3-6 shows the distribution of radionuclides and chemicals across the Hanford Site. Other constituents frequently analyzed include Tc-99, uranium, and CCl_4. The monitoring results are reported in the Hanford Site groundwater monitoring reports, which are produced annually.

Operable Unit 200-PO-1 encompasses the southern portion of the 200 East Area and a large part of the Hanford Site extending to the east and southeast. Groundwater within 200-PO-1 is contaminated with plumes of tritium, nitrate, and I-129. Tritium concentrations continued to decline as a result of radioactive decay and dispersion. Other contaminants (e.g., Sr-90 and Tc-99) were detected in limited areas near cribs or tank farms (Hartman et al. 2007).



Key: µg/L=micrograms per liter; DWS=drinking water standard; mg/L=milligrams per liter; pCi/L=picocuries per liter; SALDS=State-Approved Land Disposal Site; TEDF=Treated Effluent Disposal Facility; WTP=Waste Treatment Plant.
Source: Modified from DOE 2010:xxii.

FIGURE 6.1.3-6 Distribution of Major Radionuclides and Hazardous Chemicals in the Unconfined Aquifer System during the 2009 Reporting Period

TABLE 6.1.3-1 Maximum Concentrations of Selected Groundwater Contaminants at Operable Unit 200-PO-1 during FY 2006

Contaminant/Unit	DWS (DCG)[a]	Wells	Aquifer Tubes
Antimony (filtered) (μg/L)[b]	6		
Arsenic (filtered) (μg/L)	10	10.5	
Carbon tetrachloride (μg/L)	5	0.44	
C-14 (pCi/L)	2,000 (70,000)		
Cs-137 (pCi/L)	200 (3,000)		
Chloroform (TCM)[c] (μg/L)	100	0.62	
Chromium (dissolved) (μg/L)	100	41.1	
cis-1,2-Dichloroethene (μg/L)	70		
Co-60 (pCi/L)	100 (5,000)		
Cyanide (μg/L)	200		
Fluoride (mg/L)	4	7.3	0.21
Gross alpha (pCi/L)	15	33.5	
Gross beta (pCi/L)	50	2,020	3.27
I-129 (pCi/L)	1 (500)	9.11	
Mercury (μg/L)	2	0.09	
Nitrate (mg/L)	45	127	5.75
Nitrite (mg/L)	3.3	1.05	
Pu-239/240 (pCi/L)	NA[d] (30)		
Sr-90 (pCi/L)	8 (1,000)	20.6	
Tc-99 (pCi/L)	900 (100,000)	7,740	
Tetrachloroethene (PCE)[c] (μg/L)	5	1.7	
Trichloroethene (TCE)[c] (μg/L)	5	0.81	
Tritium (pCi/L)	20,000 (2,000,000)	571,000	3,790
Uranium (μg/L)	30	27.2	

[a] DWS = drinking water standard, DCG = DOE derived concentration guide.

[b] Detection limit is higher than DWS; not a known contaminant of interest on the Hanford Site.

[c] TCM = chloroform, PCE = tetrachloroethylene, TCE = trichloroethylene.

[d] NA = no DWS for Pu-239/240.

Source: Hartman et al. (2007)

6.1.3.3 Water Use

Prior to closure of the plutonium processing facilities at Hanford, a large quantity of process water was used. This water was primarily obtained from the Columbia River. Since the plutonium facilities were closed and the FFTF was placed on standby in 2007, much less water is being used. Currently, the 100-B Area Export Water System supplies raw/untreated water to the 200 Area Plateau and provides source water for fire protection, processing, and domestic water systems located across the entire Hanford Site (Klein 2007). Water is pumped from the Columbia River by using a 28,000-L/min (7,500-gpm) pump at the 181B River Pump Station. Water flows to the 182B Pump House and Reservoir for further distribution across the site. In

1998, the 200 East Area of Hanford had an annual water use of about 690 million L (182 million gal) and a capacity of about 2.6 billion L (686 million gal). This water was supplied by the Export Water System (DOE 1998).

> American Indian Text
>
> Hanford has delineated contamination areas called operable units (OUs); both subsurface contamination OUs and surface contamination OUs. When describing the affected environment for land use it is essential to reference this information that should be presented in the soils and groundwater sections. Understanding the types and extent of surface and subsurface contamination will give better understanding of the CLUP land use designations. For example, the proposed GTCC site at Hanford lies somewhere in or near the 200 ZP-1 groundwater OU. This OU has contamination from uranium, technetium, iodine 129 and other radioactive and chemical constituents.

6.1.4 Human Health

Potential radiation exposures to the off-site general public residing in the vicinity of the Hanford Site could result from the airborne release of radionuclides through stacks or vents,

> American Indian Text
>
> Tribal health involves access to traditional foods and places. Both of these are located on the Hanford facility and can be impacted by placement of the GTCC waste in the 200 area.
>
> Definition of Tribal health – Native American ties to the environment are much more complex and intense than is generally understood by risk assessors. All of the foods and implements gathered and manufactured by the traditional American Indian are interconnected in at least one way, but more often in many ways. Therefore, if the link between a person and his/her environment is severed through the introduction of contamination or physical or administrative disruption, the person’s health suffers, and the well being of the entire community is affected.
>
> To many American Indians, individual and collective well being is derived from membership in a healthy community that has access to, and utilization of, ancestral lands and traditional resources. This wellness stems from and is enhanced by having the opportunity and ability to live within traditional community activities and values. If the links between a tribal person and his or her environment were severed through contamination or DOE administrative controls, the well being of the entire community is affected.

discharge of liquid effluent to the Columbia River, and movement of contaminated groundwater to the Columbia River. As a result, potential exposure pathways for members of the off-site public include inhalation, air submersion, ingestion of foods contaminated through air deposition and water irrigation, external radiation from ground deposition, ingestion of aquatic food taken from the Hanford Reach of the Columbia River, and external radiation and ingestion of water through boating, swimming, and shoreline activities along the Hanford Reach of the Columbia River (Poston et al. 2010).

The doses to the general public in the vicinity of the Hanford Site are a small fraction of the dose limit of 100 mrem/yr set by DOE to protect the public from the operations of its facilities (DOE Order 458.1). Table 6.1.4-1 provides the radiation doses estimated for an individual located in the Horn Rapids Road area of the site vicinity in 2014. In addition to doses for this individual, the table also provides the collective dose for the population living within 80 km (50 mi) of the Hanford Site. The collective dose was estimated by considering similar exposure pathways to the highest exposed individual, with estimated fractions of the population expected to be affected by each pathway (DOE 2015a).

The off-site dose to the individual receiving the highest impacts from airborne releases was estimated to be 0.11 mrem/yr (DOE 2015a), which represents less than 1.1% of the EPA standard of 10 mrem/yr for airborne releases given in 40 CFR Part 61. When the estimated dose from radioactive liquid effluents is added to this, the total dose received by the off-site individual would be about 0.33 mrem/yr (DOE 2015a). This dose is well below the DOE limit of 100 mrem/yr from all applicable exposure pathways.

The collective radiation dose for the population of about 553,516 living within 80 km (50 mi) of the Hanford Site was estimated to be about 2.1 person-rem in 2014. When the collective dose is distributed evenly among this population, the average dose received by an off-site individual would be about 0.004 mrem/yr. This is about 0.00064% of the dose expected for a member of the U.S. population from natural background radiation and man-made sources (620 mrem/yr).

American Indian Text

Risk assessments should take a public health approach to defining community and individual health. Public health naturally integrates human, ecological, and cultural health into an overall definition of community health and well-being. This broader approach used with risk assessments is adaptable to indigenous communities that, unlike westernized communities, turn to the local ecology for food, medicine, education, religion, occupation, income, and all aspects of a good life.

TABLE 6.1.4-1 Estimated Annual Radiation Doses to Workers and the General Public at the Hanford Site

Receptor	Radiation Source	Exposure Pathway	Dose to Individual (mrem/yr)	Dose to Population (person-rem/yr)
On-site workers	Groundwater contamination	Water ingestion	0.019[a]	
	Air contamination	Inhalation	0.36[b]	
	Soil contamination and waste storage	Direct radiation	62[c]	40.7[c]
General public	Airborne release	Submersion, inhalation, ingestion of plant foods (contaminated through deposition), direct radiation from deposition	0.11[d]	0.86[e]
	Liquid effluent	Direct radiation from recreation, ingestion of water and plant foods (contaminated through irrigation)	0.04[f]	1.234[g]
	On-site waste management and storage	Direct radiation	0.01[h]	
	Liquid effluent	Ingestion of fish	0.18[i]	0.066[i]
Worker/public	Natural background radiation and man-made sources		620[k]	340,000[l]

[a] Dose corresponds to drinking 1 L of water per day for 250 days in a year. It was calculated on the basis of measured groundwater concentrations at the FFTF in 2014 (DOE 2015a).

[b] The inhalation dose was calculated with CAP88-PC along with stack emission data. According to the CAP88-PC results, in 2014, the dose from stack emissions to a worker at the Laser Interferometer Gravitational Wave Observatory was 0.36 mrem/yr (DOE 2015a).

[c] In 2014, 659 workers receiving measurable doses had a collective dose of 40.7 person-rem. When this collective dose is distributed evenly, the average individual dose is calculated to be 62 mrem/yr.

[d] The radiation dose from an airborne release was estimated with Hanford Site air emission data and the GENII computer code. In 2014, the location of the individual receiving the highest impacts was determined to be at 638 Horn Rapids Road. In addition, the dose from airborne releases at this location was also calculated by CAP88-PC to demonstrate compliance with the 10-mrem/yr standard given in 40 CFR Part 61. The dose calculated by using CAP88-PC was well below the standard (DOE 2015a).

Footnotes continue on next page.

TABLE 6.1.4-1 (Cont.)

[e] The collective dose was estimated for the population residing within 80 km (50 mi) of a Hanford Site facility. The maximum population size is about 553,516 (DOE 2015a).

[f] The radiation dose attributable to liquid effluents was calculated on the basis of the differences in radionuclide concentrations between upstream and downstream sampling points on the Columbia River (DOE 2015a).

[g] The collective dose was calculated by considering a population of 130,000 for the drinking water pathway, 125,000 for the aquatic recreation pathway, and 2,000 for the ingestion of plant foods (contaminated through irrigation) pathway.

[h] Data collected over years indicate the current radiation levels are at or near background levels and are stable or decreasing as on-site cleanup activities progress (Poston et al. 2010). Thermoluminescent dosimeter (TLD) measurements indicate the highest external dose rate at the site boundary is along the 100-N Area shoreline, with a reading of 0.002 mrem/h greater than the average shoreline readings (Poston et al. 2006). An assumed stay time of 5 hours per year along the 100-N Area shoreline would give a dose of 0.01 mrem/yr. The boundary external exposures were not included in the dose estimated for the general public because no one could actually reside in these boundary locations. However, the Columbia River allows public access to within approximately 100 m (330 ft) of the N Reactor and supporting facilities at this location (Poston et al. 2006).

[i] The dose was estimated to result from ingesting 40 kg (88 lb) of fish caught from the Columbia River (DOE 2015a).

[j] The collective dose was estimated by assuming a total catch of 15,000 kg (33,075 lb) per year from the Columbia River. All of the catch was consumed by the population surrounding the Hanford Site (DOE 2015a).

[k] Average dose to a member of the U.S. population as estimated in Report No. 160 of the National Council on Radiation Protection and Measurements (NCRP 2009).

[l] Collective dose to the population of 553,516 within 80 km (50 mi) of the Hanford Site from natural background radiation and man-made sources.

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The following four categories of an undisturbed environment contribute to individual and community health. Impacts to any of these functions can adversely affect health. Metrics associated with impacts within each of these categories are presented by Harper and Harris.

Human Health-Related Goods and Services: This category includes the provision of water, air, food, and native medicines. In a tribal subsistence situation, the land provided all the food and medicine that was necessary to enjoy long and healthy lives. From a risk perspective, those goods and services can also be exposure pathways.

Environmental Functions and Services: This category includes environmental functions such as soil stabilization and the human services that this provides, such as erosion control or dust reduction. Dust control in turn would provide a human health service related to asthma reduction.

Environmental functions such as nutrient production and plant cover would provide wildlife services such as shelter, nesting areas, and food, which in turn might contribute to the health of a species important to ecotourism. Ecological risk assessment includes narrow examination of exposure pathways to biota as well as examination of impacts to the quality of ecosystems and the services provided by individual biota, ecosystems, and ecology.

Social and Cultural Goods, Functions, Services, and Uses: This category includes many things valued by suburban and tribal communities about particular places or resources associated with intact ecosystems and landscapes. Some values are common to all communities, such as the aesthetics of undeveloped areas, intrinsic existence value, environmental education, and so on.

Economic Goods and Services: This category includes conventional dollar-based items such as jobs, education, health care, housing, and so on. There is also a parallel non-dollar indigenous economy that provides the same types of services, including employment (i.e., the functional role of individuals in maintaining the functional community and ensuring its survival), shelter (house sites, construction materials), education (intergenerational knowledge required to ensure sustainable survival throughout time and maintain personal and community identity), commerce (barter items and stability of extended trade networks), hospitality, energy (fuel), transportation (land and water travel, waystops, navigational guides), recreation (scenic visitation areas), and economic support for specialized roles such as religious leaders and teachers.

Individuals working at the Hanford Site are routinely monitored for radiation exposure. The primary radiation dose limit established by DOE to control worker exposure is 5 rem/yr (10 CFR Part 835). As discussed in Section 5.3.4.1.1, DOE established an administrative control level of 2 rem/yr for all DOE activities. The Hanford Site established a site-specific administrative control limit of 500 mrem/yr for the majority of the workers, and only on rare occasions would workers incur doses greater than 500 mrem/yr. Worker doses at the Hanford Site have been significantly below the 500-mrem/yr limit, largely as a result of the implementation of the ALARA program. Use of DOE's ALARA program ensures that worker doses are kept well below applicable standards.

For on-site workers, potential radiation exposures from the inhalation and water ingestion pathways were much smaller than those from the external radiation pathway. The estimated inhalation dose to a non-DOE individual working at the site was estimated to be 0.0055 mrem/yr (DOE 2015a), and the estimated dose to an on-site worker from drinking contaminated water was estimated to be 0.019 mrem/yr (DOE 2015a). Both of these dose estimates are conservative; the actual doses from these two pathways were probably much lower (DOE 2015a).

According to the worker radiation exposure data published by DOE (2015b), in 2015, 659 workers received measurable doses from activities at the Hanford Site. A collective dose of 40.7 person-rem was recorded, which would result in an average individual dose of 62 mrem/yr.

6.1.5 Ecology

The Hanford Site is located within a shrub-steppe desert dominated by perennial shrubs and bunchgrasses (*Agropyron* spp.). The relatively undisturbed shrub-steppe, riverine, and riparian habitats at the Hanford Site are considered to be biologically important (The Nature Conservancy 2003b). Shrub-steppe habitat is considered a priority habitat (habitat types or elements with unique or significant value to a diverse assemblage of species) by the State of Washington (WDFW 2008) and a Level III resource (biological resources that require mitigation because of their state listing, potential for federal or state listing, unique or significant value for biota, special administration designation, or environmental sensitivity) under the Hanford Site Biological Resources Management Plan (DOE 2001b). On upland, undisturbed areas (especially on zonal, silt loam soils), the vegetation is dominated by big sagebrush (*Artemisia tridentata*) and associated shrubs, perennial bunchgrasses, and forbs, whereas plant communities on sandy soils and stony loams are characterized by bitterbrush (*Purshia tridentata*) and several species of desert buckwheat (*Eriogonum* spp.). In the areas where fires have removed shrubs, large areas of grass-dominated communities have developed (Poston and Sackschewsky 2007).

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Indian People have lived in these lands for a very long time and thus have learned about the resources and their ecological interrelationships. They knew about environmental indicators that foretold seasons and conditions that guided them. When Cliff Swallows first appear in the spring, their arrival is an indicator that the fish are coming up the river. Doves are the fish counters, telling how many fish are coming. Many natural phenomena foretell when the earth is coming alive again in the spring, even if things are dormant underground. The Tribes have traditional ecological knowledge of this environment and tribal people have ceremonies that acknowledge the arrival of Spring. The winds bring information about what will happen. It provides guidance about how to bring balance back to the land.

In 2000, 66,322 ha (163,884 ac) of land were burned by the 24 Command Fire (a wildfire); 56,246 ha (138,986 ac) of the burning took place within the Hanford Site. This wildfire consumed nearly all of the vegetative cover within the Fitzner Eberhardt Arid Lands Ecology Reserve and a large portion of Hanford's central plain (Tiller et al. 2000). The extent of the fire included areas to the west, south, and east of but not including the GTCC reference location at the Hanford Site. About 85% of the vegetation was significantly reduced within the fire area, including 18 ha (44 ac) of willow riparian habitat. Potential long-term impacts from the fire include establishment of invasive species and changes in natural plant communities (DOE 2012). Most of the disturbed areas at Hanford (including areas burned by wildfire and abandoned farmlands), where the native shrub component has been modified severely or replaced altogether, are dominated by nearly pure stands of cheatgrass (DOE 1999).

Invasive plant species are one of the most serious threats to native biodiversity at the Hanford Site (The Nature Conservancy 2003a,b). About 25% of the nearly 730 plant species that occur on the Hanford Site are nonnative species (Sackschewsky and Downs 2001), with cheatgrass and diffuse knapweed (*Centaurea diffusa*) being among the dominant nonnative species. Vegetation types with a significant cheatgrass understory (which often occur in heavily grazed or disturbed areas) are generally of lower habitat quality than those areas with a bunchgrass understory (Poston and Sackschewsky 2007).

The GTCC reference location primarily contains a sagebrush/bunchgrass-cheatgrass plant community (Poston et al. 2010). The dominant plant species on the 200 Area Plateau are big sagebrush, rabbitbrush (*Chrysothamnus* spp.), cheatgrass, and Sandberg's bluegrass (*Poa secunda*) (Sackschewsky and Downs 2001). The understory vegetation in these communities includes forbs, bunchgrasses, and a cryptogamic soil crust. The common bunchgrass species include needle-and-thread (*Hesperostipa comata*), Indian ricegrass (*Achnatherum hymenoides*), Cusick's bluegrass (*Poa cusickii*), and Idaho fescue (*Festuca idahoensis*) (Sackschewsky and Downs 2001). Most of the waste disposal and storage sites in the 200 Areas are planted with nonnative crested or Siberian wheatgrass (*Agropyron cristatum* or *A. fragile*) to stabilize surface soil, control soil moisture, or displace more invasive deep-rooted species, such as Russian thistle (*Salsola kali*) (Poston and Sackschewsky 2007). Russian thistle and rabbitbrush that occur in these areas are deeply rooted. Deeply rooted plants have the potential to accumulate radionuclides or other contaminants (DOE 1999).

Wetlands on the Hanford Site primarily occur in the riparian zone along the Columbia River. Rattlesnake and Snively Springs also support riparian wetland habitats. Large wetland ponds created by irrigation runoff occur north of the Columbia River. These ponds are used extensively as nesting sites by waterfowl (DOE 2012). Other wetland habitats include the man-made ponds and ditches occurring on the Hanford Site, including the B Pond Complex near the 200 East Area. Since effluent flows to the B Pond Complex have ceased, that complex is slowly reverting to an upland shrub-steppe ecosystem. Wetland plants, such as cattails and bulrushes, occur in scattered patches at West Lake (DOE 1999). No wetland habitats occur within the immediate vicinity of the GTCC reference location.

More than 300 species of terrestrial vertebrates occur on the Hanford Site (46 mammals, 246 birds, 12 reptiles, and 5 amphibians) (Poston and Sackschewsky 2007). Common mammal species at the Hanford Site include elk (*Cervus elaphus*), mule deer (*Odocoileus hemionus*), coyote (*Canis latrans*), bobcat (*Lynx rufus*), American badger (*Taxidea taxus*), black-tailed jackrabbit (*Lepus californicus*), mountain cottontail (*Sylvilagus nuttallii*), Townsend's ground squirrel (*Spermophilus townsendii*), northern pocket gopher (*Thomomys talpoides*), bushy-tailed woodrat (*Neotoma cinerea*), brown rat (*Rattus norvegicus*), and house mouse (*Mus musculus*) (Downs et al. 1993). During summer, the pallid bat (*Antrozous pallidus*), little brown myotis (*Myotis lucifugus*), and Yuma myotis (*M. yumanensis*) are common at riparian habitats and near buildings (Downs et al. 1993). The Great Basin pocket mouse (*Perognathus parvus*) and North American deermouse (*Peromyscus maniculatus*) are the most abundant and second most abundant mammal species on the Hanford Site, respectively. The coyote is the most abundant large carnivore. Mule deer are common and range over the entire Hanford Site but are most common along the Columbia River (Downs et al. 1993; Fitzner and Gray 1991). Within the Hanford Site, elk occur primarily within the Fitzner Eberhardt Arid Lands Ecology Reserve. They do not occur in the vicinity of the 200 East Area (Tiller et al. 2000) but are occasionally observed on the 200 Area Plateau and at the White Bluffs boat launch area. A number of bat species, the Norway rat, and the house mouse are common near buildings (Fitzner and Gray 1991). The black-tailed jackrabbit is commonly associated with mature stands of sagebrush, while mountain cottontails are commonly associated with buildings, debris piles, and equipment laydown areas associated with laboratory and industrial activities (DOE 1999).

Among the bird species that have been recorded at the Hanford Site, 145 species are considered to be common (Poston and Sackschewsky 2007). Common passerines include the western meadowlark (*Sturnella neglecta*), horned lark (*Eremophila alpestris*), long-billed curlew (*Numenius americanus*), vesper sparrow (*Pooecetes gramineus*), sage sparrow (*Amphispiza belli*), sage thrasher (*Oreoscoptes montanus*), grasshopper sparrow (*Ammodramus savannarum*), and loggerhead shrike (*Lanius ludovicianus*) (DOE 1999). Common upland game birds include the chukar (*Alectoris chukar*), California quail (*Callipepla californica*), and ring-necked pheasant (*Phasianus colchicus*). Western sage grouse (*Centrocercus urophasianus*), gray partridge (*Perdix perdix*), and scaled quail (*Callipepla squamata*) also occur on the site. Twenty-six species of raptors have been observed on the Hanford Site, with 11 species known to nest on the site (DOE 1999). These species include the American kestrel (*Falco sparverius*), red-tailed hawk (*Buteo jamaicensis*), Swainson's hawk (*Buteo swainsoni*), golden eagle (*Aquila chrysaetos*), northern harrier (*Circus cyaneus*), prairie falcon (*Falco mexicanus*), barn owl (*Tyto alba*), great horned owl (*Bubo virginianus*), long-eared owl (*Asio otus*), and burrowing owl occur year long at the Hanford Site. The ferruginous hawk (*Buteo regalis*) will nest on transmission line support structures (DOE 1999). Bird species that occur within wetland and riparian habitats include a number of neotropical migrants, migratory waterfowl, and shorebirds. Large numbers of ducks and geese occur along the Hanford Reach of the Columbia River during fall and winter months, with white pelicans (*Pelecanus erythrorhynchos*), double-crested cormorants (*Phalacrocorax auritus*), and common loons (*Gavia immer*) also occurring during winter months (DOE 1999). Waterfowl, shorebirds, and other birds also make use of the on-site waste ponds and West Lake (Fitzner and Gray 1991). Fitzner and Rickard (1975) observed 126 bird species that utilized the small waste ponds (including their associated vegetation and air space) on the 200 Area Plateau.

The side-blotched lizard (*Uta stansburiana*) is the most common reptile species occurring throughout the Hanford Site. The most common snake species include the racer (*Coluber constrictor*), the gophersnake (*Pituophis catenifer*), and the western rattlesnake (*Crotalus viridis*) (Poston and Sackschewsky 2007). Amphibians reported from the Hanford Site include the Great Basin spadefoot toad (*Spea intermontana*), western toad (*Anaxyrus boreas*), Woodhouse's toad (*Anaxyrus woodhousii*), tiger salamander (*Ambystoma tigrinum*), bullfrog (*Lithobates catesbeianus*), and Pacific treefrog (*Pseudacris regilla*) (Poston and Sackschewsky 2007; Bilyard et al. 2002). They occur near permanent water bodies and along the Columbia River (DOE 1999).

American Indian Text

There are big horned rattlesnakes that are very big rattlesnakes. These were a part of our lives and we treated them with respect. We called them grandfather. Most of these green and black rattlesnakes began to disappear years ago but some lasted until a few years ago. These big horned snakes seem to be gone now due to changes in the land. The elk used to live down here, but now the changes have pushed most of them away (Wanupum elder).

The major aquatic habitat on the Hanford Site is the Columbia River (DOE 2012). It is located about 11 km (6.8 mi) from the 200 East Area (DOE 2012). The Yakima River, a major tributary to the Columbia River, also crosses through a small portion of the southern boundary of the site. Other natural aquatic habitats on the site include small spring-streams and seeps located primarily in the Rattlesnake Hills area; West Lake (also known as West Pond) located north of the 200 East Area (currently less than 2 ha [5 acres] in size); and three clusters of about 20 vernal pools and ponds located at the eastern end of Umatanum Ridge, central portion of Gable Butte, and at the eastern end of Gable Mountain. Several artificial ponds also occur on the Hanford Site. Three Liquid Effluent Retention Facility impoundments occur just east of the 200 East Area. None of these habitats occur within the immediate vicinity of the GTCC reference location.

The federally and state-listed species occurring or potentially occurring on the Hanford Site are listed in Table 6.1.5-1. None of the federally threatened, endangered, or candidate species occur within the GTCC reference location (Poston and Sackschewsky 2007).

6.1.6 Socioeconomics

Socioeconomic data for Hanford describe an ROI consisting of two counties, Benton and Franklin Counties in Washington, that surrounds the site. More than 90% of Hanford workers reside in these counties (Fowler and Scott 2007).

American Indian Text

Columbia River salmon runs, once the largest in the world, have declined over 90% during the last century. The 7.4 – 12.5 million average annual number of fish above Bonneville Dam have dropped to 600,000. Of these, approximately 350,000 are produced in hatcheries. Many salmon stocks have been removed from major portions of their historic range.

Multiple salmon runs reach the Hanford Nuclear Reservation. These runs include Spring Chinook, Fall Chinook, Sockeye, Silver and Steelhead. The runs tend to begin in April and end in November. Salmon runs have been decimated as a result of loss and change to habitat. The changes include non-tribal commercial fisheries, agriculture interests, and especially construction of hydro-projects on the Columbia River. Protection and preservation of anadromous fisheries were not a priority when the 227 Columbia River dams were constructed. Some dams were constructed without fish ladders and ultimately eliminated approximately half of the spawning habit available in the Columbia System.

The Hanford Reach is approximately 51 miles long and is the only place on the upper main stem of the Columbia River where Chinook salmon still spawn naturally. This reach is the last free flowing section of the Columbia River above Bonneville Dam. It produces about eighty to ninety percent of the fall Chinook salmon run on the Columbia River.

Tribal elders say that the last runs of big salmon (Chinook) that came through the Hanford Reach occurred in 1905. Non-Tribal Commercial fisheries on the lower Columbia are largely responsible for the loss of the large Chinook salmon. The Columbia River Tribes, out of a deep commitment to the fisheries and in spite of the odds, plan to restore stocks of Chinook, Coho, Sockeye, Steelhead, Chum, Sturgeon and Pacific Lamprey. This effort was united in 1995 under a recovery plan called the Wy-Kan-Ush-Mi Wa-Kish-Wit (Spirit of the Salmon). Member tribes are the Nez Perce Umatilla, Warm Springs and Yakama.

Indian People see themselves as the keepers of ancient truths and laws of nature. Respect and reverence for the perfection of Creation are the foundation of their culture. Salmon are part of our spiritual and cultural identity. Tribal values are transferred from generation to generation with the salmon returns. Without salmon, tribes would lose the foundation of their spiritual and cultural identity.

All tribes affected by the Hanford site are co-managers of Columbia River fisheries including assisting in tagging fry and counting redds along the Hanford Reach for the purposes of estimating fish returns. This information is essential in the negotiation of fish harvest between the USA and Canada as well as between Indian and non-Indian fishermen. In many ways, the loss of salmon mirrors the plight of native people. Elders remind us that the fate of humans and salmon are linked. The circle of life has been broken with the loss of traditional fishing sites and salmon runs on the Columbia River.

TABLE 6.1.5-1 Federally and State-Listed Threatened, Endangered, and Other Special-Status Species on the Hanford Site

Common Name (Scientific Name)	Status[a] Federal/State
Plants	
Awned halfchaff sedge (*Lipocarpha aristulata*)	-/ST
Beaked spike-rush (*Eleocharis rostellata*)	-/SS
Canadian St. John's wort (*Hypericum majus*)	-/SS
Chaffweed (*Anagallis minima*)	-/ST
Columbia milkvetch (*Astragalus columbianus*)	SC/SS
Columbia yellowcress (*Rorippa columbiae*)	SC/SE
Coyote tobacco (*Nicotiana attenuata*)	-/SS
Desert cryptantha (*Cryptantha scoparia*)	-/SS
Desert dodder (*Cuscuta denticulata*)	-/ST
Desert evening-primrose (*Oenothera primiveris*)	-/SS
Dwarf evening primrose (*Camissonia pygmaea*)	-/SS
Fuzzytongue penstemon (*Penstemon eriantherus*)	-/SS
Geyer's milkvetch (*Astragalus geyeri*)	-/ST
Grand redstem (*Ammannia robusta*)	-/ST
Gray cryptantha (*Cryptantha leucophaea*)	SC/SS
Great Basin gilia (*Gilia leptomeria*)	-/ST
Hepatic monkeyflower (*Mimulus jungermannioides*)	SC/X
Hoover's desert parsley (*Lomatium tuberosum*)	SC/SS
Lowland toothcup (*Rotala ramosior*)	-/ST
Palouse goldenweed (*Pyrrocoma liatriformis*)	SC/ST
Piper's daisy (*Erigeron piperianus*)	-/SS
Rosy pussypaws (*Cistanthe rosea*)	-/T
Small-flowered evening primrose (*Camissonia minor*)	-/SS
Snake River cryptantha (*Cryptantha spiculifera*)	-/SS
Spreading loeflingia (*Loeflingia squarrosa* ssp. *squarrosa*)	-/ST
Suksdorf's monkeyflower (*Mimulus suksdorfii*)	-/SS
Umtanum desert buckwheat (*Eriogonum codium*)	C/SE
Ute ladies'-tresses (*Spiranthes diluvialis*)	T/E
White Bluff bladderpod (*Lesquerella tuplashensis*)	C/ST
White eatonella (*Eatonella nivea*)	-/ST
Molluscs	
California floater (*Anodonta californiensis*)	SC/SCa
Giant Columbia River spire snail (*Fluminicola columbiana*)	SC/SCa
Shortfaced lanx (*Fisherola nuttalli*)	-/SCa
Insects	
Columbia clubtail (*Gomphus lynnae*)	SC/SCa
Columbia River tiger beetle (*Cicindela columbica*)	-/SCa
Silver-bordered fritillary (*Boloria selene atrocostalis*)	-/SCa
Fish	
Bull trout (*Salvelinus confluentus*)	T/SCa
Leopard dace (*Rhinichthys falcatus*)	-/SCa
Marginal sculpin (*Cottus marginatus*)	SC/SS

TABLE 6.1.5-1 (Cont.)

Common Name (Scientific Name)	Status[a] Federal/State
Fish (Cont.)	
Mountain sucker (*Catostomus platyrhynchus*)	-/SCa
Pacific lamprey (*Lampetra tridentata*)	SC/-
River lamprey (*Lampetra ayresii*)	SC/SCa
Steelhead (redband trout) (*Oncorhynchus mykiss*)	SC/SCa
Western brook lamprey (*Lampetra richardsoni*)	SC/-
Amphibians and Reptiles	
Northern sagebrush lizard (*Sceloporus graciosus graciosus*)	SC/SCa
Sagebrush lizard (*Sceloporus graciosus*)	SC/SCa
Striped whipsnake (*Masticophis taeniatus*)	-/SCa
Western toad (*Anaxyrus boreas*)	SC/SCa
Birds	
American white pelican (*Pelecanus erythrorhynchos*)	-/SE
Bald eagle (*Haliaeetus leucocephalus*)	SC/SS
Burrowing owl (*Athene cunicularia*)	SC/SCa
Common loon (*Gavia immer*)	-/SS
Ferruginous hawk (*Buteo regalis*)	SC/ST
Flamulated owl (*Otus flammeolus*)	-/SCa
Golden eagle (*Aquila chrysaetos*)	-/SCa
Greater sage-grouse (*Centrocercus urophasianus*)	C/ST
Lewis's woodpecker (*Melanerpes lewis*)	-/SCa
Loggerhead shrike (*Lanius ludovicianus*)	SC/SCa
Merlin (*Falco columbarius*)	-/SCa
Northern goshawk (*Accipiter gentilis*)	SC/SCa
Peregrine falcon (*Falco peregrinus*)	SC/SS
Sage sparrow (*Amphispiza belli*)	-/SCa
Sage thrasher (*Oreoscoptes montanus*)	-/SCa
Sandhill crane (*Grus canadensis*)	-/SE
Western grebe (*Aechmophorus occidentalis*)	-/SCa
Yellow-billed cuckoo (*Coccyzus americanus*)	C/SCa
Mammals	
Black-tailed jackrabbit (*Lepus californicus*)	-/SCa
Merriam's shrew (*Sorex merriami*)	-/SCa
Pallid Townsend's big-eared bat (*Corynorhinus townsendii pallescens*)	SC/SCa
Pygmy rabbit (*Brachylagus idahoensis*)	E/E
Townsend's ground squirrel (*Spermophilus townsendii*)	SC/SCa
Washington ground squirrel (*Spermophilus washingtoni*)	C/SCa
White-tailed jackrabbit (*Lepus townsendii*)	-/SCa

Footnotes continue on next page.

TABLE 6.1.5-1 (Cont.)

[a] C (candidate): A species for which the USFWS or National Oceanic and Atmospheric Administration (NOAA) Fisheries has on file sufficient information on biological vulnerability and threats to support a proposal to list as endangered or threatened.

E (endangered): An animal or plant species in danger of extinction throughout all or a significant portion of its range.

SC (species of concern): An informal term referring to a species that might be in need of conservation action. This may range from a need for periodic monitoring of populations and threats to the species and its habitat, to the necessity for listing as threatened or endangered. Such species receive no legal protection under the ESA and use of the term does not necessarily imply that a species will eventually be proposed for listing.

SCa (state candidate): Under review for state listing.

SE (state endangered): In danger of becoming extinct or extirpated from Washington.

SM (state monitor): Taxa of potential concern.

SS (state sensitive): Vulnerable or declining and could become endangered or threatened in state.

ST (state threatened): Likely to become endangered in Washington.

T (threatened): A species likely to become endangered within the foreseeable future throughout all or a significant portion of its range.

X: Possibly extinct or extirpated from Washington.

-: Not listed.

Sources: Caplow (2003); DOE (2009); Poston and Sackschewsky (2007); Poston et al. (2009); USFWS (2007a,b,c); WDFW (2009); WDNR (2009); letter from K.S. Berg, USFWS, to A.M. Edelman, DOE (see Appendix F of this EIS)

American Indian Text

Artificial light can be a "pollutant" when it creates measurable harm to the environment. Light can affect nocturnal and diurnal animals such as bats, owls, night crawlers and other species. Night light also has known affects on diurnal creatures and plants by interrupting their natural patterns. Light can affect reproduction, migration, feeding and other aspects of a living organism's survival. Artificial light can also reduce the quality of experience, including star gazing, during tribal cultural and ceremonial activities. Extensive light pollution is already being produced by the Hanford site.

6.1.6.1 Employment

In 2011, total employment in the ROI stood at 123,978 (U.S. Department of Labor 2012). Employment grew at an annual average rate of 2.6% between 2002 and 2011. The economy of the ROI was dominated by the agricultural and service industries, with employment in these activities contributing about 72% to all employment (Table 6.1.6-1). Trade was also a large employer in the ROI, contributing about 14% to total ROI employment. During fiscal year (FY) 2006, an average of 9,759 employees were employed by DOE and its contractors (Fowler and Scott 2007).

6.1.6.2 Unemployment

Unemployment rates have varied across the counties in the ROI (Table 6.1.6-2). Over the 10-year period 2002–2011, the average rate in Franklin County was 7.7%, with a lower rate of 6.3% in Benton County. The average rate in the ROI over this period was 6.6%, lower than the average rate in the state of 7.0%. Unemployment rates for 2011 were slightly higher than those for 2010; in Franklin County, the unemployment rate increased from 8.7% to 8.8%, while in Benton County, the rate rose from 7.4% to 7.6%. The average rates for the ROI rose from 7.8% to 7.9%, and those for the state dropped from 9.9% to 9.2% during this period.

TABLE 6.1.6-1 Hanford Site: County and ROI Employment by Industry in 2009

Sector	Benton County	Franklin County	ROI Total	% of ROI Total
Agriculture[a]	20,427	13,636	34,063	32.1
Mining	0	60	60	0.1
Construction	3,808	1,324	5,132	4.8
Manufacturing	3,224	2,058	5,282	5.0
Transportation and public utilities	814	949	1,763	1.7
Trade	10,229	4,096	14,325	13.5
Finance, insurance, and real estate	2,718	689	3,407	3.2
Services	35,380	6,700	42,080	39.6
Other	2	0	2	0.0
Total	76,665	29,515	106,180	

[a] USDA (2008).

Source: U.S. Bureau of the Census (2012a)

American Indian Text

Direct production by tribes is part of the economy that needs to be represented, especially considering the Tribe's emphasis on salmon recovery. This type of individual commerce in modern economics is termed and calculated as "direct production". The increase in direct production would be relational to the region's salmon recovery, yet there is no economic measure (within the NEPA process) to account for this robust element of a traditional economy.

In a traditional sense, direct production is a term of self and community reliance on the environment for existence as opposed to employment or modern economies. Direct production is use of salmon and raw plant materials for foods, ceremonial, and medicinal needs and the associated trading or gifting of these foods and materials. Direct production needs to be understood, and should include elements like: use of plant foods, ceremonial plants, medicinal plants, beadwork, hide work, tule mats and dried salmon.

An example of this economy would be the documented number of Native Americans that fished at Celilo Falls; as many as 1500 fisherman assembled at the site not far from Hanford during the peak fishing seasons. Trading between and among tribes include but are not limited to items like dentalia shells, mountain sheep horns, bows, horses, baskets, tule mats, art, bead work, leather and raw hide, and buffalo.

TABLE 6.1.6-2 Hanford Site: Average County, ROI, and State Unemployment Rates (%) in Selected Years

Location	2002–2011	2010	2011
Benton County	6.3	7.4	7.6
Franklin County	7.7	8.7	8.8
ROI	6.6	7.8	7.9
Washington	7.0	9.9	9.2

Source: U.S. Department of Labor (2012)

6.1.6.3 Personal Income

Personal income in the ROI stood at almost $8.9 billion in 2009, growing at an annual average rate of growth of 3.8% over the period 2000–2009 (Table 6.1.6-3). ROI personal income per capita also rose over the same period, reaching $36,214 in 2009, compared with $33,048 in 2000. Per-capita incomes were higher in Benton County ($40,164 in 2009) than elsewhere in the ROI.

American Indian Text

Modern Tribal Economy

A subsistence economy is one in which currency is limited because many goods and services are produced and consumed within families or bands, and currency is based as much on obligation and respect as on tangible symbols of wealth and immediate barter. It is well-recognized in anthropology that indigenous cultures include networks of materials interlinked with networks of obligation. Together these networks determine how materials and information flow within the community and between the environment and the community. Today, there is an integrated interdependence between formal (cash-based) and informal (barter and subsistence-based) economic sectors that exists and must be considered when thinking of economics and employment of tribal people.

Indian People engage in a complex web of exchanges that often involves traditional plants, minerals, and other natural resources. These exchanges are a foundation of community and intertribal relationships. Thus there are natural resource issues, some of which are located on Hanford, that involve direct production that permeate Indian life. Indian People catch salmon that become gifts to others living near and far. Sharing self-gathered food or self-made items is a part of establishing and maintaining reciprocal relationships. People have similar relationships between places and elements of nature, which are based on mutual respect for the rights of animals, plants, places and people.

Use of the Hanford site and surrounding areas by tribes was tied primarily to the robust Columbia River fishery. Past social activities of native people include gatherings for such activities like marriages, trading, feasts, harvesting, fishing, and mineral collection. Tribal families and bands lived along the Columbia either year round or seasonally for catching, drying and smoking salmon. The reduction of salmon runs, loss of fishing sites due to dam impoundments and Hanford land use restrictions have contributed to the degradation of the supplies necessary for this gifting and barter system of our tribal culture.

The future of salmon and treaty-reserved fisheries will likely be determined during the life of the GTCC waste. With the tremendous efforts to recover salmon (and other fish species) by tribes, government agencies, and conservation organizations, Tribal expectations are that these species will be recovered to healthy populations.

If aquatic species were to recover, the regional economy and tribal barter economy would likely greatly increase in the Hanford area. These fish returns and the associated social and economic potential should be considered within the lifecycle of a GTCC waste repository.

TABLE 6.1.6-3 Hanford Site: County, ROI, and State Personal Income in Selected Years

Income	2000	2009	Average Annual Growth Rate (%), 2000–2009
Benton County			
Total personal income (2011 $ in billions)	5.0	6.8	3.3
Personal income per capita (2011 $)	35,444	40,164	1.4
Franklin County			
Total personal income (2011 $ in billions)	1.3	2.1	5.8
Personal income per capita (2011 $)	26,130	27,619	0.6
ROI total			
Total personal income (2011 $ in billions)	6.3	8.9	3.8
Personal income per capita (2011 $)	33,048	36,214	1.0
Washington			
Total personal income (2011 $ in billions)	250.2	299.5	2.0
Personal income per capita (2011 $)	42,454	44,949	0.6

Source: DOC (2012)

6.1.6.4 Population

The population of the ROI was at 253,340 in 2010 (U.S. Bureau of the Census 2012b) and was expected to reach 267,833 by 2012 (Table 6.1.6-4). In 2010, 175,177 people were living in Benton County (about 69% of the ROI total). Over the period 2000–2010, the population in the ROI as a whole grew moderately, with an average annual growth rate of 2.8%, with a higher-than-average annual growth in Franklin County (4.7%). The population in Washington as a whole grew at a rate of 1.3% over the same period.

TABLE 6.1.6-4 Hanford Site: County, ROI, and State Population in Selected Years

Location	1990	2000	2010	Average Annual Growth Rate (%), 2000–2010	2012[a]
Benton County	112,560	142,478	175,177	2.1	182,568
Franklin County	37,473	49,347	78,163	4.7	85,694
ROI total	150,033	191,825	253,340	2.8	267,833
Washington	4,866,692	5,894,121	6,724,540	1.3	6,904,167

[a] Argonne National Laboratory projections.

Source: U.S. Bureau of the Census (2012b)

6.1.6.5 Housing

The housing stock in the ROI as a whole grew at an annual rate of 2.6% over the period 2000–2010 (Table 6.1.6-5). A total of 20,994 new units were added to the existing housing stock in the ROI between 2000 and 2010. In 2010, 4,492 housing units in the ROI were vacant, of which 1,449 were rental units that could be available to construction workers at the GTCC LLRW and GTCC-like waste disposal facility.

6.1.6.6 Fiscal Conditions

Expenditures of the various jurisdictions and school districts in the ROI are presented in Table 6.1.6-6. Additional revenues to support these expenditures could come primarily from state and local sales tax revenues associated with employee spending during construction and operations and be used to support additional local community services currently provided by each jurisdiction.

6.1.6.7 Public Services

Data on employment related to providing public safety, fire protection, community and educational services, and local physician services in the counties, cities, and school districts

TABLE 6.1.6-5 Hanford Site: County and ROI Housing Characteristics in Selected Years

Parameter	2000	2010
Benton County		
Owner occupied	36,344	44,852
Rental	16,522	20,722
Vacant units	3,097	3,314
Total units	55,963	68,618
Franklin County		
Owner occupied	9,740	23,245
Rental	5,100	7,846
Vacant units	1,244	1,178
Total units	16,084	24,423
ROI		
Owner occupied	46,084	67,827
Rental	21,622	28,568
Vacant units	4,341	4,492
Total units	72,047	93,041

Source: U.S. Bureau of the Census (2012b)

TABLE 6.1.6-6 Hanford Site: County, ROI, and State Public Service Expenditures in 2006 ($ 2011 in millions)[a]

Location	Local Government	School District
Benton County	124.5	147.1
Franklin County	48.4	66.5
ROI total	172.9	213.6
Washington	34,005	8,648

[a] Argonne National Laboratory projections.

likely to host relocating construction workers and operations employees are presented. This information is used to determine whether additional demands on these various public services could result from the construction and operations of a GTCC LLRW and GTCC-like waste disposal facility. Table 6.1.6-7 presents data on employment and levels of service (number of employees per 1,000 population) for public safety. Table 6.1.6-8 provides staffing and level-of-service data for school districts. Table 6.1.6-9 covers physicians.

TABLE 6.1.6-7 Hanford Site: County, ROI, and State Public Service Employment in 2009

	Benton County		Franklin County	
Service	No.	Level of Service[a]	No.	Level of Service[a]
Police protection	56	0.3	27	0.3
Fire protection[b]	150	0.9	47	0.6
	ROI		**Washington[c]**	
Service	No.	Level of Service[a]	No.	Level of Service[a]
Police protection	83	0.3	9,527	0.5
Fire protection[b]	197	0.8	6,696	1.0

[a] Level of service represents the number of employees per 1,000 persons in each county.

[b] Does not include volunteers.

[c] 2006 data.

Sources: U.S. Bureau of the Census (2008a,b; 2012b,c); FBI (2012); Fire Departments Network (2012)

TABLE 6.1.6-8 Hanford Site: County, ROI, and State Education Employment in 2011

Location	No. of Teachers	Level of Service[a]
Benton	1,590	20.4
Franklin	870	19.2
ROI total	2,460	19.9
Washington	53,448	19.3

[a] Level of service represents the number of teachers per 1,000 persons in each county.

Sources: National Center for Educational Statistics (2012); U.S. Bureau of the Census (2012b,c)

TABLE 6.1.6-9 Hanford Site: County, ROI, and State Medical Employment in 2010

County	No. of Physicians	Level of Service[a]
Benton	452	2.6
Franklin	68	0.9
ROI total	520	2.1
Washington[b]	16,243	2.5

[a] Level of service represents the number of physicians per 1,000 persons in each county.

[b] 2006 data.

Sources: AMA (2012); U.S. Bureau of the Census (2008b, 2012b)

6.1.7 Environmental Justice

Figures 6.1.7-1 and 6.1.7-2 and Table 6.1.7-1 show the minority and low-income compositions of the total population located in the 80-km (50-mi) buffer around the Hanford Site from Census Bureau data for the year 2010 and from CEQ guidelines (CEQ 1997). Persons whose incomes fall below the federal poverty threshold are designated as low income. Minority persons are those who identify themselves as Hispanic or Latino, Asian, Black or African American, American Indian or Alaska Native, Native Hawaiian or other Pacific Islander, or multi-racial (with at least one race designated as a minority race under CEQ). Individuals identifying themselves as Hispanic or Latino are included in the table as a separate entry. However, because Hispanics can be of any race, this number also includes individuals who also identified themselves as being part of one or more of the population groups listed in the table.

A large number of minority and low-income individuals are located in the 50-mi (80-km) area around the boundary of the reference location. Within the 50-mi (80-km) radius in Oregon, 38.4% of the population is classified as minority, while 14.9% is classified as low income.

However, the number of minority individuals does not exceed the state average by 20 percentage points or more, and the number of minority individuals does not exceed 50% of the total population in the area; that is, there is no minority population in the Oregon portion of the 50-mi (80-km) area as a whole based on 2010 Census data and CEQ guidelines. The number of low-income individuals does not exceed the state average by 20 percentage points or more and does not exceed 50% of the total population in the area; that is, there are no low-income populations in the Oregon portion of the 50-mi (80-km) area around the reference location as a whole.

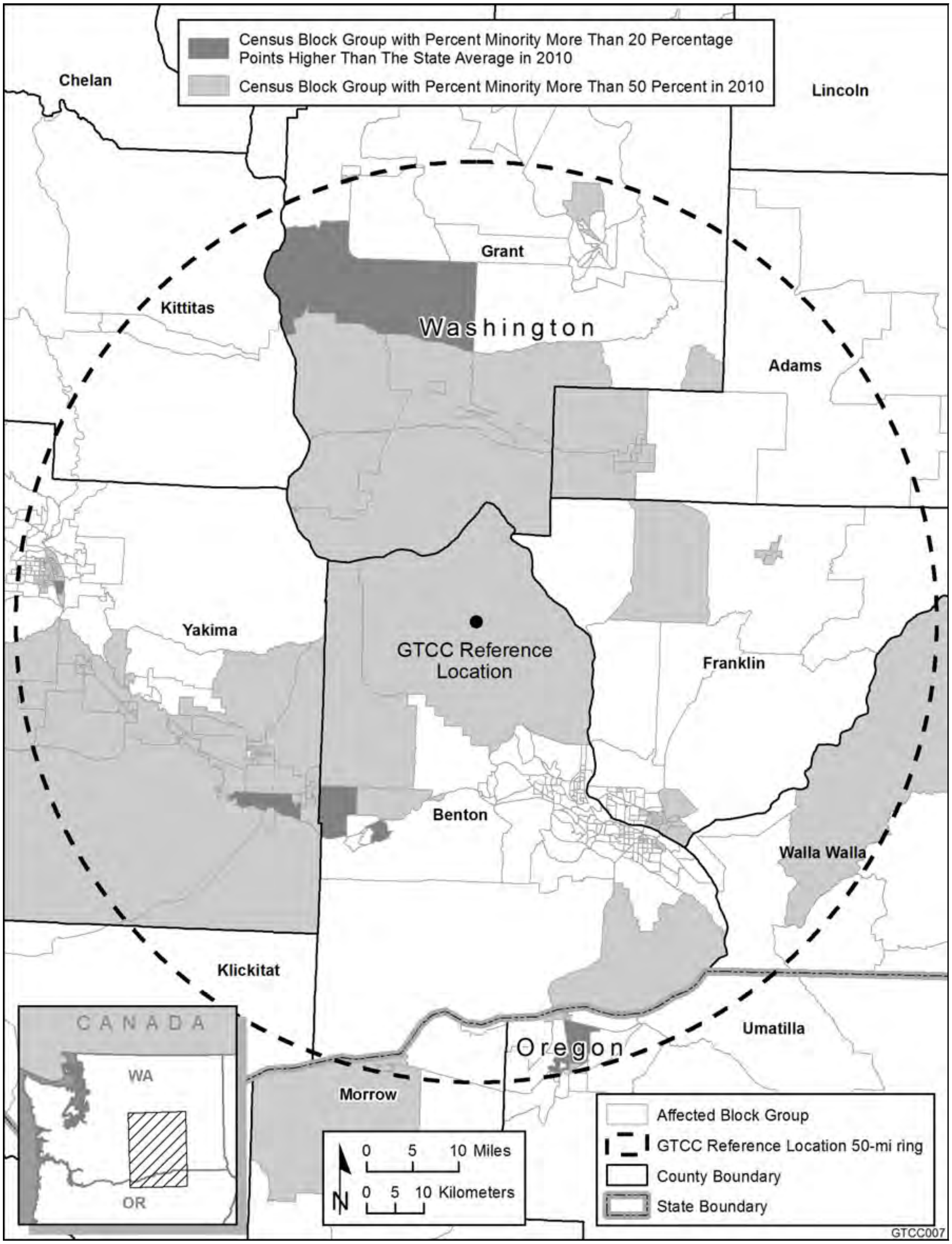

FIGURE 6.1.7-1 Minority Population Concentrations in Census Block Groups within an 80-km (50-mi) Radius of the GTCC Reference Location at the Hanford Site (Source: U.S. Bureau of the Census 2012b)

FIGURE 6.1.7-2 Low-Income Population Concentrations in Census Block Groups within an 80-km (50-mi) Radius of the GTCC Reference Location at the Hanford Site (Source: U.S. Bureau of the Census 2012b)

TABLE 6.1.7-1 Minority and Low-Income Populations within an 80-km (50-mi) Radius of the Hanford Site

Population	Oregon Block Groups	Washington Block Groups
Total population	44,846	566,519
White, non-Hispanic	27,620	312,541
Hispanic or Latino	15,183	218,904
Non-Hispanic or Latino minorities	2,043	35,074
One race	1,427	25,391
Black or African American	438	5,648
American Indian or Alaskan Native	441	9,757
Asian	440	8,714
Native Hawaiian or other Pacific Islander	71	496
Some other race	37	776
Two or more races	616	9,683
Total minority	17,226	253,978
Percent minority	38.4%	44.8%
Low-income	2,081	28,365
Percent low-income	14.9%	16.0%
State percent minority	21.5%	27.5%
State percent low-income	14.3%	12.3%

Source: U.S. Bureau of the Census (2012b)

Within the 50-mi (80-km) radius in Washington, 44.8% of the population is classified as minority, while 16.0% is classified as low income. The number of minority individuals does not exceed the state average by 20 percentage points or more, and the number of minority individuals does not exceed 50% of the total population in the area; that is, there is no minority population in the Washington portion of the 50-mi (80-km) area as a whole area based on 2010 Census data and CEQ guidelines. The number of low-income individuals does not exceed the state average by 20 percentage points or more and does not exceed 50% of the total population in the area; that is, there are no low-income populations in the Washington portion of the 50-mi area (80-km) area around the reference location as a whole.

6.1.8 Land Use

The 151,775-ha (375,040-ac) Hanford Site was established in 1943 as a defense materials production site that included nuclear reactor operations, uranium and plutonium processing, storage and processing of SNF, and management of radioactive and hazardous wastes. To support its mission, nine plutonium production reactors were constructed on the site. People who had been residing on the site were relocated, and the existing farmsteads and villages were abandoned. The reactors operated through the 1960s; most of them were phased out by 1969. By 1970, only the N Reactor was operational. It stopped producing plutonium in 1988 (Fitzner and Gray 1991).

American Indian Text

President Clinton signed Executive Order 12898 to address Environmental Justice issues and to commit each federal department and agency to “make achieving Environmental Justice part of its mission.” According to the Executive Order, no single community should host disproportionate health and social burdens of society’s polluting facilities. Many American Indians are concerned about the interpretation of “Environmental Justice” by the U.S. Federal Government in relation to tribes. By this definition, tribes are included as a minority group. However, the definition as a minority group fails to recognize tribes’ sovereign nation-state status, the federal trust responsibility, or protection of treaty and statutory rights of American Indians. Because of a lack of the these details, tribal governments and federal agencies have not been able to develop a clear definition of Environmental Justice in Indian Country, and thus it is difficult to determine appropriate actions.

American Indian and Alaskan Natives use and manage the environment holistically; everything is viewed as living and having a spirit. Thus, many federal and state environmental laws and regulations designed to protect the environment do not fully address the needs and concerns of American Indian and Alaskan Natives. Land based resources are the most important assets to tribes spiritually, culturally and economically.

DOE analysis of Environmental Justice is uniformly inadequate to address Native American rights, resources, and concerns. At Hanford, Tribal rights, health, and resources are always more impacted than those of the general population due to the traditional lifeways, close connections to the natural and cultural resources, and natural resource trusteeship. Thus, Hanford EJ analyses generally find that beneficial impacts of new missions, such as new jobs or more taxes, accrue to the local non-native community, yet fail to recognize that the majority of negative impacts accrue to Native Americans, such as higher health risk, continuation of restricted access, lack of natural resource improvement, and so on. The identification of rural EJ populations, particularly Native Americans, is not always obvious if an impacted area is not directly on a reservation. Further, Native American communities face environmental exposures that are greater than those faced by other EJ communities because of their greater contact with the environment that occurs during traditional practices and resource uses.

Since its incorporation into the Hanford Site, the land has been protected from livestock grazing, agricultural encroachment, and recreational off-highway use (Vaughan and Rickard 1977). In 1967, a 26,000-ha (64,000-ac) area of Hanford (the Arid Land Ecology Reserve in the southwestern section of the Hanford Site) was designated as an environmental research area. In 1977, the entire Hanford Site was designated as a NERP. In 1978, the Hanford Reach of the Columbia River was re-opened for public access after a period of 25 years of restricted access. Public access west of the river is still restricted. However, wildlife research by Hanford Site contractors and university personnel is encouraged within this area (Fitzner and Gray 1991).

American Indian Text

The Indian People recommend that DOE continue efforts to identify special places and landscapes with spiritual significance. Newly identified sites would be added to those already requiring American Indian ceremonial access and needing long-term stewardship.

The Tribes maintain that aboriginal and treaty rights allow for the protection, access to, and use of resources. These rights were established at the origin of the Native People and persist forever. There are sites or locations within the existing Hanford reservation boundary with tribal significance that are presently restricted through DOE's institutional controls and should be considered for special protections or set aside for traditional and contemporary ceremonial uses. Sites like the White Bluffs, Gable Mountain, Rattlesnake Mountain, Gable Butte, and the islands on the river are known to have special meaning to Tribes and should be part of the discussion for special access and protection. These locations should be placed in co-management with DOE, FWS and the Tribes for long-term management and protection.

American Indian Text

The Native people will continue to work with DOE via its cooperative agreement on cleanup issues to ensure that treaty rights and cultural and natural resources are being protected and that interim cleanup decisions are protective of human health and the environment.

Land use categories at Hanford include preservation, conservation, recreation, industrial, and R&D (DOE 2012). Only about 6% of the site has been disturbed for DOE facilities, which are widely dispersed throughout the site (DOE 2012). Much of the site is undeveloped, providing a safety and security buffer for the smaller areas used for site operations. Programs currently conducted at the Hanford Site include management of radioactive wastes; cleanup of waste sites, soils, and groundwater related to past releases; stabilization and storage of SNF; renewable energy technologies; waste disposal technologies; contamination cleanup; and plutonium stabilization and storage. The GTCC reference location would be situated within an industrial (exclusive) area that borders the extensive conservation (mining) land use area.

The 200 Areas cover about 5,100 ha (12,600 ac) within the Central Plateau portion of the Hanford Site. The 200 East and West Area facilities were built to process irradiated fuel from production reactors. Subsequent liquid wastes that were produced as a result of fuel processing were placed in tanks or disposed of in cribs, ponds, or ditches in the 200 Area. Treatment, storage, and disposal of solid wastes are conducted near the 200 Area. Unplanned releases of radioactive and nonradioactive waste have contaminated some portions of the 200 Area. The U.S. Navy also uses Hanford nuclear waste treatment, storage, and disposal facilities. DOE constructed the Environmental Restoration Disposal Facility (ERDF) next to the southeast corner of the 200 West Area to provide disposal capacity for environmental remediation waste (e.g., LLRW, mixed LLRW, and dangerous wastes) generated during remediation of the 100, 200, and 300 Areas of the Hanford Site. A commercial LLRW disposal facility operated by American Ecology currently occupies about 40 ha (100 ac) of the 200 Area Plateau. This facility, located just west of the GTCC reference location, is located on lands leased by the State of Washington from the federal government and subleased to US Ecology, Inc. Descriptions of the activities that occur in the other operational areas and other developed areas of the Hanford Site can be found in DOE (2012).

Most of the Hanford Site is administered by DOE for waste management, environmental restoration, and R&D. Some portions are administered by other agencies. In 2000, the President issued a proclamation establishing the 78,900-ha (195,000-ac) Hanford Reach National Monument that surrounds the central portion of the Hanford Site (The Nature Conservancy 2003b). The Monument includes land adjacent to the Columbia River and other areas on the Hanford Site that encompass the Saddle Mountain National Wildlife Refuge and the Fitzner-Eberhardt Arid Lands Ecology Reserve. The USFWS manages most of the lands within the Monument under existing agreements with DOE. Those lands within the Monument not subject to existing agreements are managed by DOE; however, DOE must consult with the Secretary of the Interior when developing any management plans that could affect these lands.

Land use within the vicinity of the Hanford Site includes urban and industrial development, wildlife protection areas, recreation, irrigated and dry land farming, and livestock grazing. These land use practices are not expected to change drastically during the upcoming decades. An LLRW decontamination, supercompaction, plasma gasification, macro-encapsulation, and vitrification unit (operated by Permafix) and a commercial nuclear fuel fabrication facility (operated by AREVA) adjoin the Hanford Site.

6.1.9 Transportation

The Tri-Cities (Kennewick, Pasco, and Richland) serve as a regional transportation and distribution center with major air, land, and river connections. Interstate highways that serve the

American Indian Text

A Presidential Proclamation established the Hanford Reach National Monument (Monument) (Presidential Proclamation 7319) and it directed the DOE and the U.S. Fish and Wildlife Service (FWS) jointly manage the monument. The Monument covers an area of 196,000 acres on the Department of Energy's (DOE) Hanford Reservation. DOE permits and agreements delegate authorities to FWS for 165,000 acres. The DOE directly manages approximately 29,000 acres, and the Washington Department of Fish and Wildlife currently manages the remainder (approximately 800 acres) through a separate DOE permit. The Monument is co-managed by the FWS and the DOE; each agency has several missions they fulfill at the Hanford Site. The FWS is responsible for the protection and management of Monument resources and people's access to

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Continued

Monument lands under FWS control. The FWS also has the responsibility to protect and recover threatened and endangered species; administer the Migratory Bird Treaty Act; and protect fish, wildlife and Native American and other trust resources within and beyond the boundaries of the Monument.

The FWS developed a comprehensive conservation plan (CCP) for management of the Monument as part of the National Wildlife Refuge System as required under the National Wildlife Refuge System Improvement Act. The CCP is a guide to managing the Monument lands (165,000 acres). It should be understood that FWS management of the Monument is through permits or agreements with the DOE.

The National Monument encompasses a biologically diverse landscape containing an irreplaceable natural and historic legacy. Limited development over approximately 70 years has allowed for the Monument to become a haven for important and increasingly scarce plants and animals of scientific, historic and cultural interest. It supports a broad array of newly discovered or increasingly uncommon native plants and animals. Migrating salmon, birds and hundreds of other native plant and animal species, some found nowhere else in the world, rely on its natural ecosystems. The Monument also includes 46.5 miles of the last free-flowing, non-tidal stretch of the Columbia River, known as the “Hanford Reach.”

Tribes participated in the development of the CCP with regard to protection of natural and cultural resources and tribal access. Based on the Presidential Proclamation that established the Hanford Reach National Monument, Affected tribes assume that all of Hanford will be restored and protected.

American Indian Text

The present DOE land use document for Hanford, called the Comprehensive Land Use Plan (CLUP), has institutional controls that limit present and future use by Native Americans. DOE plans to remove some institutional controls over time as the contamination footprint is reduced as a result of instituting the 2015 vision along the river and also the proposed cleanup of the 200 area. With removal of institutional controls, the affected tribes assume they can resume access to usual and accustomed areas. Future decisions about land transfer must consider the implications for Usual and Accustomed uses (aboriginal and treaty reserved rights) in the long-term management of resource areas. The 50-year management time horizon of the CLUP does not create permanent land use designations. On the contrary, land use designations or their boundaries can be changed in the interim at the discretion of DOE and/or Hanford stakeholders. The CLUP is often misused by assuming designations are permanent. Also, it is important to note that the interim land use designations in the CLUP cannot abrogate treaty rights. That requires an act of Congress.

American Indian Text

There are several federal regulations, policies, and executive orders that define tribal access that override institutional controls of the Comprehensive Land Use Plan (CLUP) or the Comprehensive Conservation Plan (CCP) when risk levels are acceptable for access. The following is a brief summary of those legal references:

- According to the American Indian Religious Freedom Act, tribal members have a protected right to conduct religious ceremonies at locations on public lands where they are known to have occurred before. There has been an incomplete effort to research the full extent of tribal ceremonial use of the Hanford site.

- Executive Order 13007 supports the American Religions Freedom Act by stating that Tribal members have the right to access ceremonial sites. This includes agencies to maintain existing trails or roads that provide access to the sites.

- DOE managers that are considering the placement of GTCC waste at Hanford must evaluate any potential impact to ceremonial access as part of their trust responsibility to Tribes.

There are locations that have specific protections due to culturally significant findings, burial sites, artifact clusters, etc. These types of areas are further described under the Cultural Resources Sections. As decommissioning and reclamation occurs across the Hanford site, any culturally significant findings will continue to expand the list of sites and their locations with special protections that override existing land use designation as outlined in the CLUP or other documents.

area are I-82 and I-182. I-82 is 8 km (5 mi) south-southwest of the Hanford Site. I-182, an urban connector route that is 24-km (15-mi) long and located 8 km (5 mi) south-southeast of the site, provides an east-west corridor linking I-82 to the Tri-Cities area. I-90, located north of the site, is the major link to Seattle and Spokane and extends to the East Coast. I-82 serves as a primary link between Hanford and I-90, as well as I-84. I-84, located south of the Hanford Site in Oregon, is a major corridor leading to Portland, Oregon. SR 224, also south of the site, serves as a 16-km (10-mi) link between I-82 and SR 240. SR 24 enters the site from the west, continues eastward across the northernmost portion of the site, and intersects SR 17 approximately 24 km (15 mi) east of the site boundary. SR 17 is a north-south route that links I-90 to the Tri-Cities and joins US 395, continuing south through the Tri-Cities. Northern US 395 also provides direct access to I-90. SR 240 and 24 traverse the Hanford Site and are maintained by the state.

Access to the Hanford Site is via three main routes: Hanford Route 4S from Stevens Drive or George Washington Way in the City of Richland, Route 10 from SR 240 near its intersection with SR 225, or Route 11A from SR 240. Another route, through the Rattlesnake Barricade, is located 35 km (22 mi) northwest of Stevens Drive and is accessible only to passenger vehicles. The estimated total number of commuters to this area is 3,100. Approximately 87% of the workers commuting to the 200 Areas are from the Tri-Cities, West Richland, Benton City, and Prosser. Table 6.1.9-1 summarizes traffic counts in the vicinity of the Hanford Site.

TABLE 6.1.9-1 Traffic Counts in the Vicinity of the Hanford Site

Location	Average Daily Traffic Volume
I-182, vicinity of SR 240	35,000
SR 240, between Columbia Center Blvd. and I-182	54,000
Stevens Drive	
At Horn Rapids Road	8,300
North of SR 240	22,000
George Washington Way	
At Hanford Site entrance	1,800
North of McMurray	18,000
Just north of I-182	43,000

A DOE-maintained road network within the Hanford Site consists of 607 km (377 mi) of asphalt-paved road and provides access to the various work centers. Primary access roads on the Hanford Site are Routes 1, 2, 3, 4, 6, 10, and 11A. The 200 East Area is accessed primarily by Route 4 South from the east, by Route 4 North off Route 11A from the north, and by Route 11A for vehicles entering the site at the Yakima Barricade. A new access road was opened in late 1994 to provide access directly to the 200 Areas from SR 240. Public access to the 200 Areas and interior locations of the Hanford Site has been restricted by guarded gates at the Wye Barricade (at the intersection of Routes 10 and 4), the Yakima Barricade (at the intersection of SR 240 and Route 11A), and Rattlesnake Barricade south of the 200 West Area.

The Hanford Site rail system originally consisted of approximately 210 km (130 mi) of track. It connected to the Union Pacific commercial track at the Richland Junction (at Columbia Center in Kennewick) and to a now-abandoned commercial ROW (Chicago, Milwaukee, St. Paul, and Pacific Railroad) near Vernita Bridge in the northwest section of the site. Prior to 1990, annual railcar movements numbered about 1,400 sitewide, and they transported materials such as coal, fuel, hazardous process chemicals, and radioactive materials and equipment. In October 1998, 26 km (16 mi) of track from Columbia Center to Horn Rapids Road were transferred to the Port of Benton and are currently operated by the Tri-City & Olympia Railroad.

6.1.10 Cultural Resources

The Hanford Site is located in central Washington and is bordered on the north and east by the Columbia River. The Hanford Site is located in an arid shrub-steppe climate. The area is rich in cultural material and has been used extensively both in the prehistoric and historic periods. The earliest evidence for human activity at the site dates from roughly 8,000 years ago. Most activity was concentrated near the Columbia River and its tributaries; the surrounding areas were used primarily for hunting. Historic use of the area began in 1805 when the Lewis and Clark expedition traveled through the area on the Columbia River. More permanent settlement began in the 1860s when a ferry was established on the Columbia River. Towns that developed

American Indian Text

Native people have been traveling this homeland to usual and accustomed areas for a very long time. Early modes of transportation began with foot travel. Domesticated dogs were utilized to carry burdens. Dugout canoes were manufactured and used to traverse the waterways when the waters were amiable. Otherwise, trails along the waterways were used. The arrival of the horse changed how people traveled. Numerous historians note its arrival to the Columbia Plateau in the late 1700's but they are mistaken. The arrival of the horse was actually a full century earlier in the late 1600's. Its acquisition merely quickened movement on an already extant and heavily used travel network. This travel network was utilized by many tribal groups on the Columbia Plateau and was paved by thousands of years of foot travel. Early explorers and surveyors utilized and referenced this extensive trail network. Some of the trails have become major highways and the Columbia and Snake Rivers are still a crucial part of the modern transportation network.

The Middle Columbia Plateau of the Hanford area is the crossroads of the Columbia Plateau located half way between the Great Plains and the Pacific Northwest Coast. In this area, major Columbia River tributaries (the Walla Walla, Snake, and Yakima Rivers) flow into this section of the main stem Columbia River. These rivers formed a critical part of a complex transportation network north, south, east, and west through the region including the Columbia River through the Hanford site. The slow water at the Wallula Gap was one of the few places where horses could traverse the river year round. The river crossing at Wallula provided access to a vast web of trails that crossed the region. Portions of these trails are known to cross the Hanford site.

Present Transportation:

There are two interstate highways that near the site [Interstate 90 (I-90) and Interstate 84 (I-84)]. Interstate 84 was part of the ancient trail system, at one time called the Oregon Trail, and is a primary transportation corridor for nuclear waste that enters the State of Oregon at Ontario, Oregon. I-84 and a Union Pacific rail line also cross the Umatilla Indian Reservation, including some steep and hazardous grades that are notorious nationally for fog and freezing fog, freezing rain and snow.

GTCC waste would need to be delivered to Hanford by rail, barge or highway. The Native people believe that decision-making criteria need to be presented in the EIS to clarify how rail, barge or highway routing will be determined. Treaty resources and environmental protections are important criteria in determining a preferred repository location. The public needs to be assured that the public health and high valued resources like salmon and watersheds are going to be protected. Northwest river systems have received significant federal and state resources over recent decades in an attempt to recover salmon and rehabilitate damaged watersheds. DOE needs to describe how public safety, salmon and watersheds "fit" into the criteria selection process for determining a GTCC waste site and multiple shipping options. The protection and enhancement of existing river systems are critical to sustaining tribal cultures along the Columbia River. The interstate highway system is a primary transportation corridor for shipping nuclear waste through the states of Oregon, Washington, and Idaho. Waste moving across these states will cross many major salmon bearing rivers that are important to the Tribes. Major rail lines also cross multiple treaty resource areas.

along the river include Hanford, White Bluffs, Ringold, Wahluke, and Richland. The locations of the towns of Hanford and White Bluffs were chosen in 1943 by officials in the Manhattan Engineer District (Manhattan Project) for the location of a plutonium production plant. The site was chosen because of its remoteness from population centers and its proximity to railroads and clean water. Plutonium created at the Hanford Site was used in the Trinity Test and in the bomb that was detonated over Nagasaki, Japan. The Hanford Site's role in nuclear research expanded throughout the Cold War (1946–1989).

During 1990, the National Park Service formalized the concept of the traditional cultural property as a means to identify and protect cultural landscapes, places, and objects that have special cultural significance to American Indians and other ethnic groups. A traditional cultural property that is eligible for the NRHP is associated with the cultural practices or beliefs of a living community that are rooted in that community's history and are important in maintaining the continuing cultural identity of the community. The Hanford Reach and the greater Hanford Site are central to the practice of the American Indian religion of the region. Native plants and animals are used in ceremonial foods. Prominent landforms such as Rattlesnake Mountain, Gable Mountain, and Gable Butte, as well as various sites along and including the Columbia River, remain sacred. American Indian traditional cultural properties within Hanford include, but are not limited to, a wide variety of landscapes, such as archaeological sites, cemeteries, trails and pathways, campsites and villages, fisheries, hunting grounds, plant-gathering areas, holy lands, landmarks, and important places of American Indian history and culture (Duncan 2007).

Cultural resources at the Hanford Site are managed through the DOE-Richland Operations Office (DOE-RL) PNNL Hanford Cultural Resources Management Program with support from the various Hanford Site contractors. Evidence from both the prehistoric and historic periods has been found at the Hanford Site (Kennedy et al. 2007); 1,550 cultural resources sites and isolated finds and 531 buildings and structures have been documented (Duncan et al. 2007). DOE-RL, the SHPO, and the ACHP have entered into a programmatic agreement (PA) to help guide the management of Cold War historic structures at the site.

The DOE Cultural Resources Management Program at the Hanford Site actively engages and consults with members of area Native American Indian Tribal Governments, including the Confederated Tribes and Bands of the Yakama Nation (Yakama Nation), Confederated Tribes of the Umatilla Indian Reservation (CTUIR), Nez Perce Tribe, and Wanapum, concerning activities that may affect important cultural, religious, and historic resources. Tribal representatives participate in field activities as well as attend numerous project meetings to provide input into project planning.

DOE's relationship with American Indian tribes is based on treaties, statutes, and DOE directives. Representatives of the United States negotiated treaties with leaders of various Columbia Plateau American Indian tribes and bands in June 1855 at Camp Stevens in the Walla Walla Valley. The negotiations resulted in three treaties, one with the 14 tribes and bands of the group that would become the Confederated Tribes and Bands of the Yakama Nation, one with the 3 tribes that would become the Confederated Tribes of the Umatilla Indian Reservation, and one with the Nez Perce Tribe. The U.S. Senate ratified the treaties in 1859. The negotiated treaties are as follows:

- Treaty with the Walla Walla, Cayuse, etc., Tribes (June 9, 1855; 12 Stat. 945);
- Treaty with the Yakama Nation (June 9, 1855; 12 Stat. 951); and
- Treaty with the Nez Perce Tribe (June 11, 1855; 12 Stat. 957).

The Confederated Tribes and Bands of the Yakama Nation of the Yakama Reservation, the Confederated Tribes of the Umatilla Indian Reservation, and the Nez Perce Tribe of Idaho are federally recognized tribes that are eligible for funding and services from the U.S. Bureau of Indian Affairs by virtue of their status as Indian tribes (68 FR 68180, December 5, 2003).

The terms of the three preceding treaties are similar. Each of the three tribal organizations agreed to cede large blocks of land to the United States. Hanford is within the ceded lands. The treaties reserved to the tribes certain lands for their exclusive use (the three reservations). The treaties also secured to the tribes certain rights and privileges to continue traditional activities outside the reservations. These included (1) the right to fish at usual and accustomed places in common with citizens of the United States and (2) the privileges of hunting, gathering roots and berries, and pasturing horses and cattle on open and unclaimed lands. No portion of the Hanford Site constitutes open and unclaimed land.

The 200 Area at the Hanford Site was created during the Manhattan Project in 1943. The location was the site of the first chemical separations plant. Chemical separation was the third step in the process of creating plutonium for use in weapons. The first step was creating the fuel rods for use in a reactor. The second step was installing the fuel rods in a reactor. Once the fuel rods were removed from the reactor, they were taken to the 200 Area, where the plutonium was removed through chemical separation. The 200 Area once contained more than 500 buildings. It has been heavily disturbed by historic era activity. Numerous archaeological surveys indicate that the 200 Area was used sporadically. During the historic period, a trail that would later become White Bluffs Road crossed the 200 Area. Findings indicate that historic activity has concentrated along White Bluffs Road. White Bluffs Road is located only in the 200 West Area. No features associated with the road appear in the 200 East Area. Most post-1943 cultural resources found in the 200 Area relate to the atmospheric dispersion grid that monitored contaminant dispersion from Hanford Site facilities. The grid is located between the 200 East and West Area sites.

Archaeological surveys of the 200 East Area have recovered only isolated artifacts and not sites (Kennedy et al. 2007). No farming or ranching is reported for the 200 East Area. The only historically significant structures in the 200 East Area relate to Manhattan Project era activities. The Hanford Site Plant Railroad historic property is within the viewshed of the 200 East Area. The 200 Area is within the Gable Mountain and Gable Butte Cultural District, which is associated with American Indian traditional hunting and religious activities.

American Indian Text

From a tribal perspective, all things of the natural environment are recognized as a cultural resource. This is a different perspective from those who think of cultural resources as artifacts or historic structures. The natural environment provides resources for a subsistence lifestyle for tribal people. This daily connection to the land is crucial to Tribal culture and has been throughout time. All elements of nature therefore are the connection to tribal religious beliefs. Oral histories confirm this cultural and religious connection.

6.1.11 Waste Management

Site management of the waste types generated by the land disposal methods for Alternatives 3 to 5 is discussed in Section 5.3.11.

6.2 ENVIRONMENTAL AND HUMAN HEALTH CONSEQUENCES

The potential impacts from the construction, operations, and post-closure of the land disposal methods (borehole, trench, and vault) are presented in this section for the resource areas evaluated. The affected environment for each resource area is described in Section 6.1. The GTCC reference location for Hanford is presented in Figure 6.1-1.

6.2.1 Climate and Air Quality

This section discusses potential climate and air quality impacts from the construction and operations of each of the three disposal methods (borehole, trench, and vault) at the Hanford Site.

6.2.1.1 Construction

During the construction period, emissions of criteria pollutants (e.g., SO_2, NO_x, CO, PM_{10}, and $PM_{2.5}$), VOCs, and the primary greenhouse gas CO_2 would be caused by fugitive dust emissions from earth-moving activities and engine exhaust emissions from heavy equipment and commuter, delivery, and support vehicles. Typically, the potential impacts from exhaust emissions on ambient air quality would be smaller than those from fugitive dust emissions.

American Indian Text

According to our religion, everything is based on nature. Anything that grows or lives, like plants and animals, is part of our religion. Horace Axtell (Nez Perce Tribal Elder)

The area you are talking about with this GTCC disposal is in a very important place which we think of as the center of our lives. Rattlesnake Mountain is one point, Saddle Mountain is another point, and Hog Butte (a part of Umtanum Ridge) is another point and together they outline this area. Each of these mountains is connected with the others and both these mountains and the ceremonies conducted on them are interrelated. A song from Rattlesnake Mountain can go to Saddle Mountain, then to Hog Butte and if it comes back to you that is special. When you holler from one mountain to another and if it came back changed, it would be interpreted then it would be used to guide life.

This area had a wheel – a calendar which guided us in our movements and activities. The wheel had spokes which we duplicated at our villages. At each village we placed a white stone in the ground and atop this we stood a high post. The post would cast a shadow which was read. When it reached a certain angle, like the spoke in the wheel, we would respond. The wheel was a reference point that held our time schedules. Gable Mountain is a central area which is also a point of reference for many of our ceremonies. Into this area comes the wind. It blows the sand which transforms spirits. Some of these we call horses which were both real and not real. They lived along the big river. The wind and some of the spirits were guided (controlled) by stick people, which live between the river and Rattlesnake Mountain. Across the river is what you call White Bluffs. This is a part of our physical origin. Many of the reference points you see on the ground are organized like the stars – they are related in important ways that are described in our detailed songs and stories. So you see, this area is so important to us. We cannot tell you all the stories – just enough so you understand the importance of this place to us and why we are so concerned to repair it and have it returned to us as the Creator intended. (Wanapum People)

Air emissions of criteria pollutants, VOCs, and CO_2 from construction activities are estimated for the peak year when site preparation and construction of the support facility and some disposal cells would take place. Estimates for PM_{10} and $PM_{2.5}$ include diesel particulate emissions. These estimates are provided in Table 6.2.1-1 for each disposal method. Detailed information on emission factors, assumptions, and emission inventories is available in Appendix D. As shown in Table 6.2.1-1, total peak-year emission rates are estimated to be rather small when compared with the emission total for the four counties encompassing the Hanford Site (Adams, Benton, Franklin, and Grant Counties). Peak-year emissions for all criteria pollutants (except PM_{10} and $PM_{2.5}$) and VOCs would be the highest for the vault facility because constructing it would consume more materials and resources than would constructing the other two facilities. Emissions from building the borehole facility would be almost as high as those from building the vault facility. Construction of the borehole facility would disturb a larger

American Indian Text

At Hanford there are three overlapping cultural landscapes that overlie the natural landscape. These are not displacements of a previous landscape by a new landscape, but a coexistence of all three simultaneously even if one landscape is more visible in a particular area. The first represents the American Indians, who have created a rich archeological and ethnographic record spanning more than 10,000 years. This is the only stretch of the Columbia River that is still free-flowing, and one of the few areas in the Mid-Columbia Valley without modern agricultural development. As a result, this is one of the few places where native villages and campsites can still be found. Still today, local American Indian tribes revere the area for its spiritual and cultural importance, as they continue the traditions practiced by their ancestors. The second landscape was created by early settlers, and the third by the Manhattan Project. Today, DOE is removing much of the visible portion of the Manhattan landscape, returning the surface of the site to a more natural state (restoration and conservation) and thus revealing the cultural landscape that remains underneath.

For thousands of years American Indians have utilized the lands in and around the Hanford Site. Historically, groups such as the Yakama, the Walla Walla, the Wanapum, the Palouse, the Nez Perce, the Columbia, and others had ties to the Hanford area. “The Hanford Reach and the greater Hanford Site, a geographic center for regional American Indian religious activities, is central to the practice of the Indian religion of the region and many believe the Creator made the first people here. Indian religious leaders such as Smoholla, a prophet of Priest Rapids who brought the Washani religion to the Wanapum and others during the late 19th century, began their teachings here. Prominent landforms such as Rattlesnake Mountain, Gable Mountain, and Gable Butte, as well as various sites along and including the Columbia River, remain sacred. American Indian traditional cultural places within the Hanford Site include, but are not limited to, a wide variety of places and landscapes: archaeological sites, cemeteries, trails and pathways, campsites and villages, fisheries, hunting grounds, plant gathering areas, holy lands, landmarks, important places in Indian history and culture, places of persistence and resistance, and landscapes of the heart. Because affected tribal members consider these places sacred, many traditional cultural sites remain unidentified.”

American Indian Text

Salmon remain a core part of the oral traditions of the tribes of the Columbia Plateau and still maintains a presence in native peoples’ diet just as it has for generations. Salmon are recognized as the first food at tribal ceremonies and feasts. One example is the ke’uyit, which translates to “first bite.” It is a ceremonial feast that is held in spring to recognize the foods that return to take care of the people. It is a long-standing tradition among the people and it is immersed in prayer songs and dancing. Salmon is the first food that is eaten by the attendants. Extending gratitude to the foods for sustaining the life of the people is among the tenets of plateau lifestyle. Nez Perce life is perceived as being intertwined with the life of the Salmon. A parallel can be seen between the dwindling numbers of the Salmon runs and the struggle of native people.

American Indian Text

Viewsheds tend to be panoramic and are made special when they contain prominent topography. Viewscapes are tied with songscapes and storyscapes, especially when the vantage point has a panorama composed of multiple locations from either song or story. Viewscapes are critical to the performance of some Indian ceremonies. The Native people utilize vantage points to maintain a spiritual connection to the land. Viewsheds must remain in their natural state; they tend to be panoramic and are made special when they contain prominent uncontaminated topography. The viewshed panorama is further enhanced by abrupt changes in topography and or habitats. Nighttime viewsheds are also significant to indigenous people who still use the Hanford Reach. Each tribe has stories about the night sky and why stars lie in their respective places. The patterns convey spiritual lessons via oral traditions. Often, light pollution from neighboring developments diminishes the view of the constellations. It is getting difficult to find places to simultaneously relate the oral traditions and view the corresponding constellations. There are several culturally significant viewsheds located on the Hanford site. The continued use of these sites brings spiritual renewal. Special considerations should be given to tribal elders and youth to accommodate traditional ceremonies. Interruption of the vista by large facilities or bright lights impairs the cultural services associated with the viewshed.

American Indian Text

"Subsistence" in the narrow sense refers to the hunting, fishing, and gathering activities that are fundamental to the way of life and health of many indigenous peoples. The more concrete aspects of a subsistence lifestyle are important to understanding the degree of environmental contact and how subsistence is performed in contemporary times. Also, traditional knowledge can be learned directly from nature. Through observation this knowledge is recognized and a spiritual connection is often attained as a result. Subsistence utilizes traditional and modern technologies for harvesting and preserving foods as well as for distributing the produce through communal networks of sharing and bartering. The following is a useful explanation of “subsistence,” slightly modified from the National Park Service:

> “While non-native people tend to define subsistence in terms of poverty or the minimum amount of food necessary to support life, native people equate subsistence with their culture. It defines who they are as a people. Among many tribes, maintaining a subsistence lifestyle has become the symbol of their survival in the face of mounting political and economic pressures. To Native Americans who continue to depend on natural resources, subsistence is more than eking out a living. The subsistence lifestyle is a communal activity that is the basis of cultural existence and survival. It unifies communities as cohesive functioning units through collective production and distribution of the harvest. Some groups have formalized patterns of sharing, while others do so in more informal ways. Entire families participate, including elders, who assist with less physically demanding tasks. Parents teach the young to hunt, fish, and farm. Food and goods are also distributed through native cultural institutions. Nez Perce young hunters and fisherman are required to distribute their first catch throughout the community at a first feast (first bite) ceremony. It is a ceremony that illustrates the young hunter is now a man and a provider for his community. Subsistence embodies cultural values that recognize both the social obligation to share as well as the special spiritual relationship to the land and resources.”

TABLE 6.2.1-1 Peak-Year Emissions of Criteria Pollutants, Volatile Organic Compounds, and Carbon Dioxide from Construction of the Three Land Disposal Facilities at the Hanford Site

Pollutant	Total Emissions (tons/yr)[a]	Construction Emissions (tons/yr)					
		Trench (%)		Borehole (%)		Vault (%)	
SO_2	1,655	0.90	(0.06)[b]	3.0	(0.18)	3.2	(0.20)
NO_x	23,050	8.1	(0.04)	26	(0.11)	31	(0.13)
CO	170,470	3.3	(<0.01)	11	(0.01)	11	(<0.01)
VOCs	25,930	0.90	(<0.01)	2.7	(0.01)	3.6	(0.01)
PM_{10}[c]	47,391	5.0	(0.01)	13	(0.03)	8.6	(0.02)
$PM_{2.5}$[c]	8,662	1.5	(0.02)	4.1	(0.05)	3.6	(0.04)
CO_2		670		2,200		2,300	
County[d]	4.53×10^6		(0.02)		(0.05)		(0.05)
Washington[e]	9.44×10^7		(0.0007)		(0.002)		(0.002)
U.S.[e]	6.54×10^9		(0.00001)		(0.00003)		(0.00004)
Worldwide[e]	3.10×10^{10}		(0.000002)		(0.000007)		(0.000007)

[a] Total emissions in 2002 for all four counties encompassing the Hanford Site (Adams, Benton, Franklin, and Grant Counties). See Table 6.1.1-1 for criteria pollutants and VOCs.

[b] As percent of total emissions.

[c] Estimates for GTCC construction include diesel particulate emissions.

[d] Emission data for the year 2005. Currently, data on CO_2 emissions at the county level are not available, so county-level emissions were estimated from available state total CO_2 emissions on the basis of population distribution.

[e] Annual CO_2 emissions in Washington, the United States, and the world in 2005.

Sources: EIA (2008); EPA (2008b, 2009)

area; thus, fugitive dust emissions from the borehole method are estimated to be highest. Peak-year emissions of all pollutants would be the lowest for the trench method, and this method would disturb the smallest area among the disposal methods. In terms of contribution to the emissions total, peak-year emissions of SO_2 from the vault method would be the highest, about 0.20% of the four-county emissions total, while it is estimated that emissions of other criteria pollutants and VOCs would each be 0.14% or less of the four-county emissions total.

Background concentration levels for PM_{10} and annual $PM_{2.5}$ at the Hanford Site are well below the standards (less than 63%), but those for 24-hour $PM_{2.5}$ are about 120% of the standard (see Table 6.1.1-4). All construction activities at the Hanford Site would occur at least 6 km (4 mi) from the site boundary and thus would not contribute much to concentrations at the boundary or at the nearest residence. Construction activities would still be conducted so as to minimize potential impacts of construction-related emissions on ambient air quality. Also, construction permits typically require fugitive dust control by established, standard, dust-control practices, primarily by watering unpaved roads, disturbed surfaces, and temporary stockpiles.

Although O_3 levels in the area approach the standard (about 93%) (see Table 6.1.1-4), the four counties encompassing the Hanford Site are currently in attainment for O_3 (40 CFR 81.348). O_3 precursor emissions from the GTCC disposal facility under all methods would be relatively small, less than 0.13% and 0.01% of the four-county total for NO_x and VOC emissions, respectively, and they would be much lower than those for the regional air shed in which emitted precursors are transported and formed into O_3. Accordingly, potential impacts of O_3 precursor releases from construction on regional O_3 would not be of concern.

The major air quality concern with respect to emissions of CO_2 is that it is a greenhouse gas, which traps solar radiation reflected from the earth, keeping it in the atmosphere. The combustion of fossil fuels makes CO_2 the most widely emitted greenhouse gas worldwide. CO_2 concentrations in the atmosphere have continuously increased, from about 280 ppm in preindustrial times to 379 ppm in 2005, a 35% increase. Most of this increase has occurred in the last 100 years (IPCC 2007).

The climatic impact of CO_2 does not depend on the geographic locations of its sources because CO_2 is stable in the atmosphere and is essentially uniformly mixed; that is, the global total is the important factor with respect to global warming. Therefore, a comparison between U.S. and global emissions and the total emissions from the construction of a disposal facility is useful in understanding whether CO_2 emissions from the site are significant with respect to global warming. As shown in Table 6.2.1-1, the highest peak-year amount of CO_2 emission from construction would be under 0.05%, 0.002%, and 0.00004%, respectively, of the 2005 four-county total, state, and U.S. CO_2 emissions (EIA 2008). Potential impacts on climate change from construction emissions would be small.

Appendix D assumes an initial construction period of 3.4 years. The disposal units would be constructed as the waste became available for disposal. The construction phase would extend over more years; thus, emissions for nonpeak years would be lower than peak-year emissions in the table. In addition, construction activities would occur only during daytime hours, when air dispersion is most favorable. Accordingly, potential impacts from construction activities on ambient air quality would be minor and intermittent.

General conformity applies to federal actions taking place in nonattainment or maintenance areas and is not applicable to the proposed action at the Hanford Site because the area is classified as being in attainment for all criteria pollutants (40 CFR 81.348).

6.2.1.2 Operations

Criteria pollutants, VOCs, and CO_2 would be released into the atmosphere during the operational period. These emissions would include fugitive dust emissions from emplacement activities and exhaust emissions from heavy equipment and commuter, delivery, and support vehicles. Estimated annual emissions of criteria pollutants, VOCs, and CO_2 at the facility are presented in Table 6.2.1-2. Detailed information on emission factors, assumptions, and emission inventories is available in Appendix D. As shown in Table 6.2.1-2, estimates indicate that annual emissions for the trench and vault methods during operations would be at almost the same levels

TABLE 6.2.1-2 Annual Emissions of Criteria Pollutants, Volatile Organic Compounds, and Carbon Dioxide from Operations of the Three Land Disposal Facilities at the Hanford Site

Pollutant	Total Emissions (tons/yr)[a]	Operation Emissions (tons/yr)					
		Trench (%)		Borehole (%)		Vault (%)	
SO_2	1,655	3.3	(0.20)[b]	1.2	(0.07)	3.3	(0.20)
NO_x	23,050	27	(0.12)	10	(0.04)	27	(0.12)
CO	170,470	15	(0.01)	6.7	(<0.01)	15	(0.01)
VOCs	25,930	3.1	(0.01)	1.2	(<0.01)	3.1	(0.01)
PM_{10}[c]	47,391	2.5	(0.01)	0.91	(<0.01)	2.5	(0.01)
$PM_{2.5}$[c]	8,662	2.2	(0.03)	0.81	(0.01)	2.2	(0.03)
CO_2		3,200		1,700		3,300	
County[d]	4.53×10^6		(0.07)		(0.04)		(0.07)
Washington[e]	9.44×10^7		(0.003)		(0.002)		(0.003)
U.S.[e]	6.54×10^9		(0.00005)		(0.00003)		(0.00005)
Worldwide[e]	3.10×10^{10}		(0.00001)		(0.00001)		(0.00001)

[a] Total emissions in 2002 for all four counties encompassing the Hanford Site (Adams, Benton, Franklin, and Grant Counties). See Table 6.1.1-1 for criteria pollutants and VOCs.

[b] As percent of total emissions.

[c] Estimates for GTCC operations include diesel particulate emissions.

[d] Emission data for the year 2005. Currently, data on CO_2 emissions at the county level are not available, so county-level emissions were estimated from available state total CO_2 emissions on the basis of population distribution.

[e] Annual CO_2 emissions in Washington, the United States, and the world in 2005.

Sources: EIA (2008); EPA (2008b, 2009)

and higher than emissions during construction; emissions for the borehole method would be lower than for the trench and vault methods and lower during operations than construction. Compared with annual emissions for the counties encompassing the Hanford Site, the annual emissions of SO_2 for the trench and vault methods would be the highest, about 0.20% of the emissions total, while emissions of other criteria pollutants and VOCs would be about 0.01% or less.

It is expected that concentration levels from operational activities for PM_{10} and $PM_{2.5}$ (which include diesel particulate emissions) would remain below the standards, except for the 24-hour $PM_{2.5}$ level, which is already above the standard. As discussed in the construction section, established fugitive dust control measures (primarily by watering unpaved roads, disturbed surfaces, and temporary stockpiles) would be implemented to minimize potential impacts on ambient air quality.

With regard to regional O_3, precursor emissions of NO_x and VOCs from operations would be comparable to those from construction (about 0.12% and 0.01% of the four-county emission totals, respectively) and are not anticipated to contribute much to regional O_3 levels. The highest CO_2 emissions among the disposal methods would be comparable to the highest construction-related emissions; thus, their potential impacts on climate change would also be negligible. PSD regulations are not applicable to the proposed action because the proposed action is not a major stationary source.

6.2.2 Geology and Soils

Direct impacts from land disturbance would be proportional to the total area of land disturbed during site preparation activities (e.g., grading and backfilling) and construction of the GTCC LLRW and GTCC-like waste disposal facility and related infrastructure (e.g., roads). Land disturbance would include the surface area covered for each disposal method and the vertical displacement of geologic materials for the trench and borehole methods. An increased potential for soil erosion would be an indirect impact from land disturbance at the construction site. Indirect impacts would also result from the use of geologic materials (e.g., aggregate) for facility construction. The impact analysis also considers whether the proposed action would preclude the future extraction and use of mineral materials or energy resources.

6.2.2.1 Construction

Impacts from disturbing the land surface area would be a function of the disposal method implemented at the site (Table 5.1-1). Of the three disposal facilities, the borehole facility would have the greatest impact in terms of land area disturbed. It also would result in the greatest disturbance with depth, with boreholes being completed in unconsolidated clay, silt, sand, and gravel (Hanford Formation).

Geologic and soil material requirements are listed in Table 5.3.2-1. Of the three disposal methods, the vault method would require the most material since it would involve the installation of interim and final cover systems. This material would be considered permanently lost. However, none of the three disposal methods are expected to result in adverse impacts on geologic and soil resources at the Hanford Site, since these resources are in abundant supply at the site and in the surrounding area. However, follow-on evaluations would have to be done so that potential impacts on any new borrow area that would be used as the source for the soil required to build the proposed GTCC LLRW and GTCC-like waste disposal facility would be considered.

No significant changes in surface topography or natural drainages are anticipated in the construction area. However, the disturbance of soil during the construction phase would increase the potential for erosion in the immediate vicinity. This potential would be greatly reduced, however, by the low precipitation rates at the Hanford Site. Also, mitigation measures would be implemented to avoid or minimize the risk of erosion.

The GTCC LLRW and GTCC-like waste disposal facility would be sited and designed with safeguards to avoid or minimize the risks associated with seismic and volcanic hazards. The

Hanford Site is in a seismically active region, and earthquake swarms of low magnitude occur frequently on and around the site. The annual probability of a volcanic event (basaltic eruption) is considered to be negligible, since there has been no such volcanic activity in the last 6 million years. Volcanic hazard studies that account for volcanism in the Cascade Range estimate that there would be design ashfall loads at the site. The potential for other hazards (e.g., subsidence and liquefaction) is considered to be low.

6.2.2.2 Operations

The disturbance of soil and the increased potential for soil erosion would continue throughout the operational phase as waste was delivered to the site for disposal over time. The potential for soil erosion would be greatly reduced, however, by the low precipitation rates at the Hanford Site. Mitigation measures would also be implemented to avoid or minimize the risk of erosion.

Impacts related to the extraction and use of valuable geologic materials are expected to be low, since only the area within the facility itself would be unavailable for mining, and the potential for energy development at the site is considered to be low. Activities on-site would not have adverse impacts on the extraction of economic minerals in the surrounding region.

6.2.3 Water Resources

Direct and indirect impacts on water resources could occur as a result of water use at the proposed GTCC LLRW and GTCC-like waste disposal facility during construction and operations. Table 5.3.3-1 provides an estimate of the water consumption and discharge volumes for the three land disposal methods; Tables 5.3.3-2 and 5.3.3-3 summarize the impacts on water resources (in terms of change in annual water use) from construction and normal operations, respectively. A discussion of potential impacts during each project phase is presented in the following sections. In addition, contamination due to potential leaching of radionuclides from the waste inventory into groundwater could occur, depending on the post-closure performance of the land disposal facilities discussed in Section 6.2.4.2

6.2.3.1 Construction

Of the three land disposal facilities considered for the Hanford Site, construction of a vault facility would have the highest water requirement (Table 5.3.3-1). Water demands for construction at the Hanford Site would be met by using surface water from the Columbia River and the 100-B Area Export Water System. No groundwater would be used at the site during construction. As a result, no direct impacts on groundwater resources are expected. The potential for indirect surface water impacts related to soil erosion, contaminated runoff, and sedimentation would be reduced by implementing good industry practices and mitigation measures. The GTCC reference location is not within the floodplain for the probable maximum flood along the Columbia River.

As of 1998, the water capacity at Hanford's 200 East Area was about 2.6 billion L/yr (696 million gal/yr). This water is obtained from the Columbia River, which has an average flow rate of about 197 million L/min (52 million gpm). Construction of the proposed GTCC LLRW and GTCC-like waste disposal facility would increase the annual water use at the 200 East Area (as reported in 1998) by a maximum of about 0.4% (vault method) over the 20-year period that construction would occur. This increase would have a negligible effect on the flow and stage (water elevation) of the river (with a decrease in flow of about 3×10^{-6} percent).

Construction activities could potentially change the infiltration rate at the site of the proposed GTCC LLRW and GTCC-like waste disposal facility, first by increasing the rate as ground would be disturbed in the initial stages of construction and later by decreasing the rate as impermeable materials (e.g., the clay material and geotextile membrane assumed for the cover or cap for the land disposal facility designs) would cover the surface. These changes are expected to be negligible since the area of land associated with the proposed GTCC LLRW and GTCC-like waste disposal facility (up to 44 ha [110 ac], depending on the disposal method) would be small relative to the Hanford Site. Disposal of waste (including sanitary waste) generated during construction of land disposal facilities would have a negligible impact on the quality of water resources at the Hanford Site (see Sections 5.3.11 and 6.3.11). The potential for indirect impacts on surface water or groundwater related to spills at the surface would be reduced by implementing good industry practices and mitigation measures.

6.2.3.2 Operations

Of the three land disposal methods considered for the Hanford Site, operating a trench facility would have the highest water requirement (Table 5.3.3-1). Water demands for operations at the Hanford Site would be met by using surface water from the Columbia River and the 100-B Area Export Water System. No groundwater would be used at the site during operations. As a result, no direct impacts on groundwater resources are expected. The potential for indirect impacts on surface water related to soil erosion, contaminated runoff, and sedimentation would be reduced by implementing good industry practices and mitigation measures.

Operations of the proposed GTCC LLRW and GTCC-like waste disposal facility would increase annual water use at the Hanford Site by a maximum of about 0.65% (vault method). For the constant rate of use, an additional withdrawal of 10.2 L/min (2.7 gpm) would be required. This increase would have a negligible effect on the flow and stage (water elevation) of the river (with a decrease in flow of about 5×10^{-6} percent).

Disposal of waste (including sanitary waste) generated during operations of land disposal facilities would have a negligible impact on the quality of water resources at the Hanford Site (see Sections 5.3.11 and 6.3.11). The potential for indirect impacts on surface water or groundwater related to spills at the surface would be reduced by implementing good industry practices and mitigation measures.

6.2.4 Human Health

Potential impacts on members of the general public and on involved workers from the construction and operations of the waste disposal facilities are expected to be comparable for all of the sites evaluated in this EIS for the land disposal methods, and these impacts are described in Section 5.3.4. The following sections discuss the impacts from hypothetical facility accidents associated with waste handling activities and the impacts during the long-term post-closure phase. They address impacts on members of the general public who might be affected by these waste disposal activities at the Hanford Site GTCC reference location, since these impacts would be site dependent.

6.2.4.1 Facility Accidents

Data on the estimated human health impacts from hypothetical accidents at a GTCC LLRW and GTCC-like waste disposal facility located on the Hanford Site are provided in Table 6.2.4-1. The accident scenarios are discussed in Section 5.3.4.2.1 and Appendix C. A reasonable range of accidents that included operational events and natural causes was analyzed. The impacts presented for each accident scenario are for the sector with the highest impacts, and no protective measures are assumed; therefore, they represent the maximum impacts expected from such an accident.

The collective population dose includes exposure from inhalation of airborne radioactive material, external exposure from radioactive material deposited on the ground, and ingestion of contaminated crops. The exposure period is assumed to last for 1 year immediately following the accidental release. It is recognized that interdiction of food crops would likely occur if a significant release occurred, but many stakeholders are interested in what could happen if there was no interdiction. For the accidents involving CH waste (Accidents 1–9, 11, 12), the ingestion dose would account for approximately 20% of the collective population dose shown in Table 6.2.4-1. External exposure would be negligible in all cases. All exposures would be dominated by the inhalation dose from the passing plume of airborne radioactive material downwind from the hypothetical accident immediately following release.

The highest estimated impact on the general public, 95 person-rem, would result from a release from an SWB caused by a fire in the WHB (Accident 9). Such a dose is not expected to lead to any additional LCFs in the population. This dose would be to the 144,000 people living southeast of the facility, resulting in an average dose of approximately 0.0007 rem per person. Because this dose would be from internal intake (primarily inhalation, with some ingestion) and because the DCFs used in this analysis are for a 50-year CEDE, this dose would be accumulated over the course of 50 years.

The dose to an individual (expected to be a noninvolved worker because there would be no public access within 100 m [300 ft] of the GTCC reference location) includes exposure from the inhalation of airborne radioactive material and 2 hours of exposure to radioactive material deposited on the ground. As shown in Table 6.2.4-1, the highest estimated dose to an individual, 16 rem, would be for Accident 9 from inhalation exposure immediately after the postulated

TABLE 6.2.4-1 Estimated Radiological Human Health Impacts from Hypothetical Facility Accidents at the Hanford Site[a]

		Off-Site Public		Individual[b]	
Accident No.	Accident Scenario	Collective Dose (person-rem)	Latent Cancer Fatalities[c]	Dose (rem)	Likelihood of LCF[c]
1	Single drum drops, lid failure in Waste Handing Building	0.0021	<0.0001	0.00035	<0.0001
2	Single SWB drops, lid failure in Waste Handing Building	0.0048	<0.0001	0.00078	<0.0001
3	Three drums drop, puncture, lid failure in Waste Handling Building	0.0037	<0.0001	0.00063	<0.0001
4	Two SWBs drop, puncture, lid failure in Waste Handling Building	0.0067	<0.0001	0.0011	<0.0001
5	Single drum drops, lid failure outside	2.1	0.001	0.35	0.0002
6	Single SWB drops, lid failure outside	4.8	0.003	0.78	0.0005
7	Three drums drop, puncture, lid failure outside	3.7	0.002	0.63	0.0004
8	Two SWBs drop, puncture, lid failure outside	6.7	0.004	1.1	0.0007
9	Fire inside the Waste Handling Building, one SWB is assumed to be affected	95	0.06	16	0.01
10	Single RH waste canister breach	<0.0001	<0.0001	<0.0001	<0.0001
11	Earthquake affects 18 pallets, each with 4 CH drums	60	0.04	10	0.006
12	Tornado, missile hits one SWB, contents released	19	0.01	3.1	0.002

[a] CH = contact-handled, RH = remote-handled, LCF = latent cancer fatality, SWB = standard waste box.

[b] The individual receptor is assumed to be 100 m (330 ft) downwind from the release point. This individual is expected to be a noninvolved worker because there would be no public access within 100 m (330 ft) of the GTCC reference location.

[c] LCFs are calculated by multiplying the dose by the health risk conversion factor of 0.0006 fatal cancer per person-rem (see Section 5.2.4.3). Values are rounded to one significant figure.

release. This estimated dose is for a hypothetical individual located 100 m (330 ft) to the north-northwest of the accident location. As discussed above, the estimated dose of 16 rem would be accumulated over a 50-year period after intake and would not result in acute radiation syndrome. A maximum annual dose of about 5% of the total individual dose to the noninvolved worker would occur in the first year. The increased lifetime probability of a fatal cancer for this individual would be approximately 1% on the basis of a total dose of 16 rem.

6.2.4.2 Post-Closure

The potential radiation dose from the airborne release of radionuclides to off-site members of the public after the closure of a disposal facility would be small. RESRAD-OFFSITE estimates (see Table 5.3.4-3) indicate there would be no measurable exposure from this pathway for the borehole method. Small radiation exposures are estimated for the trench and vault methods. It is estimated that the potential inhalation dose at a distance of 100 m (330 ft) from the disposal facility would be less than 1.8 mrem/yr for trench disposal and 0.52 mrem/yr for vault disposal. The potential radiation exposures would be caused mainly by inhalation of radon gas and its short-lived progeny.

The borehole method would provide better protection against potential exposures from airborne releases of radionuclides because of the greater depth of the cover material. The boreholes would be 30 m (100 ft) bgs, and this depth of overlying soil would inhibit the diffusion of radon gas, CO_2 gas (containing C-14), and tritium (H-3) water vapor to the atmosphere above the disposal area. However, because the distance to the groundwater table would be closer from boreholes than from trenches or vaults, radionuclides that leached out from wastes in the boreholes would reach the groundwater table in a shorter time than radionuclides that leached out from the trenches or vaults.

Within 10,000 years, Tc-99 and I-129 could reach the groundwater table and a well installed by a hypothetical resident farmer located a distance of 100 m (330 ft) from the downgradient edge of the disposal facility. Both of these radionuclides are highly soluble in water, a quality that could lead to potentially significant groundwater doses to the hypothetical resident farmer. The peak annual dose associated with the use of contaminated groundwater from disposal of the entire GTCC LLRW and GTCC-like waste inventory at the Hanford Site was calculated to be 4.8 mrem/yr for the borehole method, 49 mrem/yr for the vault method, and 48 mrem/yr for the trench method. These two radionuclides would contribute essentially all of the dose to the hypothetical resident farmer within the first 10,000 years after closure of the disposal facility. The exposure pathways considered in this analysis include the ingestion of contaminated groundwater, soil, plants, meat, and milk; external radiation; and the inhalation of radon gas and its short-lived progeny.

Tables 6.2.4-2 and 6.2.4-3 present the peak doses and LCF risks, respectively, to the hypothetical resident farmer (from the use of potentially contaminated groundwater within the first 10,000 years after closure of the disposal facility) when disposal of the entire GTCC LLRW and GTCC-like waste inventory by using the land disposal methods evaluated is considered. In

TABLE 6.2.4-2 Estimated Peak Annual Doses (in mrem/yr) from the Use of Contaminated Groundwater within 10,000 Years of Disposal at the GTCC Reference Location at the Hanford Site[a]

	GTCC LLRW				GTCC-Like Waste				
Disposal Technology/ Waste Group	Activated Metals	Sealed Sources	Other Waste - CH	Other Waste - RH	Activated Metals	Sealed Sources	Other Waste - CH	Other Waste - RH	Peak Annual Dose from Entire Inventory
Borehole disposal									4.8[b]
Group 1 stored	0.17	-	0.0	0.013	0.0	0.0	0.0042	0.11	
Group 1 projected	2.6	0.0	-	0.00038	0.0	0.0	0.0016	0.036	
Group 2 projected	1.3	0.0	0.0091	0.047	-	-	0.0023	0.066	
Vault disposal									49[b]
Group 1 stored	0.26	-	0.0	0.044	0.0	0.0	0.012	40	
Group 1 projected	4.0	0.0	-	0.0013	0.0	0.0	0.0045	0.12	
Group 2 projected	2.0	0.0	0.025	1.6	-	-	0.0062	0.23	
Trench disposal									48[b]
Group 1 stored	0.33	-	0.0	0.042	0.0	0.0	0.014	39	
Group 1 projected	5.0	0.0	-	0.0013	0.0	0.0	0.0055	0.12	
Group 2 projected	2.5	0.0	0.031	1.5	-	-	0.0076	0.22	

[a] These annual doses are associated with the use of contaminated groundwater by a hypothetical resident farmer located 100 m (330 ft) from the edge of the disposal facility. All values are given to two significant figures, and a hyphen means there is no inventory for that waste type. The values given in this table represent the annual doses to the hypothetical resident farmer at the time of the peak annual dose from the entire GTCC LLRW and GTCC-like waste inventory. These contributions do not represent the maximum doses that could result from each of these waste types separately. Because of the different radionuclide mixes and activities contained in the different waste types, the maximum doses that could result from each waste type individually generally occur at different times than the peak annual dose from the entire inventory. The peak annual doses that could result from each of the waste types are presented in Tables E-22 through E-25 in Appendix E.

[b] The times for the peak annual doses of 4.8 mrem/yr for boreholes, 49 mrem/yr for vaults, and 48 mrem/yr for trenches were calculated to be about 1,800 years, 3,300 years, and 2,900 years, respectively, for disposal of the entire GTCC LLRW and GTCC-like waste inventory. These times represent the time after failure of the cover and engineered barriers (which is assumed to begin 500 years after closure of the disposal facility). The values reported for the other entries in this table represent the annual doses from the specific waste types at the time of these peak doses. For borehole disposal, the primary contributor to the dose is GTCC LLRW activated metals; for trench and vault disposal, the primary contributor to the dose is GTCC-like Other Waste - RH. Tc-99 and I-129 would be the primary radionuclides causing this dose.

TABLE 6.2.4-3 Estimated Peak Annual LCF Risks from the Use of Contaminated Groundwater within 10,000 Years of Disposal at the GTCC Reference Location at the Hanford Site[a]

	GTCC LLRW				GTCC-Like Waste				
Disposal Technology/ Waste Group	Activated Metals	Sealed Sources	Other Waste - CH	Other Waste - RH	Activated Metals	Sealed Sources	Other Waste - CH	Other Waste - RH	Peak Annual LCF Risk from Entire Inventory
Borehole disposal									3E-06 [b]
Group 1 stored	1E-07	-	0E+00	7E-09	0E+00	0E+00	3E-09	6E-08	
Group 1 projected	2E-06	0E+00	-	2E-10	0E+00	0E+00	1E-09	2E-08	
Group 2 projected	8E-07	0E+00	5E-09	3E-07	-	-	1E-09	4E-08	
Vault disposal									3E-05[b]
Group 1 stored	2E-07	-	0E+00	3E-08	0E+00	0E+00	7E-09	2E-05	
Group 1 projected	2E-06	0E+00	-	8E-10	0E+00	0E+00	3E-09	7E-08	
Group 2 projected	1E-06	0E+00	2E-08	1E-06	-	-	4E-09	1E-07	
Trench disposal									3E-05[b]
Group 1 stored	2E-07	-	0E+00	3E-08	0E+00	0E+00	8E-09	2E-05	
Group 1 projected	3E-06	0E+00	-	8E-10	0E+00	0E+00	3E-09	7E-08	
Group 2 projected	1E-06	0E+00	2E-08	9E-07	-	-	5E-09	1E-07	

[a] These annual LCF risks are associated with the use of contaminated groundwater by a hypothetical resident farmer located 100 m (330 ft) from the edge of the disposal facility. All values are given to one significant figure, and a hyphen means there is no inventory for that waste type. The values given in this table represent the annual LCF risks to the hypothetical resident farmer at the time of the peak annual LCF risk from the entire GTCC LLRW and GTCC-like waste inventory. These contributions do not represent the maximum LCF risks that could result from each of these waste types separately. Because of the different radionuclide mixes and activities contained in the different waste types, the maximum LCF risks that could result from each waste type individually generally occur at different times than the peak annual LCF risk from the entire inventory.

[b] The times for the peak annual LCF risks of 3E-06 for boreholes, 3E-05 for vaults, and 3E-05 for trenches were calculated to be about 1,800 years, 3,300 years, and 2,900 years, respectively, for disposal of the entire GTCC LLRW and GTCC-like waste inventory. These times represent the time after failure of the cover and engineered barriers (which is assumed to begin 500 years after closure of the disposal facility). The values reported for the other entries in this table represent the annual LCF risks for the specific waste types at the time of these peak LCF risks. For borehole disposal, the primary contributor to the LCF risk is GTCC LLRW activated metals; for trench and vault disposal, the primary contributor to the LCF risk is GTCC-like Other Waste - RH. Tc-99 and I-129 would be the primary radionuclides causing this risk.

these tables, the doses contributed by each waste type (i.e., the dose for each waste type at the time or year when the peak dose for the entire inventory is observed) to the peak dose reported are also tabulated. The doses presented from the various waste types do not necessarily represent the peak dose and LCF risk of the waste type itself when considered on its own.

For borehole disposal, it is estimated that the peak dose and LCF risk would occur at about 1,800 years, with GTCC LLRW activated metal waste being the primary dose contributor. The peak doses and LCF risks were calculated to occur at about 3,300 years and 2,900 years after disposal for vault and trench disposal, respectively. These times represent the time after failure of the engineered barriers (which is assumed to begin 500 years after closure of the disposal facility). The major dose contributor for these two disposal methods would be GTCC-like Other Waste - RH, with GTCC LLRW contributing about 15% of the total dose.

Tables E-22 through E-25 in Appendix E present peak doses for each waste type when considered on its own. Because these peak doses generally occur at different times, the results should not be summed to obtain total doses for comparison with those presented in Table 6.2.4-2 (although for some cases, these sums might be close to those presented in the site-specific chapters).

Figure 6.2.4-1 is a temporal plot of the radiation doses associated with the use of contaminated groundwater for a period extending to 10,000 years, and Figure 6.2.4-2 shows these results to 100,000 years for the three land disposal methods. Note that the time scale in Figure 6.2.4-1 is logarithmic, while the time scale in Figure 6.2.4-2 is linear. A logarithmic time scale was used in the first figure to better illustrate the projected radiation doses to a hypothetical resident farmer in the first 10,000 years following closure of the disposal facility.

Although Tc-99 and I-129 would result in measureable radiation doses for the first 10,000 years, the inventory in the disposal areas would be depleted rather quickly, and the doses would gradually decrease with time after about 5,000 years. After the depletion of these two radionuclides, no other radionuclides would reach the groundwater table within 10,000 years. In the very long term, however, various isotopes of uranium and Np-237 that were originally contained in the waste streams or generated from radioactive decay could reach the groundwater table and result in doses to this hypothetical resident farmer. The maximum annual doses would exceed 100 mrem/yr for all three disposal methods and would occur within the first 25,000 years following closure of the disposal facility. There is a high degree of uncertainty associated with estimates that project this far into the future.

The results given here are assumed to be conservative because the location selected for the residential exposure is 100 m (330 ft) from the edge of the disposal facility. Use of a longer distance, which might be more realistic for the sites being evaluated, would significantly lower the estimated doses (i.e., by as much as 70%). A sensitivity analysis performed to determine the effect of a distance longer than 100 m (330 ft) is presented in Appendix E.

These analyses assume that engineering controls would be effective for 500 years following closure of the disposal facility. This means that essentially no infiltrating water would reach the wastes from the top of the disposal units. It is assumed that after 500 years, the

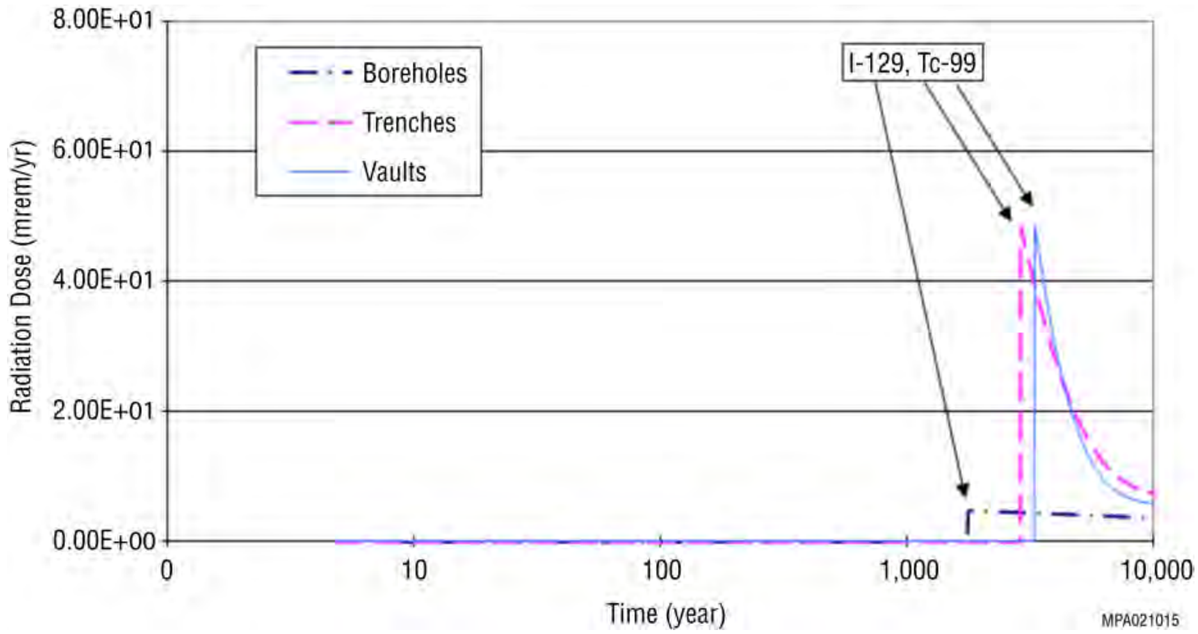

FIGURE 6.2.4-1 Temporal Plot of Radiation Doses Associated with the Use of Contaminated Groundwater within 10,000 Years of Disposal for the Three Land Disposal Methods at the Hanford Site

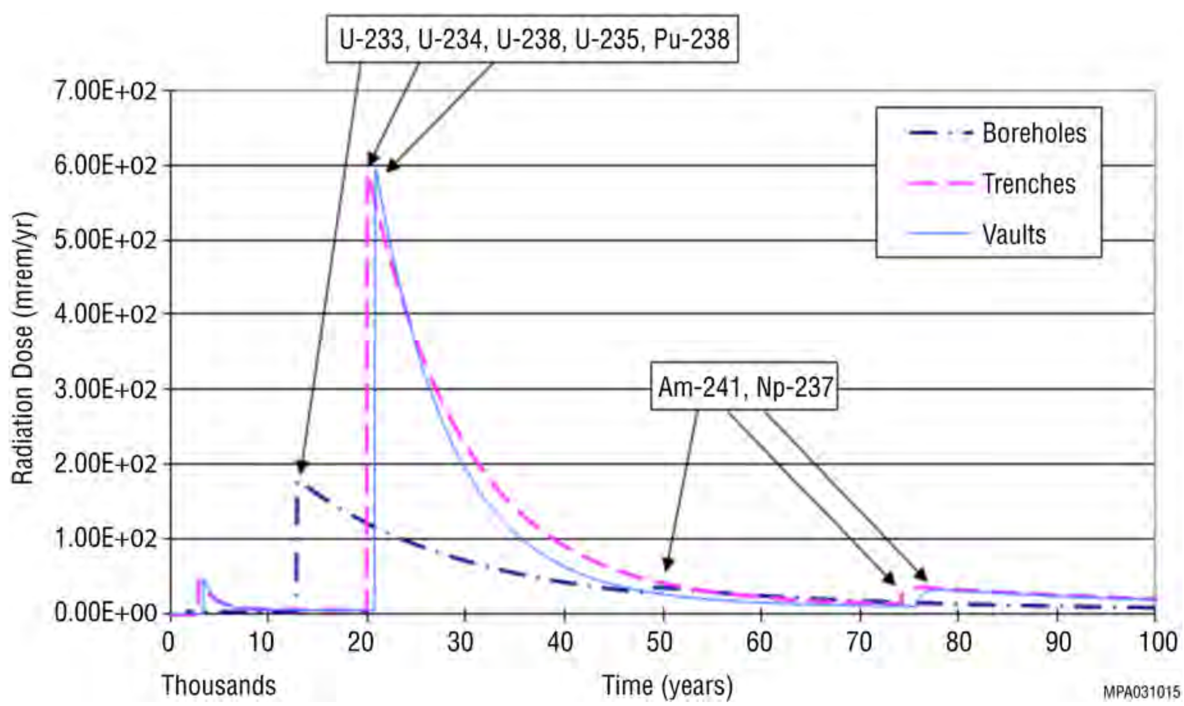

FIGURE 6.2.4-2 Temporal Plot of Radiation Doses Associated with the Use of Contaminated Groundwater within 100,000 Years of Disposal for the Three Land Disposal Methods at the Hanford Site

engineered barriers would begin to degrade, allowing infiltrating water to come in contact with the disposed-of wastes. For purposes of analysis in the EIS, it is assumed that the amount of infiltrating water that would contact the wastes would be 20% of the site-specific natural infiltration rate for the area, and that the water infiltration rate around and beneath the disposal facilities would be 100% of the natural rate for the area. This approach is assumed to be conservative because it is expected that the engineered systems (including the disposal facility cover) would last longer than 500 years, even in the absence of active maintenance measures.

It is assumed that the Other Waste would be stabilized with grout or other material and that this stabilizing agent would be effective for 500 years. Consistent with the assumptions used for engineering controls, no credit was taken in this analysis for the effectiveness of this stabilizing agent after 500 years. That is, any water that would contact the wastes after 500 years would be able to leach radioactive constituents from the disposed-of materials. These radionuclides could then move with the percolating groundwater to the underlying groundwater system. This scenario is assumed to be conservative because grout or other stabilizing materials could retain their integrity for longer than 500 years.

Sensitivity analyses performed relative to these assumptions indicate that if a higher infiltration rate to the top of the disposal facilities was assumed, the doses would increase in a linear manner from those presented. Conversely, the doses would decrease in a linear manner with lower infiltration rates. This finding indicates the need to ensure that there is a good cover over the closed disposal units. Also, the doses would be lower if it was assumed that the grout would last for a longer time. Because of the long-lived nature of the radionuclides associated with some of the GTCC LLRW and GTCC-like waste, any stabilization effort (such as grouting) would have to be effective for longer than 5,000 years in order to substantially reduce doses that could result from potential future leaching of the disposed-of waste.

The radiation doses presented in the post-closure assessment in this EIS are intended to be used for comparing the performance of each of the land disposal methods at each site evaluated. The results indicate that the use of robust engineering designs and redundant measures (e.g., types and thicknesses of covers and long-lasting grout) to contain the radionuclides in the disposal facility could delay the potential release of radionuclides and could reduce the release to very low levels, thereby minimizing the potential groundwater contamination and associated human health impacts in the future. DOE has considered the potential doses to the hypothetical resident farmer as well as other factors discussed in Section 2.9 in identifying the preferred alternative presented in Section 2.10.

6.2.5 Ecology

Section 5.3.5 presents an overview of the potential impacts on ecological resources that could result from the construction, operations, decommissioning, and post-closure maintenance of the GTCC LLRW and GTCC-like waste disposal facility, regardless of the location selected for it. This section evaluates the potential impacts of the facility on the ecological resources at the Hanford Site.

It is expected that the initial loss of sagebrush-dominated habitats followed by the eventual establishment of low-growth vegetation (including sagebrush) on the disposal site would not create a long-term reduction in the local or regional ecological diversity. Also, loss of sagebrush would be compensated for by required restoration elsewhere on the Hanford Site (e.g., at a ratio of up to 3:1). After closure of the GTCC LLRW and GTCC-like waste disposal site, the cover would become initially vegetated with annual and perennial plants. Reestablishment of mature sagebrush stands could take a minimum of 10 to 20 years (Poston and Sackschewsky 2007). As appropriate, regionally native plants would be used to landscape the disposal site in accordance with "Guidance for Presidential Memorandum on Environmentally and Economically Beneficial Landscape Practices on Federal Landscaped Grounds" (EPA 1995). An aggressive revegetation program would be necessary so that nonnative species, such as cheatgrass, Russian thistle, and diffuse knapweed, would not become established. These species are quick to colonize disturbed sites and are difficult to eradicate because each year they produce large amounts of seeds that remain viable for long periods of time (Blew et al. 2006).

It is expected that the mountain cottontail would occur where cover associated with construction was available (Downs et al. 1993). However, species associated with sagebrush habitats, such as the northern sagebrush lizard and black-tailed jackrabbits, would be locally affected by construction of the GTCC LLRW and GTCC-like waste disposal facility. Ground-nesting birds that have been observed in the 200 Area include the horned lark, killdeer (*Charadrius vociferus*), long-billed curlew, and western meadowlark. Ground disturbance during the nesting season could destroy eggs and young of these species and displace nesting individuals to other areas of the Hanford Site. Construction at other times of the year would result in a loss of the habitat available to these bird species on the Hanford Site.

Because no natural aquatic habitats occur within the immediate vicinity of the GTCC reference location, impacts on aquatic biota are not expected. DOE would use appropriate erosion control measures to minimize off-site movement of soils. It is expected that the GTCC LLRW and GTCC-like waste disposal facility retention pond would not become a highly productive aquatic habitat. However, depending on the amount of water and length of time that water would be retained within the pond, aquatic invertebrates could become established within it. Waterfowl, shorebirds, and other birds might also make use of the retention pond, as would mammal and reptile species that might enter the site. Amphibian species might also make use of the retention pond.

Since no federally listed or candidate species occur within the immediate vicinity of the GTCC reference location, none of these species would be affected by construction, operations, or post-closure of the waste disposal facility. Construction of the GTCC LLRW and GTCC-like waste disposal facility could affect state candidate species, such as the sage sparrow, northern sagebrush lizard (*Sceloporus graciosus graciosus*), and black-tailed jackrabbit, which have a strong affinity for sagebrush habitats. However, the area of sagebrush habitat that would be disturbed by construction is small relative to the overall area of such habitat on the Hanford Site. Therefore, removal of sagebrush habitat would have a small impact on the populations of these species and other species that live in sagebrush habitats.

Development of the GTCC LLRW and GTCC-like waste disposal facility would result in the loss of shrub-steppe habitat, which is considered a priority habitat by the State of Washington and a Level III resource under the Hanford Site Biological Resources Management Plan. Impacts on Level III resources require mitigation. When avoidance and minimization are not possible or are insufficient, mitigation via rectification or compensation is recommended (DOE 2001b). Therefore, impacts associated with the GTCC LLRW and GTCC-like waste disposal facility (Section 5.3.5) that could affect ecological resources would be minimized and mitigated.

6.2.6 Socioeconomics

6.2.6.1 Construction

The potential socioeconomic impacts from constructing a GTCC LLRW and GTCC-like waste disposal facility and support buildings at the Hanford Site would be relatively small for all disposal methods. Construction activities would create direct employment of 47 people (borehole method) to 145 people (vault method) in the peak construction year and an additional 56 indirect jobs (borehole method) to 152 indirect jobs (vault method) in the ROI (Table 6.2.6-1). Construction activities would constitute less than 1% of total ROI employment in the peak year. A GTCC facility would produce between $4.2 million in income (borehole method) and $12.3 million (vault method) in income in the peak year of construction.

In the peak year of construction, between 21 people (borehole method) and 64 people (vault method) would in-migrate to the ROI (Table 6.2.6-1) as a result of employment on-site. In-migration would have only a marginal effect on population growth and would require no more than 2% of vacant rental housing in the peak year for all disposal methods. No significant impact on public finances would occur as a result of in-migration, and no more than two local public service employees would be required to maintain existing levels of service in the various local public service jurisdictions in the ROI. In addition, on-site employee commuting patterns would have a small to moderate impact on levels of service in the local transportation network surrounding the site.

6.2.6.2 Operations

The potential socioeconomic impacts from operating a GTCC LLRW and GTCC-like waste disposal facility would be small for all disposal methods. Operational activities would create 38 direct jobs (borehole method) to 51 direct jobs (vault method) annually and an additional 36 indirect jobs (borehole method) to 43 indirect jobs (vault method) in the ROI (Table 6.2.6-1). A GTCC LLRW and GTCC-like waste disposal facility would also produce between $3.9 million in income (borehole method) and $5.0 million in income (vault method) annually during operations.

Two people would move to the area at the beginning of operations (Table 6.2.6-1). However, in-migration would have only a marginal effect on population growth and would

TABLE 6.2.6-1 Effects of GTCC LLRW and GTCC-Like Waste Disposal Facility Construction and Operations on Socioeconomics at the ROI for the Hanford Site[a]

	Trench		Borehole		Vault	
Impact Category	Construction	Operation	Construction	Operation	Construction	Operation
Employment (number of jobs)						
Direct	62	48	47	38	145	51
Indirect	57	42	56	36	152	43
Total	119	90	103	75	297	94
Income ($ in millions)						
Direct	2.1	3.2	1.8	2.6	6.0	3.4
Indirect	2.4	1.5	2.4	1.3	6.3	1.6
Total	4.5	4.7	4.2	3.9	12.3	5.0
Population (number of new residents)	27	2	21	2	64	2
Housing (number of units required)	14	1	10	1	32	1
Public finances (% impact on expenditures)						
Cities and counties[b]	<1	<1		<1		<1
Schools[c]	<1	<1		<1		<1
Public service employment (number of new employees)			<1 <1		<1 <1	
Local government employees[d]	0	0		0		0
Teachers	0	0	0	0	1	0
Traffic (impact on current levels of service)	Small	Small	Small	Small	Moderate	Small
			0		1	

[a] Impacts shown are for waste facility and support buildings in the peak year of construction and the first year of operations.

[b] Includes impacts that would occur in the cities of Richland, West Richland, Kennewick, Benton City, Prosser, Pasco, and Connell and in the counties of Benton and Franklin.

[c] Includes impacts that would occur in the school districts of Richland, Kennewick, Finley, Kiona-Benton, Prosser, Patterson, Pasco, Star, Education, North Franklin, and Kahlotus.

[d] Includes police officers, paid firefighters, and general government employees.

require less than 1% of vacant owner-occupied housing during facility operations. No significant impact on public finances would occur as a result of in-migration, and no new local public service employees would be required to maintain existing levels of service in the various local public service jurisdictions in the ROI. In addition, on-site employee commuting patterns would have a small impact on levels of service in the local transportation network surrounding the site.

6.2.7 Environmental Justice

6.2.7.1 Construction

No radiological risks and only very low chemical exposure and risk are expected during construction of the trench, borehole, or vault facilities. Chemical exposure during construction would be limited to airborne toxic air pollutants at less than standard levels and would not result in any adverse health impacts. Because the health impacts from each facility on the general population within the 80-km (50-mi) assessment area during construction would be negligible, no impacts on minority and low-income population as a result of the construction of a GTCC LLRW and GTCC-like waste disposal facility are expected.

6.2.7.2 Operations

Because incoming GTCC LLRW and GTCC-like waste containers would only be consolidated for placement in trench, borehole, and vault facilities, with no repackaging necessary, there would be no radiological impacts on the general public during disposal operations and no adverse health effects on the general population. In addition, no surface releases that might enter local streams would occur. Because the health impacts of routine operations on the general public would be negligible, it is expected that there would be no disproportionately high and adverse impact on minority and low-income population groups within the 80-km (50-mi) assessment area. Subsequent NEPA review to support any GTCC implementation would consider any unique exposure pathways (such as subsistence fish, vegetation, or wildlife consumption or well water use) to determine any additional potential adverse health and environmental impacts.

6.2.7.3 Accidents

An accidental radiological release from any of the land disposal facilities would not be expected to cause any LCFs to members of the public in the surrounding area. In the unlikely event of a release at a facility, the communities most likely to be affected could be minority or low-income, given the demographics within 80 km (50 mi) of the GTCC reference location. However, it is highly unlikely such a release would occur, and the risk to any population, including low-income and minority communities, is considered to be low for the accident with the highest potential impacts, estimated to be less than 0.06 LCF for the population groups residing to the southeast of the site.

Although the overall risk would be very small, the greatest short-term risk of exposure following an airborne release and the greatest one-year risk would be to the population groups residing to the southeast of the site because of the prevailing wind condition in this case. Airborne releases following an accident would likely have a larger impact on the area than would an accident that released contaminants directly into the soil surface.

Monitoring of contaminant levels in soil and surface water following an accident would provide the public with information on the extent of any contaminated areas. Analysis of contaminated areas to decide how to control the use of high-health-risk areas would reduce the potential impact on local residents.

6.2.8 Land Use

Section 5.3.8 presents an overview of the potential land use impacts that could result from the GTCC LLRW and GTCC-like waste disposal facility regardless of the location selected for it. This section evaluates the potential impacts on land use at the Hanford Site. The amount of land altered for the GTCC LLRW and GTCC-like waste disposal facility would be up to 44 ha (110 ac).

The GTCC reference location is situated within an industrial (exclusive) land use zone immediately to the south of the 200 East Area. Thus, there would be no change in overall land use patterns at the Hanford Site under any of the three land disposal methods. Land use on areas surrounding the Hanford Site would not be affected. Future land use activities that would be permitted within or immediately adjacent to the GTCC LLRW and GTCC-like waste disposal facility would be limited to those that would not jeopardize the integrity of the facility or cause a safety risk to security workers or the public.

6.2.9 Transportation

The transportation impacts from the shipments that would be required to dispose of all GTCC LLRW and GTCC-like waste at the Hanford Site were evaluated. As discussed in Section 5.3.9, the transportation of all cargo by both truck and rail modes as separate options is considered for the purposes of this EIS. There is currently no active rail transportation on the Hanford Site. Evaluations with regard to new rail spurs and upgrades to existing rail lines would be addressed in follow-on NEPA analyses, as appropriate. Transportation impacts are expected to be the same no matter which disposal method is chosen (boreholes, trenches, or vaults) because the same type of transportation packaging would be used regardless of the disposal method chosen.

As discussed in Appendix C, Section C.9, three impacts from transportation were calculated: (1) collective population risks during routine conditions and accidents

(Section 6.2.9.1), (2) radiological risks to the highest exposed individual during routine conditions (Section 6.2.9.2), and (3) consequences to individuals and populations after the most severe accidents involving a release of radioactive or hazardous chemical material (Section 6.2.9.3).

Radiological impacts during routine conditions are a result of human exposure to the low levels of radiation near the shipment. The regulatory limit established in 49 CFR 173.441 (Radiation Level Limitations) and 10 CFR 71.47 (External Radiation Standards for All Packages) to protect the public is 0.1 mSv/h (10 mrem/h) at 2 m (6 ft) from the outer lateral sides of the transport vehicle. This dose rate corresponds roughly to 14 mrem/h at 1 m (3 ft). As discussed in Appendix C, Section C.9.4.4, the external dose rate for CH shipments to Hanford is assumed to be 0.5 and 1.0 mrem/h at 1 m (3 ft) for truck and rail shipments, respectively. For shipments of RH waste, the external dose rate is assumed to be 2.5 and 5.0 mrem/h at 1 m (3 ft) for truck and rail shipments, respectively. These assignments are based on shipments of similar types of waste. Dose rates from rail shipments are approximately double those for truck shipments because rail shipments are assumed to have twice the number of waste packages as a truck shipment. Impacts from accidents are dependent on the amount of radioactive material in a shipment and on the fraction that is released if an accident occurs. The parameters used in the transportation accident analysis are described further in Appendix C, Section C.9.4.3.

6.2.9.1 Collective Population Risk

The collective population risk is a measure of the total risk posed to society as a whole by the actions being considered. For a collective population risk assessment, the persons exposed are considered as a group; no individual receptors are specified. Exposure to four different groups were considered: (1) persons living and working along the transportation routes, (2) persons sharing the route, (3) persons at stops along the route, and (4) transportation crew members. The collective population risk is used as the primary means of comparing various options. Collective population risks are calculated for cargo-related causes for routine transportation and accidents. Vehicle-related risks are independent of the cargo in the shipment and are calculated only for traffic accidents (fatalities caused by physical trauma).

Estimated impacts from the truck and rail options are summarized in Tables 6.2.9-1 and 6.2.9-2, respectively. For the truck option, it is estimated that about 12,600 shipments resulting in about 50 million km (30 million mi) of travel would cause no LCFs in the truck crew or the public. One fatality directly related to accidents might result. It is projected that no LCFs would result from the rail option, but one fatality from an accident could occur. The rail option would involve approximately 5,010 railcar shipments involving about 20 million km (12 million mi) of travel. The estimated total truck distance travelled of about 50 million km (30 million mi) would be about 0.04% of the total vehicle miles travelled (173,130 million km or 107,602 million mi) by heavy-duty trucks in the United States in 2002 (DOT 2005).

TABLE 6.2.9-1 Estimated Collective Population Transportation Risks for Shipment of GTCC LLRW and GTCC-Like Waste by Truck for Disposal at the Hanford Site[a]

			Cargo-Related[b] Radiological Impacts								Vehicle-Related Impacts[c]
			Dose Risk (person-rem)						Latent Cancer Fatalities[d]		
				Routine Public							
Waste	No. of Shipments	Total Distance (km)	Routine Crew	Off-Link	On-Link	Stops	Total	Accident[e]	Crew	Public	Physical Accident Fatalities
Group 1											
GTCC LLRW											
Activated metals - RH											
Past BWRs	20	77,600	0.81	0.023	0.12	0.14	0.28	0.00017	0.0005	0.0002	0.0017
Past PWRs	143	490,000	5.1	0.14	0.73	0.9	1.8	0.00085	0.003	0.001	0.011
Operating BWRs	569	2,180,000	23	0.57	3.2	4	7.8	0.0034	0.01	0.005	0.046
Operating PWRs	1,720	6,620,000	69	1.8	9.8	12	24	0.012	0.04	0.01	0.14
Sealed sources - CH	209	698,000	0.29	0.066	0.4	0.5	0.96	0.041	0.0002	0.0006	0.014
Cesium irradiators - CH	240	802,000	0.34	0.076	0.45	0.58	1.1	0.0061	0.0002	0.0007	0.016
Other Waste - CH	5	17,700	0.0074	0.0016	0.01	0.013	0.024	<0.0001	<0.0001	<0.0001	0.0004
Other Waste - RH	54	240,000	2.5	0.071	0.35	0.44	0.86	<0.0001	0.001	0.0005	0.0055
GTCC-like waste											
Activated metals - RH	38	69,800	0.73	0.017	0.1	0.13	0.25	<0.0001	0.0004	0.0001	0.0035
Sealed sources - CH	1	3,340	0.0014	0.00032	0.0019	0.0024	0.0046	<0.0001	<0.0001	<0.0001	<0.0001
Other Waste - CH	69	271,000	0.11	0.029	0.16	0.19	0.38	0.00088	<0.0001	0.0002	0.0055
Other Waste - RH	1,160	4,620,000	48	1.2	6.8	8.5	16	0.0022	0.03	0.01	0.093

TABLE 6.2.9-1 (Cont.)

			Cargo-Related[b] Radiological Impacts								Vehicle-Related Impacts[c]
			Dose Risk (person-rem)						Latent Cancer Fatalities[d]		
				Routine Public							
Waste	No. of Shipments	Total Distance (km)	Routine Crew	Off-Link	On-Link	Stops	Total	Accident[e]	Crew	Public	Physical Accident Fatalities
Group 2											
GTCC LLRW											
Activated metals - RH											
Past BWRs	202	801,000	8.3	0.21	1.2	1.5	2.9	0.0017	0.005	0.002	0.017
Past PWRs	833	3,100,000	32	0.89	4.6	5.7	11	0.0058	0.02	0.007	0.065
Additional commercial waste	1,990	8,160,000	85	2.2	12	15	29	<0.0001	0.05	0.02	0.16
Other Waste - CH	139	570,000	0.24	0.06	0.33	0.41	0.8	0.0029	0.0001	0.0005	0.011
Other Waste - RH	3,790	15,700,000	160	4.3	23	29	56	0.00083	0.1	0.03	0.32
GTCC-like waste											
Other Waste - CH	44	178,000	0.074	0.018	0.1	0.13	0.25	0.00039	<0.0001	0.0001	0.0035
Other Waste - RH	1,400	5,730,000	59	1.5	8.4	11	20	0.0023	0.04	0.01	0.12
Total Groups 1 and 2	12,600	50,300,000	500	13	71	90	170	0.08	0.3	0.1	1

a BWR = boiling water reactor, PWR = pressurized water reactor, CH = contact-handled, RH = remote-handled.

b Cargo-related impacts are impacts attributable to the radioactive nature of the material being transported.

c Vehicle-related impacts are impacts independent of the cargo in the shipment.

d LCFs were calculated by multiplying the dose by the conversion factor of 6×10^{-4} fatal cancer per person-rem (see Section 5.2.4.3).

e Dose risk is a societal risk and is the product of accident probability and accident consequence.

TABLE 6.2.9-2 Estimated Collective Population Transportation Risks for Shipment of GTCC LLRW and GTCC-Like Waste by Rail for Disposal at the Hanford Site[a]

			Cargo-Related[b] Radiological Impacts								Vehicle-Related Impacts[c]
			Dose Risk (person-rem)						Latent Cancer Fatalities[d]		
				Routine Public							
Waste	No. of Shipments	Total Distance (km)	Routine Crew	Off-Link	On-Link	Stops	Total	Accident[e]	Crew	Public	Physical Accident Fatalities
Group 1											
GTCC LLRW											
Activated metals - RH											
Past BWRs	7	26,600	0.2	0.064	0.0038	0.084	0.15	0.00039	0.0001	<0.0001	0.0017
Past PWRs	37	131,000	1	0.31	0.019	0.44	0.77	0.0016	0.0006	0.0005	0.0066
Operating BWRs	154	609,000	4.6	1.4	0.089	1.9	3.4	0.0041	0.003	0.002	0.021
Operating PWRs	460	1,850,000	14	4.3	0.25	6	10	0.012	0.008	0.006	0.067
Sealed sources - CH	105	365,000	0.84	0.24	0.015	0.51	0.76	0.0019	0.0005	0.0005	0.0064
Cesium irradiators - CH	120	417,000	0.95	0.27	0.017	0.58	0.87	0.00027	0.0006	0.0005	0.0073
Other Waste - CH	3	10,700	0.024	0.011	0.00078	0.015	0.027	<0.0001	<0.0001	<0.0001	0.00053
Other Waste - RH	27	124,000	0.91	0.3	0.019	0.35	0.67	<0.0001	0.0005	0.0004	0.0038
GTCC-like waste											
Activated metals - RH	11	21,300	0.2	0.042	0.0027	0.092	0.14	<0.0001	0.0001	<0.0001	0.0026
Sealed sources - CH	1	3,480	0.008	0.0023	0.00014	0.0048	0.0073	<0.0001	<0.0001	<0.0001	<0.0001
Other Waste - CH	35	140,000	0.31	0.14	0.0089	0.19	0.34	0.00016	0.0002	0.0002	0.0048
Other Waste - RH	579	2,380,000	18	5.5	0.35	7.5	13	0.00039	0.01	0.008	0.08

TABLE 6.2.9-2 (Cont.)

			Cargo-Related[b] Radiological Impacts								Vehicle-Related Impacts[c]
			Dose Risk (person-rem)						Latent Cancer Fatalities[d]		
				Routine Public							
Waste	No. of Shipments	Total Distance (km)	Routine Crew	Off-Link	On-Link	Stops	Total	Accident[e]	Crew	Public	Physical Accident Fatalities
Group 2											
GTCC LLRW											
Activated metals - RH											
New BWRs	54	232,000	1.7	0.5	0.029	0.79	1.3	0.0016	0.001	0.0008	0.0075
New PWRs	227	913,000	6.9	2.1	0.12	3	5.3	0.0046	0.004	0.003	0.03
Additional commercial waste	498	2,080,000	16	4.9	0.31	6.6	12	<0.0001	0.009	0.007	0.072
Other Waste - CH	70	292,000	0.64	0.29	0.019	0.4	0.71	0.00055	0.0004	0.0004	0.01
Other Waste - RH	1,900	8,000,000	60	19	1.2	25	45	0.0001	0.04	0.03	0.27
GTCC-like waste											
Other Waste - CH	22	93,000	0.2	0.092	0.0057	0.12	0.22	<0.0001	0.0001	0.0001	0.003
Other Waste - RH	702	2,940,000	22	6.9	0.43	9.2	1.7	0.00035	0.01	0.01	0.1
Total Groups 1 and 2	5,010	20,600,000	150	46	2.9	63	110	0.028	0.09	0.07	0.7

a BWR = boiling water reactor, PWR = pressurized water reactor, CH = contact-handled, RH = remote-handled.

b Cargo-related impacts are impacts attributable to the radioactive nature of the material being transported.

c Vehicle-related impacts are impacts independent of the cargo in the shipment.

d LCFs were calculated by multiplying the dose by the health risk conversion factor of 6×10^{-4} fatal cancer per person-rem (see Section 5.2.4.3).

e Dose risk is a societal risk and is the product of accident probability and accident consequence.

6.2.9.2 Highest-Exposed Individuals during Routine Conditions

During the routine transportation of radioactive material, specific individuals might be exposed to radiation in the vicinity of a shipment. Risks to these individuals for a number of hypothetical exposure-causing events were estimated. The receptors include transportation workers, inspectors, and members of the public exposed during traffic delays, while working at a service station, or while living and or working near a destination site. The assumptions about exposure are given in Section C.9.2.2 of Appendix C, and transportation impacts are discussed in Section 5.3.9. The scenarios for exposure are not meant to be exhaustive; they were selected to provide a range of representative potential exposures. On a site-specific basis, if someone was living or working near the Hanford Site entrance and present for all 12,600 truck or 5,010 rail shipments projected, that individual's estimated dose would be approximately 0.5 or 1.0 mrem, respectively. The individual's associated lifetime LCF risk would then be 3×10^{-7} or 6×10^{-7} for truck or rail shipments, respectively.

6.2.9.3 Accident Consequence Assessment

Whereas the collective accident risk assessment considers the entire range of accident severities and their related probabilities, the accident consequence assessment assumes that an accident of the highest severity category has occurred. The consequences, in terms of committed dose (rem) and LCFs for radiological impacts, were calculated for both exposed populations and individuals in the vicinity of an accident. Because the exact location of such a transportation accident is impossible to predict and thus not specific to any one site, generic impacts were assessed, as presented in Section 5.3.9.

6.2.10 Cultural Resources

There are no known historic properties within the GTCC reference location, although isolated prehistoric artifacts have been found in the area. The project area is within the viewshed of the historically significant Hanford Site Plant Railroad and the Gable-Butte-Gable Mountain traditional cultural property. If the location at the Hanford Site was chosen for development, the NHPA Section 106 process for considering potential project effects on historic properties would be followed. The Section 106 process requires that the facility location and any ancillary locations that would be affected by the project be investigated for the presence of historic properties prior to disturbance. Consultation requirements associated with the NHPA and DOE American Indian & Alaska Native Tribal Government Policy would also be followed.

It is expected that most of the impacts on cultural resources would occur during the construction phase. Previous research in the region indicates that some isolated prehistoric artifacts would be found in the project area. If archaeological sites were identified, they would require evaluation for listing on the NRHP. For any effects associated with historic properties, the appropriate mitigation would be determined through the requirements of the NHPA and DOE American Indian & Alaska Native Tribal Government Policy.

The borehole method has the greatest potential to affect cultural resources because of its requirements for 44 ha (110 ac) of land. The amount of land needed to employ this method is twice that needed to employ the vault or trench method.

Impacts would likely occur during the ground clearing needed for disposal facilities. The vault method also requires large amounts of soil to cover the waste. Impacts on cultural resources could occur during the removal and hauling of the soil required for this method. Impacts on cultural resources would need to be considered for the soil extraction locations by means of additional NEPA review, as appropriate. Where applicable, the NHPA Section 106 process would be followed. Potential impacts on cultural resources from the operation of a vault facility could be comparable to those expected from the borehole method. While the actual footprint would be smaller for the vault method, the amount of land disturbed for the cover could exceed the land required for the borehole method.

Activities associated with operations and post-closure are expected to have a minimal impact on cultural resources. No new ground-disturbing activities are expected to occur in association with operations and post-closure activities.

6.2.11 Waste Management

The construction of the land disposal facilities would generate small quantities of hazardous and nonhazardous solids and hazardous and nonhazardous liquids. Nonhazardous wastes include sanitary wastes. Waste generated from operations would include small quantities of solid LLRW (e.g., spent HEPA filters) and nonhazardous solid waste (including recyclable wastes). These waste types would either be disposed of on-site or sent off-site for disposal. It is expected that waste that could be generated from the construction and operations of the land disposal methods would have no impacts on waste management programs at the Hanford Site. Section 5.3.11 provides a summary of the waste handling programs at the Hanford Site for the waste types generated.

6.3 SUMMARY OF POTENTIAL ENVIRONMENTAL CONSEQUENCES AND HUMAN HEALTH IMPACTS

The potential environmental consequences presented in Section 6.2 from the disposal of GTCC LLRW and GTCC-like waste under Alternatives 3 to 5 are summarized by resource area as follows:

Air quality. Potential impacts from construction and operations would be negligible or minor at most. It is estimated that during construction and operations, total peak-year emissions of criteria pollutants, VOCs, and CO_2 would be small (see Tables D-15 and D-17 in Appendix D). The highest emissions would be associated with the borehole and vault disposal methods, about 0.20% of the four-county emissions total for SO_2. O_3 levels in the four counties encompassing the Hanford Site are currently in attainment; O_3 precursor emissions from construction and operational activities would be relatively small, less than 0.14% and 0.01% of

NO_X and VOC emissions, respectively, and much lower than those for the regional air shed. During construction and operations, maximum CO_2 emissions would be less than 0.00001% of global emissions, a value that is considered negligible. All construction and operational activities would occur at least 6 km (4 mi) from the site boundary and would not contribute significantly to PM concentrations at the boundary or at the nearest residence. Fugitive dust emissions during construction and operations would be controlled by best management practices. Activities for decommissioning would be similar to those for construction but on a more limited scale and for a more limited duration. Potential impacts on ambient air quality would therefore be correspondingly less for decommissioning than for construction.

Noise. The highest composite noise during construction would be about 92 dBA at 15 m (50 ft) from the source. Noise levels at 690 m (2,300 ft) from source would be below the EPA guideline. This distance is well within the Hanford Site boundary, and there are no residences within this distance. No ground-borne vibration impacts are anticipated. Noise generated from operations would be less than noise during the construction phase.

Geology. No adverse impacts from the extraction and use of geologic and soil resources are expected, and there would be no significant changes in surface topography or natural drainages. The potential for erosion would be reduced by the low precipitation rates at Hanford and would be further reduced by best management practices.

Water resources. Construction of a vault facility would have the highest water requirement. Water demands for construction at the Hanford Site would be met by using surface water from the Columbia River and the 100-B Area Export Water System. No groundwater would be used at the site during construction; therefore, no direct impacts on groundwater are expected. Indirect impacts on surface water would be reduced by implementing good industry practices and mitigation measures. Construction and operations of the proposed GTCC LLRW and GTCC-like waste disposal facility would increase the annual water use at the Hanford Site by a maximum of about 0.4% and 0.65%, respectively, both for the vault method (see Tables 5.3.3-2 and 5.3.3-3). Since these increases would be well within the capacity of Hanford's 200 East Area, it is expected that impacts from surface water withdrawals would be negligible. Groundwater could become contaminated with some highly soluble radionuclides during the post-closure period; indirect impacts on surface water could result from aquifer discharges to springs and rivers.

Human health. The impacts on workers from disposal operations would be mainly those from the radiation doses associated with waste handling. The annual doses to the workers would be 2.6 person-rem/yr for the borehole method, 4.6 person-rem/yr for the trench method, and 5.2 person-rem/yr for the vault method. None of these doses are expected to result in any LCFs (see Table 5.3.4.1.1). The maximum dose to any individual worker would not exceed the project (Hanford Site) administrative control level of 500 mrem/yr. It is expected that the maximum dose to any individual worker over the entire project would not exceed a few rem.

The worker impacts from accidents would be associated with the physical injuries and possible fatalities that could result from construction and waste handling activities. It is estimated that the annual number of lost workdays due to injuries and illnesses would range from 1 (for the borehole method) to 2 (for the trench and vault methods) and that there would be no fatalities from construction and waste handling accidents (see Section 5.3.4.1.1). These injuries would not be associated with the radioactive nature of the wastes but would simply be those that are expected to occur in any construction project of this size.

With regard to the general public, no measurable doses are expected to occur during waste disposal operations at the site, given the solid nature of the wastes and the distance of waste handling activities from potentially affected individuals. It is estimated that the highest dose to an individual from an accident involving the waste packages prior to disposal (from a fire affecting an SWB) would be 16 rem and would not result in any LCFs. It is estimated that the collective dose to the affected population from such an event would be 95 person-rem. It is estimated that the peak dose in the first 10,000 years after closure of the disposal facility to a hypothetical nearby receptor (resident farmer) who resided 100 m (330 ft) from the disposal site would be 4.8 mrem/yr for boreholes, 49 mrem/yr for vaults, and 48 mrem/yr for trenches. These peak annual doses would occur at 1,800 years, 3,300 years, and 2,900 years, respectively, after failure of the cover and engineered barriers (which is assumed to begin 500 years after closure of the disposal facility). The peak annual dose for borehole disposal would be mainly from GTCC LLRW activated metals, and the peak annual doses for trench and vault disposal would be mainly from GTCC-like Other Waste - RH.

Ecological resources. Although loss of sagebrush habitat, followed by eventual establishment of low-growth vegetation, would affect species dependent on sagebrush (e.g., black-tailed jackrabbit, pygmy rabbit, sage sparrow, and northern sagebrush lizard), population-level impacts on these species are not expected. Reestablishment of sagebrush after closure could take a minimum of 10 to 20 years. Also, loss of sagebrush would be compensated for by required restoration elsewhere on the Hanford Site. Ground-nesting birds observed in the 200 Area include the horned lark, killdeer, long-billed curlew, and western meadowlark. Ground disturbance during the nesting season could destroy the eggs and young of these species and displace nesting individuals to other areas of the Hanford Site. There are no natural aquatic habitats (including wetlands) within the immediate vicinity of the GTCC reference location. No federally listed species have been reported in the project area.

Socioeconomics. Impacts from constructing a GTCC LLRW and GTCC-like waste disposal facility would be small. Construction would create direct employment for up to 145 people (vault method) in the peak construction year and 152 indirect jobs (vault method) in the ROI; the annual average employment growth rate would increase by less than 0.1 of a percentage point. The land disposal facilities would produce up to $12.3 million in income in the peak construction year. An estimated 64 people would in-migrate to the ROI as a result of employment on-site; in-migration would have only a marginal effect on population growth and require less than 1% of vacant housing in the peak year. Impacts from operating the facility would also be small; operations would create 51 direct jobs (vault method) annually and an additional 43 indirect jobs (vault method) in the ROI. The land disposal facilities would produce about $5.0 million in income annually during operations (vault method).

Environmental justice. Health impacts on the general population within the 80-km (50-mi) assessment area during construction and operations would be negligible, and no impacts on minority and low-income populations as a result of the construction and operations of a GTCC LLRW and GTCC-like waste disposal facility are expected. If analyses that accounted for any unique exposure pathways (such as subsistence fish, vegetation, or wildlife consumption or well-water consumption) determined that health and environmental impacts would not be significant, then there would be no high and adverse impacts on minority and low-income populations. If impacts were found to be significant, disproportionality would be determined by comparing the proximity of high and adverse impacts to the location of low-income and minority populations.

Land use. The GTCC reference location would be an additional facility to the south of the 200 Area complex; land use patterns at the Hanford Site would not be changed under any of the three land disposal methods.

Transportation. Shipment of all waste to the Hanford Site by truck would result in approximately 12,600 shipments with a total distance of 50 million km (31 million mi) traveled. For shipment of all waste by rail, 5,010 railcar shipments involving 20 million km (12 million mi) of travel would be required. It is estimated that no LCFs would occur to the public or crew members for either mode of transportation, but one fatality from an accident could occur.

Cultural resources. There are no known cultural resources within the project area, although isolated prehistoric artifacts have been found in the surrounding area, and the project area is within the viewshed of the Hanford Site Plant Railroad and the Gable Butte-Gable Mountain traditional cultural property. Section 106 of NHPA would be followed to determine the impact of the project on significant cultural resources. Local tribes would be consulted to ensure that no traditional cultural properties would be affected by the project under the land disposal methods. The trench method has the least potential to affect cultural resources (especially during the construction phase) because it requires the smallest amount of land.

Waste management. The small quantity of wastes that could be generated from the construction and operations of the land disposal methods (see Table 5.3.11-1) are not expected to affect current waste management programs at the Hanford Site.

6.4 CUMULATIVE IMPACTS

Section 5.4 presents the methodology for the cumulative impacts analysis. In the analysis that follows, impacts of the proposed action are considered in combination with the impacts of past, present, and reasonably foreseeable future actions. This section begins with a description of reasonably foreseeable future actions at the Hanford Site, including those that are ongoing, under construction, or planned for future implementation. Past and present actions are generally accounted for in the affected environment section (Section 6.1).

6.4.1 Reasonably Foreseeable Future Actions

Reasonably foreseeable future actions at the Hanford Site are summarized in the following sections. These actions were identified primarily from a review of the *Final Tank*

American Indian Text

There is a growing recognition that conventional risk assessment methods do not address all of the things that are “at risk” in communities facing the prospect of contaminated waste sites, permitted chemical or radioactive releases, or other environmentally harmful situations. Conventional risk assessments do not provide enough information to "tell the story" or answer the questions that people ask about risks to their community, health, resource base, and way of life. As a result, cumulative risks, as defined by the community, are often not described, and therefore the remedial decisions may not be accepted. The full span of risks and impacts needs to be evaluated within the risk assessment framework in order for cumulative risks to be adequately characterized. This is in contrast to a more typical process of evaluating risks to human health and ecological resources within the risk assessment phase and deferring the evaluation of risks to sociocultural and socioeconomic resources until the risk management phase.

Within this EIS process, a cumulative risk assessment needs to be developed for the Hanford option. This risk assessment needs to utilize the existing Hanford Tribal risk scenarios (CTUIR, Yakama Indian Nation, DOE default), and include existing Hanford risk values to determine cumulative impacts.

Institutional control boundaries need to be clearly displayed in a map, showing the GTCC proposed repository and the extent it will add to the size, scope, and timeframe of limiting access. For Indian People, a 10,000-year repository extends institutional controls without reasonable compensation or mitigation.

Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington (TC&WM EIS; DOE 2012). The actions listed are planned, under construction, or ongoing. A comprehensive list of the actions and activities considered for the TC&WM EIS cumulative analysis and their source documents is provided in Table R-4 of DOE (2012) and is not reproduced here.

6.4.1.1 DOE Actions at the Hanford Site

Current DOE activities with the potential to contribute to cumulative impacts at the Hanford Site are related to site cleanup, waste disposal, and tank stabilization (DOE 2012). These include:

- Cleanup and restoration activities across all areas of the Hanford Site;

- Changes in land use;

- Decommissioning of the eight surplus reactors and their support facilities in the 100 Areas along the Columbia River;

- Decommissioning of the N Reactor and support facilities;

- Safe storage of surplus plutonium at the Plutonium Finishing Plant in the 200 West Area (until it can be shipped to the SRS for disposition);

- Deactivation of the Plutonium Finishing Plant in the 200 West Area;

- Actions to empty the K Basins in the 100 K Area and to implement dry storage of the fuel rods in the Canister Storage Building in the 200 East Area;

- Completion of the U Plant regional closure;

- Final disposition and cleanup of facilities at the 200 East and West Areas (e.g., canyons, PUREX Plant, PUREX tunnels) to comply with industrial exclusive land use standards;

- Transport of sodium-bonded spent nuclear fuel to the INL Site for treatment;

- Deactivation of the Fast Flux Test Facility in the 400 Area;

- Construction and operations of a PNNL Physical Sciences Facility;

- Excavation and use of geologic materials from existing borrow pits;

- Construction and operations of the Environmental Restoration Disposal Facility near the 200 West Area;

- Implementation of the decisions described in the RODs for the final waste management programmatic EIS;

- Retrieval of suspect TRU waste (buried in 1970);

- Cleanup and protection of groundwater; and

- Transport of TRU waste to WIPP near Carlsbad, New Mexico.

6.4.1.2 Non-DOE Actions at the Hanford Site

Non-DOE activities with the potential to contribute to cumulative impacts at the Hanford site are related to site cleanup, waste disposal, and tank stabilization (DOE 2012). These include:

- Transport of U.S. Navy reactor plants from the Columbia River and their disposal in the 200 East Area,

- Continued operation of the Columbia Generating Station,

- Operation of the U.S. Ecology commercial LLRW disposal site near the 200 East Area,

- Management of the Hanford Reach National Monument and Saddle Mountain National Wildlife Refuge, and

- Operation of the Laser Interferometer Gravitational-Wave Observatory.

6.4.1.3 Off-Site Activities

Off-site activities with the potential to contribute to cumulative impacts relate to land clearing for agriculture and urban development, water diversion and irrigation projects, waste management, industrial and commercial development, mining, power generation, and the development of transportation and utility infrastructure (DOE 2012). Specific off-site activities near the Hanford Site include:

- Changes in regional land use as described in local city and county comprehensive land use plans;

- U.S. Department of Defense base realignment and closure;

- Cleanup of toxic, hazardous, and dangerous waste disposal sites;

- Water management for the Columbia and Yakima River basins;

- Power generation and transmission projects;

- Pipeline projects; and

- Transportation projects.

6.4.2 Cumulative Impacts from the GTCC Proposed Action at the Hanford Site

Potential impacts of the proposed action are considered in combination with the impacts of past, present, and reasonably foreseeable future actions. The summary of environmental impacts in Section 6.3 indicates that the potential impacts from the GTCC EIS proposed action (construction and operations of a borehole, trench, or vault disposal facility) would be small for all the resource areas evaluated and would not result in a meaningful contribution to overall cumulative impacts, except to human health post-closure impacts (groundwater pathway and resultant dose) from past, present, and reasonably foreseeable future actions at the Hanford Site. To obtain perspective on the cumulative impacts that could occur at the Hanford Site when the potential impacts from this EIS are considered, the cumulative impacts presented in the Hanford TC&WM EIS (DOE 2012) were reviewed for comparison of some of the resource areas evaluated in this EIS. According to the Hanford TC&WM EIS (DOE 2012), the receipt of off-site waste streams that contain specific amounts of certain isotopes, specifically iodine-129 and technetium-99, could cause an adverse impact on the environment. The evaluation presented in the TC&WM EIS indicates that 2.3 Ci of iodine-129 from off-site waste streams results in impacts above the maximum contaminant levels (MCLs), regardless of whether the waste streams are disposed of in the 200 East Area under Waste Management Alternative 2 or in the 200 West Area under Waste Management Alternative 3. The impacts from the technetium-99 inventory of 1,460 Ci from off-site waste streams evaluated in this Hanford EIS are shown to be less significant than those from iodine-129. However, when the impacts of technetium-99 from past leaks and cribs and trenches (ditches) are combined, DOE believes it may not be prudent to add significant additional technetium-99 to the existing environment. Therefore, one means of mitigating this impact would be for DOE to limit disposal of off-site waste streams containing iodine-129 or technetium-99 at Hanford.

The GTCC reference location would be south of the 200 East Area that has been committed to industrial exclusive use; as such, the GTCC proposed action would be consistent with this land use designation. The largest land use impacts at the Hanford Site from Alternatives 3 to 5 as presented in this EIS would result from the use of 44 ha (110 ac) for the borehole method. This amount of land is small when added to the approximately 25,800 ha (63,800 ac) that could be disturbed from cumulative actions at Hanford (DOE 2012).

The vault method could require up to 200,000 m^3 (260,000 yd^3) of soil. The cumulative soil requirements for actions at Hanford would exceed the current soil resource availability (i.e., about 87.7 million m^3 [115 million yd^3] required versus 49.6 million m^3 [64.9 million yd^3] available) (DOE 2012). Hence, the GTCC proposed action could require an additional small amount of soil for which a source has to be identified. Potential impacts from this future borrow area, if needed, would have to be considered in follow-on evaluations.

The relatively small acreage that would be disturbed for the GTCC proposed action would likely not contribute to cumulative impacts for cultural resources at Hanford. The Hanford TC&WM EIS indicates that cultural resources (prehistoric, historic, and paleontological resources) have a low potential of being present for a majority of DOE and non-DOE activities at Hanford (DOE 2012).

Likewise, peak annual employment resulting from the GTCC proposed action (approximately 145 direct jobs) would be small when compared with the possible cumulative total of 14,700 FTEs discussed in the Hanford TC&WM EIS.

A potential long-term impact from the GTCC proposed action would be the groundwater radionuclide concentrations that could result if the integrity of the facility did not remain intact in the distant future. The human health evaluation for the post-closure phase of the proposed action indicates that a dose of up to 48 mrem/yr (trench disposal method) or 49 mrem/yr (vault method) could be incurred by the hypothetical resident farmer assumed to be located 100 m (330 ft) from the edge of the disposal facility. It is estimated that the dose to the hypothetical receptor would be about 10 times lower if the borehole disposal method was used. These doses were calculated to occur about 1,800 years (borehole method), 3,300 years (vault method), and 2,900 years (trench method) after failure of the cover and engineered barriers, which are assumed to retain their integrity for 500 years following the closure of the disposal facility.

These doses would be primarily associated with GTCC-like RH waste, and the primary radionuclide contributors within 10,000 years would be Tc-99 and I-129. The Hanford TC&WM EIS (DOE 2012) cumulative estimates for Alternative Combination 1 indicate that the peak concentrations for Tc-99 and I-129 would be about 35,000 pCi/L and 58.8 pCi/L, respectively, in the calendar years 1956 and 3577. The GTCC EIS estimates of the peak concentrations for Tc-99 and I-129 corresponding to the highest dose given above (49 mrem/yr) are about 10,000 pCi/L and 100 pCi/L; these concentrations would occur at approximately the same time as the time reported in the Hanford TC&WM EIS. As stated in the Hanford TC&WM EIS (DOE 2012), when the impacts of technetium-99 from past leaks and cribs and trenches (ditches) are combined, DOE believes it may not be prudent to add significant additional technetium-99 to the existing environment. Therefore, one means of mitigating this impact would be for DOE to limit disposal of off-site waste streams containing iodine-129 or technetium-99 at Hanford. Finally, follow-on NEPA evaluations and documents prepared to support any further considerations of siting a new borehole, trench, or vault disposal facility at Hanford would provide more detailed analyses of site-specific issues, including cumulative impacts.

6.5 SETTLEMENT AGREEMENTS AND CONSENT ORDERS FOR THE HANFORD SITE

The TC&WM EIS implements a Settlement Agreement signed on January 6, 2006, by DOE, the State of Washington Department of Ecology, and the Washington State Attorney General's Office. The TC&WM EIS includes several preferred alternatives for the actions analyzed, including disposing of Hanford's LLRW and mixed LLRW on-site and deferring Hanford's importation of off-site waste at least until the WTP was operational, consistent with DOE's recently proposed Settlement Agreement with the State of Washington. Off-site waste would be addressed after the WTP was operational, subject to appropriate NEPA reviews. Consistent with its preference regarding receipt at Hanford of LLRW and mixed LLRW, DOE announced in the December 18, 2009, *Federal Register* (74 FR 67189) that DOE would not ship GTCC LLRW to Hanford at least until the WTP was operational. Therefore, disposal of GTCC LLRW and GTCC-like waste in a new trench, vault, or borehole facility at Hanford would be contingent upon the start of WTP operations.

In the ROD (69 FR 39449, June 30, 2004) to the January 2004 *Final Hanford Site Solid (Radioactive and Hazardous) Waste Program Environmental Impact Statement, Richland, Washington* (HSW EIS), DOE announced its decision to limit the amount of off-site LLRW and mixed LLRW received at Hanford to 62,000 m^3 (81,000 yd^3) and 20,000 m^3 (26,000 yd^3), respectively, and to dispose of LLRW and mixed LLRW in lined rather than unlined trenches at Hanford. The GTCC LLRW and GTCC-like waste disposed of at Hanford would be in addition to the 62,000-m^3 (81,000-yd^3) and the 20,000 m^3 (26,000 yd^3) limits established in the ROD to the HSW EIS.

6.6 REFERENCES FOR CHAPTER 6

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7 IDAHO NATIONAL LABORATORY SITE: AFFECTED ENVIRONMENT AND CONSEQUENCES OF ALTERNATIVES 3, 4, AND 5

This chapter provides an evaluation of the affected environment, environmental and human health consequences, and cumulative impacts from the disposal of GTCC LLRW and GTCC-like waste under Alternative 3 (in a new borehole disposal facility), Alternative 4 (in a new trench disposal facility), and Alternative 5 (in a new vault disposal facility) at the INL Site. Alternatives 3, 4, and 5 are described in Section 5.1. Environmental consequences that are common to the sites for which Alternatives 3, 4, and 5 are evaluated (including the INL Site) are discussed in Chapter 5 and not repeated in this chapter. Impact assessment methodologies used for this EIS are described in Appendix C. Federal and state statutes and regulations and DOE Orders relevant to the INL Site are discussed in Chapter 13 of this EIS.

7.1 AFFECTED ENVIRONMENT

This section discusses the affected environment for the various environmental resource areas evaluated for the 230,000 ha (580,000 ac) area spanned by the INL Site. The reference location shown in Figure 7.1-1 is situated to the southwest of the Advanced Test Reactor (ATR) Complex in the south central portion of the INL Site. As a result of the Final RH LLW EA (INL 2011b), the preferred site is located to the southwest of the ATR Complex in the same area as the GTCC reference location. The reference location was selected primarily for evaluation purposes for this EIS. If DOE decides to locate a GTCC land disposal facility at the INL Site, the location of such a facility would not be expected to affect the preferred location for the proposed Idaho RH LLW disposal facility, and it would not be located in an area that would allow doses to exceed regulatory limits when combined with other radionuclide sources (i.e., CERCLA releases) in accordance with the requirements for composite analyses of DOE Order 435.1. The actual GTCC disposal location would be identified on the basis of follow-on evaluations if and when it is decided to locate a land disposal facility at the INL Site. As indicated in the following discussion, the INL site is unique in the overall heterogeneity represented because of the geologic genesis of the Snake River Plain. In the absence of site-specific data, and for the purpose of estimating groundwater impacts, conservative input parameters were assumed to represent the previously unanalyzed GTCC reference location. Collection and analysis of site-specific data in support of a GTCC disposal facility would be considered as part of any follow-on NEPA review for the INL Site.

7.1.1 Climate, Air Quality, and Noise

7.1.1.1 Climate

At the INL Site and the surrounding area, which are located along the western edge of the Eastern Snake River Plain (ESRP), the climate is characterized as that of a semiarid steppe (DOE 2005). The location of the INL Site and its surrounding area in the ESRP, including their altitude above sea level, latitude, and inter-mountain setting, affects the climate of the site

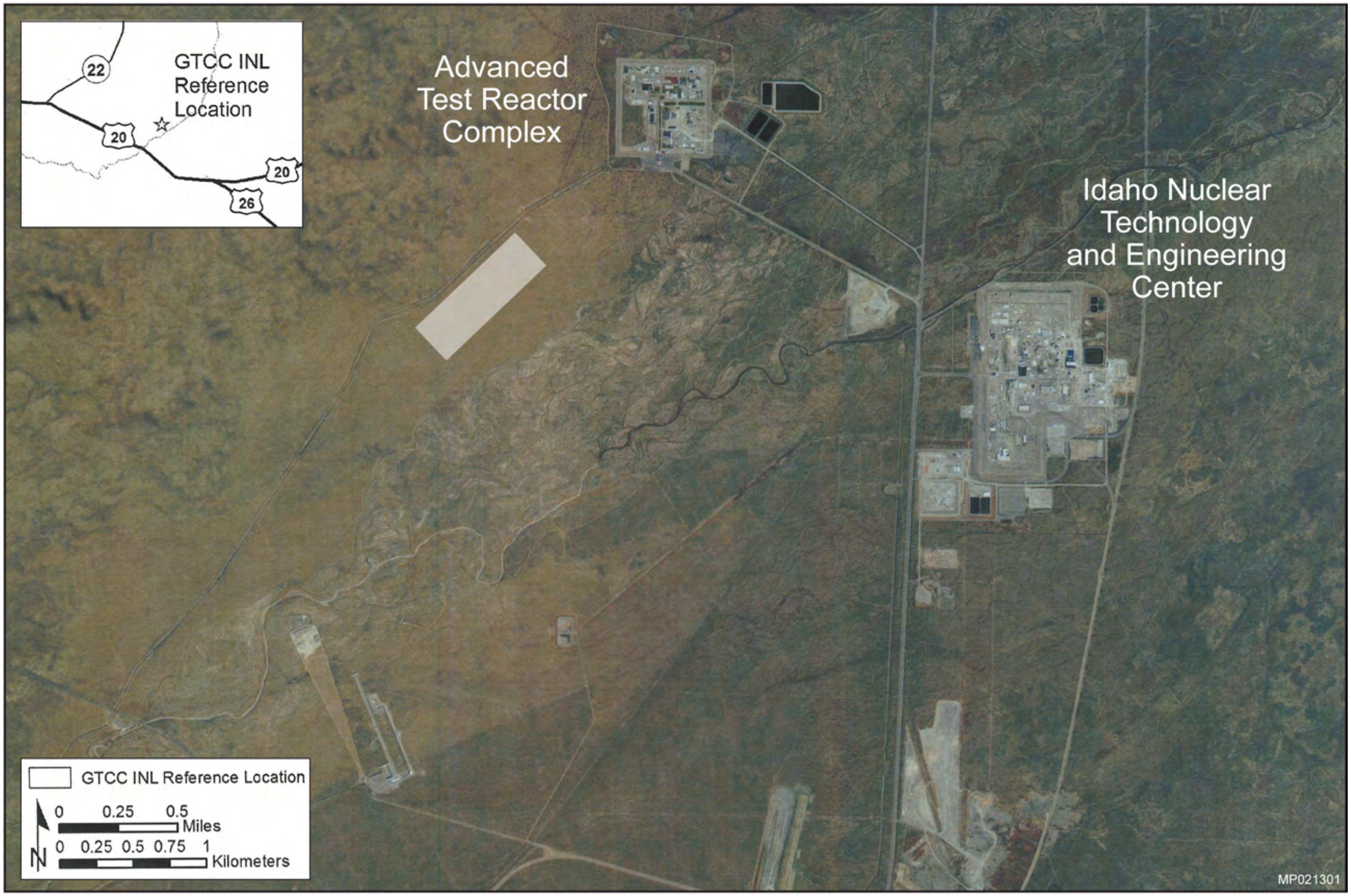

FIGURE 7.1-1 GTCC Reference Location at the INL Site (The RH LLW EA [INL 2011b] identified its preferred site to be one that is located to the southwest of the ATR Complex in the same area as the GTCC reference location. The GTCC site, if sited at the INL Site, would not be expected to affect the preferred site selected by the RH LLW EA.)

(Clawson et al. 1989). Air masses crossing the ESRP, which gather moisture over the Pacific Ocean and traverse several hundred miles of mountainous terrains, have been responsible for a large percentage of any inherent precipitation. The relatively dry air and infrequent low clouds allow intense solar heating of the surface during the day and rapid radiative cooling at night. Accordingly, the climate exhibits low relative humidity, wide daily temperature swings, and large variations in annual precipitation. Most of the following discussion is extracted from Clawson et al. (1989) for the period 1950–1988. Because of the size and topographic features of the INL Site, meteorological data differ from station to station within and around the site. Meteorological data are presented for the Central Facilities Area (CFA), which is the area closest to the GTCC reference location that has an on-site station with comprehensive meteorological data.

As shown in Figure 7.1.1-1, most on-site locations experience the predominant southwest-northeast wind flow of the ESRP, although some discrepancies from this flow pattern exist because of local terrain features (Clawson et al. 1989). The mountains bordering the ESRP act to channel the prevailing west winds into a southwesterly flow. This flow results because of the northeast-southwest orientation of the ESRP between the bordering mountain ranges. The second most frequent wind direction is from the northeast. Average annual wind speeds at the CFA 6-m (20-ft) tower are about 3.4 m/s (7.5 mph). Wind speeds are fastest in spring (4.1 m/s or 9.1 mph), slower in summer and fall, and slowest (2.6 m/s or 5.9 mph) in winter. The highest hourly average near-ground wind speed measured for CFA was 23 m/s (51 mph) from west-southwest, with a maximum instantaneous gust of 35 m/s (78 mph).

For the 1950–1988 period, the annual average temperature for CFA was 5.6°C (42.0°F) (Clawson et al. 1989). January was the coldest month, averaging –8.8°C (16.1°F) and ranging from –13.9 to –1.1°C (7.0 to 30.0°F), and July was the warmest month, averaging 20.0°C (68.0°F) and ranging from 18.3 to 22.2°C (64.9 to 72.0°F). For the same period, temperature extremes for CFA ranged from a summertime maximum of 38.3°C (101°F) to a wintertime minimum of –43.9°C (–47°F). As mentioned above, the average daily average temperature ranges are significant. July and August had an average daily air temperature of 21°C (70°F), while December and January had an average daily air temperature of 13°C (55°F) at CFA.

Although the total amount of precipitation at CFA is light, it can be expected in any month of the year. Annual precipitation at the INL Site averages about 22.1 cm (8.7 in.) for CFA (Clawson et al. 1989). Precipitation is relatively evenly distributed by season, with the pronounced precipitation peak in May and June primarily due to regional major synoptic conditions. The maximum 24-hour precipitation is 4.2 cm (1.6 in.), which is primarily attributable to thunderstorms occurring 2 to 3 days per month in summer. Snow typically occurs from September through May, peaking in December and January. The annual average snowfall in the area is about 70 cm (28 in.), with extremes of 17 cm (6.8 in.) and 150 cm (60 in.).

Other than thunderstorms, severe weather is uncommon because high mountains block air masses from penetrating into the area, although blowing dust occurs during spring and summer, and dust devils are common in summer. the INL Site may experience an average of two or three thunderstorm days during the summer months, with considerable year-to-year variation (Clawson et al. 1989).

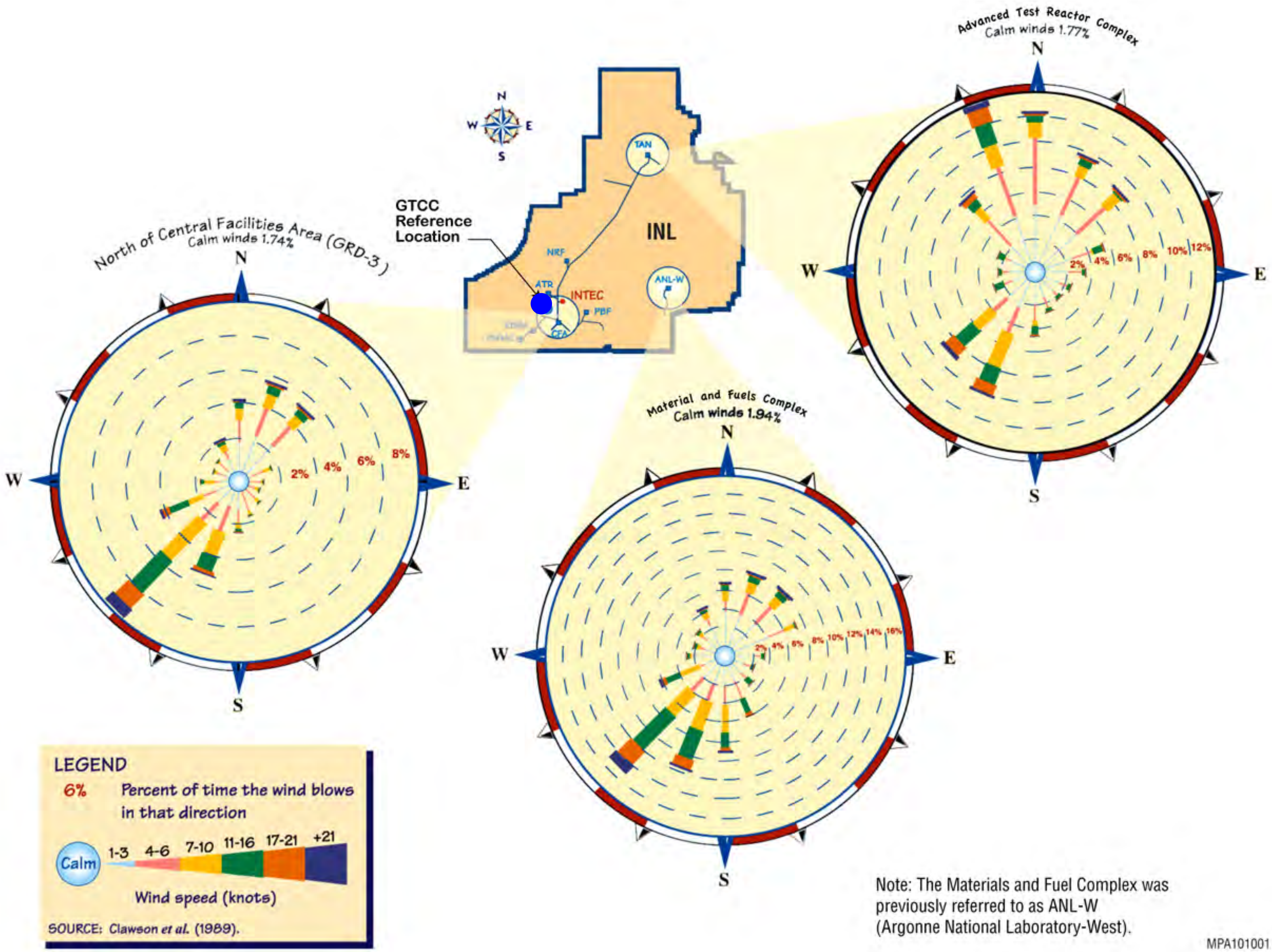

FIGURE 7.1.1-1 Wind Roses at Meteorological Stations on the INL Site (Source: DOE 2002)

Tornadoes in the area surrounding the INL Site are much less frequent and destructive than those in the tornado alley in the central United States. For the period 1950–2008, 185 tornadoes were reported in Idaho, with an average of 3.2 tornadoes per year (NCDC 2008). For the period 1950–2008, 45 tornadoes (an average of 0.8 tornado per year) were reported in five counties encompassing the INL Site (Bingham, Bonneville, Butte, Clark, and Jefferson). However, most of these tornadoes were relatively weak (i.e., 44 were F0 or F1, and 1 was F2). No deaths and three injuries were associated with these tornadoes. Five funnel clouds and no tornadoes were reported on-site between 1950 and 1997 (DOE 2002).

7.1.1.2 Existing Air Emissions

Title V of the CAAA requires the EPA to develop a federally enforceable operating permit program for air pollution sources to be administered by state and/or local air pollution agencies. The EPA promulgated regulations in July 1992 that defined the requirements for state programs. Idaho has promulgated regulations, and the EPA has given interim approval of the Idaho Title V (Tier I) operating permit program. As of 2008, the INL Site has one Tier I operating permit and 15 active “permits to construct.”

Annual emissions for major facility sources and total point and area source emissions (for year 2002) for criteria pollutants and VOCs in the five counties encompassing the INL Site are presented in Table 7.1.1-1 (EPA 2009). (Data for 2002 are available on the EPA website). There are few major point sources in the area (INL Site sources are the major ones in the area); thus, area sources account for most of the emissions of criteria pollutants and VOCs. On-road sources, solvent utilization sources, and miscellaneous sources, respectively, are major contributors to total emissions of NO_x; of VOCs; and of CO, PM_{10}, and $PM_{2.5}$. Nonradiological emissions associated with activities at the INL Site are less than 50% of those in Butte County and less than 3.5% of those in the five counties combined, as shown in the table.

The primary source of air pollutants at the INL Site is fuel oil combustion for heating (DOE 2005). Other emission sources include waste burning, industrial processes, stationary diesel engines, vehicles, and fugitive dust from waste burial and construction activities. Table 7.1.1-2 presents emissions for criteria pollutants and VOCs under the Title V permit for the year 2004.

7.1.1.3 Air Quality

Among criteria pollutants (SO_2, NO_2, CO, O_3, PM_{10} and $PM_{2.5}$, and lead), the Idaho SAAQS are identical to the NAAQS for SO_2, NO_2, CO, 1-hour O_3, PM_{10}, and lead (EPA 2008a; Idaho Administrative Procedures Act [IDAPA] 58.01.01), as shown in Table 7.1.1-3. However, no standards have been established for 8-hour O_3 and $PM_{2.5}$ in Idaho, and the state has adopted standards for fluorides, as presented in the table.

The INL Site is located primarily within Butte County, but portions are also in Bingham, Bonneville, Clark, and Jefferson Counties. Currently, the entire counties encompassing the INL Site are designated as being in attainment for all criteria pollutants (40 CFR 81.313). However,

TABLE 7.1.1-1 Annual Emissions of Criteria Pollutants and Volatile Organic Compounds from Selected Major Facilities and Total Point and Area Source Emissions in Five Counties Encompassing the INL Site[a]

	Emission Rate (tons/yr)					
Emission Category	SO_2	NO_x	CO	VOCs	PM_{10}	$PM_{2.5}$
Bingham County						
Basic American Foods[b]	*8.5*	*116*	*203*	*7.2*	*98*	*63*
Point sources	32	251	380	16	222	133
Area sources	175	3,614	28,385	7,456	17,102	2,806
Total	207	3,865	28,765	7,472	17,324	2,939
Bonneville County						
Point sources	56	20	0	0.8	13	8.3
Area sources	282	4,200	25,899	8,944	13,318	2,385
Total	338	4,220	25,899	8,945	13,331	2,393
Butte County						
INL Site	*68*	*117*	*29*	*5.3*	*14*	*7.4*
	75.78%[c]	*27.14%*	*0.87%*	*0.69%*	*0.63%*	*1.55%*
	8.71%	*1.11%*	*0.04%*	*0.02%*	*0.03%*	*0.10%*
Point sources	68	120	29	5.3	14	7.4
Area sources	22	314	3,254	768	2,269	471
Total	90	432	3,283	773	2,283	479
Clark County						
Larsen Farms	*0.9*	*139*	*23*	*3.7*	*34*	*12*
Point sources	0.9	139	23	3.7	34	12
Area sources	15.3	147	6,217	3,269	864	215
Total	16.2	286	6,240	3,273	898	227
Jefferson County						
Point sources	2.0	32	0.0	1.5	50	33
Area sources	129	1,705	13,851	4,154	10,078	1,478
Total	131	1,738	13,851	4,156	10,128	1,511
Five-county total	782	10,541	78,038	24,619	43,964	7,549

[a] Emission data for selected major facilities and total point and area sources are for year 2002. CO = carbon monoxide, NO_x = nitrogen oxides, $PM_{2.5}$ = particulate matter ≤2.5 μm, PM_{10} = particulate matter ≤10 μm, SO_2 = sulfur dioxide, VOCs = volatile organic compounds.

[b] Data in italics are not added to yield total.

[c] The top row and bottom row with % signs show the above source's emissions as percentages of Butte County total emissions and five-county total emissions, respectively.

Source: EPA (2009)

parts of Bannock and Power Counties, about 48 km (30 mi) southeast and 56 km (35 mi) south of the INL Site boundary, respectively, are designated nonattainment for PM_{10}.

In 2006, the environmental surveillance, education, and research contractor sampled ambient air, including 24-hour PM_{10} levels, at communities beyond the INL Site boundary (DOE 2007). Concentrations at Rexburg ranged from 0.0 to 44.8 μg/m^3, while those at Blackfoot ranged from 0.3 to 50.1 μg/m^3. Concentrations at Atomic City ranged from 0.0 to 66.1 μg/m^3, and thus all 24-hour concentrations were well below the EPA standard of 150 μg/m^3. In addition, all measurements were less than the EPA standard for annual average concentrations.

TABLE 7.1.1-2 Annual Emissions of Criteria Pollutants and Volatile Organic Compounds at the INL Site in 2004

Emission Rate (tons/yr)[a]			
SO_x	NO_x	VOCs	PM_{10}
9.1	63.9	1.7	3.5

Source: DOE (2005)

Nearby urban or suburban measurements are typically used as being representative of background concentrations for the INL Site. The highest concentration levels for SO_2, NO_2, CO, and lead around the INL Site are less than or equal to 39% of their respective standards in Table 7.1.1-3 (EPA 2009). However, the highest O_3, PM_{10}, and $PM_{2.5}$ concentrations somewhat approach or exceed the applicable standards (maximum of 169% for $PM_{2.5}$ due to recent standard revision) in the area. Relatively high PM levels are attributable to agricultural activities in the region, frequent dust storms, and forest fires.

The INL Site and its vicinity are classified as PSD Class II areas. The only Class I area within 100 km (62 mi) is the Crater of the Moon Wilderness Area, about 40 km (25 mi) west-southwest of the GTCC reference location (40 CFR 81.410).

7.1.1.4 Existing Noise Environment

Except for the prohibition of nuisance noise, neither the state of Idaho nor local governments around the INL Site have established quantitative noise-limit regulations. For the general area surrounding the INL Site, countywide day-night sound levels (L_{dn}) based on population density are estimated to be the highest (at 39 dBA) in Bonneville County. They are around 35 dBA in Bingham and Jefferson Counties, a level that is typical of rural areas (Miller 2002; Eldred 1982). They are less than 30 dBA in Butte and Clark Counties, a level that is similar to the natural background noise level of a wilderness area.

The major noise sources at the INL Site include various industrial activities and equipment (e.g., cooling systems, transformers, engines, pumps, boilers, steam vents, paging systems), construction and material-handling equipment, and vehicles (DOE 2005). Most INL Site industrial facilities are far enough from the site boundary that noise levels from these sources are not measurable or are barely distinguishable from background levels at the boundary. Existing noise levels related to the INL Site that are of public significance result from the transportation of people and material to and from the site and facilities located in town via buses, private vehicles, and freight trains.

TABLE 7.1.1-3 National Ambient Air Quality Standards (NAAQS) or Idaho State Ambient Air Quality Standards (SAAQS) and Highest Background Levels Representative of the GTCC Reference Location at the INL Site, 2003–2007

			Highest Background Level	
Pollutant[a]	Averaging Time	NAAQS/ SAAQS[b]	Concentration[c,d]	Location (Year)
SO_2	1-hour	75 ppb	–[e]	–
	3-hour	0.50 ppm	0.059 ppm (12%)	Pocatello, Bannock Co. (2005)
	24-hour	0.14 ppm	0.024 ppm (17%)	Pocatello, Bannock Co. (2007)
	Annual	0.03 ppm	0.006 ppm (20%)	Pocatello, Bannock Co. (2007)
NO_2	1-hour	0.100 ppm	–	–
	Annual	0.053 ppm	0.008 ppm (16%)	Power Co. (2004)
CO	1-hour	35 ppm	6.0 ppm (17%)	Nampa, Canyon Co. (2003)[f]
	8-hour	9 ppm	3.5 ppm (39%)	Nampa, Canyon Co. (2003)[f]
O_3	1-hour	0.12 ppm[g]	0.078 ppm (65%)	Butte Co. (2007)
	8-hour	0.075 ppm	0.070 ppm (93%)	Butte Co. (2003)
PM_{10}	24-hour	150 µg/m^3	120 µg/m^3 (80%)	Bingham Co. (2003)
	Annual	50 µg/m^3	37 µg/m^3 (74%)	Bingham Co. (2003)
$PM_{2.5}$	24-hour	35 µg/m^3	59 µg/m^3 (169%)	Idaho Falls, Bonneville Co. (2004)
	Annual	15.0 µg/m^3	10.1 µg/m^3 (67%)	Idaho Falls, Bonneville Co. (2004)
Lead[h]	Calendar quarter	1.5 µg/m^3	0.03 µg/m^3 (2.0%)	Kellogg, Shoshone Co. (2002)[f]
	Rolling 3-month	0.15 µg/m^3	–	–
Fluorides	Monthly	80 ppm	–	–
	Bimonthly	60 ppm	–	–
	Annual arithmetic mean	40 ppm	–	–

[a] CO = carbon monoxide, NO_2 = nitrogen dioxide, O_3 = ozone, $PM_{2.5}$ = particulate matter ≤2.5 µm, PM_{10} = particulate matter ≤10 µm, SO_2 = sulfur dioxide.

[b] The more stringent between the NAAQS and the SAAQS is listed when both are available.

[c] Monitored concentrations are the highest arithmetic mean for calendar-quarter lead; second-highest for 3-hour and 24-hour SO_2, 1-hour and 8-hour CO, 1-hour O_3, and 24-hour PM_{10}; fourth-highest for 8-hour O_3; 98th percentile for 24-hour $PM_{2.5}$; arithmetic mean for annual SO_2, NO_2, PM_{10}, and $PM_{2.5}$.

[d] Values in parentheses are monitored concentrations as a percentage of SAAQS or NAAQS.

[e] A dash indicates that no measurement is available.

[f] These locations with highest observed concentrations in the state of Idaho are not representative of the INL Site but are presented to show that these pollutants are not a concern over the state of Idaho.

Footnotes continue on next page.

TABLE 7.1.1-3 (Cont.)

[g] On June 15, 2005, the EPA revoked the 1-hour O_3 standard for all areas except the 8-hour O_3 nonattainment Early Action Compact (EAC) areas (those do not yet have an effective date for their 8-hour designations). The 1-hour standard will be revoked for these areas 1 year after the effective date of their designation as attainment or nonattainment for the 8-hour O_3 standard.

[h] Used old standard because no data in the new standard format are available.

Sources: 40 CFR 52.21; EPA (2008a, 2009); IDAPA 58.01.01 (refer to http://adm.idaho.gov/adminrules/rules/idapa58/0101.pdf)

Although no environmental survey data on noise around the site boundaries were available, noise measurement data were available for 15 m (50 ft) from the roadway along U.S. Route 20 (DOE 2005). Traffic noise levels ranged from 64 to 86 dBA,[1] and the primary source was buses (71 to 80 dBA). While few residences exist within 15 m (50 ft) from the roadway, INL-related traffic noise might be objectionable to members of the public residing near principal highways or busy bus routes. Noise levels along these routes may have decreased somewhat as a result of reductions in employment and bus service at the INL Site in the last few years. Because noise levels from industrial activities at the INL Site are not measurable or are only barely distinguishable at the INL Site boundary, the acoustic environment along the INL Site boundary has relatively low ambient noise levels, ranging from 35 to 40 dBA (DOE 2002).

7.1.2 Geology and Soils

7.1.2.1 Geology

7.1.2.1.1 Physiography. The INL Site sits on a relatively flat area along the northwestern edge of the ESRP, within the ESRP Physiographic Province (Figure 7.1.2-1). The ESRP was built up from multiple eruptions of basaltic lava between 4 million and 2,100 years ago. Four volcanic rift zones, each with a northwestern trend, cut across the plain and have been identified as the source areas for these eruptions. The volcanic rift zone orientations are the result of basalt dikes that intruded perpendicular to the northeast-southwest direction of extension associated with the Basin and Range Physiographic Province. The most recent episode of basalt volcanism occurred 2,000 years ago in the Great Rift volcanic rift zone to the south of the INL Site (DOE 2005; Payne 2006).

Surficial sediments overlying the uppermost basalt consist of unconsolidated clay, silt, sand, and gravel and range in thickness from 0 to 95.4 m (0 to 313 ft). These materials represent

[1] The levels seem to be peak pass-by measurements, so L_{dn} values that use a 24-hour averaging time would be much lower, except when there are high traffic volumes during the day and night.

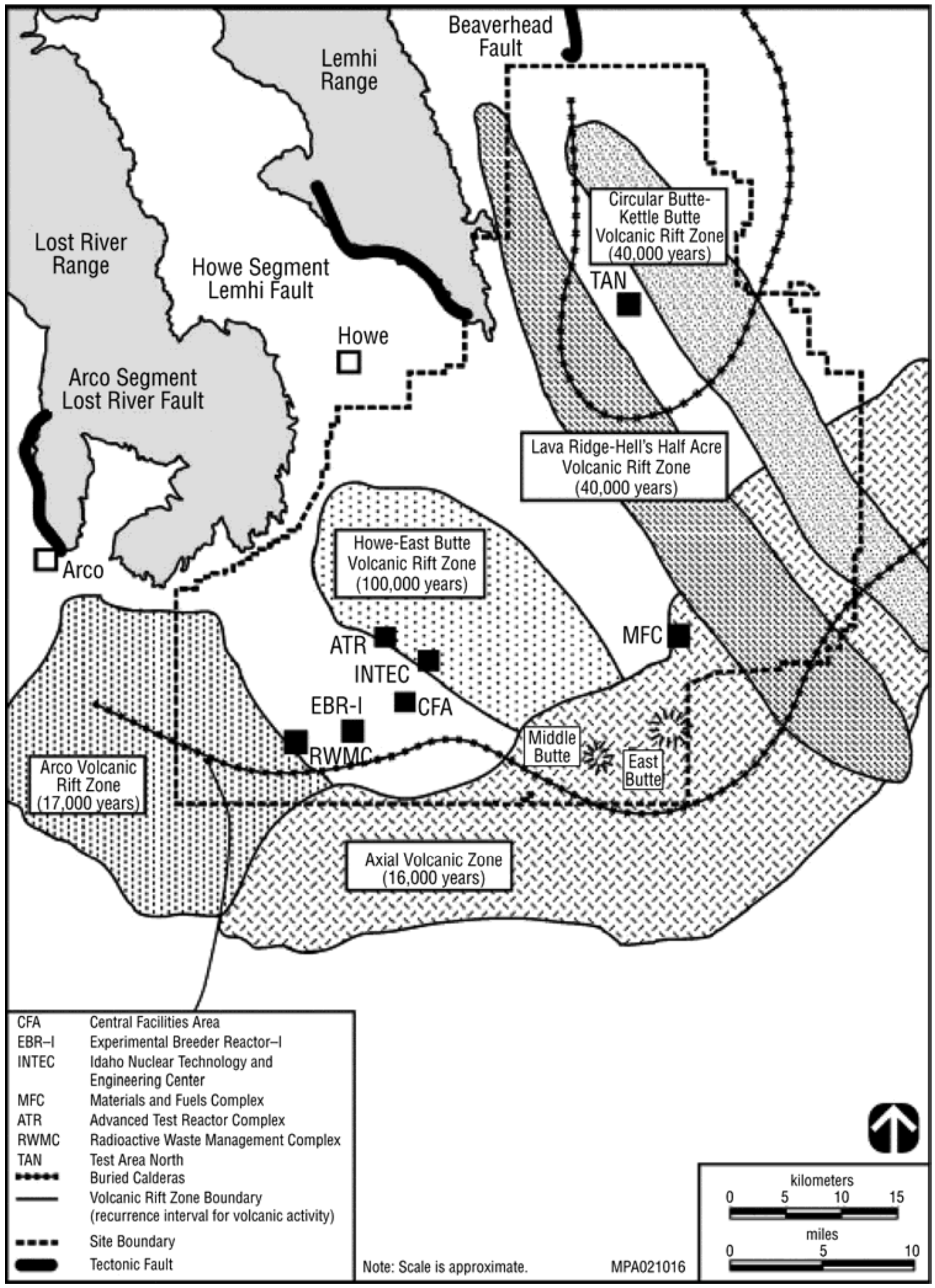

FIGURE 7.1.2-1 Location of the INL Site on the Eastern Snake River Plain (The values in parentheses represent volcanic recurrence intervals derived by dividing the number of volcanic events into the age range of volcanism.) (Figure reproduced from Hackett et al. [2002]. Source: DOE 2005)

alluvial, lacustrine (lake or playa basins), eolian, and colluvial deposits that have accumulated on the plain during the past 200,000 years (Anderson et al. 1996; DOE 2005).

The ESRP is bounded on the north and south by the north-to-northwest trending mountains of the northern Basin and Range Physiographic Province. The mountain peaks, reaching heights of 3,660 m (12,000 ft), are separated by basins filled with terrestrial sediments and volcanic rocks. The basins are 5- to 20-km (3- to 12- mi) wide and grade onto the ESRP. The Yellowstone Plateau lies to the northeast of the ESRP (DOE 2005).

7.1.2.1.2 Topography. The land surface in the INL Site region is relatively flat, with elevations ranging from 1,460 m (4,790 ft) in the south to 1,802 m (5,912 ft) in the northeast. Predominant relief occurs as volcanic buttes or as unevenly surfaced basalt flows or flow vents and fissures. Mountain ranges border the site on the north and west (Mattson et al. 2004).

7.1.2.1.3 Site Geology and Stratigraphy. The INL Site is underlain by about 1 to 2 km (0.6 to 1.2 mi) of Quaternary age basaltic lava flows interbedded with poorly consolidated sedimentary materials. Interbedded sediments consist of materials deposited by streams (silts, sands, and gravels), lakes (clays, silts, and sands), and wind (silts) that accumulated on the ESRP between volcanic events. During long periods of inactivity, sediments accumulated to thicknesses greater than 60 m (197 ft). The interbedded basalt flow sequences are collectively known as the Snake River Group (DOE 2005). Stratigraphic data from wells in the vicinity of the GTCC reference location indicate that the first basalt unit is encountered at depths of 13 to 17 m (43 to 57 ft). The average thickness of the basalt unit is about 30 m (100 ft). Layers of sedimentary materials exist between basalt units near the reference location; they range in thicknesses and depths that total about 23.9 m (78.4 ft) (INL 2010).

Underlying the Snake River Group is a thick sequence of Tertiary rhyolitic volcanic rocks that erupted when the area was over the Yellowstone Hotspot, over 4 million years ago.

Several Quaternary rhyolitic domes are located along the Axial Volcanic Zone near the south and southeastern borders of the INL Site. Paleozoic limestones, Late Tertiary rhyolitic volcanic rocks, and large alluvial fans are located in limited areas along the northwestern border. A wide band of Quaternary alluvium extends across the site along the course of the Big Lost River. Ice-age lake deposits (Lake Terreton), eroded by winds in the late Pleistocene and Holocene, were redeposited to form large dune fields in the northeastern portion of the INL Site. The wind-blown loess deposits (silts) may be up to 2.1-m (7-ft) thick on basaltic lava flows throughout the INL Site (DOE 2005).

The GTCC reference location is situated immediately southwest of the ATR Complex in the south-central part of the INL Site. It sits at the southern edge of the Howe-East Butte Volcanic Rift Zone on a thick sequence of Quaternary basalt interbedded with sediments of various textures. Figure 7.1.2-2 presents the lithologic logs of deep drill holes across the INL Site and near the ATR Complex (e.g., INEEL-1).

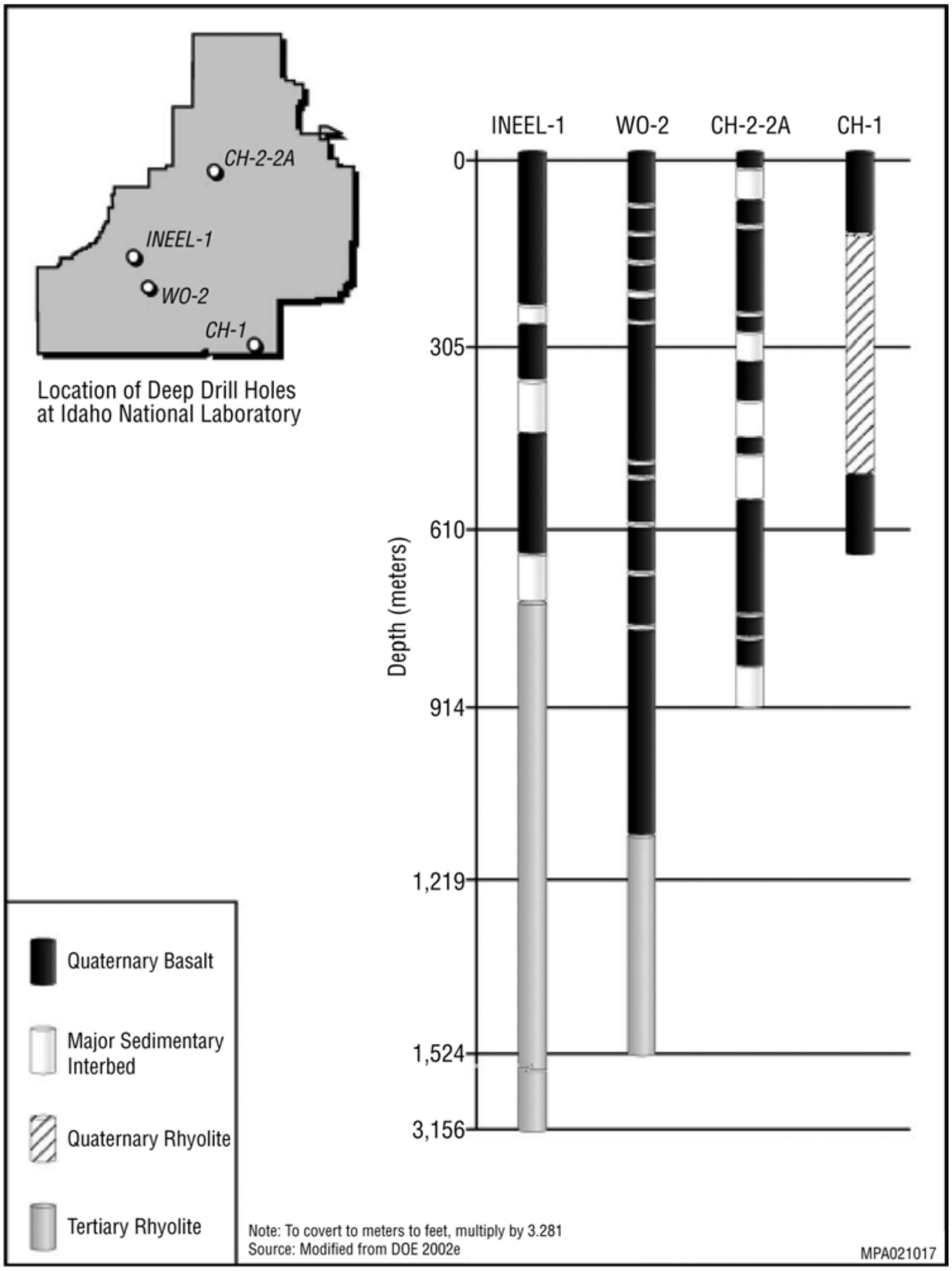

FIGURE 7.1.2-2 Lithologic Logs of Deep Drill Holes at the INL Site (Source: DOE 2005)

7.1.2.1.4 Seismicity. The historical earthquake record between 1872 and 2004 shows the ESRP to be aseismic compared to the surrounding Basin and Range Province (Figure 7.1.2-3). Earthquakes within the Basin and Range Province to the northwest of the INL Site indicate extension in a predominantly northeast-southwest direction. Crustal extension began in this area in the Middle Miocene, about 16 million years ago. The southern segments of three northwest-trending Basin and Range normal faults are located along the northwest boundary of the INL Site (Figure 7.1.2-4). The largest normal-faulting earthquakes occurred more than 80 km (50 mi) from the INL Site: in 1959, near Hebgen Lake, Montana (7.3 magnitude), and in 1983, near Borah Peak, Idaho (7.0 magnitude) (Figure 7.1.2-3). The earthquakes were felt at the INL Site but caused no significant damage (Payne 2006).

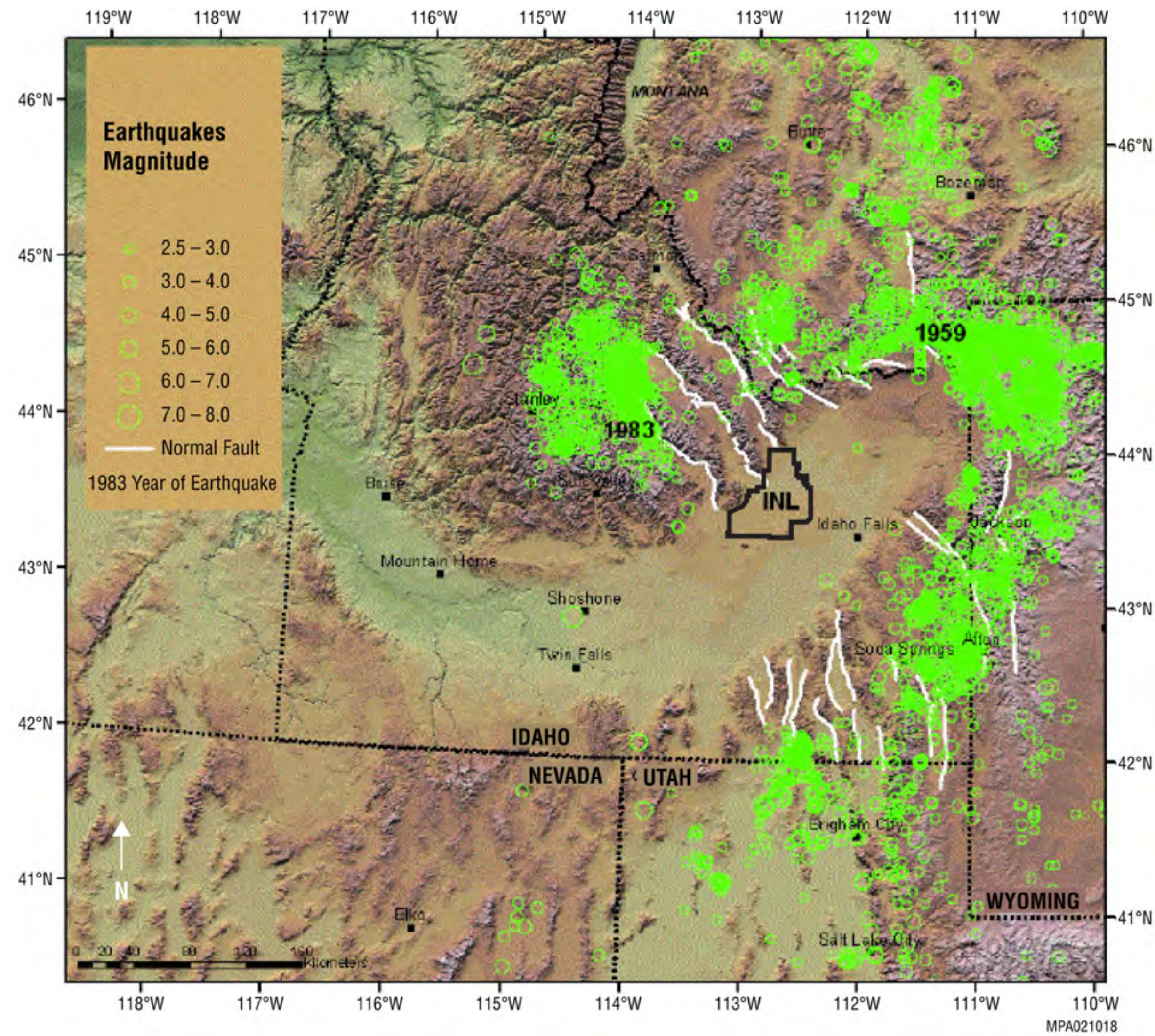

FIGURE 7.1.2-3 Map of Earthquakes with Magnitudes of 2.5 or Greater Occurring from 1872 to 2004 near the INL Site (The Hebgen Lake and Borah Peak earthquakes are indicated as "1959" and "1983" on the map, respectively.) (Source: Payne 2006)

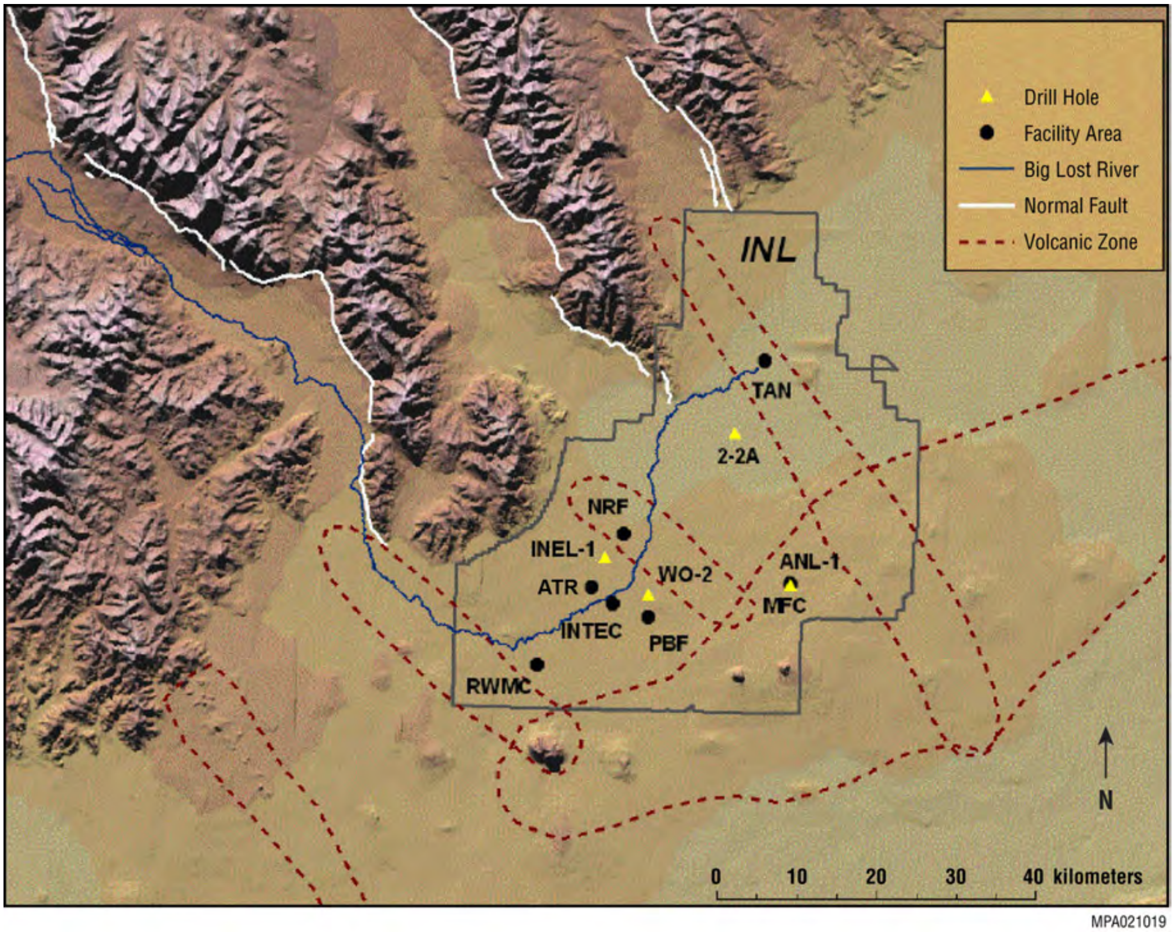

FIGURE 7.1.2-4 Locations of Normal Faults, Volcanic Rift Zones, Deep Drill Holes, and INL Site Facility Areas (Source: Payne 2006)

The nearest capable fault to the ATR Complex is the Howe Segment of the Lemhi Fault. The fault terminates near the northwestern INL Site boundary about 32 km (20 mi) north of the ATR Complex (Figure 7.1.2-1). Other significant faults include the Arco Segment of the Lost River Fault and the Beaverhead Fault. These faults also run along the range front to the northwest of the INL Site.

The INL Site Seismic Monitoring Program, which began in 1971, has 27 permanent seismic stations to determine the time, location, and size of earthquakes occurring near the INL Site. The program also operates 24 strong-motion accelerographs in INL Site facility buildings to record strong ground motions from local moderate or major earthquakes. Seismic monitoring provides data for validating current ground motion models and serves as an early detection system for future volcanism, since low-magnitude earthquake swarms accompany the upward movement of magma. The locations of seismic stations and accelerographs are provided in Payne et al. (2007). In 2006, 356 earthquakes occurred within a 161-km (100-mi) radius of the INL Site. Three of these earthquakes had moment magnitudes greater than 3.0 (the largest earthquake had a magnitude of 4.5). The majority of earthquakes were located in areas that are known to be seismically active, along the normal faults of the Basin and Range Province to the northwest of the INL Site. Three earthquakes occurred along the ESRP in 2006. Two of the 2006 earthquakes (magnitude of 2.0 and 0.4) were located within the INL Site boundaries.

Seismic history and geologic conditions indicate that earthquakes with a moment magnitude of more than 5.5 and the associated strong ground shaking and surface rupture would probably not occur within the ESRP; however, moderate to strong ground shaking from earthquakes in the Basin and Range Province could be felt at the INL Site.

A probabilistic assessment of seismic hazard was conducted by Woodward-Clyde Federal Services in 1996 for all INL Site facility areas, including the Test Reactor Area. It was recomputed in 2000 (WCFS 1996; Payne et al. 2000). The assessments determined that the probabilistic seismic hazard for annual probabilities of once in 2000 years (0.0005) and once in 10,000 years (0.0001) would be 0.11g and 0.18g, respectively, for the ATR Complex, where g is the acceleration of gravity (9.8 m/s/s). These levels are now part of the seismic design criteria for new facilities (Payne 2008). Payne (2007) summarizes the modeling aspects of these assessments, including the modeling of site-specific attenuation relationships.

7.1.2.1.5 Volcanic Activity. Most of the basalt volcanic activity along the ESRP in the vicinity of the INL Site occurred from 4 million to 2,100 years ago. The most recent and closest volcanic eruption occurred at Craters of the Moon National Monument, 44 km (27 mi) southwest of the INL Site.

A volcanic hazard risk assessment by Hackett and Khericha (1993) determined that the major volcanic hazard at the INL Site is the inundation of basaltic lava flows in the event of an eruption within the Great Rift volcanic rift zone. The frequency of a basaltic eruption that could impact areas near the ATR Complex is very low (7.0×10^{-7}), which places it in the "beyond design basis" frequency range (DOE 2002). More explosive rhyolitic volcanism is not expected to occur since the Yellowstone Hotspot is no longer present beneath the site (Payne 2008). The Yellowstone Hotspot currently underlies the Yellowstone National Park area, about 113 km (70 mi) to the northeast.

7.1.2.1.6 Slope Stability, Subsidence, and Liquefaction. No natural factors in the ATR Complex region that would affect the engineering aspects of slope stability have been reported. Ground stability is not expected to be affected by the presence of lava tubes at the site. The potential hazard due to liquefaction is expected to be low (DOE 2005).

7.1.2.2 Soils

Unconsolidated material covers the GTCC reference location and consists of alluvial sediments deposited by the Big Lost River. Sediments are composed mostly of gravel, gravelly sands, and sands ranging in thickness from about 13 to 17 m (43 to 57 ft). A thin layer of silt and clay may underlie the alluvium in places, creating a low-permeability layer at the sediment-basaltic rock contact (Anderson et al. 1996; DOE 2005).

No soils have been designated as prime farmland within INL Site boundaries (DOE 2005).

7.1.2.3 Mineral and Energy Resources

Mineral resources at the INL Site include sand, gravel, pumice, silt, clay, and aggregate. These resources are extracted at several quarries or pits at the site for use in road construction and maintenance, new facility construction and maintenance, waste burial activities, and landscaping. There is a gravel pit at the ATR Complex.

The geology of the ESRP makes the potential for petroleum production very low. The potential for geothermal energy development exists at the INL Site; however, a study conducted in 1979 found no economic geothermal resources (Mitchell et al. 1980).

7.1.3 Water Resources

7.1.3.1 Surface Water

7.1.3.1.1 Rivers and Streams. The INL Site is located within the Mud Lake-Lost River Basin (also called the Pioneer Basin), a closed drainage basin in which surface water infiltrates the ground surface or is lost through evapotranspiration (DOE 2005). There are three main streams within the basin: the Big and Little Lost Rivers and Birch Creek (Figure 7.1.3-1 and Figure 1.4.3-5). These streams drain the mountain areas to the north and west of the INL Site and are intermittent (DOE 2005).

Stream flow in the Big Lost River is extensively regulated to provide irrigation water for the Big Lost Valley. Water is stored in Mackay Reservoir, a 4.75×10^7-m^3 (38,500 ac-ft) capacity reservoir that is located about 72.4 km (45 mi) upstream of the INL Site, and it is delivered by many large diversion channels throughout the growing season (April through October). The river flows southeast from Mackay Dam, past the towns of Mackay, Leslie, and Arco, and onto the ESRP. It drains more than 3,600 km^2 (1,400 mi^2) of mountainous area, including parts of the Lost River Range and Pioneer Range to the west of the INL Site, as shown in Figure 7.1.3-1 (Berenbrock et al. 2007; Hortness and Rousseau 2003). The average annual discharge for the Big Lost River near Arco (Station 13132500) for 51 years of stream flow data (1947 though 1960, 1967 through 1979, and 1983 through 2006) is highly variable, ranging from zero during several years to 13.82 cms (488 cfs) in 1984. The average annual discharge between 1986 and 2006 was 2.39 cms (84.3 cfs) (USGS 2008a).

Since 1958, a diversion dam near the INL Site southwestern boundary has diverted water to a series of natural depressions or spreading centers to the south to prevent flooding of

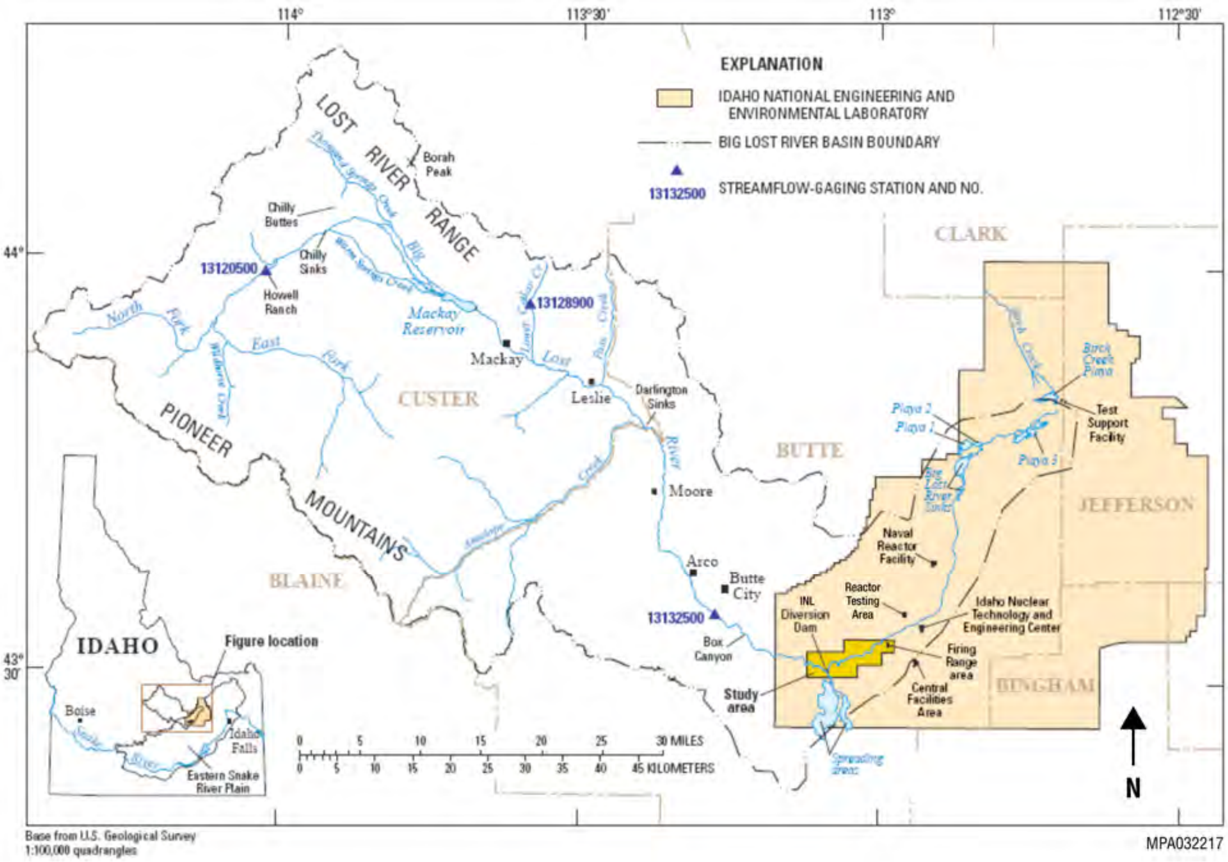

FIGURE 7.1.3-1 Location of Big Lost River Basin and the INL Site (Source: Berenbrock et al. 2007)

downstream areas during periods of heavy runoff. In summer months, most of the flow in the Big Lost River is diverted for irrigation before it reaches the INL Site boundary. Stream flow that reaches the INL Site infiltrates the ground surface along the length of the streambeds in the spreading areas and, if stream flow is sufficient, in the ponding areas (playas or sinks) in the northern part of the site (Figure 7.1.3-1). During periods of high flow or low irrigation demand, the Big Lost River continues northeastward past the diversion dam and disappears via infiltration within a series of playas about 32 km (20 mi) northeast of the ATR Complex (Berenbrock et al. 2007; Orr 1997; DOE 2005). The GTCC reference location at the INL Site is situated immediately southwest of the ATR Complex.

The Little Lost River and Birch Creek flow southeast from the mountains to the north. In summer months, flow from these streams is diverted for irrigation and rarely reaches the INL Site boundary. During periods of high precipitation or rapid snow melt, however, stream flow may enter the site and infiltrate the ground surface (DOE 2005).

7.1.3.1.2 Other Surface Water. Other surface water bodies within the INL Site boundaries include natural wetland-like ponds and several man-made percolation and evaporation ponds used for wastewater management. Wastewater discharge to the land surface is permitted and monitored (DOE 2005).

7.1.3.1.3 Surface Water Quality. The Big and Little Lost Rivers and Birch Creek have been designated for cold water aquatic communities, salmonid spawning, and primary contact recreation, with the Big Lost River sinks and channel and lowermost Birch Creek also classified for domestic water supply and as special resource waters. Water quality in these streams is similar, reflecting the carbonate mineral compositions of the mountain ranges they drain and the quality of irrigation water return flows. No surface waters are used for drinking water at the INL Site, nor is effluent discharged directly to them. No streams have been classified as Wild and Scenic (DOE 2005).

Surface water locations just outside the INL Site boundary are sampled by the contractor for environmental surveillance, education, and research twice a year for gross alpha, gross beta, and tritium. In 2005, 12 surface water samples were collected from five off-site locations along the Snake River, downgradient from the INL Site. No gross alpha activity was detected in these samples. Gross beta activity was detected in 11 of the 12 samples, ranging from 3.22 ±0.90 pCi/L (Hagerman) to 7.09 ± 0.96 pCi/L (Bliss), well below the EPA screening level of 50 pCi/L. Tritium (H-3) was detected at Idaho Falls, about 65 km (40 mi) to the southeast, with a concentration of 231.0 ±31.0 pCi/L in a November sample. It was also detected in a November sample from the Hagerman area to the southwest, with a concentration of 384.0 ±32.9 pCi/L. These concentrations were well below Idaho's primary constituent standards (PCSs) and the EPA maximum contaminant level (MCL) of 20,000 pCi/L (DOE 2006).

7.1.3.2 Groundwater

7.1.3.2.1 Unsaturated Zone. The unsaturated zone extends from the land surface down to the Eastern Snake River Plain Aquifer. It is generally composed of basalt (95%), with a layer of soil (loess) or sediment on top of the basalt and with thin layers of sediment (0.3- to 6.1-m or 1- to 20-ft intervals) between basalt flows. The continuity of the sedimentary units is controlled by basalt flow topography, the rate of sediment deposition, and the time period between volcanic events. At the GTCC reference location, the interbedded sedimentary material is laterally continuous and is composed of fine-grained sands and clays.

At the INL Site, the basalts are highly permeable, and the fine-grained sediments are less permeable. In areas of high infiltration, typically associated with large surface water discharges at INL industrial sites or the Big Lost River, the layers of sediment cause local areas of perched water to form. The GTCC reference location is situated to the southwest of the Advanced Test Reactor (ATR) Complex in the south-central portion of the INL Site (see Figure 7.1-1.). The reference location was selected primarily for evaluation purposes for this EIS. The actual location would be identified on the basis of follow-on evaluations if and when it is decided to locate a land disposal facility at the INL Site. The actual location would not be influenced by perched water.

7.1.3.2.2 Aquifer Units. The INL Site overlies the north-central portion of the 28,000-km^2 (10,800-mi^2) Eastern Snake River Plain Aquifer. This highly productive aquifer is the major source of drinking water for southeastern Idaho and has been designated a Sole Source Aquifer by the EPA (56 FR 50634). The aquifer itself extends to depths greater than 1,067 m (3,500 ft); however, the USGS has estimated that the thickness of the most active portion of the Eastern Snake River Plain Aquifer at the INL Site ranges from 75 to 250 m (250 to 820 ft) thick (Mann 1986). Depth to the water table ranges from about 61 m (200 ft) below the land surface in the northern part of the site to more than 274 m (900 ft) in the southern part. The depth to the top of the Eastern Snake River Plain Aquifer is about 146 m (480 ft) below the GTCC reference location (INL 2011a).

7.1.3.2.3 Groundwater Flow. Groundwater in the Snake River Plain aquifer flows to the south-southwest (Figure 7.1.3-2), with flow velocities ranging from 0.03 to 20 m/d (0.10 to 66 ft/d) (INL 2007). Water mainly moves horizontally through highly permeable basalt interflow zones (Figure 7.1.3-3); vertical movement occurs through joints and interfingering edges of interflow zones. Movement of groundwater is affected locally by various natural conditions (infiltration, seasonal fluxes in recharge and discharge) and man-made conditions (heavy pumpage) (Knobel et al. 2005).

Groundwater is discharged through large spring flows to the Snake River about 110 km (70 mi) south of the INL Site and pumped for irrigation. Major areas of springs and seeps occur near the American Falls Reservoir (southwest of Pocatello) and the Thousand Springs area (near Twin Falls) between Milner Dam and King Hill. It is estimated that the aquifer discharges 8.8 billion m^3 (7.1 million ac-ft) annually to springs and rivers (DOE 2005).

Recharge to the Eastern Snake River Plain Aquifer is principally from infiltration of applied irrigation water, infiltration of stream flow from the Big Lost River, and groundwater inflow from adjoining mountain drainage basins (Garabedian 1992; Orr 1997).

7.1.3.2.4 Groundwater Quality. Groundwater quality at the INL Site is monitored by the USGS using a network of 178 observation or production wells and auger holes. Drinking water is also monitored via 17 production wells and 10 distribution systems. Historical waste disposal practices at the INL Site have created localized plumes of radiochemical contamination within the Snake River Plain aquifer. Of particular concern are tritium and Sr-90. The extent of tritium and Sr-90 plumes at the INL Site is shown in Figure 7.1.3-4. Monitoring wells downgradient of the ATR Complex have continually shown the highest tritium concentrations in the aquifer over time; however, maximum tritium concentrations in these wells dropped below the Idaho PCS and the EPA MCL of 20,000 pCi/L in 1997 and remained below these standards as of 2005 (DOE 2006).

The SR-90 contamination originated from the INTEC as a result of wastewater injection. Sr-90 was not detected in groundwater in the vicinity of the ATR Complex in 2005. Instead, it was retained in surficial sediments, interbeds, and perched groundwater zones. Concentrations of Sr-90 have remained constant at about 1.0 ± 0.6 pCi/L since 1989, which is below the PCS and MCL of 8 pCi/L for drinking water.

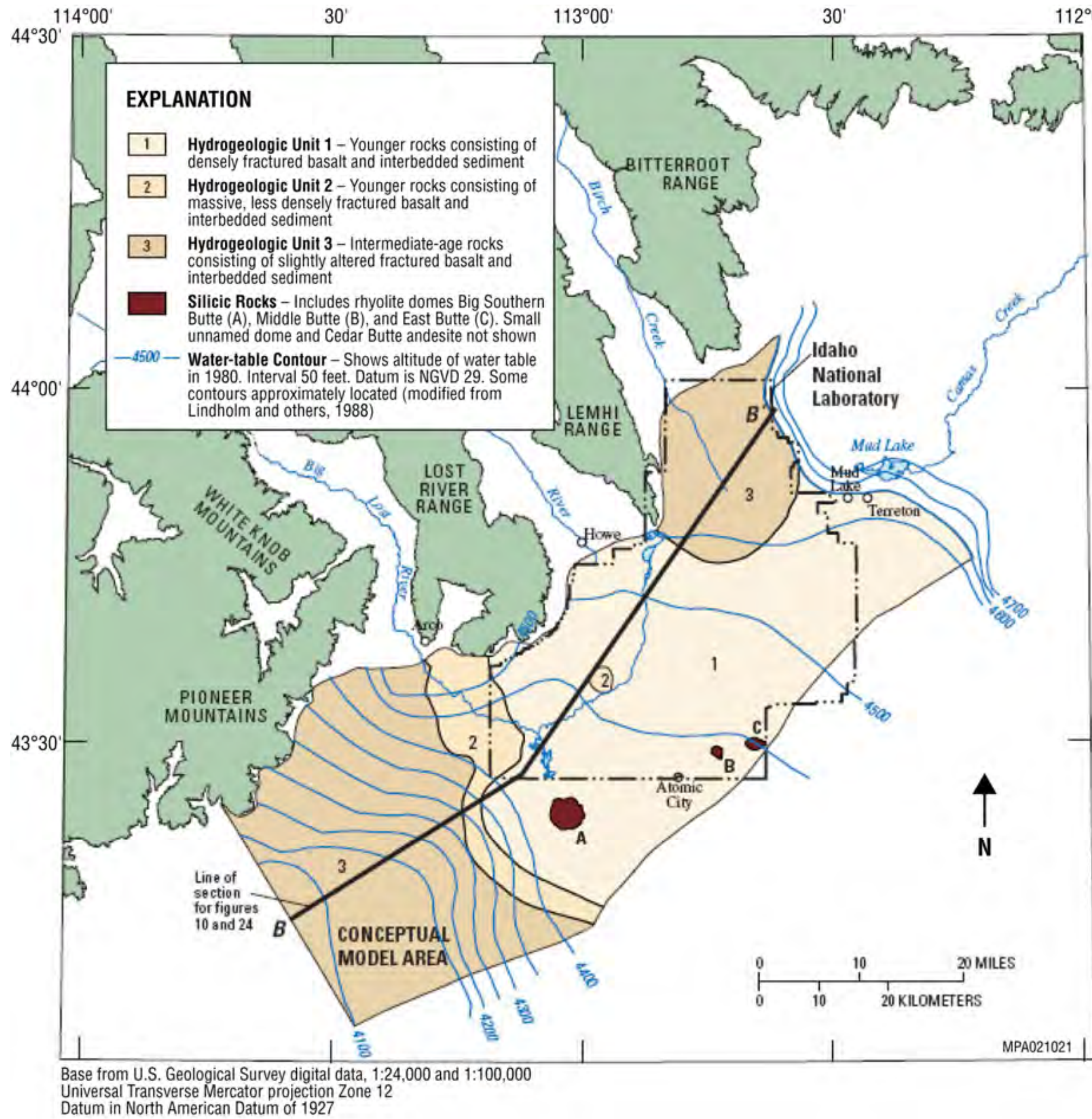

FIGURE 7.1.3-2 Water Table Contours for 1980 (Hydrogeologic units at the water table are also shown.) (Source: Ackerman et al. 2006)

7.1.3.2.5 INL Site Water Use. The entire water supply for the INL Site, including drinking water, is obtained from the Snake River Plain aquifer (USGS 2007). The water is provided by a system of about 30 wells, together with pumps and storage tanks. The system is administered by DOE, which holds the Federal Reserved Water Right of 43 billion L (11.4 billion gal) per year for the site. INL Sitewide groundwater production and usage is approximately 4.2 billion L (1.1 billion gal) annually. INL Site discharges result in a much smaller net water use than what is pumped from the aquifer.

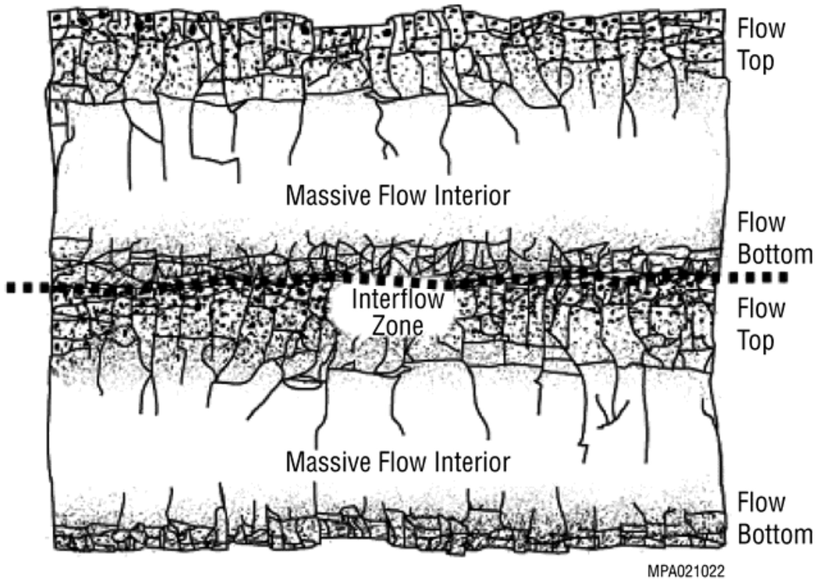

FIGURE 7.1.3-3 Diagram Showing Permeable Interflow Zone (Source: Wood et al. 2007)

In the past, the INL Site used percolation ponds, drain fields, ditches, and deep-well injection for discharging liquid wastes. This practice led to contamination in the underlying aquifer. Currently, most liquid sewage, chemical, and radioactive wastes are discharged to evaporation ponds; deep-well injection has ceased. The soil and rocks beneath the ponds filter some of the pollutants from the water as it passes through, but not all of the pollutants adhere to the soil and rocks, and some end up in the aquifer. DOE used percolation ponds to dispose of radioactive and chemical wastes at the ATR Complex from 1952 to the 1990s. These ponds are known contributors to groundwater contamination beneath the INL Site. In the 1990s, the percolation ponds at the Test Reactor Area were capped and replaced with lined evaporation ponds. With this change, water quality near the Test Reactor Area improved over time (IDEQ 2008).

Current groundwater use in nearby Butte County falls into four categories: public supply, domestic, livestock, and irrigation. In 2005, total water deliveries were estimated to be about 440 million L (116 million gal). The greatest demand was for irrigation (about 99% or 435 million L [115 million gal]). The net per capita use was 156,800 million L/d (42,000 million gal/d). Butte County has a population of only 2,808 (USGS 2008b).

7.1.4 Human Health

Exposures of the off-site general public to radiation can occur as a result of exposure to airborne releases of radionuclides during normal operations from current site activities. Because these exposures are too low to be measured by available monitoring techniques, the reported amounts of radionuclides released from INL Site facilities and appropriate air dispersion

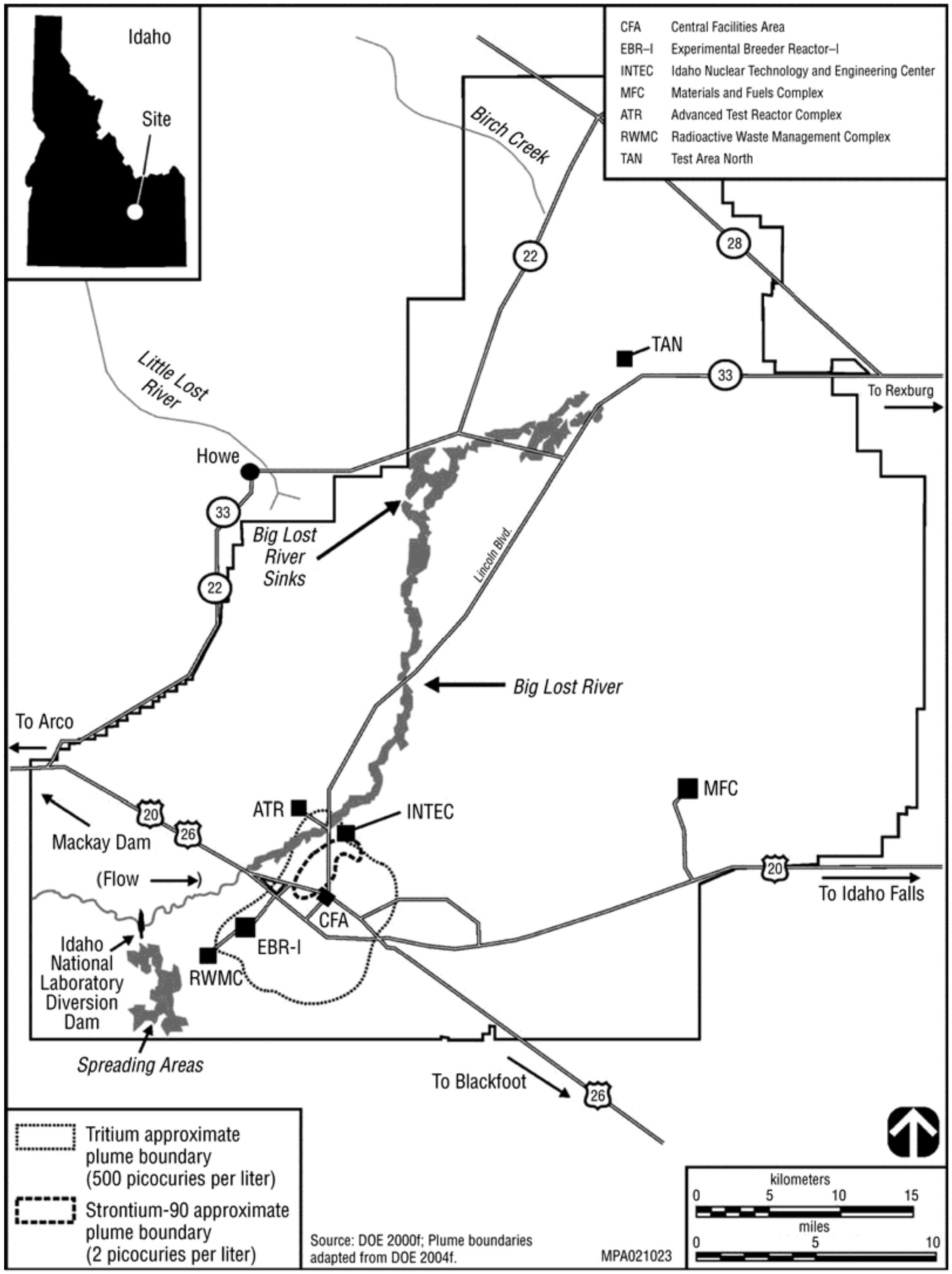

FIGURE 7.1.3-4 Extent of Tritium and Strontium-90 Plumes within the Snake River Plain Aquifer (Source: DOE 2005)

computer codes were used to calculate potential radiation doses to the public. Table 7.1.4-1 summarizes the calculated results. The maximum individual dose to the off-site public from airborne releases of radionuclides was calculated to be 0.0365 mrem/yr. Inhalation accounts for most of the exposure. Other pathways considered included direct radiation from deposition, immersion, and ingestion of leafy vegetables (DOE 2015). The maximum dose is 0.36% of the dose limit (10 mrem/yr) set for airborne release (40 CFR Part 61). The collective dose to the population residing within 80 km (50 mi) of the INL Site from airborne releases was estimated to be about 0.607 person-rem/yr, which is very small compared with the collective dose to the same population from natural background and man-made sources (197,000 person-rem/yr) (DOE 2015).

According to air monitoring data, on-site air concentrations for radionuclides were no different from those measured at the site boundary or distant off-site locations (DOE 2015). An estimate of the potential inhalation dose for workers was made by scaling the off-site dose to the individual receiving the highest impact of 0.0365 mrem/yr from airborne releases by the exposure duration (8,760 h/yr for the general public and 2,000 h/yr for workers). The resulting estimate for inhalation exposure for an on-site worker is 0.008 mrem/yr.

Potential radiation doses could also occur as a result of ingestion. Game animals are hunted in this area, and the maximum dose from eating contaminated meat and waterfowl is estimated to be 0.032 mrem/yr. This value is based on data from sampling the tissue of elk, prong and ducks in 2014 (DOE 2015). Potential exposure for workers from drinking on-site contaminated water is estimated to be 0.18 mrem/yr (DOE 2015), which is less than 5% of the EPA standard of 4 mrem/yr for drinking water.

Direct radiation throughout the site was monitored by placing TLDs at locations likely to show the highest gamma radiation readings. The maximum reading recorded during 2014 was 209 mR (i.e., 215 mrem) after applying a dose equivalent conversion factor of 1.03 mrem/mR (NRC 1997) at the ATR Complex near controlled radioactive materials areas. After the average reading at distant off-site (background) locations (127 mrem) was subtracted, the maximum on-site reading was determined to be 88 mrem above background levels. Applying the reading to estimate the direct radiation dose to a worker at the TLD location with the highest reading gives a dose of 20 mrem for an exposure duration of 2,000 hours per year (i.e., 88 mrem × 2,000 h/8,766 h/yr = 20 mrem/yr). For most on-site workers, the potential direct radiation exposure dose would be much lower than this value because they would not be radiation workers and would not work near radioactive materials storage and management areas. In addition, application of DOE's ALARA program would ensure that all worker doses would be below DOE's administrative control level of 2 rem/yr.

7.1.5 Ecology

The INL Site is located within a cool desert ecosystem dominated by relatively undisturbed shrub-steppe and grassland vegetation (DOE 2002; Vilord 2004). The climate is arid, with about 22 cm/yr (8.7 in./yr) average annual precipitation. About 29,950 ha (74,000 ac) in the north-central portion of the INL Site is designated as the INL Sagebrush Steppe Ecosystem

1 **TABLE 7.1.4-1 Estimated Annual Radiation Doses to Workers and the General Public at the INL Site**

Receptor	Radiation Source	Exposure Pathway	Dose to Individual (mrem/yr)	Dose to Population (person-rem/yr)
On-site workers	Groundwater contamination	Water ingestion	0.18[a]	
	Air contamination	Inhalation	0.008[b]	
	Soil contamination and waste storage	Direct radiation	20[c]	
General public	Airborne release	Immersion, inhalation, ingestion of leafy vegetables, direct radiation from deposition	0.0365[d]	0.607[e]
	Routine site operations	Game ingestion (waterfowl)	0.032[f]	
		Game ingestion (antelope)	0[g]	
Worker/public	Natural background radiation and man-made sources		620[h]	197,000[i]

[a] The drinking water dose was estimated on the basis of the mean tritium concentration measured at the CFA and the assumption that the maximally exposed worker obtained all the water he or she drank from an on-site well (DOE 2015). The CFA had the highest concentration of tritium in 2015.

[b] The inhalation dose was obtained by scaling the dose (0.0365 mrem/yr) for the highest exposed individual in the general public from an airborne release (see text).

[c] Estimated by using the maximum TLD reading at the ATR complex, subtracting the reading at distant off-site (background) locations, then scaling with an exposure duration of 2,000 h/yr.

[d] Estimated dose is to an individual residing at Frenchman's Cabin at the southern boundary of the INL Site. The estimate was made by using the reported amount of radionuclides released during 2014 from the INL Site facilities and the air dispersion computer code CAP88-PC (DOE 2015).

[e] The collective dose was estimated for the population residing within 80 km (50 mi) of an INL Site facility. The collective population dose was calculated by using the air dispersion code MDIFF. The population size is reported to be 318,528 (DOE 2015).

[f] Maximum potential dose estimated for consuming 225 g (8 oz) of edible (muscle) waterfowl tissue (DOE 2015).

[g] Maximum potential dose estimated for consuming the entire muscle (27,000 g [952 oz]) and liver mass (500 g [17.6 oz]) of an antelope with the highest levels of radioactivity (DOE 2015).

[h] Average dose to a member of the U.S. population as estimated in Report No. 160 of the National Council on Radiation Protection and Measurements (NCRP 2009).

[i] Collective dose to the reported population of 318,528 within 80 km (50 mi.) of an INL Site facility from natural background radiation and man-made sources.

Reserve. This area represents some of the last relatively undisturbed, contiguous sagebrush steppe habitat in the United States and provides habitat for many rare and sensitive plants and animals (DOE 2000). More than 400 species of plants have been identified within the 20 plant communities that occur on the INL Site (Anderson et al. 1996). The plant communities can be grouped into six basic types: juniper woodland, grassland, shrub-steppe (including sagebrush-steppe and salt desert shrubs), lava, bareground-disturbed, and wetlands. Shrub-steppe vegetation, covering about 90% of the INL Site, is dominated by big sagebrush (*Artemisia tridentata*) and saltbush (*Atriplex* spp.), with other common shrubs including green rabbitbrush (*Chrysothamnus viscidiflorus*), shadscale (*Atriplex confertifolia*), prickly phlox (*Leptodactylon pungens*), spineless horsebrush (*Tetradymia canescens*), spiny hopsage (*Grayia spinosa*), and winterfat (*Krascheninnikovia lanata*) (Anderson et al. 1996).

Wildland fires at the INL Site generally result in a loss of big sagebrush, but most of the other native perennial plant species resprout the next spring to initiate recovery. Although recovery of herbaceous perennials and resprouting shrubs is complete in two to three years, big sagebrush must return to the burned area by seed, and it may take decades for sagebrush to return to pre-burn conditions.

Sensitive habitats at the INL Site include the big sagebrush communities throughout the site and the low sagebrush communities in the northern portion of the site, which provide critical winter and spring range for greater sage-grouse (*Centrocercus urophasianus*) and pronghorn (*Antilocapra americana*), and the juniper communities in the northwestern and southeastern portions of the site, which are important for nesting raptors and songbirds. Vegetative communities in the vicinity of the ATR Complex include one community dominated by big sagebrush, a grassland community dominated by crested wheatgrass (*Agropyron cristatum*), and native perennial grasslands resulting from a 2000 fire. The developed portions of the ATR Complex area are either unvegetated or contain little native vegetation (e.g., lawns and ornamental vegetation).

Wetlands do not occur in the area of the ATR Complex (DOE 2005). The major wetlands at the INL Site are associated with the Big Lost River, the Big Lost River spreading areas, and the Big Lost River sinks, which are located about 2.0 km (1.2 mi) southeast, 13 km (8 mi) southwest, and 21 km (13 mi) north-northeast of the ATR Complex, respectively (DOE 2000). The Big Lost River sinks are the only wetlands on the INL Site that may be jurisdictional wetlands (DOE 2002).

More than 270 wildlife species have been observed at the INL Site (DOE 2002), including 46 species of mammals, 225 species of birds, and 13 species of reptiles and amphibians (DOE 2002, 2005). Common mammal species include the black-tailed jackrabbit (*Lepus californicus*) and Townsend's ground squirrel (*Spermophilus townsendii*). Game species include the mule deer (*Odocoileus hemionus*), elk (*Cervus elaphus*), and pronghorn (Reynolds et al. 1986). Up to 6,000 pronghorn (about 30% of Idaho's pronghorn population) may winter at the INL Site during some years (DOE 2005). About 100 elk and 500 pronghorn summer at the INL Site (Blew et al. 2006). Carnivores such as the mountain lion (*Puma concolor*) and coyote (*Canis latrans*) also occur at the INL Site (Reynolds et al. 1986). Bats use the INL Site throughout the year, with the western small-footed myotis (*Myotis ciliolabrum*) being the most abundant species at the INL Site (Reynolds et al. 1986). During the spring and summer, it roosts in sagebrush, junipers, buildings, and rocky outcroppings (Blew et al. 2006). Mammals have been observed at disposal ponds at the INL Site despite perimeter fences, and amphibians have been reported at industrial waste and sewage disposal ponds.

The INL Site qualifies as an Important Bird Area in Idaho because it (1) supports bird species in greatest need of conservation, (2) is an exceptional representative of a natural habitat, and (3) supports long-term research or monitoring programs. The goal of the Important Bird Area program is to identify, monitor, and conserve key sites for birds (Moulton 2007). Among the bird species observed during the 2006 breeding bird survey at the INL Site, 62% were shrub-steppe/grassland species; 28% were sagebrush obligates; 4% were urban and exotic species; 3% were raptors and corvids; and 2% were waterfowl, shorebirds, and wading birds (Vilord 2007). The most abundant bird species observed at the INL Site included the horned lark (*Eremophila alpestris*), western meadowlark (*Sturnella neglecta*), Brewer's sparrow (*Spizella breweri*), sage sparrow (*Amphispiza belli*), sage thrasher (*Oreoscoptes montanus*), mourning dove (*Zenaida macroura*), and greater sage-grouse (Vilord 2007).

Since greater sage-grouse depend on sagebrush for habitat, the INL Site is one of the most important wintering areas for the species in Idaho. Loss of sagebrush from wildfires may be having a detrimental impact on the greater sage-grouse. Juniper communities occurring in the northwestern and southeastern portions of the INL Site and riparian areas with cottonwoods (*Populus* spp.) and willows (*Salix* spp.) provide important nesting habitats for raptors and songbirds.

Bird species that would not normally be observed in the sagebrush steppe or grassland habitats of the INL Site have been found in altered or man-made habitats within these areas because of the addition of permanent water, different food resources, buildings, and planted trees. The ponds in and around the ATR Complex are frequented by waterfowl, shorebirds, swallows, passerines, and some raptors such as the American kestrel (*Falco sparverius*), ferruginous hawk (*Buteo regalis*), and northern harrier (*Circus cyaneus*) (DOE 2000).

The gopher snake (*Pituophis catenifer*), western rattlesnake (*Crotalus viridis*), sagebrush lizard (*Sceloporus graciosus*), and short-horned lizard (*Phrynosoma hernandesi*) are among the common reptile species (Reynolds et al. 1986).

The main aquatic habitats that occur on the INL Site are the Big Lost River, Little Lost River, and Birch Creek. All three are intermittent water bodies. Flow in Big Lost River that reaches the INL Site infiltrates into the ground along the streambeds at the southern end of the INL Site or, if the flow is sufficient, it infiltrates into the playas or sinks in the northern portion of the site. The Big Lost River is located southeast of the GTCC reference location (1.9 km [1.2 mi] southeast of the ATR Complex). During dry years, little or no surface water flows on the INL Site. During periods of high precipitation or rapid snowmelt, water from Little Lost River enters the INL Site and infiltrates into the ground. Flows from Birch Creek seldom enter the INL Site during summer because of its off-site use for irrigation, but flows from Birch Creek do enter the INL Site during winter months when agricultural diversions cease. The only other aquatic habitats on the INL Site are natural wetland-like ponds and man-made percolation and evaporation ponds. Six fish species have been observed on the INL Site (Reynolds et al. 1986). The evaporation ponds in the vicinity of the ATR Complex do not support fish but are inhabited by aquatic invertebrates and amphibians.

Seventeen federally listed and state-listed threatened, endangered, and other special-status species have been identified on the INL Site (Table 7.1.5-1). No federally listed threatened or endangered species and no critical habitat for any federally listed threatened or endangered species occur on the INL Site (DOE 2005). Both the greater sage-grouse (a candidate species) and the pygmy rabbit (*Brachylagus idahoensis*, under review for listing) are considered to be common on the INL Site. No threatened, endangered, or other special-status species have been recorded in the vicinity of the ATR Complex. However, the bald eagle (*Haliaeetus leucocephalus*), greater sage-grouse, pygmy rabbit, and Townsend's big-eared bat (*Corynorhinus townsendii*) may potentially occur in the area (DOE 2005). Several state species of special concern have been observed in the area surrounding the ATR Complex area, including the northern goshawk (*Accipiter gentilis*), loggerhead shrike (*Lanius ludovicianus*), black tern (*Chlidonias niger*), and trumpeter swan (*Cygnus buccinator*). Among these, only the loggerhead shrike is commonly observed in the surrounding areas (Vilord 2004, 2007).

7.1.6 Socioeconomics

Socioeconomic data for the INL Site covers an ROI composed of four Idaho counties surrounding the site: Bannock County, Bingham County, Bonneville County, and Jefferson County. More than 80% of INL Site workers reside in these counties (DOE 1997).

7.1.6.1 Employment

In 2011, total employment in the ROI stood at 117,563 (U.S. Department of Labor 2012). Employment grew at an annual average rate of 1.1% between 2002 and 2011. The economy of the ROI is dominated by the trade and service industries, with employment in these activities currently contributing 68% of all employment (see Table 7.1.6-1). Agriculture and manufacturing are both smaller employers in the ROI, contributing 17% of total ROI employment. Employment at the INL Site stood at 8,452 in 2006 (Black et al. 2006).

7.1.6.2 Unemployment

Unemployment rates varied across the counties in the ROI (Table 7.1.6-2). Over the 10-year period 2002–2011, average rates were 5.1% in Bannock County and 4.6% in Bingham County, with lower rates in Bonneville County (4.0%) and Jefferson County (4.3%). The average rate in the ROI over this period was 4.5%, which was lower than the average rate for the state of 5.5%. Unemployment rates for 2010 were similar to rates for 2011; in Bingham County, the unemployment rate increased from 7.0% to 7.3%, while in Jefferson County, the rate declined from 7.3% to 7.2%. The average rate for the ROI increased from 7.2% to 7.4% between 2010 and 2011, while the state rate declined slightly from 8.8% to 8.7%.

TABLE 7.1.5-1 Federally and State-Listed Threatened, Endangered, and Other Special-Status Species at the INL Site

Common Name (Scientific Name)	Status[a] Federal/State
Plants	
Cushion milk vetch (*Astragalus gilviflorus*)	–/SS
Painted milkvetch (*Astragalus ceramicus* var. *apus*)	SC/–
Puzzling halimolobos (*Halimolobos perplexa* var. *perplexa*)	–/SM
Narrowleaf oxytheca (*Oxytheca dendroidea*)	–/SS
Spreading gilia (*Ipomopsis polycladon*)	–/SP2
Winged-seed evening primrose (*Camissonia pterosperma*)	–/SS
Reptiles	
Northern sagebrush lizard (*Sceloporus graciosus graciosus*)	SC/–
Birds	
Bald eagle (*Haliaeetus leucocephalus*)	–/ST
Ferruginous hawk (*Buteo regalis*)	SC/–
Greater sage-grouse (*Centrocercus urophasianus*)	C/–
Long-billed curlew (*Numenius americanus*)	SC/–
Mammals	
Gray wolf (*Canis lupus*)	EXPN/–
Long-eared myotis (*Myotis evotis*)	SC/–
Merriam’s shrew (*Sorex merriami*)	SC/–
Pygmy rabbit (*Brachylagus idahoensis*)	UR/–
Townsend’s big-eared bat (*Corynorhinus townsendii*)	SC/–
Western small-footed myotis (*Myotis ciliolabrum*)	SC/–

[a] C (candidate): A species for which USFWS or NOAA Fisheries has on file sufficient information on biological vulnerability and threats to support a proposal to list as endangered or threatened.

EXPN (experimental population): A population (including its offspring) of a listed species designated by rule published in the *Federal Register* that is wholly separate geographically from other populations of the same species. An experimental population may be subject to less stringent prohibitions than are applied to the remainder of the species to which it belongs.

SC (species of concern): An informal term referring to a species that might be in need of conservation action. This may range from a need for periodic monitoring of populations and threats to the species and its habitat to a need for listing as threatened or endangered. Such species receive no legal protection under the ESA, and use of the term does not necessarily imply that a species will eventually be proposed for listing.

SM (state monitor): A species that is common within a limited range or a species that is uncommon but has no identified threats.

Footnote continues on next page.

TABLE 7.1.5-1 (Cont.)

SP2 (state priority 2): A species likely to be classified as state priority 1 within the foreseeable future in Idaho, if factors contributing to its population decline, habitat degradation, or loss continue. State priority 1 refers to species in danger of becoming extinct from Idaho in the foreseeable future, if factors contributing to their population decline, habitat degradation, or loss continue.

SS (state sensitive): A species with small populations or localized distributions within Idaho that presently do not meet the criteria for classification as priority 1 or 2, but whose populations and habitats may be jeopardized without active management or removal of threats.

ST (state threatened): A native species likely to be classified as state endangered within the foreseeable future throughout all or a significant portion of its Idaho range.

UR (under review): A species undergoing a status review to determine if listing of the species as threatened or endangered is warranted.

–: Not listed.

Sources: DOE (2005); IDFG (2008a,b)

TABLE 7.1.6-1 INL Site: County and ROI Employment by Industry in 2009

Sector	Bannock County	Bingham County	Bonneville County	Jefferson County	ROI Total	% of ROI Total
Agriculture[a]	506	4,324	1,427	1,930	8,187	9.0
Mining	10	0	10	10	30	0.0
Construction	1,281	926	2,476	437	5,120	5.6
Manufacturing	2,124	1,750	2,391	864	7,129	7.8
Transportation and public utilities	1,676	320	1,211	185	3,392	3.7
Trade	5,277	2,330	9,926	947	18,480	20.3
Finance, insurance, and real estate	1,854	325	1,664	120	3,963	4.4
Services	14,715	3,950	23,773	1,297	43,735	48.1
Other	10	10	0	10	30	0.0
Total	27,386	14,204	43,780	5,582	90,952	

[a] USDA (2008).

Source: U.S. Bureau of the Census (2012a)

TABLE 7.1.6-2 INL Site: Average County, ROI, and State Unemployment Rates (%) in Selected Years

Location	2002–2011	2010	2011
Bannock County	5.1	8.5	8.5
Bingham County	4.7	7.3	7.6
Bonneville County	4.1	7.0	7.3
Jefferson County	4.4	7.7	7.6
ROI	4.6	7.6	7.8
Idaho	5.5	8.8	8.7

Source: U.S. Department of Labor (2012)

7.1.6.3 Personal Income

Personal income in the ROI stood at almost $8.0 billion in 2009, growing at an annual average rate of growth of 2.7% over the period 2000–2009 (Table 7.1.6-3). ROI personal income per capita also rose over the same period, growing to $32,822 in 2009 from $28,704 in 2000. Per-capita incomes were higher in Bonneville County ($37,961 in 2009) and Bannock County ($30,909) than elsewhere in the ROI.

7.1.6.4 Population

The population of the ROI in 2010 stood at 258,8200 (U.S. Bureau of the Census 2012b) and was expected to reach 267,835 by 2012 (Table 7.1.6-4). In 2010, 104,234 people were living in Bonneville County (40% of the ROI total), and 82,839 people (32% of the total) resided in Bannock County. Over the period 2000–2010, the population in the ROI as a whole grew slightly, with an average growth rate of 1.7%, while higher-than-average growth occurred in Jefferson County (3.2%) and Bonneville County (2.4%). The population of Idaho as a whole grew at a rate of 1.9% over the same period.

7.1.6.5 Housing

Housing stock in the ROI as a whole grew at an annual rate of 2.0% over the period 2000–2010 (Table 7.1.6-5). A total of 17,609 new units were added to the existing housing stock in the ROI between 2000 and 2010. There were 7,329 vacant housing units in the ROI in 2010, of which 2,023 could be rental units available to construction workers at the proposed facility.

TABLE 7.1.6-3 INL Site: County, ROI, and State Personal Income in Selected Years

Income	2000	2009	Average Annual Growth Rate (%), 2000–2009
Bannock County			
Total personal income (2011 $ in billions)	2.1	2.5	1.9
Personal income per capita (2011 $)	27,830	30,909	1.2
Bingham County			
Total personal income (2011 $ in billions)	1.1	1.2	1.1
Personal income per capita (2011 $)	25,605	27,135	0.6
Bonneville County			
Total personal income (2011 $ in billions)	2.6	3.7	3.7
Personal income per capita (2011 $)	31,811	37,961	2.0
Jefferson County			
Total personal income (2011 $ in billions)	0.5	0.7	3.4
Personal income per capita (2011 $)	25,515	28,778	1.3
ROI total			
Total personal income (2011 $ in billions)	6.3	8.0	2.7
Personal income per capita (2011 $)	28,704	32,822	1.5
Idaho			
Total personal income (2011 $ in billions)	41.9	51.6	2.3
Personal income per capita (2011 $)	32,382	33,402	0.3

Source: DOC (2012)

TABLE 7.1.6-4 INL Site: County, ROI, and State Population in Selected Years

Location	1990	2000	2010	Average Annual Growth Rate (%), 2000–2010	2012[a]
Bannock	66,026	75,565	82,839	0.9	84,376
Bingham	37,583	41,735	45,607	0.9	46,423
Bonneville	72,207	82,522	104,234	2.4	109,219
Jefferson	16,543	19,155	26,140	3.2	27,817
ROI total	192,359	218,977	258,820	1.7	267,835
Idaho	1,006,749	1,293,953	1,567,582	1.9	1,628,893

[a] Argonne National Laboratory projections.

Source: U.S. Bureau of the Census (2012b)

TABLE 7.1.6-5 INL Site: County and ROI Housing Characteristics in Selected Years

Housing	2000	2010
Bannock County		
Owner occupied	19,215	20,817
Rental	7,977	9,865
Vacant units	1,910	2,509
Total units	29,102	33,191
Bingham County		
Owner occupied	10,564	11,563
Rental	2,753	3,436
Vacant units	986	1,142
Total units	14,303	16,141
Bonneville County		
Owner occupied	21,467	26,336
Rental	7,286	10,293
Vacant units	1,731	3,102
Total units	30,484	39,731
Jefferson County		
Owner occupied	5,008	6,774
Rental	893	1,372
Vacant units	386	576
Total units	6,287	8,722
ROI total		
Owner occupied	56,254	65,490
Rental	18,909	24,966
Vacant units	5,013	7,329
Total units	80,176	97,785

Source: U.S. Bureau of the Census (2012b)

7.1.6.6 Fiscal Conditions

Construction and operations of a GTCC LLRW and GTCC-like waste disposal facility could result in increased expenditures for local government jurisdictions, including counties, cities, and school districts. Revenues to support these expenditures would come primarily from state and local sales tax revenues associated with employee spending during construction and operations and would be used to support additional local community services currently provided by each jurisdiction. Table 7.1.6-6 presents information on expenditures by the various local government jurisdictions and school districts in the ROI.

TABLE 7.1.6-6 INL Site: County, ROI, and State Public Service Expenditures in 2006 ($ 2011 in millions)[a]

Location	Local Government	Schools
Bannock County	45.9	57.4
Bingham County	11.8	42.1
Bonneville County	51.1	74.3
Jefferson County	6.6	21.3
ROI total	115.4	195.6
Idaho	5,110	1,784

[a] Argonne National Laboratory projections.

7.1.6.7 Public Services

Construction and operations of a GTCC LLRW and GTCC-like waste disposal facility could require increases in employment to provide public safety, fire protection, community, and educational services in the counties, cities, and school districts likely to host relocating construction workers and operations employees. Additional demands could also be placed on local physician services. Table 7.1.6-7 presents data on employment and levels of service (number of employees per 1,000 population) for public safety. Table 7.1.6-8 provides data on staffing and levels of service for school districts. Table 7.1.6-9 covers physicians.

7.1.7 Environmental Justice

Table 7.1.7-1 and Figures 7.1.7-1 and 7.1.7-2 show the minority and low-income compositions of the total population located in the 80-km (50-mi) buffer around the INL Site from Census data for the year 2010 and from CEQ guidelines (CEQ 1997). Minority persons are those who identify themselves as Hispanic or Latino, Asian, Black or African American, American Indian or Alaska Native, Native Hawaiian or other Pacific Islander, or multi-racial (with at least one race designated as a minority race under CEQ). Individuals identifying themselves as Hispanic or Latino are included in the table as a separate entry. However, because Hispanics can be of any race, this number also includes individuals who also identified themselves as being part of one or more of the population groups listed in the table.

A large number of minority and low-income individuals are located in the 50-mi (80-km) area around the boundary of the reference location. Within the 50-mi (80-km) radius, 18.1% of the population is classified as minority, while 11.4% is classified as low income. However, the number of minority individuals does not exceed the state average by 20 percentage points or more, and the number of minority individuals does not exceed 50% of the total population in the area; that is, there is no minority population in the 50-mi (80-km) area as a whole based on 2010 Census data and CEQ guidelines. The number of low-income individuals does not exceed

TABLE 7.1.6-7 INL Site: County, ROI, and State Public Service Employment in 2009

	Bannock County		Bingham County		Bonneville County	
Service	No.	Level of Service[a]	No.	Level of Service[a]	No.	Level of Service[a]
Police protection	40	0.5	33	0.8	64	0.7
Fire protection[b]	76	0.9	39	0.9	95	1.0
	Jefferson County		ROI		Idaho[c]	
Service	No.	Level of Service[a]	No.	Level of Service[a]	No.	Level of Service[a]
Police protection	19	0.8	156	0.6	2,432	1.7
Fire protection	1	0.0	211	0.9	1,179	0.8

[a] Level of service represents the number of employees per 1,000 persons in each county.

[b] Does not include volunteers.

[c] 2006 data.

Sources: U.S. Bureau of the Census (2008a,b; 2012b,c); FBI (2012); Fire Departments Network (2012)

TABLE 7.1.6-8 INL Site: County, ROI, and State Education Employment in 2011

Location	No. of Teachers	Level of Service[a]
Bannock	704	19.5
Bingham	539	18.5
Bonneville	1,015	20.0
Jefferson	324	18.5
ROI	2,502	19.3
Idaho	15,201	17.9

[a] Level of service represents the number of teachers per 1,000 persons in each county.

Sources: National Center for Educational Statistics (2012); U.S. Bureau of the Census (2012b,c)

TABLE 7.1.6-9 INL Site: County, ROI, and State Medical Employment in 2010

Location	No. of Physicians	Level of Service[a]
Bannock	232	2.8
Bingham	50	1.1
Bonneville	253	2.4
Jefferson	7	0.3
ROI	542	2.1
Idaho[b]	2,645	1.8

[a] Level of service represents the number of physicians per 1,000 persons in each county.

[b] 2006 data.

Sources: AMA (2012); U.S. Bureau of the Census (2008b, 2012b)

TABLE 7.1.7-1 Minority and Low-Income Populations in an 80-km (50-mi) Radius of the INL Site

Population	Idaho Block Groups
Total population	168,876
White, non-Hispanic	138,231
Hispanic or Latino	21,909
Non-Hispanic or Latino minorities	8,736
One race	6,561
Black or African American	613
American Indian or Alaskan Native	4,487
Asian	1,163
Native Hawaiian or other Pacific Islander	139
Some other race	159
Two or more races	2,175
Total minority	30,645
Percent minority	18.1%
Low-income	6,279
Percent low-income	11.4%
State percent minority	16.0%
State percent low-income	14.3%

Source: U.S. Bureau of the Census (2012b)

the state average by 20 percentage points or more and does not exceed 50% of the total population in the area; that is, there are no low-income populations in the 50-mi (80-km) area around the reference location as a whole.

7.1.8 Land Use

The INL Site is owned by the federal government and is administered, managed, and controlled by DOE. The mission of the INL Site has evolved from energy development and the safety testing of nuclear reactors to radioactive waste management and cleanup, national security, and energy research and development.

The INL Site occupies about 230,670 ha (570,000 ac), but only about 4,610 ha (11,400 ac) have been developed to support facility and program operations associated with energy research and waste management activities (DOE 2002). These facilities are located within a 93,080-ha (230,000-ac) central core of the INL Site (DOE 2000). An 18,200-ha (45,000-ac) security and safety buffer zone surrounds the developed area. About 13,760 ha (34,000 ac) of the INL Site are devoted to utility ROWs and public roads (DOE 2002).

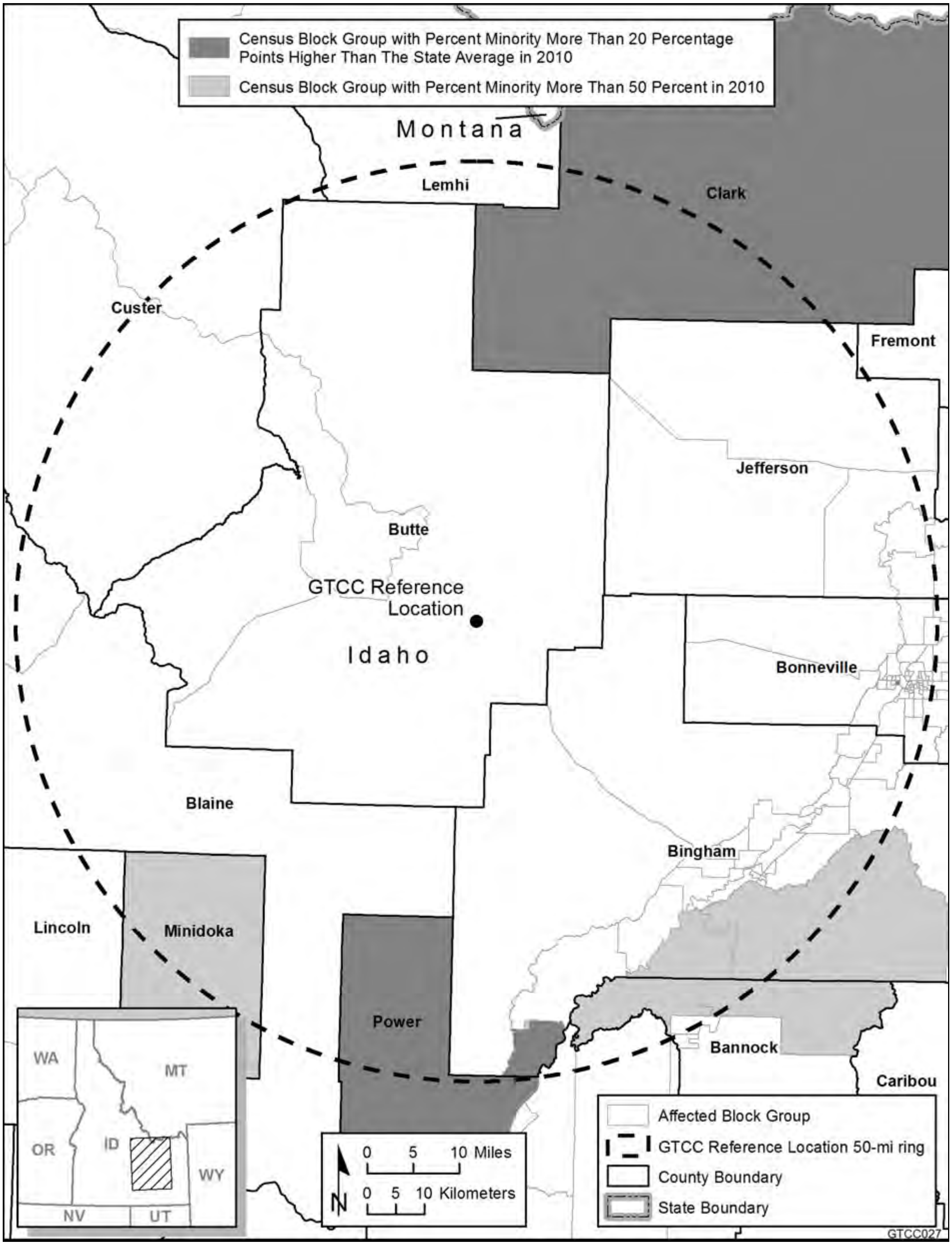

FIGURE 7.1.7-1 Minority Population Concentrations in Census Block Groups within an 80-km (50-mi) Radius of the GTCC Reference Location at the INL Site (Source: U.S. Bureau of the Census 2012b)

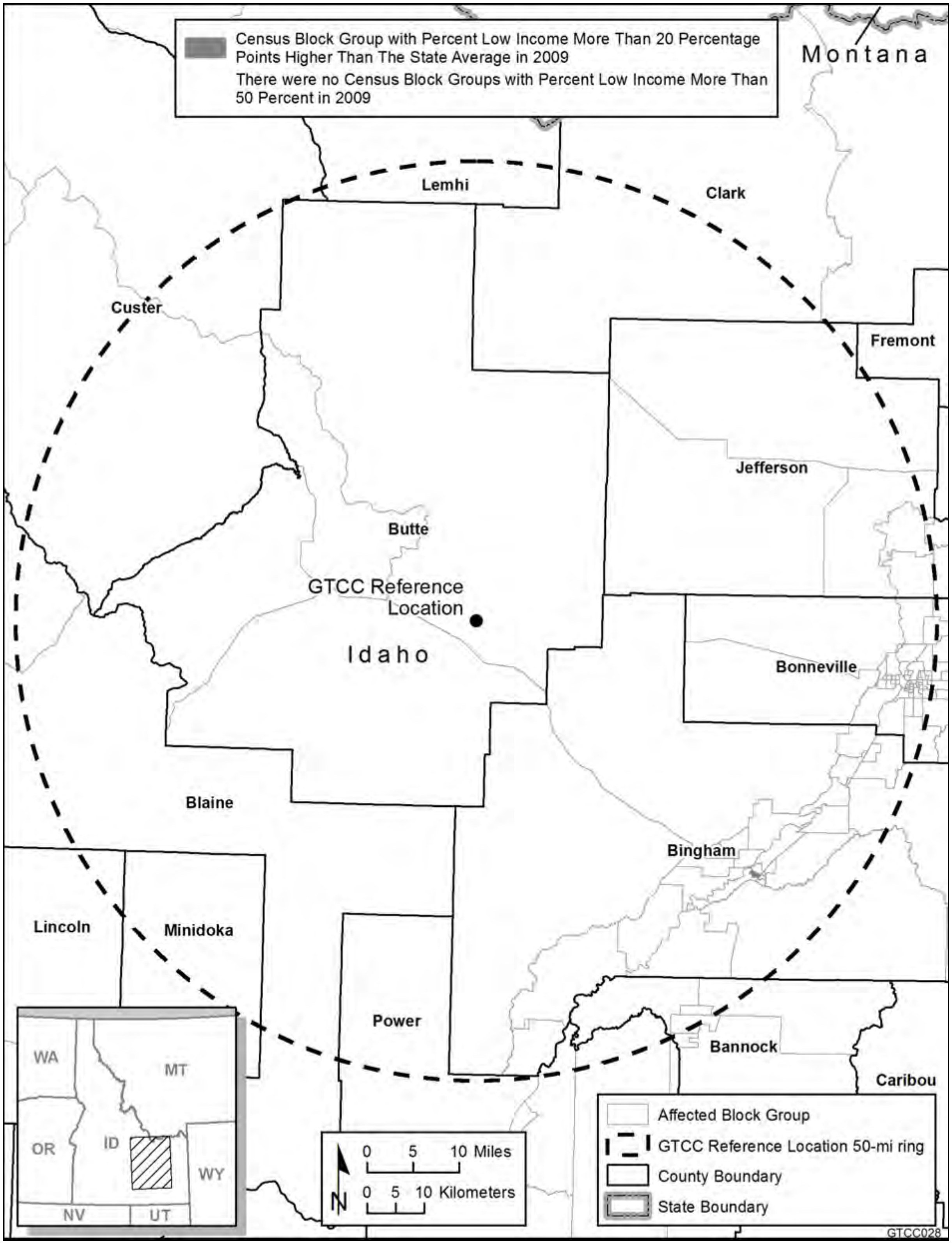

FIGURE 7.1.7-2 Low-Income Population Concentrations in Census Block Groups within an 80-km (50-mi) Radius of the GTCC Reference Location at the INL Site (Source: U.S. Bureau of the Census 2012b)

Fifty-two research and test reactors have been used over the years at the INL Site to test reactor systems, fuel and target designs, and overall safety. Other INL Site facilities support reactor operations. These facilities include low-level and high-level radioactive waste processing, storage, and disposal sites; hot cells; analytical laboratories; machine shops; and laundry, railroad, and administrative facilities.

Land use categories at the INL Site include facility operations, grazing, general open space, and infrastructure (e.g., roads). Much of the INL Site is open space and is not designated for a specific use (DOE 2000). Up to 137,590 ha (340,000 ac) of the INL Site are leased for livestock grazing, with the grazing permits administered by the BLM. No livestock grazing is allowed within 0.8 km (0.5 mi) of any primary facility boundary and within 3.7 km (2 mi) of any nuclear facility. A 364-ha (900-ac) winter feedlot for sheep used by the U.S. Sheep Experiment Station is located at the intersection of Idaho State Highways 28 and 33 (DOE 2002). Through a Memorandum of Agreement (MOA) with the Western Shoshone-Bannock tribes, tribal members are allowed access to the Middle Butte on the INL Site to perform sacred or religious ceremonies or other educational or cultural activities (DOE 2000).

Land use at the INL Site is moving toward radioactive and hazardous waste management, environmental restoration and remedial technologies, and technology transfer (DOE 2002).

Recreational use of the INL Site includes public tours of general facility areas and the EBR-I (a National Historic Landmark) and controlled hunting that is restricted to specific locations. The INL Site was designated as a NERP in 1975, functioning as a field laboratory that is set aside for ecological research and evaluation of the environmental impacts from nuclear energy development (DOE 2002). About 29,540 ha (74,000 ac) of open space in the north-central portion of the INL Site was designated as the INL Sagebrush Steppe Ecosystem Reserve.

The GTCC reference location is located within a general open space land use area. The location is primarily sagebrush habitat that is situated near the ATR Complex on the south-central portion of the INL Site (Figure 7.1-1). Land in the ATR Complex is mostly disturbed and is designated for reactor operations. Located within the ATR Complex are the Materials Testing Reactor and Engineering Test Reactor (both shut down), the ATR Complex hot cells, and the ATR itself. There are also numerous support facilities in the area, including storage tanks, maintenance buildings, warehouses, laboratories, and sanitary and radioactive waste treatment facilities. The ATR Complex includes about 15 ha (37 ac) within a security fence, plus several sewage and evaporation ponds located outside the fenced area (DOE 2000).

About 75% of the lands surrounding the INL Site are public lands administered by the BLM that provide wildlife habitat and are managed for multiple uses, such as mineral and energy production, grazing, and recreation. About 1% is owned by the state of Idaho and is used for the same purposes. The rest of the surrounding lands are privately owned and used for livestock grazing and crop production (DOE 2002). Irrigated farmlands make up about 25% of the land bordering the INL Site. Several small rural communities are scattered around the borders of the INL Site (i.e., Howe, Mud Lake, Atomic City, Butte City, and Arco). Recreational and agricultural uses are expected to increase in the surrounding areas, with agricultural use resulting from the conversion of rangeland to cropland (DOE 2002). Since the INL Site is remote from most developed areas, the lands adjacent to it are not likely to experience residential and commercial development, and no new development is planned near the site (DOE 2000).

7.1.9 Transportation

Major highway access to the region is via Interstate 15, which runs north-south through Idaho Falls, Idaho, roughly parallel to the eastern edge of the site. The eastern edge of the INL Site is located approximately 40 km (25 mi) to the west of Idaho Falls along US 20, which passes through the southern portion of the site and continues on to Arco, Idaho, to the west. Access to the southern boundary of the site is from Blackfoot, Idaho, which is 50 km (31 mi) to the southeast along US 26. State Route (SR) 22 and SR 28, from Dubois and Salmon, respectively, provide access to the northern portion of the INL Site, along with SR 33 from the east, from Rexburg. Approximately 145 km (90 mi) of paved highways are used by the general public on the site (Cahn et al. 2006). Average daily traffic counts in the vicinity of the INL Site are provided in Table 7.1.9-1.

Rail service is available on-site. About 23 km (14 mi) of Union Pacific Railroad tracks cross the southern portion of the site. A government-owned spur off these tracks passes through the CFA to INTEC (Cahn et al. 2006), passing by the ATR Complex on its way to the Naval Reactors Facility.

7.1.10 Cultural Resources

The INL Site is a science-based, applied engineering laboratory with its roots extending back to World War II. Battelle Energy Alliance maintains the INL Site Cultural Resource Management Office (CRMO) to monitor cultural resource reviews and compliance issues. Cultural resource compliance efforts are guided by a Cultural Resource Management Plan and a programmatic agreement among the DOE Idaho Operations Office (DOE-ID), the Idaho SHPO, and the ACHP. Compliance activities at the INL Site include the review of all major undertakings to determine if there could be effects on cultural resources. Compliance with the various cultural resource laws is the ultimate responsibility of DOE-ID, which relies heavily on the INL CRMO for implementing the cultural resource program at the INL Site. The DOE-ID and INL CRMO work closely with the Western Shoshone-Bannock tribes. The three groups have entered into an Agreement in Principle (AIP) that allows the Western Shoshone-Bannock to oversee the INL Site environmental programs, transportation safety, and cultural resource management (DOE-ID 2002).

Cultural resource surveys have identified 2,250 archaeological sites on INL Site property (Braun et al. 2007). They represent 9% of the total land managed by the INL Site. These sites show that people have been using the INL Site property for the last 13,000 years. Most sites are located close to water sources. The INL Site property once contained a large, shallow lake, Lake Terreton. When rainfall volumes decreased 13,000 years ago, the lake began to dry up. Remnant wetlands are all that remain of Lake Terreton. Several rivers, including the Big and Little Lost Rivers and Birch Creek, are found on the INL Site property. Because of the soil

TABLE 7.1.9-1 Annual Average Daily Traffic (AADT) Counts in the Vicinity of the INL Site

	Location	AADT[a]	Commercial AADT[b]
US 26	South of junction with US 20 north of Atomic City	1,100	260
US 20	East of junction with US 26 north of Atomic City	1,900	270
US 20/26	East of US 20/26 junction north of Atomic City	2,200	250
	East of junction with SR 22/33	1,500	250
SR 22/33	North of junction with US 20/26	620	120
	West of Howe	650	120
	East of Howe	670	120
	West of SR 22/33 split	600	120
SR 22	North of SR 22/33 split before SR 28 junction	250	90
	North of junction with SR 28	200	60
SR 33	East of SR 22/33 split	380	90
	West of junction with SR 28	680	90
SR 28/33	East of SR 28/33 split	1,800	120
SR 28	North of split with SR 33	1,200	70
	South of SR 22 junction	530	50
	North of SR 22 junction	600	50

[a] Source: ITD (2007a)

[b] Source: ITD (2007b)

characteristics, much of the water at the INL Site is held underground, rendering it inaccessible for much of the history of the facility. Only in the last 100 years has technology allowed this water to be used. No large Native American villages have been found on INL Site property. Transient hunting and gathering activities were the primary activities supported by the INL Site landscape throughout the prehistoric period and into the contact period.

Historic use of the property began in the early 1800s when trappers came into the area to collect beaver skins. More frequent use of the land began in 1852 with the establishment of Goodale's Cutoff in the northern portion of the INL Site property. The cutoff began as a northern extension of the Oregon Trail. By 1860, the route began to be used for moving cattle and sheep from Oregon and Washington to eastern markets. During the 1860s to 1880, numerous mines began to open in central Idaho, which led to increased traffic on Goodale's Cutoff and the creation of numerous other roads and trails through the area. Ranches were established along the Big Lost River by the 1880s; here livestock were raised and then transported across what would become the INL Site. Populations began to rise steadily with passage of the Carey Land Act of 1894 and the Desert Reclamation Act of 1902.

By the early 20th century, the town of Powell had been established on INL Site property near the intersection of the Oregon Shortline Railroad (now the Union Pacific Railroad) and the Big Lost River. The town was located near the current location of the RWMC. Most of the homesteads failed by the 1920s because of the water use that was occurring upstream of the INL Site property and were abandoned. Roughly 100 historic archaeological sites from the homesteading era have been recorded on INL Site property. Numerous others are known but have yet to be recorded.

Ten main facilities are scattered across the laboratory's land. The first government facility constructed at the INL Site was the Arco Naval Proving Ground, which was built in 1942 for the testing of naval ordnance. The facility was expanded in 1949 and renamed the National Reactor Testing Station. The site was renamed several times between 1949 and 2008. Roughly 52 reactors were constructed at the INL Site over the last 57 years. Major reactors constructed at the INL Site include EBR-1 (Experimental Breeder Reactor 1) and naval propulsion reactors. Throughout much of its existence, the INL Site was linked with Argonne National Laboratory, located in Illinois; that is, the past Argonne-West was a small part surrounded by the laboratory, then called Idaho National Engineering Laboratory. In 2007, the INL Site became a stand-alone laboratory. The facility is managed and operated by Battelle Energy Alliance for DOE-ID.

The INL Site was the location for numerous one-of-a-kind test reactors. Many of the early reactors constructed at the INL Site are located in the ATR Complex. Facilities in the ATR Complex include the Materials Testing Reactor built in 1950, the Engineering Test Reactor built in 1957, and the Advanced Test Reactor built in 1967. Each of these reactors represented the pinnacle of reactor design when it was constructed. These reactors, together with the ancillary structures used to support the research (such as the Hot Cell Facility), formed a core research center for the AEC's research on nuclear reactor design and the basic properties of nuclear materials.

7.1.11 Waste Management

Site management of the waste types generated by the land disposal methods for Alternatives 3 to 5 are discussed in Section 5.3.11. Waste management programs at the INL Site are operated by the Office of Nuclear Energy.

7.2 ENVIRONMENTAL AND HUMAN HEALTH CONSEQUENCES

The following sections address the potential environmental and human health consequences for each resource area discussed in Section 7.1.

7.2.1 Climate and Air Quality

This section presents potential climate and air quality impacts from the construction and operations of each of the disposal facilities (borehole, trench, and vault) at the INL Site. Noise impacts are discussed in Section 5.3.1.

7.2.1.1 Construction

During the construction period, emissions of criteria pollutants (e.g., SO_2, NO_x, CO, PM_{10}, and $PM_{2.5}$), VOCs, and the primary greenhouse gas CO_2 would be caused by fugitive dust emissions from earth-moving activities and engine exhaust emissions from heavy equipment and commuter, delivery, and support vehicles. Typically, the potential impacts from exhaust emissions on ambient air quality would be smaller than those from fugitive dust emissions.

Air emissions of criteria pollutants, VOCs, and CO_2 from construction activities are estimated for the peak year when site preparation and construction of the support facility and some disposal cells would take place. Estimates for PM_{10} and $PM_{2.5}$ include diesel particulate emissions. These estimates are provided in Table 7.2.1-1 for each disposal method. Detailed information on emission factors, assumptions, and emission inventories is available in Appendix D. As shown in the table, total peak-year emission rates are estimated to be rather small when compared with emission totals for all five counties encompassing the INL Site (Bingham, Bonneville, Butte, Clark, and Jefferson Counties). Peak-year emissions for all criteria pollutants and VOCs would be the highest for the vault method because it would involve more soil handling (i.e., for the cover system) than the other two methods. Peak-year emissions of all criteria pollutants and VOCs would be the lowest for the trench method, because it would disturb the smallest area among the disposal methods. In terms of their contribution to the emissions total, peak-year emissions of SO_2 from the vault method would be the highest, about 0.41% of the five-county emissions total, while emissions of other criteria pollutants and VOCs would be 0.30% or less of the five-county emissions total.

Background concentration levels for PM_{10} and annual $PM_{2.5}$ at the INL Site are below the standards (less than 80%), but those for 24-hour $PM_{2.5}$ are about 169% of the standard (Table 7.1.1-3). All construction activities at the INL Site would occur at least 11 km (7 mi) from the site boundary and thus would not contribute much to concentrations at the boundary or at the nearest residence. Construction activities would be conducted so as to minimize potential impacts from construction-related emissions on ambient air quality, and construction permits typically require fugitive dust control by established, standard, dust control practices, primarily by watering unpaved roads, disturbed surfaces, and temporary stockpiles.

Although O_3 levels in the area approached the standard (about 93%) (Table 7.1.1-3), the five counties encompassing the INL Site are currently in attainment for O_3 (40 CFR 81.313). Ozone precursor emissions from the proposed facility for all methods would be relatively small, less than 0.29% and 0.01% of five-county total NO_x and VOC emissions, respectively, and would be much lower than those for the regional air shed in which emitted precursors are

TABLE 7.2.1-1 Peak-Year Emissions of Criteria Pollutants, Volatile Organic Compounds, and Carbon Dioxide from Construction of the Three Land Disposal Facilities at the INL Site

Pollutant	Total Emissions (tons/yr)[a]	Construction Emissions (tons/yr)					
		Trench (%)		Borehole (%)		Vault (%)	
SO_2	784	0.90	(0.11)[b]	3.0	(0.38)	3.2	(0.41)
NO_x	10,540	8.1	(0.08)	26	(0.25)	31	(0.29)
CO	78,038	3.3	(<0.01)	11	(0.01)	11	(0.01)
VOCs	24,619	0.90	(<0.01)	2.7	(0.01)	3.6	(0.01)
PM_{10}[c]	43,964	5.0	(0.01)	13	(0.03)	8.6	(0.02)
$PM_{2.5}$[c]	7,549	1.5	(0.02)	4.1	(0.05)	3.6	(0.05)
CO_2		670		2,200		2,300	
County[d]	1.99×10^6		(0.03)		(0.11)		(0.12)
Idaho[e]	1.74×10^7		(0.004)		(0.013)		(0.013)
U.S.[e]	6.54×10^9		(0.00001)		(0.00003)		(0.00004)
World[e]	3.10×10^{10}		(0.000002)		(0.000007)		(0.000007)

[a] Total emissions in 2002 for all five counties encompassing the INL Site (Bingham, Bonneville, Butte, Clark, and Jefferson Counties). See Table 7.1.1-1 for criteria pollutants and VOCs.

[b] Numbers in parentheses are percent of total emissions.

[c] Estimates for GTCC construction include diesel particulate emissions.

[d] Emission data for the year 2005. Currently, CO_2 emissions at county level are not available, so county-level emissions were estimated from available state total CO_2 emissions on the basis of the population distribution.

[e] Annual CO_2 emissions in Idaho, the United States, and the world in 2005.

Sources: EIA (2008); EPA (2008b, 2009)

transported and formed into O_3. Accordingly, potential impacts of O_3 precursor releases from construction on regional ozone would not be of concern.

The major air quality concern with respect to emissions of CO_2 is that it is a greenhouse gas, which traps solar radiation reflected from the earth, keeping it in the atmosphere. The combustion of fossil fuels makes CO_2 the most widely emitted greenhouse gas worldwide. CO_2 concentrations in the atmosphere have continuously increased, from about 280 ppm in preindustrial times to 379 ppm in 2005, a 35% increase, and most of this increase has occurred in the last 100 years (IPCC 2007).

The climatic impact of CO_2 does not depend on the geographic location of sources because CO_2 is stable in the atmosphere and is essentially uniformly mixed; that is, the global total is the important factor with respect to global warming. Therefore, a comparison between U.S. and global emissions and the total emissions from the construction of a disposal facility is useful in understanding whether CO_2 emissions from the site are significant with respect to global warming. As shown in Table 7.2.1-1, the highest peak-year amount of CO_2 emissions from construction would be under 0.12%, 0.013%, and 0.00004% of 2005 five-county total, state, and U.S. CO_2 emissions. In 2005, national CO_2 emissions were about 21% of worldwide emissions (EIA 2008); emissions from construction would thus be less than 0.00001% of global emissions. Potential impacts on climate change from construction emissions would be small.

The period over which major land clearing and the construction of surface facilities would occur is assumed to be 3.4 years (see Appendix D). In fact, the disposal units would likely be constructed as the waste would become available for disposal. The construction phase would be extended over more years; thus, emission levels for nonpeak years would be lower than peak-year levels in the table. In addition, construction activities would occur only during daytime hours, when air dispersion is most favorable. Accordingly, potential impacts from construction activities on ambient air quality would be minor and intermittent.

General conformity applies to federal actions taking place in nonattainment or maintenance areas and is not applicable to the proposed action at the INL Site because the area is classified as being in attainment for all criteria pollutants (40 CFR 81.313).

7.2.1.2 Operations

Criteria pollutants, VOCs, and CO_2 would be released into the atmosphere during operations. These emissions would include fugitive dust emissions from emplacement activities and exhaust emissions from heavy equipment and commuter, delivery, and support vehicles. Estimated annual emissions of criteria pollutants, VOCs, and CO_2 at the facility are presented in Table 7.2.1-2. Detailed information on emission factors, assumptions, and emission inventories is available in Appendix D. Annual emission levels for the trench method would be the highest because of the use of forklifts. The annual emission levels for the borehole method would be the lowest. Compared with annual emissions for counties encompassing the INL Site, the annual emissions of SO_2 for the trench and vault methods would be the highest, about 0.42% of the total emissions, while emissions of all the other criteria pollutants and VOCs would be about 0.25% or less.

It is expected that emission concentration levels from operational activities for PM_{10} and $PM_{2.5}$ (which include diesel particulate emissions) would remain below the standards, except for the 24-hour $PM_{2.5}$ level, which is already above the standard. As discussed in the construction section, established fugitive dust control measures (primarily watering of unpaved roads, disturbed surfaces, and temporary stockpiles) would be implemented to minimize potential impacts on ambient air quality.

With regard to regional O_3, precursor emissions of NO_x and VOCs would come from operational activities (about 0.26% and 0.01% of the five-county emission totals, respectively), and it is not anticipated that they would contribute much to regional O_3 levels. The highest CO_2 emissions among the disposal methods would be comparable to the highest construction-related emissions; thus, their potential impacts on climate change would also be small.

TABLE 7.2.1-2 Annual Emissions of Criteria Pollutants, Volatile Organic Compounds, and Carbon Dioxide from Operations of the Three Land Disposal Facilities at the INL Site

Pollutant	Total Emissions (tons/yr)[a]	Operation Emissions (tons/yr)					
		Trench (%)		Borehole (%)		Vault (%)	
SO_2	784	3.3	(0.42)[b]	1.2	(0.16)	3.3	(0.42)
NO_x	10,540	27	(0.26)	10	(0.09)	27	(0.26)
CO	78,038	15	(0.02)	6.7	(0.01)	15	(0.02)
VOCs	24,619	3.1	(0.01)	1.2	(<0.01)	3.1	(0.01)
PM_{10}[c]	43,964	2.5	(0.01)	0.91	(<0.01)	2.5	(0.01)
$PM_{2.5}$[c]	7,549	2.2	(0.03)	0.81	(0.01)	2.2	(0.03)
CO_2		3,200		1,700		3,300	
County[d]	1.99×10^6		(0.16)		(0.09)		(0.17)
Idaho[e]	1.74×10^7		(0.018)		(0.010)		(0.019)
U.S.[e]	6.54×10^9		(0.00005)		(0.00003)		(0.00005)
World[e]	3.10×10^{10}		(0.00001)		(0.00001)		(0.00001)

a Total emissions in 2002 for all five counties encompassing the INL Site (Bingham, Bonneville, Butte, Clark, and Jefferson Counties). See Table 7.1.1-1 for criteria pollutants and VOCs.

b Numbers in parentheses are percent of total emissions.

c Estimates from GTCC operations include diesel particulate emissions.

d Emission data for the year 2005. Currently, CO_2 emissions at county level are not available, so county-level emissions were estimated from available state total CO_2 emissions on the basis of population distribution.

e Annual CO_2 emissions in Idaho, the United States, and the world in 2005.

Sources: EIA (2008); EPA (2008b, 2009)

PSD regulations are not applicable to the proposed action because the proposed action is not a major stationary source.

7.2.2 Geology and Soils

Direct impacts from land disturbance would be proportional to the total area of land disturbed during site preparation activities (e.g., grading and backfilling) and construction of the waste disposal facility and related infrastructure (e.g., roads). Land disturbance would include the surface area covered by each disposal method and the vertical displacement of geologic materials for the borehole and trench disposal methods. The increased potential for soil erosion would be an indirect impact of land disturbance at the construction site. Indirect impacts would also result from the consumption of geologic materials (e.g., aggregate) to construct the facility and new roads. The impact analysis also considers whether the proposed action would preclude the future extraction and use of mineral materials or energy resources.

7.2.2.1 Construction

Land surface area disturbance impacts would be a function of the disposal method implemented at the site (Table 5.1-1). Of the three land disposal methods, the borehole facility layout would result in the greatest impact in terms of land area disturbed (44 ha or 110 ac). It also would result in the greatest disturbance with depth (40 m or 130 ft), with boreholes completed in an alternating sequence of unconsolidated sediment and basalt (with the first basalt layer encountered at depths of 13 to 17 m [43 to 57 ft]). A trench might also penetrate the upper basalt layer.

Geologic and soil material requirements are provided in Table 5.3.2-1. Of the three disposal methods, the vault facility would require the most material since it would involve the installation of interim and final cover systems. This material would be considered permanently lost. However, none of the three disposal methods are expected to result in adverse impacts on geologic and soil resources at the INL Site, since these resources are in abundant supply at the site and in the surrounding area.

No significant changes in surface topography or natural drainages are anticipated in the construction area. However, the disturbance of soil during the construction phase would increase the potential for erosion in the immediate vicinity. This potential would be greatly reduced, however, by the low precipitation rates at the INL Site. Mitigation measures also would be implemented to avoid or minimize the risk of erosion.

The GTCC LLRW and GTCC-like waste disposal facility would be sited, designed, and constructed to meet existing site design criteria (including safeguards to avoid or minimize the risks associated with seismic and volcanic hazards). Although ground shaking has been reported at the INL Site, the ESRP on which the INL Site is situated is a region of relatively low seismicity. The annual probability of a volcanic event (basaltic eruption) is considered low; the risk of silicic volcanism is negligible. The potential for other hazards (e.g., subsidence, liquefaction) is also considered to be low.

7.2.2.2 Operations

The disturbance of soil and the increased potential for soil erosion would continue throughout the operations phase as waste would be delivered to the site for disposal over time. The potential for soil erosion would be greatly reduced by the low precipitation rates at the INL Site. Mitigation measures also would be implemented to avoid or minimize the risk of erosion.

Impacts related to the extraction and use of valuable geologic materials would be low, since only the area within the facility itself would be unavailable for mining, and the potential for oil production and geothermal energy development at the site is considered to be low.

7.2.3 Water Resources

Direct and indirect impacts on water resources could occur as a result of water use at the proposed GTCC LLRW and GTCC-like waste disposal facility during construction and operations. Table 5.3.3-1 provides an estimate of the water consumption and discharge volumes for the three land disposal methods; Tables 5.3.3-2 and 5.3.3-3 summarize the water use impacts (in terms of change in annual water use) to water resources from construction and normal operations, respectively. A discussion of potential impacts during each project phase is presented in the following sections. In addition, contamination due to potential leaching of radionuclides into groundwater from the waste inventory could occur, depending on the post-closure performance of the land disposal facilities discussed in Section 7.2.4.2.

7.2.3.1 Construction

Of the three land disposal methods considered for the INL Site, construction of a vault facility would have the highest water requirement (Table 5.3.3-1).Water demands for construction at the INL Site would be met by using groundwater from on-site wells completed in the Snake River Plain aquifer. No surface water would be used at the site during construction. As a result, no direct impacts on surface water resources are expected. The potential for indirect surface water impacts on the Big Lost River (to the south of the GTCC reference location) related to soil erosion, contaminated runoff, and sedimentation would be reduced by implementing good industry practices and mitigation measures. The GTCC reference location at the INL Site is not located within the 100-yr floodplain.

Currently, the INL Site uses about 4.2 billion L/yr (1.1 billion gal/yr) of groundwater, about 10% of its Federal Reserved Water Right of 43.1 billion L/yr (11.4 billion gal/yr). Construction of the proposed GTCC LLRW and GTCC-like waste disposal facility would increase the annual water use at the INL Site by a maximum of about 0.08% (vault method) over the 20-year period that construction would occur. This increase would be well within the INL Site’s water right. Because withdrawals of groundwater would be relatively small, they would not significantly lower the water table or change the direction of groundwater flow at the INL Site. As a result, impacts due to groundwater withdrawals are expected to be small.

Construction activities could potentially change the infiltration rate at the site of the proposed GTCC LLRW and GTCC-like waste disposal facility, first by increasing the rate as ground would be disturbed in the initial stages of construction and then later by decreasing the rate as impermeable materials (e.g., the clay material and geotextile membrane assumed for the cover or cap for the land disposal facility designs) would cover the surface. These changes are expected to be negligible since the area of land associated with the proposed GTCC LLRW and GTCC-like waste disposal facility (up to 44 ha [110 ac], depending on the disposal method) is small relative to the INL Site.

Disposal of waste (including sanitary waste) generated during construction of the land disposal facilities would have a negligible impact on the quality of water resources at the INL Site (see Sections 5.3.11 and 7.2.11).

The potential for indirect surface water or groundwater impacts related to spills at the surface would be reduced by implementing good industry practices and mitigation measures.

7.2.3.2 Operations

Of the three land disposal methods considered for the INL Site, operation of a vault or trench facility would have the highest water requirement (Table 5.3.3-1).Water demands for operations at the INL Site would be met by using groundwater from on-site wells completed in the Snake River Plain aquifer. No surface water would be used at the site during operations. As a result, no direct impacts on surface water resources are expected. The potential for indirect surface water impacts related to soil erosion, contaminated runoff, and sedimentation would be reduced by implementing good industry practices and mitigation measures.

Operations of the proposed GTCC LLRW and GTCC-like waste disposal facility would increase the annual water use at the INL Site by a maximum of about 0.13% (vault or trench method). This increase would be well within the INL Site's water right. Because withdrawals of groundwater would be relatively small, they would not significantly lower the water table or change the direction of groundwater flow at the INL Site. As a result, impacts due to groundwater withdrawals are expected to be small.

Disposal of wastes (including sanitary waste) generated during operations of the land disposal facilities would have a negligible impact on the quality of water resources at the INL Site (see Sections 5.3.11 and 7.2.11).

The potential for indirect surface water or groundwater impacts related to spills at the surface would be reduced by implementing good industry practices and mitigation measures.

7.2.4 Human Health

Potential impacts on members of the general public and the involved workers from the construction and operations of the waste disposal facilities are expected to be comparable for all of the sites evaluated in this EIS for the three land disposal methods, and these impacts are described in Section 5.3.4. The following sections discuss the impacts from hypothetical facility accidents associated with waste handling activities and the impacts during the long-term post-closure phase. They address impacts on members of the general public who might be affected by these waste disposal activities at the INL Site GTCC reference location, since these impacts would be site dependent.

7.2.4.1 Facility Accidents

Data on the estimated human health impacts from hypothetical accidents at a GTCC land waste disposal facility located on the INL Site are provided in Table 7.2.4-1. A description of the accident scenarios is provided in Section 5.3.4.2.1 and Appendix C. A reasonable range of accidents that considered both operational events and natural causes was analyzed. The impacts presented for each accident scenario are for the sector with the highest impacts and with no protective measures assumed; thus, they are the maximum impacts expected from such an accident.

The collective population dose includes exposure from inhalation of airborne radioactive material, external exposure from radioactive material deposited on the ground, and ingestion of contaminated crops. The exposure period is considered to last for 1 year immediately following the accidental release. It is recognized that interdiction of food crops would likely occur if a significant release did occur, but many stakeholders are interested in what could happen without interdiction. For the accidents involving CH waste (Accidents 1–9, 11, 12), the ingestion dose made up about 20% of the collective population dose shown in Table 7.2.4-1. External exposure was found to be negligible in all cases. All exposures were dominated by the inhalation dose from the passing plume of airborne radioactive material downwind of the hypothetical accident immediately following release.

The highest estimated impact on the general public, 13 person-rem, would be from a hypothetical release from an SWB caused by a fire in the WHB (Accident 9). Such a dose is not expected to lead to any additional LCFs in the population. This dose would be to the 65,300 people living to the east of the facility, resulting in an average dose of about 0.0002 rem per person. Because this dose would be from internal intake (primarily inhalation, with some ingestion) and because the DCFs used in this analysis are for a 50-year CEDE, this dose would be accumulated over the course of 50 years.

The dose to an individual (expected to be a noninvolved worker because there would be no public access within 100 m [330 ft] of the GTCC reference location) includes exposure from inhalation of airborne radioactive material and 2 hours of exposure to radioactive material deposited on the ground. As shown in Table 7.2.4-1, the highest estimated dose to an individual, 11 rem, is for Accident 9 from inhalation exposure immediately after the postulated release. This estimated dose is for a hypothetical individual located 100 m (330 ft) to the west-northwest of the accident location. As discussed above, the estimated dose of 11 rem would be accumulated over a 50-year period after intake. Thus, it is not expected to result in acute radiation syndrome. A maximum annual dose of about 5% of the total dose would occur in the first year. The increased lifetime probability of a fatal cancer for this individual is approximately 0.7% on the basis of a total dose of 11 rem.

7.2.4.2 Post-Closure

The potential radiation dose from airborne releases of radionuclides to the off-site members of the public after the closure of a waste disposal facility would be small. RESRAD-OFFSITE calculation results indicate that there would be no measurable exposure from this pathway for the borehole method. Small radiation exposures are estimated for the trench and vault methods. The potential inhalation dose at a distance of 100 m (330 ft) from the disposal facility is estimated to be less than 1.8 mrem/yr for trench disposal and 0.52 mrem/yr for vault

TABLE 7.2.4-1 Estimated Radiological Human Health Impacts from Hypothetical Facility Accidents at the INL Site[a]

		Off-Site Public		Individual[b]	
Accident Number	Accident Scenario	Collective Dose (person-rem)	Latent Cancer Fatalities[c]	Dose (rem)	Likelihood of LCF[b]
1	Single drum drops, lid failure in Waste Handing Building	0.00028	<0.0001	0.00025	<0.0001
2	Single SWB drops, lid failure in Waste Handing Building	0.00063	<0.0001	0.00055	<0.0001
3	Three drums drop, puncture, lid failure in Waste Handling Building	0.0005	<0.0001	0.00045	<0.0001
4	Two SWBs drop, puncture, lid failure in Waste Handling Building	0.00088	<0.0001	0.00077	<0.0001
5	Single drum drops, lid failure outside	0.28	0.0002	0.25	0.0001
6	Single SWB drops, lid failure outside	0.63	0.0004	0.55	0.0003
7	Three drums drop, puncture, lid failure outside	0.5	0.0003	0.45	0.0003
8	Two SWBs drop, puncture, lid failure outside	0.88	0.0005	0.77	0.0005
9	Fire inside the Waste Handling Building, one SWB assumed to be affected	13	0.008	11	0.007
10	Single RH waste canister breach	<0.0001	<0.0001	<0.0001	<0.0001
11	Earthquake affects 18 pallets, each with four CH drums	7.9	0.005	7.1	0.004
12	Tornado, missile hits one SWB, contents released	2.5	0.001	2.2	0.001

[a] CH = contact-handled, RH = remote-handled, LCF = latent cancer fatality, SWB = standard waste box.

[b] The individual receptor is assumed to be 100 m (330 ft) downwind from the release point. This individual is expected to be a noninvolved worker because there would be no public access within 100 m (330 ft) of the GTCC reference location.

[c] LCFs are calculated by multiplying the dose by the health risk conversion factor of 0.0006 fatal cancer per person-rem (see Section 5.2.4.3). Values are rounded to one significant figure.

disposal. The potential radiation exposures would be caused mainly by inhalation of radon gas and its short-lived progeny.

The use of boreholes would provide better protection against potential exposures from airborne releases of radionuclides because of the greater depth of cover material involved. The top of the waste placement zone for the boreholes would be 30 m (100 ft) bgs, and this depth of overlying soil would inhibit the diffusion of radon gas, CO_2 gas (containing C-14), and tritium (H-3) water vapor to the atmosphere above the disposal area. However, because the distance to the groundwater table would be closer under the borehole method than under the trench and vault methods, radionuclides that leached out from wastes in the boreholes would reach the groundwater table in a shorter time than would radionuclides that leached out from a trench or vault disposal facility. On the other hand, the footprint of a borehole disposal facility would be greater than that of a vault or trench disposal facility; as a result, the distance radionuclides need to travel, after arriving at the groundwater table, to reach an off-site well (assumed to be located at 100 m [330 ft] from the edge of the disposal facility in the analysis) would be greater for the borehole method than for the vault/trench method. This greater distance would result in greater dilution in the well water concentrations and consequently would reduce potential radiation doses associated with the use of well water.

Within 300 years after leaching of radionuclides in the waste materials started, C-14, Tc-99, and I-129 could reach the groundwater table and a well installed by a hypothetical resident farmer located at a distance of 100 m (330 ft) from the downgradient edge of the disposal facility, regardless of the disposal methods used. All three of these radionuclides are highly soluble in water, a quality that could lead to potentially significant groundwater concentrations and subsequently to a measurable radiation dose to the resident farmer. For the trench and vault disposal methods, the time required for all other radionuclides to reach the well location would be greater than 10,000 years, although the resulting radiation dose would be greater than that from C-14, Tc-99, and I-129. For the borehole disposal method, uranium isotopes would make a breakthrough to the groundwater table right before 10,000 years – about 9,200 years as shown in Figures 7.2.4-1 and 7.2.4-2. This breakthrough would result in a slightly greater dose than that from C-14, Tc-99, and I-129, so uranium isotopes would become the dominating radionuclides for the peak radiation dose occurring within 10,000 years for the borehole method.

Tables 7.2.4-2 and 7.2.4-3 present the peak annual doses and LCF risks, respectively, to the hypothetical resident farmer (from use of potentially contaminated groundwater within the first 10,000 years after closure of the disposal facility) when the disposal of the entire GTCC LLRW and GTCC-like waste inventory by using the land disposal methods evaluated is considered. In these tables, the doses contributed by each waste type (i.e., dose for each waste type at the time or year when the peak dose for the entire inventory is observed) to the peak dose reported are also tabulated. The doses presented from the various waste types do not necessarily represent the peak dose and LCF risk of the waste type itself when it is considered on its own.

The peak annual dose associated with the use of contaminated groundwater from disposal of the entire GTCC LLRW and GTCC-like waste inventory at the INL Site was calculated to be 820 mrem/yr for the borehole method, 2,300 mrem/yr for the vault method, and 2,100 mrem/yr

TABLE 7.2.4-2 Estimated Peak Annual Doses (in mrem/yr) from the Use of Contaminated Groundwater within 10,000 Years of Disposal at the GTCC Reference Location at the INL Site[a]

	GTCC LLRW				GTCC-Like Waste				
Disposal Technology/ Waste Group	Activated Metals	Sealed Sources	Other Waste - CH	Other Waste - RH	Activated Metals	Sealed Sources	Other Waste - CH	Other Waste - RH	Peak Annual Dose for Entire Inventory
Borehole									820[b]
Group 1 stored	2.6	-	0.0	0.45	0.21	0.0	48	17	
Group 1 projected	39	32	-	0.013	0.52	0.0	8.4	580	
Group 2 projected	21	0.0	5.6	24	-	-	17	26	
Vault									2,300[b]
Group 1 stored	1.5	-	0.0	2.3	0.0	0.0	0.59	2,200	
Group 1 projected	24	0.0	-	0.069	0.0	0.0	0.22	6.4	
Group 2 projected	12	0.0	1.4	86	-	-	0.33	12	
Trench									2,100[b]
Group 1 stored	1.7	-	0.0	2.0	0.0	0.0	0.65	1,900	
Group 1 projected	28	0.0	-	0.0	0.0	0.0	0.24	5.7	
Group 2 projected	14	0.0	1.5	77	-	-	0.37	11	

[a] These annual doses are associated with the use of contaminated groundwater by a hypothetical resident farmer located 100 m (330 ft) from the edge of the disposal facility. All values are given to two significant figures, and a hyphen means there is no inventory for that waste type. The values given in this table represent the annual doses to the hypothetical resident farmer at the time of peak annual dose for the entire GTCC LLRW and GTCC-like waste inventory. These contributions do not represent the maximum doses that could result from each of these waste types separately. Because of the different radionuclide mixes and activities contained in the different waste types, the maximum doses that could result from each waste type individually generally occur at different times than the peak annual dose from the entire inventory. The peak annual doses that could result from each of the waste types are presented in Tables E-22 through E-25 in Appendix E.

[b] The times for the peak annual doses of 820 mrem/yr for boreholes, 2,300 mrem/yr for vaults, and 2,100 mrem/yr for trenches were calculated to be about 9,200 years, 220 years, and 190 years, respectively, for disposal of the entire GTCC LLRW and GTCC-like waste inventory. These times represent the time after failure of the cover and engineered barriers (which is assumed to begin 500 years after closure of the disposal facility). The values reported for the other entries in this table represent the annual doses for the specific waste types at the time of these peak doses. The primary contributor to the dose in all cases is GTCC-like Other Waste - RH. For borehole disposal, the primary radionuclides causing the dose would be uranium isotopes; and C-14, Tc-99, and I-129 would be the primary radionuclides causing this dose for the vault and trench disposal methods.

TABLE 7.2.4-3 Estimated Peak Annual LCF Risks from the Use of Contaminated Groundwater within 10,000 Years of Disposal at the GTCC Reference Location at the INL Site[a]

	GTCC LLRW				GTCC-Like Waste				
Disposal Technology/ Waste Group	Activated Metals	Sealed Sources	Other Waste - CH	Other Waste - RH	Activated Metals	Sealed Sources	Other Waste - CH	Other Waste - RH	Peak Annual LCF Risk for Entire Inventory
Borehole									5E-04[b]
Group 1 stored	2E-06	-	0E+00	3E-07	1E-07	0E+00	3E-05	1E-05	
Group 1 projected	2E-05	2E-05	-	8E-09	-	-	5E-06	3E-04	
Group 2 projected	1E-05	0E+00	3E-06	1E-05	0E+00	0E+00	1E-05	2E-05	
Vault									1E-03[b]
Group 1 stored	9E-07	-	0E+00	1E-06	0E+00	0E+00	4E-07	1E-03	
Group 1 projected	1E-05	0E+00	-	4E-08	0E+00	0E+00	1E-07	4E-06	
Group 2 projected	7E-06	0E+00	8E-07	5E-05	-	-	2E-07	7E-06	
Trench									1E-03[b]
Group 1 stored	1E-06	-	0E+00	1E-06	0E+00	0E+00	4E-07	1E-03	
Group 1 projected	2E-05	0E+00	-	0E+00	0E+00	0E+00	1E-07	3E-06	
Group 2 projected	8E-06	0E+00	9E-07	5E-05	-	-	2E-07	6E-06	

[a] These annual LCF risks are associated with the use of contaminated groundwater by a hypothetical resident farmer located 100 m (330 ft) from the edge of the disposal facility. All values are given to one significant figure, and a hyphen means there is no inventory for that waste type. The values given in this table represent the annual LCF risks to the hypothetical resident farmer at the time of peak annual LCF risk for the entire GTCC LLRW and GTCC-like waste inventory. These contributions do not represent the maximum LCF risks that could result from each of these waste types separately. Because of the different radionuclide mixes and activities contained in the different waste types, the maximum LCF risks that could result from each waste type individually generally occur at different times than the peak annual LCF risk from the entire inventory.

[b] The times for the peak annual LCF risks of 5E-04 for boreholes, 1E-03 for vaults, and 1E-03 for trenches were calculated to be about 9,200 years, 220 years, and 190 years, respectively, for disposal of the entire GTCC LLRW and GTCC-like waste inventory. These times represent the time after failure of the cover and engineered barriers (which is assumed to begin 500 years after closure of the disposal facility). The values reported for the other entries in this table represent the annual LCF risks for the specific waste types at the time of peak LCF risks. The primary contributor to the LCF risk in all cases is GTCC-like Other Waste - RH. For borehole disposal, the primary radionuclides causing the risk would be uranium isotopes; and C-14, Tc-99, and I-129 would be the primary radionuclides causing this risk for the vault and trench disposal methods.

for the trench method. Although radionuclides would reach the groundwater table sooner under the borehole method, the peak annual dose within 10,000 years would occur later than it would under the other two disposal methods because of uranium isotopes from the disposal facility that would reach the groundwater table near the end of the 10,000-year time frame, as discussed previously. The uranium isotopes would produce a radiation dose to the hypothetical resident farmer that would be slightly higher than the dose resulting from the C-14, Tc-99, and I-129 that would reach the groundwater table sooner under the borehole disposal method. Calculations indicate that the uranium isotopes would not reach the groundwater table within 10,000 years under the trench and vault disposal methods.

For borehole disposal, it is estimated that the peak annual dose and LCF risks would occur about 9,200 years after disposal (contributed more by the later-arriving uranium isotopes than the mobile isotopes of C-14, Tc-99, and I-129), and calculations indicate that the peak annual dose and LCF risks would occur 220 years after disposal for the vault method and 190 years after disposal for the trench method (contributed by the mobile isotopes of C-14, Tc-99, and I-129). These times represent the time after failure of the engineered barriers (including the cover), which is assumed to begin 500 years after closure of the disposal facility. The GTCC-like Other Waste - RH would be the primary contributor to the dose in all cases.

Tables E-22 through E-25 in Appendix E present peak doses for each waste type when considered on its own. Because these peak doses generally occur at different times, the results should not be summed to obtain total doses for comparison with those presented in Table 7.2.4-2 (although for some cases, these sums might be close to those presented in the site-specific chapters).

Figure 7.2.4-1 is a temporal plot of the radiation doses associated with the use of contaminated groundwater for a period extending to 10,000 years, and Figure 7.2.4-2 shows these results to 100,000 years for the three land disposal methods. Note that the time scale is logarithmic in Figure 7.2.4-1 and linear in Figure 7.2.4-2. A logarithmic time scale was used in the first figure to better illustrate the projected radiation doses to a hypothetical resident farmer in the first 1,000 years.

Although C-14, Tc-99, and I-129 would result in measurable radiation doses in the first 10,000 years, the inventory of these radionuclides in the disposal areas would be depleted rather quickly. Under the three land disposal options, various isotopes of uranium as well as Np-237 and Am-241 would reach the groundwater table after about 9,000 to 16,000 years and contribute to radiation exposures. At that time, the radiation doses from these radionuclides could greatly exceed those from C-14, Tc-99, and I-129, and the magnitude of the calculated annual doses to the hypothetical resident farmer would be comparable to those that are predicted to occur in the first 10,000 years. However, there is a high degree of uncertainty associated with results like these, which are for such a long time of analysis.

The results given here are assumed to be conservative because the location selected for the residential exposure was 100 m (330 ft) from the edge of the disposal facility. Use of a longer distance, which might be more realistic for the sites being evaluated, would significantly lower

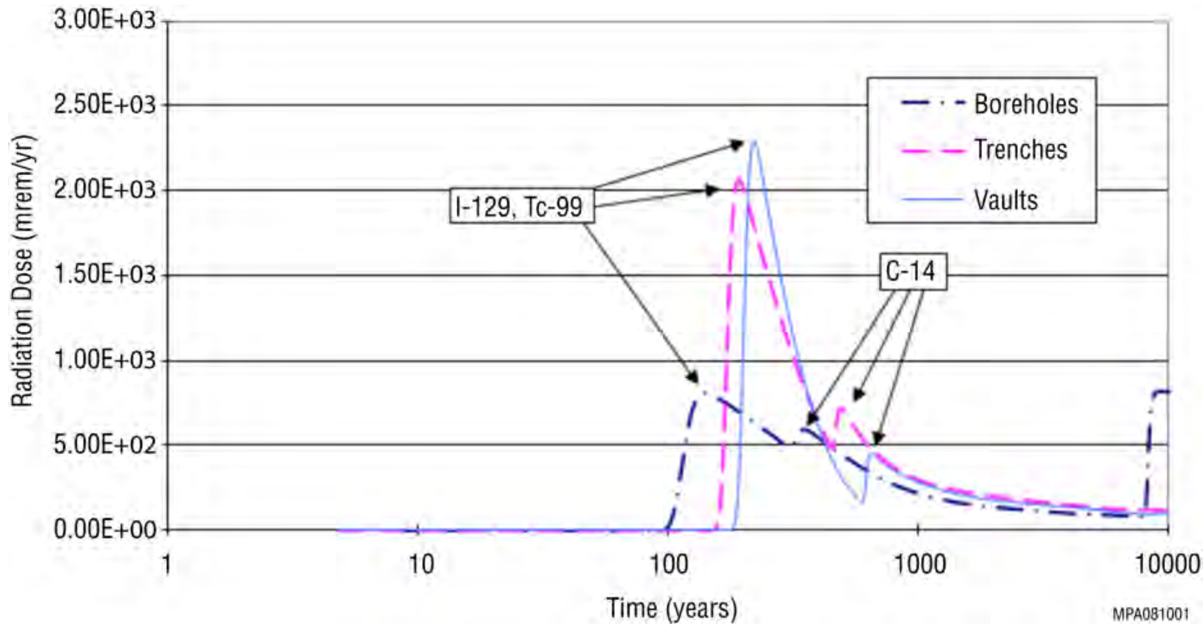

FIGURE 7.2.4-1 Temporal Plot of Radiation Doses Associated with the Use of Contaminated Groundwater within 10,000 Years of Disposal for the Three Land Disposal Methods at the INL Site

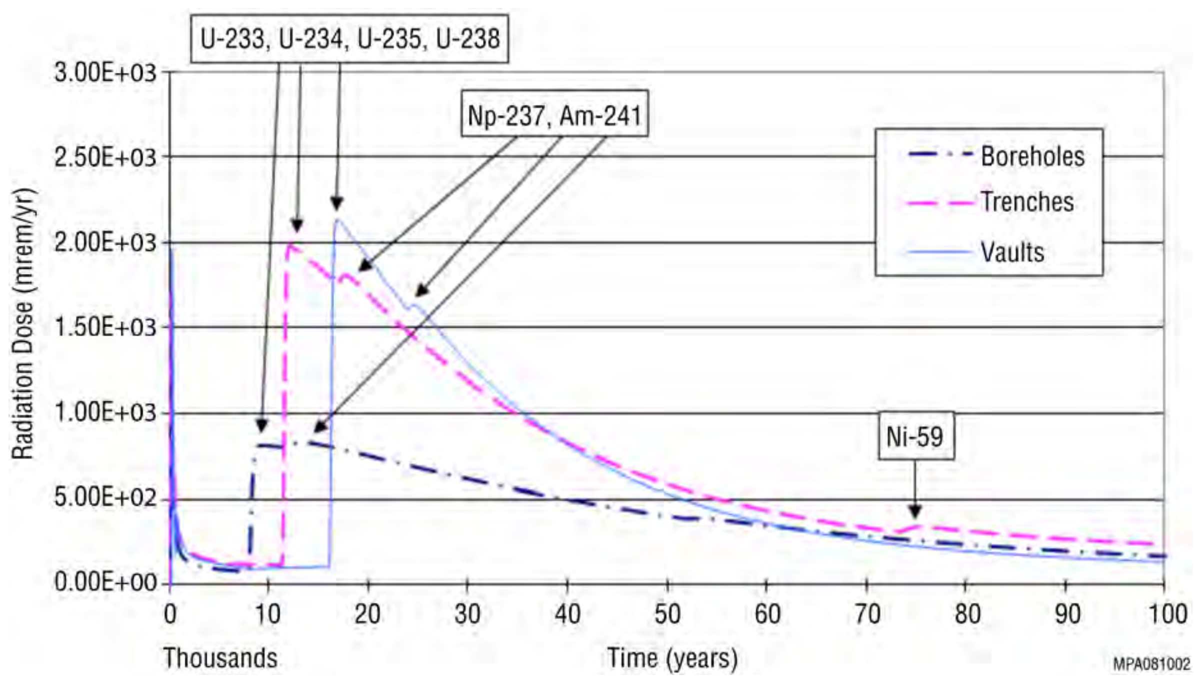

FIGURE 7.2.4-2 Temporal Plot of Radiation Doses Associated with the Use of Contaminated Groundwater within 100,000 Years of Disposal for the Three Land Disposal Methods at the INL Site

these estimated doses (i.e., by as much as 70%). A sensitivity analysis performed to determine the effect of a distance longer than 100 m (330 ft) is presented in Appendix E.

These analyses assume that engineering controls would be effective for 500 years following closure of the disposal facility. This means that essentially no infiltrating water would reach the wastes from the top of the disposal units during the first 500 years. It is assumed that after 500 years, the engineered barriers would begin to degrade, allowing infiltrating water to come in contact with the disposed-of wastes. For purposes of analysis in the EIS, it is assumed that the amount of infiltrating water that would contact the wastes would be 20% of the site-specific natural infiltration rate for the area, and that the water infiltration rate around and beneath the disposal facilities would be 100% of the natural rate for the area. This approach is conservative because it is expected that the engineered systems (including the disposal facility cover) would last significantly longer than 500 years, even in the absence of active maintenance measures.

It is assumed that the Other Waste would be stabilized with grout or other material and that this stabilizing agent would be effective for 500 years. Consistent with the assumptions used for engineering controls, no credit was taken for the effectiveness of this stabilizing agent after 500 years in this analysis. That is, any water that would contact the wastes after 500 years would be able to leach radioactive constituents from the disposed-of materials. These radionuclides could then move with the percolating groundwater to the underlying groundwater system. This assumption is conservative because grout or other stabilizing materials could retain their integrity for longer than 500 years.

Sensitivity analyses performed relative to these assumptions indicate that if a higher infiltration rate to the top of the disposal facilities was assumed, the doses would increase in a linear manner from those presented. Conversely, the doses would decrease in a linear manner with lower infiltration rates. This finding indicates that there is a need to ensure a good cover over the closed disposal units. Also, the doses would be lower if the grout was assumed to last for a longer time. Because of the long-lived nature of the radionuclides associated with the GTCC LLRW and GTCC-like waste, any stabilization effort (such as grouting) would have to be effective for longer than 5,000 years in order to substantially reduce doses that could result from potential future leaching of the disposed-of waste (particularly that from GTCC-like Other Waste - RH).

The radiation doses presented in the post-closure assessment in this EIS are intended to be used for comparing the performance of each of the land disposal methods at each site evaluated. The results indicate that the use of robust engineering designs and redundant measures (e.g., types and thicknesses of covers and long-lasting grout) in the disposal facility could delay the potential release of radionuclides and could reduce the release to low levels, thereby minimizing the potential groundwater contamination and associated human health impacts in the future. DOE has considered the potential doses to the hypothetical resident farmer as well as other factors discussed in Section 2.9 in identifying the preferred alternative presented in Section 2.10.

7.2.5 Ecology

It is expected that the initial loss of sagebrush habitat would not create a long-term reduction in the local or regional ecological diversity. After closure of the waste disposal facility, the cover would initially become vegetated with annual and perennial grasses and forbs. Reestablishment of mature sagebrush stands would be difficult because of the arid climate and could take a minimum of 10 to 20 years (Poston and Sackschewsky 2007). As appropriate, regionally native plants would be used to landscape the disposal site in accordance with "Guidance for Presidential Memorandum on Environmentally and Economically Beneficial Landscape Practices on Federal Landscape Grounds" (EPA 1995). An aggressive revegetation program would be necessary so that nonnative cheatgrass (*Bromus tectorum*) and halogeton (*Halogeton glomeratus*) would not become established. These species are quick to colonize disturbed sites and are difficult to eradicate because they produce large amounts of seeds yearly that remain viable for long periods of time (Blew et al. 2006).

Because wetlands do not occur within the area of the ATR Complex (DOE 2005), impacts on INL Site wetlands from construction, operations, and post-closure of the waste disposal facility would not occur. Wetland plants could develop along the borders of the waste facility retention pond, and depending on the slope of the pond margins and amount and length of time that the pond would retain water, the shoreline areas of the pond might function in a manner similar to that of a natural emergent wetland.

At the GTCC reference location, species such as pygmy rabbit, greater sage-grouse, sage thrasher, loggerhead shrike, sage sparrow, and Brewer's sparrow, which depend on sagebrush, would be replaced by species that thrive in grasslands, such as mountain cottontail, western meadowlark, horned lark, grasshopper sparrow, and vesper sparrow (Vilord et al. 2005; Blew et al. 2006).

Because no natural aquatic habitats occur within the immediate vicinity of the GTCC reference location, impacts on aquatic biota are not expected. DOE would use appropriate erosion control measures to minimize off-site movement of soil. It is expected that the waste disposal facility retention pond would not become a highly productive aquatic habitat. However, depending on the amount of water and length of time that water would be retained within the pond, aquatic invertebrates could become established within it. Waterfowl, shorebirds, and other birds might also make use of the retention pond, as would mammal species that might enter the site.

No federally or state-listed or special-status species have been reported from the vicinity of the ATR Complex (DOE 2005). However, several species that inhabit sagebrush habitats (e.g., greater sage-grouse and pygmy rabbit) could be affected by the habitat loss that would result from construction of a waste disposal facility. Since only a small proportion of the sagebrush habitat on the INL Site would be affected by the waste disposal facility, it is not expected that it would have a population-level impact on these species.

Among the goals of the waste management mission at the INL Site is to design, construct, operate, and maintain disposal facilities in a manner that protects the environment and complies with regulations (DOE 2002). Therefore, impacts on ecological resources that could result from the disposal facility for GTCC LLRW and GTCC-like waste would be minimized and mitigated.

7.2.6 Socioeconomics

7.2.6.1 Construction

The potential socioeconomic impacts from constructing a GTCC LLRW and GTCC-like waste disposal facility and support buildings at the INL Site would be relatively small for all disposal methods. Construction activities would create direct employment for 62 people (trench method) to 145 people (vault method) in the peak construction year and an additional 70 indirect jobs (trench method) to 184 indirect jobs (borehole method) in the ROI (Table 7.2.6-1). Construction activities would increase the annual average employment growth rate by less than 0.1 of a percentage point over the duration of construction. A GTCC facility would produce between $4.6 million in income (trench method) and $12.1 million in income (vault method) in the peak year of construction.

In the peak year of construction, between 27 people (trench method) and 64 people (vault method) would in-migrate to the ROI (Table 7.2.6-1) as a result of employment on-site. In-migration would have only a marginal effect on population growth and would require no more than 2% of vacant rental housing in the peak year. No significant impact on public finances would occur as a result of in-migration, and no more than one new local public service employee would be required to maintain existing levels of service in the various local public service jurisdictions in the ROI. In addition, on-site employee commuting patterns would have a small to moderate impact on levels of service in the local transportation network surrounding the site.

7.2.6.2 Operations

The potential socioeconomic impacts from operating a GTCC LLRW and GTCC-like waste disposal facility would be small for all disposal methods. Operational activities would create 38 direct jobs (borehole method) to 51 direct jobs (vault method) annually and an additional 42 indirect jobs (borehole method) to 50 indirect jobs (vault method) in the ROI (Table 7.2.6-1). A GTCC facility would also produce between $3.9 million in income (borehole method) and $4.9 million in income (vault method) annually during operations.

Two people would move to the area at the beginning of operations (Table 7.2.6-1). In-migration would have only a marginal effect on population growth and would require less than 1% of vacant owner-occupied housing during facility operations. No significant impact on public finances would occur as a result of in-migration, and no new local public service employees would be required to maintain existing levels of service in the various local public service jurisdictions in the ROI. In addition, on-site employee commuting patterns would have a small impact on levels of service in the local transportation network surrounding the site.

TABLE 7.2.6-1 Effects of GTCC LLRW and GTCC-Like Waste Disposal Facility Construction and Operations on Socioeconomics at the ROI for the INL Site[a]

Impact Category	Trench		Borehole		Vault	
	Construction	Operation	Construction	Operation	Construction	Operation
Employment (number of jobs)						
Direct	62	48	72	38	145	51
Indirect	70	48	197	42	184	50
Total	132	96	269	80	329	101
Income ($ in millions)						
Direct	2.4	3.2	3.3	2.6	6.3	3.4
Indirect	2.2	1.5	5.5	1.3	5.8	1.5
Total	4.6	4.7	8.8	3.9	12.1	4.9
Population (number of new residents)	27	2	32	2	64	2
Housing (number of units required)	14	1	16	1	32	1
Public finances (% impact on expenditures)						
Cities and counties[b]	<1	<1	<1	<1	<1	<1
Schools[c]	<1	<1	<1	<1	<1	<1
Public service employment (number of new employees)						
Local government employees[d]	0	0	0	0	1	0
Teachers	0	0	0	0	1	0
Traffic (impact on current levels of service)	Small	Small	Small	Small	Moderate	Small

[a] Impacts shown are for waste facility and support buildings in the peak year of construction and the first year of operations.

[b] Includes impacts that would occur in the cities of Arimo, Chubbock, Downey, Inkom, Lava Hot Springs, McCammon, Pocatello, Aberdeen, Basalt, Blackfoot, Firth, Shelley, Ammon, Idaho Falls, Iona, Irwin, Swan Valley, Ucon, Lewisville, Menan, Rigby, Ririe, and Roberts and in the counties of Bannock, Bingham, Bonneville, and Jefferson.

[c] Includes impacts that would occur in the school districts of Marsh Valley, Pocatello, Aberdeen, Blackfoot, Firth, Shelley, Snake River, Idaho Falls, Bonneville, Swan Valley, Jefferson County, Ririe, and West Jefferson.

[d] Includes police officers, paid firefighters, and general government employees.

7.2.7 Environmental Justice

7.2.7.1 Construction

No radiological risks and only very low chemical exposure and risk are expected during construction of the trench, borehole, or vault facility. Chemical exposure during construction would be limited to airborne toxic air pollutants at less than standard levels and would not result in any adverse health impacts. Because the health impacts of each facility on the general population within the 80-km (50-mi) assessment area during construction would be negligible, impacts from construction of each facility on the minority and low-income population would not be significant.

7.2.7.2 Operations

Because incoming waste containers would only be consolidated for placement in trench, borehole, and vault facilities with no repackaging necessary, there would be no radiological impacts on the general public during normal operations, and no adverse health effects on the general population. Because the health impacts of routine operations on the general public would be negligible, it is expected that there would be no disproportionately high and adverse impact on minority and low-income population groups within the 80-km (50-mi) assessment area. Subsequent NEPA review to support any GTCC implementation would consider any unique exposure pathways (such as subsistence fish, vegetation, or wildlife consumption or well water use) to determine any additional potential health and environmental impacts.

7.2.7.3 Accidents

An accidental radiological release from any of the land disposal facilities would not be expected to cause any LCFs to members of the public in the surrounding area. In the unlikely event of a release at a facility, the communities most likely to be affected could be minority or low-income, given the demographics within 80 km (50 mi) of the GTCC reference location. However, it is highly unlikely such a release would occur, and the risk to any population, including low-income and minority communities, is considered to be low for the accident with the highest potential impacts, estimated to be less than 0.008 LCF for the population groups residing to the east of the site.

Although the overall risk would be very small, the greatest short-term risk of exposure following an airborne release and the greatest one-year risk would be to the population groups residing to the east of the site because of the prevailing wind condition in this case. Airborne releases following an accident would likely have a larger impact on the area than would an accident that released contaminants directly into the soil surface. A surface release entering local steams could temporarily interfere with subsistence activities being carried out by low-income and minority populations within a few miles downstream of the site.

Monitoring of contaminant levels in soil and surface water following an accident would provide the public with information on the extent of any contaminated areas. Analysis of these contaminated areas would reduce the likelihood for exposures and potential impacts on local residents.

7.2.8 Land Use

Section 5.3.8 presents an overview of the potential land use impacts that could occur from the construction, operations, and post-closure maintenance of a waste disposal facility regardless of the location selected for it. This section evaluates the potential impacts on land use at the INL Site.

The disposal of GTCC LLRW and GTCC-like waste at the reference location would be consistent with DOE policy on land use and facility planning and existing INL Site land use plans. The Comprehensive Facility and Land Use Plan (Sperber et al. 1998) for the INL Site anticipates that future industrial development would most likely be concentrated in the central portion of the INL Site within existing major complex areas. The land use classification of the reference location for the GTCC LLRW and GTCC-like waste disposal facility would change from general open space to facility operations. Land use on areas surrounding the INL Site would not be affected.

7.2.9 Transportation

The transportation impacts from shipments that would be required to dispose of all GTCC LLRW and GTCC-like waste at the INL Site were evaluated. No impacts from transportation are assumed for the wastes generated at the INL Site, which consist of GTCC-like waste that is stored, projected activated metal wastes, and projected Other Waste - CH and Other Waste - RH. As discussed in Section 5.3.9, transportation of all cargo by the truck mode and rail mode as separate options is considered for the purposes of this EIS. Transportation impacts are expected to be the same for disposal in boreholes, trenches, or vaults because the same type of transportation packaging would be used regardless of the disposal method.

As discussed in Appendix C, three impacts from transportation were calculated: (1) collective population risks during routine conditions and accidents (Section 7.2.9.1), (2) radiological risks to individuals receiving the highest impacts during routine conditions (Section 7.2.9.2), and (3) consequences to individuals and populations after the most severe accidents involving a release of radioactive or hazardous chemical material (Section 7.2.9.3).

Radiological impacts during routine conditions are a result of human exposure to the low levels of radiation near the shipment. The regulatory limit established in 49 CFR 173.441 (Radiation Level Limitations) and 10 CFR 71.47 (External Radiation Standards for All Packages) to protect the public is 0.1 mSv/h (10 mrem/h) at 2 m (6 ft) from the outer lateral sides of the transport vehicle. This dose rate corresponds roughly to 14 mrem/h at 1 m (3 ft). As discussed in Appendix C, Section C.9.4.4, the external dose rates for CH waste shipments to the

INL Site are assumed to be 0.5 and 1.0 mrem/h at 1 m (3 ft) for truck and rail shipments, respectively. For shipments of RH waste, the external dose rate is assumed to be 2.5 and 5.0 mrem/h at 1 m (3 ft) for truck and rail shipments, respectively. These assignments are based on shipments of similar types of waste. Dose rates from rail shipments are approximately double those for truck shipments because rail shipments are assumed to have twice the number of waste packages as a truck shipment. Impacts from accidents are dependent on the amount of radioactive material in a shipment and on the fraction that is released if an accident occurs. The parameters used in the transportation accident analysis are described further in Appendix C, Section C.9.4.3.

7.2.9.1 Collective Population Risk

The collective population risk is a measure of the total risk posed to society as a whole by the actions being considered. For a collective population risk assessment, the persons exposed are considered as a group; no individual receptors are specified. Exposures to four different groups are considered: (1) persons living and working along the transportation routes, (2) persons sharing the route, (3) persons at stops along the route, and (4) transportation crew members. The collective population risk is used as the primary means of comparing various options. Collective population risks are calculated for cargo-related risks from routine transportation and accidents. Vehicle-related risks are independent of the cargo in the shipment and are only calculated for traffic accidents (fatalities caused by physical trauma).

Estimated impacts from the truck and rail options are summarized in Tables 7.2.9-1 and 7.2.9-2, respectively. For the truck option, it is estimated that about 12,600 shipments involving about 42 million km (26 million mi) of travel would cause no LCFs in both truck crew members and the public. One fatality directly related to accidents could result. For the rail option, potentially one physical fatality from accidents and no LCFs are estimated from the approximately 4,980 railcar shipments and about 17 million km (11 million mi) of travel that would be involved.

7.2.9.2 Highest-Exposed Individuals during Routine Conditions

During the routine transportation of radioactive material, specific individuals might be exposed to radiation in the vicinity of a shipment. Risks to these individuals for a number of hypothetical exposure-causing events were estimated. The receptors include transportation workers, inspectors, and members of the public exposed during traffic delays, while working at a service station, or while living and/or working near a destination site. The assumptions about exposure are given in Appendix C, and transportation impacts are discussed in Section 5.3.9. The scenarios for exposure are not meant to be exhaustive; they were selected to provide a range of representative potential exposures. On a site-specific basis, if someone was living or working near the INL Site entrance and present for all 12,600 truck or 4,980 rail shipments projected, that individual's estimated dose would be approximately 0.5 or 1.0 mrem, respectively, over the course of more than 50 years. The individual's associated lifetime LCF risk would then be 3×10^{-7} or 6×10^{-7} for truck or rail shipment, respectively.

TABLE 7.2.9-1 Estimated Collective Population Transportation Risks for Shipment of GTCC LLRW and GTCC-Like Waste by Truck for Disposal at the INL Site[a]

			Cargo-Related[b] Radiological Impacts								Vehicle-Related Impacts[c]
			Dose Risk (person-rem)						Latent Cancer Fatalities[d]		
				Routine Public							
Waste	No. of Shipments	Total Distance (km)	Routine Crew	Off-Link	On-Link	Stops	Total	Accident[e]	Crew	Public	Physical Accident Fatalities
Group 1											
GTCC LLRW											
Activated metals - RH											
Past BWRs	20	67,000	0.7	0.02	0.1	0.12	0.24	0.00016	0.0004	0.0001	0.0014
Past PWRs	143	413,000	4.3	0.12	0.62	0.76	1.5	0.00076	0.003	0.0009	0.0082
Operating BWRs	569	1,830,000	19	0.51	2.7	3.4	6.6	0.003	0.01	0.004	0.037
Operating PWRs	1,720	5,520,000	57	1.6	8.2	10	20	0.011	0.03	0.01	0.11
Sealed sources - CH	209	559,000	0.23	0.056	0.32	0.4	0.78	0.036	0.0001	0.0005	0.01
Cesium irradiators - CH	240	642,000	0.27	0.064	0.36	0.46	0.89	0.0055	0.0002	0.0005	0.012
Other Waste - CH	5	14,400	0.006	0.0013	0.0083	0.01	0.02	<0.0001	<0.0001	<0.0001	0.00032
Other Waste - RH	54	204,000	2.1	0.064	0.3	0.37	0.74	<0.0001	0.001	0.0004	0.0046
GTCC-like waste											
Activated metals - RH	11	36,600	0.38	0.01	0.053	0.067	0.13	<0.0001	0.0002	<0.0001	0.0027
Sealed sources - CH	1	2,670	0.0011	0.00027	0.0015	0.0019	0.0037	<0.0001	<0.0001	<0.0001	<0.0001
Other Waste - CH	65	224,000	0.094	0.025	0.13	0.16	0.31	0.00074	<0.0001	0.0002	0.0043
Other Waste - RH	1,120	3,840,000	40	1.1	5.6	7.1	14	0.002	0.02	0.008	0.074

TABLE 7.2.9-1 (Cont.)

			Cargo-Related[b] Radiological Impacts								Vehicle-Related Impacts[c]
			Dose Risk (person-rem)						Latent Cancer Fatalities[d]		
				Routine Public							
Waste	No. of Shipments	Total Distance (km)	Routine Crew	Off-Link	On-Link	Stops	Total	Accident[e]	Crew	Public	Physical Accident Fatalities
Group 2											
GTCC LLRW											
Activated metals - RH											
New BWRs	202	666,000	6.9	0.18	0.99	1.2	2.4	0.0016	0.004	0.001	0.014
New PWRs	833	2,600,000	27	0.8	3.9	4.8	9.5	0.0053	0.02	0.006	0.052
Additional commercial waste	1,990	6,840,000	71	1.9	10	13	25	<0.0001	0.04	0.01	0.13
Other Waste - CH	139	478,000	0.2	0.053	0.27	0.34	0.67	0.0025	0.0001	0.0004	0.0092
Other Waste - RH	3,790	13,200,000	140	3.8	19	24	47	0.00074	0.08	0.03	0.26
GTCC-like waste											
Other Waste - CH	44	148,000	0.062	0.016	0.085	0.11	0.21	0.00034	<0.0001	0.0001	0.0028
Other Waste - RH	1,400	4,800,000	49	1.4	7.1	8.8	17	0.002	0.03	0.01	0.092
Total Groups 1 and 2	12,600	42,000,000	410	12	60	75	150	0.072	0.2	0.09	0.83

a BWR = boiling water reactor, PWR = pressurized water reactor, CH = contact-handled, RH = remote-handled.

b Cargo-related impacts are impacts attributable to the radioactive nature of the material being transported.

c Vehicle-related impacts are impacts independent of the cargo in the shipment.

d LCFs were calculated by multiplying the dose by the health risk conversion factor of 6×10^{-4} fatal cancer per person-rem (see Section 5.2.4.3).

e Dose risk is a societal risk and is the product of accident probability and accident consequence.

TABLE 7.2.9-2 Estimated Collective Population Transportation Risks for Shipment of GTCC LLRW and GTCC-Like Waste by Rail for Disposal at the INL Site[a]

			Cargo-Related[b] Radiological Impacts								Vehicle-Related Impacts[c]
			Dose Risk (person-rem)						Latent Cancer Fatalities[d]		
				Routine Public							
Waste	No. of Shipments	Total Distance (km)	Routine Crew	Off-Link	On-Link	Stops	Total	Accident[e]	Crew	Public	Physical Accident Fatalities
Group 1											
GTCC LLRW											
Activated metals - RH											
Past BWRs	7	23,300	0.18	0.057	0.0034	0.082	0.14	0.00036	0.0001	<0.0001	0.0015
Past PWRs	37	109,000	0.89	0.26	0.017	0.4	0.68	0.0014	0.0005	0.0004	0.0053
Operating BWRs	154	506,000	4	1.2	0.074	1.9	3.1	0.003	0.002	0.002	0.015
Operating PWRs	460	1,530,000	12	3.6	0.21	5.5	9.3	0.01	0.007	0.006	0.05
Sealed sources - CH	105	263,000	0.66	0.16	0.011	0.48	0.66	0.0012	0.0004	0.0004	0.0043
Cesium irradiators - CH	120	300,000	0.75	0.19	0.012	0.55	0.75	0.00017	0.0005	0.0004	0.005
Other Waste - CH	3	9,480	0.022	0.0063	0.0005	0.014	0.021	<0.0001	<0.0001	<0.0001	0.00038
Other Waste - RH	27	104,000	0.8	0.28	0.013	0.36	0.65	<0.0001	0.0005	0.0004	0.0027
GTCC-like waste											
Activated metals - RH	3	10,400	0.081	0.024	0.0013	0.037	0.062	<0.0001	<0.0001	<0.0001	0.0021
Sealed sources - CH	1	2,500	0.0063	0.0016	0.0001	0.0046	0.0062	<0.0001	<0.0001	<0.0001	<0.0001
Other Waste - CH	33	115,000	0.26	0.12	0.0077	0.18	0.31	0.00013	0.0002	0.0002	0.0036
Other Waste - RH	562	1,960,000	15	4.8	0.3	7	12	0.00031	0.009	0.007	0.058

TABLE 7.2.9-2 (Cont.)

			Cargo-Related[b] Radiological Impacts								Vehicle-Related Impacts[c]
			Dose Risk (person-rem)						Latent Cancer Fatalities[d]		
				Routine Public							
Waste	No. of Shipments	Total Distance (km)	Routine Crew	Off-Link	On-Link	Stops	Total	Accident[e]	Crew	Public	Physical Accident Fatalities
Group 2											
GTCC LLRW											
Activated metals - RH											
New BWRs	54	189,000	1.5	0.43	0.025	0.71	1.2	0.0014	0.0009	0.0007	0.0057
New PWRs	227	747,000	5.9	1.8	0.097	2.8	4.7	0.0035	0.004	0.003	0.022
Additional commercial waste	498	1,730,000	14	4.3	0.27	6.2	11	<0.0001	0.008	0.006	0.054
Other Waste - CH	70	244,000	0.56	0.26	0.016	0.38	0.65	0.00046	0.0003	0.0004	0.0076
Other Waste - RH	1,900	6,680,000	52	17	1	24	41	<0.0001	0.03	0.02	0.2
GTCC-like waste											
Other Waste - CH	22	76,500	0.17	0.077	0.0046	0.12	0.2	<0.0001	0.0001	0.0001	0.0021
Other Waste - RH	702	2,440,000	19	5.9	0.38	8.8	15	0.00029	0.01	0.009	0.074
Total Groups 1 and 2	4,980	17,000,000	130	40	2.4	59	100	0.022	0.08	0.06	0.52

[a] BWR = boiling water reactor, PWR = pressurized water reactor, CH = contact-handled, RH = remote-handled.

[b] Cargo-related impacts are impacts attributable to the radioactive nature of the material being transported.

[c] Vehicle-related impacts are impacts independent of the cargo in the shipment.

[d] LCFs were calculated by multiplying the dose by the health risk conversion factor of 6×10^{-4} fatal cancer per person-rem (see Section 5.2.4.3).

[e] Dose risk is a societal risk and is the product of accident probability and accident consequence.

7.2.9.3 Accident Consequence Assessment

Whereas the collective accident risk assessment considers the entire range of accident severities and their related probabilities, the accident consequence assessment assumes that an accident of the highest severity category has occurred. The consequences, in terms of committed dose (rem) and LCFs for radiological impacts, were calculated for both exposed populations and individuals in the vicinity of an accident. Because the exact location of such a transportation accident is impossible to predict, and thus not specific to any one site, generic impacts were assessed, as presented in Section 5.3.9.

7.2.10 Cultural Resources

The GTCC reference location evaluated for land waste disposal facilities at the INL Site is situated southwest of the ATR Complex. No known cultural resources are located within the project area. However, the reference location has not been examined for the presence of cultural resources. In the event that this location at the INL Site is considered for development, the NHPA Section 106 process would be followed for considering potential project impacts on significant cultural resources, as necessary. The Section 106 process requires that the location and any ancillary locations that would be affected by the project be investigated for the presence of cultural resources prior to disturbance.

On the basis of previous research in the region, it is expected that some small prehistoric archaeological sites and also possibly some more substantial historic homesteads that were using the nearby Big Lost River for irrigation would be found in the project area. If archaeological sites were identified, they would require evaluation for listing on the NRHP. Most impacts on significant cultural resources could be mitigated through documentation. The appropriate mitigation would be determined through consultation with the Idaho SHPO and the appropriate Native American tribes.

The borehole method has the greatest potential to affect cultural resources because of its requirements for 44 ha (110 ac) of land. The amount of land needed to employ this option is about twice that needed to construct either the trench or vault disposal facility. It is expected that the majority of the impacts on cultural resources would occur during the construction phase. Visual impacts from the borehole method would be minimal compared with those from the trench or vault method because the majority of the borehole disposal facility would be below grade. Activities associated with operations and post-closure are expected to have a minimal impact on cultural resources. No new ground-disturbing activities are expected to occur in association with operational and post-closure activities.

Northeast of the GTCC reference location is the ATR Complex. A radiological release from the GTCC reference location could have an impact on the ATR, which is considered a historically significant reactor.

Unlike the other two methods being considered, the vault method would require large amounts of soil to cover the waste. Potential impacts on cultural resources could occur during the removal and hauling of the soil required for the vault method. Impacts on cultural resources would need to be considered for the soil extraction locations. The NHPA Section 106 process would be followed for all locations. Potential impacts on cultural resources from the operation of a vault facility could be comparable to those expected from the borehole and trench methods. While the actual footprint of a vault facility would be smaller, the amount of land disturbed for the vault cover could mean that the land requirements for the vault method might exceed those for the borehole method.

7.2.11 Waste Management

The construction of the land disposal facilities would generate small quantities of waste in the form of hazardous and nonhazardous solids and hazardous and nonhazardous liquids. Nonhazardous wastes include sanitary waste. Waste generated from operation would include small quantities of solid LLRW (e.g., spent HEPA filters) and nonhazardous solid waste (including recyclable waste). These waste types would either be disposed of on-site or sent off-site for disposal. No impacts on waste management programs at the INL Site are expected from the waste that could be generated from the construction and operation of the land disposal methods. Section 5.3.11 provides a summary of the waste handling programs at the INL Site for the waste types generated.

7.3 SUMMARY OF POTENTIAL ENVIRONMENTAL CONSEQUENCES AND HUMAN HEALTH IMPACTS

The potential environmental consequences from the disposal of GTCC LLRW and GTCC-like waste under Alternatives 3 and 4 are summarized by resource area as follows:

***Air quality*.** Potential impacts from construction and operations of a disposal facility at the INL Site on the ambient air quality would be negligible or minor, at most. The highest emissions associated with the vault method would be about 0.42% of the five-county emissions total for SO_2. O_3 levels in the five counties encompassing the INL Site are currently in attainment; O_3 precursor emissions from construction and operational activities would be relatively small, less than 0.30% and 0.02% of NO_x and VOC emissions, respectively, and much lower than those for the regional airshed. During construction and operations, maximum CO_2 emissions would about 0.00001% of global emissions (negligible). All construction and operation activities would occur at least 11 km (7 mi) from the site boundary and would not contribute much to concentrations at the boundary or at the nearest residence. Fugitive dust emissions during construction and operations would be controlled by best management practices.

***Noise*.** The highest composite noise level during construction would be about 92 dBA at 15 m (50 ft) from the source. Noise levels at 690 m (2,300 ft) from the source would be below the EPA guideline of 55 dBA as L_{dn}. This distance would be well within the INL Site boundary, and there are no residences within this distance. Noise generated during operations would be less than noise during the construction phase. No impacts from ground-borne vibration are anticipated because the generating equipment would not be high-vibration equipment and because there are no residences or vibration-sensitive buildings nearby.

***Geology*.** During the construction phase, the borehole facility footprint would result in the greatest impact in terms of the amount of land disturbed (44 ha or 110 ac). It also would result in the greatest degree of disturbance, with disturbance reaching a depth of 40 m (130 ft) as a result of boreholes completed in unconsolidated material interlayered with basalt. No adverse impacts from the extraction or use of geologic and soil resources are expected. No significant changes in surface topography or natural drainages would occur. The potential for erosion would be reduced by low precipitation rates and further reduced by best management practices.

Water resources. Construction of a vault facility would have the highest water requirement. Water demands for construction at the INL Site would be met by using groundwater from on-site wells completed in the Snake River Plain aquifer. No surface water would be used at the site during construction; therefore, no direct impacts on surface water are expected. Indirect impacts on surface water would be reduced by implementing good industry practices and mitigation measures. Construction and operations of the proposed GTCC LLRW and GTCC-like waste disposal facility would increase the annual water use at the INL Site by a maximum of about 0.08% and 0.13%, respectively (both from the vault method). Since these increases are well within the INL Site's water right and would not significantly lower the water table or change the direction of groundwater flow, impacts due to groundwater withdrawals are expected to be negligible. There would be no water demands during the post-closure period. Groundwater could become contaminated with some highly soluble radionuclides during the post-closure period; indirect impacts on surface water could result from aquifer discharges to springs and rivers.

***Human health*.** The impacts on workers from operations would mainly be those associated with the radiation doses resulting from handling of the wastes. The annual radiation doses would be 2.6 person-rem/yr for the borehole method, 4.6 person-rem/yr for the trench method, and 5.2 person-rem/yr for the vault method. The worker doses would result in less than one LCF (see Section 5.3.4.1.1). The maximum dose to any individual worker would not exceed the DOE administrative control level of 2 rem/yr for site operations. It is expected that the maximum dose to any individual worker over the entire project would not exceed a few rem. The worker impacts from accidents would be associated with the physical injuries and possible fatalities that could result from construction and waste handling activities. It is estimated that the annual number of lost workdays due to injuries and illnesses during disposal operations would range from 1 (for use of boreholes) to 2 (for the trench and vault methods) and that no fatalities would occur from construction and waste handling accidents (see Section 5.3.4.2.2). These injuries would not be associated with the radioactive nature of the wastes but would simply be those expected to occur during any construction project of this size.

With regard to the general public, no measurable doses are expected to occur during waste disposal at the site, given the solid nature of the wastes and the distance of waste handling activities from potentially affected individuals. It is estimated that the highest dose to an individual from an accident involving the waste packages prior to disposal (from a fire affecting an SWB) would be 11 rem and would not result in any LCFs. The collective dose to the affected population from such an event would be 13 person-rem. It is estimated that the peak annual dose in the first 10,000 years after closure of the disposal facility to a hypothetical nearby receptor (resident farmer) who resided 100 m (330 ft) from the disposal site would be 2,300 mrem/yr for the vault method. This dose would result mainly from the GTCC-like Other Waste - RH and would occur about 220 years in the future. The peak annual doses for the borehole and trench methods within the first 10,000 years after closure are somewhat lower: 820 mrem/yr and 2,100 mrem/yr, respectively. These doses would occur 9,200 years in the future for the borehole method and 190 years for the trench method. These times represent the length of time after failure of the engineered barriers (including the cover), which is assumed to begin 500 years after closure of the disposal facility.

***Ecology*.** Although the loss of sagebrush habitat, followed by eventual establishment of low-growth vegetation, would affect the species that depend on sagebrush (pygmy rabbit, greater sage-grouse, sage thrasher, loggerhead shrike, sage sparrow, and Brewer's sparrow), population-level impacts on these species are not expected. Reestablishment of sagebrush after closure could take a minimum of 10 to 20 years. There are no natural aquatic habitats or wetlands within the immediate vicinity of the GTCC reference location; however, depending on the amount of water in the retention pond and the length of the retention time, certain species (e.g., aquatic invertebrates, waterfowl, shorebirds, amphibians, and mammals) could become established. No federally or state listed or special-status species have been reported in the project area. However, the greater sage-grouse (candidate species for federal listing as threatened or endangered) and the pygmy rabbit (under review for federal listing) are common on the INL Site and could be expected to occur in the vicinity of the GTCC reference location.

***Socioeconomics*.** Impacts associated with construction and operations of the land disposal facilities would be small. Construction would create direct employment for up to 145 people (vault method) in the peak construction year and 197 indirect jobs (borehole method) in the ROI; the annual average employment growth rate would increase by less than 0.1 of a percentage point. The waste facility would produce up to $12.1 million in income in the peak construction year (vault method). Up to 64 people would in-migrate to the ROI as a result of employment on-site; in-migration would have only a marginal effect on population growth and require less than 0.5% of vacant housing in the peak year. Impacts from operating the facility would also be small, creating up to 51 direct jobs annually (vault method) and up to 50 additional indirect jobs (vault method) in the ROI. The disposal facility would produce up to $4.9 million in income annually during operations.

***Environmental justice*.** Health impacts on the general population within the 80-km (50-mi) assessment area during construction and operations would be negligible, and no impacts on minority and low-income populations as a result of the construction and operations of a GTCC LLRW and GTCC-like waste disposal facility are expected. If analyses that accounted for any unique exposure pathways (such as subsistence fish, vegetation, or wildlife consumption or well-water consumption) determined that health and environmental impacts would not be significant, then there would be no high and adverse impacts on minority and low-income populations. If impacts were found to be significant, disproportionality would be determined by comparing the proximity of high and adverse impacts to the location of low-income and minority populations.

Land use. The GTCC reference location is located within existing major complex areas and would not conflict with the area's land use designation. Land use on areas surrounding the INL Site would not be affected.

Transportation. Shipment of all waste to the INL Site by truck would result in about 12,600 shipments, with the total distance covered being 42 million km (26 million mi). For shipment of all waste by rail, 4,980 railcar shipments totaling 17 million km (11 million mi) of travel would be required. It is estimated that no LCFs would occur to the public or crew members for either mode of transportation, but one fatality from an accident could occur.

Cultural resources. There are no known cultural resources within the GTCC reference location, although prehistoric archeological sites and a substantial number of historic homestead sites could be located there. The borehole method has the greatest potential to affect cultural resources because of its 44-ha (110-ac) land requirement. It is expected that the majority of the impacts on cultural resources would occur during the construction phase. The amount of land needed to employ the borehole method is twice the amount needed to construct a vault or trench. Activities associated with operations and post-closure are expected to have a minimal impact on cultural resources since no new ground-disturbing activities would occur during these phases. Section 106 of the NHPA would be followed to determine the impact of disposal facility activities on significant cultural resources, as needed. Local tribes would be consulted to ensure that no traditional cultural properties were affected by the project.

Waste management. The wastes that could be generated from the construction and operations of the land disposal methods (i.e., nonhazardous solid and liquid waste, hazardous solid and liquid waste, and small quantities of solid LLRW, such as spent HEPA filters) are not expected to affect the current waste management programs at the INL Site.

7.4 CUMULATIVE IMPACTS

Section 5.4 presents the methodology for the cumulative impacts analysis. In the analysis that follows, impacts of the proposed action are considered in combination with the impacts of past, present, and reasonably foreseeable future actions. This section begins with a description of reasonably foreseeable future actions at the INL Site, including those that are ongoing, under construction, or planned for future implementation. Past and present actions are generally accounted for in the affected environment section (Section 7.1).

7.4.1 Reasonably Foreseeable Future Actions

Reasonably foreseeable actions at the INL Site are summarized in the following sections. These actions were identified primarily from a review of the Idaho Department of Environmental Quality (IDEQ) and INL Site websites, as cited below. The actions listed are planned, under construction, or ongoing and may not be inclusive of all actions at the site. However, they should provide an adequate basis for determining potential cumulative impacts at the INL Site.

7.4.1.1 Idaho Nuclear Technology and Engineering Center

INTEC was established in the 1950s as a location for extracting reusable uranium from SNF. Until 1992, reprocessing efforts recovered more than $1 billion worth of highly enriched uranium (HEU). The highly radioactive liquid created in this process was turned into a solid through a process known as calcining. Calcining converted more than 30 million L (8 million gal) of liquid waste to a solid granular material that is now stored in bins awaiting a final disposal location outside Idaho. Past activities at INTEC also included the storage of SNF in water basins to cool it prior to reprocessing. Ongoing activities at INTEC include storage of SNF in a modern water basin and in dry storage facilities, management of high-level waste calcine and sodium-bearing liquid waste (some of which was shipped from the Hanford Site), and the operation of the INL Site CERCLA Disposal Facility, which includes a landfill, evaporation ponds, and a storage and treatment facility (IDEQ 2009a).

7.4.1.2 Advanced Mixed Waste Treatment Project

The Advanced Mixed Waste Treatment Project (AMWTP) was constructed by British Nuclear Fuel Limited to prepare TRU waste now buried or stored at the INL Site for permanent disposal at WIPP in New Mexico. Most of the waste processed at the AMWTP resulted from the manufacture of nuclear components at the Rocky Flats Plant in Colorado and was shipped to the INL Site in the 1970s and early 1980s. The waste contains industrial debris, such as rags, work clothing, machine parts, and tools, as well as soil and sludge, and it is contaminated with TRU elements (primarily plutonium). Most of the waste is mixed waste (i.e., it is contaminated with radioactive and nonradioactive hazardous chemicals, such as oil and solvents) (INL 2008a, IDEQ 2009b).

The retrieval enclosure houses about 53,300 m^3 (69,714 yd^3) of waste and occupies an area of about 2.8 ha [7 ac]). After the containers are characterized, they are sent either to the loading facilities for packaging and shipment or to the AMWTP treatment facility for further processing. Characterized waste containers that need further treatment before they can be shipped are sent to the treatment facility, where the waste can be reduced in size, sorted, and repackaged. Waste sent to the treatment facility is transported to different areas within the facility by an intricate system of conveyers, and all waste handling is done remotely. The treatment facility houses the supercompactor, which can compact a 208-L (55-gal) drum to roughly one-fifth of its original size. Approximately 70% of the waste to be processed is sent through the supercompactor to be reduced in size. Following treatment, waste containers go through two major steps at the two AMWTP loading areas: payload assembly and TRUPACT II loading. During payload assembly, waste is separated into payloads that are then individually loaded into TRUPACT II containers for certification and shipping (INL 2008a, IDEQ 2009b).

7.4.1.3 Radioisotope Power Systems Project

In the RPS Project, radioisotope power systems (RPSs) for space exploration and national security missions are developed. DOE is currently supporting RPS production, testing, and delivery operations for a national security mission and for the NASA Mars Science Laboratory mission. The INL Space and Security Power Systems Facility was dedicated in 2004 for the assembly, testing, and delivery of RPSs in support of space and defense programs. The Facility began operations in FY 2005 (DOE 2008b). The Facility is expected to grow considerably over the coming decade, from $18 million in 2005 to $70 million by 2015 (INL 2009).

7.4.1.4 Remote-Handled Waste Disposition Project

The Remote-Handled Waste Disposition Project would accept RH wastes stored at the INL Site that currently lack a treatment and disposition plan. The types of waste include TRU, mixed TRU, LLRW, mixed low-level waste, SNF, and unirradiated fuel. Primary waste streams are the 317 m^3 (11,200 ft^3) of RH waste stored at the Materials and Fuels Complex and the RWMC. Under this project, the wastes would be moved to INTEC for characterization and treatment. Treated wastes would then be packaged and shipped for final disposal. Approximately 1,000 canisters would be processed over a 10-year period; the total project would span 16 years (Jines 2007). On April 3, 2008, DOE posted a "Request for Expression of Interest" for the RH waste processing capability at the INL Site (DOE 2008a).

7.4.1.5 AREVA Uranium Enrichment Plant

The French-based company, AREVA, is proposing to build the Eagle Rock Enrichment Facility in Bonneville County, about 32 km (20 mi) west of Idaho Falls, near the INL Site. The facility would use centrifuge technology to enrich uranium for use in manufacturing fuel for commercial nuclear power plants. AREVA has indicated its intention to submit a license application to the NRC by the end of December 2008 (NRC 2008). The project is expected to inject about $2 billion into Idaho's economy. AREVA plans to begin construction in 2011 and to have the plant operational by 2014 (Wheeler 2008).

7.4.1.6 Final Environmental Assessment for the Replacement Capability for Disposal of Remote-Handled Low-Level Radioactive Waste Generated at the Department of Energy's Idaho Site (RH LLW EA)

On December 21, 2011, DOE completed the RH LLW EA (INL 2011b) and determined that a Finding of No Significant Impact (FONSI) is appropriate. As described in the RH LLW EA, the preferred alternative is a combination of Alternative 1 (to develop on-site replacement disposal capability for RH LLW) and the No Action Alternative. As detailed in the RH LLW EA, development of replacement disposal capability for RH LLW will involve the construction and operation of a new disposal facility on the INL Site. Under the preferred alternative, Candidate Site 1, the preferred site, is located to the southwest of the ATR Complex (see Figure 2.5 of the RH LLW EA).

7.4.2 Cumulative Impacts from the GTCC Proposed Action at the INL Site

Potential impacts of the proposed action are considered in combination with the impacts of past, present, and reasonably foreseeable future actions. The impacts from Alternatives 3 to 5 at the INL Site are described in Section 7.2 and summarized in Section 7.3. These sections indicate that the potential impacts from the proposed action (construction and operation of a borehole, trench, or vault facility) would be small for all the resource areas evaluated. With the exception of potential post-closure long-term human health impacts, on the basis of the total impacts (including the reasonably foreseeable future actions summarized in Section 7.4.1), the incremental potential impacts from the GTCC proposed action are not expected to contribute substantially to cumulative impacts on the various resource areas evaluated for the INL Site. However, the estimated human health impacts from the GTCC proposed action could add an annual dose of up to 2,300 mrem/yr or result in an annual LCF risk of 1E-03 (under the vault disposal method) 220 years after closure of the disposal facility at the INL Site. This dose would be primarily from GTCC-like Other Waste - RH. The composite analysis for the RWMC low-level waste disposal facility at the INL Site estimated that a maximum dose of 48 mrem/yr would occur about 75,000 years after the institutional control period (INL 2008b).

To provide additional perspective, the data on the potential impacts given in this EIS were compared to values provided in the *Draft EIS for the Proposed Consolidation of Nuclear Operations Related to Production of Radioisotope Power Systems* (DOE 2005). For example, the maximum amount of land affected by the disposal of GTCC LLRW and GTCC-like waste would be about 44 ha (110 ac), compared to about 5,300 ha (13,000 ac) of total land use committed to various activities at the INL Site. The total amount of available land at the INL Site is about 230,000 ha (570,000 ac). The GTCC EIS socioeconomic evaluation indicates that about 51 additional (direct) jobs would be created by the operation of any of the facilities considered. This number is small relative to the 9,000 or so jobs estimated to be needed to carry out the various activities at the INL Site. For potential worker doses, the GTCC EIS estimate of about 5.2 person-rem/yr is lower than the estimate of 420 person-rem/yr as the total from various other activities at the INL Site.

Finally, follow-on NEPA evaluations and documents prepared to support any further considerations of siting a new borehole, trench, or vault disposal facility at the INL Site would provide more detailed analyses of site-specific issues, including cumulative impacts.

7.5 SETTLEMENT AGREEMENTS AND CONSENT ORDERS FOR THE INL SITE

A review of existing settlement agreements and consent orders for the INL Site was conducted to identify if any of them contained requirements that would be triggered by Alternatives 3 to 5 for this EIS. Table 7.5-1 lists those that were identified.

TABLE 7.5-1 INL Site Settlement Agreements and Consent Orders Relevant to the GTCC EIS Proposed Action

Settlement Agreement/ Consent Order	Date	Description	Rationale
Settlement Agreement: United States of America v. Philip E. Batt and Consent Order	10/16/95	Specifies that DOE shall ship TRU waste now located (as of October 16, 1995) at the INL Site to WIPP or some other such facility designated by DOE by a target date of December 31, 2015. Specifies timetables for the removal of SNF and high-level radioactive waste from the INL Site and for the shipments of SNF to the INL Site. Specifies that DOE will treat SNF, high-level radioactive waste, and TRU at the INL Site that require treatment so that they can ultimately be disposed of outside the state of Idaho. Specifies that any and all treatable waste shipped into Idaho for treatment at the Mixed Waste Treatment Facility shall be shipped outside Idaho for storage or disposal within 6 months after treatment.	Potential non-defense TRU waste at the INL Site is included in the inventory of GTCC-like waste analyzed in the GTCC EIS. Some of this INL Site TRU waste may be subject to the Settlement Agreement requirement for removal from the INL Site. The Agreement requires that treatable TRU waste received from off-site generators for treatment at the facility be shipped out of Idaho for storage or disposal within 6 months of treatment. (The GTCC EIS includes alternatives that would involve the disposal of TRU waste that was received from off-site generators at the INL Site.)
INEL Consent Order	6/1/95	Resolves RCRA Land Disposal Restriction (LDR) storage violations and approves a modified "INEL Site Treatment Plan." Establishes an enforceable framework by which DOE will meet RCRA LDRs for mixed waste to be generated or received in the future.	Potential RCRA hazardous constituents in waste are included in the inventory of GTCC-like waste analyzed in the GTCC EIS. Some potential shipments of this waste may be subject to specific provisions of the INL Site Treatment Plan.
Agreement-in-Principle (AIP) between the Western Shoshone-Bannock Tribes and the U.S. Department of Energy	12/3/2007	Promotes increased interaction, understanding, and cooperation on issues of mutual concern. DOE acknowledges its trust responsibility to the tribes and will strive to fulfill this responsibility through this AIP, DOE American Indian and Alaska Native Tribal Government policy, and other American Indian program initiatives.	This AIP dictates consultation with the Western Shoshone-Bannock tribes. DOE has initiated the consultation process for the GTCC EIS with the Western Shoshone-Bannock tribes.

TABLE 7.5-1 (Cont.)

Settlement Agreement/ Consent Order	Date	Description	Rationale
Environmental Oversight and Monitoring Agreement between the U.S. Department of Energy and the State of Idaho	10/12/2005	Goals of the Agreement are to: • Maintain an independent, impartial, and qualified State of Idaho INL Oversight Program to assess the potential impacts of present and future DOE activities in Idaho; • Assure the citizens of Idaho that all present and future DOE activities in Idaho are protective of the health and safety of Idahoans and the environment; and • Communicate the findings to the citizens of Idaho in a manner that gives them the opportunity to evaluate potential impacts of present and future DOE activities in Idaho.	The Agreement requires the assessment of the potential impacts from future DOE activities in Idaho. The GTCC EIS includes an assessment of potential future impacts from DOE activity in Idaho.

Source: DOE (2008a)

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8 LOS ALAMOS NATIONAL LABORATORY: AFFECTED ENVIRONMENT AND CONSEQUENCES OF ALTERNATIVES 3, 4, AND 5

This chapter provides an evaluation of the affected environment, environmental and human health consequences, and cumulative impacts from the disposal of GTCC LLRW and GTCC-like waste under Alternative 3 (in a new borehole disposal facility), Alternative 4 (in a new trench disposal facility), and Alternative 5 (in a new vault disposal facility) at LANL. Alternatives 3, 4, and 5 are described in Section 5.1. Environmental consequences that are common to the sites for which Alternatives 3, 4, and 5 are evaluated (including LANL) are discussed in Chapter 5 and not repeated in this chapter. Impact assessment methodologies used for this EIS are described in Appendix C. Federal and state statutes and regulations and DOE Orders relevant to LANL are discussed in Chapter 13 of this EIS. This chapter also includes tribal narrative text that reflects the views and perspectives of the Nambe Pueblo, Santa Clara Pueblo, Pueblo de San Ildefonso, and the Cochiti Pueblo.

The tribal text is included in text boxes in Section 8.1. Full narrative texts provided are in Appendix G. The perspectives and views presented are solely those of the tribes. When tribal neutral language is used (e.g., Indian People, Native People, Tribes) within the tribal text, it reflects the input from these tribes unless otherwise noted. DOE recognizes that American Indians have concerns about protecting traditions and spiritual integrity of the land in the LANL region, and that these concerns extend to the propriety of the Proposed Action. Presenting tribal views and perspectives in this EIS does not represent DOE's agreement with or endorsement of such views. Rather, DOE respects the unique and special relationship between American Indian tribal governments and the Government of the United States, as established by treaty, statute, legal precedent, and the U.S. Constitution. For this reason, DOE has presented tribal views and perspectives in this EIS to ensure full and fair consideration of tribal rights and concerns before making decisions or implementing programs that could affect tribes.

8.1 AFFECTED ENVIRONMENT

This section discusses the affected environment for the various resource areas evaluated for the GTCC reference location at LANL. In order to have enough acreage to evaluate for Alternatives 3 to 5, the GTCC reference location at LANL is composed of three undeveloped and relatively undisturbed areas within Technical Area 54 (TA-54) and TA-51, on Mesita del Buey: Zone 6, North Site, and North Site expanded (Figure 8.1-1). The reference location was selected primarily for evaluation purposes for this EIS. The actual location would be identified on the basis of follow-on evaluations if and when it is decided to locate a land disposal facility at LANL.

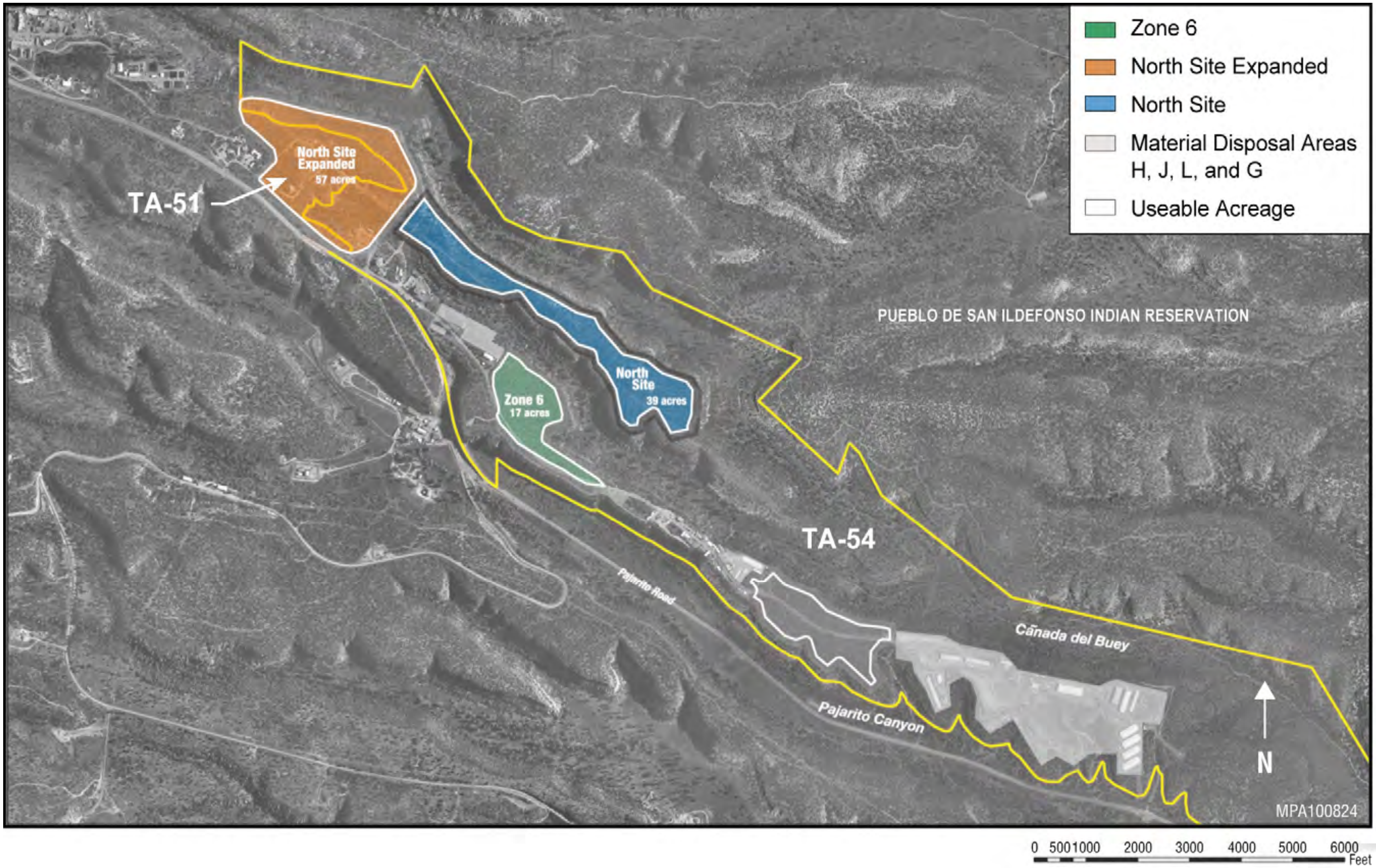


FIGURE 8.1-1 GTCC Reference Locations at LANL: North Site, North Site Expanded, and Zone 6

8.1.1 Climate, Air Quality, and Noise

8.1.1.1 Climate

The LANL site has a temperate, semiarid mountain climate with four distinct seasons (Bowen 1992). Winters are generally mild, with occasional winter storms. Spring tends to be windy and dry, and summer begins with warm, often dry, conditions, followed by a two-month rainy season. Fall has typically drier, cooler, and calmer weather. Because of the complex topography around the site (e.g., 300-m [1,000-ft] elevation changes), there are large differences in locally observed temperature and precipitation.

The complex topography of the LANL site influences local wind patterns, notably in the absence of large-scale disturbances. Surface winds often vary dramatically with time of day, location, and elevation (Bowen 1992). Daytime winds at the four Pajarito Plateau meteorological towers are predominantly from the south, consistent with the typical upslope flow of heated daytime air moving up the Rio Grande Valley, as shown in the wind roses in Figure 8.1.1-1 (LANL 2007). On the other hand, nighttime winds are lighter and more variable than daytime winds from the west. This condition results from a combination of the prevailing westerly winds and the downslope flow of cooled mountain air. Winds atop Pajarito Mountain, which are much faster than those over the Pajarito Plateau, are more representative of upper-level flows, reflecting the prevailing westerly winds in the area. In general, winds at LANL are light, averaging about 2.8 m/s (6.3 mph) in a year, and prevailing directions are from the south during the day and west-northwest at night (Bowen 1992). Wind speeds are the fastest in spring, slower in summer and fall, and the slowest in winter.

For the 1910–2010 period, the annual average temperature at the LANL site was 8.9°C (48.0°F) (WRCC 2010). January is the coldest month, averaging –1.8°C (28.7°F) and ranging from –7.7 to 4.1°C (18.1 to 39.3°F), and July is the warmest month, averaging 20.0°C (68.0°F) and ranging from 12.8 to 27.1°C (55.1 to 80.8°F). During the years 1910–2010, the highest temperatures reached 35.0°C (95°F), and the lowest reached –27.8°C (–18°F). Daily temperature ranges are large (as high as 14°C [57°F]) at Los Alamos, because of the thin, dry air and frequent clear skies (about three-quarters of the time), which allow strong solar heating during the day and rapid radiative cooling at night (Bowen 1992). Unlike other DOE facilities, LANL is located on high ground: 2,250 m (7,380 ft) above sea level. Atmospheric pressure averages 776 mbar (22.9 in. of Hg), which is about 76% of standard sea-level pressure.

For the 1910–2010 period, annual precipitation at the LANL site averages about 47 cm (18 in.) (WRCC 2010). Winter is the driest season and summer is the wettest; about 36% of the annual precipitation falls from convective storms during July and August (Bowen 1992). Because of the eastward slope of the terrain, there is a large east-to-west gradient in precipitation across the plateau. For example, in a year, White Rock often receives 13 cm (5 in.) less precipitation, and the eastern flanks of the Jemez Mountains often receive 13 cm (5 in.) more. Snow typically occurs from September through May, peaking in December through March. The annual average snowfall in the area is about 134 cm (53 in.) but is quite variable from year to year (WRCC 2010). The highest recorded snowfall for one season was 389 cm (153 in.), and the

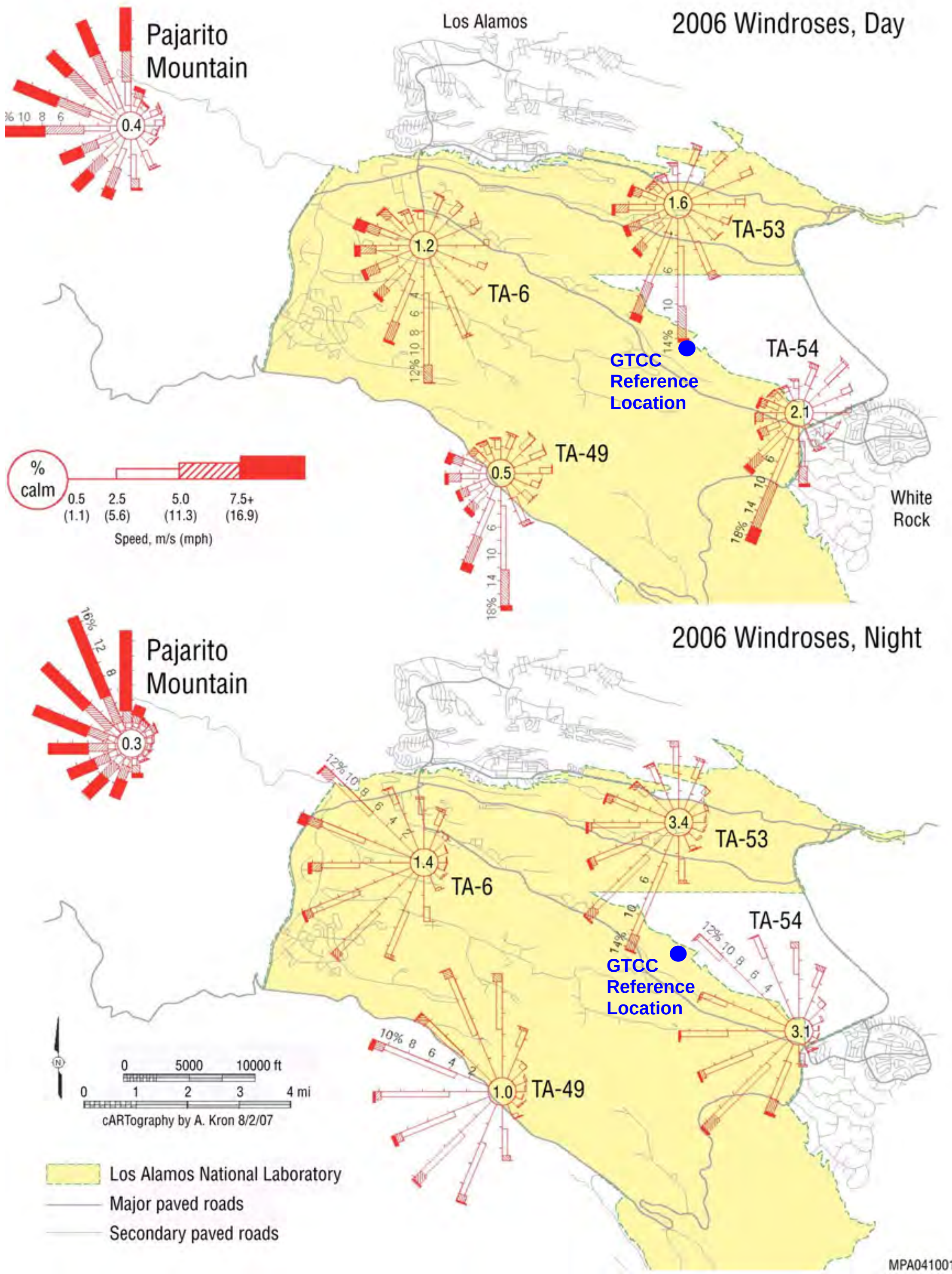


FIGURE 8.1.1-1 Daytime and Nighttime Wind Roses at and around the LANL Site in 2006 (Source: LANL 2007)

maximum daily snowfall was 56 cm (22 in.). Large snowfalls may occur locally as a result of orographic lifting of the storms by the high terrain.

Thunderstorms are common at the LANL site, with 61 occurring in an average year (Bowen 1992). Most thunderstorms occur during July and August. The combination of moist air from the Gulf of Mexico and the Pacific Ocean, strong sunshine, and warm surface temperatures promote the formation of afternoon and evening thunderstorms, especially over the Jemez Mountains. The thunderstorms yield short, heavy downpours and an abundance of lightning.

Tornadoes in the area surrounding the LANL site are much less frequent and destructive than those in the tornado alley in the central United States. For the period 1950–2008, 512 tornadoes were reported in New Mexico, with an average of 8.8 tornadoes per year. Most tornadoes occurred at lower elevations in eastern New Mexico next to Texas (NCDC 2008). Historically, no tornadoes have ever been reported in Los Alamos County. For the period 1950–2008, a total of 18 tornadoes with an average of 0.3 tornado per year were reported in Santa Fe County, which includes a portion of the LANL site. However, most tornadoes occurring in Santa Fe County were relatively weak (i.e., there were fourteen F0 and four F1 tornadoes on the Fujita scale). No deaths and no substantial property damage (in excess of $250,000) were associated with any of these tornadoes.

American Indian Text

The Pueblo people, having lived since the beginning of time in the region of the proposed GTCC waste disposal site, are concerned about meteorological climate shifts occurring over hundreds of years and longer term climate changes occurring over thousands of years. Such shifts impact vegetation. During dryer periods vegetation burns increase and post-burn erosion is accelerated. The Cerro Grande fire increased post-fire storms' runoff flows in some drainages more than 1,000 times the pre-fire levels. These higher runoff flows increased erosion and moved radioactive and hazardous materials downstream towards the Pueblo people.

During warmer periods, more intense rainfall episodes occur and less snow falls in winter, thus increasing erosion. Tree ring data document shifts in annual rainfall between 1523 and today, with a rainfall high in 1597 of 40 inches to a low in 1685 of 2.4 inches.

During the Holocene, major shifts occurred in this region, and the GTCC disposal is to be evaluated for a duration of 10,000 years. These climate shifts are both culturally important to the Pueblo people who conduct ceremonies to balance climate and pertinent to the consideration of GTCC proposal.

8.1.1.2 Existing Air Emissions

Pursuant to the federal CAAA and Title 20, Chapter 2, Part 70, "Operating Permits," of the *New Mexico Administrative Code* (20.2.70 NMAC), Los Alamos National Security LLC is authorized to operate applicable air emission sources at LANL per the terms and conditions as defined in Operating Permit No. P100–M1 (LANL 2007). Emission sources specified in the permit include multiple boilers, two steam plants, a data disintegrator, carpenter shops, three degreasers, and asphalt production. LANL also reports emissions from chemical use associated with R&D and permitted beryllium activities. In 2006, LANL demonstrated full compliance with all other permit applicable terms and conditions and met all reporting requirement deadlines, except for an excess emission at the Asphalt Plant, which slightly exceeded the smoke opacity limit.

Annual emissions for major facility sources and total point and area sources for year 2002 for criteria pollutants and VOCs in Los Alamos and Santa Fe Counties, New Mexico, which encompass the LANL site, are presented in Table 8.1.1-1 (EPA 2009). Area sources consist of nonpoint and mobile sources. Data for 2002 are the most recent data available on the EPA website. There are few major point sources in the area; LANL is one of the major sources in Los Alamos County. Area sources account for most of the emissions of criteria pollutants and VOCs.

TABLE 8.1.1-1 Annual Emissions of Criteria Pollutants and Volatile Organic Compounds from Selected Major Facilities and Total Point and Area Source Emissions in Los Alamos and Santa Fe Counties Encompassing the LANL Site[a]

	Emission Rate (tons/yr)					
Emission Category	SO_2	NO_x	CO	VOCs	PM_{10}	$PM_{2.5}$
Los Alamos County						
Los Alamos National Laboratory[b]	*1.3*	*65*	*28*	*40*	*10*	*9.6*
	2.2%[c]	*12%*	*0.82%*	*8.0%*	*0.47%*	*3.4%*
	0.31%	*0.90%*	*0.04%*	*0.47%*	*0.02%*	*0.15%*
Point sources	1.3	65	28	40	10	9.6
Area sources	60	480	3,400	460	2,200	280
Total	61	540	3,400	500	2,200	290
Santa Fe County						
Point sources	0.0	54	72	33	40	27
Area sources	370	6,600	62,000	7,900	53,000	6,000
Total	370	6,700	62,000	7,900	53,000	6,000
Two-county total	430	7,200	65,000	8,400	55,000	6,300

[a] Emission data for selected major facilities and total point and area sources are for year 2002. CO = carbon monoxide, NO_x = nitrogen oxides, $PM_{2.5}$ = particulate matter ≤ 2.5 μm, PM_{10} = particulate matter ≤ 10 μm, SO_2 = sulfur dioxide, VOCs = volatile organic compounds. Values have been rounded to two significant figures. Totals may not add up because of the independent rounding of values within the table. Traffic at LANL is the primary contributor to air quality impacts at the site.

[b] Data in italics are not added to yield total.

[c] The top row and bottom row with % signs show emissions as percentages of Los Alamos County and two-county total emissions, respectively.

Source: EPA (2009)

On-road sources are major contributors to the total emissions of SO_2, NO_x, CO, and VOCs; miscellaneous sources are major contributors to emissions of PM_{10} and $PM_{2.5}$. Nonradiological emissions associated with activities at the LANL site are 12% or less of those in Los Alamos County and 1% or less of those in the two counties combined, as shown in the table.

Under the Title V Operating Permit program, LANL is classified as a major source on the basis of its potential to emit NO_x, CO, and VOCs (LANL 2007). In 2006, the TA-3 steam plant and boilers located across the LANL site were the major contributors of NO_x, CO, and PM. R&D activities were responsible for most of the VOCs and hazardous air pollutant emissions. Stationary standby generators are major contributors to sulfur oxides (SO_x) emissions. Table 8.1.1-2 presents a five-year (2002–2006) history of criteria pollutant and VOC emissions for emissions inventory reporting to the NMED. Emissions for 2005 and 2006 were very similar and remained relatively constant following the sharp decline in 2004 emissions from the higher emissions in 2002 and 2003. The sharp decline in 2004 may have resulted from air curtain destructors being taken out of service in October of 2003.

American Indian Text

Contaminated air emissions either from fugitive dust, violent storms, dust devils, emission stacks, bomb testing, burn pits, or from the Cerro Grande fire have spread to surrounding Pueblo lands and communities. A Santa Clara Pueblo wind monitor meteorological station recorded a wind of 70 miles per hour. Dust devils have been recorded by LANL at 73 miles per hour. Santa Clara, Pueblo de San Ildefonso, Pueblo de Cochiti, and Jemez perceive that they have received contaminated ash and air from the Cerro Grande fire, from more than 110 historic and active LANL emission stacks, and bomb testing detonations. Nambe, Pojoaque, and the surrounding Pueblos perceive that they too received contaminated ash from the Cerro Grande fire. The contaminations from these events exposed natural resource users ranging from hunters of animals to gatherers of clay for pots. Even normal Pueblo residents were exposed in many ways from farming to outdoor activities to everyday life.

The Pueblo de Cochiti is situated within Sandoval County, and emissions rates here were not compared in the GTCC to emission rates of LANL. The Pueblo de Cochiti is located south of LANL and adjacent to the PSD [Prevention of Significant Deterioration] Class I Bandelier National Monument. The Pueblo de Cochiti could thus be considered a PSD Class I area as well and all emissions pose a threat to this classification.

All the Accord Pueblos (Pueblo de San Ildefonso, Pueblo de Cochiti, Santa Clara, and Jemez Pueblo) are currently conducting independent studies of air emissions from LANL. These studies have been ongoing for about ten years. Some Pueblos have their findings evaluated by independent laboratories. These studies are monitoring tritium, plutonium, uranium, americium, and other radionuclides and metals. Some of the studies have documented contaminated air emissions on Pueblo lands.

TABLE 8.1.1-2 Annual Emissions of Criteria Pollutants and Volatile Organic Compounds at LANL during 2002–2006 for Emissions Inventory Reporting to the New Mexico Environment Department[a]

	Emission Rate (tons/yr)				
Year	SO_2	NO_x	CO	VOCs	PM
2002	1	65	28	40	15
2003	2	50	32	50	22
2004	0.3	25	17	10	3
2005	0.2	24.5	18	13	3.3
2006	0.4	24.5	18	14	4.4

[a] CO = carbon monoxide, NO_x = nitrogen oxides, PM = particulate matter, SO_2 = sulfur dioxide, VOCs = volatile organic compounds.

Source: LANL (2007)

8.1.1.3 Air Quality

Among criteria pollutants (SO_2, NO_2, CO, O_3, PM_{10} and $PM_{2.5}$, and lead), the New Mexico SAAQS are identical to the NAAQS for NO_2 (EPA 2008a; 20.2.3 NMAC), as shown in Table 8.1.1-3. The State of New Mexico has established more stringent standards for SO_2 and CO, but there are no standards for O_3, PM, and lead. In addition, the State has adopted standards for hydrogen sulfide (H_2S) and total reduced sulfur and has retained the standard for total suspended particulates (TSP), which used to be one of criteria pollutants but was replaced by PM_{10} in 1987.

The GTCC reference location within LANL is situated mostly in Los Alamos County, with a small section (northeast) being in Santa Fe County. These two counties that encompass LANL are designated as being in attainment for all criteria pollutants (40 CFR 81.332).

Currently, the Nonradiological Air Sampling Network (NonRadNet), which was implemented in 2001, conducts monitoring to (1) develop a database of typical background levels for selected nonradiological species in the communities nearest LANL and (2) measure LANL's potential contribution to nonradiological air pollution in the surrounding communities (LANL 2007). The program consists of six ambient PM (PM_{10} and $PM_{2.5}$) monitoring units at three locations, plus selected Ambient Air Monitoring Network (AIRNET) samples, which are analyzed for three nonradiological constituents: aluminum, calcium, and beryllium.

The highest concentration levels of all criteria pollutants except for O_3 and $PM_{2.5}$ around LANL are less than or equal to 60% of their respective standards in Table 8.1.1-3 (EPA 2009; LANL 2004–2006, 2007). The highest O_3 and $PM_{2.5}$ concentrations are 84% and 80% of their

TABLE 8.1.1-3 National Ambient Air Quality Standards (NAAQS) or New Mexico State Ambient Air Quality Standards (SAAQS) and Highest Background Levels Representative of the GTCC Reference Location at LANL, 2003–2007

			Highest Background Level	
Pollutant[a]	Averaging Time	NAAQS/ SAAQS[b]	Concentration[c,d]	Location (Year)
SO_2	1-hour	75 ppb	–[e]	–
	3-hour	0.5 ppm[d]	0.079 ppm (16%)	San Juan Co. (2003)[f]
	24-hour	0.10 ppm	0.013 ppm (13%)	San Juan Co. (2005)[f]
	Annual	0.02 ppm	0.003 ppm (15%)	San Juan Co. (2004)[f]
NO_2	1-hour	0.100 ppm	–	–
	24-hour	0.10 ppm	–	–
	Annual	0.053 ppm	0.019 ppm (38%)	Albuquerque, Bernalillo Co. (2004)[f]
CO	1-hour	13.1 ppm	3.0 ppm (23%)	Santa Fe, Santa Fe. Co. (2005)
	8-hour	8.7 ppm	1.9 ppm (22%)	Santa Fe, Santa Fe. Co. (2003)
O_3	1-hour	0.12 ppm[g]	0.070 ppm (58%)	Santa Fe, Santa Fe. Co. (2007)
	8-hour	0.075 ppm	0.063 ppm (84%)	Santa Fe, Santa Fe. Co. (2007)
TSP	24 hours	150 $\mu g/m^3$	–	–
	7 days	110 $\mu g/m^3$	–	–
	30 days	90 $\mu g/m^3$	–	–
	Annual geometric mean	60 $\mu g/m^3$	–	–
PM_{10}	24-hour	150 $\mu g/m^3$	90 $\mu g/m^3$ (60%)	White Rock, Los Alamos Co. (2003)
$PM_{2.5}$	24-hour	35 $\mu g/m^3$	28 $\mu g/m^3$ (80%)	Los Alamos, Los Alamos Co. (2003)
	Annual	15 $\mu g/m^3$	8.0 $\mu g/m^3$ (53%)	Los Alamos, Los Alamos Co. (2005)
Lead	Calendar quarter	1.5 $\mu g/m^3$[h]	0.03 $\mu g/m^3$ (2.0%)	Albuquerque, Bernalillo Co. (2004)[f]
	Rolling 3-month	0.15 $\mu g/m^3$	–	–
H_2S	1 hour	0.010 ppm	–	–
Total reduced sulfur	1/2 hour	0.003 ppm	–	–

a CO = carbon monoxide, H_2S = hydrogen sulfide, NO_2 = nitrogen dioxide, O_3 = ozone, $PM_{2.5}$ = particulate matter ≤2.5 μm, PM_{10} = particulate matter ≤10 μm, SO_2 = sulfur dioxide, TSP = total suspended particulates.

b The more stringent standard between the NAAQS and the SAAQS is listed when both are available.

c Monitored concentrations are the highest arithmetic mean for calendar-quarter lead; the highest for 24-hour PM_{10} and $PM_{2.5}$; second-highest for 3-hour and 24-hour SO_2, 1-hour and 8-hour CO, and 1-hour O_3; 4th-highest for 8-hour O_3; arithmetic mean for annual SO_2, NO_2, and $PM_{2.5}$.

d Values in parentheses are monitored concentrations as a percentage of SAAQS or NAAQS.

e A dash indicates that no measurement is available.

f These locations with the highest observed concentrations in the state of New Mexico are not representative of the LANL site but are presented to show that these pollutants are not a concern over the state of New Mexico.

g On June 15, 2005, the EPA revoked the 1-hour O_3 standard for all areas except the 8-hour O_3 nonattainment EAC areas (those do not yet have an effective date for their 8-hour designations). The 1-hour standard will be revoked for these areas 1 year after the effective date of their designation as attainment or nonattainment for the 8-hour O_3 standard.

Footnotes continue on next page.

TABLE 8.1.1-3 (Cont.)

[h] Used old standard because no data in the new standard format are available.

Emission data for selected major facilities and total point and area sources are for year 2002. CO = carbon monoxide, NO_x = nitrogen oxides, $PM_{2.5}$ = particulate matter ≤ 2.5 μm, PM_{10} = particulate matter ≤ 10 μm, SO_2 = sulfur dioxide, VOCs = volatile organic compounds. Values have been rounded to two significant figures. Totals may not add up because of the independent rounding of values within the table. Traffic at LANL is the primary contributor to air quality impacts at the site.

Sources: EPA (2008a, 2009); LANL (2004–2006, 2007); 20.2.3 NMAC (refer to http://www.nmcpr.state.nm.us/nmac/parts/title20/20.002.0003.pdf)

standards, respectively. Overall, background concentration levels around the LANL site are below the standards for all criteria pollutants. Nearby urban or suburban measurements are typically used as being representative of background concentrations for LANL. Criteria pollutants are primarily the result of vehicular traffic of employees as part of the normal commuting to, from, and within the LANL site.

LANL and its vicinity are classified as PSD Class II areas. The nearest Class I area is Bandelier National Monument, about 5 km (3 mi) southwest of the GTCC reference location (40 CFR 81.421). Three more Class I areas are within 100 km (62 mi) of the GTCC reference location, including (in order of distance) the Pecos, San Pedro Parks, and Wheeler Peak Wilderness Areas. Currently, there are no facilities operating at LANL that are subject to PSD regulations.

8.1.1.4 Existing Noise Environment

Noise, air blasts (also known as air pressure waves or over pressures), and ground vibrations are intermittent aspects of the LANL site environment (DOE 1999a).

Although the State of New Mexico has established no quantitative noise-level regulations, Los Alamos County has promulgated a local noise ordinance that establishes noise level limits for residential land uses. Noise levels that affect residential receptors are limited to a maximum of 65 dBA during daytime hours and 53 dBA during nighttime hours (i.e., 9 p.m. to 7 a.m.). Between 7 a.m. and 9 p.m., the permissible noise level can be increased to 75 dBA in residential areas, provided that the noise is limited to 10 minutes in any one hour. Activities that do not meet the noise ordinance limits require a permit (DOE 1999a).

Noise levels around the LANL site are combined effects from LANL-related activities and activities unrelated to LANL. LANL-related noise sources include the movement of vehicles to and from LANL, activities at technical areas, aboveground testing of high explosives, and security guards' firearms practice sessions (DOE 1999a). Noise sources within Los Alamos County unrelated to LANL include predominantly traffic movements and, to a much lesser degree, other residential-, commercial-, and industrial-related activities within Los Alamos and White Rock communities. Detailed noise and vibration sources at LANL and noise measurements are presented in the 1999 LANL SWEIS (DOE 1999a). The 2008 SWEIS (DOE 2008c) also refers to the data in the 1999 SWEIS.

Currently, data on the levels of routine background noise, air blasts, and ground vibrations generated by LANL operations (including explosives detonations) are limited (DOE 1999a). Measurements of nonspecific background ambient noise in the LANL area have been taken at a couple of locations near LANL boundaries next to public roadways. Background noise levels ranged from 31 to 35 dBA at the vicinity of the entrance to Bandelier National Monument and New Mexico State Road (SR) 4. At White Rock, background noise levels ranged from 38 to 51 dBA; this is slightly higher than the level found near Bandelier National Monument, probably because of the higher levels of traffic and the presence of a residential neighborhood as well as the different physical setting. These noise levels are typical of rural or quiet suburban residential areas (Eldred 1982).

For the general area surrounding the LANL site, the countywide L_{dn} (based on population density) is estimated to be 40 dBA for Santa Fe County and 44 dBA for Los Alamos County — typical of rural areas (Miller 2002; Eldred 1982).

American Indian Text

The Sacred Area is currently monitored for noise by Pueblo de San Ildefonso. Noise, which from a Pueblo perspective is an unnatural sound, does disturb ceremony and the place itself. Currently non-Indian voices, machinery, and processing equipment have been recorded by Pueblo de San Ildefonso monitors as coming from Area G to the Sacred Area.

8.1.2 Geology and Soils

8.1.2.1 Geology

8.1.2.1.1 Physiography. LANL is located on the Pajarito Plateau, within the Rio Grande rift zone, in the Southern Rocky Mountain physiographic province (and immediately adjacent to the eastern edge of the Colorado Plateau), in north-central New Mexico. The east-sloping Pajarito Plateau is composed predominantly of volcanic material (tuffs) and covers an area of about 620 km^2 (240 mi^2). LANL is situated on about 93 km^2 (36 mi^2 or 23,040 ac) in its central part. The plateau overlies the western portion of the Española Basin, extending to the southeast from the Sierra de los Valles on the eastern rim of the Jemez Mountains to White Rock Canyon and the Española Valley (Figure 8.1.2-1). The plateau was formed by the deposition of volcanic ash from calderas in the central part of the Jemez Mountains. Surface water flow across the Pajarito Plateau has created a mesa and canyon landscape. Its surface is deeply dissected, consisting of narrow, flat mesas separated by deep, narrow, east- to southeast-trending canyons. The canyon bottoms are covered with a thin layer of alluvium; mesa tops show little soil formation. Drainage is by ephemeral and intermittent streams that discharge to the Rio Grande, which lies just to the east of the plateau (Purtymun 1995; Broxton and Vaniman 2005; DOE 2008c).

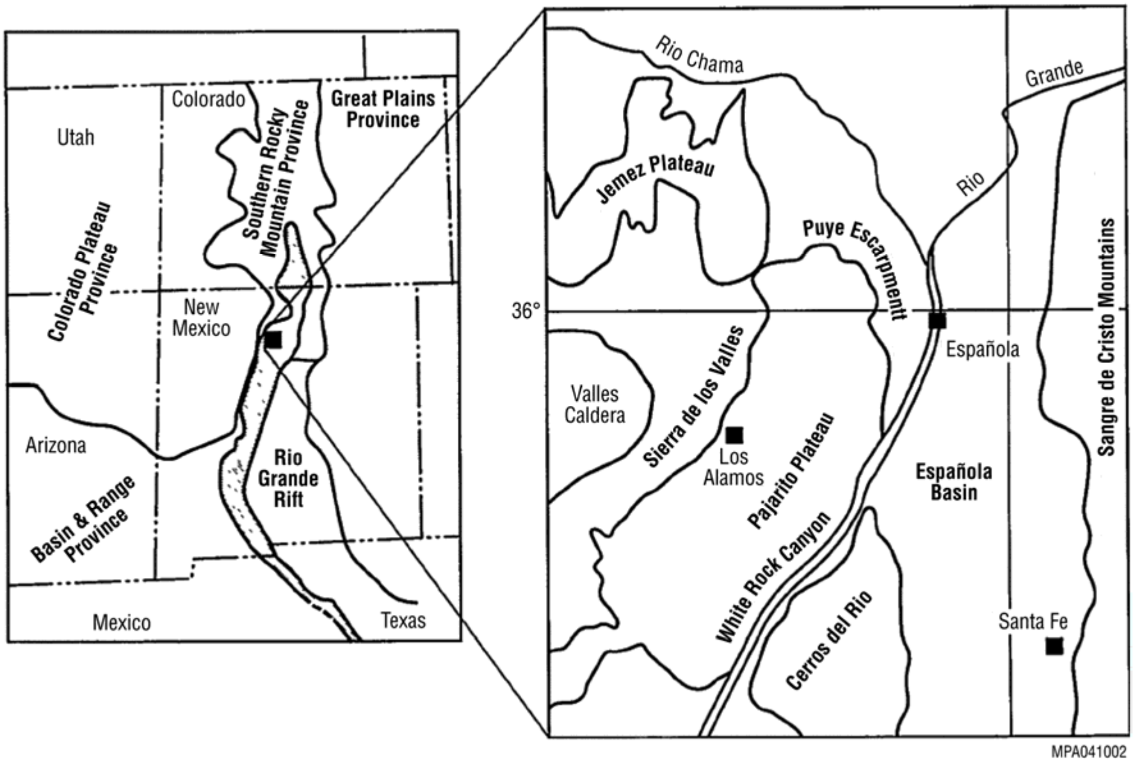
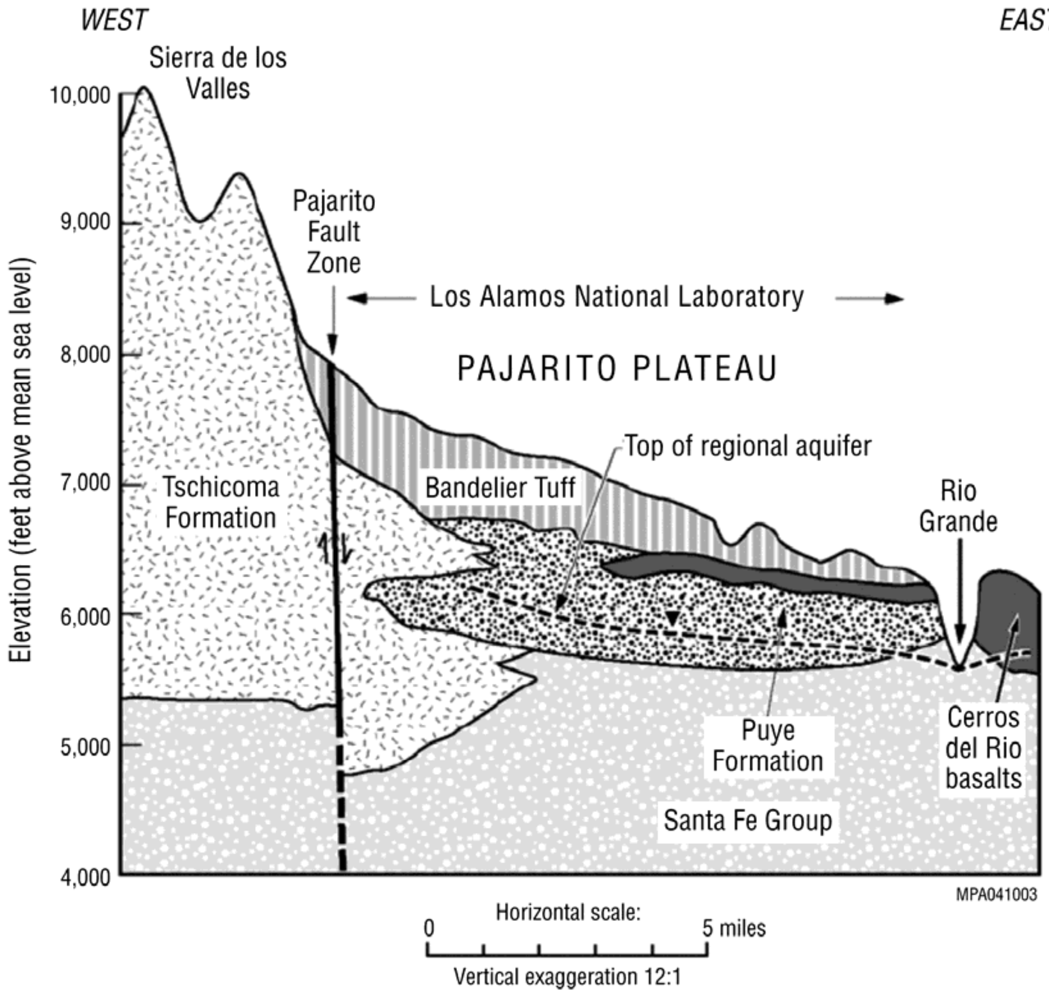


FIGURE 8.1.2-1 Location of LANL in the Southern Rocky Mountain Physiographic Province (Source: Purtymun 1995)

8.1.2.1.2 Topography. The maximum elevation in the Sierra de los Valles is 3,505 m (11,500 ft) MSL. The Pajarito Plateau forms an apron 13- to 26-km (8- to 16-mi) wide and 48- to 64-km (30- to 40-mi) long around the eastern flanks of the Sierra de los Valles (Purtymun 1995). Elevations on the plateau range from 2,377 m (7,800 ft) MSL on the slopes of the Sierra de los Valles to 1,900 m (6,200 ft) MSL along the eastern edge, where it terminates at the Puye Escarpment and White Rock Canyon (Figure 8.1.2-1). The mesa top elevation at TA-54 is about 1,768 m (5,800 ft) MSL.

Running along the east side of the plateau, the Rio Grande drops from an elevation of about 1,676 m (5,500 ft) MSL to about 1,634 m (5,360 ft) MSL as it flows from Los Alamos Canyon to Frijoles Canyon (Purtymun 1995; DOE 2008c).

8.1.2.1.3 Site Geology and Stratigraphy. The Pajarito Plateau consists of a complex sequence of rocks of volcanic and fluvial origins that together form a vertical intergradation of wedge-shaped strata (Figure 8.1.2-2). Volcanic units consist of volcaniclastics and volcaniclastic-derived sediments from the Jemez Mountain volcanic field to the west. Fluvial deposits are associated with alluvial fan development from Precambrian basement rock in the highlands to the north and east of the site (DOE 2008c).



Notes:
1. The thickness of geologic units has been exaggerated on this figure to illustrate unit relationships and topography.
2. Offset of the Tschicoma formation on the Pajarito Fault zone is schematic due to the variation along the trace of the fault.
3. To convert feet to meters, multiply by 0.3048.

Source: LANL 2005j.

FIGURE 8.1.2-2 Generalized Cross Section of Pajarito Plateau (Source: DOE 2008c)

The GTCC reference locations are situated on the northwest end of TA-54. TA-54 is an elongated area with a northwest-southeast trend that sits on the narrow part of Mesita del Buey (Figure 8.1-1). It is bounded to the south by Pajarito Canyon and to the north by Cañada del Buey. The boundary between LANL and the Pueblo de San Ildefonso is on the far side of Cañada del Buey. The Bandelier Tuff makes up the majority of surface exposures and near surface rocks; it is composed of nonwelded to moderately welded rhyolitic ash-flow and ash-fall tuffs deposited during eruptions of the Valles caldera, about 18 km (11 mi) west of TA-54 (Krier et al. 1997).

The following summary of stratigraphy for Mesita del Buey is based on the work of Purtymun (1995), Krier et al. (1997), Reneau et al. (1998), Gardner et al. (1999), and Broxton and Vaniman (2005) and on material presented in the latest SWEIS (DOE 2008c). A generalized cross section of the plateau is shown in Figure 8.1.2-2. Figure 8.1.2-3 presents a stratigraphic column of the Pajarito Plateau.

Middle to Upper Tertiary (Oligocene to Miocene) Rocks.

Santa Fe Group. The Santa Fe Group encompasses the sediments of the Española Basin. It is subdivided into several formations (from oldest to youngest): the Tesuque Formation, the older fanglomerate deposits of the Jemez Mountain volcanic field, the Totavi Lentil, and the Puye Formation.

The Miocene Tesuque Formation is composed of fluvial deposits derived from Precambrian granite, pegmatite, sedimentary rocks from the Sangre de Cristo Range, and Tertiary volcanic rocks from northern New Mexico. Beds are typically greater than 3-m (10-ft) thick, massive to planar- and cross-bedded, light pink to buff siltstone and sandstone, with minor lenses of pebbly conglomerate. There are no exposures of this formation within LANL site boundaries; however, exposures may be found on the eastern margins of the Pajarito Plateau and along the canyon walls to the north (e.g., Los Alamos Canyon).

Older fanglomerate deposits are widespread on the Pajarito Plateau. Deposits are composed of volcanic detritus and dark lithic sandstone with gravel and cobbles. The unit is up to 500-m (1,650-ft) thick and interfingers with the Tschicoma Formation.

The Totavi Lentil consists of poorly consolidated and well rounded sands, gravels, and cobbles deposited by the ancestral Rio Grande. The unit is highly variable in thickness (from 10 to 30 m [30 to 100 ft]) and rests conformably on top of the older fanglomerate deposits.

The Puye Formation is composed of large alluvial fans made up of volcanic material and alluvium; its source rocks are the domes and flows in the Sierra de los Valles. The formation has two facies: fanglomerate and lacustrine. The fanglomerate is an intertonguing mixture of stream flow, sheet flow, debris flow, block and ash fall, pumice fall, and ignimbrite deposits, up to 330-m (1,100-ft) thick. The lacustrine facies may be up to 9-m (30-ft) thick and include lake and river deposits in the upper part of the section, consisting of fine sand, silt, and clay. The Puye Formation is well exposed on the Pajarito Plateau and unconformably overlies the Santa Fe Group.

The total thickness of the Santa Fe Group is as much as 1,460 m (4,800 ft) in the eastern and northern part of the basin. Prebasin strata are exposed along the basin margins; they include Upper Paleozoic (Mississippian to Permian), Mesozoic marine, terrestrial sedimentary rocks, and Upper Tertiary Laramide synorogenic deposits.

Cerros del Rio Basalts. The thick, dense-fractured mafic lava flows and rubbly flow breccias of the Cerros del Rio Basalts underlie and interfinger with the sedimentary

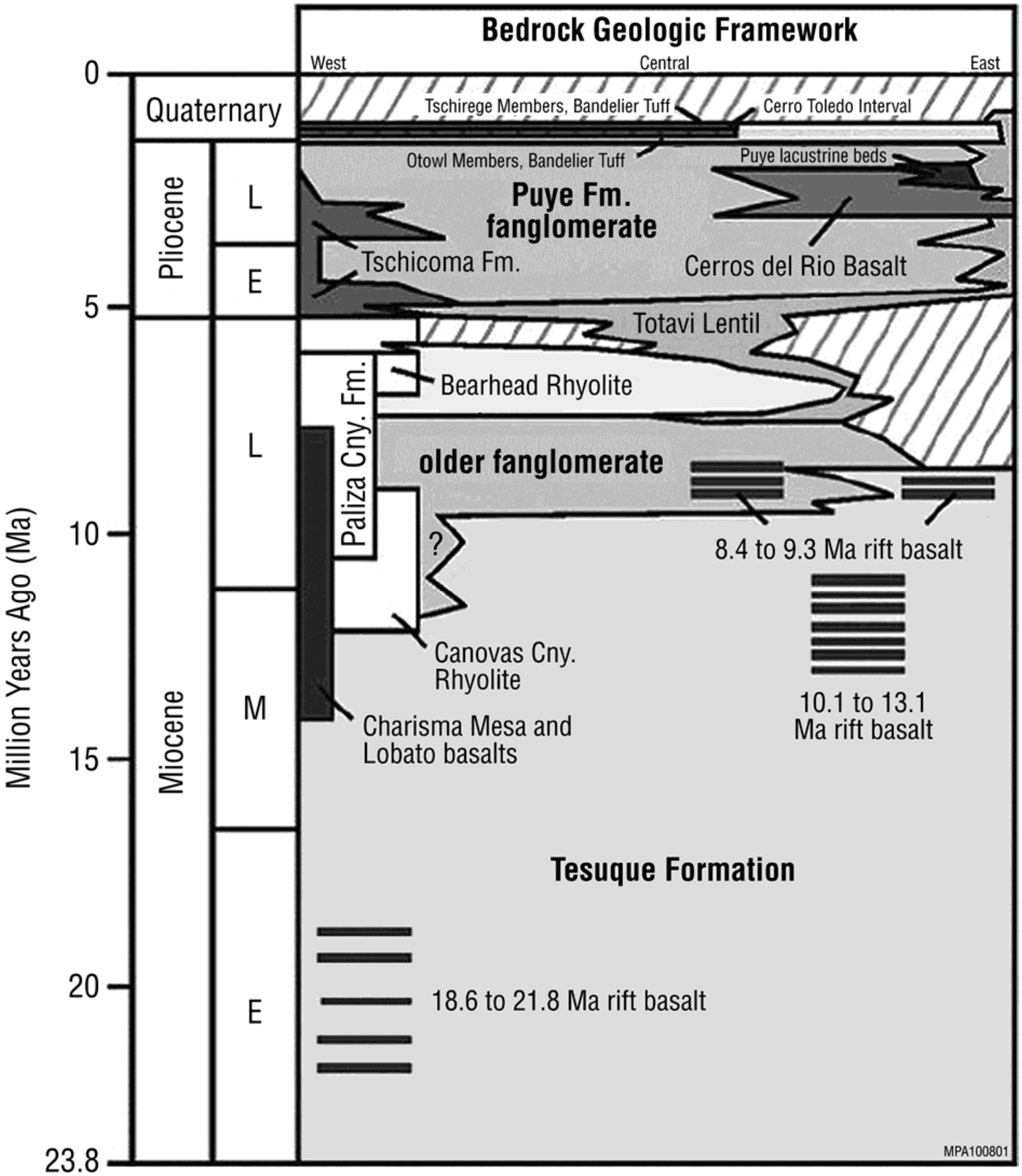


FIGURE 8.1.2-3 Stratigraphic Column for the Pajarito Plateau at LANL (Source: Modified from DOE 2008c)

conglomerates and fanglomerates of the Puye Formation (Figures 8.1.2-2 and 8.1.2-3). Their thicknesses beneath T-54 are unknown but are at least 82 m (269 ft) in places.

Tschicoma Formation. The Tschicoma Formation interfingers with the deposits of the Puye Formation. It consists of thick dacite and low-silica rhyolite lava flows erupted from the Sierra del los Valles. The unit has a thickness of up to 762 m (2,500 ft) in the Sierra del los Valles (Figure 8.1.2-1). Beneath the Pajarito Plateau surface, the formation is lenticular. It extends broadly across the plateau, thinning eastward.

Quaternary Deposits.

Bandelier Tuff. The Bandelier Tuff forms the upper surface of the Pajarito Plateau, lapping up onto the Tschicoma Formation along its western edge (Figure 8.1.2-2). The tuff is thickest to the west of LANL (near its source) and gets thinner as it goes eastward across the plateau. The upper two members of the Bandelier Tuff, the Tshirege Member (upper) and the Otowi Member (lower), are separated by an ash-fall/fluviatile sedimentary interval (referred to as the Cerro Toledo interval) (Figure 8.1.2-4). The lowest member, the Guaje Member, underlies the Cerro Toledo interval and rests conformably on rocks of the Puye Formation. All three members are present on Mesita del Buey.

The following discussion uses the nomenclature originally adopted by Baltz et al. (1963) to describe the stratigraphic units of the Bandelier Tuff (e.g., Units 1a, 1b, 2a, 2b, and 3) because investigators such as Krier et al. (1997) have used it, both for simplicity and to maintain continuity with previous investigations related to waste disposal and hydrologic issues in TA-54.

The Tshirege Member at Mesita del Buey consists of (from youngest to oldest) Units 2b, 2a, 1b, and 1a and the basal Tsankawi pumice bed. According to Krier et al. (1997), Units 2b through 1b crop out on the tops and sides of Mesita del Buey; units older than 1b have only been observed in borehole samples deeper than the base of the mesa. Unit 2b is the brittle and resistant caprock that forms the tops of mesas, including Mesita del Buey. It is about 12-m (40-ft) thick in the southeastern portion of TA-54 and is composed of crystal-rich devitrified pumice fragments in a matrix of ash, shards, and abundant phenocrysts. It is extensively fractured as a result of contraction due to cooling after deposition. Fractures are typically filled with smectite clays to a depth of about 3 to 4 m (10 to 13 ft), with opal and calcite below this depth. Opal and calcite deposition is associated with the presence of tree root molds; live tree roots have been observed at depths of up to 20 m (66 ft). The base of this unit is commonly marked by a thin interval (less than 10 cm or 4 in.) of crystal-rich material that is the size of fine-grained sand (called surge beds) that represents deposition from the basal surge associated with violent eruptions. The surge beds on Mesita del Buey have been displaced by small faults.

Unit 2a underlies Unit 2b; it consists of devitrified ash-fall and ash-flow tuff. The unit is about 14-m (46-ft) thick in the southeastern portion of TA-54 and is slightly welded at its base, becoming moderately welded further up the section. Some of the more prominent cooling

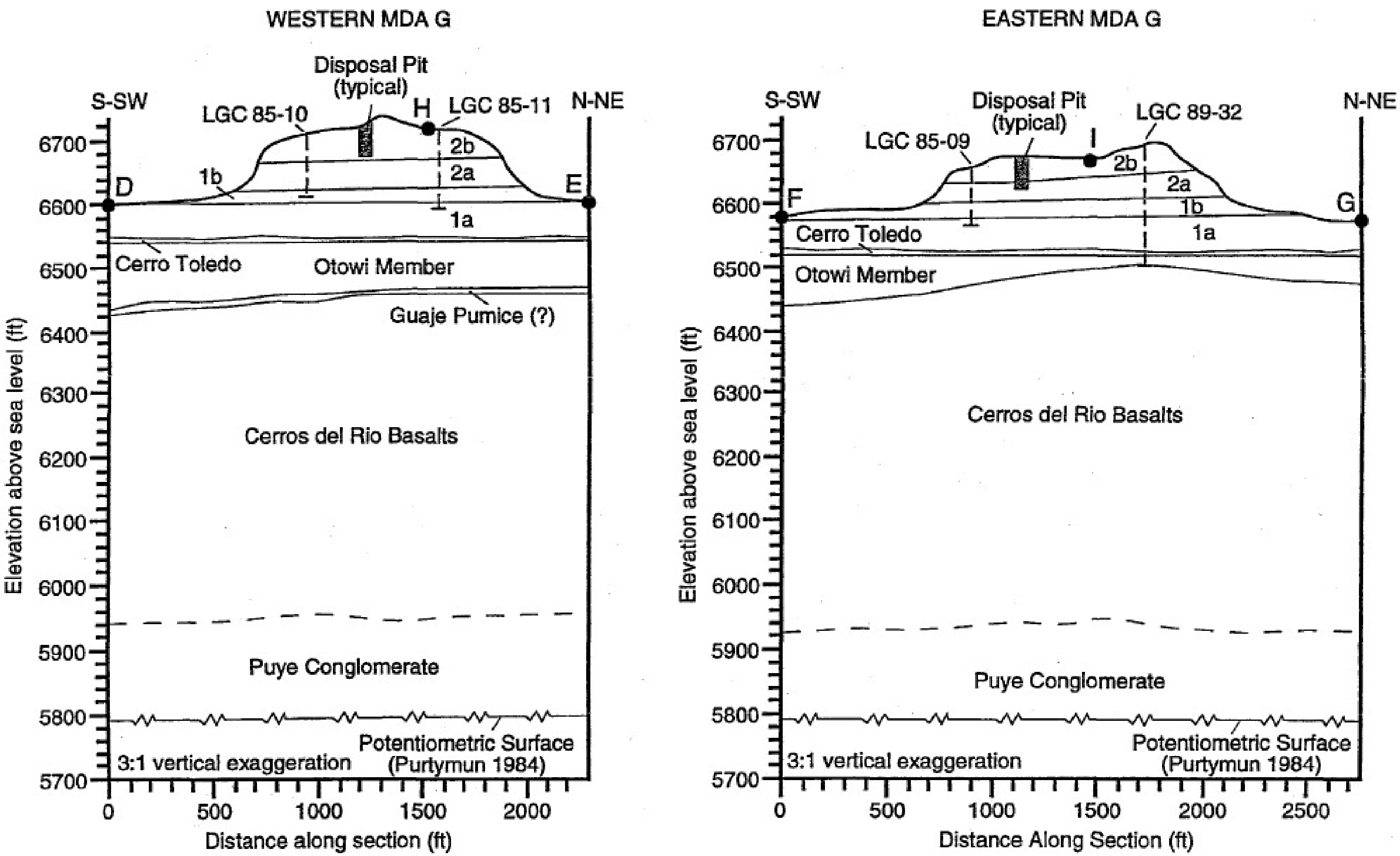


FIGURE 8.1.2-4 Stratigraphy of the Bandelier Tuff at Material Disposal Area G, to the Southeast of the GTCC Reference Location (Source: Krier et al. 1997)

fractures originating in Unit 2b extend down into Unit 2a. Attempts to retrieve core samples from this unit invariably result in unconsolidated material.

Unit 1b underlies Unit 2a; it is a slightly welded to welded, devitrified ash-flow tuff that becomes increasingly welded toward its center. It has a greater content of unwelded pumice lapilli than the overlying Unit 2b, and it exhibits little of its fracturing characteristics. Unit 1b ranges from 7- to 15-m (23- to 49-ft) thick in the southeastern portion of TA-54.

Unit 1a is the oldest unit of the Tshirege Member. It is a vitric, pumiceous, nonwelded ash-flow tuff with a thickness of up to 15 m (50 ft) in the southeastern portion of TA-54. Because of its weak matrix properties, this unit likely has few fractures.

The Tsankawi Pumice Bed is fairly thin (i.e., less than 0.30 m or 1 ft) at TA-54. It consists of a layer of gravel-sized, vitric, nonwelded pumice. The bed is extensive on the Pajarito Plateau and marks the base of the Tshirege Member. Underlying this basal unit is the Cerro Toledo interval, which is composed of sedimentary deposits, including tuffaceous sandstones, siltstones, and gravel and cobbles of mafic to intermediate lavas. It also contains deposits of ash and pumice. The Cerro Toledo interval has a thickness of about 5 m (16 ft) in the southeastern portion of TA-54; it typically gets thinner to the east across the Pajarito Plateau.

The Otowi Member at Mesita del Buey is a massive, nonwelded, pumiceous rhyolite tuff. It has a fine-grained ash matrix that contains an unsorted mix of phenocrysts (e.g., quartz and sanidine), glass shards, mafic minerals, and various rock fragments (e.g., latite, rhyolite, quartz latite, and pumice). The unit is about 30-m (100-ft) thick in the southeastern portion of TA-54 and typically gets thinner to the east. It rests conformably on the Guaje Member, the basal unit of the Bandelier Tuff. The Guaje Member is composed of nonwelded pumice fragments that are silicified and brittle. The bed is about 3.7-m (12-ft) thick.

Mesa Top Alluvium. Silts, sands, gravels, soils, and reworked pyroclastic deposits overlie the Bandelier Tuff in many mesa-top localities, including Mesita del Buey. These deposits generally sit on the erosional surface that cuts the upper units of the Tshirege Formation. Alluvial gravels, deposited by a fluvial system that predates the incision of canyons on the Pajarito Plateau, contain abundant pumice and dacite clasts. The age of these deposits has been estimated to be several hundred thousand years old.

Canyon Alluvium. Canyon alluvium is derived from the weathering and erosion of rocks from the Sierra de los Valles and the Pajarito Plateau. The thickness of the alluvium varies but is typically less than 6 m (20 ft) and increases as it goes eastward. Alluvial deposits are composed of unconsolidated silty to coarse sands of quartz and sanidine (feldspar), crystal fragments, and fragments of pumice. Occasional fragments of latite or latite-composition lava and welded tuff are also present.

8.1.2.1.4 Seismicity. LANL is located in the Española Basin within the Rio Grande rift zone. The Rio Grande rift is a north-trending, active tectonic feature that extends from central Colorado to northern Mexico (Figure 8.1.2-5). Basins in the rift zone are bounded by normal faulting that occurs along the rift zone margins and within the basins. The Española Basin is a west-tilting half-graben bounded on the west edge by north-trending normal faults of the Pajarito fault zone, bounded on the north by northeast-trending transverse faults of the Embudo fault zone, and bounded on the south by northwest-trending transverse faults of the Bajada fault zone (LANL 2007; Broxton and Vaniman 2005; Gardner et al. 1999).

The seismicity of north central New Mexico is concentrated along the rift structures within the Rio Grande rift — stretching from Socorro to Albuquerque — and tends to be shallow (i.e., less than 20 km [12 mi]). It is absent in areas of high heat flow, as in the calderas in the Jemez Mountains, because of the increased ductility of rocks; this situation reduces the likelihood of brittle fracture and faulting even at shallow depths (Cash and Wolff 1984).

The main strand of the Pajarito fault system, a major structural element of the Rio Grande rift, lies along the western boundary of LANL (Figures 8.1.2-5 and 8.1.2-6). The fault system is a north-northeast trending series of en echelon faults; it consists of the Pajarito fault zone and the related Guaje Mountain and Rendija Canyon faults (Figure 8.1.2-6). Activity along the fault system has been recurrent, with abundant evidence at the surface showing that Quaternary vertical displacement has taken place (e.g., stream gradient discontinuities and topographic scarps of up to 125 m [410 ft] in the Bandelier Tuff). Horizontal movement is also evident, particularly along the segment north of LANL. For these reasons, the fault system is considered capable[1] and has the potential to generate earthquakes in the region (Dransfield and Gardner 1985; Gardner and House 1987; Wachs et al. 1988; Wong 1990). It is considered to be the primary source of seismic risk at LANL (LANL 2007; DOE 2008c).

As many as 37 faults with vertical displacements of 5 to 65 cm (0.5 to 25 in.) have been observed in the surge beds of the Tshirege Member in outcrops of Mesita del Buey along Pajarito Canyon. Fault planes are steeply dipping, indicating normal displacement, and most displacements are down to the west. Lateral movement may also have occurred along these faults. Faults are thought to be no more than 1.2 million years old. Fracture studies have characterized the fractures in Unit 2 of the Tshirege Member in TA-54 (Area G) as steeply dipping, with preferential dips to the north and east. Fractures become more closely spaced with depth (Reneau and Vaniman 1998; Reneau et al. 1998; DOE 2008c). These faults are likely secondary effects associated with large earthquakes in the main Pajarito fault system, and the principal faults likely experience small amounts of movement during earthquakes (DOE 2008c).

The record of earthquakes in the vicinity of LANL goes back only to the 1940s when the town of Los Alamos was first established. Reports of earthquakes felt before 1950 are rare. Earthquakes of particular note that were felt in Los Alamos occurred on August 17, 1952 (magnitude estimate of 4); February 17, 1971 (magnitude estimate of 3.4); December 5, 1971

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[1] The NRC defines a capable fault as a fault with demonstrable historic macroseismicity, recurrent movements within the last 500,000 years, and/or one movement within the last 35,000 years (10 CFR Part 100, Appendix A).

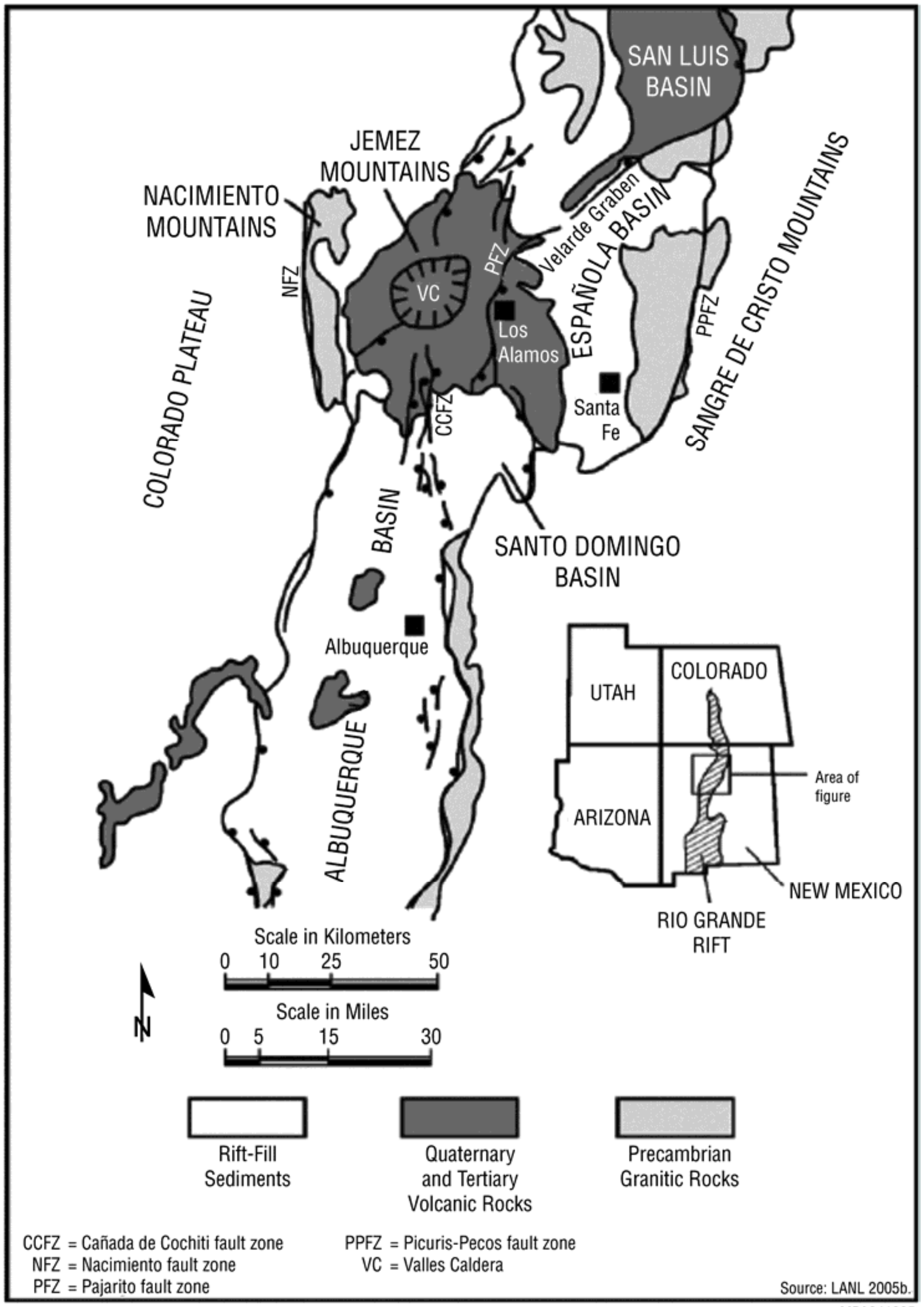

FIGURE 8.1.2-5 Structural Elements of the Rio Grande Rift Zone (Source: DOE 2008c)

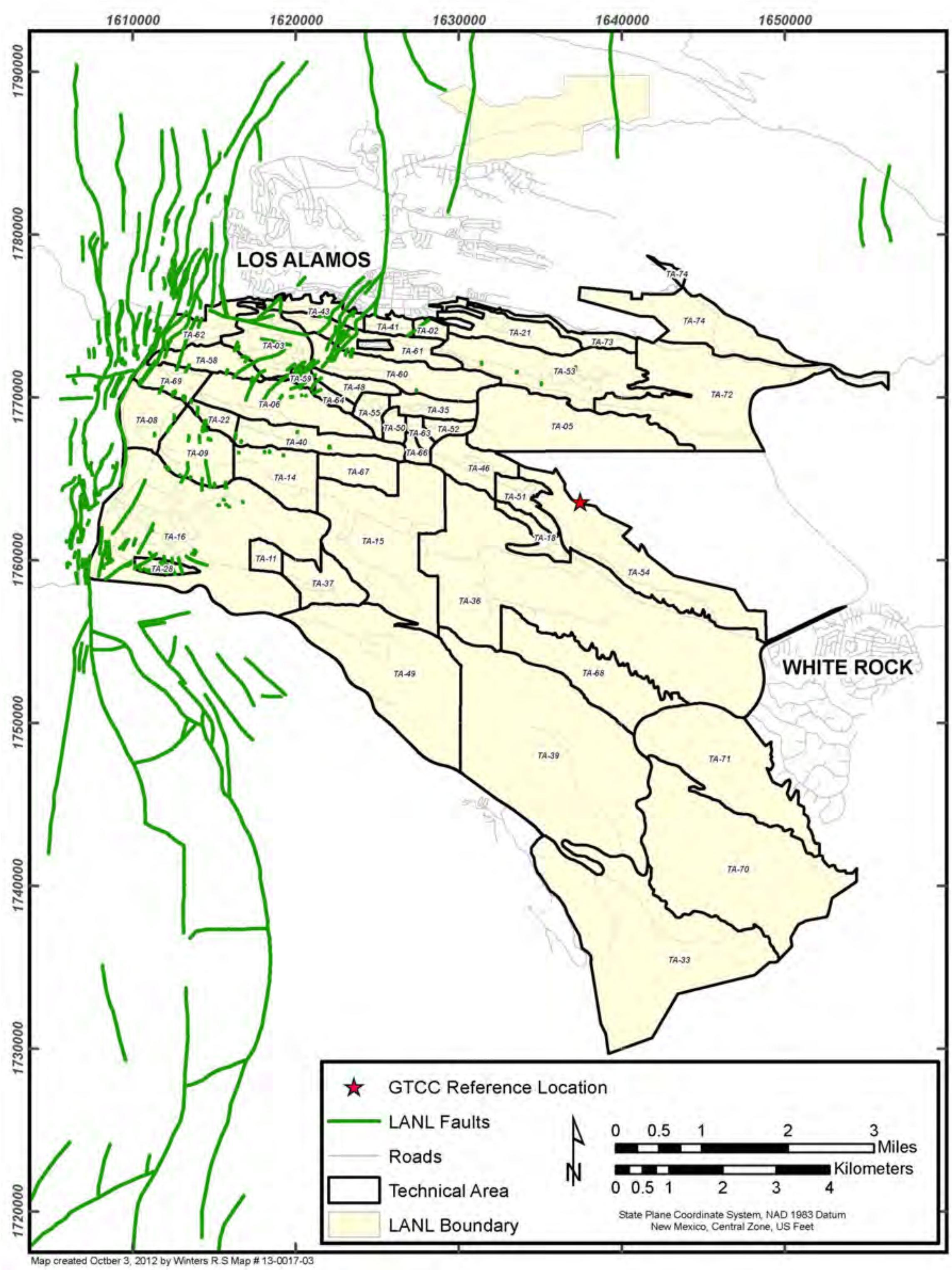

FIGURE 8.1.2-6 Mapped Faults in the LANL Area (Source: DOE 2008c)

(magnitude estimate of 3.3); and March 17, 1973 (magnitude estimate of 3.3). The largest reported earthquake in the region occurred in Cerrillos in 1918, about 50 km (31 mi) to the southeast of LANL; it had an estimated Richter local magnitude (ML) of about 5.3 (House and Cash 1988; DOE 1999a).

As many as 2,000 earthquakes have been recorded since the inception of the Los Alamos Seismograph Network in 1973. The largest event occurred in 1976, about 60 km (37 mi) to the west of LANL (near Gallup, New Mexico), with a magnitude of 5.2 (Cash and Wolff 1984; House and Cash 1988). A catalog of earthquakes occurring in the vicinity of LANL from 1893 to 1991 has been compiled by Wong et al. (1995). The latest SWEIS (DOE 2008c) documents more recent seismic events. Since 1991, five small earthquakes (with magnitudes of 2 or less on the Richter scale) have been recorded along the Pajarito fault (DOE 2008c).

A seismic hazard study, conducted in 2007, was based on more recent geological studies that characterize the faults within the Pajarito fault system and their relationships in the LANL area. The study determined that a 0.0004-per-year earthquake (with a return frequency of 2,500 years) would produce peak horizontal accelerations of about 0.47 to 0.52g for a surface facility in technical areas to the west of TA-54 (where the principal faults, and thus the principal seismic risks at LANL, are located). A 0.001-per-year earthquake (with a return frequency of 1,000 years) would produce peak horizontal accelerations of about 0.25 to 0.27g (DOE 2007; DOE 2008c).

An updated seismic hazard study was completed in 2009 to refine estimates of the 2007 study (DOE 2009b). The 2009 study used the new set of empirical ground motion attenuation models, available as part of the Pacific Earthquake Engineering Research Center’s Next Generation Attenuation (NGA) Models for the Western United States Project (based on the latest geologic data published in Lewis et al. [2009] and documented in DOE [2007]). It refined estimates made in the 2007 study, finding that horizontal and peak acceleration values for a 0.0004-per-year earthquake (with a return frequency of 2,500 years) were 0.47g and 0.51g, respectively, a reduction from the 2007 study. The dominant earthquake was determined to be in the range of moment magnitude (M) 6.0 to 7.0 at close distances (DOE 2009b).

Facilities near a cliff edge or in a canyon bottom are potentially susceptible to slope instability, rock falls, and landslides. Slope stability studies have been performed at LANL facilities where a mass movement hazard has been identified. The potential for seismically induced land subsidence at LANL is considered low; the potential for soil liquefaction is considered negligible (DOE 2003).

American Indian Text

The Pueblo people are aware of the occurrence of major earthquakes in the GTCC study area (up to 2000 have been recorded in recent times). These cause vertical displacements, large fissures, and small fractures. Water seeps into these fissures and plant roots follow them to great depths (up to 66 feet). Pueblo people believe that plant roots will eventually penetrate the GTCC facility.

8.1.2.1.5 Volcanic Activity. Most of the volcanic activity in the vicinity of LANL has occurred in the Jemez Mountains, just to the west of the Pajarito Plateau (Figure 8.1.2-1). Volcanic activity dates to 16.5 million years ago. The oldest activity was concentrated to the southwest of the plateau and was dominated by basaltic to andesitic lavas (with minor dacites and rhyolites). About 3 to 7 million years ago, the activity shifted to the north and became dominated by dacites and rhyolites. Two major eruptions about 1.6 to 1.2 million years ago produced the ash fall material making up the Otowi and Tshirege Members of the Bandelier Tuff and formed the Valles Caldera, about 8 km (5 mi) to the west of LANL. The most recent volcanic activity within Valles Caldera is estimated to have occurred about 150,000 years ago (although some suggest activity occurred as recently as 50,000 to 60,000 years ago), creating rhyolitic lava domes and minor pyroclastic deposits. Currently, the Jemez Mountains show little seismic or volcanic activity (DOE 1999a; Rosenberg and Turin 1993).

The low seismic activity is attributed to the adsorption of seismic energy deep in the subsurface due to elevated temperatures and high heat flow, thus masking the movement of magma and adding to the difficulty of predicting a volcanic event in the LANL area (although a large Bandelier-Tuff-type eruption would give years of warning, as regional uplift and doming occurred). The Jemez Mountains continue to be considered a zone of potential volcanic activity (DOE 1999a, 2008c).

The Cerros del Rio basaltic field to the southeast of the Pajarito Plateau represents other volcanic activity in the vicinity of LANL (Figure 8.1.2-1). These basalts range in age from 1.1 to 1.4 million years (Rosenberg and Turin 1993).

8.1.2.1.6 Slope Stability, Subsidence, and Liquefaction. Steep canyon walls within LANL are susceptible to rock falls and landslides. The potential for these processes to occur is related to wall steepness, canyon depth, and stratigraphy. At greatest risk are facilities near a cliff edge or in a canyon bottom. Slope instability may be triggered by excessive rainfalls, erosion, and seismic activity (DOE 1999a). However, a study conducted for TA-3 indicated that rock spalling near canyon walls was determined not to be of concern even in an earthquake (Bradley et al. 2007). Fires, such as the Cerro Grande fire that occurred in 2000, also contribute to slope instability because they cause a loss of vegetative cover and the formation of hydrophobic soil, increasing soil erosion in localized areas. This risk is reduced as vegetation returns (DOE 2008c).

Subsidence and soil liquefaction are less likely to affect areas within LANL than are rock falls or landslides. The potential for subsidence is reduced by the firm rock beneath LANL. The potential for liquefaction is minimal, since bedrock, soils, and other unconsolidated materials at LANL tend to be unsaturated (DOE 1999a).

8.1.2.2 Soils

The undisturbed soils within the study area were formed from material weathered from tuff on the nearly level surface (with slopes of 1% to 5%) of Mesita del Buey. These soils are shallow to moderately deep and well drained, with low to moderate permeability and a small to moderate erosion hazard. At the surface (to a depth of 10 cm [4 in.]), soils are predominantly brown loam to sandy loam. They become clay loam to clay with increasing depth (up to 50 cm [20 in.]). The substratum is a gravelly sandy loam, containing up to 30% pumice, with a thickness of about 40 cm (16 in.). The depth to tuff bedrock is from 30 to 100 cm (12 to 40 in.) (DOE 1999a; Nyhan et al. 1978).

8.1.2.3 Mineral and Energy Resources

Mineral resources at LANL consist of rock and soil that are excavated for use as backfill or borrow material for construction of remedial structures, such as waste unit caps. Most borrow materials are taken from sedimentary deposits of the Santa Fe Group and Pliocene-age volcanic rocks (e.g., the Bandelier Tuff) and from Quaternary alluvium along stream channels (in limited volumes). The only borrow pit currently in use at LANL is the East Jemez Road Borrow Pit in TA-61 to the northwest of TA-54. The pit is cut into the Bandelier Tuff and is used for soil and rubble storage and retrieval. There are at least 11 commercial borrow pits and quarries within 48 km (30 mi) of LANL; these produce mostly sand and gravel (DOE 2008c). Pumice has been mined on U.S. Forest Service (USFS) land in Guaje Canyon (DOE 1999a).

LANL has conducted extensive research on geothermal energy systems throughout the United States (including the Valles Caldera in New Mexico) and in other countries. This research involves both conventional and dry hot rock geothermal energy. There are currently seven experimental geothermal (gradient) wells at LANL. Currently, there are no geothermal production wells on-site.

American Indian Text

The Pueblo people who visited the proposed GTCC disposal site note the likelihood of traditionally used minerals occurring there. They assess that this is a medium to high probability. There is a need for a cultural mineral assessment and study to identify the existence of minerals of cultural significance and use.

Although there is no current Pueblo ethnogeology studies for the LANL, one was recently developed for Bandelier National Monument. That study, which was approved by the participating pueblos, documented that 96 geological resources were found to have specific uses by Pueblo people, which is estimated to be the bulk of the occurring minerals in Bandelier NM. The following are the ten most frequently cited mineral resources, presented in order of frequency of reference. Included also is the number of pueblos that were documented to have used the named resource (1) Clay 17 times mentioned for 7 pueblos; (2) Turquoise 15 times mentioned for 7 pueblos; (3) Basalt 15 times mentioned for 5 pueblos; (4) Obsidian 9 times mentioned for 4 pueblos; (5) Gypsum 8 times mentioned for 5 pueblos; (6) Rock Crystal 8 times mentioned for 5 pueblos; (7) Salt 7 times mentioned for 4 pueblos; (8) Mica 6 times mentioned for 5 pueblos; (9) Sandstone 6 times mentioned for 5 pueblos; and (10) Hematite 6 times mentioned for 4 pueblos. Just as there are certain minerals that are more frequently documented, certain pueblos were more often the subject of observations and ethnographies.

8.1.3 Water Resources

8.1.3.1 Surface Water

8.1.3.1.1 Rivers and Streams. LANL covers 100 km^2 (40 mi^2) of the Pajarito Plateau in north-central New Mexico, approximately 56 km (35 mi) northwest of Santa Fe. The surface of the Pajarito Plateau is deeply dissected, consisting of narrow, flat mesas separated by deep, narrow, east- to southeast-trending canyons. There are about 140 km (85 mi) of drainage courses within LANL boundaries, of which only about 3.2 km (2 mi) are naturally perennial. About 5 km (3 mi) of streams flow perennially because they are supplemented by wastewater discharge. Most streams, however, are dry for most of the year and flow only in response to storm runoff or snowmelt.[2] Surface water also flows from shallow groundwater discharging as springs into canyons. Figure 8.1.3-1 shows the 16 watersheds in the vicinity of LANL; 12 of them cross LANL boundaries. The watersheds are named for the canyons that receive their runoff. TA-54 is situated on Mesita del Buey, between Pajarito Canyon to the south and Cañada del Buey to the north (LANL 2005; DOE 2008c). The GTCC reference sites at LANL are situated on Mesita del Buey.

Stream flow is monitored at six locations in Pajarito Canyon and three locations in Cañada del Buey (Figure 8.1.3-2; Table 8.1.3-1). Gauges monitoring the Pajarito Canyon during water year 2006 were dry for most of the year, with recorded average annual flows of less than 0.028 cms (1 cfs) and maximum flows of up to 12 cms (425 cfs) on August 25. Similarly, gauges monitoring Cañada del Buey were dry for most of the year, with average annual flows of less than 0.028 cms (1 cfs) and maximum flows of up to 6.4 cms (228 cfs) on August 25 (Table 8.1.3-1).

American Indian Text

Pueblo people know that drainages in LANL flow during major runoff and storm events. These flows, though at times low in volume, have a potential to reach the Rio Grande and lower water bodies. In 1996, the Pueblo of Cochiti conducted a cooperative sediment study with LANL and the USGS in which Pre-1960s Legacy Waste was identified using the Thermal Ionization Mass Spectroscopy (TIMS) method. This Pre-1960s Legacy Waste has been recorded on the up-river portion of the Cochiti Reservoir, which is on the Rio Grande as it passes through the Cochiti Reservation.

There exists high potential for continuing pollution flows as indicated in the GTCC text above, and now the Cerro Grande fire has increased the potential for constituent movement as indicated in the Site-Wide EIS. Evidence of radioactivity and hazardous waste (PCBs) movement from LANL has led to fish consumption warnings on eating fish from the Rio Grande.

2 Environmental surveillance reports distinguish between streams that are ephemeral (always above the water table) and those that are intermittent (sometimes below the water table) because of the different biological communities they support.

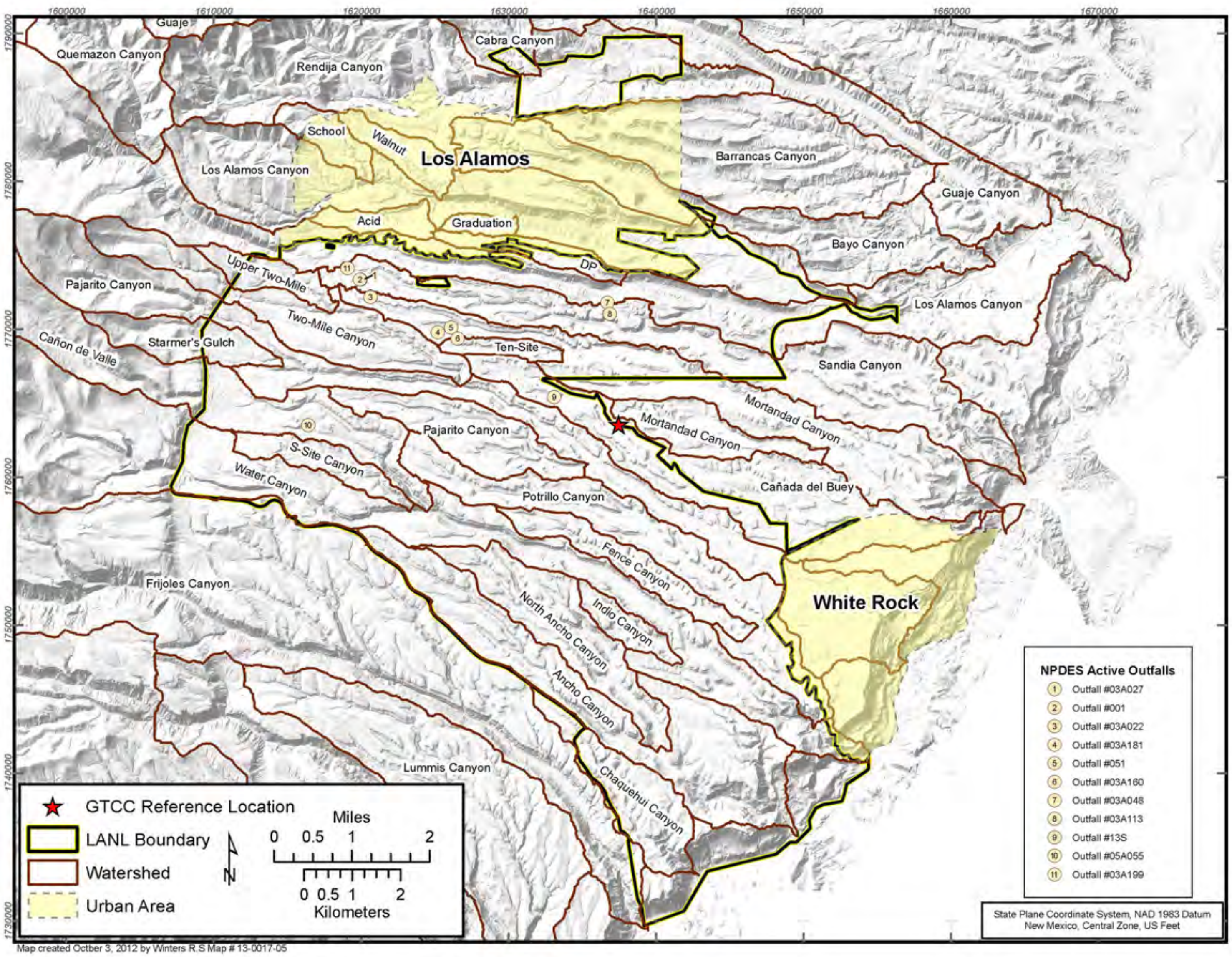

FIGURE 8.1.3-1 Watersheds in the LANL Region (Source: DOE 2008c)

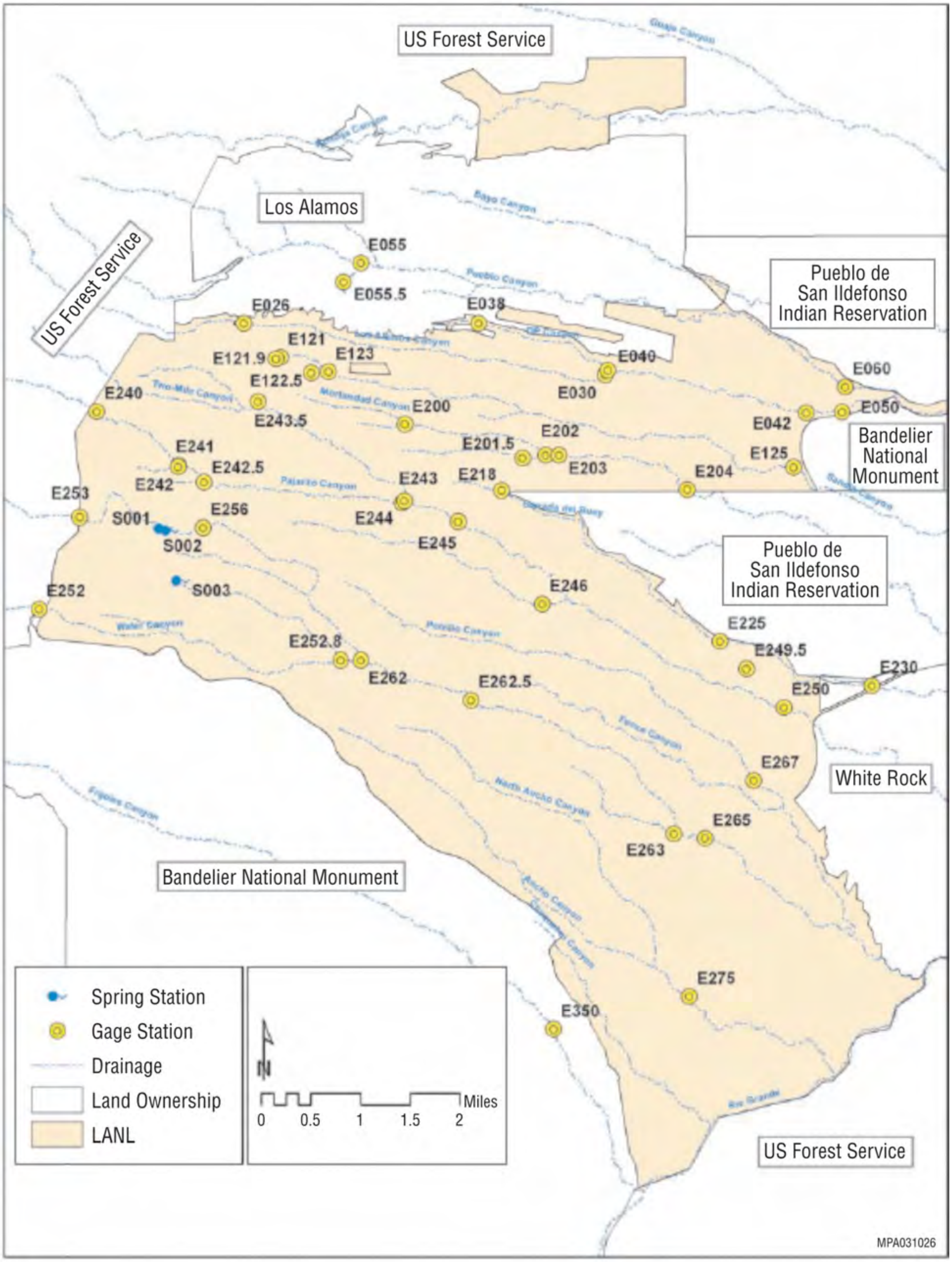

FIGURE 8.1.3-2 LANL Stream Gauging Stations (Source: Romero et al. 2007)

TABLE 8.1.3-1 Stream Flow at U.S. Geological Survey Gauging Stations Monitoring Pajarito Canyon and Cañada del Buey in Water Year 2006[a]

Gauge Station	Maximum Stream Flow in cfs (Date)	Annual Mean
Pajarito Canyon		
E240	16 (Aug. 8)	0.0030
E241	20 (Aug. 8)	0.014
E242.5	12 (Aug. 25)	0.024
E243	101 (Aug. 8)	0.081
E245	425 (Aug. 25)	0.16
E250	206 (Aug. 25)	0.043
Cañada del Buey		
E218	228 (Aug. 25)	0.028
E225	0.49 (Aug. 8)	0
E230	54 (Aug. 6)	0.0090

[a] Water year 2006 is from Oct. 2005 through Sept. 2006.

Source: Romero et al. (2007)

At LANL, perennial streams are not a source of municipal, industrial, irrigation, or recreational water; however, they have the designated uses of coldwater aquatic life use and wildlife habitat use (secondary contact). None of LANL perennial streams have been designated as Wild and Scenic. Ephemeral and intermittent streams, such as those within the Pajarito Canyon and Cañada del Buey, have designated uses of limited aquatic life use and wildlife habitat use (secondary contact). Beyond the site boundaries, water is used by tribal members of the Pueblo de San Ildefonso for traditional or ceremonial purposes. Water may discharge to the Rio Grande, which lies just to the east of the Pajarito Plateau (DOE 2008c; LANL 2007).

8.1.3.1.2 Other Surface Water. There are approximately 14 ha (34 ac) of wetlands within LANL boundaries. Most wetlands are associated with canyon stream channels; some are located on mesas and are associated with springs, seeps, and effluent outfalls. A 2005 survey found that about 45% of the site's wetlands are located in Pajarito Canyon. The acreage of wetlands at LANL has decreased since 1999 as effluent outfalls have been closed or rerouted. About 3.6 ha (9 ac) of wetlands were transferred to Los Alamos County and the DOI to be held in trust for the Pueblo de San Ildefonso and are no longer under DOE's control (DOE 2008c).

8.1.3.1.3 Surface Water Quality. Potential sources of surface water contamination at LANL include industrial effluents discharged through NPDES permitted outfalls, stormwater runoff, dredge and fill activities, isolated spills, former photographic processing facilities, highway runoff, residual Cerro Grande fire ash (the fire occurred in May 2000), and sediment transport (DOE 2008c). LANL samples surface water within the major canyons that cross the site and at locations along the site perimeter. Stormwater runoff is sampled along the site boundary and at discreet mesa-top sites (including two near North Site at TA-54). Sediment samples are also collected at stations along the canyons and from drainages downstream of two material disposal areas (MDAs), including nine stations just outside the perimeter fence of MDA G at TA-54. Exceedances between 2000 and 2005 were generally of excess total residual chlorine (LANL 2007).

Although every major watershed at LANL shows some effect from site operations, the overall quality of surface water is considered good. Environmental monitoring at NPDES-permitted outfalls indicates that levels of dissolved solutes are low and that levels of most analytes are below regulatory standards or risk-based levels (LANL 2007).

Past discharges of radioactive liquid effluents into Pueblo Canyon (including its tributary in Acid Canyon), and Los Alamos Canyons and current releases from the Radioactive Liquid Waste Treatment Facility into Mortandad Canyon have introduced Am-241, Cs-137, Pu-238, Pu-239, Pu-240, Sr-90, and tritium into both surface waters and canyon sediments. Table 8.1.3-2 summarizes radionuclide concentrations in Pueblo and Mortandad Canyons (DOE 2008c).

TABLE 8.1.3-2 Summary of Surface Water Radionuclide Concentrations in Pueblo and Mortandad Canyons in 2005

Radionuclide	DOE 100-mrem Derived Concentration Guide for Public Exposure (pCi/L)[a]	Biota Concentration Guide (pCi/L)	Concentration in Lower Pueblo Canyon at SR (pCi/L) 502	Concentration in Mortandad Canyon below TA-50 Radioactive Liquid Waste Treatment Facility Outfall (pCi/L)
Am-241	30	400	0.4	5.1
Cs-137	3,000	20,000	ND[b]	20
Tritium	NR[b]	300,000,000	ND	237
Pu-238	40	200	ND	2.1
Pu-239 and Pu-240	30	200	11	2.9
Sr-90	1,000	300	0.4	3.4
U-234	NR	200	1.7	2.0
U-235 and U-236	NR	200	0.1	1.1
U-238	NR	200	1.6	1.9

[a] Source for the Derived Concentration Guide: DOE (2006).

[b] NR means not reported and ND means not detected.

Source: DOE (2008c)

During New Mexico's summer rainy season, a large volume of stormwater runoff can flow over LANL facilities and construction sites, picking up pollutants. The most common pollutants transported in stormwater flows are radionuclides, polychlorinated biphenyls (PCBs), and metals. Recent data from stormwater runoff monitoring detected some contaminants on and off-site, but the exposure potential for these contaminants is limited. Radionuclides have been detected in runoff at higher-than-background levels in Pueblo, DP, Los Alamos, and Mortandad Canyons, with sporadic detections extending off-site in Pueblo and Los Alamos Canyons. Stormwater runoff has exceeded the wildlife habitat standard for gross alpha activity of 15 pCi/L since the Cerro Grande fire that occurred in nearly all of the canyons in 2000. Los Alamos Canyon and Sandia Canyon runoff and base flows contain PCBs at levels above New Mexico human health stream standards. Dissolved copper, lead, and zinc have been detected above the New Mexico acute aquatic life stream standards in many canyons, and these metals were detected off-site in Los Alamos Canyon. Some of these PCB and metal detections were upstream of LANL facilities, indicating that non-LANL urban runoff was one source of the contamination. Mercury was detected slightly above wildlife habitat stream standards in Los Alamos and Sandia Canyons (DOE 2008c).

Dissolved aluminum concentrations exceeded the acute aquatic life standard for some locations in 2006; however, it is thought that these concentrations resulted from particulate (colloidal) aluminum passing through the filter, because LANL surface waters, which are slightly alkaline, rarely contain aluminum in solution. Selenium levels, which had been high following the Cerro Grande fire in 2000 (likely due to ash from the fire), were found to be below the wildlife habitat standard in 2006.

PCBs have also been detected in streams and sediment at LANL. Surface water was analyzed for PCBs in 14 water courses, and PCBs were detected in 6 of them. Consistent with previous years, multiple PCB detections were reported in Sandia, Los Alamos, and Mortandad Canyons. Sandia Canyon accounted for about half of the detections, and Los Alamos Canyon accounted for an additional one-third.

In Los Alamos Canyon, PCBs were detected in sediments throughout the watershed and extending to the confluence with the Rio Grande near Otowi. The highest sediment concentration for total PCBs in Los Alamos Canyon, approximately 0.5 μg/g, occurred at the confluence with DP Canyon. PCB concentrations tend to decrease with distance from the source; at the LANL boundary, the maximum total PCB sediment concentration was about 0.2 μg/g. The main sources of PCBs on LANL lands are probably from past spills and leaks of transformers rather than from current effluent discharges (LANL 2007).

PCBs were detected throughout the Sandia Canyon watershed from near LANL's main technical area at TA-3 to LANL's downstream boundary at SR 4. Unlike the Los Alamos Canyon watershed, however, there is minimal off-site stream flow in Sandia Canyon. Although most PCBs were detected in stormwater samples, they were also detected in three base flow samples collected near the Sandia Canyon wetlands. Sediment samples collected in the upper portion of Sandia Canyon contained PCB concentrations. The highest PCB concentration was approximately 7 μg/g. Concentrations of PCBs in downstream sediment decline quickly with distance and usually are not detected at the site's boundary (LANL 2007).

In 2006, approximately 50 surface water samples were collected from water-course and hillside sites and analyzed for PCBs within Mortandad Canyon and its tributaries: Cañada del Buey, Ten Site Canyon, and Pratt Canyon. In only two samples were concentrations of PCBs detected; both were from middle Mortandad Canyon. These results indicate that PCB concentrations in the drainage are occasionally detected but are relatively small (LANL 2007).

8.1.3.2 Groundwater

8.1.3.2.1 Unsaturated Zone. Groundwater occurs in both the unsaturated (vadose) and saturated (phreatic) zones at LANL. Groundwater was encountered in characterization Well R-22 (located near MDA G on Mesita del Buey to the southeast of the North Site and Zone 6 in TA-54) at a depth of 270 m (890 ft). However, intermediate-depth perched groundwater also occurs within the vadose zone beneath wet canyons (e.g., within the more-porous breccia zones in basalt) and along the western portion of the site. The unsaturated zone varies in thickness from about 183 m (600 ft) to more than 366 m (1,200 ft), decreasing in thickness with increasing distance down the canyon to the southeast.

8.1.3.2.2 Aquifer Units. Saturated groundwater at LANL occurs in three hydrologic settings. It is perched at shallow depths in canyon bottom alluvium; it is perched at intermediate depths below canyon bottoms; and it is found at greater depths within units that make up the regional aquifer beneath the Pajarito Plateau. Figure 8.1.3-3 shows the hydrogeologic units at LANL and their relationship to the lithologic units of the Pajarito Plateau described in Section 8.1.2.1.3.

The following descriptions are taken from the SWEIS (DOE 2008c), Birdsell et al. (2005b), and LANL (2005, 2007) and include information specific to characterization Well R-22 and municipal water supply Wells PM-2 and PM-4. Well R-22, on the mesa above Pajarito Canyon, penetrates the Bandelier Tuff and Cerros del Rio lavas and is completed in the lower Puye Formation. Wells PM-2 and PM-4 are more than 451-m (1,500-ft) deep. Table 8.1.3-3 lists the hydrostratigraphic data for Well R-22.

Perched Alluvial Groundwater. Alluvial aquifers at the bottoms of canyons are made up of fluvial deposits interbedded with deposits of alluvial fans and colluvium from the adjacent mesas. The primary source of sediment is the Bandelier Tuff and other units, such as the Tschicoma Formation. The Bandelier Tuff produces sand-sized alluvium; colluvial deposits are more coarse-grained. The interbedded units range in thickness from a few meters (feet) to up to 30 m (100 ft) and serve as conduits for groundwater movement both laterally and with depth. The alluvial aquifers are perched on top of the less permeable Bandelier Tuff (Figure 8.1.3-4).

Many of the canyons are dry, with little surface water flow and little or no alluvial groundwater. In wet canyons, surface water flows along the canyon bottoms and infiltrates downward until it hits the less permeable tuff or other rocks, creating shallow zones of perched

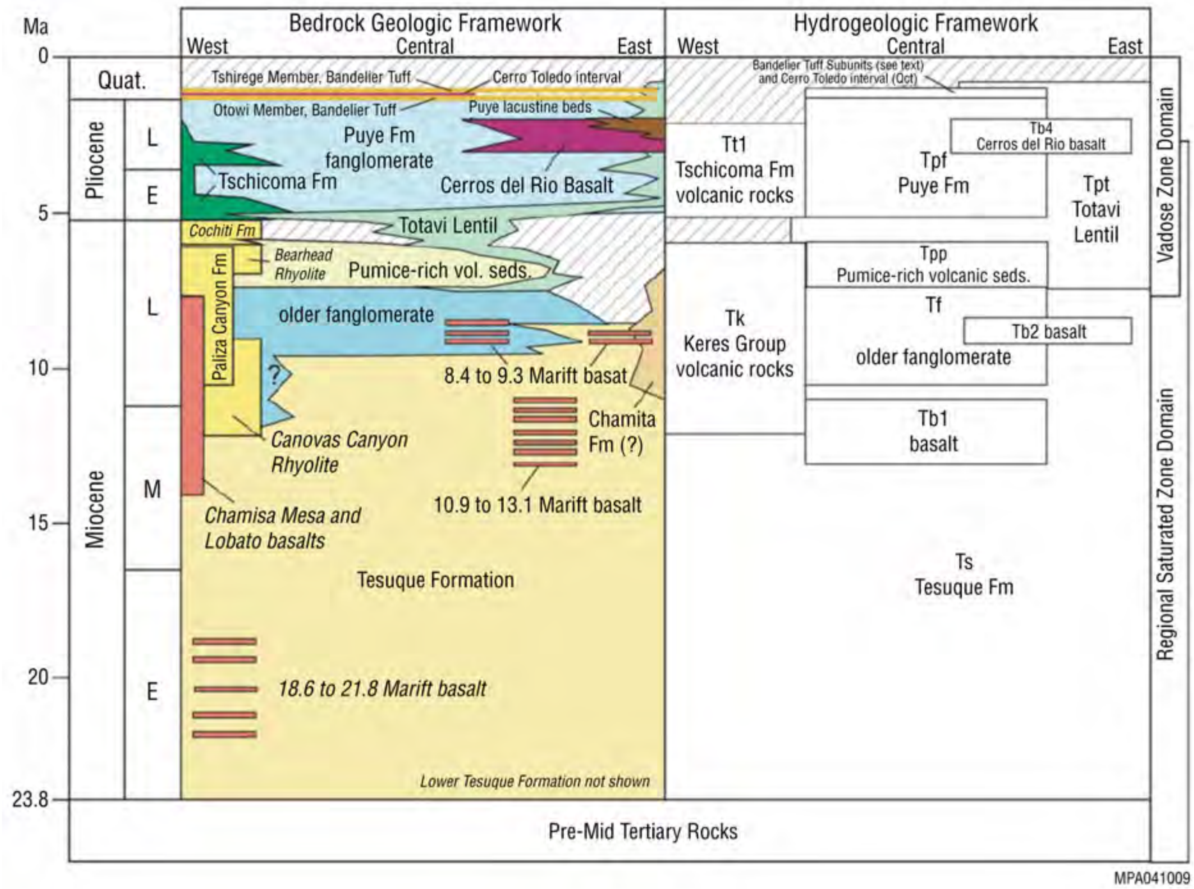

FIGURE 8.1.3-3 Hydrogeologic Units at LANL (Source: Birdsell et al. 2005b)

TABLE 8.1.3-3 Hydrostratigraphic Data from Well R-22 at LANL[a]

Hydrostratigraphic Unit	Top Depth	Base Depth	Top Elevation	Unit Thickness
Depth to groundwater/vadose zone	0	883	6,650.5	883
Tshirege ash flows	0	128	6,650.5	128
Otowi ash flows	128	179	6,522.5	51
Guaje pumice bed	179	190	6,471.5	11
Cerros del Rio lavas	190	1,173	6,460.5	983
Upper Puye Formation	1,173	1,338	5,477.5	165
Older basalt unit (Santa Fe Group)	1,338	1,406	5,312.5	68
Lower Puye Formation	1,406	1,489[b]	5,244.5	>83

[a] All thicknesses and depths are in feet; all elevations are in feet relative to MSL.

[b] Value represents the total depth of the borehole and not the depth or thickness of the unit.

Source: Ball et al. (2002)

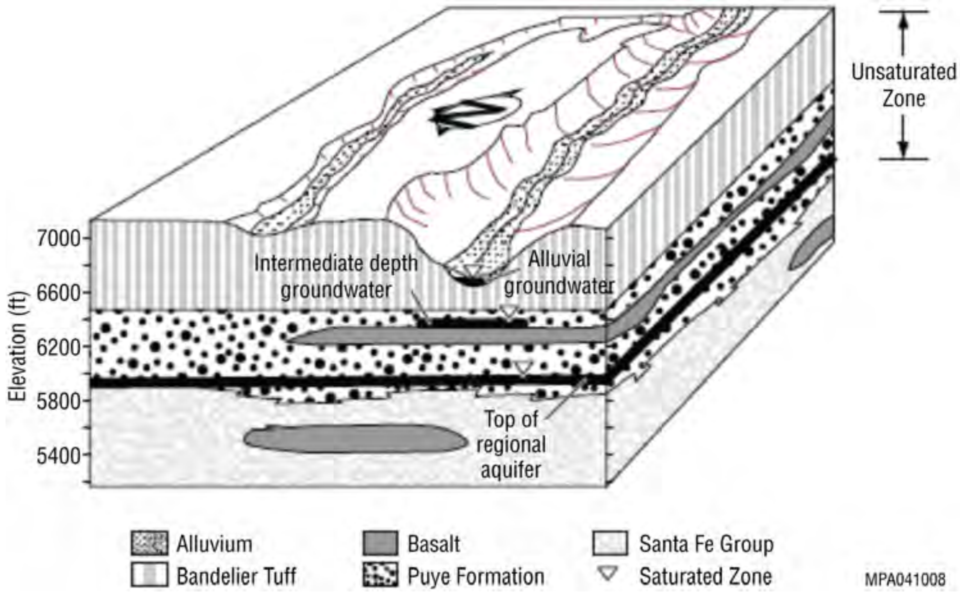

FIGURE 8.1.3-4 Three Modes of Groundwater Occurrence at LANL (Source: DOE 2008c)

groundwater within the alluvium. Infiltration rates beneath the alluvial systems of wet canyons are estimated to be the highest across the plateau, approaching several meters per year. The water table slopes toward the east, as do the canyon floors. Because of water losses due to evapotranspiration and infiltration, alluvial groundwater is generally not sufficiently extensive for domestic use.

Intermediate-Depth Perched Groundwater. Intermediate-depth perched groundwater aquifers are associated with wet canyons. These systems occur within the unsaturated portion of the Bandelier Tuff and the underlying Puye Formation and Cerros del Rio basalt (Figure 8.1.3-4) and are recharged by the overlying perched alluvial groundwater. Depths vary among canyons, ranging from 36.6 m (120 ft) in Pueblo Canyon to 230 m (750 ft) in Mortandad Canyon. It has been estimated that the rate of movement of the intermediate perched groundwater is about 18 m/d (60 ft/d), or about 6 months from recharge to discharge (LANL 2003a).

Regional Aquifer. The regional aquifer (known as the Española Basin aquifer system) is the only aquifer in the LANL vicinity that can serve as a municipal water supply. It is a major source of drinking and agricultural water for northern New Mexico, and, in January 2008, it was designated by EPA Region 6 as a sole source aquifer (EPA 2008c). The regional aquifer extends throughout the Española Basin and consists of both sedimentary and volcanic units that have vastly different hydrologic properties. Sedimentary units include the Puye Formation, pumice-rich volcaniclastic rocks, Totavi Lentil, older fanglomerate rocks, Santa Fe Group sands, and sedimentary deposits between basalt flows. These units are highly heterogeneous and strongly anisotropic, with lateral conductivity (parallel to the sedimentary beds) as much as 100 to 1,000 times higher than vertical conductivity.

Correlation (and therefore lateral continuity) between individual beds in the Puye Formation is difficult to find because of the complex arrangement of channel and overbank deposits in the alluvial fans that make up this unit. Pumice-rich volcaniclastic rocks are expected to have high porosity, which may, in turn, translate into high permeability, depending on the degree of clay alteration. The Totavi Lentil is thought to be the most transmissive of the sedimentary units, since it consists of unconsolidated sands and gravels. It also contains fine-grained sediments.

Volcanic rocks on the plateau include the lavas of the Tschicoma Formation and various basalt units (Cerros del Rio, Bayo Canyon, and the Miocene basalts within the Santa Fe Group). These rocks consist of stacked lava flows separated by interflow zones of highly porous breccias, clinker, cinder deposits, and sedimentary deposits. Lava flow interiors are made up of dense impermeable rock with varying degrees of fracture. Beneath Mesita del Buey, the Cerros del Rio basalt is 300-m (1,000-ft) thick, indicating fill within a paleocanyon (Ball et al. 2002).

North-south trending fault zones on the Pajarito Plateau — including the Pajarito fault zone and the Guaje Mountain and Rendija Canyon faults — may facilitate or impede groundwater flow in the north-south direction, depending on whether they are open or clay-filled.

Elevations of the regional aquifer water table decrease to the east-southeast and range from 1,780 m (5,850 ft) MSL near North Site to about 1,750 m (5,750 ft) MSL at Area G on Mesita del Buey (Figure 8.1.3-5). Vadose zone thickness ranges from about 183 m (600 ft) to more than 366 m (1,200 ft), decreasing with increasing distance down canyon (to the east-southeast). Groundwater was encountered at a depth of 269 m (883 ft) in characterization Well R-22 when it was installed in 2000 (Ball et al. 2002). Intermediate-depth perched aquifers occur within the vadose zone beneath major (wet) canyons (e.g., within the more porous, breccia zones in basalt) and along the western portion of the LANL site. In the vicinity of TA-54, the thickness of the saturated zone (Cerro del Rio basalts saturated zone) is about 37 m (120 ft).

8.1.3.2.3 Groundwater Flow. Unsaturated flow is through the welded and nonwelded units of the Bandelier Tuff and the basalt flow interior and interflow units of the Cerros del Rio lavas. Flow within the densely welded tuffs (which occur on the western edge of the plateau) and the dense, basalt flow interiors of the Cerros del Rio basalt is predominantly through fractures. Downward movement is thought to be more rapid in the basalt than through moderately welded tuff (Birdsell et al. 2005b). Matrix flow likely occurs within the nonwelded and moderately welded tuffs (with porosities of 40% to 50%) and within the more porous brecciated interflow zones in the basalt (Birdsell et al. 2005a).

Groundwater takes decades to move from the surface to perched groundwater zones. Movement within perched zones is not well characterized, but it is, in general, controlled by factors such as the topography of the perching layer, bedding features, and the orientation of interconnected fractures (LANL 2005; Birdsell et al. 2005b).

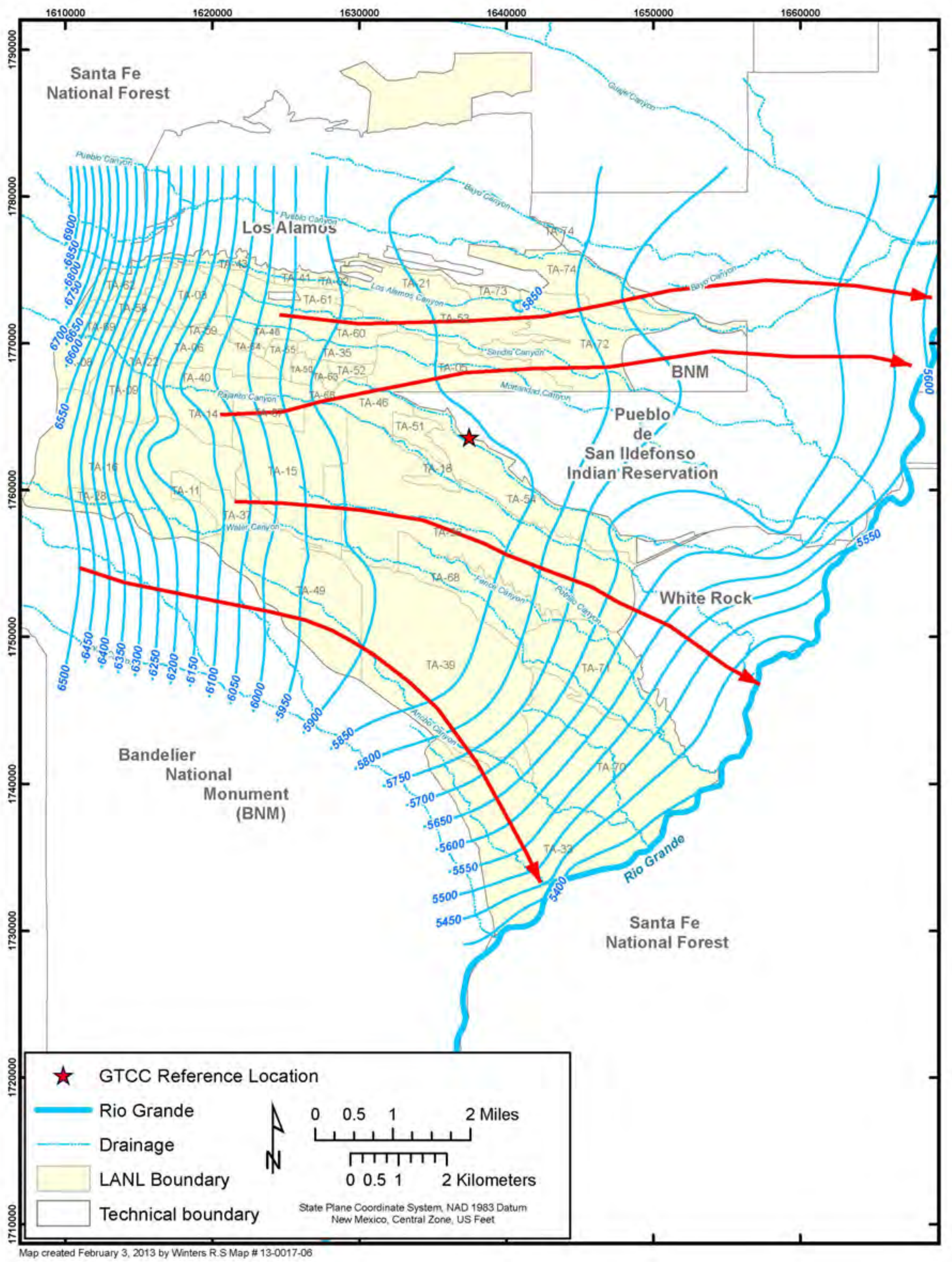

FIGURE 8.1.3-5 Water Table Elevation of LANL Regional Aquifer (Source: Birdsell et al. 2005b)

Saturated flow in the upper 90 m (300 ft) of the regional aquifer beneath Mesita del Buey (at Well R-22) is within the fractures and interflow zones of the Cerros del Rio basalt. Flow direction in the perched alluvial and regional aquifer systems is to the east-southeast, toward the Rio Grande; the direction of groundwater flow in the intermediate perched zones is less certain. Flow within deeper parts of the regional aquifer (i.e., deeper than 150 m [500 ft]) is currently unknown, but it could be different than the flow occurring at shallower depths. Groundwater flow is anisotropic, with preferential flow parallel to bedding planes.

The Rio Grande is the principal discharge point for the alluvial and regional aquifers. Discharge to the river may occur as lateral flow or upward flow or as flow from springs in White Rock Canyon (LANL 2005; Birdsell et al. 2005b).

8.1.3.2.4 Groundwater Quality. Natural groundwater chemistry at LANL varies with the acidity of the water and the chemistry of local rock. Natural constituents, including uranium, silicon, and sodium, are common in the volcanic rocks of the region. Since the 1940s, liquid effluents from operations at LANL have degraded the water quality in the perched alluvial groundwater beneath the floor of several canyons. In some cases, impacts extend to the intermediate perched aquifers (particularly below wet canyons). Water quality impacts on the regional aquifer are minimal, since several hundred feet of dry rock separate the regional aquifer from the shallow perched groundwater. Although there is evidence that some contaminants (tritium, perchlorate, cyclonite or RDX, trinitrotoluene or TNT, perchloroethylene or PCE, and trichloroethylene) are reaching the regional aquifer, none of the drinking water wells in the regional aquifer have been contaminated to date. Table 8.1.3-4 lists the major contaminants found in groundwater sampled beneath Pajarito Canyon and Cañada del Buey in 2006. Details of

TABLE 8.1.3-4 Summary of Groundwater Contamination in Pajarito Canyon and Cañada del Buey at LANL in 2006

		Groundwater Contaminants[a]		
Canyon	Contaminant Sources	Alluvial	Intermediate	Regional
Pajarito Canyon	Major dry sources, past major but minor present liquid sources	Chloride above and nitrate at 50% of NMGWS	1,1-DCE and 1,1,1-TCA above NMGWS, RDX above EPA excess cancer risk level, TCE, 1,1-dichloroethane, 1,4-dioxane	Trace RDX
Cañada del Buey	Major dry, minor liquid sources	None, little alluvial groundwater	No intermediate groundwater	None

[a] DCE = dichloroethene, NMGWS = New Mexico groundwater standards, RDX = the explosive cyclonite, TCA = trichloroethane, TCE = trichloroethene.

Source: LANL (2007)

the monitoring program at LANL can be found in the Laboratory's annual surveillance reports (DOE 2008c; LANL 2007).

Waste was disposed of in pits and shafts at MDA L, which is within TA-54, adjacent to pueblo sacred areas. As part of the monitoring program, MDA L has been monitored for vapor-phase contaminants in soil. A subsurface VOC vapor plume is present in the vadose zone at MDA L. The primary sources of subsurface VOC vapors are the two shaft fields at MDA L, and they appear to be a continuing source of VOC vapors (LANL 2011).

The lower Pajarito Canyon has a saturated alluvium that does not extend past LANL's east boundary. Past discharges to the canyon via its tributaries include small amounts of wastewater from TA-9. A nuclear materials experimental facility was located on the floor of the canyon at TA-18. Mesita del Buey, to the north of the canyon, is the site of several waste management areas, including MDA G, used for the disposal of LLRW. In 2006, several organic compounds (including chlorinated solvents) were detected in the intermediate-depth perched aquifer below the canyon. Traces of RDX were detected in the regional aquifer (LANL 2007).

Cañada del Buey has a shallow alluvial groundwater system of limited extent and is monitored by a network of five shallow wells and two moisture monitoring wells. Most of these wells are dry at any given time. Past discharges include accidental releases from experimental reactors and laboratories at TA-46. Treated effluent from LANL's sanitary wastewater system is also discharged to the canyon at times. As of 2006, no contamination had been detected in any of the aquifer systems below the canyon (LANL 2007).

8.1.3.2.5 Groundwater Use. All water used at LANL is derived from groundwater drawn from the regional aquifer (the Española Basin aquifer system) in three well fields: Otowi, Pajarito, and Guaje. The Guaje, Pajarito, and Otowi Well Fields are located in the mesas and canyons of the Pajarito Plateau. The 12 deep wells that supply water are all completed within the regional aquifer, located beneath the Pajarito Plateau. This sole source aquifer is the only local aquifer capable of supplying municipal and industrial water in the Los Alamos area. The piezometric surface of the regional aquifer ranges in depth from about 6 m (20 ft) above ground level (artesian water conditions) in portions of lower Los Alamos Canyon near the confluence with Guaje Canyon, to about 230 m (750 ft) bgs along the eastern edge of LANL property, to more than 375 m (1,230 ft) bgs near the center of the Pajarito Plateau (LANL 2003b). Water levels in the wells are declining by 30 to 60 cm/yr (1 to 2 ft/yr) (LANL 2003a).

Potable groundwater is pumped from the wells into the distribution system. Yields from individual production wells ranged from about 1,400 to 5,600 L/min (370 to 1,480 gpm) from 1998 through 2001 (LANL 2003a). Booster pumps lift the water to terminal storage for distribution to LANL and the community. The entire water supply is disinfected with mixed-oxidant solution before it is distributed to Los Alamos, White Rock, Bandelier National Monument, and LANL areas. Potable water storage tanks at Los Alamos have a combined terminal storage of 132 to 150 million L (35 to 40 million gal). Under drought-like conditions, daily water production alone may not be sufficient to meet water demands, and Los Alamos

County relies on the terminal storage supply to make up the difference. The firm rated capacity[3] of the Los Alamos water production system is 7,797 gpm (42 million L/d or 11 million gal/d) (LANL 2003b).

Water use by LANL between 1998 and 2001 ranged from 1,430 million L (380 million gal) in 2000 to 1,745 million L (460 million gal) in 1998. LANL water use in 2001 was 1,490 million L (390 million gal), or 27% of the total water use at Los Alamos. Water use by Los Alamos County ranged from 3,300 million L (870 million gal) in 1999 to 4.2 billion L (1.1 billion gal) in 2000, and it averaged 3.8 billion L/yr (1.0 billion gal/yr) (LANL 2003b).

In September 1998, DOE leased the Los Alamos water supply system to Los Alamos County, and in September 2001, ownership of the water supply system was officially transferred to Los Alamos County. The water rights owned by DOE from all permitted sources (surface water and groundwater) in 1998 were about 5,500 ac-ft/yr or about 6.8 billion L/yr (1.8 billion gal/yr). In September 1998, these water rights were leased to Los Alamos County. DOE retained ownership of 30% of the water rights; this amount of water has been established as a maximum “target quantity” for water use by LANL. Transfer of ownership of the water supply system and water rights was completed in September 2001. LANL now purchases water from Los Alamos County. Water meters were installed at all delivery points to LANL, and water now provided to LANL is metered for documentation and billing (LANL 2003b).

Current water use in Los Alamos County falls into five categories: residential, commercial/institutional, industrial, public landscape irrigation, and other (e.g., firefighting, main flushing, swimming pools, construction projects, schools). In 2004, total water deliveries were estimated to be 3,920 million L (1,035 million gal). The greatest demand was for single-family use (62% or 2,400 million L [630 million gal]). The net per capita use was 572 L/d (151 gal/d). Water demand is expected to be about 8,285 million L (2,189 million gal) in 2020 (Daniel B. Stephens and Associates, Inc. 2006).

Water demand by LANL as a percentage of the total diversions varied from 34% in 1999 to 21% in 2002. Demand at LANL increases about 35% in the summer months because of its increased use of water in its cooling towers. In 2004, its per capita demand was 191 L/d (50 gal/d) (Daniel B. Stephens and Associates, Inc. 2006).

8.1.4 Human Health

Potential radiation exposures to the off-site general public residing in the vicinity of LANL would be only a very small fraction of the dose limit of 100 mrem/yr set by DOE to

3 The firm rated capacity is the maximum amount of water that can be pumped immediately to meet peak demand.

American Indian Text

Pueblo people know that extensive work has been completed to map and determine flow rates, direction, and quality of groundwater systems. There are independent studies published which challenge these findings. These other studies maintain that monitoring at sites is inadequate and that the drilling practices influence the results.

Santa Clara Pueblo is concerned that their groundwater is being contaminated by LANL – especially from TA 54 waste deposits. Even though Santa Clara Pueblo is upstream when only surface water is considered, known faults between LANL and SCP are suspected to connect reservation groundwater and TA 54 wastes in LANL groundwater. Current investigations by Santa Clara Pueblo science teams and funded by the Pueblo are on-going to determine if Santa Clara Pueblo groundwater is connected through water bearing faults.

protect the public from the operations of its facilities (DOE Order 458.1). The pathways of potential exposure include ingestion of contaminated soil, groundwater, and fish and respiration of air emissions. In 2014, the dose from each of these pathways was estimated to be less than 1 mrem/yr (LANL 2015), as shown in Table 8.1.4-1.

In 2014, the highest dose to a member of the general public was determined to be along Jemez Road as it passes TA-53 (LANL 2015). The occupancy factor at this location is less than 1% resulting in a dose of <0.01 mrem/yr (LANL 2015). The location of the individual receiving the highest dose from airborne emissions was determined to be at the East Gate, and the dose at this location was reported to be 0.24 mrem/yr. Potential radiation exposure from airborne emissions is expected to remain low in the future. The collective dose for the 343,000 people living within 80 km (50 mi) around the LANL site was estimated to be 0.284 person-rem, which is less than 0.00013% of the collective dose that the same population would receive from natural background and man-made sources.

Among all the on-site workers who were monitored for radiation exposure, 1,335 had measurable doses in 2014. (The total number of monitored workers at LANL was 9,666.) The collective total dose was 95.4 person-rem (DOE 2015), which gives an average individual dose of 94 mrem/yr to the radiation workers at the site. The collective dose decreased by 31% from the previous year, and most of it was incurred by workers performing operational activities at the TA-55 Plutonium Facility. In addition to workers at TA-55, workers at the radioactive solid waste facilities in TA-50 and TA-54, and workers at the TA-53 Los Alamos Neutron Science Center also registered higher radiation exposures than the average (DOE 2015). Among the workers who registered measurable doses, most received only external radiation; only 17 workers had measurable internal doses. The collective internal dose was 0.143 person-rem;

1 **TABLE 8.1.4-1 Estimated Annual Radiation Doses to Workers and the General Public at LANL**

Receptor	Radiation Source	Exposure Pathway	Dose to Individual (mrem/yr)	Dose to Population (person-rem/yr)
On-site workers	Radioactive materials handled in operations	Inhalation and ingestion	8[a]	0.14 [a]
	Radioactive materials handled in operations	Direct radiation	68[b]	95.4[b]
General public	Airborne release	Submersion, inhalation, ingestion of plant foods (contaminated through deposition), direct radiation from deposition	0.24[c]	0.284[d]
	Groundwater contamination	Water ingestion	< 0.1[e]	
	Soil contamination	External radiation, dust inhalation, soil ingestion	< 0.1[f]	
	Surface water contamination	Fish ingestion	~0g	
	On-site waste storage and shipment	Direct radiation	<0.01[h]	
Worker/public	Natural background radiation and man-made sources		620[i]	213,000[j]

[a] In 2014, among the workers monitored for internal exposure, 17 had measurable doses. A collective dose of 0.14 person-rem was recorded, which would give an average internal dose of 8 mrem per worker (DOE 2015).

[b] In 2014, 1,401 workers monitored for radiation exposures received measurable doses (DOE 2015). The total collective dose for these workers was 95.4 person-rem (DOE 2015). When the collective dose for internal exposure is subtracted from the total collective dose, and the remainder is distributed evenly among the workers, an average individual external dose of 68 mrem/yr is obtained.

[c] The radiation dose was conservatively estimated as the sum of the dose calculated with CAP88-PC for airborne emissions from the Los Alamos Neutron Science Center and the dose calculated for ambient air monitoring data. In 2014, the location of the highest-exposed individual was determined to be at East Gate (LANL 2015). The potential maximum dose from airborne emissions is expected to remain low.

[d] The collective dose was estimated with CAP88-PC for the population residing within 80 km (50 mi) of LANL. The population size is about 343,000 (LANL 2015).

[e] The dose corresponds to drinking 730 L/yr (190 gal/yr) of water from the Otowi-4 well located in Upper Los Alamos Canyon.

Footnotes continue on next page.

TABLE 8.1.4-1 (Cont.)

[f] The dose was calculated on the basis of measured surface soil concentrations at off-site locations. The soil concentrations measured indicate the potential dose would be less than 0.1 mrem/yr (LANL 2015).

[g] The dose from ingesting fish from the Rio Grande downstream from the LANL site would be negligible because surface water concentrations were well within the background levels (LANL 2015).

[h] Dose corresponds to an occupancy factor less than 1% at the Jemez Road location (LANL 2015).

[i] Average dose to a member of the general public (NCRP 2009).

[j] Collective dose to the population of 343,000 within 80 km (50 mi) of the LANL site from natural background radiation and man-made sources.

if distributed evenly among the 17 workers, the average individual dose was 8 mrem/yr (DOE 2015, Exhibit B-4). According to LANL records (DOE 2015), no radiation worker received a dose greater than the DOE administrative control level of 2 rem/yr in 2014. Use of DOE's ALARA program ensures that worker doses are kept well below applicable standards.

> American Indian Text
>
> Standard calculations of human heath exposure as used for the General Public are not applicable to Pueblo populations. The concept General Public is an EPA term that is a generalization that derives from studies of average adult males. Residency time for the General Public tends to be a short period of an individual's lifetime and exposure is voluntary. Pueblo people live here in their Sacred Home Lands for their entire lives and will continue to reside here forever.
>
> Pueblo people use their resources differently than average US citizens so standard dosing rates do not apply. For ceremonial purposes, for example, water is consumed directly from surface water sources and natural springs. Potters, for example, have direct and intimate contact with stream and surface clay deposits. Natural pigment paints, for example, are placed on people's bodies and kept there through long periods of time during which strenuous physical activities opens the pores.

8.1.5 Ecology

LANL consists of five vegetation zones: (1) grassland, (2) ponderosa pine (*Pinus ponderosa*) forest, (3) pinyon-juniper (*P. edulis-Juniperus monosperma*) woodland, (4) juniper savannah, and (5) mixed conifer forest (Douglas fir [*Pseudotsuga menziesii*], ponderosa pine, and white fir [*Abies concolor*]) (DOE 2008c). The GTCC reference location at LANL would be located mostly within the pinyon-juniper woodland, although a portion might be located within the ponderosa pine forest zone. More than 900 species of plants occur on LANL. About 150 of them are nonnative plants (DOE 1999a). Exotic plant species of concern on LANL include salt-cedar (*Tamarix ramosissima*), tree-of-heaven (*Ailanthus altissima*), cheatgrass (*Bromus tectorum*) and Russian thistle (*Salsola kali*) (DOE 1999a). The vegetation that is planted as disposal pits are closed includes native grasses, such as blue grama grass (*Bouteloua gracilis*), buffalo grass (*Bouteloua dactyloides*), western wheatgrass (*Pascopyrum smithii*), and dropseed (*Sporobolus* spp.), as well as alfalfa (*Medicago sativa*) (Shuman et al. 2002).

Most wetlands in the LANL area are associated with canyon stream channels or occur on mountains or mesas as isolated meadows containing ponds or marshes, often associated with springs or seeps (DOE 2008c). About 14 ha (34 ac) of wetlands have been identified within LANL, and about 6.1 ha (15 ac) of these occur within Pajarito Canyon (DOE 2008c). Lake-associated wetlands occur at Cochiti Lake and near LANL Fenton Hill site (TA-57), while spring-associated wetlands occur within White Rock Canyon (DOE 1999a). No wetlands occur in the TA-54 area, although wetlands and floodplains exist in the lower portion of Pajarito Canyon.

American Indian Text

A Pueblo Writers' GTCC site visit and a draft LANL LLRW study for Area G documented the presence of the following plants:

Plants from LLRW Areas	Listed in Area G LLRW Study	Observed by Pueblo Writer's Group
Blue Grama (*Bouteloua gracilis*)	X	P
Indian Rice Grass (*Achnatherum hymenoides*)		P
Cutleaf evening primrose (*Oenothera caespitosa*	X	
Mullein Amaranth (*Verbascum thapsus*)	X	P
Indian Paintbrush (*Castilleja* sp.)		P
4-o'Clock (*Mirabilis jalapa*)		P
Narrowleaf Yucca (*Yucca angustissima*)	X	P
Penstemon spp.		P
Prickly Pear (*Opuntia polyacantha*)	X	P
Small Barrel (*Sclerocactus*)		P
Sunflower (*Helianthus petiolaris*)	X	P
Apache Plume (*Fallugia paradoxa*)	X	P
Big Sage (*Artemisia tridentada*)	X	P
Chamisa (*Ericamerica nauseosa* ssp. *nauseosa* var. *nauseosa*)	X	P
Four-Wing Saltbush (*Atriplex canescens*)	X	P
Mountain Mahogany (*Cercocarpus montanus*)	X	
New Mexico Locust (*Robinia neomexicana*)	X	
Oak (*Quercus* spp.)	X	
Snakeweed (*Guiterrezia sarathrae*)	X	
Squawberry (*Rhus trilobata*)	X	
Wax Currant (*Ribes cereum*)	X	
Wolfberry (*Lycium barbarum*)		P
One-Seed Juniper (*Juniperus monosperma*)	X	P
Pinon Pine (*Pinus edulis*)	X	P
Ponderosa Pine (*Pinus ponderosa*)	X	P

While a full list of the traditional use animals was not available at the time of this analysis, a recent study conducted on the adjacent Bandelier National Monument identified 76 Pueblo use animals there. The use animals represent 76% of the animals on the official animal inventory.

American Indian Text

Pueblo People know that they have many traditional plants and animals located on and near to the GTCC proposal area. During a brief visit to the proposed GTCC site, Pueblo EIS writers identified traditional use plants, which include medicinal, ceremonial, and domestic use plants. These plants were identified in a brief period and it was noted that many plants could be identified were a full ethnobotany of the site to be conducted. During this site visit the Pueblo EIS writers identified the presence of traditional animals, but noted that more could easily be identified during a full ethnozoological study.

While a full list of the traditional use plants was not available at the time of this analysis, a recent study conducted on the adjacent Bandelier National Monument identified 205 Pueblo use plants there. These use plants represent 59% of the known plants on the official plant inventory of Bandelier.

American Indian Text

A Pueblo GTCC site visit and a LANL LLRW study for Area G documented the presence of the following animals: Deer; Elk; Lizards; Harvester Ants; Rattlesnake; Cicadas; Mocking Bird; Pocket Mice and Kangaroo Rats; Pocket Gophers; Chipmunks and Ground Squirrels.

Only about 5% of LANL is developed and unavailable for use by wildlife (e.g., due to security fencing) (DOE 2008c). Within LANL, 57 species of mammals, 200 species of birds, and 37 species of reptiles and amphibians have been reported (DOE 2008c). Mammals that occur in the area of the GTCC reference location (e.g., Pajarito Plateau) include a number of rodent species (e.g., North American deermouse, pinyon mouse [*Peromyscus truei*], western harvest mouse [*Reithrodontomys megalotis*], brush mouse [*P. boylii*], silky pocket mouse [*Perognathus flavus*], Colorado chipmunk [*Tamias quadrivittatus*], and woodrats [*Neotoma* spp.]), mountain cottontail (*Sylvilagus nuttallii*), mule deer (*Odocoileus hemionus*), elk (*Cervus elaphus*), American black bear (*Ursus americanus*), mountain lion (*Puma concolor*), bobcat (*Lynx rufus*), gray fox (*Urocyon cinereoargenteus*), and coyote (*Canis latrans*). Common bird species include Cassin's kingbird (*Tyrannus vociferans*), cliff swallow (*Petrochelidon pyrrhonota*), ash-throated flycatcher (*Myiarchus cinerascens*), and brown-headed cowbird (*Molothrus ater).* Common reptile species include fence lizard (*Sceloporus undulatus*), plateau striped whiptail (*Cnemidophorus velox*), gophersnake (*Pituophis catenifer*), and terrestrial garter snake (*Thamnophis elegans*) (DOE 1999a; Shuman et al. 2002).

The streams on LANL drain into the Rio Grande, the major aquatic habitat in the area of LANL. Many of the streams on LANL are intermittent and flow in response to precipitation or snowmelt. Of the 140 km (85 mi) of water courses on LANL, about 3.2 km (2 mi) are naturally occurring perennial streams and another 5 km (3 mi) are perennial waters supported by supplemental wastewater discharge flows (DOE 1999a). No fish species have been reported within LANL boundaries (DOE 2008c).

The federally and state-listed species identified on or in the immediate vicinity of LANL are listed in Table 8.1.5-1. DOE and LANL coordinate with the USFWS and New Mexico Department of Game and Fish to locate and conserve these species (DOE 2008c). LANL has developed a *Threatened and Endangered Species Habitat Management Plan* (LANL 1998) whose goals are to (1) develop a comprehensive management plan that protects undeveloped portions of LANL that are suitable or potentially suitable habitat for threatened or endangered species, while allowing current operations to continue and future development to occur with a minimum of project or operational delays or additional costs related to protecting species or their habitats; (2) facilitate DOE compliance with the Endangered Species Act and related federal regulations by protecting and aiding in the recovery of threatened or endangered species; and (3) promote good environmental stewardship by monitoring and managing threatened and endangered species and their habitats using sound scientific principles. The plan identifies areas of environmental interest for federally listed species that have suitable habitat within LANL. In 1998, these species included the peregrine falcon (*Falco peregrinus*), Mexican spotted owl (*Strix occidentalis lucida*), Southwestern willow flycatcher (*Empidonax traillii extimus*), and

TABLE 8.1.5-1 Federally and State-Listed Threatened, Endangered, and Other Special-Status Species on or in the Immediate Vicinity of LANL

Common Name (Scientific Name)	Status[a] Federal/State
Plants	
Santa Fe stickyleaf *(Mentzelia springeri)*	-/SSC
Sapello Canyon larkspur *(Delphinium sapellonis)*	-/SSC
Wood lily (*Lilium philadelphicum* L. var. *anadinum*)	-/SE
Yellow lady's slipper orchid (*Cyripedium parviflorum* var. *pubescens*)	-/SE
Insects	
New Mexico silverspot butterfly (*Speyeria nokomis nitocris*)	SC/-
Fish	
Rio Grande chub (*Gila pandora*)	-/SS
Amphibians	
Jemez Mountain salamander (*Plethodon neomexicanus*)	SC/ST
Birds	
American peregrine falcon (*Falco peregrinus anatum*)	SC/ST
Arctic peregrine falcon (*Falco peregrinus tundrius*)	SC/ST
Bald eagle (*Haliaeetus leucocephalus*)	-/ST
Gray vireo (*Vireo vicinior*)	-/ST
Loggerhead shrike (*Lanius ludovicianus*)	-/SS
Mexican spotted owl (*Strix occidentalis lucida*)	T/SS
Northern goshawk (*Accipiter gentilis*)	SC/SS
Southwestern willow flycatcher (*Empidonax traillii extimus*)	E/SE
Yellow-billed cuckoo (*Coccyzus americanus*)	C/SS
Mammals	
Big free-tailed bat (*Nyctinomops macrotis*)	-/SS
Black-footed ferret (*Mustela nigripes*)	E/-
Fringed myotis (*Myotis thysanodes*)	-/SS
Goat Peak pika (*Ochotona princeps saxatilis*)	SC/SS
Long-eared myotis (*Myotis* evotis)	-/SS
Long-legged myotis (*Myotis volans*)	-/SS
New Mexico meadow jumping mouse (*Zapus hudsonius luteus*)	SC/ST
Ringtail (*Bassariscus astutus*)	-/SS
Spotted bat (*Euderma maculatum*)	-/ST
Townsend's big-eared bat (*Plecotus townsendii*)	SC/SS
Western small-footed myotis (*Myotis ciliolabrum*)	-/SS
Yuma myotis (*Myotis yumanensis*)	-/SS

Footnote on next page.

TABLE 8.1.5-1 (Cont.)

[a] C (candidate): A species for which the USFWS or NOAA Fisheries has on file sufficient information on biological vulnerability and threats to support a proposal to list as endangered or threatened.

E (endangered): A species in danger of extinction throughout all or a significant portion of its range.

SC (species of concern): An informal term referring to a species that might be in need of conservation action. This may range from a need for periodic monitoring of populations and threats to the species and its habitat, to a need for listing as threatened or endangered. Such species receive no legal protection under the Endangered Species Act, and use of the term does not necessarily imply that a species will eventually be proposed for listing.

SE (state endangered): An animal species or subspecies whose prospects of survival or recruitment in New Mexico are in jeopardy; or a plant species that is listed as threatened or endangered under the Endangered Species Act, or is considered proposed under the Act, or is a rare plant across its range within New Mexico, and of such limited distribution and population size that unregulated taking could adversely impact it and jeopardize its survival in New Mexico.

SS (state sensitive): Species that, in the opinion of a qualified New Mexico Department of Game and Fish biologist, deserve special consideration in management and planning and are not listed as threatened or endangered by the state of New Mexico.

SSC (state species of concern): A New Mexico plant species that should be protected from land use impacts when possible because it is a unique and limited component of the regional flora.

ST (state threatened): A native species likely to be classified as state endangered within the foreseeable future throughout all or a significant portion of its New Mexico range.

T (threatened): A species likely to become endangered within the foreseeable future throughout all or a significant portion of its range.

-: Not listed.

Source: DOE (2008c)

bald eagle (*Haliaeetus leucocephalus*). (The peregrine falcon and bald eagle have since been delisted.) These areas of environmental interest consist of core areas that contain important breeding or wintering habitat and buffer areas that protect the core area from disturbance (LANL 1998).

8.1.6 Socioeconomics

The socioeconomic data for LANL describe an ROI surrounding the site composed of three counties: Los Alamos County, Rio Arriba County, and Santa Fe County in New Mexico. More than 85% of LANL workers reside in these counties (DOE 2008c).

8.1.6.1 Employment

In 2011, total employment in the ROI stood at 97,095 (U.S. Department of Labor 2012). Employment grew at an annual average rate of –0.1% between 2002 and 2011. The economy of the ROI is dominated by the trade and service industries, with employment in these activities currently contributing more than 91% of all employment (see Table 8.1.6-1). LANL is one of the largest institutions in northern New Mexico and has more than 12,500 employees, including laboratory, protective force, and support contractor personnel (LANL 2012).

8.1.6.2 Unemployment

Unemployment rates have varied across the counties in the ROI (Table 8.1.6-2). Over the 10-year period 2002–2011, the average rate in Rio Arriba County was 6.4%, with lower rates in Santa Fe County (4.5%) and Los Alamos County (2.7%). The average rate in the ROI over this period was 4.7%, lower than the average rate for the state of 5.7%. Unemployment rates for 2011 were slightly lower than rates for 2010; in Los Alamos County, the unemployment rate fell from 3.3% to 3.2%, while in Santa Fe County, the rate declined from 6.5% to 6.0%. However, in Rio Arriba County, the unemployment rate increased slightly from 8.2% to 8.3% from 2010 to 2011. The ROI fell from 6.5% to 6.2%, and in the state, it fell from 7.9% to 7.4% during this period.

TABLE 8.1.6-1 LANL: County and ROI Employment by Industry in 2009

	New Mexico				
Sector	Los Alamos County	Rio Arriba County	Santa Fe County	ROI Total	% of ROI Total
Agriculture[a]	0	1,231	429	1,660	2.3
Mining	10	32	60	102	0.1
Construction	183	413	2,874	3,470	4.8
Manufacturing	40	175	764	979	1.4
Transportation and public utilities	10	810	652	1,472	2.0
Trade	493	1,467	10,668	12,628	17.5
Finance, insurance, and real estate	452	452	2,930	3,686	5.1
Services	16,277	16,277	28,005	48,260	67.0
Other	0	0	2	2	0.0
Total	17,465	8,202	46,393	72,060	

[a] USDA (2008).

Source: U.S. Bureau of the Census (2012a)

TABLE 8.1.6-2 LANL: Average County, ROI, and State Unemployment Rates (%) in Selected Years

Location	2002–2011	2010	2011
Los Alamos County	2.7	3.3	3.1
Rio Arriba County	6.4	8.2	8.3
Santa Fe County	4.5	6.5	6.0
ROI	4.7	6.5	6.2
New Mexico	5.7	7.9	7.4

Source: U.S. Department of Labor (2012)

8.1.6.3 Personal Income

Personal income in the ROI stood at almost $8.9 billion in 2009, having grown at an annual average rate of growth of 2.4% over the period 2000–2009 (Table 8.1.6-3). ROI personal income per capita also rose over the same period and reached $43,195 in 2009, compared to $38,241 in 2000. Per-capita incomes were much higher in Los Alamos County ($62,842 in 2009) than elsewhere in the ROI.

8.1.6.4 Population

The population of the ROI in 2010 stood at 202,366 (U.S. Bureau of the Census 2012b) and was expected to reach 205,277 by 2012 (Table 8.1.6-4). In 2010, 144,170 people were living in Santa Fe County (71% of the ROI total), and 40,246 people resided in Rio Arriba County. Over the period 2000–2010, the population in the ROI as a whole grew slightly, with an average growth rate of 0.7%, with moderate growth occurring in Santa Fe County (1.1%) and slight declines in population elsewhere. The population in New Mexico as a whole grew at a rate of 1.2% over the same period.

8.1.6.5 Housing

Housing stock in the ROI as a whole grew at an annual rate of 1.7% over the period 2000–2010 (Table 8.1.6-5). A total of 18,605 new units were added to the existing housing stock in the ROI between 2000 and 2010. There were 13,865 vacant housing units in the ROI in 2010, of which 3,923 were rental units that could be available to construction workers at the GTCC proposed facility.

TABLE 8.1.6-3 LANL: County, ROI, and State Personal Income in Selected Years

Income	2000	2009	Average Annual Growth Rate (%), 2000–2009
Los Alamos County			
Total personal income (2011 $ in billions)	1.0	1.1	1.2
Personal income per capita (2011 $)	55,635	62,842	1.4
Rio Arriba County			
Total personal income (2011 $ in billions)	1.0	1.2	2.3
Personal income per capita (2011 $)	23,293	28,958	2.4
Santa Fe County			
Total personal income (2011 $ in billions)	5.2	6.6	2.6
Personal income per capita (2011 $)	40,535	44,713	1.1
ROI total			
Total personal income (2011 $ in billions)	7.2	8.9	2.4
Personal income per capita (2011 $)	38,241	43,195	1.4
New Mexico			
Total personal income (2011 $ in billions)	54.1	70.1	2.9
Personal income per capita (2011 $)	29,748	34,880	1.8

Source: DOC (2012)

TABLE 8.1.6-4 LANL: County, ROI, and State Population in Selected Years

Location	1990	2000	2010	Average Annual Growth Rate (%), 1990–2006	2012[a]
Los Alamos County	18,115	18,343	17,950	–0.2	17,872
Rio Arriba County	34,365	41,190	40,246	–0.2	40,060
Santa Fe County	98,928	129,292	144,170	1.1	147,345
ROI	151,408	188,825	202,366	0.7	205,277
New Mexico	1,515,069	1,819,046	2,059,179	1.2	2,110,883

[a] Argonne National Laboratory projections.

Source: U.S. Bureau of the Census (2012b)

TABLE 8.1.6-5 LANL: County and ROI Housing Characteristics in Selected Years

Type of Housing	2000	2010
Los Alamos County		
Owner occupied	5,894	5,828
Rental	1,603	1,835
Vacant units	440	691
Total units	7,937	8,354
Rio Arriba County		
Owner occupied	12,281	12,528
Rental	2,763	3,240
Vacant units	2,972	3,870
Total units	18,016	19,638
Santa Fe County		
Owner occupied	35,985	42,878
Rental	16,497	19,085
Vacant units	5,219	9,304
Total units	57,701	71,267
ROI total		
Owner occupied	54,160	61,234
Rental	20,863	24,160
Vacant units	8,631	13,865
Total units	83,654	99,259

Source: U.S. Bureau of the Census (2012b)

8.1.6.6 Fiscal Conditions

Construction and operations of a GTCC LLRW and GTCC-like waste disposal facility could result in increased expenditures for local government jurisdictions, including counties, cities, and school districts. Revenues to support these expenditures would come primarily from state and local sales tax revenues associated with employee spending during construction and operations and would be used to support additional local community services currently provided by each jurisdiction. Table 8.1.6-6 presents information on expenditures by the various jurisdictions and school districts.

8.1.6.7 Public Services

Construction and operations of a GTCC LLRW and GTCC-like waste disposal facility could require increases in employment in order to provide public safety, fire protection, and community and educational services in the counties, cities, and school districts likely to host

TABLE 8.1.6-6 LANL: County, ROI, and State Public Service Expenditures in 2006 ($ 2011 in millions)[a]

Location	Jurisdiction	School District
Los Alamos County	44.6	21.0
Rio Arriba County	13.5	32.7
Santa Fe County	102.1	68.0
ROI total	160.2	121.6
New Mexico	753.6	2,789

[a] Argonne National Laboratory projections.

relocating construction workers and operations employees. Additional demand could also be placed on local physician services. Table 8.1.6-7 presents data on employment and levels of service (number of employees per 1,000 population) for public safety and general local government services. Table 8.1.6-8 provides data on staffing and levels of service for school districts. Table 8.1.6-9 does the same for the medical field.

8.1.7 Environmental Justice

Figures 8.1.7-1 and 8.1.7-2 and Table 8.1.7-1 show the minority and low-income compositions of the total population located in the 80-km (50-mi) buffer around LANL from Census data for the year 2010 and from CEQ guidelines (CEQ 1997). Persons whose incomes fall below the federal poverty threshold are designated as low income. Minority persons are those who identify themselves as Hispanic or Latino, Asian, Black or African American, American Indian or Alaska Native, Native Hawaiian or other Pacific Islander, or multi-racial (with at least one race designated as a minority race under CEQ). Individuals identifying themselves as Hispanic or Latino are included in the table as a separate entry. However, because Hispanics can be of any race, this number includes individuals who also identified themselves as being part of one or more of the population groups listed in the table. The most affected population in the 80-km (50-mi) assessment area could be the adjacent Pueblos.

TABLE 8.1.6-7 LANL: County, ROI, and State Public Service Employment in 2009

	Los Alamos County		Rio Arriba County		Santa Fe County	
Type of Service	No.	Level of Service[a]	No.	Level of Service[a]	No.	Level of Service[a]
Police protection	NA[b]	NA	22	0.5	79	0.5
Fire protection[c]	117	6.5	1	0.0	165	1.1

	ROI		New Mexico[d]	
Type of Service	No.	Level of Service[a]	No.	Level of Service[a]
Police protection	101	0.5	3,882	2.0
Fire protection[c]	283	1.4	2,121	1.1

[a] Level of service represents the number of employees per 1,000 persons in each county.

[b] NA: not available

[c] Does not include volunteers.

[d] 2006 data.

Sources: U.S. Bureau of the Census (2008 a,b; 2012b,c); FBI (2012); Fire Departments Network (2012)

TABLE 8.1.6-8 LANL: County, ROI, and State Education Employment in 2011

Location	No. of Teachers	Level of Service[a]
Los Alamos County	251	13.5
Rio Arriba County	436	14.3
Santa Fe County	977	16.3
ROI	1,665	15.4
New Mexico	22,457	14.8

[a] Level of service represents the number of teachers per 1,000 persons in each county.

Sources: National Center for Educational Statistics (2012); U.S. Bureau of the Census (2012b,c)

TABLE 8.1.6-9 LANL: County, ROI, and State Medical Employment in 2010

Location	No. of Physicians	Level of Service[a]
Los Alamos County	71	4.0
Rio Arriba County	49	1.2
Santa Fe County	661	4.6
ROI	781	3.9
New Mexico[b]	4,421	2.3

[a] Level of service represents the number of physicians per 1,000 persons in each county.

[b] 2006 data.

Sources: AMA (2012); U.S. Bureau of the Census (2008b, 2012b)

FIGURE 8.1.7-1 Minority Population Concentrations in Census Block Groups within an 80-km (50-mi) Radius of the GTCC Reference Location at LANL (Source: U.S. Bureau of the Census 2012b)

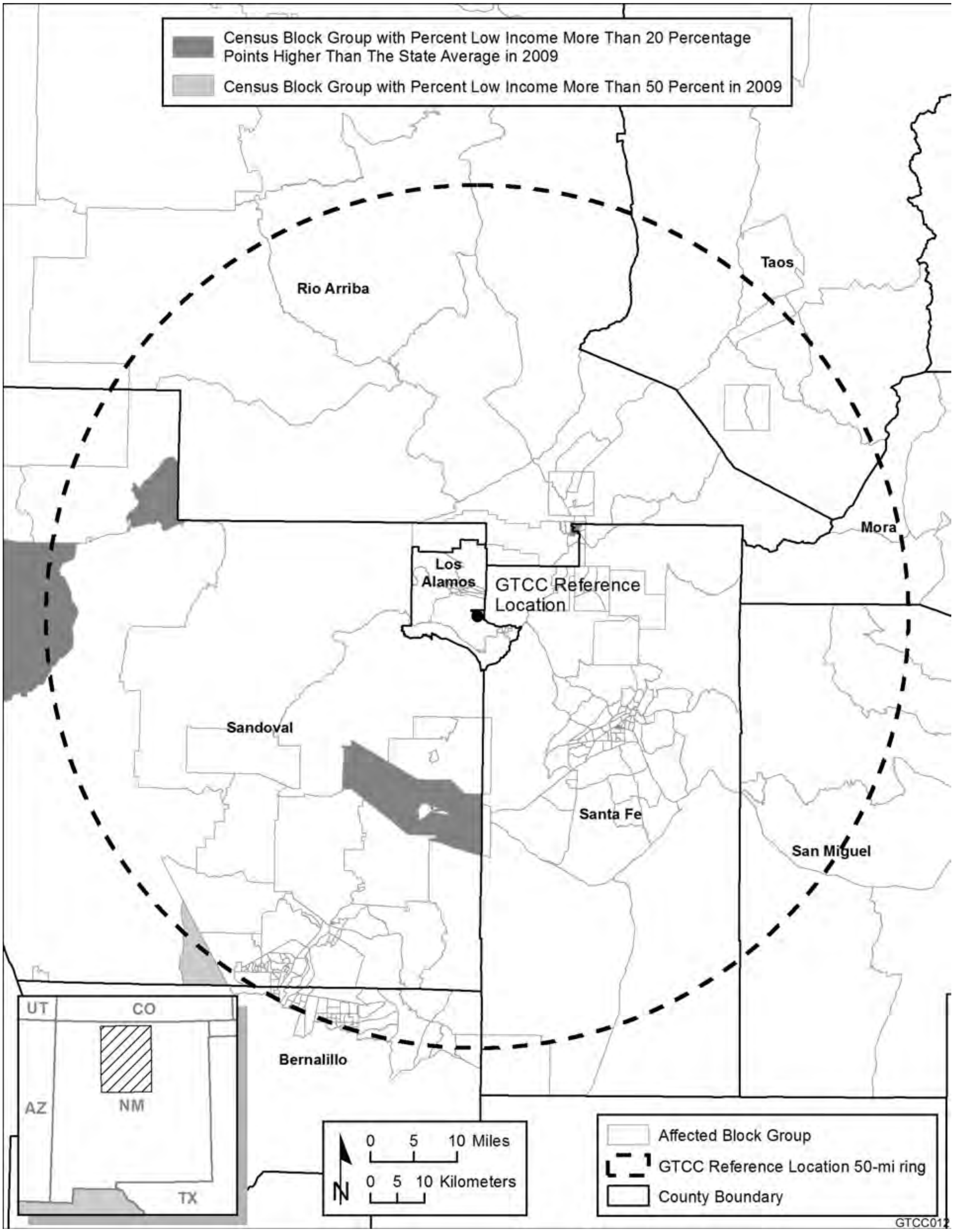

FIGURE 8.1.7-2 Low-Income Population Concentrations in Census Block Groups within an 80-km (50-mi) Radius of the GTCC Reference Location at LANL (Source: U.S. Bureau of the Census 2012b)

TABLE 8.1.7-1 Minority and Low-Income Populations within an 80-km (50-mi) Radius of LANL

Population	New Mexico Block Groups
Total population	454,879
White, non-Hispanic	210,995
Hispanic or Latino	196,394
Non-Hispanic or Latino minorities	47,490
One race	40,784
Black or African American	5,389
American Indian or Alaskan Native	25,509
Asian	8,499
Native Hawaiian or other Pacific Islander	269
Some other race	1,118
Two or more races	6,706
Total minority	243,884
Percent minority in 80-km (50-mi) buffer	53.6%
Percent minority in New Mexico	59.5%
Low-income	17,933
Percent low-income in 80-km (50-mi) buffer	10.6%
Percent low-income in New Mexico	18.0%

Source: U.S. Bureau of the Census (2012b)

American Indian Text

There are two major power transmission lines, the Norton and Reeves Power lines, which exist on both mesas that are considered by the proposed GTCC. One line goes through GTCC Zone 6 and the other through GTCC North Side and North Side Expanded. These major district power lines occupy the centers of both mesas and greatly reduce the potential areas of the GTCC. Along both lines are a series of Pueblo archaeology sites, which are currently signed as restricted access areas protected under the National Historic Protection Act.

A large number of minority and low-income individuals are located in the 50-mi (80-km) area around the boundary of the reference location. Within the 50-mi (80-km) radius, 53.6% of the population is classified as minority, while 10.6% is classified as low income. Although the number of minority individuals does not exceed the state average by 20 percentage points or more, the number of minority individuals exceeds 50% of the total population in the area; that is, there is a minority population in the 50-mi (80-km) area as a whole based on 2010 Census data and CEQ guidelines. The number of low-income individuals does not exceed the state average by 20 percentage points or more and does not exceed 50% of the total population in the area; that is, there are no low-income populations in the 50-mi (80-km) area around the reference location as a whole.

American Indian Text

As Indian peoples culturally affiliated with land currently occupied by LANL, the Pueblo people would like to expand the definition of Environmental Justice so that it reflects the unique burdens borne by them. This definition is defined more fully below.

Pueblo people and their lands have been encroached upon by Europeans since the 1500s. During this time they have experienced loss of control over many aspects of their lives including (1) loss of traditional lands, (2) damage to Sacred Home Lands, (3) negative health effects due to European diseases and shifting diet, and (4) lack of access to traditional places. Negative encroachments that occurred during the Spanish period were continued after 1849 under the United States of America's federal government. The removal of lands for the creation of LANL in 1942 were a major event causing great damage to Pueblo peoples. Resulting pollution to the natural environment and ground disturbances from LANL activities constitute a base-line of negative Environmental Justice impacts. The GTCC proposal needs to be assessed in terms how it would continue these Environmental Justice impacts and thus further increase the differential emotional, health, and cultural burdens borne by the Pueblo peoples.

The Congress of the United States recognized this violation of their human, cultural, and national rights when the American Indian Religious Freedom Act (AIRFA) was passed in 1978. In the AIRFA legislation Congress told all Federal agencies to submit plans which would assure they would no longer violate the religious freedom of American Indian peoples. Subsequent legislation like the Native American Graves Protection and Repatriation Act (NAGPRA) and Executive Order 13007 – Sacred Sites Access have further defined their rights to Sacred Home Lands and traditional resources. The Federal Government also has a Trust Responsibility to American Indian peoples which is recognized in the DOE American and Alaska Native policy (http://www.em.doe.gov/pages/emhome.aspx). Environmental Justice is one point of analysis where these concerns can be expressed by Pueblo peoples and the obligations addressed by Federal Agencies during the NEPA EIS process.

Pueblo people believe that their health has been adversely affected by LANL operations including different types of cancers. These concerns were publicly recorded in videos produced with Closing the Circle grants provided by the National Park Service and the DOE. Documentation of these adverse health affects is difficult because post-mortem analysis is not normal due to cultural rules regarding the treatment of the deceased and burial practices.

8.1.8 Land Use

The GTCC reference location is situated in three undeveloped and relatively undisturbed areas within TA-54 on Mesita del Buey: Zone 6, North Site, and North Site Expanded (Figure 1.4.3-6). Zone 6 is slightly less than 7 ha (17 ac) in area. It is not fenced, but access is controlled by staffed vehicle access portals on Pajarito Road. The total area of the North Site is about 16 ha (39 ac). The North Site Expanded section adds another 23 ha (57 ac). The primary function of TA-54 is the management of radioactive and hazardous chemical wastes. Its northern border coincides with the boundary between LANL and the Pueblo de San Ildefonso; its southeastern boundary borders the community of White Rock (LANL 2008).

LANL covers 10,360 ha (25,600 ac) and is divided into 48 technical areas or TAs. Developed areas make up only a small portion of LANL as a result of the physical constraints of the geological setting, such as steep slopes and canyons. No agriculture occurs on LANL (DOE 2008c). The GTCC reference location would be situated within TA-54 (Figure 8.1-1).

The land use categories at LANL include service and support, experimental science, R&D on high explosives, testing of high explosives, R&D on nuclear materials, physical and technical support, public and corporate interface, reserve (areas not otherwise included within other categories and that may include environmental core and buffer areas, vacant land, and proposed land transfer areas), theoretical and computational science, and waste management (DOE 2008c). The land use categories within TA-54 are (1) reserve and (2) waste management (areas that provide for activities related to handling, treatment, and disposal of all generated solid, liquid, and hazardous waste products [chemical, radiological, and explosive]). During the late 1950s, LANL, with the approval of the AEC and upon recommendation of the USGS, selected TA-54 for underground disposal of LANL-derived waste. Since that time, TA-54 has functioned as a major storage and disposal facility, with some treatment permitted for wastes generated by LANL operations (DOE 2008c).

LANL was designated as a NERP in 1977. The 405-ha (1,000-ac) White Rock Canyon Reserve, located on the southeast perimeter of LANL, was dedicated in 1999. The reserve is jointly managed by DOE and the National Park Service (NPS) for its significant ecological and cultural resources and research potential (DOE 2008c).

Communities in the region are generally small, supporting residential, commercial, light industrial, and recreational land uses. American Indian tribal communities also occur in the area, with the lands of the Pueblo de San Ildefonso sharing LANL's eastern border. The largest nearby city is Santa Fe, the state capital, which has a population of about 70,000 (2009).

Land stewards that determine the land uses within the LANL region include DOE, USFS, NPS, the county of Los Alamos, private land owners, the state of New Mexico, the Pueblos, the Bureau of Indian Affairs, and BLM (DOE 2008c). The Santa Fe National Forest lands adjacent to LANL support multiple activities. Bandelier National Monument has only a small portion that is developed for visitors; about 70% of the main unit, which is located immediately south of LANL, has been designated as a Wilderness Area.

8.1.9 Transportation

SR 502 and SR 4 are the only two major roads that access Los Alamos County, and the traffic volume on these two segments of highway is primarily associated with LANL activities. SR 502 passes along the northern border of the site, connecting to US 84 north of Santa Fe. SR 4 borders the eastern edge of LANL, starting from SR 502 going southward, passing through the community of White Rock and then eventually looping through the southern portion of the site, separating it from Bandelier National Monument. SR 4 passes along the site's southwestern border on its way to Jemez Springs and intersects the junction with West Jemez Road (S 501) near TA-16.

American Indian Text

Pueblo people note that all waste shipments move by highway. There are no local railroads. Pueblo people believe that GTCC waste shipments will adversely impact natural resources, reservation communities, tribal administration activities, public schools, day schools, and businesses located along Highway 502 and Highway 84/285.

The Pueblo of Nambe is located on Highway 84/285 between the Pueblos of Pojoaque and Tesuque. The Pueblo of Nambe is located on the Rio Nambe, which joins the Rio Grande a few miles downstream. The Rio Nambe is the major water source for the Pueblo. Nambe Falls is on the reservation is an eco-tourism destination. Also on the reservation is Nambe Lake, which is used for irrigation of fields (crops) and recreation. Nambe has established several businesses on Highway 84/285, such as the Nambe Pueblo Development Corporation, Nambe Falls Travel Center, Hi-Tech, and many more businesses are planned for this location. New businesses include a water bottling factory, a housing complex, and solar and wind energy projects.

The Pueblo of Nambe raises the issue of security. The Pueblo government wants to know when radioactive waste is being transported past the reservation lands. We have a “need to know” and this information should be provided to appropriate tribal authorities such as First Responders and Emergency Managers. The tribes with Indian Land on transportation routes should be funded by the DOE to train their own radiation monitor teams, to maintain capability for their own safety and to protect sovereign immunity of Native American Tribes as independent Nations within the United States. This would enable tribes to be effective participants in handling hazards and threats as mandated by US. Department of Homeland Security in the “Metrics for Tribes” to be compliant with NIMS. Tribes should be able to participate in the preparations of waste materials for transportation at DOE sites. This participation/observation would give Tribes confidence that proper packing techniques and guidelines are adhered to. Currently Tribes are expected to “trust” that State and Federal authorities are doing this phase properly. The Indian people will feel more comfortable if we have some role in observing the process/procedures particularly if our observers are properly trained to understand the scientific reasons associated with packaging methodology.

The Pueblo of Nambe wants to monitor the transportation of GTCC materials in the same way that transuranic waste is monitored on its route from LANL to WIPP site at Carlsbad.

The Pueblo of Santa Clara is traversed by NM 30. Near this road are tribal residential areas, tribal businesses, schools, and economic developments. This highway is not an alternate route for radioactive waste hauling. A violation of this rule occurred in 2006 when three semi-trailer trucks loaded with radioactive soils from LANL were seen using NM30 as a short-cut route (they should have remained on NM 502) Drivers had disregarded tribal regulations. A tribal representative caught up with them nearby and recorded the violation.

Other Pueblo people have business and tribal resources along potential transportation routes. The Pueblo de San Ildefonso, for example, is concerned about radioactive waste transportation along Highway 502. The Totavi Business Plaza, is an area that was traditionally occupied, and is now a restaurant and gas station and may be a location for new tribal housing. The Pueblo de San Ildefonso youth attend a Day School, a District High School, Middle School, and Elementary Schools along 502. Pojoaque has a business park and two gas stations along 502 and 84/285 as well as their youth attend these schools.

Hazardous and radioactive material shipments leave or enter LANL from East Jemez Road to SR 4 to SR 502. East Jemez Road, as designated by the State of New Mexico and governed by 49 CFR 177.825, is the primary route for the transportation of hazardous and radioactive materials. The average daily traffic flows at LANL's main access points are presented in Table 8.1.9-1.

The primary route designated by the State of New Mexico to be used for radioactive and other hazardous material shipments to and from LANL is the approximately 64-km (40-mi) corridor between LANL and I-25 at Santa Fe (DOE 2006). This route passes through the Pueblo de San Ildefonso, and the Pueblos of Pojoaque, Nambe, and Tesuque and is adjacent to the northern segment of Bandelier National Monument. This primary transportation route bypasses the city of Santa Fe on SR 599 to I-25. SR 599, the Santa Fe bypass, was built and funded by DOE primarily to convey LANL WIPP trucks around Santa Fe.

Motor vehicles are the primary means of transportation to LANL. The nearest commercial rail connection is at Lamy, New Mexico, 83 km (52 mi) southeast of LANL. The New Mexico Rail Runner commuter rail service operates between Santa Fe and Albuquerque. It uses the ROW and new tracks where there was previously a spur into central Santa Fe (the spur is still used by the Santa Fe Southern Railway for some freight and a tourist railroad). LANL does not currently use rail transport for commercial shipments. However, a recently completed supplement analysis to the 2008 SWEIS evaluated rail for shipping wastes off-site to Clive, Utah (DOE 2009a).

Most commuter traffic originates from within or east of Los Alamos County (Rio Grande Valley and Santa Fe) because a large number of LANL employees live in these areas (DOE 2006). A small number of LANL employees commute to LANL from the west along SR 4. The average weekday traffic volumes at various points in the vicinity of SR 502 and SR 4 measured in September 2004 are presented in Table 8.1.9-2. The intersection that serves all of TA-54 on Mesita del Buey is substandard and needs to be improved to comply with modern traffic engineering safety standards and would not support the activities proposed in this EIS. Upgrades to this intersection would be required (Werdel 2010).

TABLE 8.1.9-1 Main Access Points at LANL[a]

Location	Average No. of Daily Vehicle Trips
Diamond Drive across the Los Alamos Canyon Bridge	24,545
Pajarito Road at SR 4	4,984
East Jemez Road at SR 4	9,502
West Jemez Road at SR 4	2,010
DP Road at Trinity Drive	1,255
Total	42,296

[a] Source: DOE (2006)

TABLE 8.1.9-2 Average Weekday Traffic Volumes in the Vicinity of State Routes 502 and 4

Location	Average No. of Daily Vehicle Trips
Eastbound on SR 502, east of the intersection with SR 4	10,100
Westbound on SR 502, east of the intersection with SR 4	7,765
Eastbound on SR 502, west of the intersection of SR 502 and SR 4	6,540
Westbound on SR 502, west of the intersection of SR 502 and SR 4	4,045
Westbound on SR 4, between East Jemez Road and the SR 502/4 intersection	6,505
Eastbound on SR 4, between East Jemez Road and the SR 502/4 intersection	6,665
Transition road from northbound SR 4 to eastbound SR 502	5,170
Transition road from eastbound SR 502 to southbound SR 4	1,610

Source: DOE (2006)

Park-and-ride services are provided by a commercial corporation in conjunction with the New Mexico State Highway and Transportation Department. More than 80 daily departures between Santa Fe and Española, between Santa Fe and Los Alamos, between Española and Los Alamos, between Albuquerque and Santa Fe, and between Albuquerque and Los Alamos are provided for commuters (DOE 2006). Monthly passes are sold for use of most park-and-ride routes. Los Alamos County operates Atomic City Transit with five weekday no-fare routes. The transit center at LANL is located in TA-3.

8.1.10 Cultural Resources

LANL's foundation was associated with the development of the first atomic bomb during World War II. The Laboratory's mission continues to be national security. LANL also has a strong stewardship role over the facilities it has used for the last 60 years and is managing the contamination that resulted from years of experiments. Management of cultural resources at LANL is the ultimate responsibility of DOE's NNSA. Since 2006, operations at LANL have been managed for DOE by Los Alamos National Security LLC.

The management of cultural resources at LANL is guided by several documents and plans. The first is a PA among DOE, the ACHP, New Mexico SHPO, and Los Alamos County. In addition, a mitigation action plan was developed as part of the 1999 SWEIS to aid in the future operation of LANL. This plan outlines the process and procedures for considering cultural resources during operations. LANL developed an integrated natural and cultural resources management plan in 2002. In 1992, LANL and DOE signed accords with four pueblos (Pueblo of Jemez, Cochiti Pueblo, Pueblo de San Ildefonso, and Santa Clara Pueblo) to facilitate communication on cultural issues.

Evidence of prehistoric people goes back to 9500 B.C. in north central New Mexico. Archaeological evidence at LANL shows extensive use of the region beginning in the Archaic period (roughly 5500 B.C.) through the Ancestral Pueblo Classic period (around A.D. 1600). There is no archaeological evidence for agriculturalists on the LANL Plateau during the Archaic period (5500 B.C. to A.D. 600). Between A.D. 900 and A.D. 1150, agriculturalists expanded up the Rio Grande Valley. Pithouses persisted in some places, but sites are typically small adobe and masonry structures that are found at a wide range of elevations. There are only about 10 sites that date to this time period at LANL. These sites consist of artifact scatters, one- to three-room structures (jacal and masonry), and small masonry roomblocks. The sites appear to represent an initial attempt by agriculturalists to colonize the Pajarito Plateau. However, it appears that this strategy was not a success until about A.D. 1150 (Ancestral Pueblo Coalition period) when higher-yielding varieties of 12- to 14-row maize were available for planting in these upland settings. The plateau was presumably being used by both foragers and farmers during this time period.

Between A.D. 1150 and A.D. 1325, there was a substantial increase in the number, size, and distribution of above-ground habitation sites, with year-round settlements expanding into upland areas on the Pajarito Plateau. Early sites contained adobe and masonry rectangular structures with 10 to 20 rooms. These small rubble mound sites are the most common sites at LANL. In contrast, later sites of this period consist of large masonry-enclosed plaza pueblos that contain more than 100 rooms.

Ancestral Pueblo settlements on the Pajarito Plateau between A.D. 1325 and A.D. 1600 (Classic period) are aggregated into three population clusters with outlying one- to two-room fieldhouses. The central site cluster consists of four temporally overlapping sites: Navawi, Otowi, Tsirege, and Tsankawi. Only Tsirege is located on LANL land. The initial occupation of these pueblos occurred during the 14th century. Tsirege, Tsankawi, and Otowi continued to be occupied during the 15th century. Only Tsirege and Tsankawi remained by the 16th century. Oral traditions at Pueblo de San Ildefonso indicate that Tsankawi was the last of the plateau pueblos to be abandoned. As the result of a series of droughts, the Pajarito Plateau was eventually abandoned during the 1580s. New pueblos were occupied in the Rio Grande Valley.

There is evidence for American Indian, Hispanic, and Euro-American use of the area during the Historic period from A.D. 1600 to A.D. 1943. A.D. 1600 corresponds with the first Spanish settlement in New Mexico and the initiation of economic and political influence over the previously established Rio Grande populations. The Pueblo Indians revolted against the Spanish in 1680. Some pueblos were abandoned when the Spanish returned. Some sites on the plateau were reoccupied at the end of this refugee period (e.g., Nake'muu at LANL).

Mexico declared its independence from Spain in 1821. Trade between Mexico and Santa Fe along the Santa Fe Trail began soon after, and this trade dominated events in New Mexico for the next quarter-century. This trade introduced some comparatively inexpensive Euro-American goods to New Mexico; it is reflected in the increase of manufactured items found on sites from this period. New Mexico remained a part of Mexico until war broke out with the United States; New Mexico became part of the United States on August 18, 1846.

During the early 1900s in New Mexico, there was a continuation of traditional farming strategies, cattle grazing, timbering, and a wide variety of cultural practices. However, large-scale sheep herding, timbering, and mining activities during this period displaced some Hispanic communities. Seasonal homesteading continued to be prevalent on the plateau. Wooden cabins, corral structures, and rock or concrete cisterns characterize Hispanic and Anglo Homestead era sites. Many of the wooden structures burned during the May 2000 Cerro Grande fire. Artifact scatters, consisting of historic debris associated with household and farming/grazing activities, are also commonly found at this time period. The period 1890 to 1942 is typically referred to as the Homestead period at LANL. Most of the central Pajarito Plateau homestead patents were filed by Hispanic people who maintained permanent homes in the Rio Grande Valley, using the Pajarito Plateau sites for seasonal farming and resource gathering. Notable exceptions to this pattern included the establishment of a few permanent Anglo commercial concerns, such as the Anchor Ranch and Los Alamos Ranch School, the latter of which operated from 1918 until the late spring of 1943. The end of the Homestead period coincides with the appropriation of lands on the Pajarito Plateau for the Manhattan Project in 1943.

Manhattan Project personnel chose the LANL location in 1943 as the primary facility for research on developing an atomic bomb because it was remote and access could be controlled. The project proved a success when the first atomic bomb was detonated at the Trinity Site in July 1945. With the conclusion of World War II, research continued at LANL; it focused on new weapons. The first hydrogen bomb was successfully tested in 1951. By the late 1950s, research focused on reducing the size of bombs for use with intercontinental missiles. Weapons testing continued until the early 1990s, when the Test Ban Treaty was enacted. Environmental concerns began to be a major issue in the 1970s. Currently LANL focuses on its military and security missions as well as environmental stewardship.

Roughly 90% of the land at LANL has been surveyed for cultural resources. Cultural resource surveys at LANL have identified 1,915 archaeological sites. Of the 1,915 sites, 1,776 date to the prehistoric period. A total of 139 American Indian, Hispanic, and Euro-American historic sites represent populations that lived and/or worked in the region from the 1600s to the 1990s. The majority of these sites are structures or artifact scatters that date between 1600 and 1890. Researchers recommend that 400 of the sites identified be listed on the NRHP. The majority of the remaining sites have yet to be evaluated for their significance (DOE 2006). Archaeological remains include multiroom pueblos, field houses, talus houses, cavates, rock shelters, shrines, animal traps, hunting blinds, water control features, agricultural fields and terraces, quarries, rock art, trails, and limited-activity sites.

Historic buildings at LANL relate to both Manhattan Project and Cold War era research. A total of 510 buildings that date to this period remain. Of these, a total of 98 are considered eligible for listing on the NRHP, and 81 were determined ineligible. A small number of buildings at LANL that are less than 50 years old are considered eligible because of their exceptional importance to American history.

Several pueblos have expressed an interest in traditional cultural properties found on LANL. The Pueblo of Jemez, Cochiti Pueblo, Pueblo de San Ildefonso, and Santa Clara Pueblo signed accords with DOE to facilitate communication about cultural resources on LANL.

Traditional cultural properties identified on LANL include 15 ceremonial archaeological sites, 14 natural features, 10 ethnobotanical sites, 7 artisan material sites, and 8 subsistence features.

Numerous cultural resources have been identified in TA-54, which includes both Zone 6 and the North Site (including North Site Expanded). Cultural resource surveys have been conducted for the proposed GTCC reference location. Eighteen archaeological sites are situated within the assessment area boundaries, including six in Zone 6, five in the North Site, and seven in the North Site Expanded area. These sites include large diffuse chipped and ground stone artifact scatters that, based on diagnostic projectile points, date back to the Archaic period. Ancestral Pueblo sites dating from A.D. 1150 to A.D. 1600 include numerous structural foundations and partial structures representing one- to three-room fieldhouses to multiroom (ranging from 4 to 50 rooms) pueblos; possible kivas (circular subterranean ceremonial structures); and lithic (stone tool) scatters containing thousands of artifacts (2,500 or more). Remains of the Pajarito Plateau Wagon Road from the Homestead era (1890–1942) were also found.

Section 106 of NHPA requires federal agencies to take into account the effect of any federal or federally funded undertaking on any district, site, building, structure, or object that is included in or is eligible for inclusion in the NRHP. Under NHPA, the SHPO is required to identify and inventory historic properties within the state and nominate eligible properties to the NRHP, and it is tasked to ensure that NRHP-eligible properties are taken into account during an undertaking's planning and development. Of the 18 archaeological sites located in the proposed GTCC reference location, four have SHPO concurrence with regard to their eligibility, and LANL has assessed all of the other sites as being NRHP eligible or having undetermined NRHP eligibility. A site with an undetermined eligibility is treated as eligible until a formal determination can be made. The site eligibility and potential effect determinations will involve any American Indian groups determined to be culturally affiliated with respect to the area proposed for development. Affiliated tribes will have to be consulted to determine if traditional cultural properties are present within the GTCC reference location.

American Indian Text

Pueblo oral histories document that they have lived in and used the entire area of LANL including the GTCC proposed site since the beginning of time. Because of this Pueblo people are the descendants of the people who have lived here throughout time and included time periods referred by LANL archaeologists by the terms (1) Paleo-Indian, (2) Archaic, (3) Ancestral Pueblo, (4) American Indian, and (5) Federal Scientific Laboratory. Pueblo people lived in the area before the Ancestral Pueblo period, which is dated at 1600AD. Pueblo people continue to know about and value lands, natural resources, and archaeological materials located on LANL.

Pueblo people continue to desire and have a culturally important role and responsibilities in the management of all of these traditional lands.

Recent cultural resource surveys have been conducted on LANL, which have identified some sites that were not identified when LANL was established after 1943. Pueblo people

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believe that these sites are connected with other much larger sites that were destroyed when the LANL facility was built and operated. The Pueblo people express concern that many early LANL developments destroyed culturally significant sites and that no effort has been made to conduct ceremonies that may alleviate the violations association with site destruction.

A known Sacred Area, primarily identified with Pueblo de San Ildefonso, is located on the next mesa to the north of the proposed GTCC waste site. It is spiritually connected to the surrounding area and is not bounded any federal boundaries. It is recognized as a Sacred Area on old USGS quads. The Sacred Area is continually monitored by Pueblo de San Ildefonso to constantly check on its cultural integrity. It has visual, auditory, and spiritual dimensions. Pueblo de San Ildefonso air quality program consistently monitors for tritium releases, which derive from nearby area G on TA 54 on LANL. Winds blow across this area from the Southwest from LANL on to the Sacred Area. The Cerro Grande fire brought ash debris which contained radionuclides to the Sacred Area. The Sacred Area is thus believed to have been contaminated by the ash from Cerro Grande fire. Dust contaminated from ongoing operations from area G has blown into the Sacred Area.

Although four American Indian pueblos, called by LANL the Accord Tribes: Santa Clara Pueblo, Pueblo de San Ildefonso, Jemez Pueblo, and Pueblo de Cochiti have been singled out during the GTCC consultation process as being both nearby and culturally connected with LANL, there is a widely recognized understanding that other American Indian tribes are also culturally connected with LANL. These include but are not limited to (1) all 8 northern pueblos including San Juan O'Hkayowingee, Nambe O-weenge, Pojoaque, Picuris; (2) Jicarilla Apache; (3) southern Pueblos like Santo Domingo; and (4) western pueblos like Zuni and Hopi. Important LANL actions like the GTCC EIS undergoing a major analysis should include all the culturally connected (affiliated) American Indian tribes.

The LANL NAGPRA consultation report includes the following statement "It is noted that since around 1994, LANL has consistently consulted with five tribes on issues relating to cultural resources management, or at least have informed them of proposed construction projects and other issues surrounding cultural resources management at LANL." These include the "Accord Pueblos" of San Ildefonso, Santa Clara, Cochiti, and Jemez, each of which has signed agreements with LANL, along with the Mescalero Apache Tribe. In addition, the Pueblo of Acoma and the Jicarilla Apache Nation have been recognized as having an active interest in cultural resources management at LANL. A draft version of that NAGPRA report was subsequently also sent in January 2002 to all New Mexico Pueblos and to the Pueblos of Hopi in Arizona and Ysleta del Sur in Texas, as well as to the Jicarilla Apache Nation, the Mescalero Apache Tribe, the Navajo Nation, and the Ute Mountain and Southern Ute Tribes. The pueblo writers find the patterns of consultation by LANL to be confusing and not clearly grounded in a formal policy based on an agreed to Cultural Affiliation study.

Meaning of Artifacts, Places, and Resources – There is a general pueblo concern for pre-agricultural period Indian artifacts and the places where they were left. These include the role of ceremony itself as an act of sanctifying places, such as has been conducted and occurred near Sacred Area over the past thousands of years. Pueblo people believe they have been in the area since the beginning of time. This connection back in time thus connects them to all places, artifacts, and resources in the area.

American Indian Text

The Pueblo people would like to point out a direct conflict in current LANL policy and the GTCC proposal. Today LANL is officially remediating contaminated areas. These actions result in the waste being moved to new sites such as WIPP. Some of this may be transported past Pueblo communities and economic business along transportation routes. LANL has already agreed to remove radioactive waste from Area G to WIPP. Currently LANL is shipping most kinds of radioactive and TRU waste off-site. This current LANL policy is in conflict with the GTCC proposal, which would place radioactive waste and TRU waste on LANL and near Area G. In addition, the Pueblos along the transportation routes will now be exposed twice – once to current LANL waste leaving for elsewhere like the WIPP site, and secondly to new GTCC waste shipments that are arriving from elsewhere.

The Pueblo people note that one of the potential GTCC sites, indicated as Zone 4, that is being considered in the EIS appears to have been withdrawn (June 2009) from consideration for GTCC waste because LANL is continuing to dispose of LLRW waste there. This is LLRW that has been or will be produced by LANL. These additional LANL wastes add to perceived contamination risks by the Pueblo people.

The Pueblo people note that the potential site for the GTCC waste disposal is already leaking radioactive contaminants around the perimeter of Area G and DARHT. GTCC waste could only increase the contamination of this area and add to the off-site flow of contaminants.

There is a known Sacred Area on the next ridge next to the existing LANL Area G radioactive waste isolation facility and also across from the proposed GTCC site. This Sacred Area is spiritually connected to the surrounding area and is not bounded any federal boundaries (it is even recognized as a sacred area on old USGS quads). Area is constantly monitored by Pueblo de San Ildefonso to check on its integrity. The Sacred Area has visual, auditory dimension, which are consistently monitoring for tritium from nearby areas. Winds blow across this area. The Cerro Grande fire brought ash debris, which contained radionuclides to the Sacred Area, thus the area is believed to have been contaminated by the ash from Cerro Grande fire. Radioactive Dust has blown away from Area G and has been recorded near Sacred Area. The Pueblo de San Ildefonso and other pueblo people believe that locating a GTCC facility in this area will further diminish the spiritual integrity of the Sacred Area.

Radioactivity studies using the TIMS (Thermo Ionization Mass Spectrometry) method have been fingerprinted and thus identified the source (1996) of radioactivity found in the sediments of Cochiti Reservoir as coming from LANL. This is a major concern for the Cochiti people. Storm and snow run off bring LANL radioactivity downstream to places where clay is deposited. There has even been a 100-year runoff event since the Cerro Grande fire. Automated recorders have documented radioactivity being recently brought down as far as the Pueblo de San Ildefonso. Jemez Pueblo potters also express concerns they these radioactive movement will impact them when they dig through these deposits while collecting clay for pottery and minerals for other uses.

8.1.11 Waste Management

Site management of the waste types generated by the land disposal methods for Alternatives 3 to 5 is discussed in Section 5.3.11.

8.2 ENVIRONMENTAL AND HUMAN HEALTH CONSEQUENCES

The following sections address the potential environmental and human health consequences for each resource area in Section 8.1.

8.2.1 Climate and Air Quality

This section presents potential climate and air quality impacts from the construction and operations of each of the disposal facilities (borehole, trench, and vault) at LANL. Noise impacts are discussed in Section 5.3.1.

8.2.1.1 Construction

During the construction period, emissions of criteria pollutants (e.g., SO_2, NO_x, CO, PM_{10}, and $PM_{2.5}$), VOCs, and the primary greenhouse gas CO_2 would be caused by fugitive dust emissions from earth-moving activities and engine exhaust emissions from heavy equipment and commuter, delivery, and support vehicles. Typically, the potential impacts from exhaust emissions on ambient air quality would be smaller than those from fugitive dust emissions.

Air emissions of criteria pollutants, VOCs, and CO_2 from construction activities are estimated for the peak year when site preparation and the construction of support facility and some disposal cells would take place. The estimates for PM_{10} and $PM_{2.5}$ include the diesel particulate emissions from engine exhaust. These estimates are provided in Table 8.2.1-1 for each disposal method. Detailed information on emission factors, assumptions, and emission inventories is available in Appendix D. As shown in the table, total peak-year emission rates are estimated to be rather small when compared with emission totals for the two counties encompassing LANL (Los Alamos and Santa Fe Counties). Peak-year emissions for all criteria pollutants (except PM_{10} and $PM_{2.5}$) and VOCs would be the highest for the vault method because it would consume more materials and resources for construction than would the other two methods. Construction for the borehole method would disturb a larger area, so it is estimated that fugitive dust emissions would be the highest. Peak-year emissions of all pollutants would be the lowest for the trench method, which would also involve the smallest disturbed area among the disposal methods. In terms of contribution to the emissions total, peak-year emissions of SO_2 for the vault method would be the highest, about 0.75% of the two-county emissions total, while it is estimated that emissions of other criteria pollutants and VOCs would each be 0.43% or less of the two-county emissions total.

TABLE 8.2.1-1 Peak-Year Emissions of Criteria Pollutants, Volatile Organic Compounds, and Carbon Dioxide from Construction of the Three Land Disposal Facilities at LANL

Pollutant	Total Emissions (tons/yr)[a]	Construction Emissions (tons/yr)					
		Trench (%)		Borehole (%)		Vault (%)	
SO_2	429	0.90	(0.21)[b]	3.0	(0.70)	3.2	(0.75)
NO_x	7,210	8.1	(0.11)	26	(0.36)	31	(0.43)
CO	65,596	3.3	(0.01)	11	(0.02)	11	(0.03)
VOCs	8,423	0.90	(0.01)	2.7	(0.03)	3.6	(0.05)
PM_{10}[c]	55,674	5.0	(0.01)	13	(0.02)	8.6	(0.02)
$PM_{2.5}$[c]	6,303	1.5	(0.02)	4.1	(0.07)	3.6	(0.06)
CO_2		670		2,200		2,300	
County[d]	5.28×10^6		(0.01)		(0.04)		(0.04)
New Mexico[e]	6.50×10^7		(0.001)		(0.003)		(0.004)
U.S.[e]	6.54×10^9		(0.00001)		(0.00003)		(0.00004)
World[e]	3.10×10^{10}		(0.000002)		(0.000007)		(0.000007)

[a] Total emissions in 2002 for the two counties encompassing LANL (Los Alamos and Santa Fe Counties).

[b] Numbers in parentheses are percent of total emissions.

[c] Estimates for GTCC construction include diesel particulate emissions.

[d] Emission data for the year 2005. Currently, data on CO_2 emissions at the county level are not available, so county-level emissions were estimated from available state total CO_2 emissions on the basis of population distribution.

[e] Annual CO_2 emissions in New Mexico, the United States, and worldwide in 2005.

Sources: EIA (2008); EPA (2008b, 2009)

Background concentration levels for PM_{10} and $PM_{2.5}$ at LANL are below the standards (less than 80%) (see Table 8.1.1-3). Construction at LANL could occur within about 200 m (660 ft) of the site boundary. Under unfavorable dispersion conditions, it is expected that high concentrations of PM_{10} or $PM_{2.5}$ could occur and could exceed the standards at the site boundary, although such exceedances would be rare. Construction activities would not contribute much to concentrations at the nearest residence in White Rock, about 3.5 km (2.2 mi) from the GTCC reference location. Construction activities would be conducted so as to minimize potential impacts of construction-related emissions on ambient air quality. In so doing, where appropriate, fugitive dust would be controlled by following established standard dust control practices (primarily by watering unpaved roads, disturbed surfaces, and temporary stockpiles), as stipulated in the construction permits.

Levels of O_3 in Santa Fe, about 29 km (18 mi) southwest of the GTCC reference location, are below the standard (about 84%) (see Table 8.1.1-3). Los Alamos and Santa Fe Counties are currently in attainment for O_3 (40 CFR 81.332). O_3 precursor emissions from the possible GTCC LLRW and GTCC-like waste disposal facility for all methods would be relatively small, less than 0.43% and 0.05% of two-county total NO_x and VOC emissions, respectively, and would be much lower than those for the regional air shed in which emitted precursors are transported and formed into O_3. Accordingly, potential impacts of O_3 precursor releases from construction on regional O_3 would not be of concern.

The major air quality concern with respect to emissions of CO_2 is that it is a greenhouse gas, which traps solar radiation reflected from the earth, keeping it in the atmosphere. The combustion of fossil fuels makes CO_2 the most widely emitted greenhouse gas worldwide. CO_2 concentrations in the atmosphere increased continuously from about 280 ppm in preindustrial times to 379 ppm in 2005 (a 35% increase), and most of this increase occurred in the last 100 years (IPCC 2007).

The climatic impact of CO_2 does not depend on the geographic location of the sources because CO_2 is stable in the atmosphere and is essentially uniformly mixed; that is, it is the global total that is the important factor with respect to global warming. Therefore, a comparison between U.S. and global emissions and the total emissions from the construction of a disposal facility is useful in understanding whether CO_2 emissions from the site are significant with respect to global warming. As shown in Table 8.2.1-1, the highest peak-year amounts of CO_2 emissions from construction would be 0.04%, 0.004%, and 0.00004% of 2005 county, state, and U.S. CO_2 emissions, respectively. In 2005, CO_2 emissions in the United States were about 21% of worldwide emissions (EIA 2008). Emissions from construction would be less than 0.00001% of global emissions. Potential impacts on climate change from construction emissions would be small.

Appendix D assumes an initial construction period of 3.4 years. The disposal units would be constructed as the waste became available for disposal. The construction phase would be extended over more years, and thus emissions for nonpeak years would be lower than peak-year emissions, as shown in the table. In addition, construction activities would likely occur only during daytime hours, when air dispersion is most favorable. Accordingly, potential impacts from construction activities on ambient air quality would be minor and intermittent in nature.

General conformity applies to federal actions taking place in nonattainment or maintenance areas and is not applicable to the proposed action at the LANL site because the area is classified as being in attainment for all criteria pollutants (40 CFR 81.332).

8.2.1.2 Operations

Criteria pollutants, VOCs, and CO_2 would be released into the atmosphere during operations. These emissions would include fugitive dust emissions from emplacement activities and exhaust emissions from heavy equipment and commuter, delivery, and support vehicles. Annual emissions of criteria pollutants, VOCs, and CO_2 at the facility are estimated in Table 8.2.1-2. Detailed information on emission factors, assumptions, and emission inventories is provided in Appendix D. As shown in the table, for the borehole and vault methods, annual emissions from operations are estimated to be lower than those from construction. Annual

TABLE 8.2.1-2 Annual Emissions of Criteria Pollutants, Volatile Organic Compounds, and Carbon Dioxide from Operations of the Three Land Disposal Facilities at LANL

Pollutant	Total Emissions (tons/yr)[a]	Operation Emissions (tons/yr)					
		Trench (%)		Borehole (%)		Vault (%)	
SO_2	429	3.3	(0.7)[b]	1.2	(0.28)	33	(0.77)
NO_x	7,210	27	(0.37)	10	(0.14)	27	(0.37)
CO	65,596	15	(0.02)	6.7	(0.01)	15	(0.02)
VOCs	8,423	3.1	(0.04)	1.2	(0.01)	3.1	(0.04)
PM_{10}[c]	55, 674	2.5	(<0.01)	0.91	(<0.01)	2.5	(<0.01)
$PM_{2.5}$[c]	6,303	2.2	(0.03)	0.81	(0.01)	2.2	(0.03)
CO_2		3,200		1,700		3,300	
County[d]	5.28×10^6		(0.06)		(0.03)		(0.06)
New Mexico[e]	6.50×10^7		(0.005)		(0.003)		(0.005)
U.S.[e]	6.54×10^9		(0.00005)		(0.00003)		(0.00005)
World[e]	3.10×10^{10}		(0.00001)		(0.00001)		(0.00001)

[a] Total emissions in 2002 for the two counties encompassing LANL (Los Alamos and Santa Fe Counties). See Table 8.1.1-1 for criteria pollutants and VOCs.

[b] Numbers in parentheses are percent of total emissions.

[c] Estimates for GTCC operations include diesel particulate emissions.

[d] Emission data for the year 2005. Currently, data on CO_2 emissions at the county level are not available, so county-level emissions were estimated from available state total CO_2 emissions on the basis of population distribution.

[e] Annual CO_2 emissions in New Mexico, the United States, and the world in 2005.

Sources: EIA (2008); EPA (2008b, 2009)

emissions for the trench and vault methods would be higher than those for the borehole. Compared with annual emissions for counties encompassing LANL, annual emissions of SO_2 for the trench and vault methods would be about 0.77% of the county total, respectively, while annual emissions of other criteria pollutants and VOCs would be about 0.37% or less.

It is expected that except for particulates, concentration levels from operations would remain well below the standards. Estimates for PM_{10} and $PM_{2.5}$ include diesel particulate emissions. However, the impacts of emissions from fugitive dust during emplacement would be lower than the impacts during construction activities, although fugitive dust emissions could exceed the standards under unfavorable meteorological conditions because of the proximity of the GTCC reference location to the site boundary. As discussed in the construction section, established fugitive dust control measures (primarily by watering unpaved roads, disturbed surfaces, and temporary stockpiles) could be implemented to minimize potential impacts on ambient air quality.

With regard to regional O_3, precursor emissions of NO_x and VOCs would be comparable to those resulting from construction activities (about 0.37% and 0.04% of the two-county total, respectively), and it is not anticipated that they would contribute much to regional O_3 levels. The highest emissions of CO_2 among the disposal methods would be comparable to the highest construction-related emissions; thus, the potential impacts of CO_2 emissions on climate change would also be negligible.

PSD regulations are not applicable to the proposed action because the proposed action is not a major stationary source.

8.2.2 Geology and Soils

Direct impacts from land disturbance would be proportional to the total area of land disturbed during site preparation activities (e.g., grading and backfilling) and construction of the waste disposal facility and related infrastructure (e.g., roads). Land disturbance would include the surface area covered by each disposal method and the vertical displacement of geologic materials for the borehole and trench disposal methods. The increased potential for soil erosion would be an indirect impact of land disturbance at the construction site. Indirect impacts would also result from the consumption of geologic materials (e.g., aggregate) for facility and other associated infrastructure construction. The impact analysis also considers whether the proposed action would preclude the future extraction and use of mineral materials or energy resources.

8.2.2.1 Construction

Land surface area disturbance impacts would be a function of the disposal method implemented at LANL (Table 5.1-1). Of the three disposal methods, the borehole facility layout would result in the greatest impact in terms of land area disturbed (44 ha or 110 ac). It also would result in the greatest disturbance with depth, 40 m (130 ft), with boreholes completed in unconsolidated mesa top alluvium and tuff.

Geologic and soil material requirements are provided in Table 5.3.2-1. Of the three disposal methods, the vault facility would require the most material since it involves the installation of interim and final cover systems. This material would be considered permanently lost. However, none of the three disposal methods are expected to result in adverse impacts on geologic and soil resources at LANL, since these resources are in abundant supply at the site and in the surrounding area.

No significant changes in surface topography or natural drainages are anticipated in the construction area. However, the disturbance of soil during the construction phase would increase the potential for erosion in the immediate vicinity. This potential would be somewhat reduced by the low precipitation rates at LANL (although catastrophic rainfall events do occur). Mitigation measures (e.g., siting the facility away from the cliff edge of the mesa) also would be implemented to avoid or minimize the risk of erosion.

The GTCC LLRW and GTCC-like waste disposal facility would be sited and designed with safeguards to avoid or minimize the risks associated with seismic and volcanic hazards. LANL is in a seismically active region, and earthquakes with magnitudes of more than 5 have been recorded in recent history. The annual probability of a volcanic event at LANL has not been determined; however, it is believed that volcanism would be detected years in advance by regional uplift and doming (in the event of a large eruption) or weeks in advance by the existing LANL seismographic network (in the event of smaller eruptions). Airborne ash could be deposited on-site, depending on the location of the eruption and the prevailing wind direction. The potential for other hazards (e.g., subsidence and liquefaction) is considered to be low.

8.2.2.2 Operations

The disturbance of soil and the increased potential for soil erosion would continue throughout the operational phase while waste was being delivered to the site for disposal over time. The potential for soil erosion would be somewhat reduced by the low precipitation rates at LANL (although catastrophic rainfall events do occur). Mitigation measures also would be implemented to avoid or minimize the risk of erosion.

Impacts related to the extraction and use of valuable geologic materials would be low, since only the area within the facility itself would be unavailable for mining and geothermal energy development.

8.2.3 Water Resources

Direct and indirect impacts on water resources could occur as a result of water use at the proposed GTCC LLRW and GTCC-like waste disposal facility during construction and operations. Table 5.3.3-1 provides an estimate of the water consumption and discharge volumes for the three land disposal methods; Tables 5.3.3-2 and 5.3.3-3 summarize the water use impacts (in terms of change in annual water use) to water resources from construction and normal operations, respectively. A discussion of potential impacts during each project phase is presented in the following sections. In addition, contamination due to potential leaching of radionuclides into groundwater from the waste inventory could occur, depending on the post-closure performance of the land disposal facilities discussed in Section 8.2.4.2.

8.2.3.1 Construction

Of the three land disposal methods considered for LANL, construction of a vault facility would have the highest water requirement (Table 5.3.3-1). Water demands for construction at LANL would be met by using groundwater from on-site wells completed in the regional aquifer in three well fields: Otowi, Pajarito, and Guaje. No surface water would be used at the site during construction. As a result, no direct impacts on surface water resources would be expected. The potential for indirect surface water impacts (in nearby canyons) related to soil erosion, contaminated runoff, and sedimentation would be reduced by implementing good industry practices and mitigation measures.

LANL uses about 1.4 billion L/yr (359 million gal/yr) of groundwater, about 21% of its water right of 6.8 billion L/yr (1.8 billion gal/yr). Construction of the proposed GTCC LLRW and GTCC-like waste disposal facility would increase the annual water use at LANL by a maximum of about 0.24% (vault method) over the 20-year period that construction would occur. This increase would be well within LANL's water right. Because withdrawals of groundwater would be relatively small, they would not significantly lower the water table or change the direction of groundwater flow at LANL. As a result, impacts due to groundwater withdrawals are expected to be small.

Construction activities could potentially change the infiltration rate at the site of the proposed GTCC LLRW and GTCC-like waste disposal facility, first by increasing the rate as ground would be disturbed in the initial stages of construction, and later by decreasing the rate as impermeable materials (e.g., the clay material and geotextile membrane assumed for the cover or cap for the land disposal facility designs) would cover the surface. These changes are expected to be negligible since the area of land associated with the proposed GTCC LLRW and GTCC-like waste disposal facility (up to 44 ha [110 ac], depending on the disposal method) is small relative to the LANL site.

Disposal of waste (including sanitary waste) generated during construction of the land disposal facilities would have a negligible impact on the quality of water resources at LANL (see Sections 5.3.11 and 8.2.11). The potential for indirect surface water or groundwater impacts related to spills at the surface would be reduced by implementing good industry practices and mitigation measures.

8.2.3.2 Operations

Of the three types of land disposal facilities considered for LANL, a vault or trench facility would have the highest water requirement during operations (Table 5.3.3-1). Water demands for operations at LANL would be met by using groundwater from on-site wells completed in the regional aquifer. No surface water would be used at the site during operations. As a result, no direct impacts on surface water resources are expected. The potential for indirect surface water impacts related to soil erosion, contaminated runoff, and sedimentation would be reduced by implementing good industry practices and mitigation measures.

Operations of the proposed GTCC LLRW and GTCC-like waste disposal facility would increase annual water use at LANL by a maximum of about 0.39% (vault or trench method). This increase would be well within LANL's water right. Because withdrawals of groundwater would be relatively small, they would not significantly lower the water table or change the direction of groundwater flow at LANL. As a result, impacts due to groundwater withdrawals are expected to be small.

Disposal of waste (including sanitary waste) generated during operations of the land disposal facilities would have a negligible impact on the quality of water resources at LANL. The potential for indirect surface water or groundwater impacts related to spills at the surface would be reduced by implementing good industry practices and mitigation measures.

8.2.4 Human Health

Potential impacts on members of the general public and the involved workers from the construction and operations associated with the land disposal facilities are expected to be comparable for all of the sites evaluated in this EIS for the land disposal method, and these are presented in Section 5.3.4. The following sections discuss the impacts from hypothetical facility accidents associated with waste handling activities and the impacts during the post-closure phase. They address impacts on members of the general public who might be affected by these waste disposal activities at the LANL GTCC reference location, since these impacts would be site dependent.

8.2.4.1 Facility Accidents

Data on the estimated human health impacts from hypothetical accidents at a land GTCC LLRW and GTCC-like waste disposal facility at LANL are provided in Table 8.2.4-1. The accident scenarios are discussed in Section 5.3.4.2.1 and Appendix C. A reasonable range of accidents that included operational events and natural causes was analyzed. The impacts presented for each accident scenario are for the sector with the highest impacts, and no protective measures are assumed; therefore, the impacts represent the maximum expected for such an accident.

The collective population dose includes exposure from inhalation of airborne radioactive material, external exposure from radioactive material deposited on the ground, and ingestion of contaminated crops. The exposure period is considered to last for 1 year immediately following the accidental release. It is recognized that interdiction of food crops would likely occur if a significant release did occur, but many stakeholders are interested in what could happen without interdiction. For the accidents involving CH waste (Accidents 1–9, 11, 12), the ingestion dose accounts for approximately 20% of the dose to the collective population shown in Table 8.2.4-1. External exposure was found to be negligible in all cases. All exposures are dominated by the inhalation dose from the passing plume of airborne radioactive material downwind of the hypothetical accident immediately following release.

The highest estimated impact on the general public, 160 person-rem, would be from a hypothetical release from an SWB caused by a fire in the Waste Handling Building (Accident 9). Such a dose is not expected to lead to any additional LCFs in the population. This dose would be to the 83,100 people living to the southeast of the facility, resulting in an average dose of approximately 0.002 rem per person. Because this dose would result from internal intake (primarily inhalation, with some ingestion) and because the DCFs used in this analysis are for a 50-year CEDE, this dose would be accumulated over the course of 50 years.

The dose to an individual (expected to be a noninvolved worker because there would be no public access within 100 m [330 ft] of the GTCC reference location) includes exposure from inhalation of airborne radioactive material and 2 hours of exposure to radioactive material deposited on the ground. As shown in Table 8.2.4-1, the maximum estimated dose to an individual, 12 rem, is for Accident 9 from inhalation exposure immediately after the postulated

TABLE 8.2.4-1 Estimated Radiological Human Health Impacts from Hypothetical Facility Accidents at LANL

		Off-Site Public		Individual[b]	
Accident Number	Accident Scenario	Collective Dose (person-rem)	Latent Cancer Fatalities[c]	Dose (rem)	Likelihood of LCF[c]
1	Single drum drops, lid failure in Waste Handing Building	0.0035	<0.0001	0.00025	<0.0001
2	Single SWB drops, lid failure in Waste Handing Building	0.008	<0.0001	0.00058	<0.0001
3	Three drums drop, puncture, lid failure in Waste Handling Building	0.0063	<0.0001	0.00045	<0.0001
4	Two SWBs drop, puncture, lid failure in Waste Handling Building	0.011	<0.0001	0.00081	<0.0001
5	Single drum drops, lid failure outside	3.5	0.002	0.25	0.0001
6	Single SWB drops, lid failure outside	8	0.005	0.58	0.0003
7	Three drums drop, puncture, lid failure outside	6.3	0.004	0.45	0.0003
8	Two SWBs drop, puncture, lid failure outside	11	0.007	0.81	0.0005
9	Fire inside the Waste Handling Building, one SWB assumed to be affected	160	0.1	12	0.007
10	Single RH waste canister breach	<0.0001	<0.0001	<0.0001	<0.0001
11	Earthquake affects 18 pallets, each with 4 CH drums	100	0.06	7.2	0.004
12	Tornado, missile hits one SWB, contents released	32	0.02	2.3	0.001

[a] CH = contact-handled, RH = remote-handled, LCF = latent cancer fatality, SWB = standard waste box.

[b] The individual receptor is assumed to be 100 m (330 ft) downwind from the release point. This individual is expected to be a noninvolved worker because there would be no public access within 100 m (330 ft) of the GTCC reference location.

[c] LCFs are calculated by multiplying the dose by the health risk conversion factor of 0.0006 fatal cancer per person-rem (see Section 5.2.4.3). Values are rounded to one significant figure.

release. This estimated dose is for a hypothetical individual located 100 m (330 ft) to the south-southeast of the accident location. As discussed above, the estimated dose of 12 rem would be accumulated over a 50-year period after intake; thus, it is not expected to result in symptoms of acute radiation syndrome. A maximum annual dose of about 5% of the total dose would occur in the first year. The increased lifetime probability of a fatal cancer for this individual would be approximately 0.07% on the basis of a total dose of 12 rem.

8.2.4.2 Post-Closure

The potential radiation dose from airborne releases of radionuclides to the off-site members of the public after the closure of the disposal facility would be small. The RESRAD-OFFSITE calculation results (see Table 5.3.4-3) indicate that there would be no measurable radiation exposure for this pathway if a borehole facility was used, but small radiation exposures would result from either a trench or vault facility. The potential inhalation dose at a distance of 100 m (330 ft) from the disposal facility would be less than 1.8 mrem/yr for trench disposal and 0.52 mrem/yr for vault disposal. The potential radiation exposures would be caused mainly by inhalation of radon gas and its short-lived progeny.

The use of boreholes would provide better protection against potential exposures from airborne releases of radionuclides because of the greater depth of cover material involved. The top of the waste placement zone of the boreholes would be 30 m (100 ft) bgs, and this depth of overlying soil would inhibit the diffusion of radon gas, CO_2 gas (containing C-14), and tritium (H-3) water vapor to the atmosphere above the disposal area. However, because the distance to the groundwater table would be closer under the borehole method than under the trench and vault methods, radionuclides that leached out from wastes in the boreholes would reach the groundwater table in a shorter time than would radionuclides that leached out from a trench or vault facility.

Within 10,000 years, C-14, Tc-99, and I-129 could reach the groundwater table and a well installed by a hypothetical farmer at a distance of 100 m (330 ft) from the downgradient edge of the disposal facility. All three of these radionuclides are highly soluble in water, a quality that could lead to potentially significant groundwater concentrations and subsequently a measurable radiation does to the resident farmer. The peak annual dose associated with the use of contaminated groundwater from disposal of the entire GTCC inventory at LANL was calculated to be 160 mrem/yr for the borehole method, 430 mrem/yr for the vault method, and 380 mrem/yr for the trench method. Exposure pathways related to the use of contaminated groundwater include ingestion of water, soil, plants, meat, and milk; external radiation; and inhalation of radon gas and its short-lived progeny. Except for the water ingestion pathway, all the pathways that contribute significantly to the dose to this hypothetical resident farmer are associated with the accumulation of radionuclides in agricultural fields due to the use of contaminated groundwater for irrigation.

In Tables 8.2.4-2 and 8.2.4-3, the peak annual doses and LCF risks to the hypothetical resident farmer (from use of potentially contaminated groundwater within the first 10,000 years after closure of the disposal facility) are those associated with the disposal of the entire GTCC

TABLE 8.2.4-2 Estimated Peak Annual Doses (in mrem/yr) from the Use of Contaminated Groundwater within 10,000 Years of Disposal at the GTCC Reference Location at LANL[a]

	GTCC LLRW				GTCC-Like Waste				
Disposal Technology/ Waste Group	Activated Metals	Sealed Sources	Other Waste - CH	Other Waste - RH	Activated Metals	Sealed Sources	Other Waste - CH	Other Waste - RH	Peak Annual Dose from Entire Inventory
Borehole									160[b]
Group 1 stored	3.0	-	0.0	0.065	0.33	0.0	0.74	67	
Group 1 projected	46	0.0	-	0.0	0.81	0.0	0.21	0.18	
Group 2 projected	22	0.0	0.35	13	-	-	0.42	0.96	
Vault									430[b]
Group 1 stored	60	-	0.0	0.22	0.45	0.0	1.8	230	
Group 1 projected	64	0.0	-	0.0	1.1	0.0	0.52	0.62	
Group 2 projected	30	0.0	0.87	40	-	-	1.0	3.1	
Trench									380[b]
Group 1 stored	5.2	-	0.0	0.21	0.55	0.0	2.2	210	
Group 1 projected	78	0.0	-	0.0	1.4	0.0	0.63	0.58	
Group 2 projected	37	0.0	1.1	38	-	-	1.2	2.9	

[a] These annual doses are associated with the use of contaminated groundwater by a hypothetical resident farmer located 100 m (330 ft) from the edge of the disposal facility. All values are given to two significant figures, and a hyphen means there is no inventory for that waste type. The values given in this table represent the annual doses to the hypothetical resident farmer at the time of peak annual dose for the entire GTCC LLRW and GTCC-like waste inventory. These contributions do not represent the maximum doses that could result from each of these waste types separately. Because of the different radionuclide mixes and activities contained in the different waste types, the maximum doses that could result from each waste type individually generally occur at different times than the peak annual dose from the entire inventory. The peak annual doses that could result from each of the waste types are presented in Tables E-22 through E-25 in Appendix E.

[b] The times for the peak annual doses of 160 mrem/yr for boreholes, 430 mrem/yr for vaults, and 380 mrem/yr for trenches were calculated to be about 500 years, 1,100 years, and 1,000 years, respectively, for disposal of the entire GTCC LLRW and GTCC-like waste inventory. These times represent the time after failure of the cover and engineered barriers (which is assumed to begin 500 years after closure of the disposal facility). The values reported for the other entries in this table represent the annual doses from the specific waste types at the time of these peak doses. The primary contributors to the dose in all cases are GTCC LLRW activated metals and GTCC-like Other Waste - RH. The primary radionuclides causing this dose would be C-14, Tc-99, and I-129.

TABLE 8.2.4-3 Estimated Peak Annual LCF Risks from the Use of Contaminated Groundwater within 10,000 Years of Disposal at the GTCC Reference Location at LANL[a]

	GTCC LLRW				GTCC-Like Waste				
Disposal Technology/ Waste Group	Activated Metals	Sealed Sources	Other Waste - CH	Other Waste - RH	Activated Metals	Sealed Sources	Other Waste - CH	Other Waste - RH	Peak Annual LCF Risk from Entire Inventory
Borehole									9E-05[b]
Group 1 stored	2E-06	-	0E+00	4E-08	2E-07	0E+00	4E-07	4E-05	
Group 1 projected	3E-05	0E+00	-	0E+00	-	-	1E-07	1E-07	
Group 2 projected	1E-05	0E+00	2E-07	8E-06	0E+00	0E+00	3E-07	6E-07	
Vault									3E-04[b]
Group 1 stored	4E-05	-	0E+00	1E-07	3E-07	0E+00	1E-06	1E-04	
Group 1 projected	4E-05	0E+00	-	0E+00	7E-07	0E+00	3E-07	4E-07	
Group 2 projected	2E-05	0E+00	5E-07	2E-05	-	-	6E-07	2E-06	
Trench									2E-04[b]
Group 1 stored	3E-06	-	0E+00	1E-07	3E-07	0E+00	1E-06	1E-04	
Group 1 projected	5E-05	0E+00	-	0E+00	8E-07	0E+00	4E-07	3E-07	
Group 2 projected	2E-05	0E+00	6E-07	2E-05	-	-	7E-07	2E-06	

[a] These annual LCF risks are associated with the use of contaminated groundwater by a hypothetical resident farmer located 100 m (330 ft) from the edge of the disposal facility. All values are given to one significant figure, and a hyphen means there is no inventory for that waste type. The values given in this table represent the annual LCF risks to the hypothetical resident farmer at the time of peak annual LCF risk for the entire GTCC LLRW and GTCC-like waste inventory. These contributions do not represent the maximum LCF risks that could result from each of these waste types separately. Because of the different radionuclide mixes and activities contained in the different waste types, the maximum LCF risks that could result from each waste type individually generally occur at different times than the peak annual LCF risk from the entire inventory.

[b] The times for the peak annual LCF risks of 9E-05 for boreholes, 3E-04 for vaults, and 2E-04 for trenches were calculated to be about 500 years, 1,100 years, and 1,000 years, respectively, for disposal of the entire GTCC LLRW and GTCC-like waste inventory. These times represent the time after failure of the cover and engineered barriers (which is assumed to begin 500 years after closure of the disposal facility). The values reported for the other entries in this table represent the annual LCF risks from the specific waste types at the time of peak LCF risks. The primary contributors to the LCF risk in all cases are GTCC LLRW activated metals and GTCC-like Other Waste - RH. The primary radionuclides causing this risk would be C-14, Tc-99, and I-129.

LLRW and GTCC-like waste inventory by using the land disposal methods evaluated. In these tables, the annual doses and LCF risks contributed by each waste type (i.e., dose and risk for each waste type at the time or year when the peak dose or risk for the entire inventory is observed) to the peak dose and risk are also tabulated. The doses and LCF risks presented for the various waste types do not necessarily represent the peak dose and LCF risk of the waste type itself when it is considered on its own.

For borehole disposal, it is estimated that the peak annual dose and LCF risks would occur at about 500 years, and calculations indicate that the peak annual doses and LCF risks would occur at about 1,100 years after disposal for vaults and at about 1,000 years for trenches. These times represent the time after failure of the engineered barriers (including the cover), which is assumed to begin 500 years after closure of the disposal facility. The GTCC LLRW activated metals and GTCC-like Other Waste - RH would be the primary contributors to the doses in all cases. The doses from C-14 and Tc-99 would be largely attributable to the GTCC LLRW activated metal wastes and the doses from I-129 and Tc-99 would be largely attributable to GTCC-like Other Waste - RH.

Tables E-22 through E-25 in Appendix E present peak doses for each waste type when considered on its own. Because these peak doses generally occur at different times, the results should not be summed to obtain total doses for comparison with those presented in Table 8.24-2 (although for some cases, those sums might be close to those presented in the site-specific chapters).

Figure 8.2.4-1 is a temporal plot of the radiation doses associated with the use of contaminated groundwater for a time period extending to 10,000 years, and Figure 8.2.4-2 shows these results to 100,000 years for the three land disposal methods. Note that the time scale is logarithmic in Figure 8.2.4-1 and linear in Figure 8.2.4-2. A logarithmic time scale was used in the first figure to better illustrate the projected radiation doses to a hypothetical resident farmer in the first 2,000 years after closure of the disposal facility.

Although C-14, Tc-99, and I-129 would result in measureable radiation doses for the first 10,000 years, the inventory in the disposal areas would be depleted rather quickly, and the doses would gradually decrease with time after about 2,000 years. After the depletion of these three radionuclides, there would be no other radionuclides reaching the groundwater table within 100,000 years. The lack of groundwater contamination from other radionuclides at the LANL site between 10,000 and 100,000 years would be attributable to a low water infiltration rate of 0.5 cm/yr (0.2 in./yr) and the relatively long distance to the groundwater table (about 270 m [890 ft]).

The results given here are assumed to be conservative because the location selected for the residential exposure is 100 m (330 ft) from the edge of the disposal facility. Use of a longer distance, which might be more realistic for the sites being evaluated, would significantly lower the estimated doses (i.e., by as much as 70%). A sensitivity analysis performed to determine the effect of a distance longer than 100 m (330 ft) is presented in Appendix E.

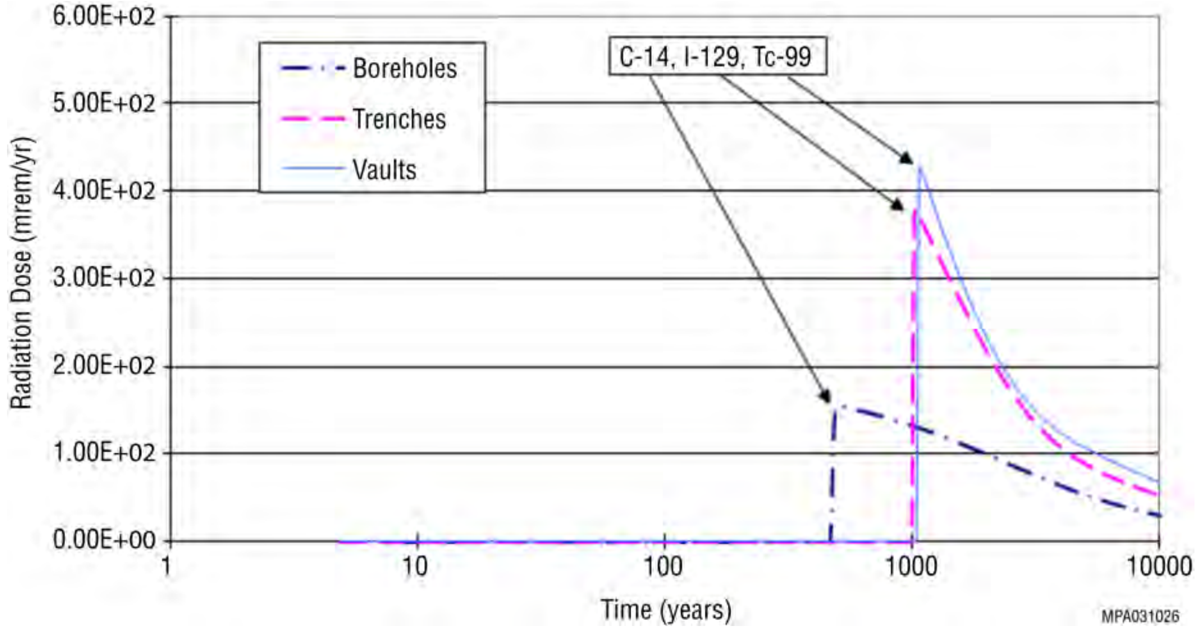

FIGURE 8.2.4-1 Temporal Plot of Radiation Doses Associated with the Use of Contaminated Groundwater within 10,000 Years of Disposal for the Three Land Disposal Methods at LANL

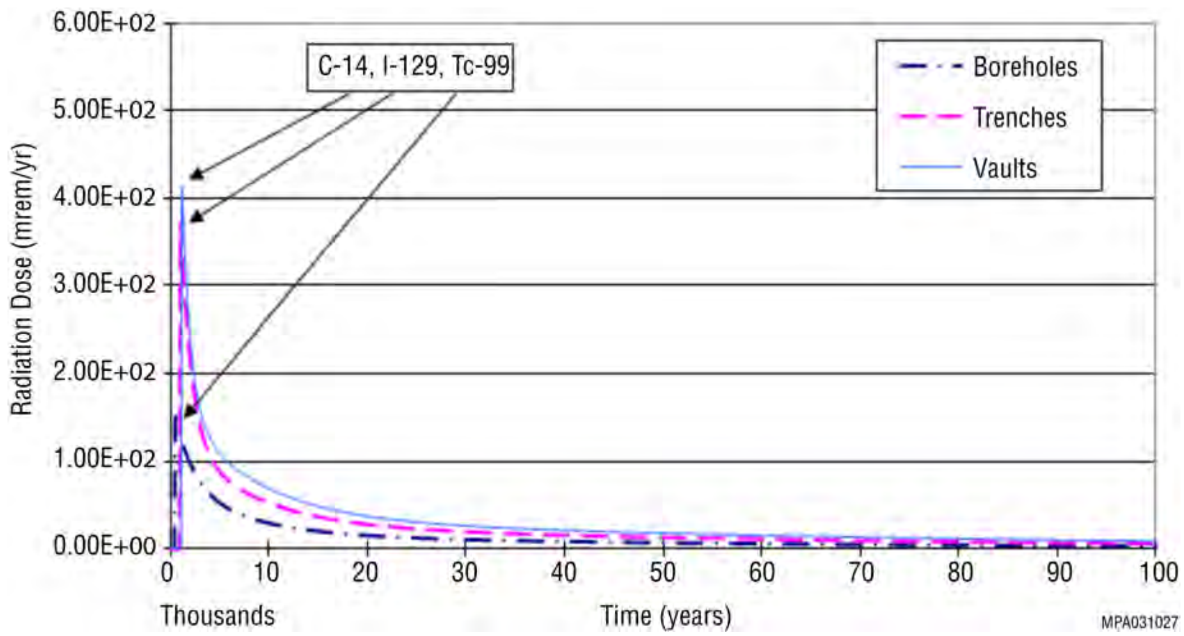

FIGURE 8.2.4-2 Temporal Plot of Radiation Doses Associated with the Use of Contaminated Groundwater within 100,000 Years of Disposal for the Three Land Disposal Methods at LANL

These analyses assume that engineering controls would be effective for 500 years following closure of the disposal facility. This means that essentially no infiltrating water would reach the wastes from the top of the disposal units during the first 500 years. It is assumed that after 500 years, the engineered barriers would begin to degrade, allowing infiltrating water to come in contact with the disposed-of wastes. For purposes of analysis in this EIS, it is assumed that the amount of infiltrating water that would contact the wastes would be 20% of the site-specific natural infiltration rate for the area, and that the water infiltration rate around and beneath the disposal facilities would be 100% of the natural rate for the area. This approach is conservative because the engineered systems (including the disposal facility cover) are expected to last significantly longer than 500 years, even in the absence of active maintenance measures.

It is assumed that the Other Waste would be stabilized with grout or other material and that this stabilizing agent would be effective for 500 years. Consistent with the assumptions used for engineering controls, no credit was taken for the effectiveness of this stabilizing agent after 500 years in this analysis. That is, it is assumed that any water that would contact the wastes after 500 years would be able to leach radioactive constituents from the disposed-of materials. These radionuclides could then move with the percolating groundwater to the underlying groundwater system. This assumption is conservative because grout or other stabilizing materials could retain their integrity for longer than 500 years.

Sensitivity analyses performed relative to these assumptions indicate that if a higher infiltration rate to the top of the disposal facilities was assumed, the doses would increase in a linear manner from those presented. Conversely, they would decrease in a linear manner with lower infiltration rates. This finding indicates the need to ensure a good cover over the closed disposal units. Also, the doses (particularly for the GTCC-like Other Waste - RH) would be lower if the grout was assumed to last for a longer time. Because of the long-lived nature of the radionuclides associated with the GTCC LLRW and GTCC-like waste, any stabilization effort (such as grouting) would have to be effective for longer than 5,000 years in order to substantially reduce doses that could result from potential future leaching of the disposed-of waste.

The radiation doses presented in the post-closure assessment in this EIS are intended to be used for comparing the performance of each land disposal method at each site evaluated. The results indicate that the use of robust engineering designs and redundant measures (e.g., types and thicknesses of covers and long-lasting grout) in the disposal facility could delay the potential release of radionuclides and could reduce the release to very low levels, thereby minimizing the potential groundwater contamination and associated human health impacts in the future. DOE has considered the potential doses to the hypothetical resident farmer as well as other factors discussed in Section 2.9 in identifying the preferred alternative presented in Section 2.10.

8.2.5 Ecology

Section 5.3.5 presents an overview of the potential impacts on ecological resources that could result from the construction and operations of the potential GTCC LLRW and GTCC-like waste disposal facility, regardless of the location selected for the facility. This section evaluates the potential impacts of the GTCC LLRW and GTCC-like waste disposal facility on the ecological resources at LANL.

Habitat lost during construction would be mostly pinyon-juniper woodland. It is not expected that the initial loss of mostly pinyon-juniper woodland habitat, followed by eventual establishment of low-growth vegetation on the disposal site, would create a long-term reduction in the local or regional ecological diversity. After closure of the GTCC LLRW and GTCC-like waste disposal site, the cover would become vegetated with annual and perennial grasses and forbs. As appropriate, regionally native plants would be used to landscape the disposal site (EPA 1995). The vegetation that would be planted as the disposal facility was closed would include native grasses, such as blue grama grass (*Bouteloua gracilis*), buffalo grass (*Bouteloua dactyloides*), western wheatgrass (*Pascopyrum smithii*), and dropseed (*Sporobolus* spp.), as well as alfalfa (*Medicago sativa*) (Shuman et al. 2002). An aggressive revegetation program would be necessary so that nonnative species, such as cheatgrass and Russian thistle, would not become established. These species are quick to colonize disturbed sites and are difficult to eradicate because each year, they produce large amounts of seeds that remain viable for long periods of time (Blew et al. 2006).

Construction of the GTCC LLRW and GTCC-like waste disposal facility would affect wildlife species that inhabit the TA-54 area (see Section 8.1.5). Small mammals, ground-nesting birds, and reptiles would recolonize the site once a vegetative cover was reestablished. Larger mammals, such as elk, American black bears, mountain lions, and bobcats, would probably avoid the area. Species such as mule deer, coyote, and gray fox, which forage or hunt in early successional habitats, would be excluded from the GTCC LLRW and GTCC-like waste disposal facility because of the fencing (during the institutional control/monitored post-closure period). Nesting habitat would also be lost for raptors and other tree-nesting species.

Because no aquatic habitats or wetlands occur within the immediate vicinity of the GTCC reference location, direct impacts on aquatic or wetland biota are not expected. DOE would use appropriate erosion control measures to minimize off-site movement of soils. The GTCC LLRW and GTCC-like waste disposal facility retention pond would probably not become a highly productive aquatic habitat. However, depending on the amount of water and the length of time that the water was retained within the pond, aquatic invertebrates could become established within it. Waterfowl, shorebirds, and other birds might also make use of the retention pond, as would mammal and amphibian species that might enter the site.

Several federally and state-listed bird and mammal species occur within the area of the GTCC reference location. Localized impacts on these species might result from the construction and operations of the disposal facility. However, the area of pinyon-juniper woodland habitat that might be disturbed by construction would be small relative to the overall area of such habitat on the LANL site. Therefore, removal of pinyon-juniper woodland habitat would have a small impact on the populations of special-status species at LANL.

Among the goals of the waste management mission at DOE sites is to design, construct, operate, and maintain disposal facilities in a manner that protects the environment and complies with regulations. Therefore, impacts associated with the GTCC LLRW and GTCC-like waste disposal facility that could affect ecological resources (Section 5.3.3.6) would be minimized and mitigated.

8.2.6 Socioeconomics

8.2.6.1 Construction

The potential socioeconomic impacts from constructing a GTCC LLRW and GTCC-like waste disposal facility and support buildings at LANL would be small for all disposal methods. Construction activities would create direct employment of 47 people (borehole method) and 145 people (vault method) in the peak construction year and an additional 64 indirect jobs (trench method) to 169 indirect jobs (vault method) in the ROI (Table 8.2.6-1). Construction activities would constitute less than 1% of total ROI employment in the peak year. A GTCC LLRW and GTCC-like waste disposal facility would produce between $4.6 million in income (trench method) and $12.2 million in income (vault method) in the peak year of construction.

In the peak year of construction, between 21 people (borehole method) and 64 people (vault method) would in-migrate to the ROI (Table 8.2.6-1) as a result of employment on the site. In-migration would have only a marginal effect on population growth and would require up to 1% of vacant rental housing in the peak year. No significant impact on public finances would occur as a result of in-migration, and no more than one new public service employee would be required to maintain existing levels of service in the various local public service jurisdictions in the ROI. In addition, on-site employee commuting patterns would have a small to moderate impact on levels of service in the local transportation network surrounding the site.

8.2.6.2 Operations

The potential socioeconomic impacts from operating a GTCC LLRW and GTCC-like waste disposal facility would be relatively small for all disposal methods. Operational activities would create 38 direct jobs (borehole method) to 51 direct jobs (vault method) annually, and an additional 41 indirect jobs (borehole method) to 48 indirect jobs (vault method) in the ROI (Table 8.2.6-1). A GTCC LLRW and GTCC-like waste disposal facility would also produce between $4.0 million in income (borehole method) and $5.0 million in income (vault method) annually during operations.

Two people would move to the ROI area at the beginning of operations (Table 8.2.6-1). However, in-migration would have only a marginal effect on population growth and would require less than 1% of vacant owner-occupied housing during facility operations. No significant impact on public finances would occur as a result of in-migration, and no local public service employees would be required to maintain existing levels of service in the various local public service jurisdictions in the ROI. In addition, on-site employee commuting patterns would have only a small impact on levels of service in the local transportation network surrounding the site.

TABLE 8.2.6-1 Effects of GTCC LLRW and GTCC-Like Waste Disposal Facility Construction and Operations on Socioeconomics at the ROI for LANL[a]

	Trench		Borehole		Vault	
Impact Category	Construction	Operation	Construction	Operation	Construction	Operation
Employment (number of jobs)						
Direct	62	48	47	38	145	51
Indirect	64	46	93	41	169	48
Total	126	94	140	79	314	99
Income ($ in millions)						
Direct	2.3	3.2	2.0	2.6	6.2	3.4
Indirect	2.3	1.6	3.4	1.4	6.0	1.6
Total	4.6	4.8	5.4	4.0	12.2	5.0
Population (number of new residents)	27	2	21	2	64	2
Housing (number of units required)	14	1	10	1	32	1
Public finances (% impact on expenditures)						
Cities and counties[b]	<1	<1	<1	<1	<1	<1
Schools in ROI[c]	<1	<1	<1	<1	<1	<1
Public service employment (number of new employees)						
Local government employees[d]	1	0	0	0	1	0
Teachers	0	0	0	0	1	0
Traffic (impact on current levels of service)	Small	Small	Small	Small	Moderate	Small

a Impacts shown are for waste facility and support buildings in the peak year of construction and the first year of operations.

b Includes impacts that would occur in the cities of Los Alamos, Espanola, and Santa Fe and in Los Alamos, Rio Arriba, and Santa Fe Counties.

c Includes impacts that would occur in the Los Alamos, Chama, Dulce, Espanola, Jemez, Santa Fe, and Pojoaque school districts.

d Includes police officers, paid firefighters, and general government employees.

8.2.7 Environmental Justice

8.2.7.1 Construction

No radiological risks and only a very low level of chemical exposure and risk are expected during construction of the trench, borehole, or vault facility. Chemical exposure during construction would be limited to airborne toxic air pollutants at less than standard levels and would not result in any adverse health impacts. Because the health impacts of each facility on the general population within the 80-km (50-mi) assessment area during construction would be negligible, the impacts from the construction of each facility on the minority and low-income population would not be significant. The most potentially affected population in the 80-km (50-mi) assessment area is the adjacent Pueblos.

8.2.7.2 Operations

Because incoming GTCC LLRW and GTCC-like waste containers would only be consolidated for placement in trench, borehole, and vault facilities, with no repackaging necessary, there would be no radiological impacts on the general public during operations, and no adverse health effects on the general population. In addition, no surface releases that might enter local streams or interfere with subsistence activities by low-income or minority populations would occur. Because the health impacts of routine operations on the general public would be negligible, it is expected that there would be no disproportionately high and adverse impact on minority and low-income population groups within the 80-km (50-mi) assessment area. As was the case for the construction phase, the most potentially affected population in the 80-km (50-mi) assessment area is the adjacent Pueblos. Subsequent NEPA review to support any GTCC implementation would consider any unique exposure pathways (such as subsistence fish, vegetation, or wildlife consumption or well water use) to determine any additional potential health and environmental impacts.

8.2.7.3 Accidents

An accidental radiological release from any of the land disposal facilities would not be expected to cause any LCFs to members of the public in the surrounding area. In the unlikely event of a release at a facility, the communities most likely to be affected could be minority or low-income, given the demographics within 80 km (50 mi) of the GTCC reference location. However, it is highly unlikely such a release would occur, and the risk to any population, including low-income and minority communities, is considered to be low for the accident with the highest potential impacts, estimated to be less than 0.1 LCF for the population groups residing to the southeast of the site.

Although the overall risk would be very small, the greatest short-term risk of exposure following an airborne release and the greatest one-year risk would be to the population groups residing to the southeast of the site because of the prevailing wind condition in this case.

Airborne releases following an accident would likely have a larger impact on the area than would an accident that released contaminants directly into the soil surface. A surface release entering local steams could temporarily interfere with subsistence activities being carried out by low-income and minority populations within a few miles downstream of the site.

Monitoring of contaminant levels in soil and surface water following an accident would provide the public with information on the extent of any contaminated areas. Analysis of contaminated areas to decide how to control the use of high-health-risk areas would reduce the potential impact on local residents.

8.2.8 Land Use

Section 5.3.8 presents an overview of the potential land use impacts that could result from a GTCC LLRW and GTCC-like waste disposal facility regardless of the location selected for the facility. This section evaluates the potential impacts from a GTCC LLRW and GTCC-like waste disposal facility on land use at LANL.

Siting the GTCC LLRW and GTCC-like waste disposal facility at LANL would alter portions of TA-54 that are currently reserve or experimental science areas to waste management areas. Addition of the GTCC LLRW and GTCC-like waste disposal facility within TA-54 would expand the amount of this technical area that is currently used for disposal of radioactive wastes. Land use areas surrounding LANL are considered sacred land and are sovereign lands of the Pueblo de San Ildefonso and the Santa Clara Pueblo. Future land use activities within LANL adjacent to the proposed GTCC LLRW and GTCC-like waste disposal facility would be limited to those that would not jeopardize surrounding sacred and sovereign lands and would also be limited within LANL to those uses that would not jeopardize the integrity of the facility, create a security risk, or create a work or public safety risk.

8.2.9 Transportation

The transportation of GTCC LLRW and GTCC-like waste necessary for the disposal of all such waste at LANL was evaluated. As discussed in Section 5.3.9, transportation of all cargo is considered for both truck and rail modes of transport as separate methods for the purposes of this EIS. Currently, there is no rail at LANL, and construction of a rail spur would have additional potential impacts. Upgrades on-site roads needed for truck transportation on the TA-54 area would also have additional impacts. Transportation impacts are expected to be the same for disposal in boreholes, trenches, or vaults because the same type of transportation packaging would be used regardless of the disposal method chosen.

As discussed in Appendix C, Section C.9, the impacts of transportation were calculated in three areas: (1) collective population risks during routine conditions and accidents (Section 8.2.9.1), (2) radiological risks to individuals receiving the highest impacts during routine conditions (Section 8.2.9.2), and (3) consequences to individuals and populations after the most severe accidents involving the release of a radioactive or hazardous chemical material (Section 8.2.9.3).

Radiological impacts during routine conditions are a result of human exposure to the low levels of radiation near the shipment. The regulatory limit established in 49 CFR 173.441 (Radiation Level Limitations) and 10 CFR 71.47 (External Radiation Standards for All Packages) to protect the public is 0.1 mSv/h (10 mrem/h) at 2 m (6 ft) from the outer lateral sides of the transport vehicle. This dose rate corresponds roughly to 14 mrem/h at 1 m (3 ft). As discussed in Appendix C, Section C.9.4.4, the external dose rates for CH shipments to LANL are assumed to be 0.5 and 1.0 mrem/h at 1 m (3 ft) for truck and rail shipments, respectively. For shipments of RH waste, the external dose rates are assumed to be 2.5 and 5.0 mrem/h for truck and rail shipments, respectively. These assignments are based on shipments of similar types of waste. Dose rates from rail shipments are approximately double those for truck shipments because rail shipments are assumed to have twice the number of waste packages as a truck shipment. Impacts from accidents are dependent on the amount of radioactive material in a shipment and on the fraction that is released if an accident occurs. The parameters used in the transportation accident analysis are described further in Appendix C, Section C.9.4.3.

8.2.9.1 Collective Population Risk

The collective population risk is a measure of the total risk posed to society as a whole by the actions being considered. For a collective population risk assessment, the persons exposed are considered as a group, without specifying individual receptors. Exposures to four different groups are considered: (1) persons living and working along the transportation routes, (2) persons sharing the route, (3) persons at stops along the route, and (4) transportation crew members. The collective population risk is used as the primary means of comparing various options. Collective population risks are calculated for cargo-related causes for routine transportation and accidents. Vehicle-related risks are independent of the cargo in the shipment and are calculated only for traffic accidents (fatalities caused by physical trauma).

Estimated impacts from the truck and rail options are summarized in Tables 8.2.9-1 and 8.2.9-2, respectively. For the truck option, it is estimated that about 12,600 shipments would result in about 36 million km (22 million mi) of travel and no LCFs among truck crew members or the public. One fatality directly related to accidents could result. For the rail option, it is estimated that no LCFs and potentially one physical fatality from accidents would occur, with about 5,010 railcar shipments resulting in about 14 million km (9 million mi) of travel. In addition, for the purpose of the analysis, no intermodal shipments were assumed.

8.2.9.2 Highest-Exposed Individuals during Routine Conditions

During the routine transportation of radioactive material, specific individuals in the vicinity of a shipment may be exposed to radiation. Risks to these individuals for a number of hypothetical exposure-causing events were estimated. The receptors include transportation

TABLE 8.2.9-1 Estimated Collective Population Transportation Risks for Shipment of GTCC LLRW and GTCC-Like Waste by Truck for Disposal at LANL[a]

			Cargo-Related[b] Radiological Impacts								Vehicle-Related Impacts[c]
			Dose Risk (person-rem)						Latent Cancer Fatalities[d]		Physical Accident Fatalities
				Routine Public							
Waste	No. of Shipments	Total Distance (km)	Routine Crew	Off-Link	On-Link	Stops	Total	Accident[e]	Crew	Public	
Group 1											
GTCC LLRW											
Activated metals - RH											
Past BWRs	20	63,900	0.66	0.025	0.1	0.12	0.24	0.00019	0.0004	0.0001	0.0015
Past PWRs	143	399,000	4.2	0.15	0.63	0.73	1.5	0.001	0.002	0.0009	0.0088
Operating BWRs	569	1,580,000	16	0.55	2.4	2.9	5.9	0.0031	0.01	0.004	0.036
Operating PWRs	1,720	4,350,000	45	1.5	6.7	8	16	0.0085	0.03	0.01	0.098
Sealed sources - CH	209	344,000	0.14	0.036	0.2	0.25	0.48	0.018	<0.0001	0.0003	0.0087
Cesium irradiators - CH	240	396,000	0.17	0.041	0.23	0.28	0.56	0.0029	<0.0001	0.0003	0.01
Other Waste - CH	5	5,750	0.0024	0.00052	0.0034	0.0041	0.008	<0.0001	<0.0001	<0.0001	0.00014
Other Waste - RH	54	157,000	1.6	0.057	0.24	0.29	0.59	<0.0001	0.001	0.0004	0.0036
GTCC-like waste											
Activated metals - RH	38	76,100	0.79	0.02	0.11	0.14	0.27	<0.0001	0.0005	0.0002	0.0034
Sealed sources - CH	1	1,650	0.00069	0.00017	0.00096	0.0012	0.0023	<0.0001	<0.0001	<0.0001	<0.0001
Other Waste - CH	69	205,000	0.086	0.03	0.12	0.15	0.3	0.00099	<0.0001	0.0002	0.0042
Other Waste - RH	1,160	3,330,000	34	1.2	5.1	6.1	12	0.0021	0.02	0.007	0.069

TABLE 8.2.9-1 (Cont.)

			Cargo-Related[b] Radiological Impacts								Vehicle-Related Impacts[c]
			Dose Risk (person-rem)						Latent Cancer Fatalities[d]		
				Routine Public							
Waste	No. of Shipments	Total Distance (km)	Routine Crew	Off-Link	On-Link	Stops	Total	Accident[e]	Crew	Public	Physical Accident Fatalities
Group 2											
GTCC LLRW											
Activated metals - RH											
New BWRs	202	432,000	4.5	0.12	0.65	0.79	1.6	0.00089	0.003	0.0009	0.01
New PWRs	833	2,040,000	21	0.7	3.2	3.8	7.6	0.0038	0.01	0.005	0.045
Additional commercial waste	1,990	6,050,000	63	2.3	9.3	11	23	<0.0001	0.04	0.01	0.12
Other Waste - CH	139	423,000	0.18	0.063	0.26	0.3	0.62	0.003	0.0001	0.0004	0.0087
Other Waste - RH	3,790	11,400,000	120	4.3	18	21	43	0.00065	0.07	0.03	0.24
GTCC-like waste											
Other Waste - CH	44	118,000	0.05	0.016	0.071	0.085	0.17	0.00041	<0.0001	0.0001	0.0025
Other Waste - RH	1,400	4,150,000	43	1.5	6.4	7.6	16	0.0021	0.03	0.009	0.086
Total Groups 1 and 2	12,600	35,500,000	350	13	53	64	130	0.048	0.2	0.08	0.76

a BWR = boiling water reactor, PWR = pressurized water reactor, CH = contact-handled, RH = remote-handled.

b Cargo-related impacts are impacts attributable to the radioactive nature of the material being transported.

c Vehicle-related impacts are impacts independent of the cargo in the shipment.

d LCFs were calculated by multiplying the dose by the health risk conversion factor of 6×10^{-4} fatal cancer per person-rem (see Section 5.2.4.3).

e Dose risk is a societal risk and is the product of accident probability and accident consequence.

TABLE 8.2.9-2 Estimated Collective Population Transportation Risks for Shipment of GTCC LLRW and GTCC-Like Waste by Rail for Disposal at LANL[a]

			Cargo-Related[b] Radiological Impacts								Vehicle-Related Impacts[c]
			Dose Risk (person-rem)						Latent Cancer Fatalities[d]		
				Routine Public							
Waste	No. of Shipments	Total Distance (km)	Routine Crew	Off-Link	On-Link	Stops	Total	Accident[e]	Crew	Public	Physical Accident Fatalities
Group 1											
GTCC LLRW											
Activated metals - RH											
Past BWRs	7	20,400	0.17	0.054	0.0032	0.077	0.13	0.00035	0.0001	<0.0001	0.0016
Past PWRs	37	101,000	0.84	0.28	0.017	0.39	0.69	0.0014	0.0005	0.0004	0.0054
Operating BWRs	154	422,000	3.5	1.1	0.062	1.7	2.9	0.0025	0.002	0.002	0.016
Operating PWRs	460	1,200,000	10	3.4	0.18	4.9	8.4	0.0091	0.006	0.005	0.052
Sealed sources - CH	105	190,000	0.53	0.16	0.0085	0.38	0.56	0.00095	0.0003	0.0003	0.0062
Cesium irradiators - CH	120	217,000	0.61	0.19	0.0097	0.44	0.64	0.00013	0.0004	0.0004	0.0071
Other Waste - CH	3	2,740	0.011	0.0025	0.00017	0.0083	0.011	<0.0001	<0.0001	<0.0001	<0.0001
Other Waste - RH	27	85,600	0.68	0.27	0.012	0.33	0.61	<0.0001	0.0004	0.0004	0.0025
GTCC-like waste											
Activated metals - RH	11	23,400	0.21	0.051	0.0028	0.1	0.16	<0.0001	0.0001	<0.0001	0.0023
Sealed sources - CH	1	1,810	0.0051	0.0016	<0.0001	0.0037	0.0053	<0.0001	<0.0001	<0.0001	<0.0001
Other Waste - CH	35	99,700	0.24	0.11	0.0066	0.18	0.29	0.00011	0.0001	0.0002	0.0036
Other Waste - RH	579	1,670,000	14	4.5	0.25	6.7	11	0.00024	0.008	0.007	0.061

TABLE 8.2.9-2 (Cont.)

			Cargo-Related[b] Radiological Impacts								Vehicle-Related Impacts[c]
			Dose Risk (person-rem)						Latent Cancer Fatalities[d]		
				Routine Public							
Waste	No. of Shipments	Total Distance (km)	Routine Crew	Off-Link	On-Link	Stops	Total	Accident[e]	Crew	Public	Physical Accident Fatalities
Group 2											
GTCC LLRW											
Activated metals - RH											
New BWRs	54	119,000	1.1	0.3	0.018	0.52	0.84	0.0012	0.0006	0.0005	0.0051
New PWRs	227	587,000	5	1.7	0.082	2.4	4.2	0.0033	0.003	0.003	0.025
Additional commercial waste	498	1,450,000	12	3.8	0.23	6	10	<0.0001	0.007	0.006	0.054
Other Waste - CH	70	203,000	0.49	0.23	0.014	0.36	0.6	0.00035	0.0003	0.0004	0.0076
Other Waste - RH	1,900	5,550,000	45	15	0.85	23	38	<0.0001	0.03	0.02	0.2
GTCC-like waste											
Other Waste - CH	22	64,300	0.15	0.078	0.0039	0.11	0.19	<0.0001	<0.0001	0.0001	0.0023
Other Waste - RH	702	2,040,000	17	5.4	0.31	8.3	14	0.00022	0.01	0.008	0.076
Total Groups 1 and 2	5,010	14,000,000	110	36	2.1	56	94	0.02	0.07	0.06	0.53

a BWR = boiling water reactor, PWR = pressurized water reactor, CH = contact-handled, RH = remote-handled.

b Cargo-related impacts are impacts attributable to the radioactive nature of the material being transported.

c Vehicle-related impacts are impacts independent of the cargo in the shipment.

d LCFs were calculated by multiplying the dose by the health risk conversion factor of 6×10^{-4} fatal cancer per person-rem (see Section 5.2.4.3).

e Dose risk is a societal risk and is the product of accident probability and accident consequence.

workers, inspectors, and members of the public exposed during traffic delays, while working at a service station, or while living and or working near a destination site. The assumptions about exposure are given in Section C.9.2.2 of Appendix C, and transportation impacts are provided in Section 5.3.9. The scenarios for exposure are not meant to be exhaustive; they were selected to provide a range of representative potential exposures. On a site-specific basis, if someone was living or working near the LANL entrance and present for all 12,600 truck or 5,010 rail shipments projected, that individual's estimated dose would be approximately 0.5 or 1.0 mrem, respectively, over the course of more than 50 years. The individual's associated lifetime LCF risk would then be 3×10^{-7} or 6×10^{-7} for truck or rail shipments, respectively.

8.2.9.3 Accident Consequence Assessment

Whereas the collective accident risk assessment considers the entire range of accident severities and their related probabilities, the accident consequence assessment assumes that an accident of the highest severity category has occurred. The consequences, in terms of committed dose (rem) and LCFs for radiological impacts, were calculated for both exposed populations and individuals in the vicinity of an accident. Because the exact location of such a transportation accident is impossible to predict and thus not specific to any one site, generic impacts were assessed, as presented in Section 5.3.9.

8.2.10 Cultural Resources

The GTCC reference location is situated in the easternmost portion of the LANL site in TA-54. Most of TA-54 has been surveyed for cultural resources. Eighteen cultural resources (sites) are reported to be in or near the project area, and some of the sites in the GTCC reference location are considered eligible for listing on the NHRP. Several sites need evaluation. In addition, several traditional cultural properties are located in the area. If the location is chosen for development, the NHPA Section 106 process would be followed for considering the impact of the project on significant cultural resources. The Section 106 process requires that the project location and any ancillary locations that would be affected by the project be investigated for the presence of cultural resources prior to disturbance. All resources present would be evaluated for historical significance. Impacts on significant resources would be assessed and mitigated during the project. DOE would consult with the New Mexico SHPO and the Pueblo of Jemez, Cochiti Pueblo, Pueblo de San Ildefonso, and Santa Clara Pueblo, and any other appropriate American Indian tribes. The tribes would be consulted to ensure that no traditional cultural properties were located in the project area.

It is expected that the majority of the impacts on cultural resources would occur during the construction phase. The intermediate-depth borehole method has the greatest potential to affect cultural resources because of its 44-ha (110-ac) land requirement. The amount of land needed to employ this method is twice the amount needed to construct a vault or trench.

Unlike the other two methods being considered, the vault method requires large amounts of soil to cover the waste. Potential impacts on cultural resources could occur during the removal and hauling of the soil required for this method. Impacts on cultural resources would need to be considered for the soil extraction locations. The NHPA Section 106 process would be followed for all locations. Potential impacts on cultural resources from the operation of a vault facility could be comparable to those expected from the borehole method. While the actual footprint would be smaller for the vault method, the amount of land disturbed to obtain the soil for the cover could exceed the land requirements for the boreholes. Impacts on culturally significant resources could result from the project. The appropriate tribes would be consulted to ensure that no traditional cultural properties were affected by the project. Most impacts on significant cultural resources could be mitigated through data recovery, but avoidance is preferred.

Activities associated with operations and post-closure are expected to have a minimal impact on cultural resources. No new ground-disturbing activities are expected to occur in association with operational and post-closure activities.

8.2.11 Waste Management

The construction of the land disposal facilities would generate small quantities of hazardous and nonhazardous solids and hazardous and nonhazardous liquids. Waste generated from operations would include small quantities of solid LLRW (e.g., spent HEPA filters) and nonhazardous solid waste (including recyclable wastes). These waste types would either be disposed of on-site or sent off-site for disposal. It is expected that no impacts on waste management programs at LANL would result from the waste that could be generated from the construction and operations of the land disposal methods. Section 5.3.11 provides a summary of the waste handling programs at LANL for the waste types generated.

8.3 SUMMARY OF POTENTIAL ENVIRONMENTAL CONSEQUENCES AND HUMAN HEALTH IMPACTS

The potential environmental consequences from the disposal of GTCC LLRW and GTCC-like waste under Alternatives 3 to 5 are summarized by resource area as follows:

Air quality. It is estimated that during construction and operations, total peak-year emissions of criteria pollutants, VOCs, and CO_2 would be small. The highest construction emissions would be from the vault method and would be about 0.75% of the two-county emissions total for SO_2. The highest operational emissions would be from the trench and vault methods and would be about 0.76% and 0.77%, respectively, of the two-county emissions total for SO_2. O_3 levels in the two counties encompassing LANL are currently in attainment; O_3 precursor emissions from construction and operational activities would be relatively small, less than 0.43% and 0.05% of NO_x and VOC emissions, respectively, and much lower than those for the regional air shed. During construction and operations, maximum CO_2 emissions would be negligible.

Some construction and operational activities might occur within about 200 m (660 ft) of the site boundary. Under unfavorable dispersion conditions, high concentrations of PM_{10} or

$PM_{2.5}$ would likely occur and could at times exceed the standards at the site boundary. However, these activities would not contribute significantly to concentrations at the nearest residence in White Rock, about 3.5 km (2.2 mi) from the GTCC reference location. Fugitive dust emissions during construction would be controlled by following established standard dust control practices.

Noise. The highest composite noise during construction would be about 92 dBA at 15 m (50 ft) from the source. Noise levels at 690 m (2,300 ft) from sources would be below the EPA guideline of 55 dBA as the L_{dn} for residential zones. There are no residences within this distance; the nearest residence is in White Rock, about 3.5 km (2.2 mi) away. Noise generated from operations would be less than noise during the construction phase. No ground-borne vibration impacts are anticipated, since low-vibration generating equipment would be used and since there are no residences or vibration-sensitive buildings in the area.

Geology. No adverse impacts from the extraction or use of geologic and soil resources are expected, nor would there be significant changes in surface topography or natural drainages. Boreholes (at depths of 40 m or 130 ft) would be completed in unconsolidated mesa top alluvium and tuff. The potential for erosion would be reduced by the low precipitation rates (although catastrophic rainfall events do occur) and would be further reduced by best management practices.

Water resources. Construction of a vault facility would have the highest water requirement. Water demands for construction at LANL would be met using groundwater from on-site wells completed in the regional aquifer. No surface water would be used at the site during construction; therefore, no direct impacts on surface water are expected. Indirect impacts on surface water would be reduced by implementing good industry practices and mitigation measures. Construction and operations of the proposed GTCC LLRW and GTCC-like waste disposal facility would increase the annual water use at LANL by a maximum of about 0.24% (vault method) and 0.39% (vault or trench method), respectively. Since these increases are well within LANL's water right and would not significantly lower the water table or change the direction of groundwater flow, impacts due to groundwater withdrawals are expected to be negligible. Groundwater could become contaminated with some highly soluble radionuclides during the post-closure period; indirect impacts on surface water could occur as a result of aquifer discharges to seeps, springs, and rivers.

Human health. The worker impacts during operations would mainly be those from the radiation doses associated with handling of the wastes. It is expected that the annual radiation dose would be 2.6 person-rem/yr for boreholes, 4.6 person-rem/yr for trenches, and 5.2 person-rem/yr for vaults. These worker doses are not expected to result in any LCFs (see Section 5.3.4.1.1). The maximum dose to any individual worker would not exceed the DOE administrative control level (2 rem/yr) for site operations. It is expected that the maximum dose to any individual worker over the entire project would not exceed a few rem. The worker impacts from accidents would be associated with the physical injuries and possible fatalities that could result from construction and waste handling activities. It is estimated that the annual number of lost workdays due to injuries and illnesses during disposal operations would range from 1 (for boreholes) to 2 (for trenches and vaults) and that no fatalities would result from construction and waste handling accidents (see Section 5.3.4.2.2). These injuries would not be associated with the radioactive nature of the wastes but would simply be those expected to occur during any construction project of this size.

With regard to the general public, no measurable doses are expected to occur during waste disposal operations at the site, given the solid nature of the wastes and the distance of waste handling activities from potentially affected individuals. It is estimated that the highest dose to an individual from an accident involving the waste packages prior to disposal (from a fire impacting an SWB) would be 12 rem and would not result in any LCFs. The collective dose to the affected population from such an event is estimated to be 160 person-rem. The peak annual dose in the first 10,000 years after closure of the disposal facility to a hypothetical nearby receptor (resident farmer) who resides 100 m (330 ft) from the disposal site is estimated to be 430 mrem/yr for the vault method. This dose would result mainly from the GTCC LLRW activated metal waste and GTCC-like Other Waste - RH and is projected to occur about 1,100 years in the future. The peak annual doses for the borehole and trench methods would be lower: 160 mrem/yr and 380 mrem/yr, respectively. These doses would occur at 500 years for the borehole method and 1,000 years for the trench method. These times represent the length of time after failure of the engineered barrier (including the cover), which is assumed to begin 500 years after closure of the disposal facility.

***Ecology*.** The initial loss of mostly pinyon-juniper woodland habitat, followed by the eventual establishment of low-growth vegetation, would not create a long-term reduction in the local or regional ecological diversity. After closure, the cover would become vegetated with annual and perennial grasses and forbs. Construction of the GTCC LLRW and GTCC-like waste disposal facility would affect wildlife species inhabiting TA-54; however, small mammals, ground-nesting birds, and reptiles would recolonize the site once vegetative cover was reestablished. Larger mammals, such as elk, American black bears, mountain lions, and bobcats, would likely avoid the area. Foragers and hunters (e.g., mule deer, coyotes, and gray foxes) would be excluded by fences (during the institutional control/monitored post-closure period) around the facility. There are no natural aquatic habitats or wetlands within the immediate vicinity of the GTCC reference location; however, depending on the amount of water in the retention pond and length of retention, certain species (e.g., aquatic invertebrates, waterfowl, shorebirds, amphibians, and mammals) could become established. Several federally and state-listed bird and mammal species occur within the project area. Impacts on these species would likely be small, since the area of habitat disturbance would be small relative to the overall area of such habitat at LANL.

Socioeconomics. Impacts associated with construction and operations of the land disposal facilities would be small. Construction would create direct employment for a maximum of 145 people in the peak construction year and 169 indirect jobs in the ROI (vault method); the annual average employment growth rate would increase by less than 0.1 of a percentage point. The waste facility would produce a maximum of $12.2 million in income in the peak construction year. An estimated 64 people would in-migrate to the ROI as a result of employment on-site; in-migration would have only a marginal effect on population growth and require less than 1% of vacant housing in the peak year. Impacts from operating the facility would also be small, creating a maximum of 51 direct jobs annually and an additional 48 indirect jobs in the ROI (vault method). The disposal facility would produce up to $5.0 million in income annually during operations.

Environmental justice. Health impacts on the general population within the 80-km (50-mi) assessment area during construction and operations would be negligible, and no impacts on minority and low-income populations as a result of the construction and operations of a GTCC LLRW and GTCC-like waste disposal facility are expected. If analyses that accounted for any unique exposure pathways (such as subsistence fish, vegetation, or wildlife consumption or well-water consumption) determined that health and environmental impacts would not be significant, then there would be no high and adverse impacts on minority and low-income populations. If impacts were found to be significant, disproportionality would be determined by comparing the proximity of high and adverse impacts to the location of low-income and minority populations.

Land use. Portions of TA-54 that are currently designated as reserve or experimental science areas would need to be reclassified as waste management areas. The addition of the facility within TA-54 would expand the area that is currently used for disposal of radioactive waste. Land use in areas surrounding LANL would not be affected.

Transportation. Shipment of all waste to LANL by truck would result in approximately 12,600 shipments involving a total distance of 36 million km (22 million mi). For shipment of all waste by rail, 5,010 railcar shipments involving 14 million km (9 million mi) would be required. It is estimated that no LCFs would occur to the public or crew members for either mode of transportation, but one fatality from an accident could occur.

Cultural resources. There are 18 cultural resources within TA-54. Some of these resources are considered significant and would require consideration under the NHPA. The borehole method has the greatest potential to affect cultural resources because of its 44-ha (110-ac) land requirement. The amount of land needed to employ this method is twice the amount needed to construct a vault or trench. It is expected that the majority of the impacts on cultural resources would occur during the construction phase. Activities associated with operations and post-closure are expected to have a minimal impact on cultural resources since no new ground-disturbing activities would occur during these phases. Section 106 of the NHPA would be followed to determine the impact of the project on significant cultural resources. Local tribes would be consulted to ensure no traditional cultural properties were impacted by the project.

Waste management. The wastes that could be generated from the construction and operations of the land disposal methods are not expected to affect the current waste management programs at LANL.

8.4 CUMULATIVE IMPACTS

Section 5.4 presents the methodology for the cumulative impacts analysis. In the analysis that follows, impacts of the proposed action are considered in combination with the impacts of past, present, and reasonably foreseeable future actions. This section begins with a description of reasonably foreseeable future actions at LANL, including those that are ongoing, under construction, or planned for future implementation. Past and present actions are generally accounted for in the affected environment section (Section 8.1).

8.4.1 Reasonably Foreseeable Future Actions at LANL

Reasonably foreseeable future actions at LANL are summarized in the following sections. These actions were included in the cumulative impacts discussion presented in the 2008 SWEIS (DOE 2008c) and consist of the actions described under "expanded operations alternative" in the SWEIS, other DOE or NNSA actions, and actions planned by other agencies for the region surrounding LANL. The cumulative impacts analysis presented in the 2008 SWEIS is used as the baseline for the discussion of potential cumulative impacts at LANL from the proposed action discussed in this EIS. The actions listed are planned, under construction, or ongoing and may not be inclusive of all actions at the site. However, they should provide an adequate basis for determining potential cumulative impacts at LANL.

8.4.1.1 Radioisotope Power Systems Project

In the RPS Project, radioactive power systems are developed for space exploration and national security missions. DOE is currently supporting RPS production, testing, and delivery operations for a national security mission and for the NASA Mars Science Laboratory mission launched in 2011.

8.4.1.2 Plutonium Facility Complex

The production of pits (detonation device for a nuclear bomb) would be achieved by consolidating a number of plutonium processing and support activities (such as analytical chemistry and materials characterization at the Chemistry and Metallurgy Research Replacement Facility [DOE 2008c]). The *Final Supplemental Environmental Impact Statement for the Nuclear Facility Portion of the Chemistry and Metallurgy Research Building Replacement Project at Los Alamos National Laboratory, Los Alamos, New Mexico* (CMRR-NF SEIS), DOE/EIS-0350-S1, was issued in August 2011, with a Modified ROD issued in October 2011 selecting the Modified CMRR-NF Alternative described in the Final SEIS: to proceed forward with the design and construction of the nuclear facility at LANL. However, in the FY 2013 budget request decision, DOE was made to defer the construction of the facility for at least five years. NNSA has determined, in consultation with the national laboratories, that the existing infrastructure in the nuclear complex has the inherent capacity to provide adequate support.

8.4.1.3 Biosafety Level-3 Facility

Construction on the Biosafety Level-3 (BSL-3) Facility was substantially completed in the fall of 2003, but the facility has not yet been put into operation. The facility is a windowless, single-story, 3,200-ft^2 building, housing one BSL-2 laboratory and two BSL-3 laboratories. DOE is preparing an EIS to evaluate the environmental consequences of operating the BSL-3 Facility, which was built upon fill material, including the ability of the facility to withstand seismic loads (LANL 2010).

8.4.1.4 NNSA Complex Transformation

Under the NNSA Complex Transformation, the U.S. nuclear weapons complex would be modified to one that is smaller, more efficient, more secure, and better able to respond to changes in national security requirements. This action would be covered by the national stockpile, stewardship, and management program (DOE 2008b). The current NNSA Complex consists of sites located in seven states (California, Missouri, Nevada, New Mexico, South Carolina, Tennessee, and Texas). Possible alternatives are to restructure special nuclear materials manufacturing and R&D facilities; consolidate special nuclear materials throughout the NNSA Complex; consolidate, relocate, or eliminate duplicate facilities and programs and improve operating efficiencies; and identify one or more sites for conducting NNSA flight test operations (DOE 2008b). In the December 19, 2008, ROD for the Complex Transformation Supplemental Programmatic EIS (73 FR 245, page 77644), the NNSA stated its decision to continue conducting manufacturing and R&D activities involving plutonium at LANL.

8.4.1.5 BLM Electrical Power Transmission Project

Under the BLM Electrical Power Transmission Project, DOE would construct and operate a 31-km (19-mi) electric transmission power line reaching from the Norton Substation, west across the Rio Grande, to locations within LANL TA-3 and TA-5. The construction of one electric substation at LANL would be included in the project, as would the construction of two line segments less than 366-m (1,200-ft) long that would allow for uncrossing a crossed portion of two existing power lines. In addition, a fiber-optic communications line would be included and installed concurrently as part of the required overhead ground conductor for the power line. The new power line would improve the reliability of electric service in LANL and Los Alamos County areas, as would the uncrossing of the crossed segments of the existing lines. In addition, installation of the new power line would enable the LANL and Los Alamos County electric grid, which is a shared resource, to be adapted to accommodate future increased power imports when additional power service becomes available in northern New Mexico (DOE 2000, 2008a).

8.4.1.6 New Mexico Products Pipeline Project

The New Mexico Products Pipeline Project would involve the construction and operation of two additional segments for an existing petroleum products pipeline between distribution terminals in Odessa, Texas, and Bloomfield, New Mexico. Neither of the new segments would be within 80 km (50 mi) of LANL (DOE 2008a).

8.4.1.7 Mid-America Pipeline Western Expansion Project

The Mid-America Pipeline Western Expansion Project would add 12 separate loop sections to the existing liquefied natural gas pipeline to increase system capacity. A 37-km (23-mi) segment would be placed in Sandoval County, 48 km (30 mi) from the LANL boundary. This segment would be constructed parallel to and 7.6 m (25 ft) away from the existing pipeline ROWs (DOE 2008a).

8.4.1.8 Santo Domingo Pueblo-Bureau of Land Management Land Exchange

The Santo Domingo Pueblo-BLM land exchange involves an equal-value exchange of approximately 2,985 ha (7,376 ac) of BLM lands for 261 ha (645 ac) of Santo Domingo Pueblo land in Santa Fe and Taos Counties (BLM 2002).

8.4.1.9 Land Conveyance and Transfer Program

Under P.L. 105-119, DOE, through the Los Alamos Site Office Land Conveyance and Transfer Project, has transferred over 840 ha (2,100 ac) to the Bureau of Indian Affairs in trust for the Pueblo de San Ildefonso and approximately 130 ha (330 ac) to the County of Los Alamos and the Los Alamos Public Schools. In continuation with this program, the Los Alamos Site Office is scheduled to convey an additional 690 ha (1,700 ac) in the next 10 years (DOE 1999b). Several RODs (65 FR 14952, 67 FR 45495, 70 FR 48378, 77 FR 3257) have been issued in support of these actions. To date, 16 tracts have been conveyed to Los Alamos County, 3 tracts have been conveyed to the Los Alamos School Board, and 3 tracts have been conveyed to the Bureau of Indian Affairs to be held in trust for the Pueblo de San Ildefonso.

8.4.1.10 Treatment of Saltcedar and Other Noxious Weeds

The treatment of saltcedar and other noxious weeds is an ongoing adaptive management program for the control of exotic weeds at LANL. An environmental assessment prepared for this project resulted in a finding of no significant impact (FONSI). The project area is approximately 64 km (40 mi) from the LANL boundary (DOE 2008a).

8.4.1.11 Buckman Water Diversion Project

The Buckman Water Diversion Project diverts water from the Rio Grande for use by the City of Santa Fe and Santa Fe County. The diversion project withdraws water from the Rio Grande approximately 5 km (3 mi) downstream from where SR 4 crosses the river. The pipelines for this project largely follow existing roads and utility corridors. Decreased water withdrawals from the Buckman Well Field benefit groundwater levels. Potential impacts on fish and aquatic habitats below the proposed project due to effects on water flow would be minimal (DOE 2008a).

8.4.1.12 46-kV Transmission Loop System

Another project at LANL would upgrade the existing 46-kV transmission loop system that serves central Santa Fe County with a 115-kV system (DOE 2008a).

8.4.1.13 Radioactive Liquid Waste Treatment Facility (RLWTF-UP)

The RLWTF-UP will replace the capabilities that are currently provided by the existing RLWTF, which is beyond its design life. The process systems are required to collect, store, treat, and dispose of up to 5.0 million L (1.3 million gal) per year of low-level waste and industrial waste and 0.029 million L (0.0077 million gal) per year of TRU liquid waste (acid and caustic) generated primarily by weapons manufacturing and R&D activities. The RLWTF-UP is currently being implemented in a phased approach due to budget and programmatic conditions. The overall project scope includes the following subprojects:

- *Zero Liquid Discharge Subproject*: This subproject involves evaporation tanks; transfer lines and pumping from existing and new (i.e., proposed) radioactive liquid waste facilities; and discharge capabilities for off-normal events. The subproject constitutes a “best management practice.” This subproject is currently completing construction.

- *Low-Level Waste Subproject*: This subproject involves the construction of a less than Hazard Category 3 (HC-3) nuclear structure for treatment of this low-level waste. Specifically, the scope of this low-level waste treatment capability includes facility/infrastructure and low-level waste treatment process piping; secondary waste treatment (including storage, treatment, and packaging); treated effluent storage, reuse, and discharge; receipt and storage of chemicals; a laboratory for process sample analysis; secondary solid waste storage and handling; and electrical/control/data transmission and receipt of equipment associated with low-level waste influent storage, treatment processes, and effluent storage/discharge and shipment of solid waste. This subproject includes a Utility Building to support the low-level waste processes.

- *TRU Liquid Waste Subproject*: This subproject involves the construction of a new HC-3 nuclear structure for storage of the TRU liquid waste influent, treatment for the removal of TRU elements, and transfer to low-level waste treatment. Specifically, the scope of this TRU liquid waste treatment capability includes facility/infrastructure and TRU liquid waste treatment process piping; secondary waste treatment (including storage, treatment, and packaging); treated effluent transfer; receipt and storage of chemicals; secondary solid waste storage and handling; and electrical/control/data transmission and receipt of equipment associated with TRU liquid waste influent storage, treatment processes, and effluent transfer and shipment of solid waste.

8.4.1.14 TRU Waste Facility

Existing capabilities to manage solid radioactive waste must be re-established outside Area G to allow closure of Area G and maintain compliance with the Consent Order. The proposed facility will handle only Defense Program newly generated solid TRU wastes. Newly generated solid TRU wastes are defined as those generated after 1999. The TRU Waste Facility Project will be located in the TA-63 site south of Puye Road and west of Pajarito Road. The project will be designed, permitted, constructed, and commissioned as an HC-2 nuclear facility, with a RCRA permit to store hazardous wastes. The facility will consist of multiple buildings for the storage of TRU waste to meet nuclear facility requirements for staging of newly generated solid TRU wastes in support of LANL programs and missions. A RCRA-permitted pad with power hook-up will be designed and constructed for the characterization and testing trailers required to certify whether containers meet the WIPP WAC. Other functions provided at the TRU Waste Facility will include intra-site shipping and receiving, operational support, and the provision of necessary utilities and services. The project is currently in the planning and design stage.

8.4.2 Cumulative Impacts from the GTCC Proposed Action at LANL

Potential impacts of the proposed action are considered in combination with the impacts of past, present, and reasonably foreseeable future actions. The impacts from Alternatives 3 to 5 at LANL are described in Section 8.2 and summarized in Section 8.3. These sections indicate that the potential impacts from the proposed action (construction and operations of a borehole, trench, or vault facility) for all the resource areas and the transportation of waste would be small. On the basis of the total impacts (including the reasonably foreseeable future actions summarized in Section 8.4.1) reported in the 2008 SWEIS (DOE 2008c), it is unlikely that the additional potential impacts from the GTCC proposed action would contribute substantially to cumulative impacts for the resource areas evaluated for LANL.

To provide perspective, the potential impacts from this EIS were compared to values provided in the *Final Site-Wide Environmental Impact Statement for Continued Operation of Los Alamos National Laboratory, Los Alamos, New Mexico* (DOE 2008c). For example, the maximum acreage of land affected by the disposal of GTCC LLRW and GTCC-like waste would be about 44 ha (110 ac). This is a small percentage of the total amount of land (10,360 ha or 40 mi^2 or 25,600 ac) that makes up the 48 contiguous TAs at LANL. The GTCC EIS socioeconomics evaluation indicates that about 51 additional (direct) jobs would be created by the operation of any of the facilities considered. This number is small relative to the 13,500 people who currently work at LANL and the 1,890 new direct jobs projected to be created for the expanded operations alternative at LANL by 2011. With regard to potential worker doses, the GTCC EIS estimate of about 5.2 person-rem/yr is low when compared to the 540 person-rem/yr estimated as the total for LANL from various other activities under the expanded operations alternative.

However, the estimated human health impacts from the GTCC proposed action could add an annual dose of up to 430 mrem/yr or result in an annual LCF risk of 3E-04 (based on the vault disposal method) 1,100 years after closure of the GTCC LLRW and GTCC-like waste disposal facility at LANL. The performance assessment and composite analysis for LANL TA-54 indicate that the peak mean dose incurred by members of the closest residential communities would be 4 mrem/yr over the compliance period of 1,000 years (LANL 2008). Final considerations regarding any cumulative impacts on human health should incorporate the actual design of the GTCC LLRW and GTCC-like waste disposal facility at LANL and use similar assumptions and a similar compliance period. Finally, follow-on NEPA evaluations and documents prepared to support any further considerations of siting a new borehole, trench, or vault disposal facility at LANL would provide more detailed analyses of site-specific issues, including cumulative impacts.

8.5 SETTLEMENT AGREEMENTS AND CONSENT ORDERS FOR LANL

A Compliance Order on Consent, involving DOE and LANL as respondents, was issued on March 1, 2005 (revised October 29, 2012) by the NMED. As a result, LANL agreed to a schedule for completion of cleanup at various locations on the LANL site. The purposes of the Consent Order are to (1) fully determine the nature and extent of releases of contaminants at or from LANL; (2) identify and evaluate, where needed, alternatives for corrective measures, including interim measures, designed to clean up contaminants in the environment and prevent or mitigate the migration of contaminants at or from LANL; and (3) implement such corrective measures. However, the Consent Order contains no requirements for radionuclides or the radioactive portion of mixed waste.[4]

In January 2012, DOE and the State of New Mexico issued a nonbinding Framework Agreement as a blueprint on cleanup at LANL. It specifically calls for the cleanup of TRU waste currently stored in aboveground containers on the LANL grounds at Area G. The Framework Agreement sets a deadline for disposal of more than 3,700 m^3 (4,800 yd^3) of TRU waste from Area G by June 30, 2014. That disposal involves physically packing the radioactive TRU waste into approved transportation containers that are then shipped by truck to WIPP in Carlsbad, New Mexico, for permanent underground emplacement. The Framework Agreement also includes a DOE/LANL commitment to complete the removal of all newly generated TRU waste, received at Area G during FY 2012 and FY 2013, by December 31, 2014. The Framework Agreement continues to prioritize groundwater and surface water monitoring to ensure protection of human health and the environment. The Order of Consent and Framework Agreement will be taken into consideration as part of the decision-making process for disposal of GTCC LLRW and GTCC-like waste.

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THE U.S. DEPARTMENT OF ENERGY

Final Environmental Impact Statement for the

Disposal of Greater-Than-Class C (GTCC) Low-Level Radioactive Waste and GTCC-Like Waste (DOE/EIS-0375)

Volume 2: Chapter 9 through Appendix I

January 2016

U.S. DEPARTMENT OF ENERGY

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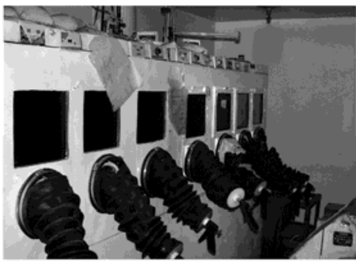

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NOTATION

ACRONYMS AND ABBREVIATIONS

ACHP	Advisory Council on Historic Preservation
AEA	Atomic Energy Act of 1954
AEC	U.S. Atomic Energy Commission
AIP	Agreement in Principle
AIRFA	American Indian Religious Freedom Act of 1978
ALARA	as low as reasonably achievable
AMC	activated metal canister
AMWTP	Advanced Mixed Waste Treatment Project
ANOI	Advanced Notice of Intent
AQRV	air-quality-related value
ARP	Actinide Removal Process
ATR	Advanced Test Reactor (INL)
bgs	below ground surface
BLM	Bureau of Land Management
BLS	Bureau of Labor Statistics
BNSF	Burlington Northern Santa Fe
BRC	Blue Ribbon Commission on America's Nuclear Future
BSL	Biosafety Level
BWR	boiling water reactor
CAA	Clean Air Act
CAAA	Clean Air Act Amendments
CAP88-PC	Clean Air Act Assessment Package 1988-Personal Computer (code)
CCDF	complementary cumulative distribution function
CEDE	committed effective dose equivalent
CEQ	Council on Environmental Quality
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFA	Central Facilities Area (INL)
CFR	*Code of Federal Regulations*
CGTO	Consolidated Group of Tribes and Organizations
CH	contact-handled
CRMD	Cultural Resource Management Office
CTUIR	Confederated Tribes of the Umatilla Indian Reservation
CWA	Clean Water Act
CX	Categorical Exclusion
DCF	dose conversion factor
DCG	derived concentration guide
DOE	U.S. Department of Energy
DOE-EM	DOE-Office of Environmental Management

DOE-ID	DOE-Idaho Operations Office
DOE-NV	DOE-Nevada Operations Office
DOE-RL	DOE-Richland Operations Office
DOI	U.S. Department of the Interior
DOT	U.S. Department of Transportation
DRZ	disturbed rock zone
DTRA	Defense Threat Reduction Agency
DWPF	Defense Waste Processing Facility
EAC	Early Action Area
EDE	effective dose equivalent
EDNA	Environmental Designation for Noise Abatement
EIS	environmental impact statement
EPA	U.S. Environmental Protection Agency
ERDF	Environmental Restoration Dispersal Facility
ESA	Endangered Species Act of 1973
ESRP	Eastern Snake River Plain (INL)
FFTF	Fast Flux Test Facility (Hanford)
FGR	Federal Guidance Report
FONSI	Finding of No Significant Impact
FR	*Federal Register*
FTE	full-time equivalent
FY	fiscal year
GAO	U.S. Government Accountability (formerly General Accounting) Office
GMS/OSRP	Office of Global Material Security/Off-Site Source Recovery Project
GSA	General Separations Area (SRS)
GTCC	greater-than-Class C
HAP	hazardous air pollutant
HC	Hazard Category
HEPA	high-efficiency particulate air
HEU	highly enriched uranium
HF	hydrogen fluoride
HFIR	High Flux Isotope Reactor (ORNL)
HMS	Hanford Meteorology Station
HOSS	hardened on-site storage
h-SAMC	half-shielded activated metal canister
HSW EIS	Final Hanford Site Solid (Radioactive and Hazardous) Waste Program Environmental Impact Statement
ICRP	International Commission on Radiological Protection
IDA	intentional destructive act
IDAPA	Idaho Administrative Procedures Act
IDEQ	Idaho Department of Environmental Quality

IDF	Integrated Disposal Facility
INL	Idaho National Laboratory
INTEC	Idaho Nuclear Technology and Engineering Center (INL)
ISFSI	independent spent fuel storage installation
LANL	Los Alamos National Laboratory
LCF	latent cancer fatality
L_{dn}	day-night sound level
L_{eq}	equivalent-continuous sound level
LEU	low-enriched uranium
LLRW	low-level radioactive waste
LLRWPAA	Low-Level Radioactive Waste Policy Amendments Act of 1985
LMP	Land Management Plan (WIPP)
LWA	Land Withdrawal Act (WIPP)
LWB	Land Withdrawal Boundary (WIPP)
MCL	maximum contaminant level
MCU	modular caustic side solvent extraction unit
MDA	material disposal area (LANL)
MOA	Memorandum of Agreement
MOU	Memorandum of Understanding
MOX	mixed oxides
MPSSZ	Middleton Place-Summerville Seismic Zone
MSL	mean sea level
NAAQS	National Ambient Air Quality Standard(s)
NAGPRA	Native American Graves Protection and Repatriation Act of 1990
NASA	National Aeronautics and Space Administration
NCRP	National Council on Radiation Protection and Measurements
NDA	NRC-licensed disposal area (West Valley Site)
NEPA	National Environmental Policy Act of 1969
NERP	National Environmental Research Park
NESHAP	National Emission Standard for Hazardous Air Pollutants
NHPA	National Historic Preservation Act
NI PEIS	Nuclear Isotope PEIS
NLVF	North Las Vegas Facility
NMAC	*New Mexico Administrative Code*
NMED	New Mexico Environment Department
NMFS	National Marine Fisheries Services
NNHP	Nevada Natural Heritage Program
NNSA	National Nuclear Security Administration (DOE)
NNSA/NSO	NNSA/Nevada Site Office
NNSS	Nevada National Security Site (formerly Nevada Test Site or NTS)
NOAA	National Oceanic and Atmospheric Administration
NOI	Notice of Intent
NPDES	National Pollutant Discharge Elimination System

NPS	National Park Service
NRC	U.S. Nuclear Regulatory Commission
NRHP	*National Register of Historic Places*
NTS SA	Nevada Test Site Supplemental Analysis
NTTR	Nevada Test and Training Range
ORNL	Oak Ridge National Laboratory
ORR	Oak Ridge Reservation
PA	programmatic agreement
PCB	polychlorinated biphenyl
PCS	primary constituent standard
PEIS	programmatic environmental impact statement
P.L.	Public Law
PM	particulate matter
$PM_{2.5}$	particulate matter with an aerodynamic diameter of 2.5 µm or less
PM_{10}	particulate matter with an aerodynamic diameter of 10 µm or less
PPV	Peak Particle Velocity
PSD	Prevention of Significant Deterioration
PSHA	Probabilistic Seismic Hazards Assessment
PWR	pressurized water reactor
R&D	research and development
RCRA	Resource Conservation and Recovery Act
RDD	radiological dispersal device
RH	remote-handled
RH LLW EA	Remote-Handled Low-Level Waste Environmental Assessment (INL)
RLWTF-UP	Radioactive Liquid Waste Treatment Facility-Upgrade (LANL)
ROD	Record of Decision
ROI	region of influence
ROW	right-of-way
RPS	Radioisotopic Power Systems
RSL	Remote Sensing Laboratory
RWMC	Radioactive Waste Management Complex (INL)
RWMS	Radioactive Waste Management Site (NNSS)
SA	Supplemental Analysis
SAAQS	State Ambient Air Quality Standards
SALDS	State-Approved Land Disposal Site
SCDHEC	South Carolina Department of Health and Environmental Control
SCE&G	South Carolina Electric Gas
SDA	state-licensed disposal area (West Valley Site)
SDWA	Safe Drinking Water Act
SHPO	State Historic Preservation Office(r)
SNF	spent nuclear fuel
SR	State Route

SRS	Savannah River Site
SWB	standard waste box
SWEIS	Site-Wide Environmental Impact Statement
TA	Technical Area (LANL)
TC&WM EIS	Tank Closure and Waste Management EIS (Hanford)
TEDE	total effective dose equivalent
TEDF	Treated Effluent Disposal Facility
TEF	Tritium Extraction Facility
TLD	thermoluminescent dosimeter
TRU	transuranic
TRUPACT-II	Transuranic Package Transporter-II
TSCA	Toxic Substances Control Act
TSP	total suspended particulates
TTR	Tonapah Test Range
TVA	Tennessee Valley Authority
US	United States
USACE	U.S. Army Corps of Engineers
USC	*United States Code*
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
VOC	volatile organic compound
WAC	waste acceptance criteria or *Washington Administrative Code*
WHB	Waste Handling Building (WIPP)
WIPP	Waste Isolation Pilot Plant
WSRC	Westinghouse Savannah River Company
WTP	Waste Treatment Plant (Hanford)
WVDP	West Valley Demonstration Project

UNITS OF MEASURE

ac	acre(s)
ac-ft	acre-foot (feet)
°C	degree(s) Celsius
cfs	cubic foot (feet) per second
Ci	curie(s)
cm	centimeter(s)
cms	cubic meter(s) per second
d	day(s)
dB	decibel(s)
dBA	A-weighted decibel(s)
°F	degree(s) Fahrenheit
ft	foot (feet)
ft^2	square foot (feet)
ft^3	cubic foot (feet)
g	gram(s) or acceleration of gravity (9.8 m/s/s)
gal	gallon(s)
gpd	gallon(s) per day
gpm	gallon(s) per minute
h	hour(s)
ha	hectare(s)
hp	horsepower
in.	inch(es)
kg	kilogram(s)
km	kilometer(s)
km^2	square kilometer(s)
kph	kilometer(s) per hour
kV	kilovolt(s)
L	liter(s)
lb	pound(s)
m	meter(s)
m^2	square meter(s)
m^3	cubic meter(s)
MCi	megacurie(s)
mg	milligram(s)
mi	mile(s)
mi^2	square mile(s)
min	minute(s)
mL	milliliter(s)
mm	millimeter(s)
mph	mile(s) per hour
mR	milliroentgen(s)
mrem	millirem
mSv	millisievert(s)
MW	megawatt(s)
MWh	megawatt-hour(s)
nCi	nanocurie(s)
oz	ounce(s)
pCi	picocurie(s)
ppb	part(s) per billion
ppm	part(s) per million
R	roentgen(s)
rad	radiation absorbed dose
rem	roentgen equivalent man
s	second(s)
t	metric ton(s)
VdB	vibration velocity decibel(s)
yd	yard(s)
yd^2	square yard(s)
yd^3	cubic yard(s)
yr	year(s)
μg	microgram(s)
μm	micrometer(s)

9 NEVADA NATIONAL SECURITY SITE: AFFECTED ENVIRONMENT AND CONSEQUENCES OF ALTERNATIVES 3, 4, AND 5

This chapter provides an evaluation of the affected environment, environmental and human health consequences, and cumulative impacts from the disposal of GTCC LLRW and GTCC-like waste under Alternative 3 (in a new borehole disposal facility), Alternative 4 (in a new trench disposal facility), and Alternative 5 (in a new vault disposal facility) at NNSS. (NNSS was formerly the Nevada Test Site or NTS; this site is referred to as NNSS throughout this EIS except when citing site reports that were published as NTS reports.) Alternatives 3, 4, and 5 are described in Section 5.1. Environmental consequences that are common to the sites for which Alternatives 3, 4, and 5 are evaluated (including NNSS) are discussed in Chapter 5 and not repeated in this chapter. Impact assessment methodologies used for this EIS are described in Appendix C. Federal and state statutes and regulations and DOE Orders relevant to NNSS are discussed in Chapter 13 of this EIS.

This chapter also includes tribal narrative text that reflects the views and perspectives of the Consolidated Group of Tribes and Organizations representing 16 Paiute and Western Shoshone tribes affiliated with NNSS. The tribal text is included in text boxes in Section 9.1. Full narrative texts provided by the tribes are in Appendix G. The perspectives and views presented are solely those of the tribes. When tribal neutral language is used (e.g., Indian People, Native People, Tribes) within the tribal text, it reflects the input from these tribes unless otherwise noted. DOE recognizes that American Indians have concerns about protecting traditions and spiritual integrity of the land in the NNSS region, and that these concerns extend to the propriety of the Proposed Action. Presenting tribal views and perspectives in this EIS does not represent DOE's agreement with or endorsement of such views. Rather, DOE respects the unique and special relationship between American Indian tribal governments and the Government of the United States, as established by treaty, statute, legal precedent, and the U.S. Constitution. For this reason, DOE has presented tribal views and perspectives in this EIS to ensure full and fair consideration of tribal rights and concerns before making decisions or implementing programs that could affect tribes.

9.1 AFFECTED ENVIRONMENT

This section discusses the affected environment for the various environmental resource areas evaluated for the GTCC reference location at NNSS. The GTCC reference location is located within Area 5 (Figure 9.1-1). The reference location was selected primarily for evaluation purposes for this EIS. The actual location would be identified on the basis of follow-on evaluations if and when it is decided to locate a land disposal facility at NNSS.

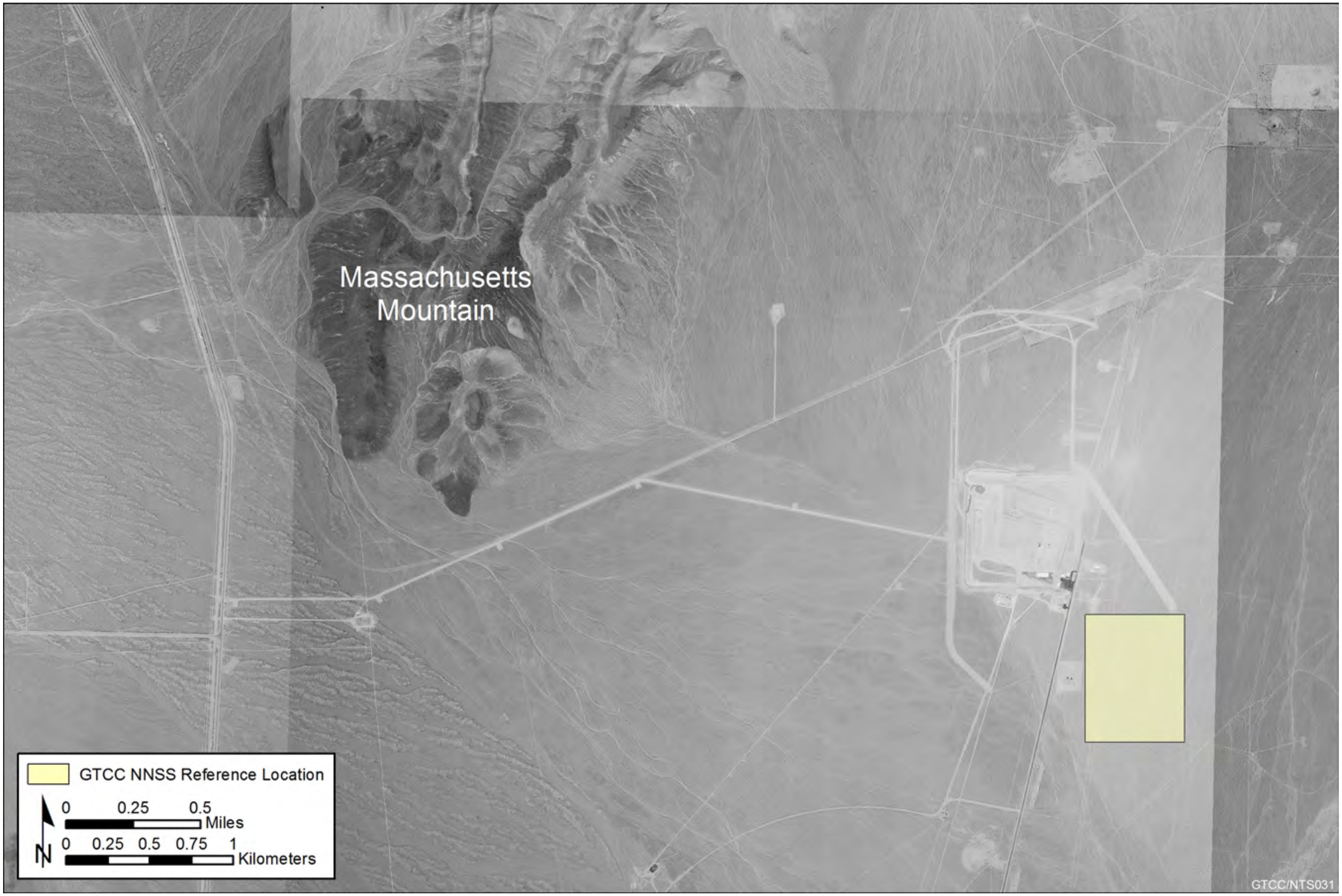

FIGURE 9.1-1 Map Showing Location of Frenchman Flat and GTCC Reference Location at NNSS

9.1.1 Climate, Air Quality, and Noise

9.1.1.1 Climate

NNSS is located in the extreme southwestern corner of the Great Basin. Consequently, the climate is arid and with limited precipitation, low humidity, large daily temperature ranges, and intense solar radiation during the summer months (NOAA 2008). The four seasons are well defined, with a hot and mostly dry summer, cool temperatures in the spring and late fall, and cool to cold temperatures in the winter (Soule 2006).

Complex topography, such as that at NNSS, can influence wind speeds and directions. Furthermore, there is a seasonal as well as strong daily periodicity to local wind conditions. The winds at NNSS exhibit strong diurnal effects near the surface during all seasons of the year. The

American Indian Text

The CGTO knows that the southern bajada (alluvial fan) of French Peak and associated hills to the east combine to periodically cause massive runoffs which flow rapidly towards Frenchman Playa making it a seasonal shallow lake. Frenchman Playa has a 140 square-mile watershed that could impact the GTCC site as it potentially does the current RWMS. Especially considered in these Indian comments are runoffs from the north of the proposed GTCC storage area. This watershed involves 13.6 square miles and directly impacts the current RWMS. This runoff from this area is normally sheetflow, but every 23 years or so a major flood occurs. This threat has resulted in the RWMS building a large diversion dike and trench to protect the current Radioactive Waste Management Complex. The Raytheon study indicates that the southwest corner of the RWMS is located in the 100-year flood hazard zone, but the entire northern alluvial fan brings runoff directly into the immediate area.

The CGTO requests an analysis of the hydrological and ecological impacts of the existing water diversion dike of the current Radioactive Waste Management Complex in Area 5. The DOE recognizes that this is a very flood prone area, with major flooding episodes occurring about every 23 years. Indian people visiting this site observed that even though the current dike has been built recently and thus not experienced a 23-year flood, it has diverted and consolidated sufficient runoff that a small arroyo has been established. The Indian people visiting this site believe that the existing dike has unnaturally stressed down-slope plants and animals who now do not receive normal sheet runoff. The Indian people visiting the site believe that by concentrating the runoff, the dike has reduced the amount of water absorbed during normal sheet runoff because the consolidated runoff moves more quickly and only flows in the new and developing eroded arroyo. It is believed by the Indian people visiting the site that were a GTCC facility to be established east of the current RWMS then the dike would necessarily have to be extended causing an even greater runoff shadow and an even greater developing arroyo. The desert tortoise in the area will have to move out of this larger runoff shadow and may be concentrated in the area of Frenchmen Playa. Moving their living areas towards the playa will expose them to higher levels of radioactivity. The Indian people visiting the site believe that these current and potential impacts should be analyzed, monitored by Indian people, and reported back to the CGTO at the next annual meeting.

American Indian Text

The CGTO knows that the climate of the region has changed over the thousands of years that the Indian people have lived in this region. The NNSS has only occupied this area since the early 1940s. It is important to recognize that major climatic changes have taken place since the end of the Pleistocene and shorter term climate changes such as the wet period in the 1980s and 1990s contrast with the current 10-year drought. It is important for the GTCC EIS to assess the impacts of short term and long term climatic changes because the DOE expects to safely manage these GTCC wastes for up to 10K years during which similar climate changes can be expected.

The current climate description in the GTCC EIS is specific to the present decade-long period of extended drought (a similar one occurred between 1896 and 1906) so this type of drought and the wet period between 1980s and 1990s may be a factor in siting the GTCC facility. An analysis of long term impacts based on current conditions will neither be representative of climate conditions viewed over much longer periods nor applicable to a short climate shift to much wetter conditions.

The climatic effects of both wet and dry periods should be analyzed and incorporated in the GTCC site assessment.

American Indian Text

One performance objective in selecting a preferred site is to protect individuals and communities who might occupy the disposal site after active and passive controls are no longer present. These individuals are to be protected from exposure to GTCC radiation while they engage in normal activities such as agriculture, dwelling construction, food acquisition, and ceremony. The CGTO believes that a wetter climate will raise the water table up to or over the GTCC waste site. Nearby wetland plants and animals would absorb radiation and then expose local people. Drinking water from these wetlands will also result in exposure. Indian people visiting the site believe their descendants will live near and use these wetlands as their ancestors did thousands of years ago.

nighttime winds are generally from the north at the lower elevations during all seasons. These nocturnal winds ("drainage winds") are disturbed only by the presence of extensive lower clouds or very strong winds aloft. The daytime winds are generally from the south during the warm seasons and from the north during the cool seasons. At the Area 5 station, the wind direction is primarily from the south-southwest and secondarily from the southwest; the wind is more pronounced in spring and fall, as shown in Figure 9.1.1-1 (NOAA 2008). For the period 1981–2001, the annual average wind speed was 2.8 m/s (6.3 mph) at the Area 5 station. Wind speed is the fastest in spring, slower in summer and autumn, and becomes the slowest in winter. During the same period, the peak wind speed was recorded at 30 m/s (67 mph).

As is typical of an arid climate, NNSS experiences large daily, as well as annual, ranges in temperature. For the 1981–2001 period, the annual average temperature at the Area 5 station was 15.2°C (59.4°F) (NOAA 2008). December was the coldest month, averaging 3.9°C (39.1°F)

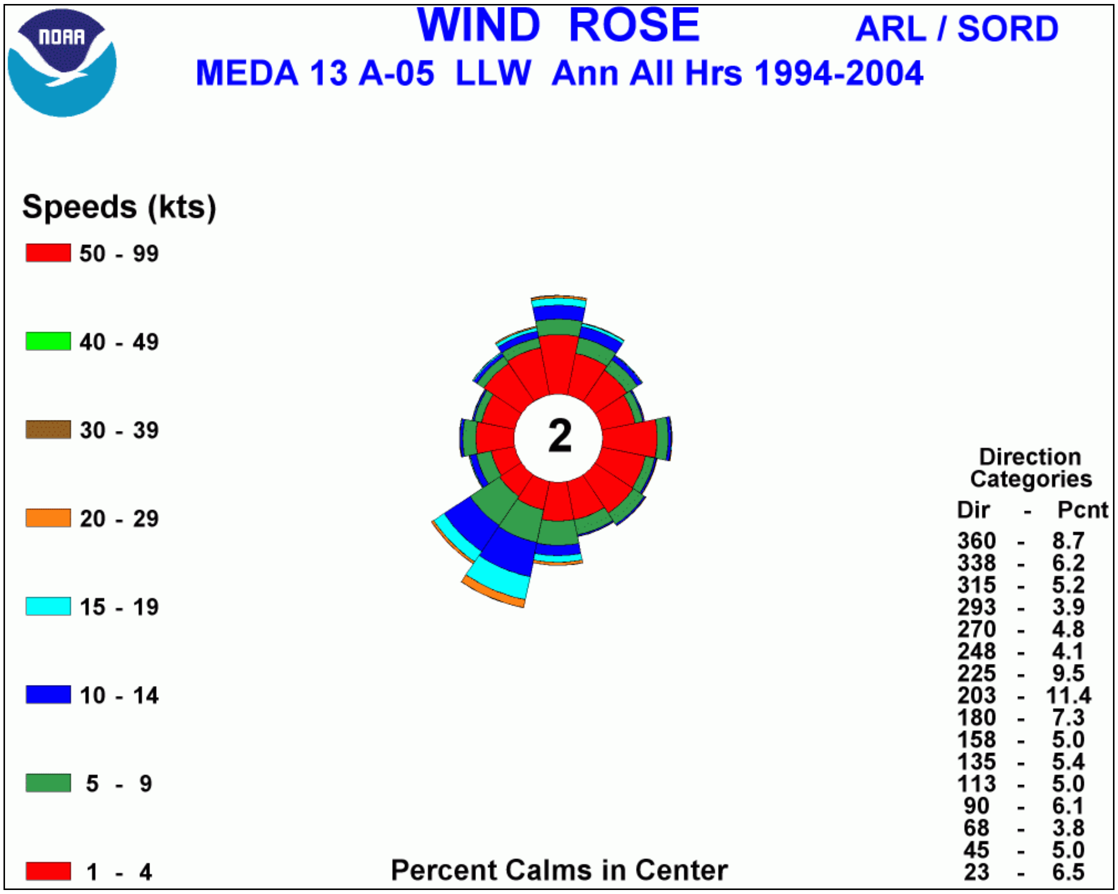

FIGURE 9.1.1-1 Wind Rose at the Area 5 North (A5N) Station at NNSS, 1994–2004 (Source: NOAA 2008)

and ranging from –5.4 to 13.3°C (22.3 to 55.9°F), and July was the warmest month, averaging 27.5°C (81.5°F) and ranging from 16.6 to 38.4°C (61.8 to 101.1°F). For the same period, the highest temperature reached was 46.1°C (115°F), and the lowest was –21.1°C (–6°F). The number of days with a maximum temperature higher than or equal to 32.2°C (90°F) was about 115, while the number of days with a minimum temperature lower than or equal to 0°C (32°F) was about 114.

Precipitation occurs mostly in the winter, early spring, and mid-summer. Elevation is not the only factor in determining the potential for precipitation at NNSS. Some locations at NNSS get more precipitation because they are in the vicinity of higher terrain (upwind barrier, upslope enhancement, etc.) (Soule 2006). Average annual precipitation is the lowest (at 12 cm or 5 in.) at Area 5 and the highest (at 32.6 cm or 12.82 in.) at the Rainier Mesa. The precipitation at NNSS is mostly in the form of rain, except at high elevations above 1,800 m (6,000 ft) MSL in the winter months. Snow falls occasionally at all locations at NNSS, but it is relatively rare at locations below 1,200 m (4,000 ft) MSL.

NNSS experiences high winds at times, mostly in the spring, associated with the passing of strong cold fronts or with thunderstorms. High winds can also occur in the winter with high pressure over the Great Basin (Soule 2006). Other than these instances, severe weather is uncommon at the NNSS.

Tornadoes in the area surrounding NNSS are much less frequent and destructive than those in the tornado alley in the central United States. For the period 1950–2008, 75 tornadoes were reported in Nevada, with an average of 1.3 tornadoes per year (NCDC 2008). For the period 1950–2008, a total of 3 tornadoes with an average of less than 0.1 tornado per year were reported in Nye County, including NNSS. However, most tornadoes occurring in the county were relatively weak; all were F0 on the Fujita tornado scale and caused no deaths or injuries.

9.1.1.2 Existing Air Emissions

Title V of the 1990 CAAA authorized the states to implement permit programs in order to regulate emissions of the criteria pollutants. At NNSS, there is one main permit that regulates operations and emissions from various major activities (Wills et al. 2007). Nevada air quality permits specify emission limits for criteria pollutants (except O_3 and lead) that are based on published emission values for other similar industries and on operational data specific to NNSS.

Annual emissions of criteria pollutants and VOCs from major facility total point and area sources for the year 2002 in Nye County, including NNSS, are presented in Table 9.1.1-1 (EPA 2009). (Data for 2002 were the most recent emission inventory data available on the EPA website.) Area sources consist of nonpoint and mobile sources. There are no major point sources nearby, so area sources account for most of the emissions of criteria pollutants and VOCs, except for SO_2. On-road sources are major contributors to the total emissions of NO_X, CO, and VOCs. Miscellaneous sources are major contributors to total emissions of PM_{10} and $PM_{2.5}$. Industrial fuel combustion is a major contributor to SO_2 emissions. Nonradiological emissions associated with the activities at NNSS are less than 0.95% of those reported for Nye County (Table 9.1.1-1).

An estimated 4.15 metric tons or t (4.57 tons) of criteria pollutants were released from the NNSS facilities and equipment that were operational in 2006. The majority of the emissions were NO_X from diesel generators and VOCs from the bulk storage of gasoline (Wills et al. 2007). Table 9.1.1-2 presents data on emissions of criteria pollutants, VOCs, and hazardous air pollutants (HAPs) for the years 2002–2006.

9.1.1.3 Air Quality

The Nevada SAAQS for six criteria pollutants – SO_2, NO_2, CO, O_3, PM_{10} and $PM_{2.5}$, and lead – are identical to the NAAQS (EPA 2008a; *Nevada Administrative Code* 445B.391), as shown in Table 9.1.1-3. However, no state standards have been established for 8-hour O_3 and $PM_{2.5}$ in Nevada, and the state has a more stringent standard for CO at higher elevations (about 1,500 m or 5,000 ft) and for O_3 at Lake Tahoe. In addition, Nevada has adopted standards for H_2S and for visibility.

TABLE 9.1.1-1 Annual Emissions of Criteria Pollutants and Volatile Organic Compounds from Selected Major Facilities and Total Point and Area Source Emissions in Nye County, Including NNSS[a]

	Emission Rate (tons/yr)					
Emission Category	SO_2	NO_x	CO	VOCs	PM_{10}	$PM_{2.5}$
Nye County						
NNSS[b]	*1.7*	*23*	*5.0*	*2.3*	*5.0*	*3.9*
	0.72%[c]	*2.6%*	*0.06%*	*0.16%*	*0.14%*	*0.55%*
Point sources	120	150	35	93	150	63
Area sources	110	720	7,900	1,400	3,500	630
Total	230	870	7,900	1,500	3,700	700

[a] Values are rounded up to two significant figures. Emission data for selected major facilities and total point and area sources are for year 2002. CO = carbon monoxide; NO_x = nitrogen oxides; $PM_{2.5}$ = particulate matter ≤2.5 μm; PM_{10} = particulate matter ≤10 μm; SO_2 = sulfur dioxide; VOCs = volatile organic compounds.

[b] Values in italics are not added to yield total.

[c] Values in this row are emissions as percentages of Nye County total emissions.

Source: EPA (2009)

The GTCC reference location within NNSS is within Nye County. Currently, the entire county is designated as being in attainment for all criteria pollutants (40 CFR 81.329). However, parts of Clark County, including Las Vegas, which is about 80 km (50 mi) southeast of the GTCC reference location, are designated nonattainment areas for CO, 8-hour O_3, and PM_{10}. NNSS is generally not located downwind of prevailing winds in Las Vegas.

Monitoring data for criteria pollutants (except 8-hour O_3, $PM_{2.5}$, and lead) are available at Yucca Mountain close to the GTCC reference location (DOE 2002b). The highest concentration levels for SO_2, NO_2, CO, and PM_{10} around NNSS are less than 45% of their respective standards in Table 9.1.1-3 (DOE 2002b). However, the highest 1-hour O_3 and 24-hour $PM_{2.5}$ concentrations are somewhat higher (around 83% and 91% of their standards, respectively). The highest 8-hour O_3 concentrations exceed the standard in Las Vegas; however, concentrations at NNSS would be lower because NNSS is not located downwind of prevailing winds in Las Vegas.

NNSS and its vicinity are classified as PSD Class II areas. No Class I area exists within 100 km (62 mi) of the GTCC reference location (40 CFR 81.418). Grand Canyon National Park in Arizona and John Muir Wilderness Area in California are the closest, and they are about 200 km (124 mi) from the GTCC reference location. There are no facilities currently operating at NNSS that are subject to PSD regulations.

TABLE 9.1.1-2 Annual Emissions of Criteria Air Pollutants, Volatile Organic Compounds, and Hazardous Air Pollutants at NNSS, 2002–2006[a]

	Emission Rate (tons/yr)					
Year	SO_2	NO_x	CO	VOCs	PM_{10}	HAPs
2002	1.6	21	4.6	2.1	3.6	0.01
2003	0.76	8.1	1.8	1.2	2.4	0
2004	0.12	1.0	0.24	4.6	0.94	0.41
2005	0.04	0.69	0.15	1.9	0.84	0.05
2006	0.03	2.0	0.43	1.4	0.69	1.9[b]

[a] Values are rounded up to two significant figures. CO = carbon monoxide; HAPs = hazardous air pollutants; NO_x = nitrogen oxides; PM_{10} = particulate matter ≤10 μm; SO_2 = sulfur dioxide; VOCs = volatile organic compounds.

[b] Of all the HAPs, 92% were emitted during chemical spill tests at the Nonproliferation Test and Evaluation Complex, and <0.006% were from lead emitted from all permitted operations.

Source: Wills et al. (2007)

9.1.1.4 Existing Noise Environment

Except for the prohibition of nuisance noise, neither the state of Nevada nor local governments around NNSS have established quantitative noise-limit regulations.

The major noise sources at NNSS include various industrial activities, equipment, and machines (e.g., cooling towers, transformers, engines, pumps, boilers, steam vents, paging systems, construction and material-handling equipment, vehicles); blasting and testing of explosives; and aircraft operations (DOE 1996). Most NNSS industrial facilities are far enough from the site boundary that noise levels from these sources are not measurable or are barely distinguishable from background levels at the boundary. In the uninhabited desert area, the major sources of noise are natural physical phenomena (e.g., wind, rain, and wildlife activities) and an occasional airplane; the predominant noise source is wind.

No data from environmental noise surveys around the site boundaries near the GTCC reference location were available. A background sound level of 30 dBA is a reasonable estimate for NNSS (DOE 1996). For the general area surrounding NNSS, the countywide L_{dn} based on population density is estimated to be less than 30 dBA in Nye County, similar to the wilderness natural background level (Miller 2002; Eldred 1982).

TABLE 9.1.1-3 National Ambient Air Quality Standards (NAAQS) or Nevada State Ambient Air Quality Standards (SAAQS) and Highest Background Levels Representative of the GTCC Reference Location at NNSS

			Highest Background Level	
Pollutant[a]	Averaging Time	NAAQS/SAAQS[b]	Concentration[c,d]	Location (Year)[e]
SO_2	1-hour	75 ppb	–[f]	–
	3-hour	0.50 ppm	0.002 ppm (0.4%)	Yucca Mtn, Nye Co.
	24-hour	0.14 ppm	0.002 ppm (1.4%)	Yucca Mtn, Nye Co.
	Annual	0.03 ppm	0.002 ppm (6.7%)	Yucca Mtn, Nye Co.
NO_2	1-hour	0.100 ppm	–	–
	Annual	0.053 ppm	0.002 ppm (4.0%)	Yucca Mtn, Nye Co.
CO	1-hour	35 ppm	0.2 ppm (0.6%)	Yucca Mtn, Nye Co.
	8-hour	9 ppm	0.2 ppm (2.2%)	Yucca Mtn, Nye Co.
O_3	1-hour	0.12 ppm[g]	0.1 ppm (83%)	Yucca Mtn, Nye Co.
	8-hour	0.075 ppm	0.089 ppm (119%)	Las Vegas, Clark Co. (2005)[h]
PM_{10}	24-hour	150 µg/m^3	67 µg/m^3 (45%)	Yucca Mtn, Nye Co.
	Annual	50 µg/m^3	12 µg/m^3 (24%)	Yucca Mtn, Nye Co.
$PM_{2.5}$	24-hour	35 µg/m^3	32 µg/m^3 (91%)	Las Vegas, Clark Co. (2003)[h]
	Annual	15 µg/m^3	10.7 µg/m^3 (71%)	Las Vegas, Clark Co. (2003)[h]
Lead[i]	Calendar quarter	1.5 µg/m^3	0.08 µg/m^3 (5.3%)	San Bernardino Co. (2003)[j]
	Rolling 3-month	0.15 µg/m^3	–	–
H_2S	1-hour	112 µg/m^3	–	–
Visibility	Observation	Insufficient amount to reduce the prevailing visibility to less than 30 mi (48 km) when humidity is less than 70%	–	–

[a] CO = carbon monoxide; H_2S = hydrogen sulfide; NO_2 = nitrogen dioxide; O_3 = ozone; $PM_{2.5}$ = particulate matter ≤2.5 µm; PM_{10} = particulate matter ≤10 µm; SO_2 = sulfur dioxide.

[b] The more stringent standard between the NAAQS and the SAAQS is listed when both are available.

[c] Monitored concentrations are the highest arithmetic mean for calendar-quarter lead; the highest for 3-hour and 24-hour SO_2, 1-hour and 8-hour CO, 1-hour O_3, and 24-hour PM_{10}; 4th highest for 8-hour O_3; 98th percentile for 24-hour $PM_{2.5}$; and arithmetic mean for annual SO_2, NO_2, PM_{10}, and $PM_{2.5}$.

[d] Values in parentheses are monitored concentrations as a percentage of SAAQS or NAAQS.

[e] No measurement year was specified for the data collected at Yucca Mountain (DOE 2002b).

[f] A dash indicates that no measurement is available.

[g] On June 15, 2005, the EPA revoked the 1-hour O_3 standard for all areas except the 8-hour O_3 nonattainment EAC areas (those do not yet have an effective date for their 8-hour designations). The 1-hour standard will be revoked for these areas 1 year after the effective date of their designation as attainment or nonattainment for the 8-hour O_3 standard.

Footnotes continue on next page.

TABLE 9.1.1-3 (Cont.)

[h] Concentration at NNSS would be lower because it is not located downwind of prevailing winds in Las Vegas.

[i] Used old standard because no data in the new standard format are available.

[j] This location with the highest observed concentration is not representative of NNSS but is presented to show that this pollutant is not a concern around NNSS.

Sources: DOE (2002b); EPA (2008a, 2009); *Nevada Administrative Code* 445B.391 (refer to http://ndep.nv.gov/baqp/monitoring/445b391.pdf)

9.1.2 Geology and Soils

9.1.2.1 Geology

9.1.2.1.1 Physiography. NNSS is located in the southern part of the Great Basin, a subprovince of the Basin and Range physiographic province (Figure 9.1.2-1). Centered in Nevada, the Basin and Range province stretches from southern Oregon to western Texas (and into Mexico) and is made up of parallel north-south-trending faulted mountain ranges separated by flat alluvium-filled basins. This landscape reflects a complex geological history: uplifting of crustal rocks, followed by extensional deformation, characterized by block faulting and rotation, and the development of active volcanic fields. Most of the intermontane basins have no drainage outlets; as a result, rainwater accumulates in the form of salt lakes or playas (dry lake beds). In the southern part of the province, drainage from the Las Vegas and Pahranagat Valleys flows to the southeast toward the lower Colorado River; Jackass Flats and the Amargosa Desert drain to Death Valley to the west via the Amargosa River (Hunt 1973; DOE 1996; Winograd and Thordarson 1975).

9.1.2.1.2 Topography. Frenchman Flat is an intermontane basin covering parts of Areas 5, 6, and 11 in the southeastern portion of NNSS and extending beyond the NNSS boundary to the east. It is bounded on the north by Massachusetts Mountain and French Peak, on the east by the Ranger Mountains and Buried Hills, on the south by the Spotted Range, and on the west by Skull Mountain and Wahmonie Hills (Figure 9.1.2-2). The basin floor at Frenchman Flat slopes gently toward a central playa. Relief at NNSS is high, with elevations ranging from about 820 m (2,700 ft) above MSL at Frenchman Flat in the southeastern portion of the site to about 2,340 m (7,680 ft) MSL on Rainier Mesa. Slopes of the upland surfaces are steep and dissected; those of the lowland areas are more gentle and less eroded (Bechtel Nevada 2005a).

The natural topography of NNSS has been altered by underground nuclear testing, which created craters in Yucca Flat and Frenchman Flat Basins and on Pahute and Rainier Mesas. Other activities that have changed the local landscape include shallow detonations (associated with Project Plowshare), waste disposal area construction, drainage improvements, road building, sand and gravel mining, and underground mining (DOE 1996).

FIGURE 9.1.2-1 Location of NNSS within the Great Basin Desert in the Basin and Range Physiographic Province (Bechtel Nevada 2005a)

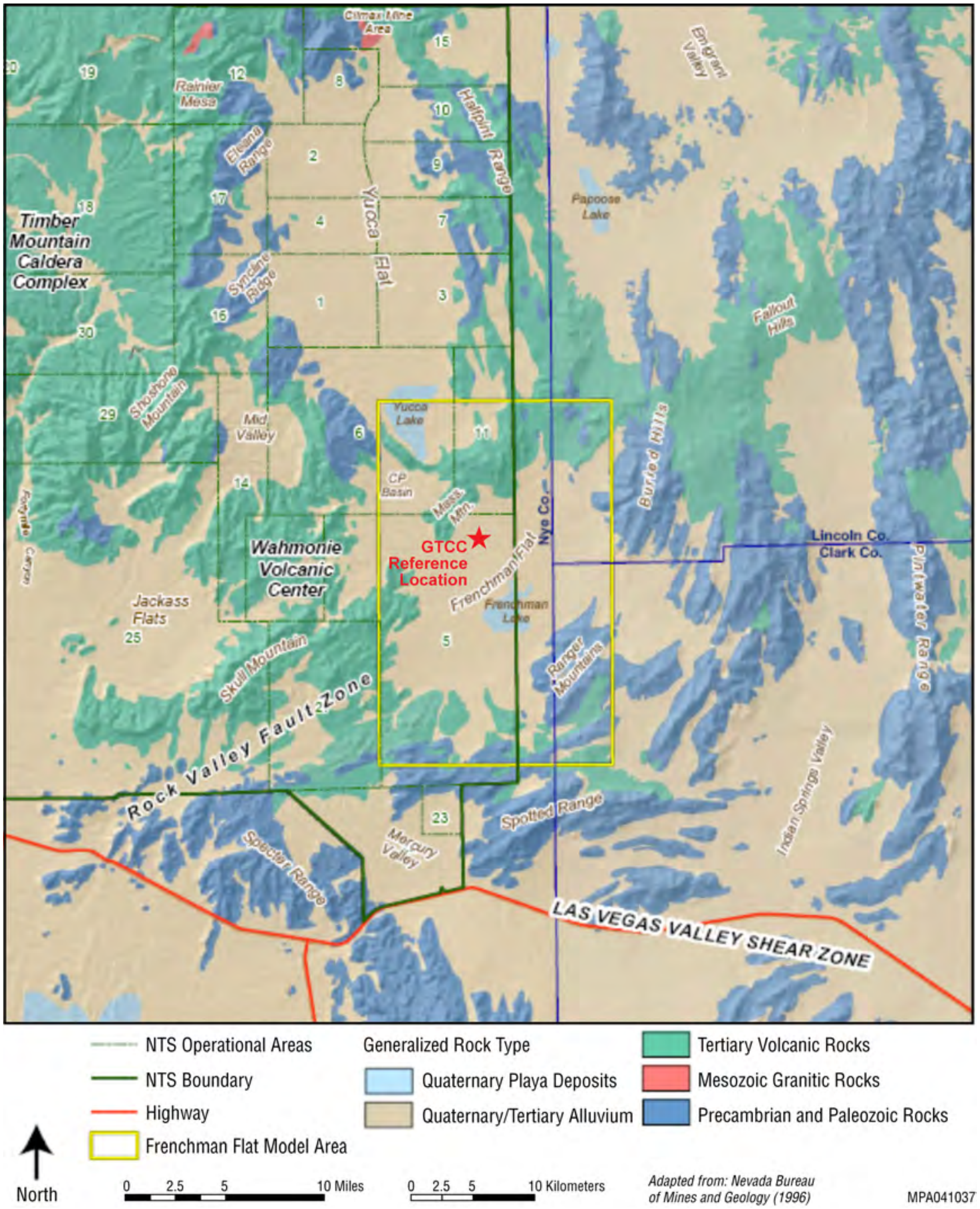

FIGURE 9.1.2-2 Topographic Features of the Frenchman Flat Region (Source: Modified from Bechtel Nevada 2005a)

9.1.2.1.3 Site Geology and Stratigraphy. The highlands surrounding Frenchman Flat are made up of Paleozoic sedimentary rocks and Cenozoic volcanic rocks (tuffs) and tuffaceous sedimentary rocks. Paleozoic rocks are exposed along the south and east edges of the basin and are predominantly carbonates ranging in age from Cambrian to Mississippian. These rocks dip to the south and east away from Frenchman Flat (Bechtel Nevada 2005a).

Volcanic rocks of Miocene age are typical of the highlands to the north and northwest of the basin. These are rhyolitic tuffs formed by ash deposits from large calderas located 40 km (25 mi) to the northwest of the Frenchman Flat Basin. Miocene age tuffs, lavas, and debris flows of intermediate composition make up the Wahmonie volcanic center to the west of the basin. These rocks dip to the southeast toward Frenchman Flat and are offset in places by numerous normal faults (Bechtel Nevada 2005a).

Tuffaceous sedimentary rocks are also present along a narrow, linear area corresponding to the topographic axis of the basin. These rocks are exposed along the southern edge and dip north into the basin.

The GTCC reference location is southeast of the RWMS. It is situated on a thick sequence of Quaternary sediments consisting mainly of alluvial fill typical of the low-lying valleys in the region (Figure 9.1.2-2). The following summary of the stratigraphy at NNSS is based on the work of Winograd and Thordarson (1975), Hoover et al. (1981), Laczniak et al. (1996), and Bechtel Nevada (2005a). Figure 9.1.2-3 presents a stratigraphic column for NNSS and vicinity.

Precambrian and Paleozoic Units. In the Paleozoic era, 11,278 m (37,000 ft) of marine sediments were deposited in the Cordilleran geosyncline, an elongated, subsiding trough in the westernmost portion of the North American continent. The part of the trough underlying NNSS and its vicinity, called the miogeosyncline, is made up predominantly of carbonates (limestone and dolomite) and mature clastic sediments (quartzite, conglomerate, argillite, and siltstone). These rocks have a complex history of folding and faulting.

Mesozoic Units. Rocks of Mesozoic age consist of several small granitic stocks, dikes, and sills. There are no Mesozoic sedimentary rocks under NNSS or its immediate vicinity.

Cenozoic Units. Tertiary volcanic and associated sedimentary rocks are as much as 2,591-m (8,500-ft) thick in Frenchman Flat. Volcanic rocks are predominantly ash-flow tuff, ash-fall tuff, and lava flows of rhyolitic, rhyodacitic, and basaltic composition. The tuffs are typically rhyolitic and quartz-latitic. Sedimentary rocks derived from these volcanics include conglomerates, tuffaceous sandstones, and freshwater limestones.

Tertiary and Quaternary deposits in the Frenchman Flat basin include fluvial deposits of coarse- to fine-grained sand, eolian sheets, and dunes, with minor basalt flows.

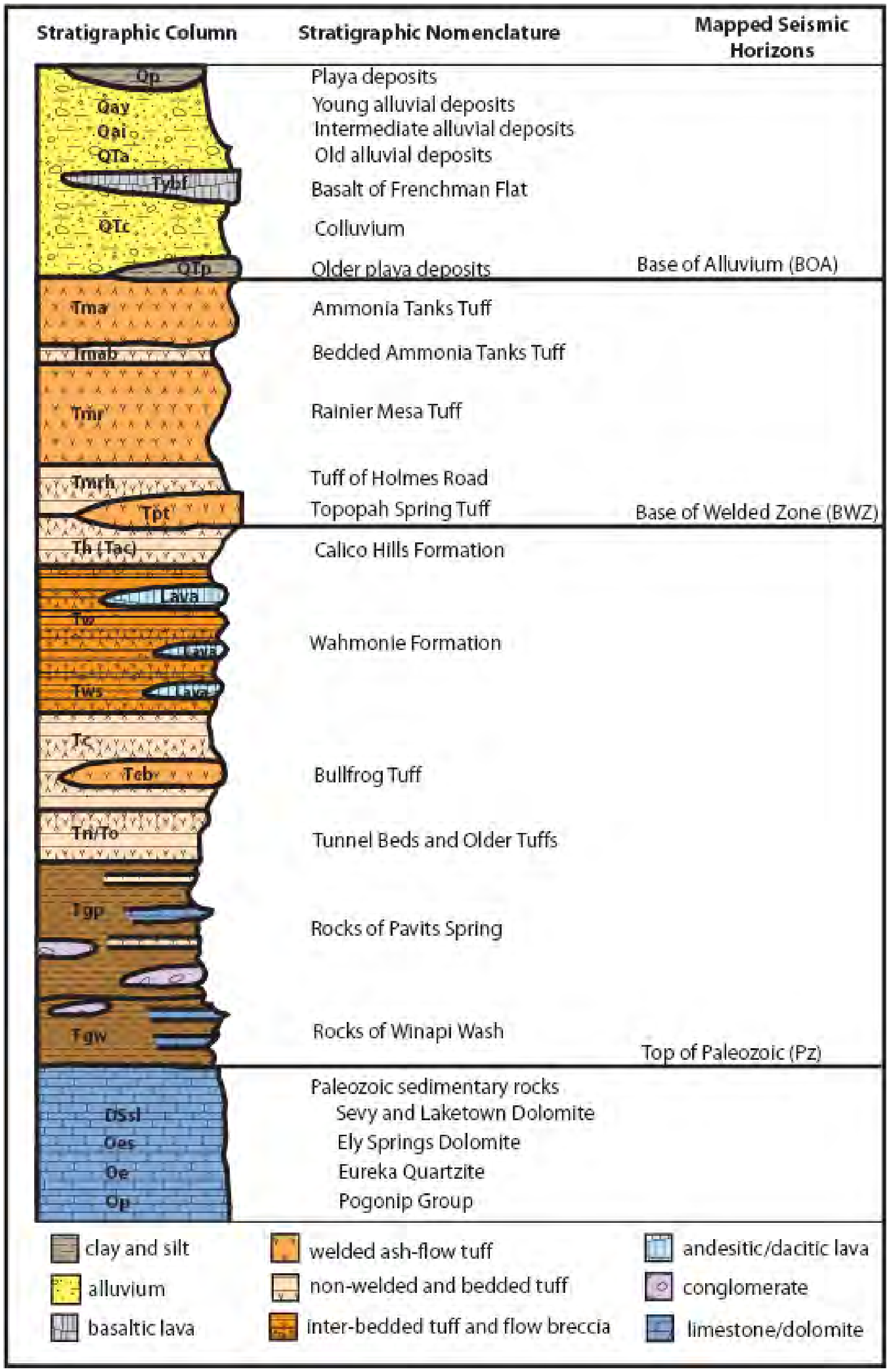

FIGURE 9.1.2-3 Stratigraphic Column for NNSS and Vicinity (Source: Bechtel Nevada 2005b)

Alluvium is up to 1,500-m (5,000-ft) thick in the deepest part of the basin. Stratigraphic logs are available for three pilot wells (Ue5PW-1, Ue5PW-2, and Ue5PW-3) shown in Figure 9.1.2-4. These logs indicate that the shallow stratigraphy, both laterally and vertically, is quite variable and discontinuous across the site (typical of alluvial fan depositional environments). For example, in Ue5PW-1, sediments are predominantly well-graded sand with silt with a maximum thickness of 8.2 m (27 ft), underlain by numerous layers of up to 5.2 m (17 ft) of well-graded sand with gravel. Sediments in Ue5PW-2 consist mainly of silty sand with a maximum thickness of 12 m (40 ft), with interbedded layers of gravel and well-graded sand with silt. Silty sand units are fairly massive at depth intervals of 42.7 to 122 m (140 to 400 ft) and 171 to 256 m (560 to 800 ft). In Ue5PW-3, sediments are composed of well-graded sand with silt, with a maximum thickness of 27.4 m (90 ft). At depths of 115.8 to 170.7 m (380 to 560 ft), the number of silty sand layers increases; at depths below 171 m (560 ft), the silty sand layer is massive and contains scatter zones of cobbles and boulders (REEC 1994).

9.1.2.1.4 Seismicity. NNSS lies within the Walker Lane belt, a northwest-trending seismic zone that extends from eastern California to western Nevada. The active faults in the Walker Lane belt accommodate the strain from the movement of the Pacific plate relative to the North American plate. The seismic zone is characterized by right-lateral strike-slip faults (although some left-lateral faults are present) as well as basin-and-range-style extensional block faults (Bechtel Nevada 2005b; University of Arizona 2008).

Nevada is among the most seismically active states in the United States. Between 1898 and 2005, there were 1,586 documented earthquakes having a magnitude of more than 3.5 (Nevada Seismological Laboratory 2008). The largest three earthquakes in Nevada occurred in northern Nevada within a 7-hour period on October 2, 1915. The last tremor had an estimated magnitude of 7.75. The movement created a scarp, about 1.5- to 4.5-m (5- to 15-ft) high and 35-km (22-mi) long, parallel to the base of the Sonoma Mountains (USGS 2008).

From 1950 to 1998, a total of 526 earthquakes of magnitude 4 or greater were documented at or near the NNSS. Researchers have noticed a significant drop in the number of earthquakes since 1992, the year that the moratorium on nuclear testing was established, which suggested a likely connection between earthquakes and the testing that took place in the Pahute Mesa and Yucca Flat areas (Bright et al. 2001).

From 1950 to 2008, five earthquakes of magnitude 3.5 to 4.2 or greater were documented within 32 km (20 mi) of Frenchman Flat; all were clustered in the Wahmonie volcanic center to the west (Figure 9.1.2-2) (ANSS 2008).

The three most recent earthquakes in the Frenchman Flat area (also within 32 km [20 mi] and to the west/northwest) occurred in January 2008 and had magnitudes of less than 2 (USGS 2008).

Figure 9.1.2-5 shows the geology and major fault lines (and relative movement along them) in Frenchman Flat and vicinity.

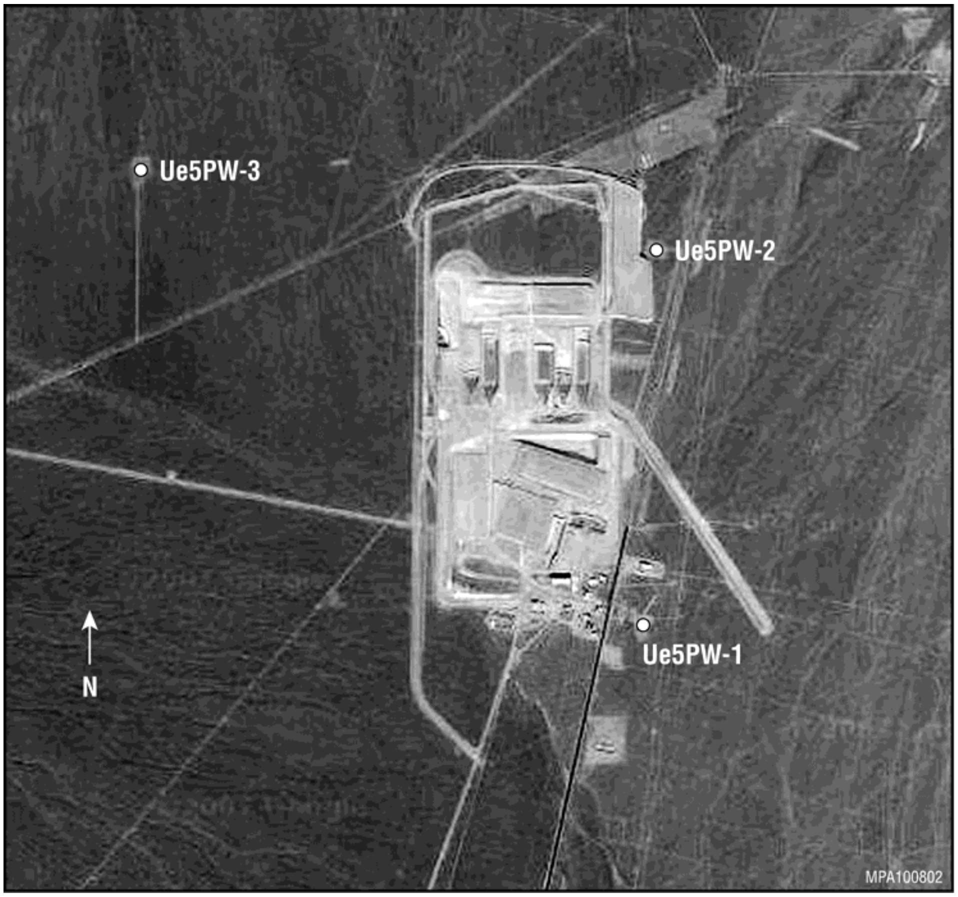

FIGURE 9.1.2-4 Location of Pilot Wells within Area 5 Radioactive Waste Management Site

In 1995, a probabilistic seismic hazard assessment (PSHA) was conducted for the Device Assembly Facility, located in Area 6 about 16 km (10 mi) northwest of Frenchman Lake. The PSHA determined that the seismic design basis for structures, systems, and components important to safety should be able to withstand the horizontal motion from an earthquake with a return frequency of once in 2,000 years (annual probability of occurrence of 0.0005). The PSHA concluded that a 0.0005-per-year earthquake would produce peak horizontal accelerations of about 30% of gravity (0.30g) for a surface facility. Analysts projected a 50% reduction in ground motion for a subsurface facility within the same area (Ng et al. 1998). A PSHA has not been conducted for the Frenchman Flat area; however, given the similarity in seismic setting and soil conditions, a similar design-basis earthquake would likely be specified.

9.1.2.1.5 Volcanic Activity. The NNSS region is situated within the southwestern Nevada volcanic field, which consists of volcanic rocks (tuffs and lavas) of the Timber Mountain-Oasis Valley caldera complex and Silent Canyon and Black Mountain calderas (Figure 9.1.2-6). Two types of fields are present in the NNSS region: (1) large-volume, long-lived fields with a range of basalt types associated with more silicic volcanic rocks

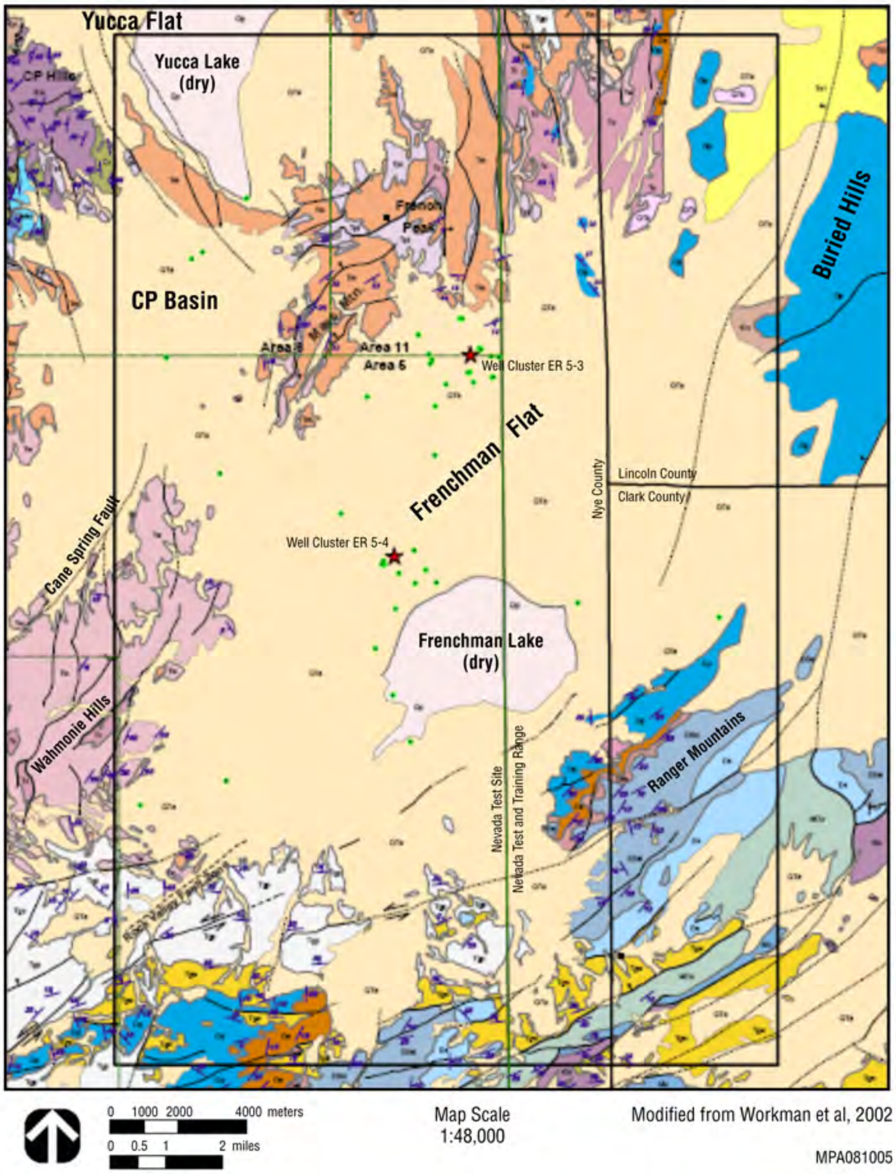

FIGURE 9.1.2-5 Surface Geologic Map and Seismic Fault Lines at Frenchman Flat (Source: Bechtel Nevada 2005b)

produced by melting of the lower crust, and (2) small-volume fields formed by scattered basaltic scoria cones during brief cycles of activity, called rift basalts because of their association with extensional structural features. The basalts of the region typically belong to the second group; examples include the basalts of Silent Canyon and Sleeping Butte (Byers et al. 1989; Crowe et al. 1983).

The oldest basalts in the NNSS region were erupted during the waning stages of silicic volcanism in the southern Great Basin in the Late Miocene and are associated with silicic volcanic centers like Dome Mountain (the first group). Rates of basaltic volcanic activity in the region have been relatively constant but generally low. There has been no silicic volcanism in the

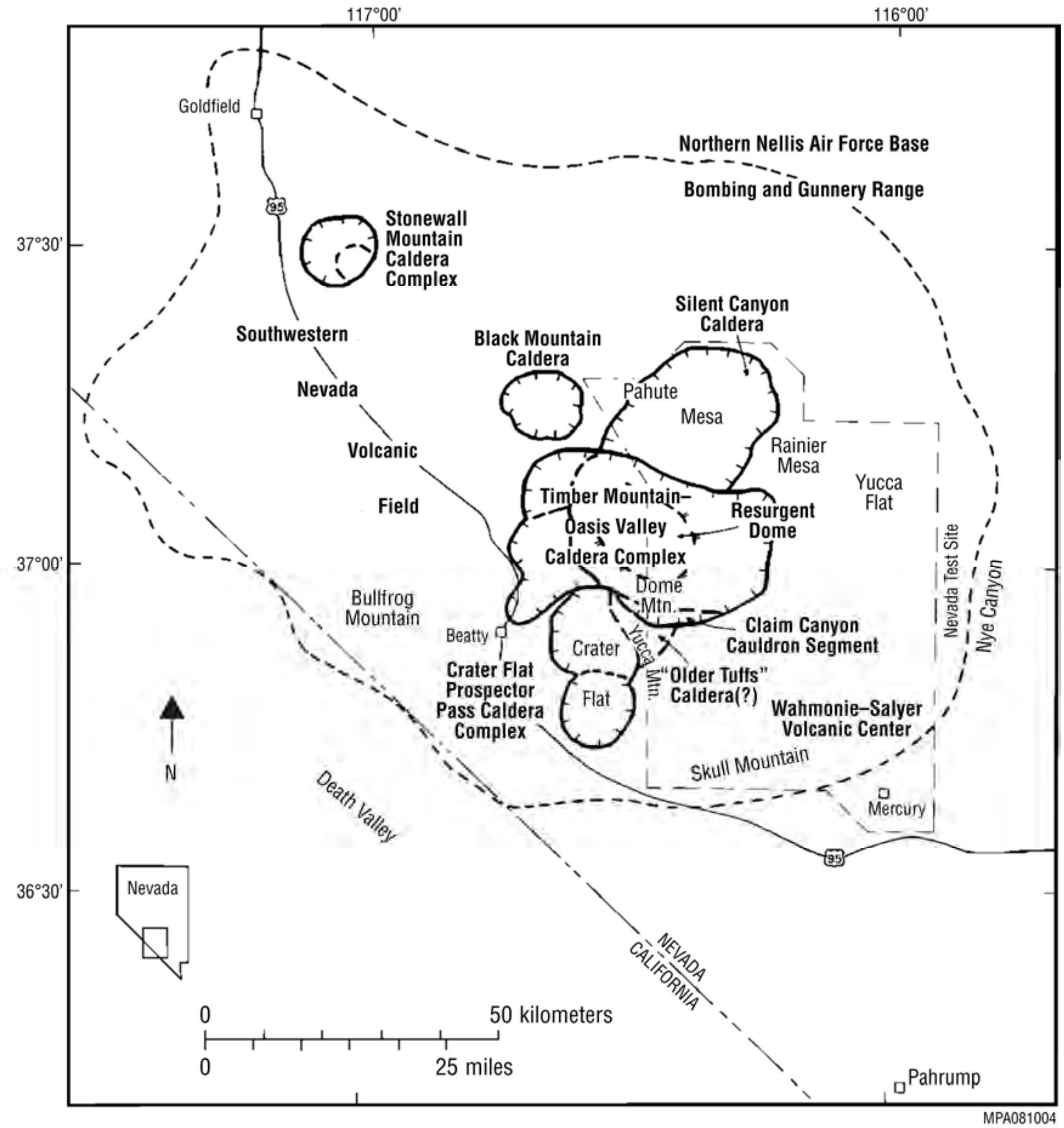

FIGURE 9.1.2-6 Volcanic Features in the NNSS Region (Byers et al. 1989)

region for the past 5 million years. Current silicic volcanic activity occurs entirely along the margins of the Great Basin.

Crowe et al. (1983) determined that the annual probability of a volcanic event for the NNSS region is very low (3.3E-10 to 4.7E-08). The volcanic risk at NNSS is associated only with basaltic eruptions; the risk of silicic volcanism is negligible. Perry (2002) cites geologic data that could increase the recurrence rate (and thus the probability of disruption). These include hypothesized episodes of an anomalously high strain rate, the hypothesized presence of a regional mantle hot spot, and new aeromagnetic data that suggest that previously unrecognized volcanoes may be buried in the alluvial-filled basins in the region.

9.1.2.1.6 Slope Stability, Subsidence, and Liquefaction. No natural factors within Frenchman Flat that would affect the engineering aspects of slope stability have been reported. External factors affecting slope stability relate to the fracturing and ground motion caused by nuclear explosions (DOE 1996).

Ground stability and the potential for subsidence have not been assessed for Frenchman Flat. While natural factors, like the development of pavement and accumulation of calcium carbonate, enhance ground stability, other factors increase the likelihood of subsidence. These include the presence of readily weathered and/or fractured rocks, a high degree of void space in sediments, and the absence of vegetation.

Liquefaction of saturated sediments is a potential hazard during or immediately following large earthquakes and underground or surface explosions. There is evidence that paleo-liquefaction has occurred in the NNSS region. Whether soils will liquefy depends on several factors, including the magnitude of the earthquake or explosion, the peak ground velocity, the liquefaction susceptibility of soils, and depth to groundwater.

9.1.2.2 Soils

Soils at NNSS and its vicinity include entisols and aridisols. Entisols form on steep mountain slopes in regions where erosion is active. Aridisols are older, more developed soils; they typically exist on more stable fans and terraces. In the southern portion of the site, including Frenchman Flat, soils are young with little evidence of leaching. These soils tend to be low in organic content and water storage capacity. Grain size varies from coarse near the mountain fronts to fine in the playa areas (typical of alluvial fans); salinity increases significantly in the direction of the playa areas, with the highest level of soluble salts having accumulated in the deeper soil horizons. Most soils are underlain by a hardpan of caliche. Desert pavement occurs in places. Soil loss through wind and water erosion is common, although the erosion rates and susceptibility of soils to erosion have not been defined (DOE 1996; Hoover et al. 1981).

Soils in portions of Frenchman Flat have been contaminated as a result of nuclear testing and ancillary operations (DOE 1996).

9.1.2.3 Mineral and Energy Resources

Geologic resources at NNSS include industrial minerals, such as silica, bentonite clay, and zeolites, building stone, and aggregate. Although NNSS has been closed to commercial mineral development since the 1940s, several mining districts in the region have been identified and sampled. Economic minerals include gold, silver, mercury, lead, copper, antimony, zinc, arsenic, tungsten, and molybdenum. These are generally found near volcanic centers (e.g., the Timber Mountain caldera complex). DOE policy does not allow extraction of NNSS mineral resources; however, the policy does require monitoring of geologic features to protect them from

American Indian Text

Minerals

The CGTO knows based on previous DOE-sponsored cultural studies that there are many minerals on the NNSS (no complete list available). Indian people visiting the proposed GTCC site identified the following traditional use minerals: (1) Obsidian, (2) chalcedony, (3) Yellow Chert or Jasper, (4) Black Chert, (5) Pumice, (6) Quartz Crystal, and (7) Rhyolite Tuff. Other minerals were perceived to be present but not observed because of the limited time and search area.

All minerals are culturally important and have significant roles in many aspects of Indian life. For example, the Chalcedony on the proposed GTCC site would have made an attractive offering which would be acquired here by a ceremonial traveler and then left at the vision quest or medicine site located to the north on top of a volcano like Scrugham Peak. Returning ceremonial travelers would also bring offerings back to where they had acquired offerings, thus the Yellow Chert or Jasper (observed on the GTCC site) which outcrops about 70 miles to the north would be gathered there and returned to the Chalcedony site as an offering.

American Indian Text

Playas

The CGTO knows, based on cultural studies funded by the DOE on the NNSS and playa-specific studies funded by Nellis Air Force Test and Training Range, that playas occupy a special place in Indian culture. Playas are often viewed as empty and meaningless places by western scientists, but to Indian people playas have a role and often contain special resources that occur no where else. The following text was prepared by the Indian people who visited the proposed GTCC site.

Is a playa a wasteland? According to Indian elders playas were used in traveling or moving to places where work, hunting, pine cutting or gathering of other important foods and medicine could be done. One elder remembers crossing over dry lake beds and traveling around but near the edges and they discussed how provisions were left there and at nearby springs by previous travelers at camping spots. Indian people left caches in playa areas for people who crossed valleys when water and food was scarce. Frenchmen Playa is such a place. Indian people took advantage of traveling through this playa as mountains completely surround this area. The CGTO knows that most dry lakes are not known to be completely dry. An example is Soda Lake near Barstow, California. The Mohave River flows into this dry lake and most of the year it looks dry but it actually flows underground. Building berms on dry lake beds to offset water and runoff doesn’t sound like a good idea to the Indian way of thinking. As one CGTO member added, to Indian people “water is life. Our water has healing powers.” So why build a GTCC site on and use this playa when the odds of radiation seem feasible? The Indian people who visited this site recommend not to bother Frenchmen Playa. It is only one of two in the immediate region and has special meanings. There should be a more descriptive study to fully understand the impacts. More time is needed, also for Indians to revisit this site. Although some people continue to view Frenchman playa as a wasteland, the CGTO knows it is not. Further ethnographic studies are needed.

impacts due to construction activities (DOE 1996, 2000). The mining of cinder occurs within the land withdrawal area, about 10 km (6 mi) northwest of Amargosa Valley (DOE 2008a).

Hydrocarbon resources in the deeper subsurface have not been evaluated at NNSS. However, a recent DOE evaluation of energy resources in the Yucca Mountain withdrawal area to the west found that the potential for economically useful energy resources was low (CRWMS M&O 2000). No occurrences of oil and gas, coal, tar sands, or oil shale have been reported in the region (DOE 1996).

Geothermal hot springs are common in the region; however, water temperatures may not be adequate for commercial development (DOE 1996). A preliminary assessment conducted by DOE (1994) found that the potential for moderate-temperature geothermal resource development was high.

9.1.3 Water Resources

9.1.3.1 Surface Water

9.1.3.1.1 Rivers and Streams. The 352,512-ha (870,400-ac) NNSS lies within the Great Basin hydrogeologic province. The province consists of numerous hydrographically closed intermontane basins, such as Frenchman Flat and Yucca Flat, and is characterized by the presence of salt lakes and dry lake beds (playas). Streams in Frenchman Flat are ephemeral, flowing only during precipitation events. Surface water runoff flows through normally dry washes toward the topographically lowest part of the basin, Frenchman Lake (also referred to as Frenchman Playa). Most runoff travels only a short distance before evaporating or infiltrating into the ground.

There are 24 known seeps or springs on the NNSS, as shown in Figure 9.1.3-1; there are no known springs or seeps within the boundaries of Frenchman Flat (DOE 1996; Bechtel Nevada 2005a). In addition to the springs and seeps, eight streams flow ephemerally on NNSS. These streams are recharged by snowmelt from nearby mountains and by small amounts of precipitation.

9.1.3.1.2 Surface Water Quality. Because of the ephemeral nature of surface water on the NNSS, no surface water quality data have been reported (DOE 1996).

9.1.3.2 Groundwater

9.1.3.2.1 Unsaturated Zone. Groundwater occurs in both the unsaturated (vadose) and saturated (phreatic) zones at NNSS. The depth to groundwater and the thickness of the

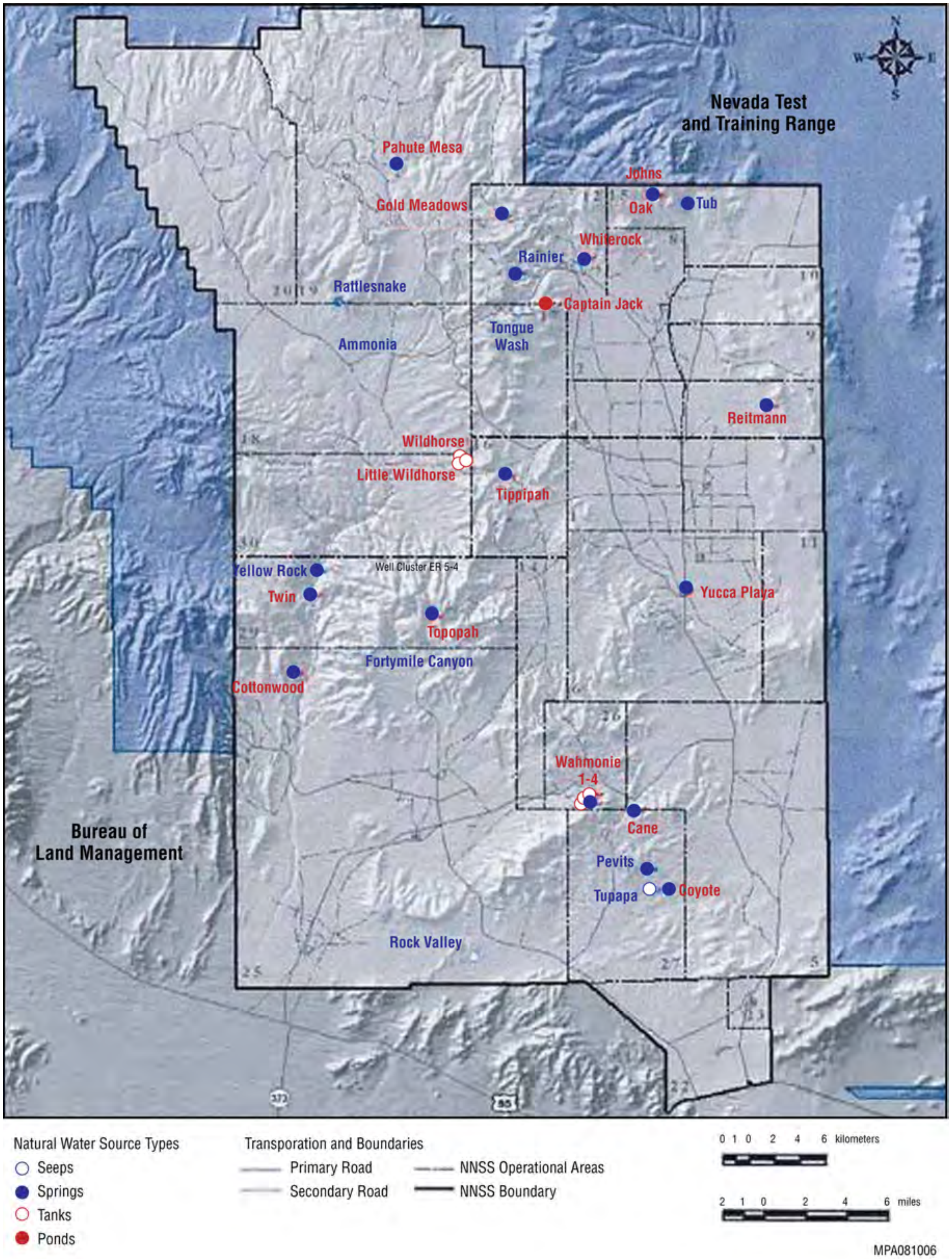

FIGURE 9.1.3-1 Natural Springs and Seeps on NNSS (Source: Bechtel Nevada 2005a)

unsaturated zone vary across the site. In the Area 3 RWMS, located on Yucca Flat within NNSS, the thickness of the vadose zone is about 488 m (1,600 ft), and the water table is assumed to occur in Tertiary tuff, on the basis of data from surrounding boreholes. The tuff-alluvium contact is estimated to occur at a depth of between 300 and 460 m (1,000 and 1,500 ft) below the land surface. In the Area 5 RWMS, located on northern Frenchman Flat at the juncture of three coalescing alluvial fans piedmonts, the thickness of the unsaturated zone is 240 m (770 ft) at the southeast corner of the RWMS (at Ue5PW-1), 260 m (840 ft) at the northeast corner of the RWMS (at Ue5PW-2), and 270 m (890 ft) to the northwest of the RWMS (at Ue5PW-3) (Bechtel Nevada 2002a).

In the vicinity of the GTCC reference location, the unsaturated zone has a thickness of about 240 m (810 ft) (Bechtel Nevada 2001, 2002a).

9.1.3.2.2 Aquifer Units. The sedimentary rocks of the Great Basin compose the principal source of groundwater for the NNSS region. Within this groundwater system, a relatively shallow component, consisting of unconsolidated basin (alluvial) fill, overlies a deeper component, consisting of carbonate rocks (Prudic et al. 1995). Beneath Frenchman Flat, the units from oldest (deepest) to youngest (shallowest) are the lower clastic confining unit, the lower carbonate aquifer, the volcanic aquifer and confining units, and the alluvial aquifer. Figure 9.1.3-2 shows the correlation between the hydrostratigraphic and lithologic units at NNSS.

The following unit descriptions are taken from Hoover et al. (1981), REEC (1994), Prudic et al. (1995), Laczniak et al. (1996), DOE (1996), Bright et al. (2001), Bechtel Nevada (2002b, 2005a), and Hershey et al. (2005). They include information specific to three monitoring

American Indian Text

The CGTO requests an analysis of the hydrological and ecological impacts of the existing water diversion dike of the current Radioactive Waste Management Complex in Area 5. The DOE recognizes that this is a very flood prone area, with major flooding episodes occurring about every 23 years. Indian people visiting this site observed that even though the current dike has been built recently and thus not experienced a 23-year flood, it has diverted and consolidated sufficient runoff that a small arroyo has been established. The Indian people visiting this site believe that the existing dike has unnaturally stressed down-slope plants and animals who now do not receive normal sheet runoff. The Indian people visiting the site believe that by concentrating the runoff, the dike has reduced the amount of water absorbed during normal sheet runoff because the consolidated runoff moves more quickly and only flows in the new and developing eroded arroyo. It is believed by the Indian people visiting the site that were a GTCC facility to be established east of the current RWMC then the dike would necessarily have to be extended causing an even greater runoff shadow and an even greater developing arroyo. The desert tortoise in the area will have to move out of this larger runoff shadow and may be concentrated in the area of Frenchmen Playa. Moving their living areas towards the playa will expose them to higher levels of radioactivity. The Indian people visiting the site believe that these current and potential impacts should be analyzed, monitored by Indian people, and reported back to the CGTO at the next annual meeting.

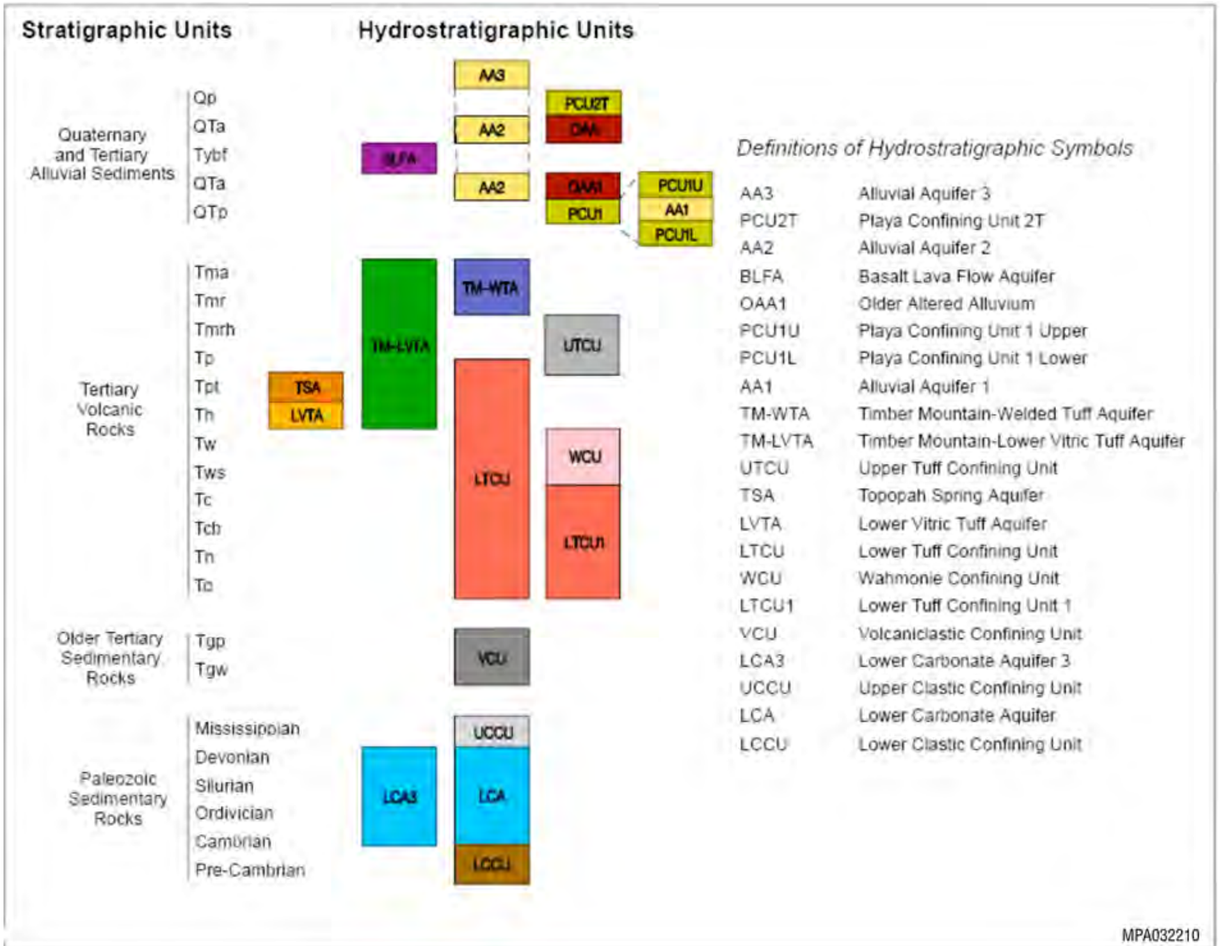

FIGURE 9.1.3-2 Correlation of Stratigraphic and Hydrostratigraphic Units at NNSS (Source: Bechtel Nevada 2005a)

wells (Ue5PW-1, Ue5PW-2, and Ue5PW-3) and two drill holes (ER-5-3#2 and ER-5-4#2) in Frenchman Flat (Figure 9.1.2-4). Wells Ue5PW-1 and Ue5PW-2 are completed in the alluvial aquifer; Well Ue5PW-3 is completed in the Timber Mountain Tuff, a volcanic aquifer. Drill Hole ER-5-3#2 is located in the northern part of Frenchman Flat; Drill Hole ER-5-4#2 is in the central part of Frenchman Flat, just to the northwest of Frenchman Lake. Table 9.1.3-1 lists the hydrostratigraphic data for the monitoring wells; Tables 9.1.3-2 and 9.1.3-3 provide hydrostratigraphic data for Drill Holes ER-5-3#2 and ER-5-4#2.

Lower Carbonate Aquifer and Lower Clastic Confining Unit. The most extensive hydrostratigraphic units within NNSS and vicinity are the Lower Carbonate Aquifer and the Lower Clastic Confining Unit. The carbonate rocks of the Lower Carbonate Aquifer are predominantly dolomite and interbedded limestone, with thin layers of shale and quartzite. They are the most transmissive hydrostratigraphic unit because of their relatively high solubility in groundwater and the abundant secondary permeability in fractures caused by tectonic activity in

TABLE 9.1.3-1 Hydrostratigraphic Data from Pilot Wells Ue5PW-1, Ue5PW-2, and Ue5PW-3[a,b]

Hydrostratigraphic Unit	Top Depth	Base Depth	Top Elevation	Unit Thickness
Ue5PW-1				
Alluvial aquifer[c]	0	839[d]	3,180	839[d]
Ue5PW-2				
Alluvial aquifer[c]	0	919.5[d]	3,248	919.5[d]
Ue5PW-3				
Alluvial aquifer[c]	0	617	3,298	617
Timber Mountain aquifer	617	955[d]	2,681	>338

[a] The locations of pilot wells Ue5PW-1, Ue5PW-2, and Ue5PW-3 are shown on Figure 9.1.2-4. Well UePW-1 was installed just outside the southeast corner of the RWMS. Wells Ue5PW-2 and UePW-3 were installed on the upgradient side of the RWMS (to the north and northwest).

[b] All thicknesses and depths are in feet; all elevations are in feet relative to MSL.

[c] Depth to groundwater is 772 ft (Ue5PW-1), 842 ft (Ue5PW-2), and 891 ft (Ue5PW-3). Source: Bechtel Nevada (2002b).

[d] Value represents the total depth of the borehole and not the depth or thickness of the unit.

Source: Drellack (1997)

the region. The unit is as thick as 5,000 m (16,400 ft) in places and crops out in the southeastern portion of Frenchman Flat (Stoller-Navarro 2006).

The Lower Clastic Confining Unit, consisting of quartzite, micaceous quartzite, and siltstone, is impermeable and considered to be the hydrologic basement throughout much of the Death Valley flow system. These rocks are brittle and commonly fractured; however, secondary mineralization has reduced their permeability. The unit has a thickness of about 2,900 m (9,400 ft).

The predominant direction of groundwater flow within the Lower Carbonate Aquifer is south-southeast. Recharge occurs in high-elevation areas in central Nevada and in the Spring Mountains and Sheep Range in southern Nevada. The major discharge areas are springs in Ash Meadows and Death Valley.

Volcanic Aquifer and Confining Units. The volcanic rocks present in the Frenchman Flat Basin are part of the southwest Nevada volcanic field that extends to the west; they consist

TABLE 9.1.3-2 Hydrostratigraphic Data from Drill Hole ER-5-3#2[a,b]

Hydrostratigraphic Unit[c]	Top Depth	Base Depth	Top Elevation	Unit Thickness
Alluvial aquifer	0	910	3,334.3	910
Basalt lava flow aquifer	910	940	2,424.3	30
Alluvial aquifer	940	1,680	2,394.3	740
Tonopah Spring aquifer	1,680	1,695	1,654.3	15
Alluvial aquifer	1,695	2,060	1,639.3	365
Timber Mountain aquifer	2,060	2,862	1,274.3	802
Tonopah Spring aquifer	2,862	3,024	472.3	162
Timber Mountain aquifer	3,024	3,055	310.3	31
Wahmonie confining unit	3,055	3,796	279.3	741
Lower tuff confining unit	3,796	4,678	–461.7	882
Paleozoic rocks – undifferentiated Pz	4,678	5,683[d]	–1,343.7	>1,005

[a] Drill hole ER-5-3#2 is in the northern portion of Frenchman Flat.

[b] All thicknesses and depths are in feet; all elevations are in feet relative to MSL.

[c] Depth to groundwater (or vadose zone thickness) is 927 ft.

[d] Value represents the total depth of the borehole and not the depth or thickness of the unit.

Source: Bechtel Nevada (2005a)

TABLE 9.1.3-3 Hydrostratigraphic Data from Drill Hole ER-5-4#2[a,b]

Hydrostratigraphic Unit[c]	Top Depth	Base Depth	Top Elevation	Unit Thickness
Alluvial aquifer	0	2,312	3,131.7	2,312
Older playa confining unit	2,312	2,702	819.7	390
Alluvial aquifer	2,702	2,707	429.7	5
Older playa confining unit	2,707	2,940	424.7	233
Alluvial aquifer	2,940	3,676	191.7	736
Timber Mountain aquifer	3,676	4,356	–544.3	680
Lower tuff confining unit	4,356	7,000[d]	–1,224.3	2,644

[a] The location of drill hole ER-5-4#2, in the northern portion of Frenchman Flat, is shown in Figure 9.1.2-4.

[b] All thicknesses and depths are in feet; all elevations are in feet relative to MSL.

[c] Depth to groundwater (or vadose zone thickness) is 708 ft.

[d] Value represents the total depth of the borehole and not the depth or thickness of the unit.

Source: Bechtel Nevada (2005a)

American Indian Text

The CGTO knows that most dry lakes are not known to be completely dry. An example is Soda Lake near Barstow, California. The Mohave River flows into this dry lake and most of the year it looks dry but it actually flows underground. Building berms on dry lake beds to offset water and runoff doesn't sound like a good idea to the Indian way of thinking. As one CGTO member added, to Indian people "water is life. Our water has healing powers." So why build a GTCC site on and use this playa when the odds of radiation seem feasible? The Indian people who visited this site recommend not to bother Frenchmen Playa. It is only one of two in the immediate region and has special meanings. There should be a more descriptive study to fully understand the impacts. More time is needed, also for Indians to revisit this site. Although some people continue to view Frenchman playa as a wasteland, the CGTO knows it is not. Further ethnographic studies are needed.

mainly of rhyolitic tuffs and have been subdivided into four units: (1) Timber Mountain Aquifer, Upper Tuff Confining Unit; (2) Topopah Spring Aquifer, Lower Vitric-Tuff Aquifer, Wahmonie Confining Unit; (3) Lower Tuff Confining Unit; and (4) Volcaniclastic Confining Unit. The Lower Tuff Confining Unit separates the underlying carbonate aquifer from the overlying tuff aquifer (Timber Mountain Tuff) and alluvial deposits throughout parts of Frenchman Flat.

Dense rocks with abundant fractures compose the volcanic aquifers; these rocks are typically welded tuff sheets (outside of the calderas) and lava flows and thick welded tuffs (within the calderas). The confining units consist of zeolitically altered nonwelded tuffs, common in the older, deeper parts of the volcanic section. At Frenchman Flat, these units range in thickness from about 610 m (2,000 ft) in the north to more than 910 m (3,000 ft) in the center of the basin.

The hydraulic conductivity of tuff depends on the degree of welding and the presence of fractures.

Alluvial Aquifer and Playa Confining Units. At Frenchman Flat, there are two alluvial hydrostratigraphic units: the alluvial aquifer and the playa confining unit. The alluvial aquifer occurs at the surface and consists mainly of gravelly sand and sandy gravel deposited on alluvial fans by debris flow and sheet-flood processes. Finer-grained eolian sand is intercalated with the coarser alluvial deposits. Tuffaceous gravels are also present. The alluvial deposits are more than 1,220-m (4,000-ft) thick in the central portion of the basin and tend to be discontinuous, gradational, and poorly sorted. Saturated thickness is high in the central portion of Frenchman Flat, and here the unit is considered an aquifer with high porosity and hydraulic conductivity (although tuffaceous intervals with zeolitic alteration may locally reduce the unit's ability to transmit water).

The hydraulic conductivity of the alluvial aquifer is lower than that of the carbonate aquifer, but higher than that of the volcanic aquifer. The hydraulic head gradient in most areas of the alluvial aquifer in Frenchman Flat is relatively flat, less than one foot per mile, except near the water supply and test wells. Groundwater generally flows northeast. The water table occurs at a depth of about 283 m (927 ft) in the northern portion of Frenchman Flat (at Drill Hole ER-5-3#2) and about 216 m (708 ft) in the central portion of the site (at Drill Hole ER-5-4#2).

The playa confining unit consists of three separate confining units, including the youngest one at the surface (at Frenchman Lake) and two older, buried units. Playa deposits are clayey silt, with intercalated sand and pumice in places. The deposits at Frenchman Lake are about 150-m (500-ft) thick.

In the vicinity of the GTCC reference location, the thickness of the saturated zone is about 220 m (720 ft) (REEC 1994).

Figure 9.1.3-3 is a schematic showing the relationship of the playa confining units and the alluvial aquifer.

9.1.3.2.3 Groundwater Flow. Groundwater in the NNSS region flows within several sub-basins of the Death Valley regional flow system, a major subprovince of the southern Great

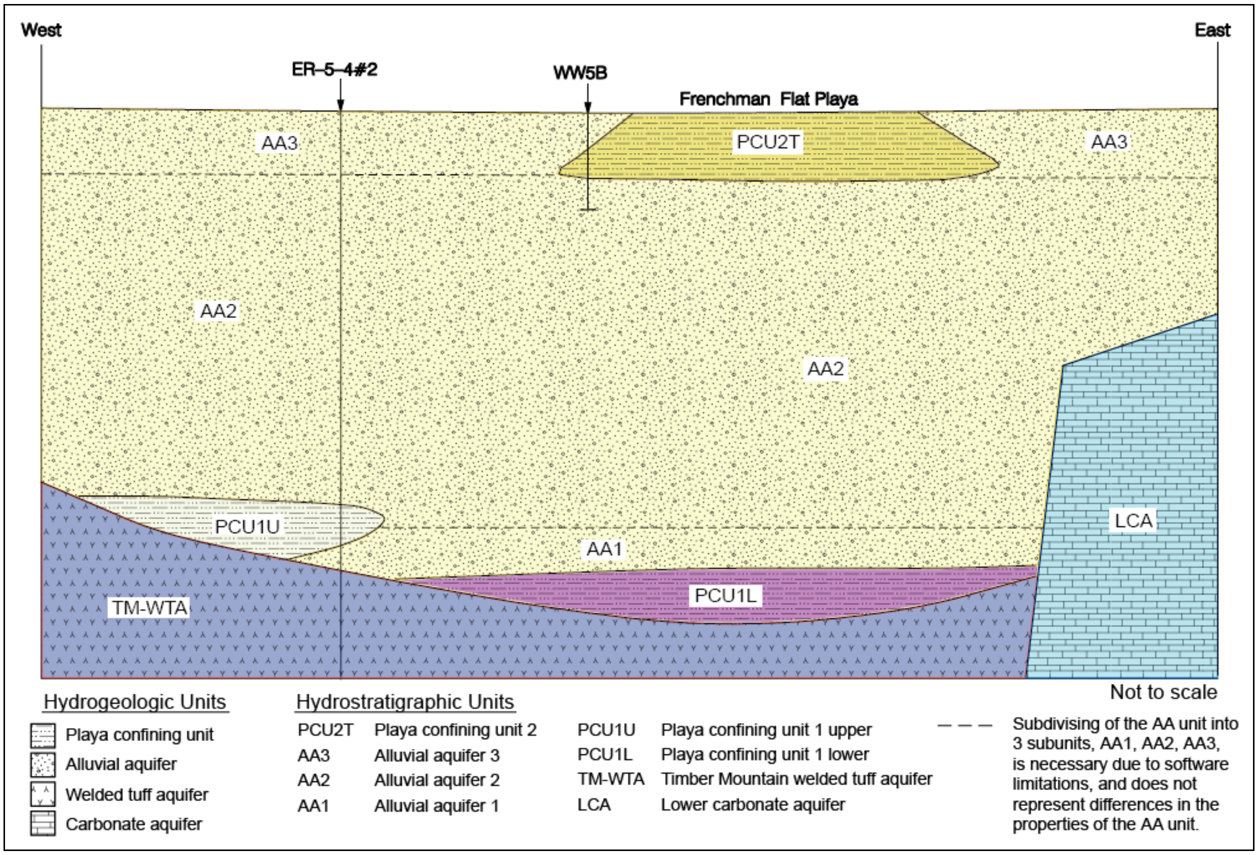

FIGURE 9.1.3-3 Hydrostratigraphic Cross Section through Central Frenchman Flat Showing the Alluvial Aquifer and Playa Confining Units (Source: Bechtel Nevada 2005a)

Basin (Figure 9.1.3-4). The Death Valley regional flow system covers an area of about 40,920 km^2 (15,800 mi^2) of the southern Great Basin, extending from recharge areas in the high mountains of central Nevada to its southernmost areas of discharge in Death Valley, California. The flow system transmits more than 86 million m^3 (70,000 ac-ft) of groundwater annually. The largest volume of groundwater flows through a thick sequence of Paleozoic carbonate rocks, occurring at depths greater than 1,370 m (4,500 ft) below Frenchman Flat and referred to as the "central carbonate corridor." Flow rates in this aquifer may be as high as 30.5 m/d (100 ft/d). The general direction of groundwater flow in these rocks is to the south-southwest (Bechtel Nevada 2005a; Laczniak et al. 1996).

Depth to groundwater in Frenchman Flat ranges from 283 m (927 ft) in the northern portion of the basin to 216 m (708 ft) in the central portion of Frenchman Flat. Groundwater recharge of the carbonate aquifer occurs mainly via lateral inflow. Most of the groundwater recharge in the alluvial aquifer at Frenchman Flat is due to upflow from the underlying carbonate rock aquifer. There is very little, if any, recharge at the surface in Frenchman Flat. Annual precipitation at Frenchman Flat is less than 25 cm (10 in.), and potential evapotranspiration is five times higher (Clark University 2006). In the vicinity of the GTCC reference location, annual precipitation is estimated to be about 12 cm (5 in.) (National Security Technologies, LLC 2008). Recharge may occur in isolated areas along large drainage washes surrounding the site during precipitation events. Discharge occurs along springs to the southwest; water also leaves the system through evapotranspiration (which has an estimated annual rate of 13 million m^3 or 10,500 ac-ft) (Laczniak et al. 1996; Bechtel Nevada 2005a; DeNovio et al. 2006).

9.1.3.2.4 Groundwater Quality. Groundwater sampled from monitoring wells in Frenchman Flat has been characterized as a sodium bicarbonate type (Bechtel Nevada 2002a). Overall, groundwater quality within NNSS aquifers is acceptable for human consumption and for industrial and agricultural uses (DOE 1996). Bechtel Nevada (2002a) provides summary tables for water chemistry and water-level measurements taken in 2001 and compares these values with historical measurements. No significant changes due to contamination were detected; hydrologic conditions in the alluvial aquifer below Frenchman Flat were found to be stable.

A total of 10 underground nuclear tests were conducted at Frenchman Flat in the saturated zone or within 100 m (330 ft) of the water table (Bechtel Nevada 2005a). Figure 9.1.3-4 shows the test area locations in the northern and central parts of Frenchman Flat. With the exception of one of the northern tests, the nuclear tests were conducted within the alluvium (Table 9.1.3-4). Groundwater from Wells Ue5PW-1, Ue5PW-2, and Ue5PW-3 was sampled for gross alpha and gross beta radioactivity in 2001; all values were found to be below the National Primary Drinking Water Standards.

9.1.3.2.5 Water Use. DOE operates four groundwater water supply systems at NNSS for its water use and operational support. The number of personnel and amount of water used have fluctuated widely in response to changes in NNSS programs since 1958, when withdrawals were about 200 ac-ft/yr (250,000 m^3/yr). Groundwater is withdrawn from six basins (Mercury Valley, Yucca Flat, Frenchman Flat, Buckboard Mesa, Jackass Flat, and Gold Flat). Ten water supply

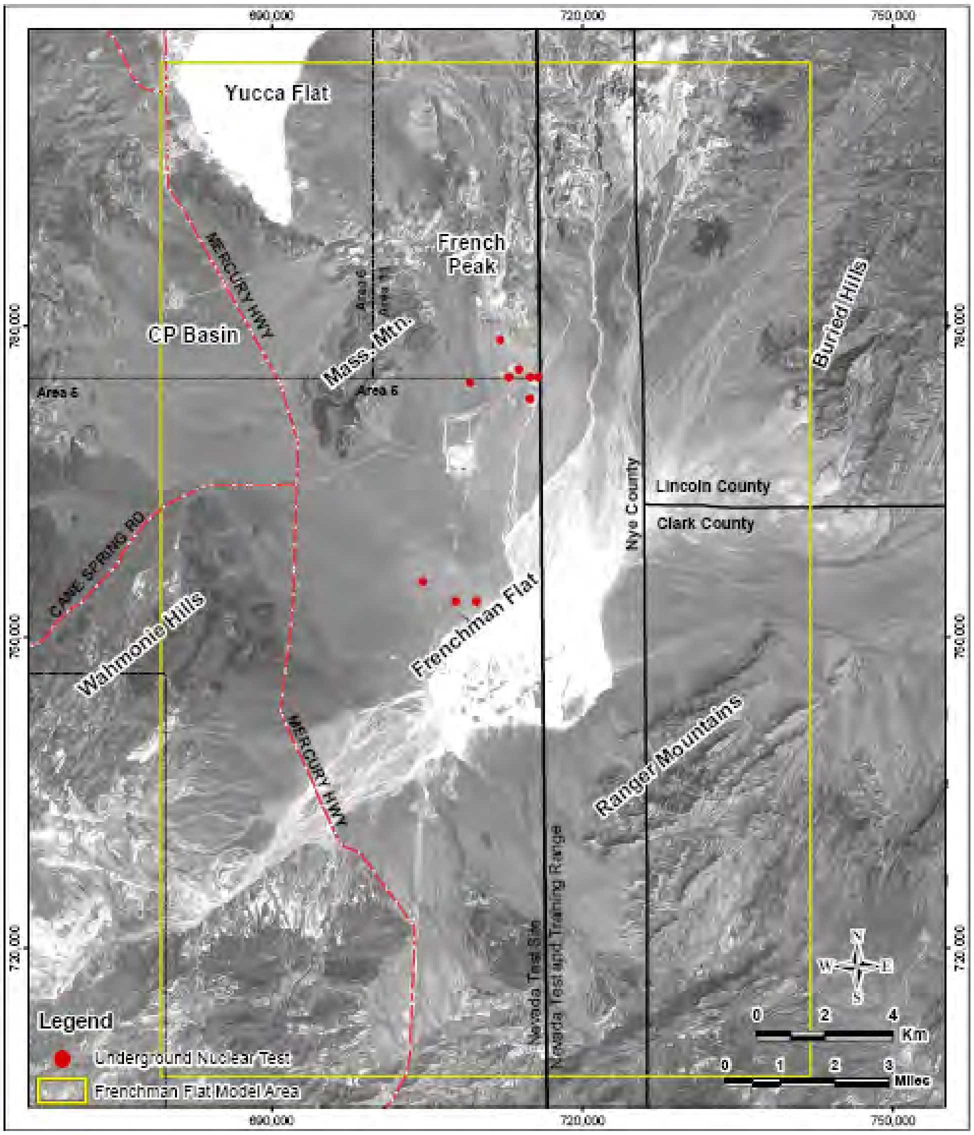

FIGURE 9.1.3-4 Locations of Underground Nuclear Testing at Frenchman Flat (Source: Bechtel Nevada 2005a)

wells, including three (WW-5A, WW-5B, and WW-5C) that are active in Frenchman Flat, are pumped into a system of storage tanks, sumps, and distribution systems. Current annual water use at NNSS is estimated to be about 1.1 billion L (290 million gal), well below the historic demand. Of the six basins tapped for water to support NNSS operations, the maximum historic withdrawal (1,664 ac-ft/yr or 2.1 million m^3/yr) was from wells located at Frenchman Flat. Withdrawals are estimated to be about 1% of the total groundwater withdrawals in the Death Valley Regional Flow System (USGS 2007; Moreo et al. 2003; Buqo 2004).

Current groundwater use in Nye County falls into five categories: public water supply systems, domestic wells, mining, agriculture, and federal use. In 1995, total water withdrawals were estimated to be 99,668 ac-ft (123 million m^3), with the greatest demands being for

American Indian Text

Indian people have raised in past radioactive waste disposal and transportation studies a range of questions regarding how to protect themselves and their natural resources from exposure to what they call the Angry Rock. The analysis of GTCC waste should address directly these potential impacts and suggest ways to either avoid or mitigate them. The potential impacts to Indian people and their life are significant including potentially blocking the path to the afterlife.

TABLE 9.1.3-4 List of Underground Nuclear Tests Conducted at Frenchman Flat

Emplacement Hole	Test Name	Date of Test	Yield (kilotons)	Depth of Burial (m [ft])	Static Water Level Depth (m [ft])	Working Point Geology	Estimated Alluvium Thickness (m [ft])
Northern Test Area							
U-5i	Derringer	9/12/1966	7.8	255 (837)	335 (1,100)	Alluvium	305 (1,000)
U-5k	Milk Shake	3/25/1968	<20	265 (868)	286 (939)	Alluvium	500 (1,640)
U-11b	Pin Stripe	4/25/1966	<20	269 (970)	349 (1,146)	Volcanic rocks	58 (190)
U-11c	New Point	12/13/1966	<20	239 (785)	299 (980)	Alluvium	478 (1,570)
U-11e	Diana Moon	8/27/1968	<20	242 (794)	305 (1,000)	Alluvium	366 (1,200)
U-11f	Minute Steak	9/12/1969	<20	265 (868)	302 (990)	Alluvium	427 (1,400)
U-11g	Diagonal Line	11/24/1971	<20	264 (867)	301 (988)	Alluvium	341 (1,120)
Central Test Area							
U-5a	Wishbone	2/18/1965	<20	175 (574)	Not available	Alluvium	590 (1,935)
U-5b	Diluted Water	6/16/1965	<20	193 (632)	213 (700)	Alluvium	400 (1,312)
U-5e	Cambric	5/14/1965	0.75	295 (967)	213 (700)	Alluvium	576 (1,890)

Source: Bechtel Nevada (2005a)

irrigation (80.0% or 60,233 ac-ft [74 million m^3] per year), mining (9.4% or 7,057 ac-ft [8.7 million m^3] per year), and domestic use (6.8% or 5,130 ac-ft [6.3 million m^3] per year). Water demand is expected to be about 166,000 ac-ft (204 million m^3) in 2020 (Buqo 2004).

Surface water is not a source of drinking water on NNSS. The closest surface water supply used for public consumption is Lake Mead, 160 km (98 mi) to the southeast of Frenchman Flat, which supplies a large portion of the water demand of Las Vegas (DOE 1996).

9.1.4 Human Health

Potential radiation exposures of the off-site general public can occur as a result of two main pathways: air transport and ingestion of game animals. The air transport pathway is a result of the resuspension of radioactive materials previously deposited in some areas of NNSS from past nuclear weapons testing activities. The airborne radionuclides can be blown off-site and expose the off-site general public through the inhalation and ingestion pathways. There are no likely exposures related to stack emissions of radionuclides at the site.

Wild animals may be exposed to radioactive materials through ingesting on-site contaminated soils or water (from containment ponds or sewage lagoons). These animals can then be consumed by members of the general public (through hunting and similar activities), resulting in a radiation dose. Drinking contaminated groundwater is not considered a potential exposure pathway because access to the site is restricted, and radioactive contamination has not been detected in off-site sources of groundwater that could be used as potable water supplies. Exposure through direct radiation from radioactive materials processed on-site is also not considered a reasonable exposure pathway for the general public because areas accessible to the public had direct gamma radiation exposure rates comparable to the background level.

Table 9.1.4-1 provides the radiation doses for the off-site general public estimated by using the results from recent environmental monitoring. The highest estimated potential radiation dose to an individual is 3.25 mrem/yr: 0.02 mrem/yr from airborne contamination and 3.23 mrem/yr from eating game animals and wildlife plants (Wills 2015). This dose is 3% of the dose limit of 100 mrem/yr from all exposure pathways set by DOE to protect the general public from the operation of its facilities. The annual collective dose to the 43,000 people living within 80 km (50 mi) of the site (Wills et al. 2005) from natural background and man-made sources of radiation is estimated to be 26,000 person-rem/yr.

According to the worker radiation exposure data published by DOE (2015), in 2014, 116 workers received measurable doses from on-site activities. A collective dose of 5.6 person-rem was recorded, which would result in an average individual dose of 48 mrem/yr. This dose would largely be from external gamma radiation, and to a much lesser extent, inhalation. The potential dose from the water ingestion pathway is expected to be zero, because no contamination was found in the on-site drinking water supply wells (Wills 2015). For comparison, the DOE administrative dose level for a radiation worker is 2 rem/yr (DOE 1994). Use of DOE's ALARA program ensures that worker doses are kept well below applicable standards.

9.1.5 Ecology

NNSS is located within the transition between the Mojave and Great Basin deserts. It is therefore ecologically diverse, since elements of both deserts are present (Wills et al. 2007). More than 750 species of vascular plants have been collected at NNSS (Wills et al. 2007). Ten major vegetation alliances have been identified on NNSS; their distributions have been linked to temperature extremes, precipitation, and soil conditions (Wills and Ostler 2001). The vegetation alliances present in the Mojave Desert ecoregion include desert thorn, creosote bush/white bursage, and shadscale/saltbrush/white bursage; those in the Great Basin Desert ecoregion include saltbrush, rabbitbrush, sagebrush, and pinyon pine/sagebrush; and those from the transition ecoregion include burrobrush/wolfberry, Nevada jointfir, and blackbrush (Wills et al. 2007). Four invasive plant species have become important components at NNSS: red brome (*Bromus rubens*), cheatgrass (*Bromus tectorum*), Russian thistle (*Salsola kali*), and barbwire Russian-thistle (*S. paulsenii*).

TABLE 9.1.4-1 Estimated Annual Radiation Doses to Workers and the General Public at NNSS

Receptor	Radiation Source	Exposure Pathway	Annual Dose to individual (mrem/yr)	Annual Dose to population (person-rem/yr)
On-site workers	Groundwater contamination	Water ingestion	0[a]	
	Airborne radionuclides	Inhalation	0.2[b]	
	Historical ground deposition and radioactive materials processed	Direct radiation	48[c]	5.6[c]
General public	Groundwater/surface water contamination	Water ingestion	0[d]	
	Airborne radionuclides	Inhalation	0.02[e]	
	Game animals and plants	Food ingestion	3.23[f]	
	On-site waste storage and shipment	Direct radiation	0[g]	
Worker/public	Natural background radiation and man-made sources		620[h]	26,600[i]

[a] Sampling results for the underground drinking water supply indicated no contamination caused by man-made radionuclides (Wills 2015), although migration of radionuclides from underground testing areas to on-site monitoring wells probably occurred. In 2014, all monitoring wells had tritium concentrations well below the drinking water limit of 20,000 pCi/L. No gamma-emitting radionuclides were detected at concentrations above detection limits in 2014. Gross alpha and gross beta levels in all monitoring wells were above detection limits. The radioactivity is most likely from natural sources (Wills 2015).

[b] By using the highest average air concentrations of man-made radionuclides at the Schooner monitoring station (Wills 2015), an inhalation dose of 0.9 mrem/yr was estimated for a hypothetical individual residing at this location. When this dose rate is scaled with exposure duration, an on-site worker working 2,000 hours at this location could receive a dose of 0.2 mrem/yr.

[c] In 2014, 116 workers monitored for radiation exposures received measurable doses. The total collective dose for these workers was 5.6 person-rem (DOE 2015). By distributing the collective dose evenly among the workers, an average individual dose of 48 mrem/yr was obtained.

[d] No off-site springs, surface water supplies, or wells had levels of tritium significantly above the detection limit. No gamma-emitting radionuclides were detected. Gross alpha and gross beta radioactivity was below drinking water standards in all potable water sources and was most likely from natural sources (Wills 2015).

[e] Dose estimated with air sampling data from the Gate 510 sampler in the far southwest corner of NNSS, which is closest to the nearest populated place (Wills 2015).

[f] Dose estimated for ingestion of NNSS game animals assumes that a person consumed a mule deer with the highest dose. The estimated dose from consuming pine nuts is extremely low and is a negligible contribution to the total potential dose (Wills 2015).

[g] No direct gamma radiation is expected because areas accessible to the public had direct gamma radiation exposure rates comparable to the background level (Wills 2015).

[h] Average dose to a member of the U.S. population as estimated in Report No. 160 of the NCRP (2009).

[i] Collective dose to the population of 43,000 within 50 mi (80 km) of NNSS (Wills et al. 2005) from natural background radiation and man-made sources.

American Indian Text

The CGTO knows that radiation can be and is viewed from both a western science and a Native American perspective (See Indian Appendix for more). These alternative and competing perspectives are key for understanding the cultural foundations of American Indian responses to the mining, processing, use, transportation, and disposal of radioactive materials. At some level of analysis from and Indian perspective, all radioactive waste is basically the same problem to Indian people. Subtle differences in classification from a western science perspective of radioactive waste only mask and do not significantly modify the basic cultural problems of radioactive waste for Indian people and their traditional lands.

The Angry Rock is a concept used by Indian people, involved in DOE funded radioactive waste transportation and disposal studies, to quickly summarize the complex cultural problems associated with what happened to this known mineral when it was improperly taken and used by non-Indians. The notion of an Angry Rock is premised on the belief that all of the earth is alive, sentient, speaks Indian, and has agency. When the elements of the earth are approached with respect and asked for the permission before being used they share their power with humans. The reverse occurs when they are taken without permission – they become angry withhold their power and often using it against humans. Thus uranium is an Angry Rock. Uranium has been known and carefully used by spiritual specialists and medicine persons for thousands of years (Lindsay et al. 1968). The following American Indian elder quote from a DOE funded report (Austin 1998) begins to explain this perspective:

We are the only ones who can talk to these things. If we do not make sure that we talk to those things, then they are going to give us more bad harm, because it is already happening throughout the country. Those are the reasons why the Indian people say ... like uranium, for one, uranium was here since the beginning of this Earth, when it was here we knew uranium at one time. And still it is used, but then they got a hold of it and made something else out of it. Now it is a man made thing, and today it accumulates waste from nuclear power plants, it accumulates more, it has its own life. Radiation has said to us at one time "If you use me make sure you tell me before you use me why you are going to use me and what for. " And we never said anything to that uranium at all, and we put something else in there with it, which shouldn't belong with it. It gives it more power to eliminate the life, of all living things on this planet of ours. Those are the reasons, why the Indian people always say, and I know because I have been there. The rocks have a voice...

Although from a Western science perspective radiation can be isolated and contained by conventional techniques, the Angry Rock has the power to move and cannot be contained by barriers. Indian people who have dealt with the Angry Rock for thousands of years note that there are traditional ways to deal with uranium, the natural rock, if used by trained Indian specialists, but these may or may not work with the Angry Rock of modern radiation waste.

Songs ... we are the ones who should be talking to those things. Radiation is going to take all of our lives; it is continuously moving over the land. The land don't want it, nobody wants it. And today, we are doing a bad thing by using radiation on each other. Radiation is something that should not be used to kill animal life...

Another elder noted:

And can it be contained? As it's transformed it can be, I think it can be contained physically but not spiritually, and again I think spiritually as it's been altered because it's in that energy field because it's been altered. The spirit, that's where it can do its harm in an altered

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form. It doesn't do any good to anybody. And there you're just in the wrong place in the wrong time, it does influence plants and animals, minerals and air, the spirit of any area it passes through. The reason somebody is sick. I don't think it's necessary to talk about how each one of these is influenced, it just is.

Another elder noted:

As far as the transportation of waste there's a lot of unknowns and we don't know what the consequences are. We know there are many sicknesses that come out from people that have been contaminated by nuclear waste and as far as Indian people go, we show respect to the land, show respect to other people, for the animals, the plants, the rocks. The power of the rock – Just looking at Chemehuevi Mountain, it's a very spiritual mountain from this perspective right here. When I look out towards the mountains and I don't just see a mountain, I see a place of power, I see a place where I can go and meditate and speak with the Creator directly and ask for prayers and blessings for people directly. Just like anything else, you have to give prayers all the time because the creator is here to watch and protect over us. I feel that we wouldn't have come this far if he wasn't here to watch over us and we are here to pray and we are here to protect the other resources.

Another elder said:

I can envision the animals standing back once it goes through for the first time and they recognize that there's a danger that they would move away because of fear. That they would no longer be there and that there's something bad coming down the road and they disperse and move away into different corridors. Kind of like a dust storm, they disperse and move further and further away. I see it from the animals' standpoint, they're a lot smarter than us and they've been doing this for longer than us and their senses are more keen and I think the animals would get back and it would create dead zones throughout the country. Through these corridors or transportation routes of course at the site there will be those that are curious who want to go see.

Another elder said:

I don't know what you would do with this rock if it's angry and this is its way of rebelling, getting back. I think as a Native American I would backstep and ask for forgiveness. Sometimes forgiving is not very easy because there's sacrifices we have to make and there's consequences … I don't think it can be done as a group, it's an individual thing and each one of us has to go back and … ask for forgiveness for what has taken place. It's not just only that I think it's going to be more complicated than going out into the mountains and saying, "hey, I'm sorry, I won't do this, I won't do that and I won't bother you anymore. There's a lot of other things that need to be forgiven. The rock is the most precious and it's the largest and it's the one that needs to be forgiven the most. There's a lot of small forgiveness that have to be given before the large rock. I think it's a stepping stone… the rocks are angry, yes, they're striking out saying "don't do this to me, don't touch me, don't let this happen. " In a sense you look at it from a spirituality standpoint, it's the spirits of Mother Earth telling us don't mess with Mother Earth. It remains a matter of debate as to whether traditional means of placating powerful rock-based forces can be used to control or placate radioactive waste. Western scientists have created a problem for Indian people that, despite being very critical to their future, is not easily resolved.

American Indian Text

The CGTO knows that this site (in Area 5) is an ancient playa, surrounded by mountain ranges. The runoff from these ranges serves to maintain the healthy desert floor. Animals frequent this area, there are numerous animals' trails, and these play a significant part in the history of the locality and of the Indian lifestyles. Our ancestors knew that the Creator always provided for them and this site is one of their favorite places to hunt and trap rabbits. We have special leaders that organized large rabbit hunts. Many people participated so this place would be occupied at times by all kinds of our people. Rabbits provided good eating, bones for tool-making, warm blankets, and even games. Indian people refrained from eating coyote, wolves, and birds but these contribute to our stories which tell us how to behave and why we are here. We have many stories and songs that include animals and birds who have human-like antics. From these antics Indian people learn the life lessons to build character to become better persons. So animals and the places where they live contribute to our history and culture.

This culturally central place was used by and important to Indian people from our agricultural and horticultural communities located to the north – near Reese River Valley and Duckwater, to the south – near Ash Meadows, to the southeast – near Indian Springs and Corn Creek, to the east – near the Pahranagat-Muddy River, and west – near the Oasis Valley. It was also used by people from our agricultural and horticultural communities to the far west in Owens Valley, to the far south near Cottonwood Island and Palo Verde Valley on the Colorado River, to the far southwest at Twenty Nine Palms, to the far east along the Virgin River, Santa Clara River, and Kanab Creeks, to the far north along the Humbolt River and Ruby Valley.

They rapidly invade disturbed sites at NNSS and delay revegetation by native species (Wills and Ostler 2001). The GTCC LLRW and GTCC-like waste disposal facility would occur within the Mojave Desert ecoregion and within the creosote bush/white bursage vegetation alliance. The climate in this area is arid, with average annual precipitation of about 12.3 cm (5 in.). Predominant plant species include white bursage (*Ambrosia dumosa*), creosote bush (*Larrea tridentata*), Nevada jointfir (*Ephedra nevadensis*), small flower ratany (*Krameria erecta*), and pale wolf-berry (*Lycium pallidum*) (DOE 2002b; Wills and Ostler 2001).

None of the natural water bodies at NNSS are considered jurisdictional wetlands. However, the final determination from the USACE regarding the status of NNSS wetlands has yet to be received (Wills 2011). Wetlands on NNSS include cave pools at spring sites, four natural rock depression pools, and two ephemeral ponds. The natural wetlands (e.g., seeps and springs) and human-made water sources (e.g., sumps and sewage lagoons) provide unique habitat areas for vegetation and wildlife at NNSS (Wills et al. 2007). None of the water bodies are in the area of the GTCC reference location.

Fifty-nine mammal species, including 15 bat species, have been reported from NNSS. Rodents are the most abundant and widespread group of mammals on NNSS (Wills and Ostler 2001), with the long-tailed pocket mouse (*Chaetodipus formosus*) and Merriam's kangaroo rat (*Dipodomys merriami*) being most abundant (DOE 2002b). Larger mammal species include the black-tailed jackrabbit (*Lepus californicus*), desert cottontail (*Sylvilagus audubonii*), mountain cottontail (*S. nuttallii*), mule deer (*Odocoileus hemionus*), pronghorn (*Antilocapra americana*), coyote (*Canis latrans*), kit fox (*Vulpes macrotis*), badger (*Taxidea taxus*), bobcat, and mountain lion (Wills et al. 2007). The mountain lion preys on wild horses (*Equus caballus*), mule deer, pronghorn, and even the desert tortoise (*Gopherus agassizii*). It also poses a potential threat to humans on NNSS (National Security Technologies, LLC 2007). Wild horses occur on the northern portion of NNSS. Between 1999 and 2006, the number of wild horses ranged from 33 to 53 (Wills et al. 2007). No hunting is allowed on NNSS (Wills and Ostler 2001). Most mammals on NNSS other than rodents are protected by the State of Nevada and managed as either game or furbearing mammals, and the bat species are considered sensitive species (Wills et al. 2007).

Nearly 240 species of birds have been observed at NNSS. Nearly 80% are migrants or seasonal residents. A total of 36 bird species, including 9 raptors, are considered year-long residents at NNSS (Wills and Ostler 2001). Twenty-two species of transient waterfowl and shorebirds have been observed on NNSS. They are observed near springs, well ponds, playas, and man-made impoundments. Nearly all bird species on NNSS are protected by the Migratory Bird Treaty Act (Wills et al. 2007).

Thirty-four reptile species are known to exist at NNSS: 16 lizard species, 17 snake species, and the desert tortoise. Four poisonous snakes occur on NNSS. The bullfrog (*Lithobates catesbeianus*), which is not native to the southwestern United States, is the only amphibian species that has been identified at NNSS (Wills et al. 2007).

There are 30 natural water bodies on NNSS, including 15 springs, 9 seeps, 4 tank sites (natural rock depressions that catch and hold surface runoff), and 2 ephemeral ponds (Wills and

American Indian Text

Plants

The CGTO knows based on previous DOE-sponsored ethnobotany studies that there are at least 364 Indian use plants on the NNSS (see Appendix G). Indian people visiting the proposed location of the GTCC facility identified the following traditional use plants: (1) Indian Tea, (2) White Sage or Winter Fat, (3) Indian Rice Grass, (4) Creosote, (5) Wolfberries, (6) Four O'clock, (7) Spiny Hop Sage, (8) Joshua Tree, (9) Daises, (10) Desert Trumpet, (11) Cholla, (12) Globe Mallow, (13) Fuzzy Sage, (14) Tortoise Food plant, (15) Sacred Datura, (16) Wheat Grass, and (17) Lichen. Other plants were present but not identified due to the late season and the dry condition of the plants.

Plants are still used for medicine, food, basketry, tools, homes, clothing, fire, and ceremony – both social and healing. The characteristics of the plants at the proposed GTCC area are smaller and thinner than in other desert areas where it is wetter. Indian people from elsewhere traveled to this area to gather specific plants because they have stronger characteristics when they grow in dry places. The sage is used for spiritual ceremonies, smudging, and medicine. The Indian rice grass and wheat grass are used for breads and puddings. Joshua trees and Yucca plants are important for hair dye, basketry, foot ware, and rope. Datura is used for hallucinogenic effects during which alternative places can be visited by medicine men. Datura also goes itself to disturbed areas and heals them. The globe mallow had traditional medicine uses, but in recent times is also used for curing European contagious diseases.

American Indian Text

Animals/Insects

The CGTO knows based on previous DOE-sponsored ethnofauna studies that there are at least 170 Indian use animals on the NNSS [*see Appendix G*]. Indian people visiting the proposed location of the GTCC facility identified the following traditional use animals: (1) Jack Rabbits, (2) Whiptail Lizards, (3) Antelope, (4) Tortoise, (5) Kangaroo Rats, (6) Horned Toad, (7) Rock Wrens, (8) Ravens, (9) Grasshoppers, and (10) Stink Bugs. Other animals (such as snakes, bats, and owls) were perceived to be present but not observed because they primarily emerge at night.

All animals and insects were and are culturally important and the relationships between them, the Earth, and Indian people are represented by the respectful roles they play in the stories of our life then and now. The GRCC valley is where a spiritual journey occurred. It involved Wolf (Tavats in Southern Paiute, Bia esha in Western Shoshone, Wi gi no ki in Owens Valley Paiute) and Coyote (Sinav in Southern Paiute, Duhvo esha in Western Shoshone, Esha in Owens Valley Paiute) and is considered a Creation Story. Only parts of this can be presented here. When Wolf and Coyote had a battle over who was more powerful, Coyote killed Wolf and felt glorious. Everyone asked Coyote what happened to his brother Wolf. Coyote felt extremely guilty and tried to run and hide but to no avail. Meanwhile, the Creator took Wolf and made him into a beautiful Rainbow (Paro wa tsu wu nutuvi in Southern Paiute, Oh ah podo in Western Shoshone, Paduguna in Owens Valley Paiute). When Coyote saw this special privilege he cried to the Creator in remorse and he too wanted to be a Rainbow. Because Coyote was bad, the Creator put Coyote as a fine white mist at the bottom of the Rainbow's arch. This story and the spiritual trails discussed in the full version are connected to the Spring Mountains and the large sacred cave in the Pintwater Mountains as well as to lands now called the Nevada National Security Site. This area is the home place of Wolf who is still present and watches over the area and us.

Ostler 2001). The water bodies total 2.5 ha (6.1 ac) and range from springs and seeps with essentially no surface water area to an area of 2.3 ha (5.7 ac) for Yucca Playa Pond, one of the ephemeral ponds (Wills and Ostler 2001). No natural water bodies are located near the GTCC reference location. Numerous man-made impoundments at several locations throughout NNSS support various operations. Many animals at NNSS, including migratory waterfowl, make use of these water sources (Wills and Ostler 2001). No native fish species occur at NNSS, but several nonnative species have been introduced into some of the man-made ponds (Wills et al. 2007).

The federally and state-listed species identified on or adjacent to NNSS are listed in Table 9.1.5-1. No federally protected plant species occur on NNSS. Also, no federal plant species of special concern (e.g., formerly known as Category 2 candidate species) were observed in the GTCC reference location at NNSS (Blomquist et al. 1995). The Death Valley beardtongue (*Penstemon fruticiformis* ssp. *amargosae*) is the only state-listed threatened species known to occur on or adjacent to NNSS. However, a number of sensitive plant species that occur on or adjacent to NNSS are on the Nevada Natural Heritage Program (NNHP) Sensitive Plant Taxa List (NNHP 2007). Some of these species are reported from Area 5 (area that contains the GTCC reference location) or from the southern portions of Areas 6 and 11, including the white bear poppy (*Arctomecon merriamii*), black milk-vetch (*Astragalus funereus*), sanicle biscuitroot (*Cymopterus ripleyi*), Beatley's milk-vetch (*Astragalus beatleyae*), and Parish's phacelia

TABLE 9.1.5-1 Federally and State-Listed Threatened, Endangered, and Other Special-Status Species on or Adjacent to NNSS

Common Name (Scientific Name)	Status[a] Federal/State
Mosses	
Planoconvex entosthodon (*Entosthodon planoconvexus*)	-/W, 5 years
Plants	
Beatley's milk-vetch (*Astragalus beatleyae*)	SC/W, 5 years
Beatley's scorpionflower (*Phacelia beatleyae*)	SC/W, 5 years
Black milk-vetch (*Astragalus funereus*)	SC/W, 5 years
Bullfrog Hills peavine (*Lathyrus hitchcockianus*)	-/W, 5 years
Charleston milk-vetch (*Astragalus oophorus* var. *clokeyanus*)	SC/W, 5 years
Clarke phacelia (*Phacelia filiae*)	-/W, 10 years
Clokey buckwheat (*Eriogonum heermannii* var. *clokeyi*)	-/W, 5 years
Death Valley beardtongue (*Penstemon fruticiformis* ssp. *amargosae*)	-/ST, 5 years
Darin's buckwheat (*Eriogonum concinnum*)	-/W, 5 years
Intermountain evening-primrose (*Camissonia megalantha*)	SC/W, 10 years
Kingston bedstraw (*Galium hilendiae* ssp. *kingstonense*)	SC/W, 10 years
Pahute green gentian (*Frasera albicaulis* var. *modocensis*)	SC/W, 10 years
Pahute Mesa beardtongue (*Penstemon pahutensis*)	SC/W, 10 years
Parish's phacelia (*Phacelia parishii*)	SC/W, 10 years
Pumice alpinegold (*Hulsea vestita* ssp. *inyoensis*)	-/W, 10 years
Rock purpusia (*Iversia arizonica* var. *saxosa*)	-/W, 5 years
Sanicle biscuitroot (*Cymopterus ripleyi* var. *saniculoides*)	SC/-
Weasel phacelia (*Phacelia mustelina*)	-/W, 10 years
White bear poppy (*Arctomecon merriamii*)	SC/W, 10 years
Reptiles	
Banded gila monster (*Heloderma suspectum cinctum*)	SC/S2
Chuckwalla (*Sauromalus ater*)	SC/-
Desert tortoise (*Gopherus agassizii*)	T/Yes
Birds	
Black tern (*Chlidonias niger*)	SC/-
Ferruginous hawk (*Buteo regalis*)	SC/Yes
Gray flycatcher (*Empidonax wrightii*)	SC/-
Lucy's warbler (*Vermivora luciae*)	SC/-
Peregrine falcon (*Falco peregrinus*)	SC/Yes
Phainopepla (*Phainopepla nitens*)	SC/Yes
Western burrowing owl (*Athene cunicularia hypugaea*)	SC/-
Western least bittern (*Ixobrychus exilis hesperis*)	SC/Yes
White-faced ibis (*Plegadis chihi*)	SC/-
Mammals	
Big free-tailed bat (*Nyctinomops macrotis*)	SC/-
Fringed myotis (*Myotis thysanodes*)	SC/Yes
Long-eared myotis (*Myotis evotis*)	SC/-
Long-legged myotis (*Myotis volans*)	SC/-
Small-footed myotis (*Myotis ciliolabrum*)	SC/-

TABLE 9.1.5-1 (Cont.)

Common Name (Scientific Name)	Status[a] Federal/State
Mammals (Cont.)	
Spotted bat (*Euderma maculatum*)	SC/Yes
Townsend's big-eared bat (*Corynorhinus townsendii*)	SC/Yes
Yuma myotis (*Myotis yumanensis*)	SC/-

[a] S: State rank indicator, based on distribution within Nevada at the lowest taxonomic level.

S2: Imperiled due to rarity or other demonstrable factors.

SC (species of concern): An informal term referring to a species that might be in need of conservation action. This may range from a need for periodic monitoring of populations and threats to the species and its habitat, to the necessity for listing as threatened or endangered. Such species receive no legal protection under the ESA, and use of the term does not necessarily imply that a species will eventually be proposed for listing.

ST (Nevada Natural Heritage Program or NNHP at-risk plant and lichen taxa, threatened): Believed to meet the ESA definition of threatened.

T (threatened): A species likely to become endangered within the foreseeable future throughout all or a significant portion of its range.

W (NNHP at-risk plant and lichen taxa, watch-list species): Potentially vulnerable to becoming threatened or endangered.

Yes: A species protected under *Nevada Revised Statute* 501 (Administration and Enforcement of Nevada Statute Title 45 – Wildlife).

5 years: Monitor a minimum of once every 5 years under the Ecological Monitoring and Compliance Program.

10 years: Monitor a minimum of once every 10 years under the Ecological Monitoring and Compliance Program.

-: Not listed.

Sources: Blomquist et al. (1995); NNHP (2007); Steen et al. (1997); Wills et al. (2007); Wills and Ostler (2001)

(*Phacelia parishii*) (Blomquist et al. 1995). At least once every five years, known populations of sensitive plant species are surveyed, and their status is evaluated (NNHP 2007).

The desert tortoise is the only federally listed animal species that resides on NNSS. It inhabits the southern third of NNSS at low estimated densities (i.e., between 0 and 34.7 tortoises/km^2 [0 and 90/mi^2]). In the area of the GTCC reference location, desert tortoise densities range from 3.7 to 17/km^2 (9.6 to 45/mi^2) (Wills et al. 2007). However, densities might be lower because of the close proximity of the GTCC reference location to the RWMS. The bald eagle, recently delisted, is a rare migrant on NNSS (Wills et al. 2007). Two reptile, nine bird, and seven bat species are species of concern on NNSS. The banded gila monster (*Heloderma suspectum cinctum*) was observed only once on NNSS, and no studies of this species on NNSS have been conducted or are planned (Wills and Ostler 2001). Among the bird species of special concern listed in Table 9.1.5-1, only the burrowing owl resides and breeds on NNSS (Wills and Ostler 2001).

9.1.6 Socioeconomics

Socioeconomic data for NNSS describe an ROI surrounding the site that is composed of two counties: Clark County and Nye County, Nevada. More than 95% of NNSS workers reside in these counties (DOE 2002b).

9.1.6.1 Employment

In 2011, total employment in the ROI stood at 871,321 (U.S. Department of Labor 2012). Employment grew at an annual average rate of 1.7% between 2002 and 2011. The economy of the ROI is dominated by the trade and service industries, with employment in these activities currently contributing 76% of all employment (see Table 9.1.6-1). Construction is also a large employer in the ROI, contributing 9% of total ROI employment. ROI employment at NNSS stood at 1,581 in 2001 (DOE 2002b).

TABLE 9.1.6-1 NNSS: County and ROI Employment by Industry in 2009

	Nevada			
Sector	Clark County	Nye County	ROI Total	% of ROI Total
Agriculture[a]	213	275	488	0.1
Mining	321	750	1,071	0.1
Construction	71,474	300	71,774	9.3
Manufacturing	20,784	256	21,040	2.7
Transportation and public utilities	33,884	252	34,136	4.4
Trade	116,963	1,540	118,503	15.4
Finance, insurance, and real estate	51,711	262	51,973	6.7
Services	467,914	3,604	471,518	61.2
Other	88	0	88	0.0
Total	762,879	7,387	770,266	

[a] Source: USDA (2008).

Source: U.S. Bureau of the Census (2012a)

9.1.6.2 Unemployment

Unemployment rates have varied across the counties in the ROI (Table 9.1.6-2). Over the 10-year period 2002–2011, the average rate in Nye County was 9.7%, with a lower rate of 7.6% in Clark County. The average rate in the ROI over this period was 7.6%, slightly higher than the average rate for the state of 7.5%. Unemployment rates for 2010 were the same or slightly higher than rates for 2011; in Nye County, the unemployment rate stayed at 16.5% for both years, while in Clark County, the rate fell from 14.1% to 13.9%. The average rate for the ROI fell from 14.1% to 13.9%, and that for the state fell from 13.7% to 13.5%.

9.1.6.3 Personal Income

Personal income in the ROI stood at almost $75 billion in 2009, growing at an annual average rate of growth of 3.3% over the period 2000–2009 (Table 9.1.6-3). However, ROI personal income per capita fell over the same period, to $38,370 in 2009, compared with $39,728 in 2000. Per-capita incomes were higher in Clark County ($38,491 in 2009) than elsewhere in the ROI.

9.1.6.4 Population

The population of the ROI was 1,995,215 in 2010 (U.S. Bureau of the Census 2012b) and was expected to reach 2,139,214 by 2012 (Table 9.1.6-4). In 2010, 1,951,269 people were living in Clark County (98% of the ROI total). Over the period 2000–2010, population in the ROI as a whole grew rapidly, with an average growth rate of 3.5%, while the population in Nevada as a whole grew at a rate of 3.1% over the same period.

TABLE 9.1.6-2 NNSS: Average County, ROI, and State Unemployment Rates (%) in Selected Years

Location	2002–2011	2010	2011
Clark County	7.6	14.1	13.9
Nye County	9.7	16.5	16.5
ROI	7.6	14.1	13.9
Nevada	7.5	13.7	13.5

Source: U.S. Department of Labor (2012)

TABLE 9.1.6-3 NNSS: County, ROI, and State Personal Income in Selected Years

Income	2000	2009	Average Annual Growth Rate (%), 2000–2009
Clark County			
Total personal income (2011 $ in billions)	54.9	73.2	3.3
Personal income per capita (2011 $)	39,903	38,491	–0.4
Nye County			
Total personal income (2011 $ in billions)	1.0	1.5	3.8
Personal income per capita (2011 $)	32,285	33,181	0.3
ROI total			
Total personal income (2011 $ in billions)	55.9	74.7	3.3
Personal income per capita (2011 $)	39,728	38,370	–0.4
Nevada			
Total personal income (2011 $ in billions)	81.7	104.4	2.8
Personal income per capita (2011 $)	40,880	39,497	–0.4

Source: DOC (2012)

TABLE 9.1.6-4 NNSS: County, ROI, and State Population in Selected Years

Location	1990	2000	2010	Average Annual Growth Rate (%), 2000–2010	2012[a]
Clark County	741,459	1,375,765	1,951,269	3.6	2,092,530
Nye County	17,781	32,485	43,946	3.1	46,684
ROI	759,240	1,408,250	1,995,215	3.5	2,139,214
Nevada	1,201,833	1,998,257	2,700,551	3.1	2,868,221

[a] Argonne National Laboratory projections.

Source: U.S. Bureau of the Census (2012b)

9.1.6.5 Housing

Housing stock in the ROI as a whole grew at an annual rate of 4.1% over the period 2000–2010 (Table 9.1.6-5). A total of 286,960 new units were added to the existing housing stock in the ROI between 2000 and 2010. In 2010, 129,296 housing units in the ROI were vacant; of these, 22,797 were rental units that could be available to construction workers at the GTCC LLRW and GTCC-like waste disposal facility.

9.1.6.6 Fiscal Conditions

Construction and operations of a GTCC LLRW and GTCC-like waste disposal facility could result in increased expenditures for local government jurisdictions, including counties, cities, and school districts. Revenues to support these expenditures would come primarily from state and local sales tax revenues associated with employee spending during construction and operations and be used to support additional local community services currently provided by each jurisdiction. Table 9.1.6-6 presents information on expenditures by the various local government jurisdictions and school districts in the ROI.

9.1.6.7 Public Services

Construction and operations of a GTCC LLRW and GTCC-like waste disposal facility could require increases in employment in order to provide public safety, fire protection, community, and educational services in the counties, cities, and school districts likely to host relocating construction workers and operations employees. Additional demands could also be placed on local physician services. Table 9.1.6-7 presents data on employment and levels of service (number of employees per 1,000 population) for public safety and general local government services. Table 9.1.6-8 provides data on teachers and level of service, and Table 9.1.6-9 covers physicians.

9.1.7 Environmental Justice

Figures 9.1.7-1 and 9.1.7-2 and Table 9.1.7-1 show the minority and low-income compositions of the total population located in the 80-km (50-mi) buffer around NNSS from Census data for the year 2010 and CEQ guidelines (CEQ 1997). Persons whose incomes fall below the federal poverty threshold are designated as low income. Minority persons are those who identify themselves as Hispanic or Latino, Asian, Black or African American, American Indian or Alaska Native, Native Hawaiian or other Pacific Islander, or multi-racial (with at least one race designated as a minority race under CEQ). Individuals identifying themselves as Hispanic or Latino are included in the table as a separate entry. However, because Hispanics can be of any race, this number also includes individuals who also identified themselves as being part of one or more of the population groups listed in the table.

TABLE 9.1.6-5 NNSS: County and ROI Housing Characteristics in Selected Years

Type of Housing	2000	2010
Clark County		
Owner occupied	302,834	408,206
Rental	209,419	307,159
Vacant units	47,546	124,978
Total units	559,799	840,343
Nye County		
Owner occupied	10,167	12,979
Rental	3,142	5,053
Vacant units	2,625	4,318
Total units	15,934	22,350
ROI		
Owner occupied	313,001	421,185
Rental	212,561	321,212
Vacant units	50,171	129,296
Total units	575,733	862,693

Source: U.S. Bureau of the Census (2012b)

TABLE 9.1.6-6 NNSS: County, ROI, and State Public Service Expenditures in 2006 ($ 2011 in millions)[a]

Location	Local Government	School District
Clark County	1,622	1,240
Nye County	34	32
ROI total	1,656	1,272
Nevada	13,572	3,020

[a] Argonne National Laboratory projections.

TABLE 9.1.6-7 NNSS: County, ROI, and State Public Service Employment in 2009

	Clark County		Nye County	
Service	No.	Level of Service[a]	No.	Level of Service[a]
Police protection	2,830	1.5	109	2.5
Fire protection[b]	1,091	0.6	83	1.9
	ROI		**Nevada[c]**	
Service	No.	Level of Service[a]	No.	Level of Service[a]
Police protection	2,939	1.5	3,974	1.6
Fire protection	1,174	0.6	2,230	0.9

[a] Level of service represents the number of employees per 1,000 persons in each county.

[b] Does not include volunteers.

[c] 2006 data.

Sources: U.S. Bureau of the Census (2008a,b, 2012b,c); FBI (2012); Fire Departments Network (2012)

TABLE 9.1.6-8 NNSS: County, ROI, and State Education Employment in 2011

Location	No. of Teachers	Level of Service[a]
Clark County	15,472	19.8
Nye County	356	17.3
ROI	15,828	19.8
Nevada	22,104	19.3

[a] Level of service represents the number of teachers per 1,000 persons in each county.

Sources: National Center for Educational Statistics (2012); U.S. Bureau of the Census (2012b,c)

TABLE 9.1.6-9 NNSS: County, ROI, and State Medical Employment in 2010

Location	No. of Physicians	Level of Service[a]
Clark County	4,507	2.3
Nye County	37	0.8
ROI	4,544	2.3
Nevada[b]	4,791	1.9

[a] Level of service represents the number of physicians per 1,000 persons in each county.

[b] 2006 data.

Sources: AMA (2012); U.S. Bureau of the Census (2008b, 2012b)

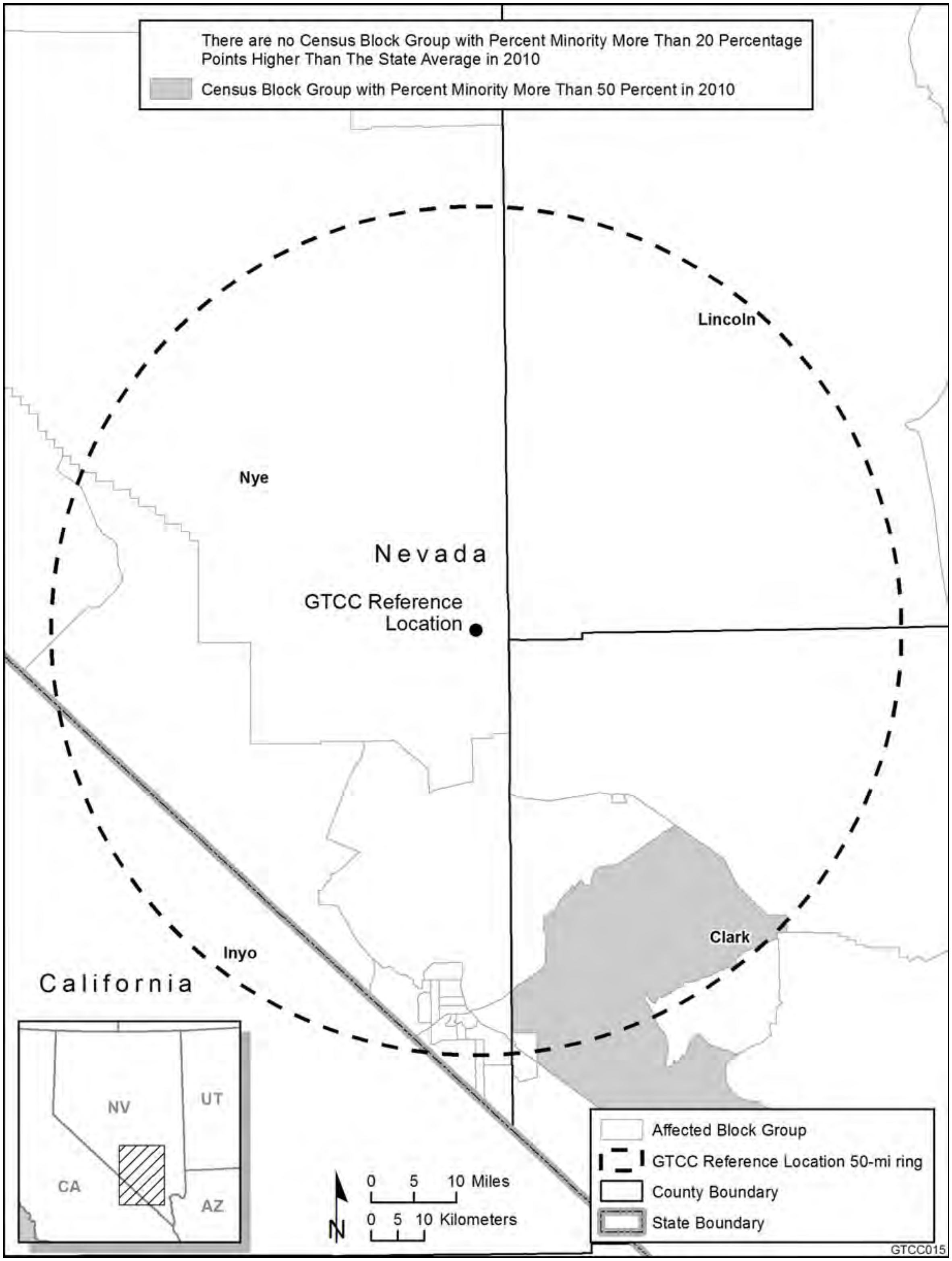

FIGURE 9.1.7-1 Minority Population Concentrations in Census Block Groups within an 80-km (50-mi) Radius of the GTCC Reference Location at NNSS (Source: U.S. Bureau of the Census 2012b)

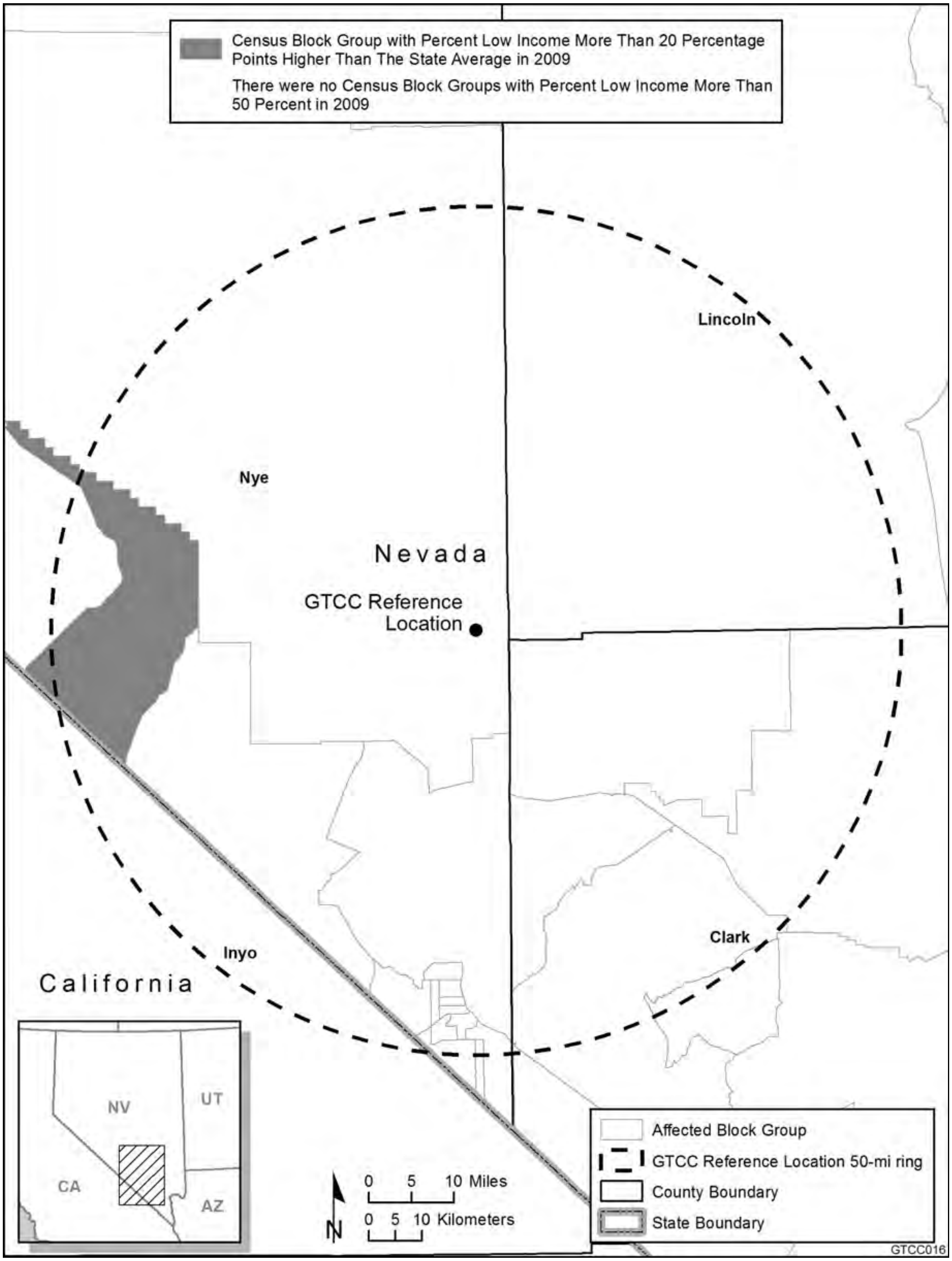

FIGURE 9.1.7-2 Low-Income Population Concentrations in Census Block Groups within an 80-km (50-mi) Radius of the GTCC Reference Location at NNSS (Source: U.S. Bureau of the Census 2012b)

TABLE 9.1.7-1 Minority and Low-Income Populations within an 80-km (50-mi) Radius of NNSS

Population	California Block Groups	Nevada Block Groups
Total population	765	50,546
White, Non-Hispanic	618	37,107
Hispanic or Latino	74	7,467
Non-Hispanic or Latino minorities	73	5,972
One race	48	4,709
Black or African American	9	2,840
American Indian or Alaskan Native	27	487
Asian	6	1,132
Native Hawaiian or other Pacific Islander	4	196
Some other race	2	54
Two or more races	25	1,263
Total minority	147	13,439
Percent minority	19.2%	26.6%
Low-income	16	2,702
Percent low-income	7.0%	8.8%
State percent minority	59.9%	45.9%
State percent low-income	14.2%	12.4%

Source: U.S. Bureau of the Census (2012b)

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DOE has recognized the need to address environmental justice concerns of the CGTO based on disproportionately high and adverse impacts to their member tribes from DOE NNSS activities. In 1996, the CGTO expressed concerns relating to environmental justice that included (1) damage to Holy Lands, (2) negative health impacts, and (3) lack of access to traditional places that contributes to breakdowns in cultural transmission. In the 2002 NNSS SA, NNSA/NSO concluded that with the selection of the Preferred Alternative, the CGTO would be impacted at a disproportionately high and adverse level consequently creating an environmental justice issue. Since 2002, NNSA/NSO has supported a few ethnographic studies involving the CGTO and culturally important places including in 2004, when NNSA/NSO arranged for tribal representatives to conduct evening ceremonies at Water Bottle Canyon. While the opportunity for the evening ceremony was a significant accommodation, disproportionately high and adverse impacts from DOE NNSS activities continue to affect American Indians. The three environmental justice issues noted by the CGTO need to be addressed.

A large number of minority and low-income individuals are located in the 50-mi (80-km) area around the boundary of the reference location. Within the 50-mi (80-km) radius in California, 19.2% of the population is classified as minority, while 7.0% is classified as low income. However, the number of minority individuals does not exceed the state average by 20 percentage points or more, and the number of minority individuals does not exceed 50% of the total population in the area; that is, there is no minority population in the California portion of the 50-mi (80-km) area as a whole based on 2010 Census data and CEQ guidelines. The number of low-income individuals does not exceed the state average by 20 percentage points or more and does not exceed 50% of the total population in the area; that is, there are no low-income populations in the California portion of the 50-mi (80-km) area around the reference location as a whole.

Within the 50-mi (80-km) radius in Nevada, 26.6% of the population is classified as minority, while 8.8% is classified as low income. The number of minority individuals does not exceed the state average by 20 percentage points or more, and the number of minority individuals does not exceed 50% of the total population in the area; that is, there is no minority population in the Nevada portion of the 50-mi (80-km) area as a whole area based on 2010 Census data and CEQ guidelines. The number of low-income individuals does not exceed the state average by 20 percentage points or more and does not exceed 50% of the total population in the area; that is, there are no low-income populations in the Nevada portion of the 50-mi area (80-km) area around the reference location as a whole.

9.1.8 Land Use

NNSS encompasses about 352,512 ha (870,400 ac) (Wills et al. 2007). The site was established in 1950 to permit testing of underground and atmospheric nuclear devices. It is bordered on all sides by federal lands: the Yucca Mountain Project Area on the southwest corner, the NTTR on the west and north, an area used by both the NTTR and the Desert National Wildlife Range on the east, and BLM-administered lands on the south (Wills et al. 2007).

DOE's NNSA Nevada Site Office (NNSA/NSO) directs the management and operation of NNSS. The three major missions at NNSS are (1) national security (involving stockpile stewardship, homeland security, and test readiness programs), (2) environmental management (involving the environmental restoration and waste management programs), and (3) stewardship of NNSS (involving the maintenance of facilities and infrastructure to support all NNSS programs and to provide a safe environment for NNSS workers). The primary role of NNSS is to ensure that the existing U.S. stockpile of nuclear weapons remains safe and reliable (Wills et al. 2007). Land use by each of the NNSS missions occurs within zones designated by the land use map depicted in the *NTS Resource Management Plan* as shown in Wills et al. (2007).

Two areas (Area 3 and Area 5) support the waste management program at NNSS. The program is designed to safely manage and dispose of LLRW and safely manage and characterize hazardous and TRU wastes for off-site disposal (Wills et al. 2007). The GTCC reference location at NNSS is located within Area 5 and serves as a basis for evaluation. If NNSS is selected, the final location for a disposal facility within Area 5 will be based on further analysis.

9.1.9 Transportation

NNSS is situated about 96 km (60 mi) northwest of Las Vegas, Nevada. The major regional road access to the area is from I-15 as it passes through Las Vegas on its journey from Los Angeles (to the southwest) to Salt Lake City, Utah (to the northeast). The site is circled by U.S. and state highways, with US 95 to the south and west, US 6 and SR 375 to the north, and US 93 to the east. Farther from the area, I-80 and I-40 are both major east-west freeways. To the north, I-80 passes through Salt Lake City, Utah, and Reno, Nevada. To the south, I-40 passes through Flagstaff, Arizona, and Barstow, California.

US 95 is a major north-south roadway extending south to the Mexican border and north to the Canadian border. It is, by far, the most frequently used road for direct access to NNSS and is used by more than 95% of the employees working on-site. It is the closest and most direct route to the site for hauling materials and waste, whether hauled directly by trucks or by rail (DOE 1996). It is a four-lane roadway between Las Vegas and the Mercury interchange and within Las Vegas, and it is a two-lane rural highway beyond the Mercury interchange to the north. US 93 is a major north-south roadway across Nevada. It extends from Las Vegas to the Canadian border, intersecting I-80 near the town of Wells, Nevada. It is an all-weather, two-lane, paved roadway. US 6 is an east-west roadway, located to the north of NNSS and the Tonopah Test Range, and it links US 93 and US 95. Nevada SR 375 provides vehicular access to NNSS via a connecting road. It runs northwest along the northeastern boundaries of the site. This stretch of two-lane highway links US 6 and US 93. Traffic counts for these roads are provided in Table 9.1.9-1.

The main access to NNSS is the Mercury Highway, which originates at US 95 and accesses the main gate in Mercury. There is another entrance 8 km (5 mi) to the west of Mercury, which is a turnoff to Jackass Flats Road; however, this entrance is presently barricaded. NNSS has restricted access into Area 25 from US 95 at Lathrop Wells Road, approximately 32 km (20 mi) west of Mercury. Access to NNSS is restricted, and guard stations are located at all entrances, as well as throughout the site (DOE 1996).

Because in the past, DOE committed to the State of Nevada that low-level radioactive waste shipments to NNSS would avoid the I-15/US 95 interchange in Las Vegas, the representative routes assumed in this EIS (see Section C.9.4.1.1 in Appendix C for a discussion) for NNSS do not pass through Las Vegas. Most shipments to NNSS were assumed to arrive via either I-80 to the north (northern access) or I-40 to the south (southern access). Northern access to the NNSS would be by way of the I-80 exit at West Wendover, Nevada, on to US 93A that continues to US 93, connecting with US 50 in Ely, Nevada. In Ely, shipments would take US 6 to the southwest from US 50, traveling to Tonopah, where they would take US 95 to the south and then east to the NNSS entrance. Southern access from I-40 would occur by exiting on to US 95 north at Needles, California, to NV 164 westbound in Searchlight, Nevada, to I-15 west/south, to CA1237 north in Baker, California, which becomes NV 373 in Nevada. NV 373 meets US 95 where shipments would travel to the east to the NNSS entrance.

TABLE 9.1.9-1 Traffic Counts in the Vicinity of NNSS

Location	Annual Average Daily Traffic
DOE access road to Mercury from US 95	1,250
US 95	
At SR 157 interchange	11,100
North of Indian Springs, south of DOE access road	3,650
4 mi north of Mercury interchange	3,050
1.5 mi south of SR 373	2,900
0.2 mi north of SR 373	2,550
Milepost 77, between SR 267 and SR 374	2,200
Just south of Goldfield	1,900
South of Tonopah	2,150
US 6	
West of Tonopah	2,000
East of Tonopah and SR 376	590
West of Warm Springs	300
SR 375	
East of Warm Springs	150
West of SR 318	220
US 93	
South of Alamo	1,550
North of I-15 interchange	2,550
I-15	
North of SR 604 interchange	26,100

Source: NDOT (2007)

These routes are representative only and depend on current road, weather, and traffic conditions at the time of shipment, with alternate routes being possible if necessary. For example, southern access to NNSS could utilize NV160 instead of CA 127/NV 373. With the expansion of I-15 and US 95 in the Las Vegas area, in conjunction with construction of the 215 Beltway as well as the Hoover Dam Bypass, more alternative shipping options have become available. No routing decisions will be made as part of this EIS process. Any future decisions on routing would be developed in accordance with NNSA's standard practices, which include consultation with the State of Nevada, and when finalized, would become publicly available through publication on the NNSS website.

On-site, the 1,127-km (700-mi) road network consists of 644 km (400 mi) of paved primary roads and 482 km (300 mi) of unpaved secondary roads (DOE 1996). Most paved roadways are two-way and two-lane with a speed limit of 89 km/h (55 mph) unless posted otherwise. The speed limit in developed areas is 32 km/h (20 mph). The maximum speed limit on dirt roads is 56 km/h (35 mph). In addition, NNSS contains numerous event-related unpaved roads that are not maintained after a test has been conducted. Traffic flow and control throughout NNSS are maintained by conventional stop and yield signs at major intersections. Traffic regulations are enforced by the Nye County Sheriff's Department.

NNSS does not have direct rail access. The closest access to commercial rail service is in Las Vegas. However, the transportation of inbound LLRW shipments through Las Vegas has been discouraged, especially through the I-15 and US 95 interchange (the “spaghetti bowl”) (DOE 2007a), which is subject to heavy traffic congestion. Use of intermodal facilities at either Barstow, California (in San Bernadino County), or Caliente, Nevada, was recommended in the past because the rail terminals can readily handle additional freight, they keep shipments from more populated areas, and they are near major highways (DOE 1999). Shipment distances by truck from Barstow and Caliente would be approximately 290 km (180 mi) and 550 km (340 mi), respectively. The route from Caliente to NNSS, which is necessarily longer to avoid Las Vegas, circles the site to the north and west (via SR 375, US 6, and US 95) before access at Mercury.

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The area comprising the NNSS is recognized as being traditionally used and occupied for ceremony and subsistence by the Owens Valley Paiutes, Western Shoshone and Southern Paiute for thousands of years. Accordingly, the central feature of subsistence involved agricultural villages located to the east in Pahranagat Valley, the Muddy River, and the Colorado river, to the south at a series of artesian springs and to the west along Oasis Valley. Farming sites were also located on the NNSS. Permanent non-farm based villages existed on water sources to the north. Seasonal hunting and gathering occurring at various locations in the hinterlands of these agricultural villages including throughout the NNSS. Ceremonial destination locations occur with some frequency atop volcanoes and basalt flows on the NNSS and throughout the region. The pilgrimage trails to these destinations criss-cross the NNSS and are marked with prayer and offering locations both on the NNSS and in the surrounding region.

9.1.10 Cultural Resources

NNSS was established in 1950 as part of Nellis Air Force Base to support nuclear and weapons testing. NNSS is located 100 km (65 mi) northwest of Las Vegas, Nevada. NNSS was the site of more than 928 nuclear tests between 1951 and 1992. The eastern portion of the site is an area known as Frenchman Flat, a dry lakebed. It is where the GTCC LLRW and GTCC-like waste disposal facility reference location is situated. Fourteen atmospheric tests were conducted in Frenchman Flat between 1951 and 1962, and five underground tests were conducted between 1965 and 1968. The first test ever conducted at NNSS occurred in Frenchman Flat. Many of the tests were done to examine the effects of a bomb blast on various objects, including bridges, buildings, and appliances.

Cultural resource management at NNSS is overseen by the DOE-Nevada Site Office (DOE-NV) (DOE 1996). The primary cultural resources support contractor for the site is the Desert Research Institute. Management of cultural resources is guided by two PAs among the DOE-NV, Nevada SHPO, and ACHP. In 1990, one of the agreements established the Long-Range Study Plan for Negating Potential Adverse Effects to Historic Properties on Pahute and Rainier Mesas. These agreements and compliance activities under the NHPA have resulted in the surveying of almost 18,000 ha (45,000 ac). More than 1,700 archaeological sites and roughly 600 historic buildings have been identified on NNSS (DOE 1996). Within Frenchman Flat, 42 archaeological surveys, covering roughly 1,320 ha (3,260 ac), have been conducted. The surveys identified 99 archaeological sites, of which 49 are considered eligible for listing on the NRHP. Resources identified included 2 temporary camps, 2 extractive localities, 38 processing localities, 52 localities, 1 residential base, 2 historic sites, and 2 sites that are related to nuclear testing (DOE 1996). NNSS is within the Great Basin Cultural Area.

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In 1985, the DOE began long-term research to inventory and evaluate American Indian cultural resources on the NNSS. This research was designed to comply with the American Indian Religious Freedom Act (AIRFA), which specified first Amendment of the United States Constitution rights of American Indian people to have access to lands and resources essential in the conduct of their traditional religion. These rights are exercised not only on tribal lands but beyond the boundaries of the reservations.

The research confirmed cultural affiliation of seventeen tribes and organizations representing the Owens Valley Paiute, Western Shoshone and Southern Paiutes. At the completion of the initial research, the DOE initiated government-to-government consultation as a means of actively involving the tribes in new, existing and proposed activities at the NNSS. Due to the complexities associated with the DOE activities, the culturally affiliated tribes aligned themselves together to form the Consolidated Group of Tribes and Organizations (CGTO). Each tribal government represented by the CGTO participates through their designated representatives to convey tribal concerns and perspectives to the DOE while concurrently providing periodic updates back to their respective tribal governments. This regional consultation model has been adapted by most federal agencies in the area and serves as the impetus for continuous tribal consultations through the NNSS American Indian Program.

Accordingly, the CGTO knows, based upon its collective knowledge of Indian culture and past American Indian studies, that American Indian people view cultural resources as being integrated. Thus, systematic studies of a variety of American Indian cultural resources must be conducted before the cultural significance of a place, area or region can be fully assessed. Although some of these studies have been conducted on the NNSS and nearby lands, many studies still need to be completed. In order for Indian people to fully assess the cultural significance of a place and its associated natural and cultural resources, systematic studies must include the following areas to be property evaluated: ethnoarchaeology, ethnobotany, ethnozology, rock art, traditional cultural properties, ethnogeography and cultural landscapes.

The materials found on NNSS come from all of the major prehistoric time periods. The earliest evidence for people on NNSS dates to 10,000 to 8,000 BC in Fortymile Canyon (National Security Technologies 2007). Over the last 12,000 years, there have been periods having both wetter and cooler conditions and dry and hot periods. The archaeological record provides evidence on how people living within the Great Basin, which is the greater cultural area that contains Nevada, reacted to these changes. During wetter periods, evidence indicates that seed and plant use increased and people tended to be more sedentary. In hot dry periods, sites tended to be smaller and more ephemeral.

During the contact period with Europeans, the two main American Indian groups living in the NNSS region were the Southern Paiute and the Western Shoshone. These groups used resources at various elevations and locations across the landscape. Groups moved in seasonal rounds and collected resources as they became available. A group consisting of members of the Southern Paiute and Western Shoshone known as the Eso were reported to have been living on what was to become NNSS during the late 1870s (Jones and Drollinger 2001). The Eso used winter residential camps near Pahute and Ranier Mesas and at major springs in the area. The Eso were reported to consist of 42 individuals (Jones and Drollinger 2001).

The earliest record of Europeans on NNSS concerns groups moving across the site en route to various mining areas in the mid-19th century. The first mining claims on NNSS were associated with the Oak Spring Mine in the northern part of NNSS (Fehner and Gosling 2000). Mining reached its peak in the region during the early part of the 20th century (Jones and Drollinger 2001). Cattle and sheep ranching also began to occur on NNSS in the late 19th century. Water supply issues restricted these activities so they achieved only moderate success. Some remnants of these activities are still visible on the landscape. For instance, the remains of the boomtown of Wohmonie, which was located southwest of Frenchman Flat near the Hornsilver Mine, are still visible (Fehner and Gosling 2000). The town sprang up in the late 1920s after gold and silver deposits were found. However, the town deteriorated quickly when the initial reports were found to be inflated.

The military began using the area around NNSS in 1941 when Nellis Air Force Base was established. Nine years later, NNSS was chosen as the location for continental bomb tests. Previous tests were conducted in the Pacific; however, the logistics of these tests and vulnerability to spying made a continental test site desirable. After a three-year study, NNSS was chosen. Testing began in 1951 in Frenchman Flat.

Adjacent to the project area in Frenchman Flat is RWMS 5. This facility is a 3,300-ha (8,200-ac) facility for the storage of LLRW. The facility consists of 22 disposal cells. Waste is placed in drums or shipping containers and then stacked in the cells. Once the cell is full, the material is sealed with soil. Area 5 has roughly 290 ha (720 ac) of land available for future waste (Becker et al. 2000).

The GTCC reference location, which is located southeast of the RWMS, contains no significant cultural resources. The area west of the RWMS has been examined for cultural resources. A small portion of this area was surveyed in 1991 as part of the research conducted for a monitoring well project (Holz 1991). The survey identified two isolated artifacts: a single broken piece of pottery and a single thinning flake. Neither site is considered eligible for the

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Views are important cultural resources that contribute to the location and performance of American Indian ceremonialism. Views combine with other cultural resources to produce special places where power is sought for medicine and other types of ceremonies. Views can be of any landscape, but more central viewscapes are experienced from high places, which are often the tops of mountains and the edges of mesas. Indian viewscapes tend to be panoramic and are special when they contain highly diverse topography. The viewscape panorama is further enhanced by the presence of volcanic cones and lava flows. Viewscapes are tied with songscapes and storyscapes, especially when the vantage point has a panorama composed of multiple locations from either song or story. Key to the Indian experience of viewscapes is isolation. Successful performance of ceremonies (whether by individuals or groups) is often commemorated by the building of rock cairns and by storied rocks and paintings. The CGTO tribes recognize the cultural significance of viewscapes and have identified a number of these on the NNSS. The Timber Mountain Caldera contains a number of significant points with different panoramas, including Scrugham Peak-Buckboard Mesa and the Shoshone Mountain massif.

The CGTO knows that American Indian cultural resources include all physical, artifactual, and spiritual aspects of the NNSS. The CGTO has established that formal studies of these aspects of the land should be conducted to identify, assess, mitigate, and manage these resources. These resources should be studied with members of the CGTO recommended for the study. Such studies are termed: (1) Ethnoarchaeology, (2) Ethnobotany, (3) Ethnozoology, (4) Storied Rocks, (5) Traditional Cultural Properties, (6) Ethnogeography, and (7) Cultural Landscapes in the Final Environmental Impact Statement for the Nevada Test Site and Off-site locations in the State of Nevada Volume 1, Appendix G.

The CGTO knows that many of these cultural resources are directly present on the GTCC proposed site, in the Indian Defined Area of Potential Effect, and immediate region surrounding the GTCC site. The Indian people who visited the GTCC site note that their time on-site was insufficient to fully identify, analyze, and evaluate resource that may be present. They recommend one or more of the kinds of resource studies identified above be conducted. Based on their site visit they do know that the area contains important cultural resources including plants, animals, minerals, trails, and portions of cultural landscapes.

Cultural Artifacts and Features

The CGTO knows based on previous DOE-sponsored cultural studies that there are many cultural artifacts and features on the NNSS. Indian people visiting the proposed GTCC site identified the following traditional cultural artifacts and features: (1) Chert Flakes, (2) Rock Alignments, (3) Boulder Grinding Indentation or metate (Mata in Owens Valley, Doso in Western Shoshone, Mada in Southern Paiute), (4) Hand Grinding Stone or mano (Paha or Tusu in Owens Valley, Botoh in Western Shoshone, Mohum in Southern Paiute), (5) Volcanoes, (6) Trails, and (7) Chalcedony, and (8) Yellow Jasper.

Continued on next page

> ***Continued***
>
> Artifacts are the evident signs of our ancestors on this land. They are proof that we were here for thousands of years. We were told by our elders never to move artifacts or take them from their place. This is their home because they were left there for us to see and understand the past. We never remove them because they still belong to the ancestors who put them there for us and still watch over them today. Artifacts come from parts of the living earth and are still alive with a right to remain where they were placed. Whether or not there is evidence of being modified, the volcanoes, stones, rocks and trails that we incorporated into our lives are artifacts. These were visited for ceremony, chosen and moved as offerings, and traveled on our journeys and thus were a part of our life, are artifacts of our ancestors that we respect, and are there for future generations.

NRHP. A larger survey was conducted in 1996 prior to construction of the RWMS. The surveys identified numerous isolated finds and two small prehistoric sites. The sites consisted of several chert flakes and core fragments that represent evidence of expedient reduction activities. None of the sites were recommended as being eligible for listing on the NRHP. The remainder of the area was examined in 2001 as part of the research conducted for an underground test area seismic lines project. While the survey identified numerous cultural resources (prehistoric and historic), none was determined eligible for the NRHP (Jones and Drollinger 2001).

9.1.11 Waste Management

Site management of the waste types generated by the land disposal methods for Alternatives 3 to 5 is discussed in Section 5.3.11.

9.2 ENVIRONMENTAL AND HUMAN HEALTH CONSEQUENCES

The following sections address the potential environmental and human health consequences for each resource area discussed in Section 9.1.

9.2.1 Climate and Air Quality

This section presents potential climate and air quality impacts from the construction and operations of the disposal facilities (borehole, trench, and vault) at NNSS. Noise impacts are presented in Section 5.3.1.

9.2.1.1 Construction

During the construction period, emissions of criteria pollutants (e.g., SO_2, NO_x, CO, PM_{10}, and $PM_{2.5}$), VOCs, and the primary greenhouse gas CO_2 would be caused by fugitive dust emissions from earth-moving activities and engine exhaust emissions from heavy equipment and commuter, delivery, and support vehicles. Typically, potential impacts on ambient air quality from exhaust emissions would be smaller than impacts from fugitive dust emissions.

Air emissions of criteria pollutants, VOCs, and CO_2 from construction activities are estimated for the peak year when site preparation and construction of the support facility and some disposal cells would take place. The estimates for PM_{10} and $PM_{2.5}$ include diesel particulate emissions from the engine exhaust. The estimates are provided in Table 9.2.1-1 for each disposal method. Detailed information on emission factors, assumptions, and emission inventories is available in Appendix D. As shown in the table, total peak-year emission rates are estimated to be rather small when compared with Nye County emission totals. Peak-year emissions for all criteria pollutants (except PM_{10} and $PM_{2.5}$) and VOCs would be the highest for

TABLE 9.2.1-1 Peak-Year Emissions of Criteria Pollutants, Volatile Organic Compounds, and Carbon Dioxide from Construction of the Three Land Disposal Facilities at NNSS

		Construction Emissions (tons/yr)					
Pollutant	Total Emissions (tons/yr)[a]	Trench		Borehole		Vault	
SO_2	236	0.90	(0.38)[b]	3.0	(1.3)	3.2	(1.4)
NO_x	866	8.1	(0.94)	26	(3.0)	31	(3.6)
CO	7,949	3.3	(0.04)	11	(0.14)	11	(0.14)
VOCs	1,444	0.90	(0.06)	2.7	(0.19)	3.6	(0.25)
PM_{10}[c]	3,640	5.0	(0.14)	13	(0.36)	8.6	(0.24)
$PM_{2.5}$[c]	696	1.5	(0.22)	4.1	(0.59)	3.6	(0.52)
CO_2		670		2,200		2,300	
County[d]	8.88×10^5		(0.08)		(0.25)		(0.26)
Nevada[e]	5.46×10^7		(0.001)		(0.004)		(0.004)
U.S.[e]	6.54×10^9		(0.00001)		(0.00003)		(0.00004)
Worldwide[e]	3.10×10^{10}		(0.000002)		(0.000007)		(0.000007)

[a] Total emissions in 2002 for Nye County, within which NNSS is located. See Table 9.1.1-1 for criteria pollutants and VOCs.

[b] As percent of total emissions.

[c] Estimates for GTCC construction include diesel particulate emissions.

[d] Emission data for the year 2005. Currently, data on CO_2 emissions at the county level are not available; thus county-level emissions were estimated from available state-total CO_2 emissions on the basis of the population distribution.

[e] Annual CO_2 emissions in Nevada, the United States, and worldwide in 2005.

Sources: EIA (2008); EPA (2008b, 2009)

the vault method because it would consume more materials and resources for construction than would the other two methods. The borehole method would disturb a bigger area, so it is estimated that fugitive dust emissions would be the highest for that method. Peak-year emissions of all pollutants would be the lowest for the trench method, which involves the smallest disturbed area among the disposal methods. In terms of contribution to the emissions total, peak-year emissions of NO_x for the vault method would be the highest, about 3.6% of the county emissions total, while it is estimated that emissions of other criteria pollutants and VOCs would be less than 1.4% of the county emissions total.

Background concentration levels for PM_{10} and $PM_{2.5}$ at NNSS are below the standards (less than 91%) (see Table 9.1.1-3). All construction activities at NNSS would occur at least 6 km (4 mi) from the site boundary and thus would not contribute much to concentrations at the boundary or at the nearest residence. Construction activities should still be conducted so as to minimize potential impacts of construction-related emissions on ambient air quality. Construction permits typically require fugitive dust control by established standard dust control practices, primarily by watering unpaved roads, disturbed surfaces, and temporary stockpiles.

One-hour O_3 levels at NNSS are below the standard (about 83%), but 8-hour O_3 levels in neighboring Clark County, including Las Vegas, exceed the standard (see Table 9.1.1-3). Nye County, including NNSS, is currently in attainment for O_3 (40 CFR 81.329). O_3 precursor emissions from the potential GTCC LLRW and GTCC-like waste disposal facility from all methods would be relatively small, less than 3.6% and 0.27% of the county total NO_x and VOC emissions, respectively, and would be much lower than those for the regional air shed in which emitted precursors are transported and formed into O_3. In particular, southwesterly winds prevail in the area that includes NNSS (see Figure 9.1.1-1) and neighboring Clark County. Accordingly, potential impacts of O_3 precursor releases from construction on regional O_3 would not be of concern.

The major air quality concern with respect to emissions of CO_2 is that it is a greenhouse gas, which traps solar radiation reflected from the earth, keeping it in the atmosphere. The combustion of fossil fuels makes CO_2 the most widely emitted greenhouse gas worldwide. CO_2 concentrations in the atmosphere have been continuously increasing; they went from approximately 280 ppm in preindustrial times to 379 ppm in 2005 (a 35% increase). Most of this increase occurred in the last 100 years (IPCC 2007).

The climatic impact of CO_2 does not depend on the geographic locations of its sources, because CO_2 is stable in the atmosphere and is essentially uniformly mixed; that is, the global total is the important factor with respect to global warming. Therefore, a comparison between U.S. and global emissions and the total emissions from the construction of a disposal facility is useful in understanding whether the CO_2 emissions from the site are significant with respect to global warming. As shown in Table 9.2.1-1, the highest peak-year amount of CO_2 emissions from construction would be 0.26%, 0.004%, and 0.00004% of 2005 county, state, and U.S. CO_2 emissions. In 2005, CO_2 emissions in the United States were about 21% of worldwide emissions (EIA 2008). Potential impacts on climate change from construction emissions would be small.

Appendix D assumes an initial construction period of 3.4 years. The disposal units would be constructed as the waste became available for disposal. The construction phase would extend over more years; thus, emissions for nonpeak years would be lower than peak-year emissions in the table. In addition, construction activities would occur only during daytime hours, when air dispersion is most favorable. Accordingly, potential impacts from construction activities on ambient air quality would be minor and intermittent in nature.

General conformity applies to federal actions taking place in nonattainment or maintenance areas and is not applicable to the proposed action at NNSS because the area is classified as attainment for all criteria pollutants (40 CFR 81.329).

9.2.1.2 Operations

Criteria pollutants, VOCs, and CO_2 would be released into the atmosphere during operations. These emissions would include fugitive dust emissions from emplacement activities and exhaust emissions from heavy equipment and commuter, delivery, and support vehicles. Estimated annual emissions of criteria pollutants, VOCs, and CO_2 at the facility are presented in Table 9.2.1-2. Detailed information on emission factors, assumptions, and emission inventories is available in Appendix D. As shown in the table, annual emissions are estimated to be higher for operational activities than for construction activities under the trench method. Annual emissions from operations for the trench and vault methods would be greater than those for the borehole method. Compared with annual emissions for counties, including NNSS, the annual emissions of NO_x from the trench and vault methods would be higher than those from the borehole method, about 3% of the emission total, while emissions of other criteria pollutants and VOCs would be about 1.4% of the total or less.

It is expected that concentration levels from operational activities would remain below the standards. Estimates for the PM_{10} and $PM_{2.5}$ include diesel particulate emissions. As discussed in the construction section, established fugitive dust control measures, including the watering of unpaved roads, disturbed surfaces, and temporary stockpiles, would be implemented to minimize potential impacts on ambient air quality.

With regard to regional O_3, precursor emissions of NO_x and VOCs would be comparable to those resulting from construction activities (about 3% and 0.21% of the county emission totals, respectively) and are not anticipated to contribute much to regional O_3 levels. The highest operations-related emissions of CO_2 among the disposal methods would be comparable to the highest construction-related emissions, and thus the potential impacts from operations on climate change would also be negligible.

PSD regulations are not applicable to the proposed action because the proposed action is not a major stationary source.

TABLE 9.2.1-2 Annual Emissions of Criteria Pollutants, Volatile Organic Compounds, and Carbon Dioxide from Operations of the Three Land Disposal Facilities at NNSS

		Operation Emissions (tons/yr)					
Pollutant	Total Emissions (tons/yr)[a]	Trench		Borehole		Vault	
SO_2	236	3.3	(1.4)[b]	1.2	(0.51)	3.3	(1.4)
NO_x	866	27	(3.1)	10	(1.2)	27	(3.1)
CO	7,949	15	(0.19)	6.7	(0.08)	15	(0.19)
VOCs	1,444	3.1	(0.21)	1.2	(0.08)	3.1	(0.21)
PM_{10}[c]	3,640	2.5	(0.07)	0.91	(0.03)	2.5	(0.07)
$PM_{2.5}$[c]	696	2.2	(0.32)	0.81	(0.12)	2.2	(0.32)
CO_2		3,200		1,700		3,300	
County[d]	8.88×10^5		(0.36)		(0.19)		(0.37)
Nevada[e]	5.46×10^7		(0.006)		(0.003)		(0.006)
U.S.[e]	6.54×10^9		(0.00005)		(0.00003)		(0.00005)
Worldwide[e]	3.10×10^{10}		(0.00001)		(0.00001)		(0.00001)

[a] Total emissions in 2002 for Nye County, within which NNSS is located. See Table 9.1.1-1 for criteria pollutants and VOCs.

[b] As percent of total emissions.

[c] Estimates for GTCC operations include diesel particulate emissions.

[d] Emission data for the year 2005. Currently, data on CO_2 emissions at the county level are not available, so county-level emissions were estimated from available state-total CO_2 emissions on the basis of the population distribution.

[e] Annual CO_2 emissions in Nevada, the United States, and worldwide in 2005.

Source: EIA (2008); EPA (2008b, 2009)

9.2.2 Geology and Soils

Direct impacts from land disturbance would be proportional to the total area of land disturbed during site preparation activities (e.g., grading and backfilling) and construction of the GTCC LLRW and GTCC-like waste disposal facility and related infrastructure (e.g., roads). Land disturbance would include the surface area covered by each disposal method and the vertical displacement of geologic materials for the borehole and trench disposal methods. The increased potential for soil erosion would be an indirect impact from land disturbance at the construction site. Indirect impacts would also result from the use of geologic materials (e.g., aggregate) for facility and new road construction. The impact analysis also considers whether the GTCC action would preclude the future extraction and use of mineral materials or energy resources.

9.2.2.1 Construction

Impacts from disturbing the land surface area would be a function of the disposal method implemented at the site (Table 5.1.1). Of the three disposal facility layouts, the borehole facility layout would have the greatest impact in terms of land area disturbed (44 ha or 110 ac). It would also result in the greatest disturbance with depth (40 m or 130 ft), with boreholes completed in unconsolidated clay, silt, sand, and gravel.

Geologic and soil material requirements are provided in Table 5.3.2-1. Of the three disposal methods, the vault method would require the most material since it would involve the installation of interim and final cover systems. This material would be considered permanently lost. However, none of the three disposal methods are expected to result in adverse impacts on geologic and soil resources at NNSS, since these resources are in abundant supply at the site and in the surrounding area.

No significant changes in surface topography or natural drainages are anticipated in the construction area. However, the disturbance of soil during the construction phase would increase the potential for erosion in the immediate vicinity. This potential would be greatly reduced, however, by the low precipitation rates at NNSS. Also, mitigation measures would be implemented to avoid or minimize the risk of erosion.

The GTCC LLRW and GTCC-like waste disposal facility would be sited and designed with safeguards to avoid or minimize the risks associated with seismic and volcanic hazards. NNSS is in a seismically active region, and small-magnitude earthquakes (usually less than 3 on the Richter scale) occur frequently in Frenchman Flat.

The annual probability of a volcanic event (basaltic eruption) is considered to be very low. The risk of silicic volcanism is negligible; however, airborne ash might be deposited on-site in the event of a silicic volcanic eruption, since silicic volcanic activity still occurs along the margins of the Great Basin. The potential for other hazards (e.g., subsidence and liquefaction) is also considered to be low.

9.2.2.2 Operations

The disturbance of soil and the increased potential for soil erosion would continue throughout the operational phase as waste was delivered to the site for disposal over time. The potential for soil erosion would be greatly reduced by the low precipitation rates at NNSS. Mitigation measures also would be implemented to avoid or minimize the risk of erosion.

Impacts related to the extraction and use of valuable geologic materials would be low, since only the area within the facility itself would be unavailable for mining, and the potential for oil production and geothermal energy development are considered to be low for the site. NNSS is currently closed to commercial mineral development; activities on-site would not have adverse impacts on the extraction of economic minerals in the surrounding region.

9.2.3 Water Resources

Direct and indirect impacts on water resources could occur as a result of water use at the proposed GTCC LLRW and GTCC-like waste disposal facility during construction and operations. Table 5.3.3-1 provides an estimate of the water consumption and discharge volumes for the three land disposal methods. Tables 5.3.3-2 and 5.3.3-3 summarize the impacts from water use (in terms of change in annual water use) on water resources during construction and normal operations, respectively. A discussion of potential impacts during each project phase is presented in the following sections. In addition, contamination due to potential leaching of radionuclides into groundwater from the waste inventory could occur, depending on the post-closure performance of the land disposal facilities discussed in Section 9.2.4.2. However, the potential for mobilization of contaminants to groundwater from all these sources is negligible because of the arid climate, the extensive depth to groundwater (thickness of the vadose zone), and the proven behavior of liquid and vapor fluxes in the vadose zone (primarily upward movement toward the ground surface).

9.2.3.1 Construction

Of the three land disposal methods considered for NNSS, construction of a vault facility would have the greatest water requirement (Table 5.3.3-1). Water demands for construction at NNSS would be met by using groundwater from on-site wells completed in the Great Basin aquifer system. No surface water would be used at the site during construction. As a result, no direct impacts on surface water resources are expected. The potential for indirect surface water impacts related to soil erosion, contaminated runoff, and sedimentation is very low but would be reduced by implementing good industry practices and mitigation measures. Streams at NNSS are ephemeral, and the GTCC reference location is not located on any known floodplains of these waters.

NNSS uses about 1.1 billion L (290 million gal) of groundwater per year. Construction of the proposed GTCC LLRW and GTCC-like waste disposal facility would increase the annual water use at NNSS by a maximum of 0.29% (vault method) over the 20-year period that construction would occur. Because withdrawals of groundwater would be relatively small, they would not significantly lower the water table or change the direction of groundwater flow at NNSS. As a result, impacts due to groundwater withdrawals are expected to be negligible.

Construction activities might change the infiltration rate at the site of the proposed GTCC LLRW and GTCC-like waste disposal facility, first by increasing the rate as ground would be disturbed in the initial stages of construction and later by decreasing the rate as impermeable materials (e.g., the clay material and geotextile membrane assumed for the cover or cap in the land disposal facility designs) would cover the surface. These changes are expected to be negligible since the area of land associated with the proposed GTCC LLRW and GTCC-like waste disposal facility (up to 44 ha [110 ac], depending on the disposal method) would be small relative to NNSS. Disposal waste generated during construction of the land disposal facilities would have a negligible impact on the quality of water resources at NNSS. The potential for indirect surface water or groundwater impacts related to spills at the surface would be reduced by implementing good industry practices and mitigation measures.

9.2.3.2 Operations

Of the three land disposal facilities considered for NNSS, the trench and vault facilities would require almost the same amount of water for operations, and that amount would be more than the amount required by a borehole facility (Table 5.3.3-1). Water demands for operations at NNSS would be met by using groundwater from on-site wells completed in the Great Basin aquifer system. No surface water would be used at the site during operations. As a result, no direct impacts on surface water resources are expected. The potential for indirect surface water impacts related to soil erosion, contaminated runoff, and sedimentation would be reduced by implementing good industry practices and mitigation measures. Streams at NNSS are ephemeral, and the GTCC reference location is not located on any known floodplains of these waters.

Operations of the proposed GTCC LLRW and GTCC-like waste disposal facility would increase annual water use at NNSS by a maximum of about 0.48% (trench or vault method). Because withdrawals of groundwater would be relatively small, they would not significantly lower the water table or change the direction of groundwater flow at NNSS. As a result, impacts due to groundwater withdrawals are expected to be negligible.

Disposal of waste (including sanitary waste) generated during operations of the land disposal facilities would have a negligible impact on the quality of water resources at NNSS. The potential for indirect surface water or groundwater impacts related to spills at the surface would be reduced by implementing good industry practices and mitigation measures.

9.2.4 Human Health

Potential impacts on members of the general public and involved workers from the construction and operations associated with the land disposal facilities are discussed in Section 5.3.4. The following sections discuss the impacts from hypothetical facility accidents associated with waste handling activities and the impacts during the post-closure phase. They address impacts on members of the general public who might be affected by these waste disposal activities at the NNSS GTCC reference location, since these impacts would be site dependent.

9.2.4.1 Facility Accidents

Data on the estimated human health impacts from hypothetical accidents at a land GTCC LLRW and GTCC-like waste disposal facility located at NNSS are shown in Table 9.2.4-1. The accident scenarios are discussed in Section 5.3.4.2.1 and Appendix C. A reasonable range of accidents that included operational events and natural causes was analyzed. The impacts presented for each accident scenario are for the sector with the highest impacts, and no protective measures are assumed; therefore, the impacts represent the maximum expected for such an accident.

TABLE 9.2.4-1 Estimated Radiological Human Health Impacts from Hypothetical Facility Accidents at NNSS[a]

		Off-Site Public		Individual[b]	
Accident Number	Accident Scenario	Collective Dose (person-rem)	Latent Cancer Fatalities[c]	Dose (rem)	Likelihood of LCF
1	Single drum drops, lid failure in Waste Handing Building	<0.0001	<0.0001	<0.0001	<0.0001
2	Single SWB drops, lid failure in Waste Handing Building	<0.0001	<0.0001	0.00012	<0.0001
3	Three drums drop, puncture, lid failure in Waste Handling Building	<0.0001	<0.0001	<0.0001	<0.0001
4	Two SWBs drop, puncture, lid failure in Waste Handling Building	<0.0001	<0.0001	0.00017	<0.0001
5	Single drum drops, lid failure outside	0.011	<0.0001	0.053	<0.0001
6	Single SWB drops, lid failure outside	0.024	<0.0001	0.12	<0.0001
7	Three drums drop, puncture, lid failure outside	0.019	<0.0001	0.095	<0.0001
8	Two SWBs drop, puncture, lid failure outside	0.033	<0.0001	0.17	0.0001
9	Fire inside the Waste Handling Building, one SWB assumed to be affected	0.47	0.0003	2.4	0.001
10	Single RH waste canister breach	<0.0001	<0.0001	<0.0001	<0.0001
11	Earthquake affects 18 pallets, each with 4 CH drums	0.3	0.0002	1.5	0.0009
12	Tornado, missile hits one SWB, contents released	0.094	<0.0001	0.48	0.0003

[a] CH = contact-handled, RH = remote-handled, LCF = latent cancer fatality, SWB = standard waste box.

[b] The individual receptor is assumed to be 100 m (330 ft) downwind from the release point. This individual is expected to be a noninvolved worker because there would be no public access within 100 m (330 ft) of the GTCC reference location.

[c] LCFs are calculated by multiplying the dose by the health risk conversion factor of 0.0006 fatal cancer per person-rem (see Section 5.2.4.3). Values are rounded to one significant figure.

The collective population dose includes exposure from inhalation of airborne radioactive material, external exposure from radioactive material deposited on the ground, and ingestion of contaminated crops. The exposure period is considered to last for 1 year immediately following the accidental release. It is recognized that interdiction of food crops would likely occur if a significant release did occur, but many stakeholders are interested in what could happen without interdiction. For the accidents involving CH waste (Accidents 1–9, 11, 12), the ingestion dose accounts for approximately 20% of the collective population dose shown in Table 9.2.4-1. External exposure was found to be negligible in all cases. All exposures were dominated by the inhalation dose from the passing plume of airborne radioactive material downwind of the hypothetical accident immediately following release.

The highest estimated impact on the general public, 0.47 person-rem, would be from a hypothetical release from an SWB caused by a fire in the WHB (Accident 9). This dose is not expected to lead to any additional LCFs in the population. This dose would be to the 22,800 people living to the south of the facility, resulting in an average dose of approximately 0.00002 rem per person. Because this dose would result from internal intake (primarily inhalation, with some ingestion), and because the DCFs used in this analysis are for a 50-year CEDE, this dose would be accumulated over the course of 50 years.

The dose to an individual (expected to be a noninvolved worker because there would be no public access within 100 m [330 ft] of the GTCC reference location) includes exposure from inhalation of airborne radioactive material and 2 hours of exposure to radioactive material deposited on the ground. As shown in Table 9.2.4-1, the highest estimated dose to an individual, 2.4 rem, is for Accident 9 from inhalation exposure immediately after the postulated release. This estimated dose is for a hypothetical individual located 100 m (330 ft) to the southeast of the accident location. A maximum annual dose of about 5% of the total individual dose (to the noninvolved worker) would occur in the first year. The increased lifetime probability of a fatal cancer for the individual is approximately 0.1% on the basis of a total dose of 2.4 rem.

9.2.4.2 Post-Closure

The potential radiation dose from airborne releases of radionuclides to the off-site public after the closure of a disposal facility would be small. On the basis of RESRAD-OFFSITE calculation results, no radiation exposure would result from this pathway for the borehole method, and the radiation doses from the trench or vault method would be small. It is estimated that the potential inhalation dose at a distance of 100 m (330 ft) from the disposal facility would be less than 1.8 mrem/yr for trench disposal and less than 0.52 mrem/yr for vault disposal. The potential radiation exposures would be caused mainly by inhalation of radon gas and its short-lived progeny.

Because of the extremely arid climate, the precipitation rate at NNSS averages only about 12 cm/yr (5 in./yr). Evapotranspiration, however, is estimated to be about 1.68 m/yr (5.5 ft/yr), or about 14 times the average precipitation rate (Bechtel Nevada 2001). As a result, water infiltration to the disposal area would be nearly zero (3.0×10^{-5} m/yr was used in the RESRAD-OFFSITE analyses). With an insufficient driving force for leaching, radionuclides are not expected to reach the groundwater table within 100,000 years. Therefore, no radiation exposure to a hypothetical resident farmer living 100 m (330 ft) from the GTCC LLRW and GTCC-like waste disposal facility is indicated by the calculations performed. Similarly, releases to rivers and springs would not be expected.

9.2.5 Ecology

Section 5.3.5 presents an overview of the potential impacts on ecological resources that could result from the construction and operations and post-closure maintenance of the proposed GTCC LLRW and GTCC-like waste disposal facility, regardless of the location selected for it. This section evaluates the potential impacts of the facility on the ecological resources at NNSS.

The amount of land cleared to dispose of GTCC LLRW and GTCC-like wastes would be up to 44 ha (110 ac) for borehole disposal, 24 ha (60 ac) for vault disposal, or 20 ha (50 ac) for trench disposal. It is not expected that the initial loss of creosote bush/white bursage vegetation habitat, followed by eventual establishment of low-growth vegetation on the disposal site, would create a long-term reduction in the local or regional ecological diversity.

After closure of the GTCC LLRW and GTCC-like waste disposal facility, the cover would be planted with annual and perennial grasses and forbs. As appropriate, regionally native plants would be used to landscape the disposal site in accordance with "Guidance for Presidential Memorandum on Environmentally and Economically Beneficial Landscape Practices on Federal Landscaped Grounds" (EPA 1995). Because of the extremely arid climate, the establishment of native plant communities would be very difficult. An aggressive revegetation program would be necessary so that nonnative species, such as red brome, cheatgrass, Russian thistle, and barbwire Russian-thistle, would not become established. These species could rapidly invade disturbed sites at NNSS and delay revegetation by native species (Wills and Ostler 2001).

Construction of the proposed GTCC LLRW and GTCC-like waste disposal facility would affect wildlife species that inhabit the area. Small mammals, ground-nesting birds, and reptiles would recolonize the site once a vegetative cover was reestablished. Larger mammals, such as pronghorn, mule deer, coyote, and mountain lion, would probably avoid the area or would be excluded from the disposal facility because of the fencing (during the institutional control/monitored post-closure period).

Because no aquatic habitats occur within the immediate vicinity of the GTCC reference location, direct impacts on aquatic biota are not expected. DOE would use appropriate erosion-control measures to minimize off-site movement of soils. The GTCC LLRW and GTCC-like waste disposal facility retention pond is not expected to become a highly productive aquatic habitat. However, depending on the amount of water and length of time that water was retained in the pond, aquatic invertebrates could become established within it. Waterfowl, shorebirds, and other birds might also make use of the retention pond, as would mammal species that might enter the site.

As discussed in Section 9.1.5, the desert tortoise is the only federal listed animal species that is resident on NNSS. It inhabits the southern third of NNSS at very low or none to moderate estimated densities (i.e., between 0.0 and 34.7 tortoises/km^2 [0.0 and 90/mi^2]). In the area of the GTCC reference location, desert tortoise densities range from 0.0 to 3.7/km^2 (0.0 to 9.6/mi^2) (William 2009). The RWMS in Area 5 of NNSS is within the exclusion area identified in the 1996 programmatic biological opinion since no desert tortoises were observed in that area of Frenchman Flat (DOE 2007b). In the recent programmatic biological opinion (Williams 2009), it was concluded that the implementation of programmatic activities at NNSS is not likely to jeopardize the continued existence of the desert tortoise or adversely modify any designated critical habitat for the species. Mitigation for the loss of desert tortoise habitat is normally required under the terms and conditions of the biological opinion received from the USFWS. In the current programmatic biological opinion, the measures include these: (1) Preactivity surveys will be conducted to determine the presence of the desert tortoise; (2) a tortoise biologist or environmental monitor will be on-site during all phases of project construction; (3) all NNSA, Nevada Site Office, and contractor personnel will complete the Desert Tortoise Conservation Education Program; (4) project personnel will halt activities, if possible, when the continuation of such activities may endanger a desert tortoise or if a tortoise is found on the project site; (5) vehicle traffic will be restricted to existing paved, graded, or utility access roads; (6) vehicles will be driven within posted speed limits on existing roads and will not exceed 15 mph within project boundaries (any tortoise observed in harm's way on a paved road will be moved off the road in the direction it was going); (7) a litter-control program will be implemented during outdoor program activities that will include the use of covered, raven-proof trash receptacles; disposal of edible trash in trash receptacles following the end of each work day; and disposal of trash in a designated sanitary landfill at the end of each work week; and (8) a habitat reclamation plan will be submitted to the USFWS that describes the methods for stabilizing and revegetating the site (Williams 2009). It is expected that DOE would enact the terms and conditions of the programmatic biological condition (Williams 2009) to minimize effects on the desert tortoise when constructing and operating the GTCC LLRW and GTCC-like waste disposal facility.

The preferred breeding habitat for the burrowing owl on NNSS is in areas most likely to be developed for new projects or to be remediated because of past disturbances. Project construction activities on NNSS could destroy burrowing owl burrows or directly kill owls. Historically, DOE's activities have had only minimal adverse effects on burrowing owls at NNSS (Hall et al. 2003). Since 1990, only one bird was killed from being hit by a vehicle; and since 1979, only two unoccupied burrows were destroyed by project activities. Hall et al. (2003) recommends a buffer zone of 60 m (197 ft) around active burrowing owl burrows at NNSS, within which human activity (e.g., walking and driving) should be limited. Klute et al. (2003) recommends that human activities should be prohibited within 200 m (660 ft) of nest burrows in Idaho and Washington. At construction sites in Nevada's Mojave Desert region, the USFWS (2007) recommends a buffer with a radius of at least 76 m (250 ft) be placed around a burrow within which no construction should occur. Some activities at NNSS (e.g., emplacing culverts and pipes, building roads, digging pits and channels, and building mounds) have benefited burrowing owls by increasing the number of available burrows and by increasing opportunities for predators to dig burrows in altered soil (Wills and Ostler 2001; Hall et al. 2003). In the later case, the burrowing owls indirectly benefit because they use abandoned predator burrows (Hall et al. 2003).

Pre-activity biological surveys are conducted at proposed project sites where disturbance may occur. The goal of these surveys is to minimize adverse impacts on important plant and animal species and their associated habitat, on important biological resources (e.g., bird nest sites and desert tortoise burrows), and on wetlands (Wills et al. 2007). Therefore, if any other special-status species from the GTCC reference location were identified, appropriate steps would be taken to minimize impacts on those species.

The overall objective of the ecological monitoring and compliance program at NNSS is to protect the biological resources at NNSS while supporting the mission of DOE in operating the site (Hall et al. 2003). This objective is met by developing procedures that ensure that NNSS activities comply with state and federal wildlife and environmental protection regulations. Therefore, impacts on ecological resources from a GTCC LLRW and GTCC-like waste disposal facility would be minimized and mitigated.

9.2.6 Socioeconomics

9.2.6.1 Construction

The potential socioeconomic impacts from constructing a GTCC LLRW and GTCC-like waste disposal facility and support buildings at NNSS would be small for all disposal methods. Construction activities would create direct employment of 47 people (borehole method) to 145 people (vault method) in the peak construction year and an additional 51 indirect jobs (borehole and trench methods) to 137 indirect jobs (vault method) in the ROI (Table 9.2.6-1). Construction activities would constitute less than 1% of total ROI employment in the peak year. Construction of a disposal facility would produce between \$4.3 million in income (borehole method) and \$12.8 million in income (vault method) in the peak year of construction.

In the peak year of construction, between 10 people (borehole method) and 32 people (vault method) would in-migrate to the ROI (Table 9.2.6-1) as a result of employment on-site. In-migration would have only a marginal effect on population growth and would require less than 1% of vacant rental housing in the peak year. No significant impact on public finances would occur as a result of in-migration, and no new local public service employees would be required to maintain existing levels of service in the various local public service jurisdictions in the ROI. In addition, on-site employee commuting patterns would have a small to moderate impact on levels of service in the local transportation network surrounding the site.

9.2.6.2 Operations

The potential socioeconomic impacts from operating a GTCC LLRW and GTCC-like waste disposal facility would be small for all disposal methods. Operational activities would create about 38 direct jobs (borehole method) to 51 direct jobs (vault method) annually and an additional 31 indirect jobs (borehole method) to 36 indirect jobs (vault method) in the ROI (Table 9.2.6-1). The waste facility would also produce between \$4.1 million in income (borehole method) and \$5.1 million in income (vault method) annually during operations.

TABLE 9.2.6-1 Effects of GTCC LLRW and GTCC-Like Waste Disposal Facility Construction and Operations on Socioeconomics at the ROI for NNSS[a]

	Trench		Borehole		Vault	
Impact Category	Construction	Operation	Construction	Operation	Construction	Operation
Employment (number of jobs)						
Direct	62	48	47	38	145	51
Indirect	51	35	51	31	137	36
Total	113	83	98	69	282	87
Income ($ in millions)						
Direct	2.0	3.2	1.7	2.6	5.9	3.4
Indirect	2.6	1.6	2.6	1.5	6.9	1.7
Total	4.6	4.8	4.3	4.1	12.8	5.1
Population (number of new residents)	14	1	10	1	32	1
Housing (number of units required)	7	1	5	0	16	1
Public finances (% impact on expenditures)						
Cities and counties[b]	<1	<1	<1	<1	<1	<1
Schools[c]	<1	<1	<1	<1	<1	<1
Public service employment (number of new employees)						
Local government employees[d]	0	0	0	0	0	0
Teachers	0	0	0	0	0	0
Traffic (impact on current levels of service)	Small	Small	Small	Small	Moderate	Small

[a] Impacts shown are for waste facility and support buildings in the peak year of construction and the first year of operations.

[b] Includes impacts that would occur in the cities of Henderson, Las Vegas, and North Las Vegas and in Clark and Nye Counties.

[c] Includes impacts that would occur in Clark and Nye County school districts.

[d] Includes police officers, paid firefighters, and general government employees.

No more than one person would move to the area at the beginning of operations (Table 9.2.6-1). In-migration would have only a marginal effect on population growth and would require less than 1% of vacant owner-occupied housing during facility operations. No significant impact on public finances would occur as a result of in-migration, and no new local public service employees would need to be hired in order to maintain existing levels of service in the various local public service jurisdictions in the ROI. In addition, on-site employee commuting patterns would have only a small impact on levels of service in the local transportation network surrounding the site.

9.2.7 Environmental Justice

9.2.7.1 Construction

No radiological risk and only very low chemical exposure and risk are expected during construction of a trench, borehole, or vault disposal facility. Chemical exposure during construction would be limited to airborne toxic air pollutants at less than standard levels and would not result in any adverse health impacts. Since the impacts of each facility on the health of the general population within the 80-km (50-mi) assessment area during construction would be negligible, impacts from the construction of each facility on the minority and low-income population would not be significant.

9.2.7.2 Operations

Because incoming GTCC LLRW and GTCC-like waste containers would only be consolidated for placement in trench, borehole, and vault facilities, with no repackaging necessary, there would be no radiological impacts on the general public during operations and no adverse health effects on the general population. Because the health impacts from routine operations on the general public would be negligible, it is expected that there would be no disproportionately high and adverse impact on minority and low-income population groups within the 80-km (50-mi) assessment area. Subsequent NEPA review to support any GTCC implementation would have to consider any unique exposure pathways (such as subsistence fish, vegetation, or wildlife consumption or well water use) to determine any additional potential health and environmental impacts.

9.2.7.3 Accidents

An accidental radiological release from any of the land disposal facilities would not be expected to cause any LCFs to members of the public in the surrounding area. In the unlikely event of a release at a facility, the communities most likely to be affected could be minority or low-income, given the demographics within 80 km (50 mi) of the GTCC reference location. However, it is highly unlikely such a release would occur, and the risk to any population, including low-income and minority communities, is considered to be low for the accident with the highest potential impacts, estimated to be less than 0.0003 LCF for the population groups residing to the south of the site.

Although the overall risk would be very small, the greatest short-term risk of exposure following an airborne release and the greatest one-year risk would be to the population groups residing to the south of the site because of the prevailing wind condition in this case. Airborne releases following an accident would likely have a larger impact on the area than would an accident that released contaminants directly into the soil surface. A surface release entering local steams could temporarily interfere with subsistence activities being carried out by low-income and minority populations within a few miles downstream of the site.

Monitoring of contaminant levels in soil and surface water following an accident would provide the public with information on the extent of any contaminated areas. Analysis of contaminated areas to decide how to control the use of areas having a high health risk would reduce the potential impact on local residents.

9.2.8 Land Use

Section 5.3.8 presents an overview of the potential land use impacts that could result from a GTCC LLRW and GTCC-like waste disposal facility regardless of the location selected for it. This section evaluates the potential impacts from a GTCC LLRW and GTCC-like waste disposal facility on land use at NNSS. The amount of land altered for the disposal facility would be up to 44 ha (110 ac) for boreholes, 24 ha (60 ac) for vaults, or 20 ha (50 ac) for trenches.

The GTCC reference location at NNSS is located southeast of the RWMS. Therefore, the area designated for a GTCC LLRW and GTCC-like waste disposal facility would be integrated into the radioactive waste management zone. The GTCC reference location is located within an area designated as a reserved zone, where defense-related activities are generally conducted (DOE 1996). Therefore, land use in the area occupied by the GTCC LLRW and GTCC-like waste disposal facility would be changed from a reserved zone to a radioactive waste management zone. Land use on areas surrounding NNSS would not be affected. Future land use activities that would be permitted within or immediately adjacent to the GTCC reference location would be limited to those that would not jeopardize the integrity of the facility, create a security risk, or create a worker or public safety risk.

9.2.9 Transportation

The transportation of GTCC LLRW and GTCC-like waste necessary for the disposal of all such waste at NNSS was evaluated. As discussed in Section 5.3.9, transportation of all cargo by both truck and rail modes as separate options is considered for the purposes of this EIS. Transportation impacts are expected to be the same for disposal in boreholes, trenches, or vaults because the same type of transportation packaging would be used regardless of the disposal method chosen. Moreover, additional environmental impacts could also result from the construction of a rail spur at NNSS since one does not currently exist.

As discussed in Appendix C, Section C.9, three impacts from transportation were calculated: (1) collective population risks during routine conditions and accidents (Section 9.2.9.1), (2) radiological risks to the highest exposed individual during routine conditions (Section 9.2.9.2), and (3) consequences to individuals and populations after the most severe accidents involving a release of radioactive or hazardous chemical material (Section 9.2.9.3).

Radiological impacts during routine conditions are a result of human exposure to the low levels of radiation near the shipment. The regulatory limit established in 49 CFR 173.441 (Radiation Level Limitations) and 10 CFR 71.47 (External Radiation Standards for All Packages) to protect the public is 0.1 mSv/h (10 mrem/h) at 2 m (6 ft) from the outer lateral sides of the transport vehicle. This dose rate corresponds roughly to 14 mrem/h at 1 m (3 ft). As discussed in Appendix C, Section C.9.4.4, the external dose rate for CH shipments to NNSS is assumed to be 0.5 and 1.0 mrem/h at 1 m (3 ft) for truck and rail shipments, respectively. For shipments of RH waste, the external dose rate is assumed to be 2.5 and 5.0 mrem/h at 1 m (3 ft) for truck and rail shipments, respectively. These assignments are based on shipments of similar types of waste. Dose rates for rail shipments are approximately double those for truck shipments because rail shipments are assumed to have twice the number of waste packages as a truck shipment. Impacts from accidents are dependent on the amount of radioactive material in a shipment and on the fraction that is released if an accident occurs. The parameters used in the transportation accident analysis are described further in Appendix C, Section C.9.4.3.

9.2.9.1 Collective Population Risk

The collective population risk is a measure of the total risk posed to society as a whole by the actions being considered. For a collective population risk assessment, the persons exposed are considered as a group; no individual receptors are specified. Exposure to four different groups are considered: (1) persons living and working along the transportation routes, (2) persons sharing the route, (3) persons at stops along the route, and (4) transportation crew members. The collective population risk is used as the primary means of comparing various options. Collective population risks are calculated for cargo-related causes for routine transportation and accidents. Vehicle-related risks are independent of the cargo in the shipment and are only calculated for traffic accidents (fatalities caused by physical trauma).

Estimated impacts from the truck and rail options are summarized in Tables 9.2.9-1 and 9.2.9-2, respectively. For the truck option, it was estimated that about 12,600 shipments resulting in about 48 million km (30 million mi) of travel would cause no LCFs for truck crew members or members of the public. One fatality directly related to accidents is expected. No LCFs from routine transport are estimated for the rail option, consisting of approximately 5,010 railcar shipments resulting in about 21 million km (13 million mi) of travel. However, one fatality from accidents could occur. With respect to the estimated 12,600 truck shipments, approximately

TABLE 9.2.9-1 Estimated Collective Population Transportation Risks for Shipment of GTCC LLRW and GTCC-Like Waste by Truck for Disposal at NNSS[a]

			Cargo-Related[b] Radiological Impacts								Vehicle-Related Impacts[c]
			Dose Risk (person-rem)								
				Routine Public					LCFs[d]		
Waste	No. of Shipments	Total Distance (km)	Routine Crew	Off-Link	On-Link	Stops	Total	Accident[e]	Crew	Public	Physical Accident Fatalities
Group 1											
GTCC LLRW											
Activated metals - RH											
Past BWRs	20	77,500	0.81	0.02	0.11	0.14	0.28	0.00016	0.0005	0.0002	0.0015
Past PWRs	143	458,000	4.8	0.11	0.67	0.84	1.6	0.00073	0.003	0.001	0.009
Operating BWRs	569	2,120,000	22	0.52	3.1	3.9	7.5	0.0027	0.01	0.005	0.044
Operating PWRs	1,720	5,810,000	60	1.5	8.5	11	21	0.008	0.04	0.01	0.12
Sealed sources - CH	209	579,000	0.24	0.045	0.32	0.42	0.78	0.02	0.0001	0.0005	0.013
Cesium irradiators - CH	240	665,000	0.28	0.051	0.37	0.48	0.9	0.0032	0.0002	0.0005	0.015
Other Waste - CH	5	11,400	0.0048	0.00073	0.0062	0.0082	0.015	<0.0001	<0.0001	<0.0001	0.00024
Other Waste - RH	54	218,000	2.2	0.062	0.32	0.4	0.78	<0.0001	0.001	0.0005	0.0046
GTCC-like waste											
Activated metals - RH	38	72,700	0.76	0.014	0.1	0.13	0.25	<0.0001	0.0005	0.0002	0.0033
Sealed sources - CH	1	2,770	0.0012	0.00021	0.0015	0.002	0.0037	<0.0001	<0.0001	<0.0001	<0.0001
Other Waste - CH	69	268,000	0.11	0.025	0.15	0.19	0.37	0.00077	<0.0001	0.0002	0.0051
Other Waste - RH	1,160	4,470,000	46	1.1	6.5	8.2	16	0.0018	0.03	0.009	0.086

TABLE 9.2.9-1 (Cont.)

			Cargo-Related[b] Radiological Impacts								Vehicle-Related Impacts[c]
			Dose Risk (person-rem)						LCFs[d]		
				Routine Public							
Waste	No. of Shipments	Total Distance (km)	Routine Crew	Off-Link	On-Link	Stops	Total	Accident[e]	Crew	Public	Physical Accident Fatalities
Group 2											
GTCC LLRW											
Activated metals - RH											
New BWRs	202	652,000	6.8	0.14	0.93	1.2	2.3	0.00091	0.004	0.001	0.014
New PWRs	833	2,780,000	29	0.72	4.1	5.1	9.9	0.0035	0.02	0.006	0.057
Additional commercial waste	1,990	8,070,000	84	1.9	12	15	28	<0.0001	0.05	0.02	0.15
Other Waste - CH	139	563,000	0.24	0.052	0.32	0.41	0.78	0.0025	0.0001	0.0005	0.011
Other Waste - RH	3,790	15,300,000	160	3.7	22	28	54	0.00068	0.09	0.03	0.29
GTCC-like waste											
Other Waste - CH	44	165,000	0.069	0.015	0.094	0.12	0.23	0.00034	<0.0001	0.0001	0.0032
Other Waste - RH	1,400	5,590,000	58	1.3	8.1	10	20	0.0019	0.03	0.01	0.11
Total Groups 1 and 2	12,600	47,800,000	470	11	68	85	160	0.048	0.3	0.1	0.94

a BWR = boiling water reactor, PWR = pressurized water reactor, CH = contact-handled, RH = remote-handled.

b Cargo-related impacts are impacts attributable to the radioactive nature of the material being transported.

c Vehicle-related impacts are impacts independent of the cargo in the shipment.

d LCFs were calculated by multiplying the dose by the health risk conversion factor of 6×10^{-4} fatal cancer per person-rem (see Section 5.2.4.3).

e Dose risk is a societal risk and is the product of accident probability and accident consequence.

TABLE 9.2.9-2 Estimated Collective Population Transportation Risks for Shipment of GTCC LLRW and GTCC-Like Waste by Rail for Disposal at NNSS[a]

			Cargo-Related[b] Radiological Impacts								Vehicle-Related Impacts[c]
			Dose Risk (person-rem)								
		Total		Routine Public					LCFs[d]		Physical
Waste	No. of Shipments	Distance (km)	Routine Crew	Off-Link	On-Link	Stops	Total	Accident[e]	Crew	Public	Accident Fatalities
Group 1											
GTCC LLRW											
Activated metals - RH											
Past BWRs	7	27,600	0.21	0.059	0.0038	0.081	0.14	0.00037	0.0001	<0.0001	0.0017
Past PWRs	37	127,000	0.99	0.27	0.018	0.4	0.69	0.0015	0.0006	0.0004	0.0057
Operating BWRs	154	636,000	4.8	1.3	0.086	1.9	3.3	0.0033	0.003	0.002	0.019
Operating PWRs	460	1,830,000	14	3.7	0.24	5.6	9.6	0.011	0.008	0.006	0.059
Sealed sources - CH	105	359,000	0.82	0.2	0.014	0.45	0.66	0.0014	0.0005	0.0004	0.0085
Cesium irradiators - CH	120	410,000	0.94	0.22	0.016	0.51	0.75	0.0002	0.0006	0.0005	0.0098
Other Waste - CH	3	8,270	0.02	0.0045	0.0004	0.012	0.017	<0.0001	<0.0001	<0.0001	0.00027
Other Waste - RH	27	125,000	0.92	0.25	0.018	0.37	0.64	<0.0001	0.0006	0.0004	0.0033
GTCC-like waste											
Activated metals - RH	11	24,300	0.22	0.037	0.0027	0.079	0.12	<0.0001	0.0001	<0.0001	0.0025
Sealed sources - CH	1	3,420	0.0078	0.0019	0.00013	0.0043	0.0063	<0.0001	<0.0001	<0.0001	<0.0001
Other Waste - CH	35	146,000	0.32	0.13	0.009	0.19	0.33	0.00015	0.0002	0.0002	0.0044
Other Waste - RH	579	2,460,000	18	5.1	0.34	7.5	13	0.00033	0.01	0.008	0.072

TABLE 9.2.9-2 (Cont.)

			Cargo-Related[b] Radiological Impacts								Vehicle-Related Impacts[c]
			Dose Risk (person-rem)						LCFs[d]		Physical Accident Fatalities
				Routine Public							
Waste	No. of Shipments	Total Distance (km)	Routine Crew	Off-Link	On-Link	Stops	Total	Accident[e]	Crew	Public	
Group 2											
GTCC LLRW											
Activated metals - RH											
New BWRs	54	216,000	1.6	0.37	0.027	0.68	1.1	0.0014	0.001	0.0006	0.0073
New PWRs	227	912,000	6.9	1.9	0.11	2.8	4.8	0.0038	0.004	0.003	0.028
Additional commercial waste	498	2,160,000	16	4.6	0.31	6.6	11	<0.0001	0.01	0.007	0.066
Other Waste - CH	70	303,000	0.66	0.28	0.019	0.4	0.69	0.00049	0.0004	0.0004	0.0092
Other Waste - RH	1,900	8,270,000	61	17	1.2	25	44	<0.0001	0.04	0.03	0.25
GTCC-like waste											
Other Waste - CH	22	95,200	0.21	0.083	0.0054	0.12	0.21	<0.0001	0.0001	0.0001	0.0026
Other Waste - RH	702	3,040,000	23	6.4	0.43	9.3	16	0.0003	0.01	0.01	0.09
Total Groups 1 and 2	5,010	21,200,000	150	42	2.8	62	110	0.024	0.09	0.06	0.64

a BWR = boiling water reactor, PWR = pressurized water reactor, CH = contact-handled, RH = remote-handled.

b Cargo-related impacts are impacts attributable to the radioactive nature of the material being transported.

c Vehicle-related impacts are impacts independent of the cargo in the shipment.

d LCFs were calculated by multiplying the dose by the health risk conversion factor of 6×10^{-4} fatal cancer per person-rem (see Section 5.2.4.3).

e Dose risk is a societal risk and is the product of accident probability and accident consequence.

4,000 would be expected to use a southern access route, as discussed in Section 9.1.9, and about 8,600 would use the northern access route over the life of the disposal facility.

9.2.9.2 Highest-Exposed Individuals during Routine Conditions

During the routine transportation of radioactive material, specific individuals could be exposed to radiation in the vicinity of a shipment. Risks to these individuals for a number of hypothetical exposure-causing events were estimated. The receptors include transportation workers, inspectors, and members of the public exposed during traffic delays, while working at a service station, or while living or working near a destination site. The assumptions about exposure are given in Section C.9.2.2 of Appendix C, and transportation impacts are provided in Section 5.3.9. The scenarios for exposure are not meant to be exhaustive; they were selected to provide a range of representative potential exposures. On a site-specific basis, if someone was living or working near the NNSS entrance and was present for all 12,600 truck or 5,010 rail shipments projected, that individual's estimated dose would be approximately 0.5 or 1.0 mrem, respectively, over the course of more than 50 years. The individual's associated lifetime risk of LCF would then be 3×10^{-7} or 6×10^{-7} for truck or rail shipments, respectively.

9.2.9.3 Accident Consequence Assessment

Whereas the collective accident risk assessment considers the entire range of accident severities and their related probabilities, the accident consequence assessment assumes that an accident of the highest severity category has occurred. The consequences, in terms of committed dose (rem) and LCFs for radiological impacts, were calculated for both exposed populations and individuals in the vicinity of an accident. Because the exact location of such a transportation accident is impossible to predict and is thus not specific to any one site, generic impacts were assessed, as presented in Section 5.3.9.

9.2.10 Cultural Resources

No cultural resources are known within the project area. The only resources that could possibly be present are those associated with traditional cultural properties and other resources of concern to American Indian tribes. If the GTCC reference location was chosen for development, the Section 106 process of the NHPA would be followed for consulting with federally recognized tribes. The Section 106 process requires that the location and any ancillary locations that would be affected by the project be investigated for the presence of cultural resources prior to disturbance. Areas geographically remote from the project area that could be used for site activities would require investigation.

No impacts on cultural resources are expected from construction, operations, decommissioning, or post-closure activities at the project site, since no cultural resources have been identified in the project area. Of the three land waste disposal methods, the borehole method would have the greatest potential to affect cultural resources, if any, because of the larger acreage needed. Potential visual impacts would be minimal compared with those from the other disposal methods, because the majority of the disposal facility would be below grade. If any activities occurred in a location remote from the GTCC reference location identified southeast of the RWMS, additional investigation would be required. If significant cultural resource sites were found, the effect of the project on these significant resources would be assessed.

Because the trench method would require only 20 ha (50 ac) for the facility, the potential for impacts is less for this method than for the other two disposal methods being considered. No known cultural resources are present within the project area; therefore, no impacts on cultural resources are expected. Visual impacts on cultural resources would need to be considered during all phases of the project; however, no known visually sensitive resources are located in the vicinity of the project area. No impacts on cultural resources are expected from any phase of the project.

Unlike the other two land disposal methods being considered, the vault method requires large amounts of soil to cover the waste. Potential impacts on cultural resources could occur during the removal and hauling of the soil required for this method. Impacts on cultural resources would need to be considered for the soil extraction locations. It is assumed that the soil used for the cover would not be excavated from within the GTCC reference location southeast of the RWMS. The NHPA Section 106 process would be followed for all reference locations utilized for the project. Although there are no known visually sensitive resources near the GTCC reference location, visual impacts would be considered during all phases of the project.

9.2.11 Waste Management

The construction of the land disposal facilities would generate small quantities of waste in the form of hazardous and nonhazardous solids and hazardous and nonhazardous liquids. Waste generated from operations would include small quantities of solid LLRW (e.g., spent HEPA filters) and nonhazardous solid waste (including recyclable wastes). These waste types would either be disposed of on-site or sent off-site for disposal. No impacts on waste management programs at NNSS are expected from the waste that could be generated from the construction and operations of the land disposal methods. Section 5.3.11 provides a summary of the waste handling programs at NNSS for the waste types generated.

9.3 SUMMARY OF POTENTIAL ENVIRONMENTAL CONSEQUENCES AND HUMAN HEALTH IMPACTS

The potential environmental consequences from the disposal of GTCC LLRW and GTCC-like waste under Alternatives 3 and 4 are summarized by resource area as follows:

Air quality. Potential impacts from construction and operations on ambient air quality would be negligible or minor at most. It is estimated that during construction and operations, total peak-year emissions of criteria pollutants, VOCs, and CO_2 would be small. The highest emissions associated with the vault method would be about 3.6% of Nye County's emissions total for NO_x. O_3 levels in Nye County are currently in attainment; O_3 precursor emissions from construction and operational activities would be relatively small, less than 3.6% and 0.27% of NO_x and VOC emissions, respectively, and much lower than those in the regional air shed. During construction and operations, maximum CO_2 emissions would be negligible. All construction activities would occur within about 6 km (4 mi) of the site boundary and would not contribute significantly to concentrations at the boundary or at the nearest residence. Fugitive dust emissions during construction and operations would be controlled by best management practices. Activities during decommissioning would be similar to those during construction but on a more limited scale and for a more limited duration. Potential impacts on ambient air quality therefore would be correspondingly less from decommissioning than from construction.

Noise. The highest composite noise during construction would be about 92 dBA at 15 m (50 ft) from the source. Noise levels at 690 m (2,300 ft) from the source would be below the EPA guideline of 55 dBA as the L_{dn} for residential zones. This distance is well within the NNSS boundary, and there are no residences within this distance. Noise generated from operations would be less than that from construction. No ground-borne vibration impacts are anticipated, since low-vibration-generating equipment would be used and since there are no residences or vibration-sensitive buildings in the area.

Geology. No adverse impacts from the extraction and use of geologic and soil resources are expected, nor are any significant changes in surface topography or natural drainages expected. Boreholes (40 m or 130 ft) would be completed in unconsolidated material. The potential for erosion would be reduced by the low precipitation rates and further reduced by best management practices.

Water resources. Construction of a vault facility would require the most water. Water demands for construction at NNSS would be met by using groundwater from on-site wells completed in the Great Basin aquifer system. No surface water would be used at the site during construction; therefore, no direct impacts on surface water are expected. Indirect impacts on surface water would be reduced by implementing good industry practices and mitigation measures. Construction and operations of the proposed GTCC LLRW and GTCC-like waste disposal facility would increase the annual water use at NNSS by a maximum of about 0.3% (vault) and 0.5% (trench). These increases would not significantly lower the water table or change the direction of groundwater flow; therefore, impacts due to groundwater withdrawals are expected to be negligible. Because of the extremely arid climate at NNSS, the rate of infiltration is insufficient to cause leaching of radionuclides to the water table (within 100,000 years). As a result, no impacts on groundwater quality and no indirect impacts on surface water quality (as a result of aquifer discharges) are expected.

Human health. Worker impacts from operations would mainly be those from the radiation doses associated with handling of the wastes. The annual radiation dose commitment would be 2.6 person-rem/yr for boreholes, 4.6 person-rem for trenches, and 5.2 person-rem/yr for vaults. These worker doses are not expected to result in any LCFs (see Section 5.3.4.1.1). The maximum dose to any individual worker would not exceed the DOE administrative control level of 2 rem/yr for operations. It is expected that the maximum dose to any individual worker would not exceed the DOE administrative control level of 2 rem/yr.

The worker impacts from accidents would be associated with the physical injuries and possible fatalities that could result from construction and waste handling activities. It is estimated that the annual number of lost workdays due to injuries and illnesses during disposal operations would range from 1 (for the borehole method) to 2 (for the trench and vault methods), and no fatalities would result from construction and waste handling accidents (see Section 5.3.4.2.2). These injuries would not be associated with the radioactive nature of the wastes but simply be those expected to occur in any construction project of this size.

With regard to the general public, no measurable doses are expected to occur during waste disposal operations at the site, given the solid nature of the wastes and the distance of waste handling activities from potentially affected individuals. It is estimated that the highest dose to an individual from an accident involving the waste packages before their disposal (from a fire affecting an SWB) would be 2.4 rem and not result in any LCFs. The total dose to the affected population from such an event is estimated to be 0.47 person-rem. Because of the extremely arid climate (and an infiltration rate of essentially zero), contamination from groundwater is not projected to reach a nearby hypothetical resident farmer within the first 10,000 years after the disposal facility closes, so this individual would receive no incremental radiation dose from disposal of these wastes.

Ecological resources. The initial loss of creosote bush/white bursage habitat, followed by the eventual establishment of low-growth vegetation, would not create a long-term reduction in the local or regional ecological diversity. After closure, the cover would become vegetated with annual and perennial grasses and forbs. Construction of the GTCC LLRW and GTCC-like waste disposal facility would affect wildlife species inhabiting the site; however, small mammals, ground-nesting birds, and reptiles would recolonize the site once vegetative cover was reestablished. Larger mammals, such as pronghorn, coyote, and mountain lion, would likely avoid the area or be excluded by fencing during the institutional control/monitored post-closure period.

There are no natural aquatic habitats or wetlands within the immediate vicinity of the GTCC reference location; however, depending on the amount of water in the retention pond and length of retention, certain species (e.g., aquatic invertebrates, waterfowl, shorebirds, and mammals) could become established.

The desert tortoise is the only federally listed species that is a resident at NNSS. It inhabits the southern third of the site at low estimated densities. Mitigation for loss of the desert tortoise is normally required under the terms and conditions of the 1996 Biological Opinion (Mendoza 1996); however, since the area adjacent to the RWMS is not considered suitable habitat for the desert tortoise, it is not subject to the requirements of the Opinion. Project construction activities could destroy the burrows of western burrowing owls or directly kill them. Adverse impacts would be minimized by conducting biological surveys in the project area and identifying mitigation measures accordingly.

Socioeconomics. Impacts would be small. Construction would create direct employment for up to 145 people (vault method) in the peak construction year and 137 indirect jobs (vault method) in the ROI. The annual average employment growth rate would increase by <1%. The

GTCC LLRW and GTCC-like waste disposal facility would produce about $12.8 million in income in the peak construction year. Up to 32 people would in-migrate to the ROI as a result of employment on-site; in-migration would have only a marginal effect on population growth and require less than 1% of vacant housing in the peak year. Impacts from operating a land disposal facility would also be small, creating as many as 51 direct jobs (vault method) annually and an additional 36 indirect jobs (vault method) in the ROI; the facility would produce up to $5.1 million in income annually during operations.

Environmental justice. Health impacts on the general population within the 80-km (50-mi) assessment area during construction and operations would be negligible, and no impacts on minority and low-income populations as a result of the construction and operations of a GTCC LLRW and GTCC-like waste disposal facility are expected. If analyses that accounted for any unique exposure pathways (such as subsistence fish, vegetation, or wildlife consumption or well-water consumption) determined that health and environmental impacts would not be significant, then there would be no high and adverse impacts on minority and low-income populations. If impacts were found to be significant, disproportionality would be determined by comparing the proximity of high and adverse impacts to the location of low-income and minority populations.

Transportation. Transporting all the waste to NNSS by truck would result in approximately 12,600 shipments involving a total of 48 million km (30 million mi) of travel. Transporting all the waste by rail would require 5,010 railcar shipments involving 21 million km (13 million mi) of travel. It is estimated that no LCFs would occur to the public or crew members for either mode of transportation, but one fatality from accidents could occur.

Land use. The GTCC LLRW and GTCC-like waste disposal facility would be integrated into the radioactive waste management zone of the Area 5 RWMS. This area currently supports defense-related activities.

Cultural resources. No known cultural resources are located within the project area. Potential resources are those associated with cultural properties or resources of concern to American Indian tribes. The borehole method has the greatest potential to affect cultural resources because of its 44-ha (110-ac) land requirement. The amount of land needed to employ this method is twice the amount needed to construct a vault or trench. No impacts are expected from construction, operations, or post-closure activities since no cultural resources have been identified in the project area. Section 106 of the NHPA would be followed to determine the impact of the project on significant cultural resources, as needed. Local tribes would be consulted to ensure no traditional cultural properties were affected by the project.

Waste management. The wastes that could be generated from construction and operations of the land waste disposal facilities are not expected to affect current waste management programs at NNSS.

9.4 CUMULATIVE IMPACTS

Section 5.4 presents the methodology for the cumulative impacts analysis. In the analysis that follows, impacts of the proposed action are considered in combination with the impacts of past, present, and reasonably foreseeable future actions. This section begins with a description of reasonably foreseeable future actions at NNSS, including those that are ongoing, under construction, or planned for future implementation. Past and present actions are generally accounted for in the affected environment section (Section 9.1).

9.4.1 Reasonably Foreseeable Future Actions

Reasonably foreseeable future actions at NNSS are summarized in the following sections. These actions were identified primarily from a review of the *Draft Supplemental Analysis for the Final Environmental Impact Statement for the Nevada Test Site and Off-Site Locations in the State of Nevada* (2008 NTS SA; DOE 2008c). These actions are planned, under construction, or ongoing and may not be inclusive of all actions at the site. However, they should provide an adequate basis for determining potential cumulative impacts at NNSS.

9.4.1.1 Defense Programs-Related Facilities and Activities

The key ongoing activities related to NNSS defense programs evaluated in the final NTS EIS (DOE 1996) and the 2002 NTS SA (DOE 2002a) include maintaining readiness to conduct full-scale nuclear testing; conducting underground nuclear weapons testing; handling damaged and foreign nuclear weapons; and conducting dynamic experiments, including subcritical experiments. The status of these activities in provided in Table 3-1 of the 2008 NTS SA (DOE 2008c). New facilities and activities initiated since the final NTS EIS and the 2002 NTS SA were prepared include the following:

- *Joint Actinide Shock Physics Experimental Research (JASPER) Facility*. The JASPER Facility, constructed in 1999, conducts shock physics experiments on special nuclear material and other actinide materials. As many as 24 special material shots could be conducted each year; more than 24 plutonium experiments have been conducted since the 2002 NTS SA (DOE 2002a). The facility generates small quantities of TRU (DOE 2008c).

- *Baker Site Facility.* The Baker Site Facility, located in NNSS Area 27, was constructed to stage, assemble, and store explosives used at various approved NNSS locations, including the Big Explosives Experimental Facility and the JASPER Facility. The Baker Site Facility was referred to as the Nevada Energetic Materials Operations Facility in the 2002 NTS SA (DOE 2002a).

- *Device Assembly Facility*. The multistructure Device Assembly Facility assembles, disassembles or modifies, stages, and component-tests nuclear devices and high explosives.

- *Big Explosives Experimental Facility*. Research at the Big Explosives Experimental Facility involves experiments on explosive pulsed-power technology and on advanced-shaped charges for augmented conventional weapons and render-safe technologies. The facility has been modified to perform high-explosives pulsed-power experiments; these modifications are not expected to increase the potential size of detonations or change the amount or type of materials involved in detonations beyond those analyzed in the 2002 NTS SA (DOE 2002a).

- *Atlas Facility*. The Atlas Facility was relocated from LANL and conducted pulsed-power experiments on macroscopic targets until it was placed in cold stand-by mode in 2006. The relocation of the facility was evaluated in an environmental assessment and a FONSI (DOE 2001).

- *U1a Complex*. The U1a Complex is an underground laboratory of horizontal tunnels, mined at the base of a vertical shaft about 960 ft (290 m) below the surface; it has several fixed and temporary metal buildings and instrument trailers on the surface. Upgrades to the facility would continue as needed to support program activities. Since June 2007, 22 subcritical experiments and 12 smaller special nuclear material recovery experiments have been conducted at the U1a Complex. The NNSA has plans to install a large-bore powder gun in the complex. The gun would be used to fire a large projectile into fixed special nuclear material targets. Experiments at the U1a Complex could become more complex with time, potentially using larger quantities of special nuclear material, although limits on special material quantities would not be exceeded during future subcritical experiments.

- *Emplacement hole subcritical experiments*. Emplacement hole experiments are similar to the subcritical experiments described for the U1a Complex, except that they are performed in vertical emplacement holes, similar to those used for underground testing.

- *G-Tunnel improvised nuclear device program*. The U12g Tunnel, also known as the G-Tunnel, is part of an ongoing program (as of 2007) that makes use of the tunnel to stage and minimally assess a damaged nuclear weapon or improvised nuclear device, should one be recovered.

- *Tonopah Test Range Fire Experiment Facility open burn experiments*. Open burn experiments at the Tonopah Test Range Fire Experiment Facility would involve the construction of a fire and thermal testing facility at either NNSS or the Tonopah Test Range. To date, these experiments have not been conducted, but the NNSA plans to do a NEPA review and analysis if these experiments become necessary in the future.

More in-depth descriptions of these facilities and activities can be found in the 2008 NTS SA (DOE 2008c); some are also described in the appendices of the final NTS EIS (DOE 1996).

9.4.1.2 Non-Defense Research and Development Program-Related Facilities and Activities

Ongoing non-defense R&D activities at NNSS are conducted by the NNSA, universities, industry, and other federal agencies. Among these are the establishment of a solar enterprise zone, an alternate fuel demonstration project, and an environmental research park. The status of these activities (and others that were either cancelled or are inactive) is provided in Table 3-4 of the 2008 NTS SA (DOE 2008c). New R&D activities initiated since the final NTS EIS and the 2002 NTS SA were prepared include the following:

- *Nonproliferation Test and Evaluation Complex*. Known originally as the Liquefied Gaseous Fuels Spill Test Facility and then as the HazMat Spill Center, the Nonproliferation Test and Evaluation Complex continues to support the Work-for-Others Program by conducting research on the behavior and safety aspects of chemical handling and releases, including releases due to explosive detonations.

- *Nevada Environmental Research Center*. Two research facilities operated by the Desert Research Institute and the University of Nevada (Las Vegas and Reno) – the Nevada Desert Free Air Carbon Dioxide Enrichment Facility and the Mojave Global Change Facility – conduct research on the impact of elevated CO_2 levels on the Mojave Desert ecosystem and research on the effects of climate change. These facilities are part of the Nevada Environmental Research Park at NNSS.

- *Solar power plant*. A utility-scale, commercial solar power plant has been proposed for the Solar Enterprise Zone at NNSS Area 22. It would be developed and constructed over the next 3 to 5 years. The plant would use concentrated solar power (Fresnel lens/trough type) and could produce up to 200 MW of electricity. Power would be transmitted through the Mercury substation and existing transmission lines, with upgrades as needed.

9.4.1.3 Work-for-Others Program-Related Facilities and Activities

The Work-for-Others Program provides management, direction, and oversight for ongoing work for the U.S. Department of Defense, the U.S. Department of Homeland Security, law enforcement agencies, and others. These programs usually involve high-hazard operations, operations with nuclear material, training, and other activities through which NNSS can support national security missions. The status of these activities is provided in Table 3-5 of the 2008 NTS SA (DOE 2008c). New work-for-others facilities and activities initiated since the final NTS EIS and the 2002 NTS SA were prepared include the following:

- *Weapons of Mass Destruction Emergency Responder Training Program*. The Weapons of Mass Destruction Emergency Responder Training Program was transferred to the Federal Emergency Management Agency in 2006. Its mission is to enhance the capacity of state and local agencies to respond to weapons of mass destruction incidents through coordinated training, equipment acquisition, technical assistance, and support of state and local exercise planning. NNSA/NSO Mobile Training Teams provide training at NNSS or at NNSA/NSO facilities in Las Vegas for the program.

- *Defense Threat Reduction Agency (DTRA) Hard Target Defeat Program*. The Hard Target Defeat Program is a multi-year testing program that demonstrates the capability to detect, identify, and characterize a target and then to disrupt, neutralize, or destroy it. Through this program, DTRA evaluates alternative capabilities by using various platforms (both ground and air) against a variety of different target configurations representing different geographic scenarios. To date, tests have been conducted in NNSS Areas 12 and 16.

- *U.S. Military development and training for counter-terrorism and national security defense*. The NNSA/NSO supports the U.S. Department of Defense in developing methods for engaging or neutralizing an adversary in a variety of topographical environments, making use of the restricted-access and high desert terrain at NNSS. The U.S. Air Force also conducts military operations in the restricted air space above NNSS and the Tonopah Test Range. It uses NNSS mainly as a transition corridor for NTTR air traffic at altitudes greater than 14,000 ft (4,300 m). Future military uses could include R&D, testing, evaluation, and integration of training and exercises with unmanned aerial vehicles and/or unmanned aircraft systems.

- *Aerial Operations Facility*. The Aerial Operations Facility operates and tests a variety of unmanned aerial vehicles. The facility was evaluated most recently in October 2004 to identify the potential impacts from constructing a new runway, hangars, and operations buildings and from performing infrastructure upgrades to accommodate an increase in personnel (DOE 2004a).

- *National Center for Combating Terrorism*. Construction of the National Center for Combating Terrorism was completed in 2006. The center provides a system of facilities and capabilities that include R&D, testing, evaluation, exercises, training, and intelligence support. The impacts of the program were evaluated in the 2003 NTS SA (DOE 2003).

- *Nonproliferation Test and Evaluation Complex*. Known originally as the Liquefied Gaseous Fuels Spill Test Facility and then as the HazMat Spill Center, the Nonproliferation Test and Evaluation Complex serves as a chemical and biological test center. It conducts research on the behavior and safety aspects of chemical handling and releases, including releases due to explosive detonations. Capabilities were expanded in 2002 to address national needs for emergency response and counter-terrorism training. Capabilities were expanded again in 2004 to include tests and experiments involving the release of biological simulants and low concentrations of chemicals at various NNSS locations (under the Work-for-Others Program).

- *Activities using biological simulants and releases of chemicals*. These activities involve chemical release tests designed to assess risks from accidental releases of hazardous and biohazardous materials, provide data on sensor development, and provide first responder training. DOE completed an EA for this facility in June 2004 (DOE 2004b). To date, there have been an average of 8 to 16 campaigns per year with approximately 10 testing days per campaign.

- *Radiological/Nuclear Countermeasures Test and Evaluation Complex*. The Radiological/Nuclear Countermeasures Test and Evaluation Complex is currently under construction. The complex is located in Area 6 south of the Device Assembly Facility. Testing and evaluation activities will include prototype detector testing; evaluation systems testing and evaluation; performance standards validation; demonstration of prototype detectors, systems, and performance standards; verified threat demonstration; concept of operations evaluation and verification; and training. DOE completed an EA for this facility in August 2004 (DOE 2004c).

9.4.1.4 Radioactive Waste Disposal Facilities

One active disposal facility is located within the boundary of NNSS: Area 5 of the RWMS. Area 5 is located in the southeastern section of NNSS in Frenchman Flat, within a topographically closed basin. One inactive disposal facility is located within the boundary of NNSS: Area 3 of the RWMS. Area 3 is located about 24 km (15 mi) north of Area 5 in the Yucca Flat basin, also a closed basin. Operations at these facilities began in the 1960s. Both facilities are shallow-land disposal facilities; Area 5 uses engineered shallow-land burial cells to dispose of packaged waste, and Area 3 uses subsidence craters formed from underground testing of nuclear weapons to dispose of packaged and unpackaged bulk waste. Originally, the waste that was being disposed of was generated by nuclear weapons research, development, and testing conducted at NNSS. Now the waste comes from environmental cleanup activities at NNSS and other DOE sites. There are 34 disposal cells within a 160-acre (65-ha) area at Area 5 RWMS; 24 cells have been closed. To date, approximately 510,000 m^3 (18 million ft^3) of low-level and mixed low-level waste has been disposed of in Area 5.

Area 3 covers 49 ha (120 ac) and includes a total of seven craters, representing five cells, designated for LLRW disposal operations. The current inventory of waste at Area 3 is about 570,000 m^3 (20 million ft^3). Available open capacity in the two developed cells is approximately 28,000 m^3 (990,000 ft^3). Capacity in the remaining craters is approximately 280,000 m^3 (10 million ft^3). The Area 3 RWMS is in cold standby. If low-level waste volumes would significantly increase or if a specific low-level waste shipment campaign would be better disposed of at the facility, then the Area 3 RWMS would be used.

9.4.1.5 Environmental Restoration Program-Related Activities

The Environmental Restoration Program continues to assess and remediate DOE-contaminated sites to ensure compliance with all applicable environmental regulations and statutes and to ensure protection of public and worker safety and health. The program addresses three "sub-project" areas: underground test area, soils media, and industrial sites (formerly referred to as corrective active units). Remedial actions include the closure of the decontamination and decommissioning facilities and DTRA (formerly the Defense Nuclear Agency) sites and the characterization and remediation of sub-projects at the Tonopah Test Range. The responsibility for characterization and remediation at two NNSS areas, the Central Nevada Test Area and the Project Shoal Area, was transferred to DOE's Office of Legacy Management, which will oversee environmental restoration and NEPA documentation (DOE 2008c). The status of all these activities is provided in Table 3-3 of the 2008 NTS SA (DOE 2008c).

9.4.1.6 Future Projects at NNSS

Future projects at NNSS are related to the proposed Complex Transformation, which identifies NNSS as an alternative site for the following facilities and activities:

- Consolidated Plutonium Center;
- Consolidated Weapons Program special nuclear material storage;
- Consolidated hydrotesting, originally proposed as the Advanced Hydrotest Facility in DOE (2002a);
- Consolidated major environmental testing on nuclear weapons components;
- NNSA flight test operations currently performed at the Tonopah Test Range; and
- Consolidated Nuclear Production Center.

The Notice of Availability (73 FR 2023) for the draft Complex Transformation Supplemental Programmatic EIS was published on January 11, 2008. The Complex Transformation will not include NNSA's original proposal to build a modern pit facility, as evaluated in the 2002 NTS SA (DOE 2002a).

9.4.2 Cumulative Impacts from the GTCC Proposed Action at NNSS

Potential impacts of the proposed action are considered in combination with the impacts of past, present, and reasonably foreseeable future actions. The impacts from Alternatives 3 to 5 at NNSS are described in Section 9.2 and summarized in Section 9.3. These sections indicate that the potential impacts from the proposed action (construction and operations of a borehole, trench, or vault facility) would be small for all the resources evaluated. On the basis of the total impacts (including the reasonably foreseeable future actions summarized in Section 9.4.1), the incremental potential impacts from the GTCC proposed action are not expected to contribute substantially to cumulative impacts on the various resource areas evaluated for NNSS. For example, the land area requirement of about 44 ha (110 ac) is a fraction of the projected 2,351 ha (5,800 ac) of new ground disturbance that is indicated in the NTS EIS (DOE 1996). In addition, the GTCC reference location would be located in an area that is already used for disposal of other types of waste. The estimated dose to the worker population from GTCC LLRW and GTCC-like waste disposal operations (2.6 to 5.2 person-rem) would be less than the worker population doses from other LLRW activities at NNSS. For example, a worker population dose of 386 person-rem is estimated under the maximum impact alternative in the Complex Transformation EIS (DOE 2008b). The estimates of human health impacts from post-closure activities at the GTCC LLRW and GTCC-like waste disposal facility indicate there would be very low doses within 10,000 years after closure (i.e., doses would be lower than the 8 mrem/yr at 250 years after closure at Area 3 and the 6 mrem/yr at 250 years after closure at Area 5 (Shott et al. 2000; Bechtel Nevada 2001). Finally, follow-on NEPA evaluations as well as the current SWEIS analysis and documents prepared to support any further considerations of siting a new borehole, trench, or vault disposal facility at NNSS would provide more detailed analyses of site-specific issues, including cumulative impacts.

9.5 SETTLEMENT AGREEMENTS AND CONSENT ORDERS FOR NNSS

A review of existing settlement agreements and consent orders for NNSS did not identify any that would contain requirements that would be triggered by Alternatives 3 to 5 for this EIS.

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10 SAVANNAH RIVER SITE: AFFECTED ENVIRONMENT AND CONSEQUENCES OF ALTERNATIVES 4 AND 5

This chapter provides an evaluation of the affected environment, environmental and human health consequences, and cumulative impacts from the disposal of GTCC LLRW and GTCC-like waste under Alternative 4 (in a new trench disposal facility) and Alternative 5 (in a new vault disposal facility) at SRS. Alternative 3 (disposal in a new borehole disposal facility) is not evaluated for SRS primarily because of the shallow depth to groundwater conditions prevalent there. Alternative 3 is described in Section 5.6.1. Environmental consequences that are common to all the sites for which Alternatives 4 and 5 are evaluated (including SRS) are discussed in Chapter 5 and not repeated in this chapter. Impact assessment methodologies used for this EIS are described in Appendix C. Federal and state statutes and regulations and DOE Orders relevant to SRS are discussed in Chapter 13 of this EIS.

10.1 AFFECTED ENVIRONMENT

This section discusses the affected environment for the various environmental resource areas evaluated for the GTCC reference location at SRS. The GTCC reference location is situated on an upland ridge within the Tinker Creek drainage, about 3.2 km (2 mi) to the northeast of the Z-Area in the north-central portion of SRS (see Figure 10.1-1). The reference location shown was selected primarily for evaluation purposes for this EIS. The actual location would be identified on the basis of follow-on evaluations if and when it is decided to locate a GTCC LLRW and GTCC-like waste disposal facility at SRS.

10.1.1 Climate, Air Quality, and Noise

10.1.1.1 Climate

South Carolina is located between the southern slopes of the Appalachian Mountains and the Atlantic Ocean. It has a long coastline along which the warm Gulf Stream current flows. During the summer, weather in South Carolina is dominated by a maritime tropical air mass known as the Bermuda high. Passing over the Gulf Stream, it brings warm and moist air inland from the ocean (SCSCO 2007). As the air comes inland, it rises and forms localized thunderstorms, resulting in maximum precipitation. The mountains to the north and west tend to block or delay many cold air masses approaching from those directions, thus making the winters somewhat milder. The area around SRS has a temperate climate, characterized by long, humid summers and short, mild winters (DCS 2002).

The annual average wind speed is 2.5 m/s (5.7 mph) at Bush Field, which is located in Augusta, Georgia, about 31 km (19 mi) west-northwest of the GTCC reference location (NCDC 2008a). Wind speed is higher in winter and spring, with the highest speed being 2.9 m/s (6.5 mph) in spring, and it is lower in summer and autumn, with the lowest speed being 2.2 m/s

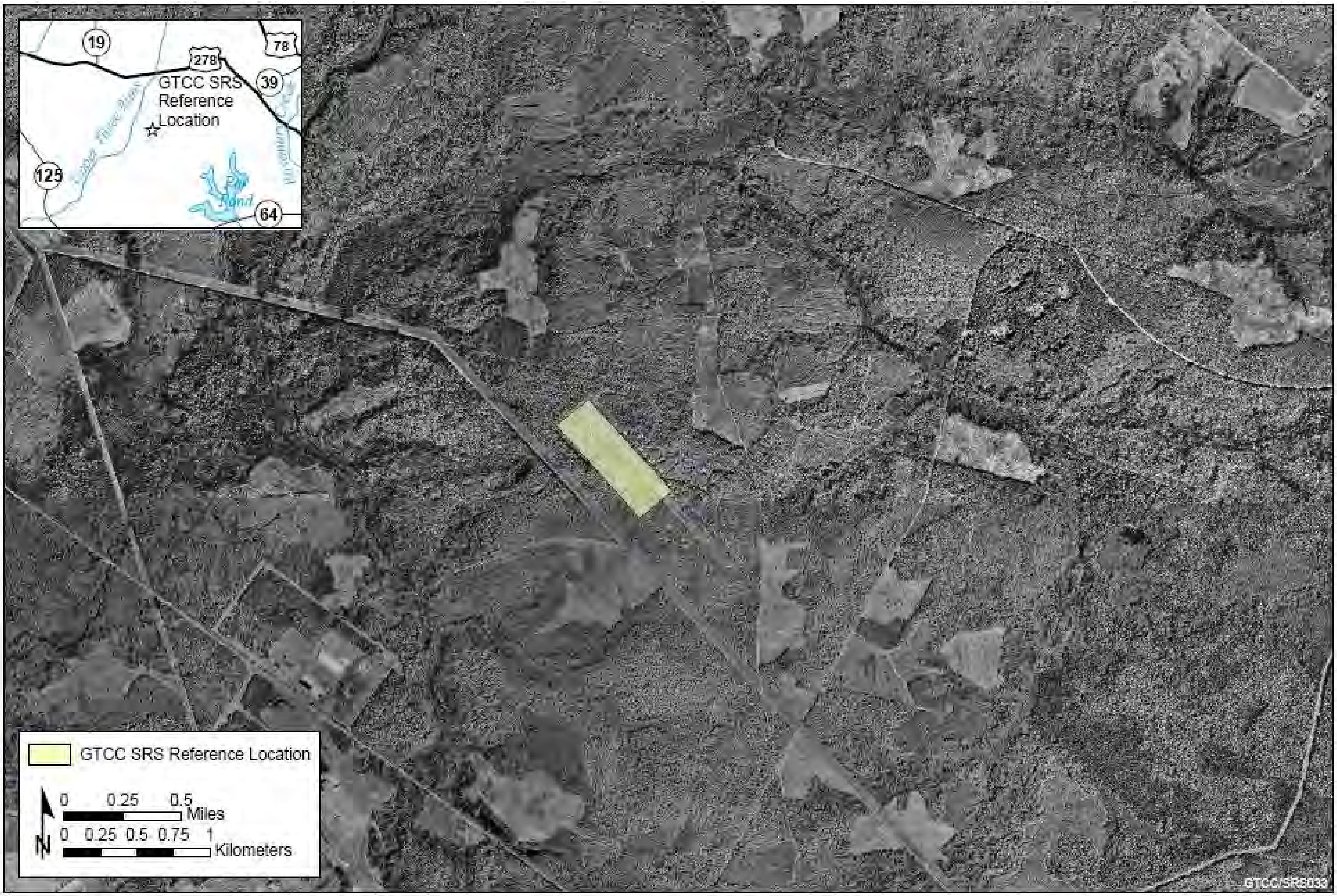


FIGURE 10.1-1 GTCC Reference Location at SRS

(5.0 mph) in autumn. Overall, the prevailing wind direction is from the west, albeit it is not prominent. Monthly prevailing wind directions vary, being mostly from west-northwest in November through March, from south to southeast in April through August, and from north-northeast in September and October.

A wind rose at the 61-m (200-ft) meteorological tower in the H-Area at SRS for the 5-year period of 1992 through 1996 is presented in Figure 10.1.1-1. There is no prominent wind direction at SRS; about 30% of the time, the wind blows from the northeast quadrant, and about 40% of the time, it blows from southwest quadrant. The annual average wind speed is about 3.9 m/s (8.8 mph), and the wind speed is relatively uniform with the wind direction. The wind patterns are different at Bush Field and at the on-site H-Area meteorological tower; the pattern at Bush Field is representative of the surface wind, which is considerably affected by surface

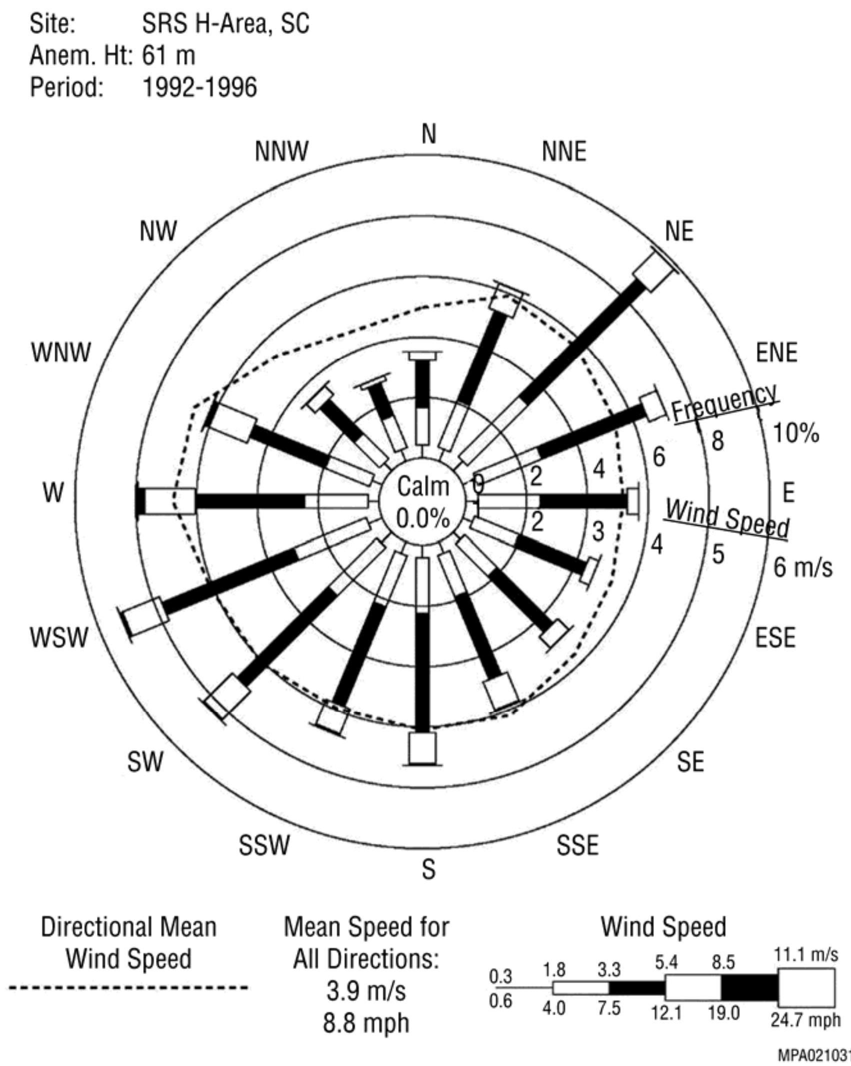


FIGURE 10.1.1-1 Wind Rose at the 61-m (200-ft) Level for the SRS H-Area Meteorological Tower, South Carolina, 1992–1996 (Source: Arnett and Mamatey 2000)

friction, and the pattern at the tower is representative of general upper wind. On-site wind patterns reflect the presence and orientation of the Appalachian Mountains somewhat, and they generally run in a general northeast-southwest direction.

For the last 30-year period, the annual average temperature at Bush Field has been 17.3°C (63.2°F) (NCDC 2008a). January is the coldest month, averaging 7.1°C (44.8°F), and July is the warmest month, averaging 27.1°C (80.8°F). During the last 57 years, the highest temperature was 42.2°C (108°F), and the lowest was −18.3°C (−1°F). The number of days with a maximum temperature higher than or equal to 32.2°C (90°F) is about 75, while days with a minimum temperature lower than or equal to 0°C (32°F) number about 52.

Generally, precipitation is ample in all parts of the state. Annual precipitation at Bush Field averages about 113.2 cm (44.58 in.) (NCDC 2008a). Precipitation is light in autumn, increases in winter and spring, and peaks in summer. Measurable precipitation of 0.025 cm (0.01 in.) or more occurs on an average of 109 days per year. Measurable snow is a rarity, and, if it occurs, remains on the ground for only a short time. Light snow typically occurs from December through February, and the annual average snowfall in the area is about 3.6 cm (1.4 in.).

Severe weather occurs in South Carolina occasionally in the form of violent thunderstorms and tornadoes (Ruffner 1985). Thunderstorms are common in the summer months, but the really violent ones generally accompany the squall lines and active cold fronts of spring. Strong thunderstorms usually bring high winds, hail, and considerable lightning, and they sometimes spawn a tornado.

Tornadoes are rare in the area surrounding SRS, and they are less frequent and destructive than those in the tornado alley in the central United States. For the period 1950–2008, 878 tornadoes were reported in South Carolina, with an average of 15.1 tornadoes per year (NCDC 2008b). For the same period, a total of 93 tornadoes, at an average of 1.6 tornadoes per year, were reported in the SRS area; 57 occurred in the three counties encompassing SRS, and 36 occurred in the neighboring counties in Georgia (Burke, Richmond, and Screven). However, most tornadoes occurring in those counties were relatively weak (i.e., 91 tornadoes were less than or equal to F2 on the Fujita tornado scale, and two were F3). Nine tornadoes caused damage on SRS, one of which had estimated wind speeds as high as 67 m/s (150 mph). None caused damage to buildings on SRS (DCS 2002).

Tropical storms or hurricanes affect South Carolina about once every other year. Most do little damage and affect only the outer coastal plains, decreasing rapidly in intensity as they move inland. Those that do move far inland can cause considerable flooding (Ruffner 1985). Between 1851 and 2007, 28 major storms (4 hurricanes and 24 tropical storms) passed within 80 km (50 mi) of the GTCC reference location (NOAA 2008). Most hurricanes had been downgraded to tropical storms or tropical depressions before reaching SRS, which is located approximately 160 km (100 mi) inland. The only hurricane-force winds measured at SRS were associated with Hurricane Gracie on September 29, 1959, when wind speeds of 34 m/s (75 mph) were measured at the F-Area (DCS 2002).

10.1.1.2 Existing Air Emissions

The CAA of 1970 and CAAA of 1990 provide the basis for protecting and maintaining ambient air quality. The EPA delegated implementation and enforcement authority for the CAA to the State of South Carolina. The air pollution control rules developed and administered by the South Carolina Department of Health and Environmental Control (SCDHEC) are designed to ensure compliance with the CAA. The SCDHEC Air Permit Program is the primary driver by which emission sources are reported to and regulated by the State. Operating permits are legally enforceable documents that permitting authorities issue to air pollution sources after the source has begun to operate. In particular, a Title V permit is required for large stationary sources, such as power plants or major industrial facilities.

The SRS currently has two Title V (or Part 70 Air Quality Permit) operating permits: one including all SRS emission sources, and one for the 484-D Powerhouse (WSRC 2007a).[1]

The primary emission sources of criteria air pollutants and/or air toxics are the coal-fired powerhouse boiler in the D-Area, No. 2 oil-fired package steam generating boilers (those in the K-Area and portable units), fuel-oil-fired water heaters, and the biomass-fired and fuel-oil-fired boilers in the A-Area (WSRC 2007a). Other emissions include those from diesel-fired equipment (including portable air compressors, generators, and emergency cooling water pumps), several soil vapor extraction units, two air strippers, coal piles and coal processing facilities, vehicle traffic, controlled burning of forestry areas, and temporary emissions from construction-related activities.

Annual emissions from major facility sources and total point and area sources of criteria pollutants and VOCs in year 2002 in Aiken, Allendale, and Barnwell Counties, South Carolina, which encompass SRS, are presented in Table 10.1.1-1 (EPA 2008a). Data for 2002 are the most recent emission inventory data available on the EPA website. Area sources consist of nonpoint and mobile sources. Annual emissions are much higher in Aiken County than in Allendale and Barnwell Counties for both source categories and pollutant types because it has many industrial facilities and Interstate 20 (I-20). Point sources account for most of the SO_2 emissions, and point and area sources are equally attributable to NO_x emissions. Area sources are major contributors to CO, VOC, PM_{10}, and $PM_{2.5}$. Emissions of criteria pollutants except CO and of VOCs from two South Carolina Electric and Gas (SCE&G) coal-fired power stations in Urquhart and in the SRS D-Area in Aiken County were predominant for point source emissions in three counties.

Annual emissions of criteria pollutants and VOCs for the period 2003–2005 were estimated by SRS and are presented in Table 10.1.1-2 (WSRC 2007a). Recently, emissions of several pollutants, notably SO_2 and NO_x, increased significantly. During the 2006 annual air compliance inspection, all SRS permitted sources were found to be in compliance with their respective permit conditions and limits, and all required reports were determined to have been submitted to SCDHEC within specified time limits.

[1] On February 1, 2006, Westinghouse Savannah River Company (WSRC) assumed operational responsibility from South Carolina Electric and Gas (SCE&G), which had operated the facility for DOE under a separate contract since 1995.

TABLE 10.1.1-1 Annual Emissions of Criteria Pollutants and Volatile Organic Compounds from Selected Major Facilities and Total Point and Area Source Emissions in Counties Encompassing SRS[a]

	Emission Rates (tons/yr)					
Emission Category	SO_2	NO_x	CO	VOCs	PM_{10}	$PM_{2.5}$
Aiken County						
SCE&G Urquhart Power Station[b]	*13,724*	*4,374*	*123*	*15.1*	*858*	*668*
	67.85%[c]	*28.68%*	*0.21%*	*0.14%*	*8.76%*	*23.13%*
	66.30%	*25.23%*	*0.17%*	*0.10%*	*6.27%*	*16.87%*
SCE&G SRS Area-D Powerhouse[d]	*3,830*	*2,479*	*40.5*	*3.3*	*429*	*315*
	18.93%	*16.26%*	*0.07%*	*0.03%*	*4.38%*	*10.91%*
	18.50%	*14.30%*	*0.05%*	*0.02%*	*3.14%*	*7.95%*
Westinghouse: Savannah River Site	*272*	*325*	*117*	*10.6*	*25.0*	*18.7*
	1.34%	*2.13%*	*0.20%*	*0.10%*	*0.26%*	*0.65%*
	1.31%	*1.87%*	*0.16%*	*0.07%*	*0.18%*	*0.47%*
Point sources	18,634	8,569	775	1,055	1,724	1,291
Area sources	1,595	6,681	57,779	9,934	8,067	1,597
Total	20,229	15,250	58,555	10,989	9,791	2,888
Allendale County						
Point sources	47.6	25.1	14.2	112	25.8	13.4
Area sources	113	807	8,143	1,896	1,917	651
Total	161	832	8,157	2,008	1,943	664
Barnwell County						
Point sources	68.2	73.2	19.5	217	16.1	14.5
Area sources	242	1,181	7,427	1,881	1,928	393
Total	310	1,254	7,447	2,098	1,944	408
Three-county total	20,700	17,336	74,159	15,095	13,678	3,960

[a] Emission data for selected major facilities and for total point and area sources are for year 2002. CO = carbon monoxide, NO_x = nitrogen oxides, $PM_{2.5}$ = particulate matter ≤2.5 μm, PM_{10} = particulate matter ≤10 μm, SO_2 = sulfur dioxide, VOCs = volatile organic compounds.

[b] Data in italics are not added to yield totals.

[c] The top and bottom rows with % signs show emissions as percentages of Aiken County total emissions and three-county total emissions, respectively.

[d] On February 1, 2006, WSRC assumed operational responsibility from SCE&G, which had operated the facility for DOE under a separate contract since 1995.

Source: EPA (2009)

TABLE 10.1.1-2 Annual Emissions of Criteria Pollutants and Volatile Organic Compounds Estimated by SRS for the Period 2003–2005[a]

	Emission Rate (tons/yr)								
Year	SO_2	NO_x	CO	O_3 (VOCs)	PM_{10}	$PM_{2.5}$	Lead	Total PM	Gaseous Fluorides (as HF)
2003	536	266	2,290	93.3	118	NC[b]	0.558	302	0.114
2004	2,150	4,240	982	544	189	NC	0.158	489	0.139
2005	6,970	7,180	1,030	548	571	477	0.174	928	0.143

[a] CO = carbon monoxide, HF = hydrogen fluoride, NO_x = nitrogen oxides, O_3 = ozone, PM = particulate matter, $PM_{2.5}$ = particulate matter ≤2.5 μm, PM_{10} = particulate matter ≤10 μm, SO_2 = sulfur dioxide, VOCs = volatile organic compounds.

[b] NC = not calculated.

Source: WSRC (2007a)

10.1.1.3 Air Quality

The South Carolina SAAQS for six criteria pollutants — SO_2, NO_2, CO, O_3, PM_{10} and $PM_{2.5}$, and lead — are almost the same as the NAAQS (EPA 2008a; Flynn 2007), as shown in Table 10.1.1-3. In addition, the State has adopted standards for gaseous fluorides (expressed as HF) and has still retained the annual standard for total suspended particulates (TSP), which used to be one of criteria pollutants but was replaced by PM_{10} in 1987 (SCDHEC 2004).

The GTCC reference location (which is within SRS, mostly in Aiken and Barnwell Counties and with a much smaller section in Allendale County) is situated in the Augusta (Georgia)-Aiken (South Carolina) Interstate Air Quality Control Region (AQCR). Currently, the entire AQCR is designated as being in attainment for all criteria pollutants (40 CFR 81.311 and 81.341).

Under existing regulations, SRS is not subject to on-site monitoring requirements for ambient air quality; however, the site is required to demonstrate compliance with various air quality standards (WSRC 2007a). To accomplish this compliance, air dispersion modeling was conducted during 2006 for new emission sources or modified sources as part of the sources' construction permitting process. The modeling analysis indicated that SRS air emission sources were in compliance with all applicable regulations.

The highest concentration levels of criteria pollutants (such as SO_2, NO_2, CO, TSP, PM_{10}, and lead) around SRS are less than or equal to 49% of their respective standards in Table 10.1.1-3 (EPA 2009; SCDHEC 2008), except for O_3, which exceeded the applicable standard, and $PM_{2.5}$, which was 97% of the applicable standard. Both pollutants are primarily of regional concern. Monitoring data in Jackson, Aiken County, showed that concentration levels for O_3 and $PM_{2.5}$ vary from year to year. It is hard to determine any trend for $PM_{2.5}$

TABLE 10.1.1-3 National Ambient Air Quality Standards (NAAQS) or South Carolina State Ambient Air Quality Standards (SAAQS) and Highest Background Levels Representative of the GTCC Reference Location at SRS, 2003–2007

			Highest Background Level	
Pollutant[a]	Averaging Time	NAAQS/ SAAQS[b]	Concentration[c,d]	Location (Year)
SO_2	1-hour	75 ppb	–[e]	–
	3-hour	0.50 ppm	0.019 ppm (3.8)	Barnwell Co. (2004)
	24-hour	0.14 ppm	0.007 ppm (5.0)	Barnwell Co. (2003)
	Annual	0.03 ppm	0.002 ppm (6.7)	Barnwell Co. (2007)
NO_2	1-hour	0.100 ppm	–	–
	Annual	0.053 ppm	0.004 ppm (7.5)	Jackson, Aiken Co. (2007)
CO	1-hour	35 ppm	3.0 ppm (8.6)	Columbia, Richland Co. (2004)
	8-hour	9 ppm	2.3 ppm (26)	Columbia, Richland Co. (2004)
O_3	1-hour	0.12 ppm[f]	0.101 ppm (84)	Jackson, Aiken Co. (2007)
	8-hour	0.075 ppm	0.082 ppm (109)	Jackson, Aiken Co. (2007)
TSP	Annual geometric mean	75 $\mu g/m^3$	35.9 (49)	Cayce, Lexington Co. (2003)
PM_{10}	24-hour	150 $\mu g/m^3$	56 $\mu g/m^3$ (37)	Barnwell Co. (2006)
	Annual	50 $\mu g/m^3$	–	–
$PM_{2.5}$	24-hour	35 $\mu g/m^3$	34 $\mu g/m^3$ (97)	Jackson, Aiken Co. (2004)
	Annual	15.0 $\mu g/m^3$	14.5 $\mu g/m^3$ (97)	Jackson, Aiken Co. (2006)
Lead[g]	Calendar quarter	1.5 $\mu g/m^3$	0.00 $\mu g/m^3$ (0.0)	Aiken Co. (2003)
	Rolling 3 month	0.15 $\mu g/m^3$	–	–
Gaseous fluorides (as HF)	12 hours	3.7 $\mu g/m^3$ [h]	–	–
	24 hours	2.9 $\mu g/m^3$ [h]	–	–
	1 week	1.6 $\mu g/m^3$ [h]	–	–
	1 month	0.8 $\mu g/m^3$ [h]	–	–

[a] CO = carbon monoxide, HF = hydrogen fluoride, NO_2 = nitrogen dioxide, O_3 = ozone, $PM_{2.5}$ = particulate matter ≤2.5 μm, PM_{10} = particulate matter ≤10 μm, SO_2 = sulfur dioxide, TSP = total suspended particulates.

[b] The more stringent standard between the NAAQS and the SAAQS is listed when both are available.

[c] Monitored concentrations are the highest arithmetic mean for calendar-quarter lead; 2nd-highest for 3-hour and 24-hour SO_2, 1-hour and 8-hour CO, 1-hour O_3, and 24-hour PM_{10}; 4th-highest for 8-hour O_3; 98th percentile for 24-hour $PM_{2.5}$; arithmetic mean for annual SO_2, NO_2, PM_{10}, and $PM_{2.5}$; geometric mean for annual TSP.

[d] Values in parentheses are monitored concentrations as a percentage of SAAQS or NAAQS.

Footnotes continue on next page.

TABLE 10.1.1-3 (Cont.)

e A dash indicates that no measurement is available.

f On June 15, 2005, the EPA revoked the 1-hour O_3 standard for all areas except the 8-hour O_3 nonattainment EAC areas (those do not yet have an effective date for their 8-hour designations). The 1-hour standard will be revoked for these areas 1 year after the effective date of their designation as attainment or nonattainment for the 8-hour O_3 standard.

g Used old standard because no data in the new standard format are available.

h Arithmetic average.

Sources: 40 CFR 52.21; EPA (2008a, 2009); Flynn (2007); SCDHEC (2004, 2008)

concentrations because data were limited (for 2004–2006 only), but there was a general downward trend in O_3 concentrations during the period 1997–2006 (SCDHEC 2008). Measured concentration levels for TSP in the neighboring county of SRS were consistently less than 50% of the SAAQS, and no recent measurement data were available for hydrogen fluoride.

SRS and its vicinity are classified as PSD Class II areas. No Class I areas are located within 100 km (62 mi) of the GTCC reference location. The nearest Class I area is the Cape Romain National Wildlife Refuge, about 190 km (120 mi) east of the GTCC reference location; it is the only Class I area in South Carolina (40 CFR 81.426). The facilities at SRS have not been required to obtain a PSD permit (DCS 2002).

10.1.1.4 Existing Noise Environment

Aiken County has quantitative noise-limit ordinances by frequency band, as shown in Table 10.1.1-4, although the States of South Carolina and Georgia do not.

Similar to those at any other industrial site, major noise sources in active areas at SRS include industrial facilities and equipment (e.g., cooling systems, transformers, engines, vents, paging systems), construction and materials-handling equipment, and vehicles. Noise impacts on the general public arise primarily from transportation of people and materials to and from the site by vehicles, helicopters, and trains (DCS 2002).

SRS is located in a rural setting, and no residences and sensitive receptors (e.g., schools, hospitals) are located in the immediate vicinity of the GTCC reference location. Most SRS activities are far enough from the site boundaries and any neighboring communities, and trees and other vegetation in-between tend to attenuate sound considerably, so the associated noise levels at the boundary are not measurable or are barely distinguishable from background levels. A noise survey was conducted in the SRS area in 1989 and 1990 (NUS Corporation 1990). Seven off-site locations were selected along major routes used by SRS employees entering and leaving the site. Summer L_{dn} levels ranged from 62 to 72 dBA; winter L_{dn} levels ranged from

TABLE 10.1.1-4 Maximum Allowable Noise Levels in Aiken County, South Carolina

Frequency Band (Hz)	Maximum Allowable Sound Pressure Levels at Property Boundary (dB)	
	Residential	Nonresidential
0–75	72	79
75–150	67	74
150–300	59	66
300–600	52	59
600–1,200	46	53
1,200–2,400	40	47
2,400–4,800	34	41
4,800–10,000	32	39

Source: County of Aiken (2008)

51 to 70 dBA. Measured L_{dn} levels at three on-site locations were in a range of 54–62 dBA in summer and 37–59 dBA in winter. These levels for a typical rural environment primarily result from the traffic and/or bird and insect noise. For the general area surrounding SRS, the countywide L_{dn} levels based on population density are estimated to be 36, 38, and 43 dBA for Allendale, Barnwell, and Aiken Counties, respectively, typical of rural areas (Miller 2002; Eldred 1982).

10.1.2 Geology and Soils

10.1.2.1 Geology

10.1.2.1.1 Physiography. SRS is located on the Aiken Plateau of the Upper Atlantic Coastal Plain physiographic province, about 40 km (25 mi) southeast of the fall line, an erosional scarp that separates the crystalline rocks of the Piedmont province to the west from the sedimentary rocks of the Atlantic Coastal Plain (Figure 10.1.2-1). The Coastal Plain is underlain by a wedge of seaward-dipping unconsolidated and poorly consolidated sediments deposited during a series of sea transgressions and regressions and reflecting a variety of depositional environments, including fluvial, deltaic, and shallow marine. The sediments increase in thickness from zero at the fall line to more than 1,219 m (4,000 ft) near the South Carolina coast. At SRS, Coastal Plain sediments range in thickness from about 183 to 366 m (600 to 1,200 ft) (Hunt 1973; Aadland et al. 1995; Denham 1995; Fallaw and Price 1992).

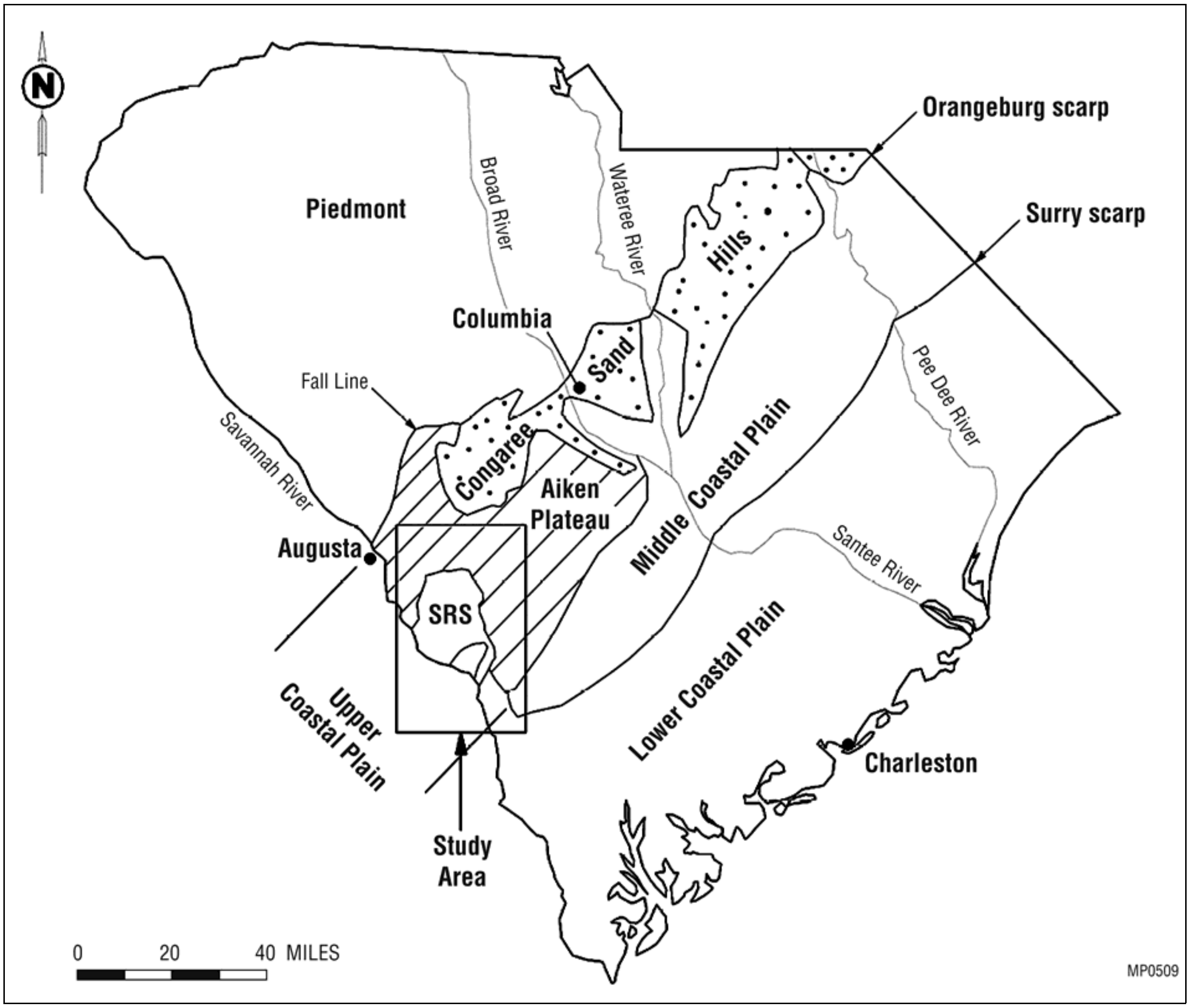


FIGURE 10.1.2-1 Location of SRS on the Atlantic Coastal Plain near the Fall Line (Source: Wyatt et al. 2000)

The Aiken Plateau is bounded by the Savannah and Congaree Rivers. It is highly dissected and characterized by broad interfluvial areas with narrow, steep-sided valleys. Regional dip is to the southeast; the plateau slopes from an elevation of approximately 200 m (650 ft) above MSL at the fall line to an elevation of about (250 ft MSL) on its southeast edge. It is typically well drained, although poorly drained sinks and depressions occur in topographically high areas (above 75 m MSL [250 ft MSL]). Because SRS is situated near the Piedmont province, its relief is greater than near-coastal areas, with on-site elevations ranging from 128 m MSL (420 ft MSL) near the Aiken Gate House on Road 2 to about 24.4 m MSL (80 ft MSL) where Steel Creek enters the Savannah River (Aadland et al. 1995; Denham 1995; Rogers 1990).

The Congaree Sand Hills region of the Coastal Plain province stretches across the base of the Piedmont province at the fall line, just to the north and northeast of the Aiken Plateau (Figure 10.1.2-1). The hills are composed of sandy soils and are typically gently sloping with rounded summits. The sand hills are remnants of ancient coastal dunes deposited during an episode of sea regression (Aadland et al. 1995).

10.1.2.1.2 Topography. The GTCC reference location is situated on a broad upland area typical of the Aiken Plateau. The elevation is fairly flat, ranging from about 90 to 100 m (300 to 330 ft) MSL, with an average slope of less than 4%. The upland area extends to the south but drops off steeply to the north, east, and west. Slopes range from 10% to 40% along the narrow valleys between the upland area and the floodplains along nearby Mill Creek, McQueen Branch, Tinker Creek, and Upper Three Runs.

10.1.2.1.3 Site Geology and Stratigraphy. Coastal Plain sediments at SRS consist of sand, silt, clay, limestone, and conglomerate ranging in age from Late Cretaceous to Holocene. These sediments are underlain by Paleozoic metamorphic rocks (gneiss and schist, with lesser amounts of quartzite) that have been intruded by somewhat younger Paleozoic granitic plutons. In the southeastern portion of SRS, coastal plain sediments have a thickness of up to 366 m (1,200 ft) and rest unconformably on (Mesozoic Triassic) age rocks in the Dunbarton basin (Fallaw and Price 1995; Prowell 1996).

The GTCC reference location is about 32 km (2 mi) to the east-northeast of the Z-Area, in the north-central portion of SRS. It is situated on an upland ridge overlooking Tinker Creek to the north, on unconsolidated Tertiary sediments (Tobacco Road sand; Figure 10.1.2-2). Tertiary deposits make up a majority of surface exposures and most of the shallow subsurface rocks at SRS. These deposits represent marine (deltaic) and marginal marine (fluvial) depositional environments typical of the Coastal Plain province (Prowell 1996).

The following summary of stratigraphy at the SRS is based on the work of Fallaw et al. (1992), Fallaw and Price (1995), Prowell (1996), and Wyatt et al. (2000). Figure 10.1.2-2 shows the geology of the area surrounding the GTCC reference location. Figure 10.1.2-3 presents a stratigraphic column for the SRS and vicinity.

Paleozoic and Triassic Basement Rock. Igneous and metamorphic rocks of the Piedmont and Blue Ridge provinces are the source of sediments in the Coastal Plain. Rocks similar to those exposed in the Piedmont province underlie the Coastal Plain sediments at the SRS. These include metamorphic rocks (slate, phyllite, schist, gneiss), volcanic and metavolcanic rocks, and intrusive rocks (granite) of Paleozoic age that formed during several orogenic episodes in the Appalachians.

The southeastern portion of SRS is underlain by rocks of the Triassic Newark Supergroup in Dunbarton Basin. The Dunbarton Basin is a Triassic-Jurassic rift basin filled with lithified terrigenous and lacustrine sediments (predominantly fanglomerate, sandstone, siltstone, and mudstone), with minor amounts of mafic volcanic and intrusive rock.

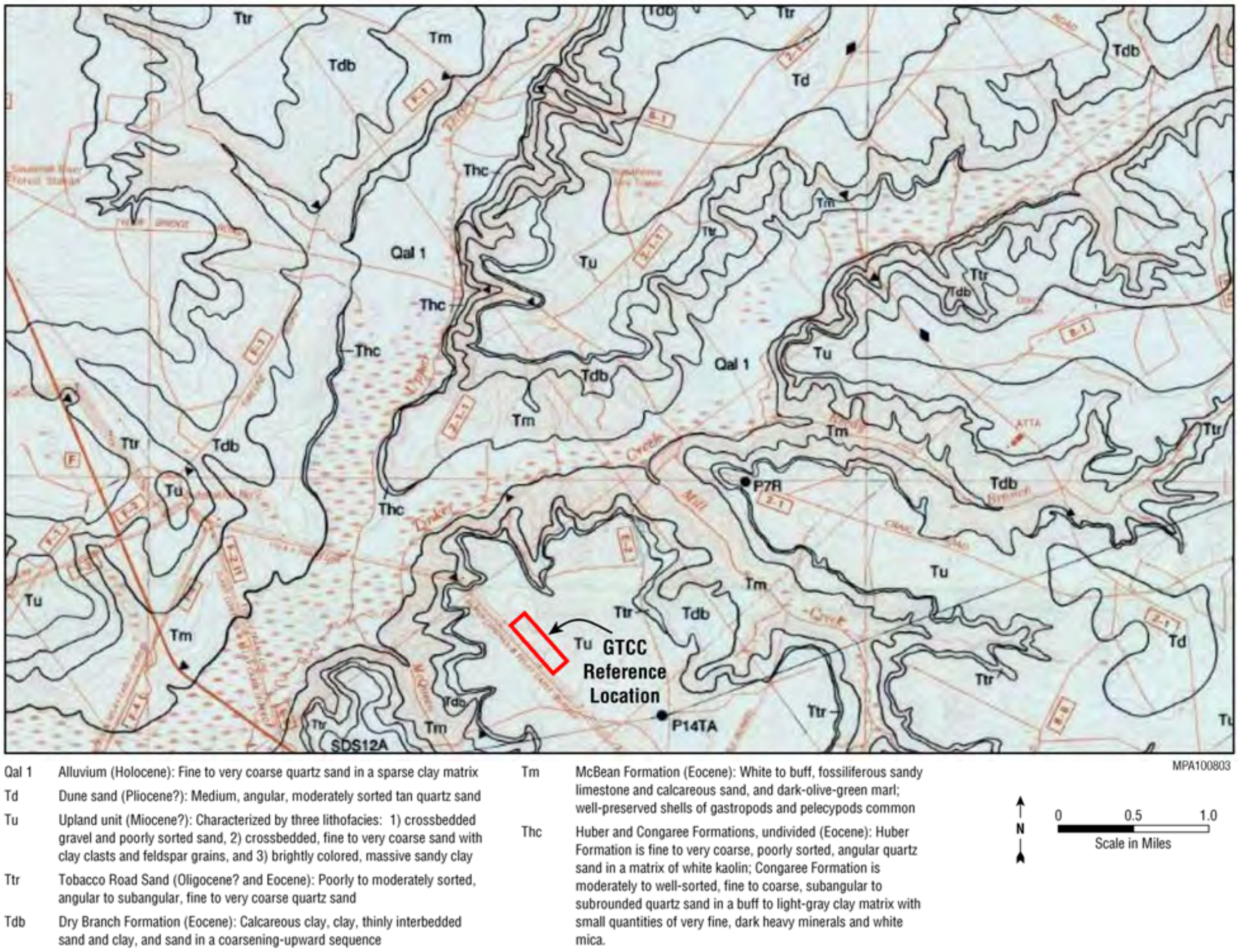


FIGURE 10.1.2-2 Geologic Map of the GTCC Reference Location at SRS (Source: Adapted from Prowell 1996)

The surface of the Paleozoic rocks and Triassic sediments was leveled by erosion over time, forming the basement rock over which Coastal Plain sediments were deposited. The surface of the basement rock dips about 9.5 m/km (50 ft/mi) to the southeast at SRS.

Upper Cretaceous Sediments. Upper Cretaceous sediments overlie Paleozoic basement rock or lower Mesozoic (Triassic) rocks throughout SRS. The Upper Cretaceous section is divided into four units (from older to younger): Cape Fear Formation, Middendorf Formation, Black Creek Group, and Steel Creek Formation. Its thickness at SRS ranges from 120 m (400 ft) at the site's northwestern boundary to 240 m (800 ft) at the southeastern boundary. The sediments are typical of braided stream deposits, consisting predominantly of poorly consolidated, clay-rich, fine- to medium-grained micaceous sand, sandy clay, and gravels, suggesting a high relief in the Appalachians during this time.

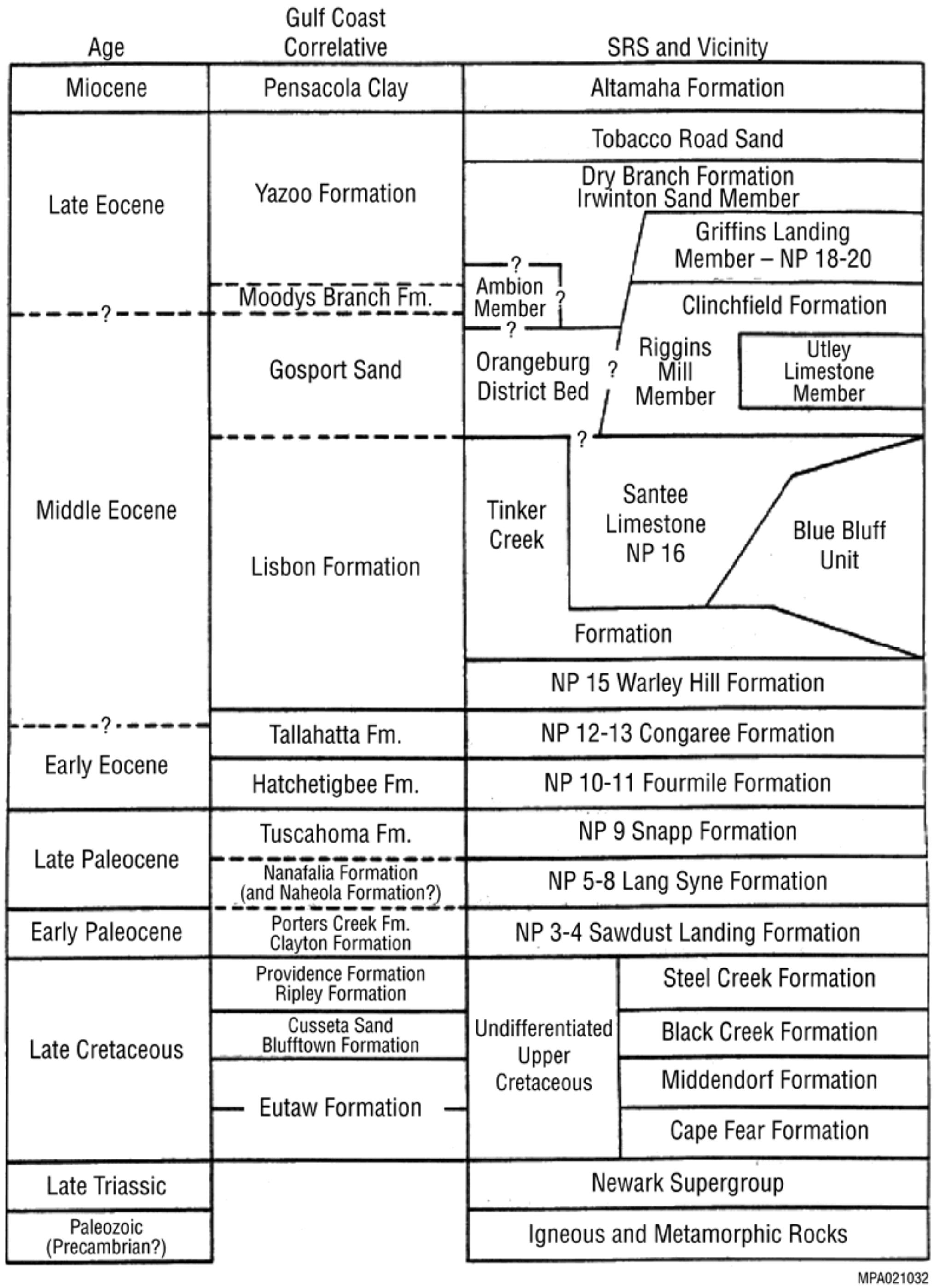


FIGURE 10.1.2-3 Stratigraphic Column for SRS and Vicinity (Source: Adapted from Fallaw and Price 1995)

Tertiary (Paleocene, Eocene and Miocene) Sediments. Tertiary sediments range in age from Early (Lower) Paleocene to Miocene. These sediments consist predominantly of light-colored, kaolinitic, coarse-grained, cross-bedded quartz sands, micaceous sands, and kaolin, and they were deposited in fluvial to marine shelf environments.

Quaternary Deposits. SRS lies within the interfluvial area between the Savannah and Salkehatchie Rivers; its drainage systems consist entirely of streams that are tributaries of the Savannah River. Fluvial terraces are preserved above the modern floodplain along the river and some of its major tributaries. These features, along with colluvial and alluvial deposits, make up the Quaternary section at SRS.

10.1.2.1.4 Seismicity. Earthquakes have been recorded in both the Piedmont and Coastal Plain provinces of South Carolina. Most of the seismicity in the Piedmont province has been associated with reservoirs in northwestern and central South Carolina. The largest earthquake in the Piedmont occurred in Union County in 1913 (with a modified Mercalli intensity of VI to VIII and an estimated body wave magnitude of 4.5), about 150 km (93 mi) north of SRS (Stephenson 1992; DOE 2002).

Seismicity in the Coastal Plain occurs in three distinct zones: Middleton Place-Summerville seismic zone (MPSSZ), about 20 km (12 mi) northwest of Charleston; Bowman seismic zone, about 60 km (37 mi) northwest of the MPSSZ; and Adams Run seismic zone, about 30 km (19 mi) southwest of the MPSSZ. Earthquakes also occur in spatially isolated areas of the Coastal Plain. The largest earthquake in the southeastern United States occurred in the South Carolina Coastal Plain in 1886 (with a measured body wave magnitude of 6.7); its epicenter was about 20 to 30 km (12 to 19 mi) northwest of Charleston in the MPSSZ. The Charleston area is considered the most seismically active region in the Coastal Plain province, and it is the most significant source of seismicity affecting SRS (Stephenson 1992).

Figure 10.1.2-4 shows the major fault lines (and relative movement along them) at SRS, based on the work of Stephenson and Stieve (1992) and Wike et al. (1996). The lines shown are projections to the ground surface; the actual faults do not reach the ground surface (most are several hundred feet bgs). The Upper Three Runs fault (a Paleozoic fault located in the crystalline rock below the Coastal Plain sediments) crosses SRS about 1.6 km (1 mi) to the north and west of E-Area.

None of the fault systems at SRS is considered “capable” (as defined in 10 CFR Part 100) because there has been no movement along these faults that can be traced to the ground surface in the past 35,000 years (DOE 2002).

The locations of earthquakes at SRS are also shown on Figure 10.1.2-4. They include the most recent earthquake, which occurred on October 8, 2001, near Upper Three Runs Creek, about 2.5 km (1.6 mi) north of the GTCC reference site. It had a body wave magnitude of 2.6 and a focal depth of about 3.9 km (2.4 mi). Three earthquakes with magnitudes ranging from 2.0 to 2.6 occurred before this 2001 event and after the SRS seismic recording network was

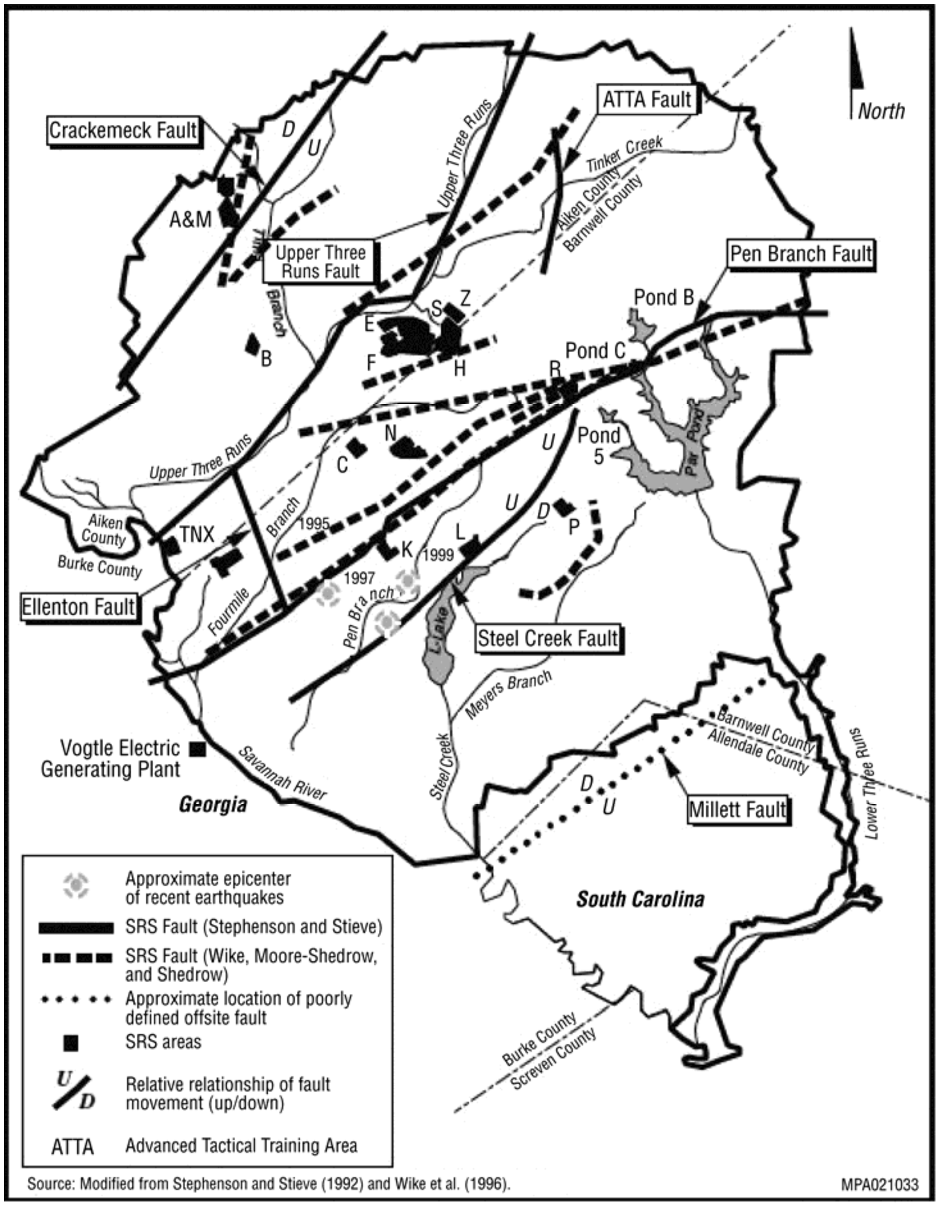


FIGURE 10.1.2-4 Seismic Fault Lines and Locations of On-Site Earthquakes at SRS (Source: Adapted from DOE 2002)

installed in 1976; all were clustered near the south-central region of SRS (Stevenson and Talwani 2004; DOE 2002). Also, a 3.2-magnitude earthquake occurred on August 8, 1993, near Aiken, South Carolina, about 19 km (12 mi) to the north of the SRS north boundary. It was felt most strongly in Couchton, South Carolina (Stevenson and Talwani 2004).

Probabilistic seismic hazard assessments conducted since the late 1960s have determined the seismic design basis for SRS reactors to be 0.20g peak horizontal ground acceleration. These assessments have estimated the annual probability of exceeding the design basis to be within a range of 0.002 to 0.00005 (once every 500 to 20,000 years) (Stephenson 1992).

10.1.2.1.5 Volcanic Activity. There are no active volcanoes in the vicinity of SRS.

10.1.2.1.6 Slope Stability, Subsidence, and Liquefaction. No natural factors at the GTCC reference location have been reported that would affect the engineering aspects of slope stability, as long as the facility is built at some distance from the edge of the upland ridge to the north, east, and west. The upland area itself is fairly flat, with a slope of generally less than 4%.

The Santee Formation (Figure 10.1.2-3) comprises a soil zone of marine origin occurring at depths of 30 to 70 m (100 to 250 ft) across SRS. This zone has locally high concentrations of calcium carbonate and is characterized by a stronger matrix of material through which weak zones, referred to as "soft zones," are interspersed. Soft zones occur in the saturated zone and are generally stable under static conditions (showing minimal carbonate dissolution). However, load increases that could result from a seismic event could lead to subsidence, especially in areas where the soft zone is thick and laterally extensive. It is not known whether soft zones exist below the GTCC reference site (Aadland et al. 1999; WSRC 2000).

Liquefaction of saturated sediments is a potential hazard during or immediately after large earthquakes. Whether soils will liquefy depends on several factors, including the magnitude of the earthquake, peak ground velocity, liquefaction susceptibility of soils, and depth to groundwater. Previous studies at other SRS sites (e.g., F-Area) found the liquefaction susceptibility of soils to be low because of their low clay content and liquid limit and because earthquakes at SRS historically do not have the shear wave velocities required to subject soils to liquefaction (WSRC 2000). Lewis et al. (2004) also report that the liquefaction potential for soils at SRS is very low; soil strength is attributed to factors such as aging and over-consolidation.

10.1.2.2 Soils

The undisturbed soils within the study area are predominantly sands, and they overlie a substratum of loamy sand or sandy clay loam. These soils tend to be low in organic content and water storage capacity. Upland soils (Ailey and Lakeland sands) are gently sloping (0 to 6%) and well to excessively drained. These soils have a permeability that ranges from low to high and a low erosion hazard rating. Soils on the southeastern banks of Upper Three Runs Creek and Tinker Creek (Troup and Lucy sands) occur on steep slopes (15 to 25%) and are well drained. These soils are moderately permeable and have a moderate erosion hazard rating (Rogers 1990).

10.1.2.3 Mineral and Energy Resources

There are no reported mineral or energy resources being developed within the boundaries of SRS. Economic mineral resources in South Carolina include gold, copper, lead, zinc, silver, titanium, rare earths, zirconium, tin, refractory minerals, lithium, mica, and feldspar minerals. Industrial resources include clay, limestone, sand, gravel, crushed rock, building stone, slate, and aggregate.

10.1.3 Water Resources

10.1.3.1 Surface Water

10.1.3.1.1 Rivers and Streams. The major surface water systems and their 100-year floodplains at the 800-km^2 (310-mi^2) SRS are shown in Figure 10.1.3-1. SRS streams and the Savannah River are classified as “freshwater,” which is defined as surface water that is suitable (1) for primary and secondary contact recreation, (2) as a source of drinking water after conventional treatment, (3) for fishing and the survival and propagation of a balanced indigenous aquatic community of fauna and flora, and (4) for industrial and agricultural uses. None of these water features are classified as Wild and Scenic.

The largest river in the area is Savannah River, which forms the southwestern border of SRS for about 32 km (20 mi). It is formed by the confluence of the Tugaloo and Seneca Rivers in northeast Georgia. The Savannah River watershed drains about 27,388 km^2 (10,547 mi^2) and encompasses western South Carolina, eastern Georgia, and a small portion of southwestern North Carolina. It forms the boundary between Georgia and South Carolina. At SRS, flow within the Savannah River averages about 283 cms (10,000 cfs) (DOE 2002; Wike et al. 2006).

Five upstream reservoirs — Jocassee, Keowee, Hartwell, Richard B. Russell, and Strom Thurmond/Clarks Hill — moderate the effects of droughts and low flows on downstream water quality and accompanying impacts on aquatic and wildlife resources that depend on the river (DOE 1997, 2002; Wike et al. 2006).

Upstream of SRS, the Savannah River supplies domestic and industrial water for Augusta, Georgia, and for North Augusta, South Carolina. The river also receives sewage treatment plant effluents from Augusta, Georgia; North Augusta, Aiken, and Horse Creek Valley, South Carolina; and from a variety of SRS operations through permitted stream discharges. About 209 river km (130 river mi) downstream, the river supplies domestic and industrial water for the Port Wentworth (Savannah, Georgia) water treatment plant at River Mile 29 and for Beaufort and Jasper Counties in South Carolina at River Mile 39.2. Georgia Power’s Vogtle Electric Generating Plant withdraws an average of 1.3 cms (46 cfs) for cooling and returns an average of 0.35 cms (12 cfs). Also, SCE&G’s Urquhart Steam Generating Station at Beech Island, South Carolina, withdraws approximately 7.4 cms (261 cfs) of once-through cooling water (DOE 1997, 2002).

There are five SRS tributaries that discharge directly into the Savannah River: Upper Three Runs Creek, Beaver Dam Creek, Fourmile Branch, Steel Creek, and Lower Three Runs (Figure 10.1.3-1). A sixth tributary, Pen Branch, discharges to the Savannah River floodplain swamp. All these streams flow to the south/southwest, descending 15.2 to 61 m (50 to 200 ft) before discharging into the river. These streams have historically received effluent from SRS operating areas; they are not commercial sources of water.

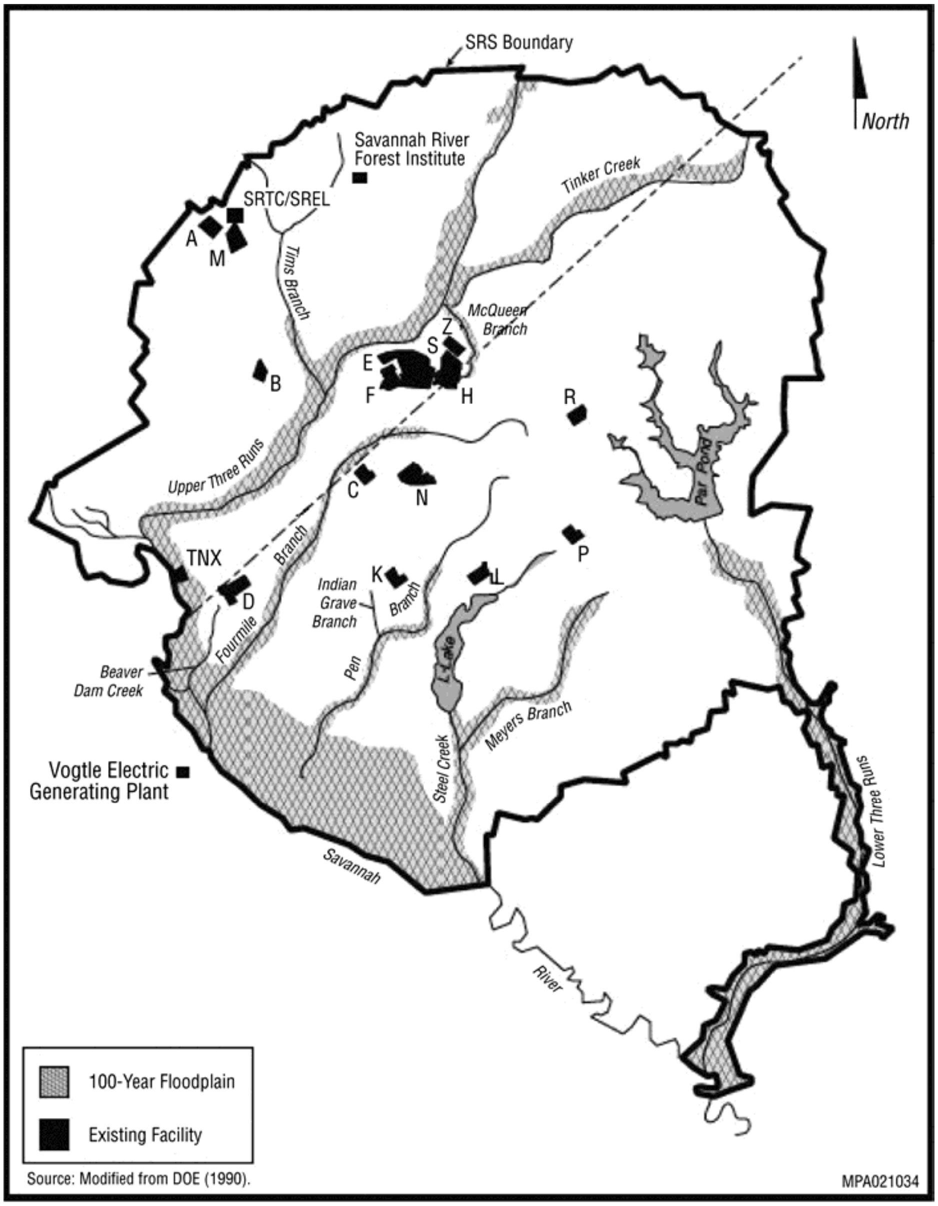


FIGURE 10.1.3-1 Major Surface Water Stream Systems and the 100-Year Floodplain at SRS (Source: DOE 2002)

E-Area is situated between F-Area and H-Area on a divide that separates the drainage into the Upper Three Runs Creek to the north (with its tributaries Tinker Creek, McQueen Branch, Crouch Branch, and Tims Branch) and Fourmile Branch to the south. The upper aquifer zone of the Upper Three Runs Aquifer crops out and seeps along both the Upper Three Runs and Fourmile Branch (DOE 2002; Wike et al. 2006). The GTCC reference location at SRS is situated a short distance northeast of Z-Area, which is located about 5 km (3 mi) northeast of E-Area.

Z-Area is located just west of McQueen Branch, near the confluence of McQueen Branch and Upper Three Runs Creek. McQueen Branch is joined by the Tinker Branch on SRS. Tinker Branch then joins Upper Three Runs Creek about 50 km (31 mi) downstream of the McQueen/Tinker Creek confluence. McQueen Branch is typical of the streams in the area; it has a small gradient, a predominantly sandy substrate, little gravel, and no cobble or bedrock (Sheldon and Meffe 1994).

10.1.3.1.2 Upper Three Runs Creek. Upper Three Runs Creek, the longest of the SRS streams, is a large, blackwater stream just north of the General Separations Area (GSA). The GSA is a 40-km^2 (15-mi^2) region in central SRS that includes the E-, F-, H-, S-, and Z-Areas (Figure 10.1.3-1). A blackwater stream has a dark color attributable to tannins released from the decomposition of leaves and acids released from heavily organic soils (North Augusta 2004). The creek is about 40-km (25-mi) long, with its lower 28 km (17 mi) being within the boundaries of SRS. It drains an area of about 545 km^2 (209 mi^2) and flows to the southwest, discharging directly into the Savannah River. Its two significant tributaries are Tinker Creek, the largest, and Tims Branch. Upper Three Runs Creek receives more water from underground sources than do other SRS streams, and it is the only stream with headwaters that arise off-site (near Aiken, South Carolina) (DOE 2002; Wike et al. 2006).

The creek receives various NPDES-permitted effluents (either directly or through its tributaries), including cooling water, blowdown, stormwater, lab drains, air stripper discharge, steam condensate, M-Area wastes, process water, neutralization wastewater, and F/H-Area Effluent Treatment Project (ETP) wastewater. It is the only major tributary that has not received thermal discharges. The F/H-Area ETP discharges to the creek just downstream of the Road C bridge (DOE 2002; Wike et al. 2006; Mast and Turk 1999).

Stream flow was monitored between 1974 and 2002 at three locations on Upper Three Runs Creek, including two on-site locations (Road A [Station 02197315] and Road C [Station 02197310]). Annual discharge at the stations at Road C between 1975 and 2002 (based on a water year, which lasts from October of one year through September of the next year) averaged 5.78 cms (204.2 cfs), with a range of 3.45 cms (121.8 cfs) in 2002 to 8.34 cms (294.5 cfs) in 1995. At Road A station, it averaged 6.63 cms (234.3 cfs), with a range of 3.68 cms (130.0 cfs) in 2002 to 8.21 cms (289.8 cfs) in 1991 (USGS 2007). Neither station is currently monitored; no data after September 2002 are available (Wike et al. 2006).

10.1.3.1.3 Fourmile Branch. Fourmile Branch is a blackwater stream that originates to the south of the GSA. It is about 24-km (15-mi) long. The stream drains an area of about 57 km^2 (22 mi^2) and flows to the southwest, discharging through a main delta channel into the Savannah River. A small portion of its discharge flows west and enters Beaver Dam Creek. When the Savannah River floods, water from Fourmile Branch flows south along the northern boundary of a floodplain swamp and joins Pen Branch and Steel Creek (DOE 2002; Wike et al. 2006).

Fourmile Branch receives various NPDES-permitted effluents from the F-, H-, and C-Areas and Central Shops. Discharges from the C Reactor ceased after it shut down in 1985. (Prior to that, thermal discharges of reactor cooling water were discharged to Castor Creek, a tributary to Fourmile Branch.) Effluent discharges from the Central Sanitary Wastewater Treatment Facility (CSWTF) began in 1995.

Stream flow was monitored between 1974 and 2002 at two locations on Fourmile Branch (Site No. 7 [Station 02197342], just upstream of Castor Creek, and Road A-12.2 [Station 02197344]). Annual discharge at Site No. 7 between 1975 and 2002 (based on a water year) averaged 0.47 cms (16.5 cfs), with a range of 0.19 cms (6.78 cfs) in 2002 to 0.93 cms (32.7 cfs) in 1991. Annual discharge at Road A-12.2 between 1986 (when C Reactor discharges were discontinued) and 2002 (based on a water year) averaged 0.90 cms (31.9 cfs), with a range of 0.30 cms (10.6 cfs) in 2002 to 1.79 cms (63.1 cfs) in 1991 (USGS 2007). Neither station is currently monitored; no data after September 2002 are available (Wike et al. 2006).

Both Fourmile Branch and Upper Three Runs Creek at SRS are prone to flooding. Upstream reservoirs, additional tributaries, and crossing conduits complicate floodplain analyses. However, a 100-year floodplain has been produced for the site (Figure 10.1.3-1). Flood potential is greatest along the southwestern boundary of the site along the Savannah River. The potential for flooding in the E-Area and nearby Z-Area is small; any flooding would occur on the north side of Upper Three Runs Creek and along McQueen Branch.

10.1.3.1.4 Reservoirs. There are two reservoirs at SRS: L Lake and Par Pond (Figure 10.1.3-1). Both ponds are located south of the GSA. L Lake is in the south-central portion of the site. It was formed in 1985 by damming the headwaters of Steel Creek about 7.2 km (4.5 mi) above its mouth. Its average width is about 0.64 km (0.40 mi), reaching a maximum of about 1.3 km (0.8 mi). At its normal pool elevation of 58 m (190 ft) MSL, the dam impounds about 31 million m^3 (1,100 million ft^3) of water. L Lake gains water via groundwater flow at its upstream end and loses water to the groundwater system along its downstream shorelines (Wike et al. 2006).

Par Pond is a 1,012-ha (2,500-ac) reactor-cooling reservoir created in 1958 by constructing an earthen dam, Cold Dam, across Lower Three Runs Creek (Wike et al. 2006). It was constructed to augment the cooling system for the P and R Reactors. Par Pond's capacity is 85,900 ac-ft (3,742 million ft^3); normal storage is 54,400 ac-ft (2,370 million ft^3). Maximum discharge from Cold Dam is 66 cms (2,340 cfs) (Find Lakes 2008). The pond runs along the course of Poplar Branch, Joyce Branch, and the upper reach of the Lower Three Runs drainage system. The reservoir surface elevation fluctuates between 61.0 and 59.4 m (200 and 195 ft) MSL.

10.1.3.1.5 Other Surface Water. Other surface waters at SRS include the Savannah River swamp, wetlands, and Carolina Bays. The SRS Savannah River swamp borders 16 km (10 mi) of SRS and has an average width of about 2.2 km (1.4 mi). About 3,800 ha (9,400 ac) of the Savannah River swamp lie within SRS between Upper Three Runs Creek and Steel Creek. A levee and embankment run along the east side of the Savannah River. Breaches in the levee allow water from Beaver Dam Creek, Fourmile Branch, and Steel Creek to flow to the river. The combined discharges of Steel Creek and Pen Branch enter the river near the southeast edge of the swamp. During periods of high water, river water overflows the levee and floods the swamp. The river begins to overflow into the swamp when river elevations reach between 27 and 28 m (89 and 92 ft) above MSL or at flows of about 433 cms (15,300 cfs). During flooding, the water from SRS streams flows through the swamp parallel to the river and enters the river downstream of Steel Creek (Wike et al. 2006). There are no wetlands in the vicinity of Z-Area.

10.1.3.1.6 Surface Water Quality. Contamination in the Upper Three Runs Creek and Fourmile Branch watersheds is related to operational areas F and H and has been listed in the *Federal Facility Agreement for the Savannah River Site* (WSRC 1993). Table 10.1.3-1 summarizes the water quality of Upper Three Runs Creek and Fourmile Branch for 1998.

Tritium, the predominant radionuclide detected above background levels in SRS streams, was observed at all stream locations in 2006 except the Upper Three Runs Creek control point and Site X-008 near T-Area. In 2006, tritium concentrations generally declined in all site streams, except in Steel Creek, where they remained stable. In 2006, tritium concentrations in Upper Three Runs Creek and Fourmile Branch were 189 and 650 pCi/L, respectively. Tritium measured in the Savannah River below SRS in 2006 was 3,830 pCi/L. No detectable concentrations of Co-60 were observed in any of the five major SRS streams. The maximum concentration of Cs-137 in Fourmile Branch was 34.9 pCi/L; for Upper Three Runs Creek, the maximum Cs-137 concentration was 5.0 pCi/L. Maximum gross beta measurements taken in 2006 at Upper Three Runs Creek and Fourmile Branch were 2.84 and 35.1 pCi/L, respectively. Gross alpha values, at the same time, were 1.59 and 14.0 pCi/L, respectively (WSRC 2007a).

Cs-137 and Co-60 were the only man-made gamma-emitting radionuclides observed in river and stream sediments. The highest Cs-137 concentration in streams, 497 pCi/g, was detected in sediment from R Canal; the lowest levels were below detection at several locations. The highest level found on the river, 0.486 pCi/g, was measured at River Mile 129. Co-60 was detected in stream sediment at a concentration of 0.441 pCi/g at the R Canal location — the only location where Co-60 was detected. Sr-89 and Sr-90 were above the minimum detectable concentrations in sediment at six stream locations. The maximum detected value was 0.37 pCi/g at the Fourmile Branch at the Road A-7 location. Pu-238 was detected in sediment during 2006 at all stream locations and at four river locations. The results ranged from a maximum of 0.139 pCi/g at FM-A7 to below detection at several locations. Pu-239 was detected in sediment

TABLE 10.1.3-1 Water Quality Data for Upper Three Runs Creek and Fourmile Branch in 1998

Parameter[a]	Unit of Measure	Fourmile Branch (FM-6) Average	Upper Three Runs (U3R-4) Average	Water Quality Criterion,[b] MCL,[c] or DCG[d]
Aluminum	mg/L	0.285[e]	0.294[e]	0.087
Cadmium	mg/L	NR[f]	NR	0.00066
Calcium	mg/L	NR	NR	NA[g]
Ce-137	pCi/L	4.74	0.67	120[d]
Chromium	mg/L	ND[h]	ND	0.011
Copper	mg/L	0.006	ND	0.0065
Dissolved oxygen	mg/L	8.31	6.3	≥5
Iron	mg/L	0.717	0.547	1
Lead	mg/L	0.18	0.011	0.0013
Magnesium	mg/L	NR	NR	0.3
Manganese	mg/L	0.045	0.026	1
Mercury	mg/L	0.0002	ND	0.000012
Nickel	mg/L	ND	ND	0.088
Nitrate (as nitrogen)	mg/L	1.29	0.26	10[c1]
pH	pH	6.4	5.8	6–8.5
Pu-238	pCi/L	0.003	ND	1.6[d]
Pu-239	pCi/L	0.001	0.005	1.2[d]
Sr-89 and Sr-90	pCi/L	6.79	0.04	8[c2]
Suspended solids	mg/L	3.9	5.9	NA
Temperature[i]	°C	20.2	18.8	32.2
Tritium	pCi/L	1.9×10^5	4.2×10^3	20,000[c2]
U-234	pCi/L	0.69	0.093	20[d]
U-235	pCi/L	0.053	0.046	24[d]
U-238	pCi/L	0.84	0.11	24[d]
Zinc	mg/L	0.019	0.02	0.059

[a] Parameters DOE routinely measures as a regulatory requirement or as part of ongoing monitoring programs.

[b] Water quality criterion is “aquatic, chronic toxicity” unless otherwise indicated.

[c] MCL = maximum contaminant level: State Primary Drinking Water Regulations.
c1 = Chapter 61-58.5 (b)(2)h of Arnett and Mamatey (1999); c2 = Chapter 61-58.5(h)(2)b of Arnett and Mamatey (1999).

[d] DCG = DOE derived concentration guides for water (DOE Order 5400.5). DCG values are based on a committed effective dose of 100 mrem per year; however, because the drinking water MCL is based on 4 mrem per year, the value listed is 4% of DCG.

[e] Concentration exceeded water quality criterion; however, these criteria are for comparison only. Water quality criteria are not legally enforceable.

[f] NR = not reported.

[g] NA = not applicable.

[h] ND = not detected.

[i] Shall not be increased more than 2.8°C (5°F) above natural temperature conditions or exceed a maximum of 32.2°C (90°F) as a result of the discharge of heated liquids, unless an appropriate temperature criterion mixing zone has been established.

Sources: Arnett and Mamatey (1999); DOE (2002) at most stream locations and four river locations. The maximum value was 0.182 pCi/g, also found at FM-A7. U-234, U-235, and U-238 were detected at most locations (WSRC 2007a).

At every site, most nonradiological water quality parameters and metals were detected in at least one sample. Only three samples had detectable pesticides/herbicides in 2006. These results continue to indicate that SRS discharges are not significantly affecting the water quality of the on-site streams or the river. The maximum mercury concentration for Fourmile Branch in 2006 was 0.022 μg/L; the maximum aluminum concentration was 0.023 mg/L. No detectable pesticides or herbicides were found. In 2006, maximum concentrations of mercury and aluminum in Tims Branch (a tributary of Upper Three Runs Creek) were 0.02 μg/L and 0.5 mg/L, respectively. As was the case for Fourmile Branch, no detectable pesticides or herbicides were found (WSRC 2007a).

In 2006, as in the previous five years, no pesticides or herbicides were found to be above the quantitation limits in sediment samples from SRS surface waters. Results from metal analyses for 2006 also were comparable to those of the previous five years (WSRC 2007a).

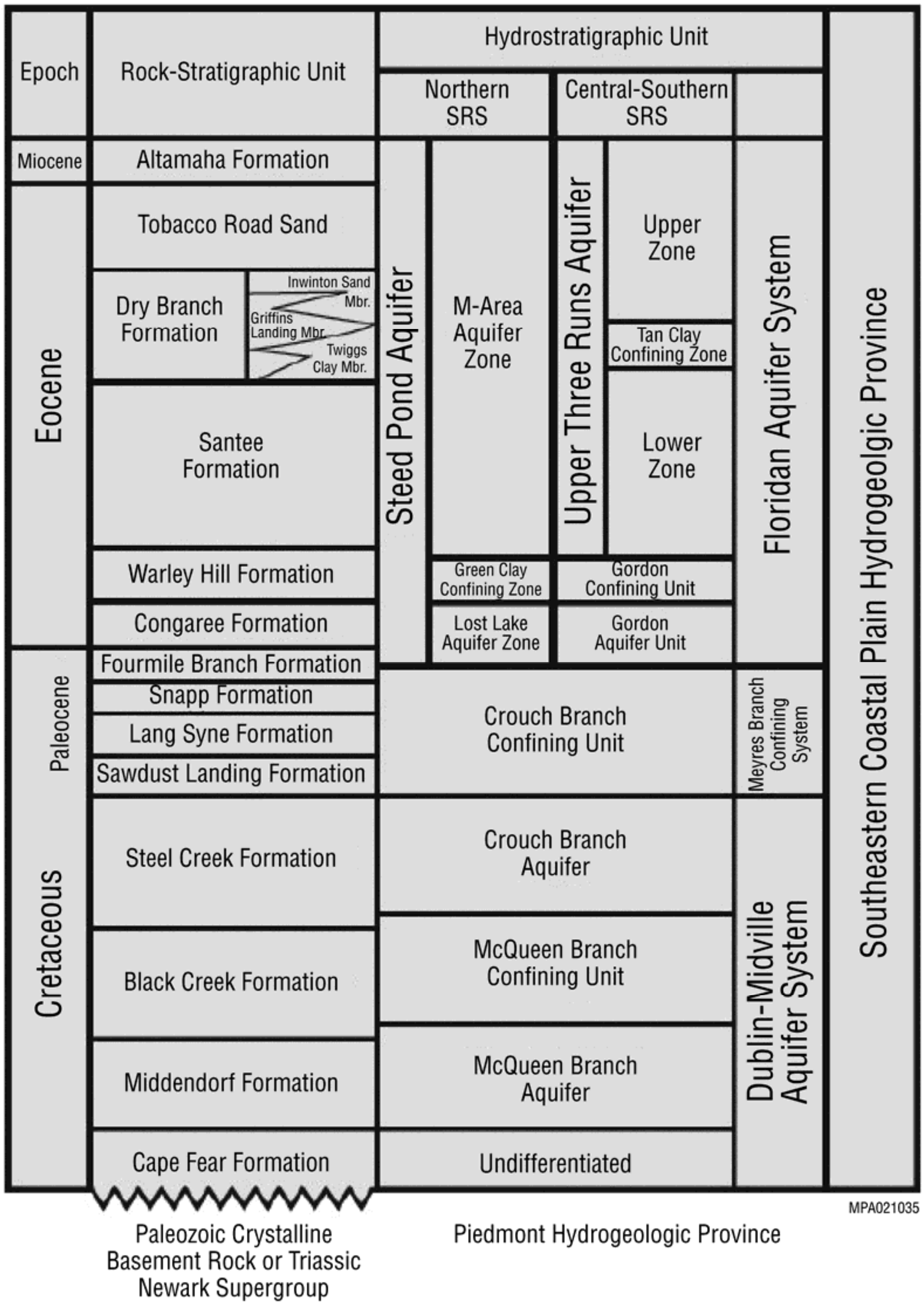
10.1.3.2 Groundwater

10.1.3.2.1 Unsaturated Zone. Groundwater at SRS occurs in both unsaturated (vadose) and saturated (phreatic) zones. In topographically high areas, the thickness of the unsaturated zone can reach 30 m (100 ft); in regions adjacent to streams, the thickness of the unsaturated zone can be small and varies from zero to tens of feet.

10.1.3.2.2 Aquifer Units. The sand and clay sediments of the Atlantic Coastal Plain are the principal source of groundwater for SRS. These sediments are collectively referred to as the Southeastern Coastal Plain hydrogeologic province. Beneath the GSA, there are two major aquifer systems — the overlying Floridan Aquifer System and the underlying Dublin-Midville Aquifer System — separated by the Meyers Branch Confining System. Figure 10.1.3-2 shows the hydrostratigraphic units within these systems at SRS and their relationship to the lithologic units described in Section 10.1.2.1, based on the nomenclature established by Aadland et al. (1995).

The following unit descriptions are taken from Aadland et al. (1995), Denham (1995), Harris et al. (1998), Flach and Harris (1999), Wyatt et al. (2000), and WSRC (2007a) and include information specific to two reference wells, P-27 and P-28, located near the GTCC reference location.

Floridan Aquifer System. The Floridan Aquifer System consists of a thick sequence of Paleocene to Miocene sands with minor amounts of gravel, clay, and limestone deposited in a marine environment. The aquifer system is divided into the overlying Upper Three Runs Aquifer and the underlying Gordon Aquifer, separated by the Gordon Confining Unit.



Source: Modified from Aadland et al. (1995) and Fallaw and Price (1995).

FIGURE 10.1.3-2 Hydrogeologic Units at SRS (Source: WSRC 2007a)

Upper Three Runs Aquifer Unit. The Upper Three Runs Aquifer Unit occurs between the water table and the Gordon Confining Unit (Figure 10.1.3-2). It includes all the strata above the Warley Hill Formation and the Blue Bluff Member of the Santee Limestone. The aquifer is defined by the hydrogeologic properties of the sediments penetrated in Reference Well P-27. In this well, the aquifer is about 40.2-m (132-ft) thick and consists mainly of quartz sand and clayey sand of the Tinker/Santee Formation; sand with interbedded tan to gray clay of the Dry Branch Formation; and sand, pebbly sand, and minor clay beds of the Tobacco Road Formation. Calcareous sand, clay, and limestone occur throughout the GSA.

The hydraulic head distribution within the Upper Three Runs Aquifer is controlled by the location and depth of incisement of streams that dissect the area. The incisement of streams divides the interstream areas of the water table aquifer into "groundwater islands" that behave independently, with their own unique recharge and discharge areas. Head distribution tends to follow the topography; higher heads occur in the interstream areas and decline in the direction of the bounding streams. Groundwater divides are present near the center of the interstream areas (Figure 10.1.3-3). Water table elevations range from 76 m (250 ft) MSL to the northwest of E-Area (Figure 10.1.3-4) and to about 30 m (100 ft) MSL near the Savannah River.

The porosity and permeability of the Upper Three Runs Aquifer are variable across SRS and are reduced by the presence of interstitial silt and clay and poorly sorted sediments.

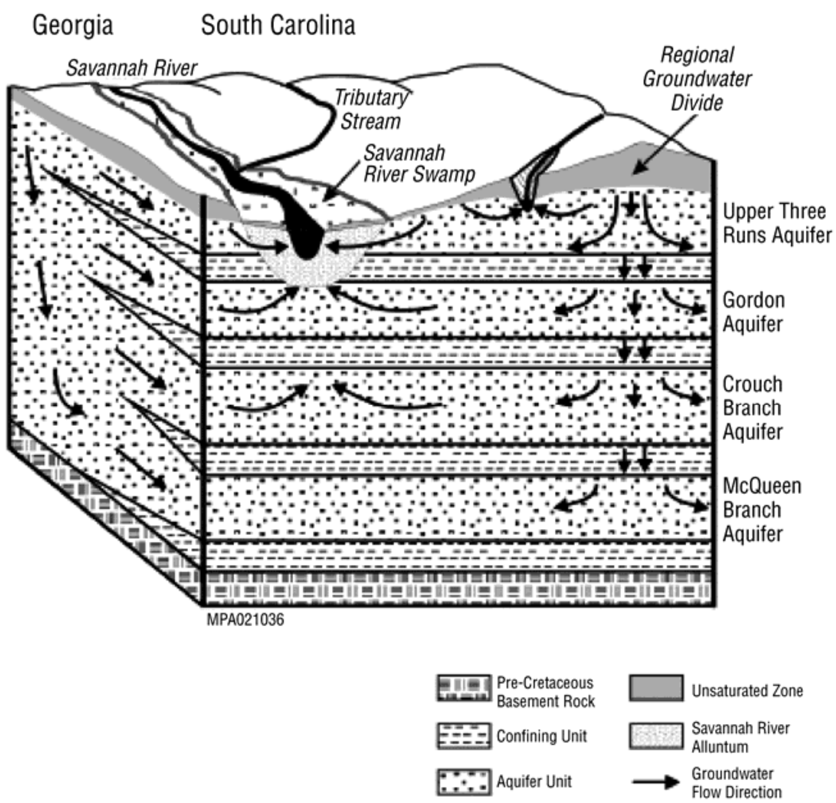


FIGURE 10.1.3-3 Groundwater Flow System at SRS
(Source: WSRC 2007a)

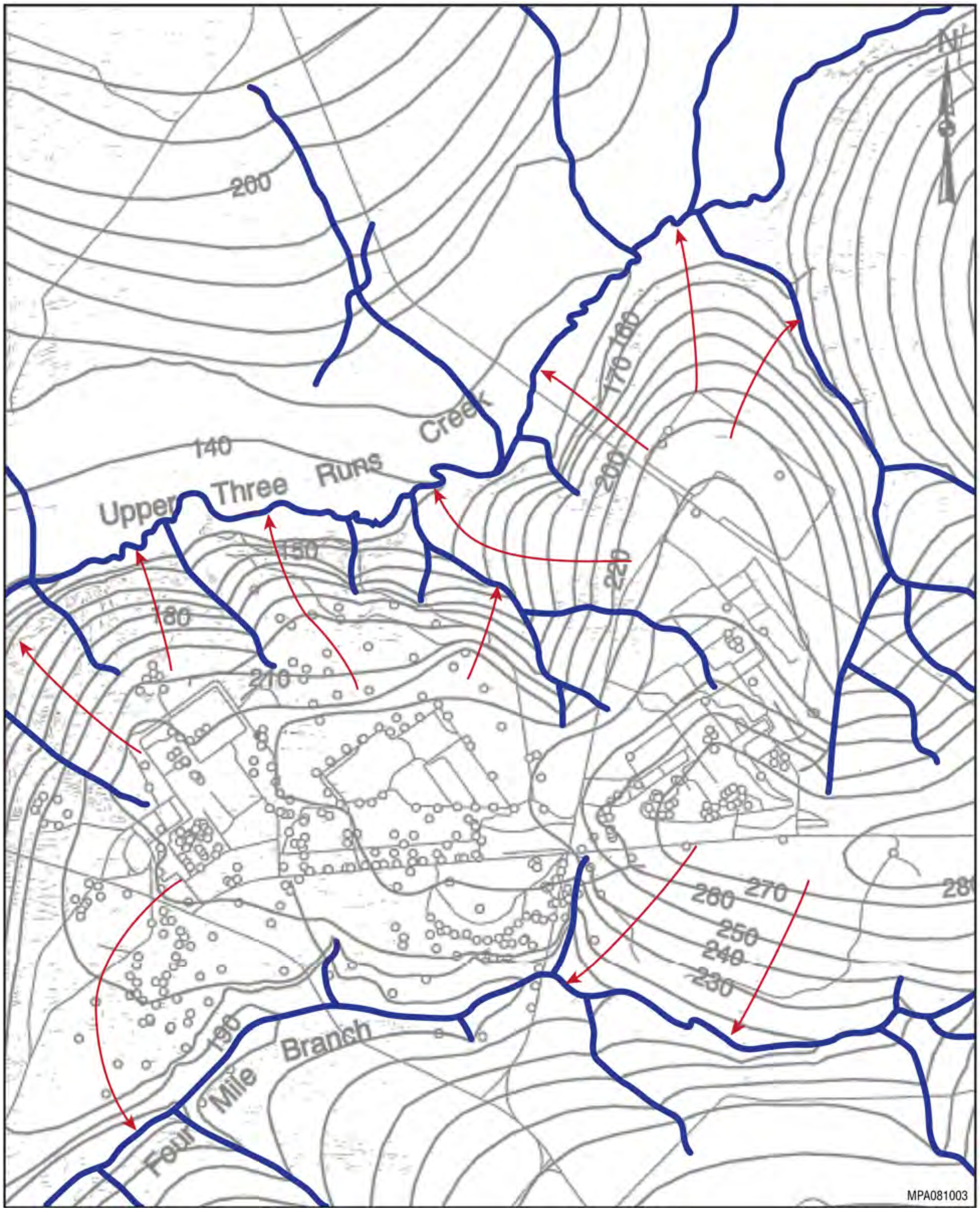


FIGURE 10.1.3-4 Water Table Elevation in the Vicinity of the General Separations Area at SRS (Source: modified from Hiergesell 1998)

High-permeability zones occur beneath the GSA and may locally increase the movement of groundwater.

The aquifer is divided into two aquifer zones — an upper aquifer zone and a lower aquifer zone — separated by the tan clay confining zone. The upper aquifer zone consists of sand and clayey sand with minor intercalated clay layers. The lower aquifer zone is predominantly fine-grained, well-sorted sand and clayey sand. The tan clay confining zone, which has an average thickness of about 3.4 m [11 ft] beneath the GSA, is leaky across most of the site and absent in places.

In the vicinity of the GTCC reference location, the thickness of the Upper and Lower Three Runs Aquifer is approximately 28 m (92 ft). This value represents the mean of the range of site-specific data (15.5 to 40.2 m [51 to 132 ft]), including thicknesses from the upper and lower aquifer zones and the tan clay confining zone (Cook et al. 2004).

Recharge of the water table in the upper aquifer zone occurs by infiltration from the land surface. The upper aquifer zone has a downward potential; groundwater leaking across the tan clay recharges the lower aquifer zone. Most of the water then moves laterally toward the bounding streams; the remainder flows vertically downward across the Gordon Confining Unit into the Gordon Aquifer.

Gordon Confining Unit. The Gordon Confining Unit consists of clayey sand and clay of the Warley Hill Formation and clayey, micritic limestone of the Blue Bluff Member of the Santee Limestone. The clay is stiff to hard and commonly fissile. Glauconite is a common constituent and imparts a distinctive greenish cast to the sediment; hence, the informal name of “green clay” was given to this unit (Hiergesell et al. 2000). Thicknesses measured by Aadland et al. (1995) in GSA Wells P-27 and P-28 were 2.1 m (7 ft) and 5.5 m (18 ft), respectively. Wyatt et al. (2000) notes that the confining unit thickens (up to 25 m [85 ft]) to the southeast.

Gordon Aquifer. The Gordon Aquifer is the basal unit of the Floridan Aquifer System. It consists of all the saturated strata that occur between the Gordon Confining Unit and the Crouch Branch Confining Unit. The strata are the sandy parts of the Snapp Formation and the overlying Fourmile and Congaree Formations. Thin clay layers and stringers occur in places but are discontinuous across SRS. Thicknesses measured by Aadland et al. (1995) in GSA Wells P-27 and P-28 were 24 m (77 ft) and 23 m (75 ft), respectively.

Recharge occurs via precipitation in outcrop areas and by leakage from overlying and underlying aquifers (upward potential occurs along streams that incise the Upper Three Runs Aquifer). Discharge areas are the swamps and marshes along Upper Three Runs Creek and the Savannah River. The aquifer is under confined to semiconfined conditions.

Meyers Branch Confining System. The Meyers Branch Confining System corresponds to clay and interbedded sand of the uppermost Steel Creek Formation and clay and laminated shale of the Sawdust Landing, Lang Syne, and Snapp Formations. The clay in these formations tends to be thick and relatively continuous. The Crouch Branch Confining Unit is the sole unit making up the Meyers Branch Confining System. It ranges in thickness from about 17 to 56 m (57 to 184 ft) and dips about 3.0 m/km (16 ft/mi) to the southeast. The unit has an upper and lower confining zone composed of clay and sandy clay beds, separated by a middle sand zone of clayey sand and sand.

Groundwater in the confining system has an upward potential mainly because of the deep incisement by the Savannah River and Upper Three Runs Creek into the overlying Gordon Aquifer (Figure 10.1.3-3).

Dublin-Midville Aquifer System. The Dublin-Midville Aquifer System includes all the Cretaceous sediments from the Middendorf Formation up to the sand beds in the lower part of the Steel Creek Formation. The aquifer system ranges in thickness from about 76 to 168 m (250 to 550 ft) and dips about 3.8 m/km (20 ft/mi) to the southeast. At GSA Well P-27, the aquifer system is about 154 m (505 ft) thick.

The Dublin-Midville Aquifer System is divided into the overlying Crouch Branch Aquifer and the underlying McQueen Branch Aquifer. These aquifers are separated by the McQueen Branch Confining Unit. The Crouch Branch Aquifer ranges in thickness from 30 to 107 m (100 to 350 ft) and thins significantly to the east. Sediments are mainly sand, muddy sand, and gravelly sand with thin, discontinuous layers of sandy clay and sandy mud. High-permeability zones occur near the Pen Branch Fault (Gellici et al. 1994).

The McQueen Branch Confining Unit consists of interbedded, silty, sandy clay, and sand beds of the middle portion of the Black Creek Formation. At GSA Well P-27, the confining unit is 17-m (55-ft) thick and occurs between elevations of −100 to −117 m (−329 to −384 ft) MSL. Clay makes up about 82% of the total thickness of the unit.

The McQueen Branch Aquifer Unit underlies the confining unit. At GSA Well P-27, the aquifer system is about 62-m (203-ft) thick and occurs between elevations of −117 to −180 m (−384 to −587 ft) MSL. It dips 4.7 m/km (25 ft/mi) to the southeast. Sand makes up about 90% of the total thickness of this unit.

10.1.3.2.2 Groundwater Flow. Upon entering the saturated zone at the water table, water moves predominantly in a horizontal direction toward local discharge zones along the headwaters and midsections of streams, while some of the water moves into the deeper aquifers. The water lost to successively deeper aquifers also migrates laterally within those units toward the more distant regional discharge zones. These are typically located along the major streams and rivers in the area, such as the Savannah River discharge zones. Groundwater flow within these units is extremely slow when compared with surface water flow. Groundwater velocities of aquitards and aquifers are also different; they range from several inches to several feet per year in aquitards and from tens to hundreds of feet per year in aquifers (WSRC 2007a).

By using a simplified model for a number of pumping scenarios on SRS (i.e., advection only), Cherry (2006) demonstrated that transriver contaminant transport from recharge areas in the central SRS (D- and K-Areas) to receptors in Georgia could occur within 80 to 1,100 years. The shortest time of travel was for particles moving vertically from the base of the Upper Three Runs Aquifer and then laterally through the Gordon Aquifer beneath the Savannah River to discharge points in Georgia. The transit times do not include the time required for groundwater to migrate vertically downward across the uppermost aquifer and do not include other processes, such as the radioactive decay of tritium. Actual travel times could be up to several decades longer than what is reported. SRS continues to maintain and sample Georgia monitoring wells annually. In 2006, none of the tritium results exceeded 1,000 pCi/L; EPA's MCL for tritium is 20,000 pCi/L (WSRC 2007a).

Measured hydraulic head distributions in the upper aquifer (water table) zone of the Upper Three Runs Aquifer and the deeper Gordon Aquifer are shown in Figures 10.1.3-5 and 10.1.3-6, respectively; they are based on the work of Flach and Harris (1999).

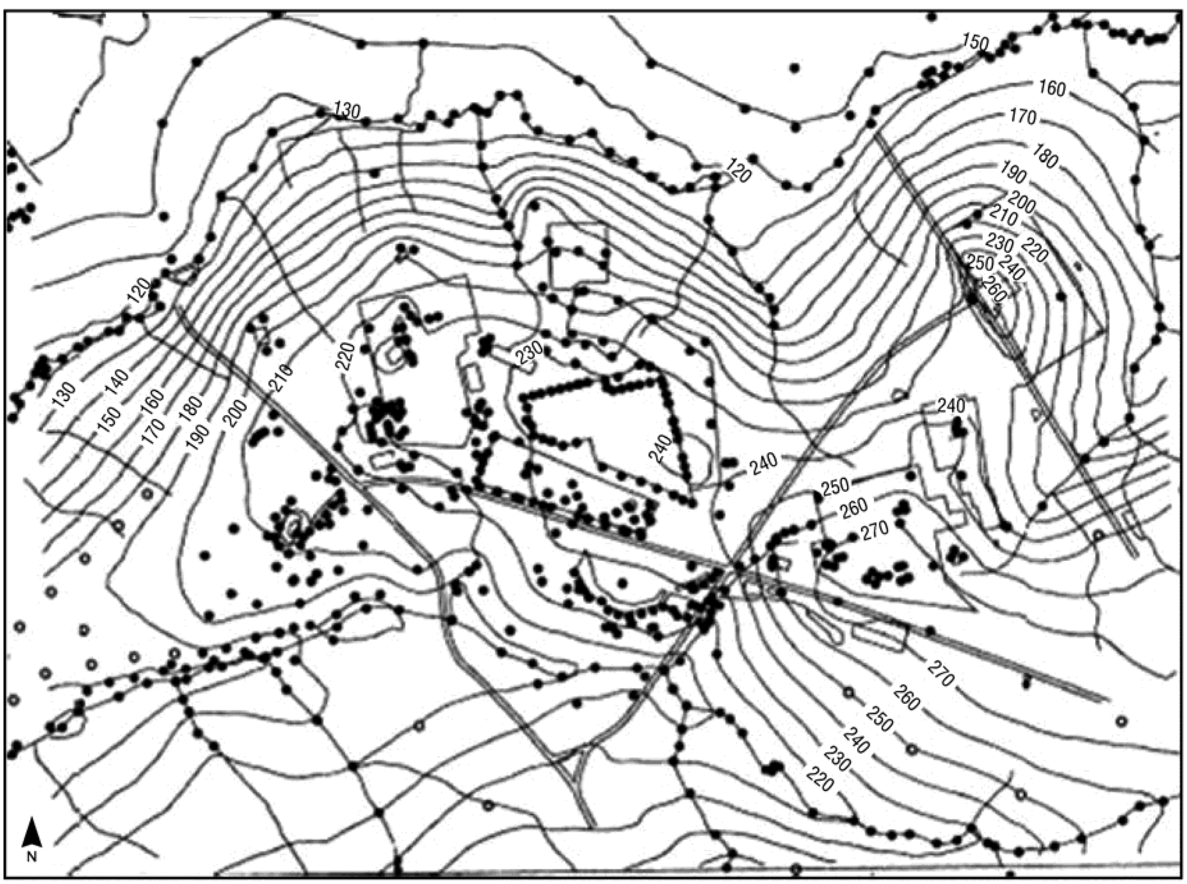


FIGURE 10.1.3-5 Measured Hydraulic Head (in feet) in the Upper Aquifer Zone of the Three Runs Aquifer (Source: Flach and Harris 1999)

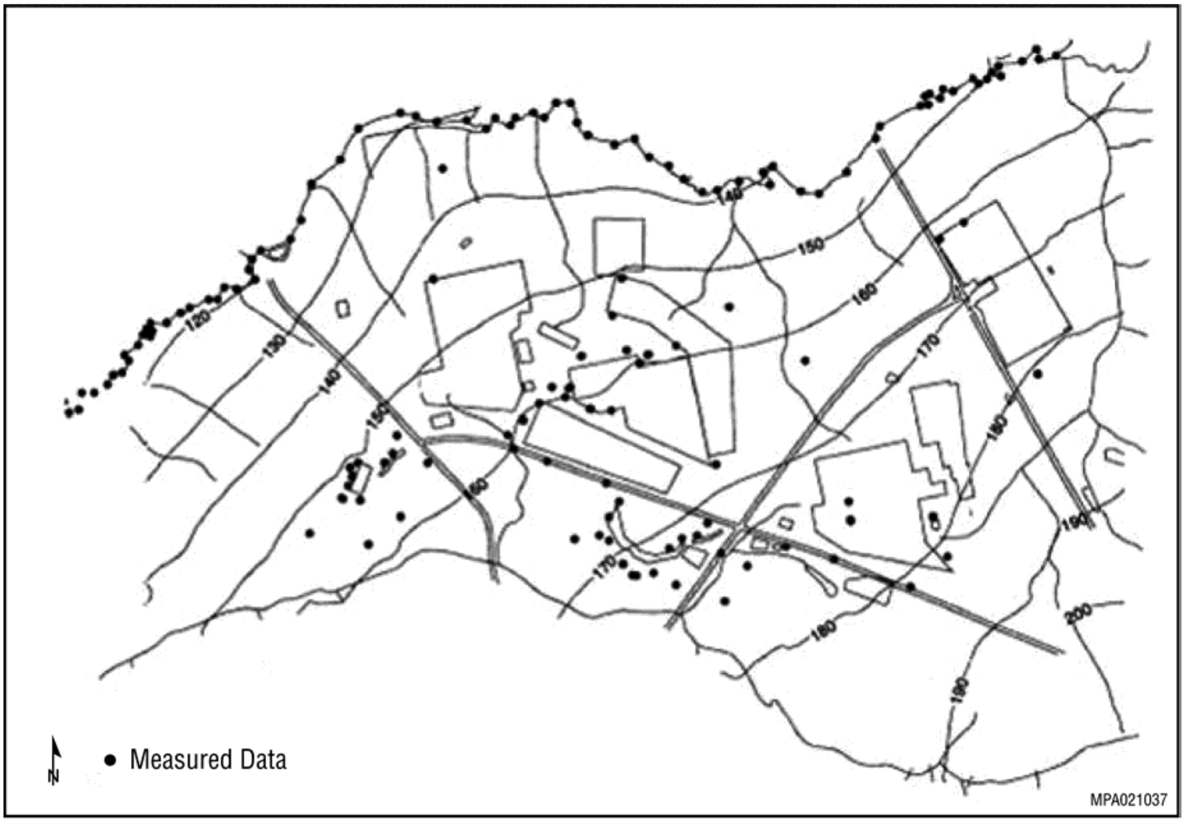


FIGURE 10.1.3-6 Measured Hydraulic Head (in feet) in the Gordon Aquifer (Source: Flach and Harris 1999)

Natural recharge for the water table aquifers (i.e., the Upper Three Runs Creek Aquifer and Gordon Aquifer) is primarily the result of infiltration of local rainfall at the land surface. Recharge areas for the deeper aquifers are updip of SRS, near the fall line, although some recharge areas are located at the northernmost edge of the site. Natural recharge over the GSA travels as deep as the Gordon Aquifer before discharging to Upper Three Runs Creek, Fourmile Branch, McQueen Branch, or a tributary of these. Artificial recharge occurs as a result of infiltration within man-made basins and ponds (as shown in Figure 10.1.3-7) and the various process, domestic, storm, and wastewater systems.

10.1.3.2.3 Groundwater Quality. The water in Coastal Plain sediments is generally of good quality and suitable for municipal and industrial use with only minimum treatment needed. The water is generally soft, slightly acidic (pH of 4.9 to 7.7), and low in dissolved and suspended solids. High dissolved iron concentrations occur in some aquifers. Groundwater is the only source of domestic water at SRS, and, where necessary, it is treated to raise the pH and remove the iron (WSRC 2007a).

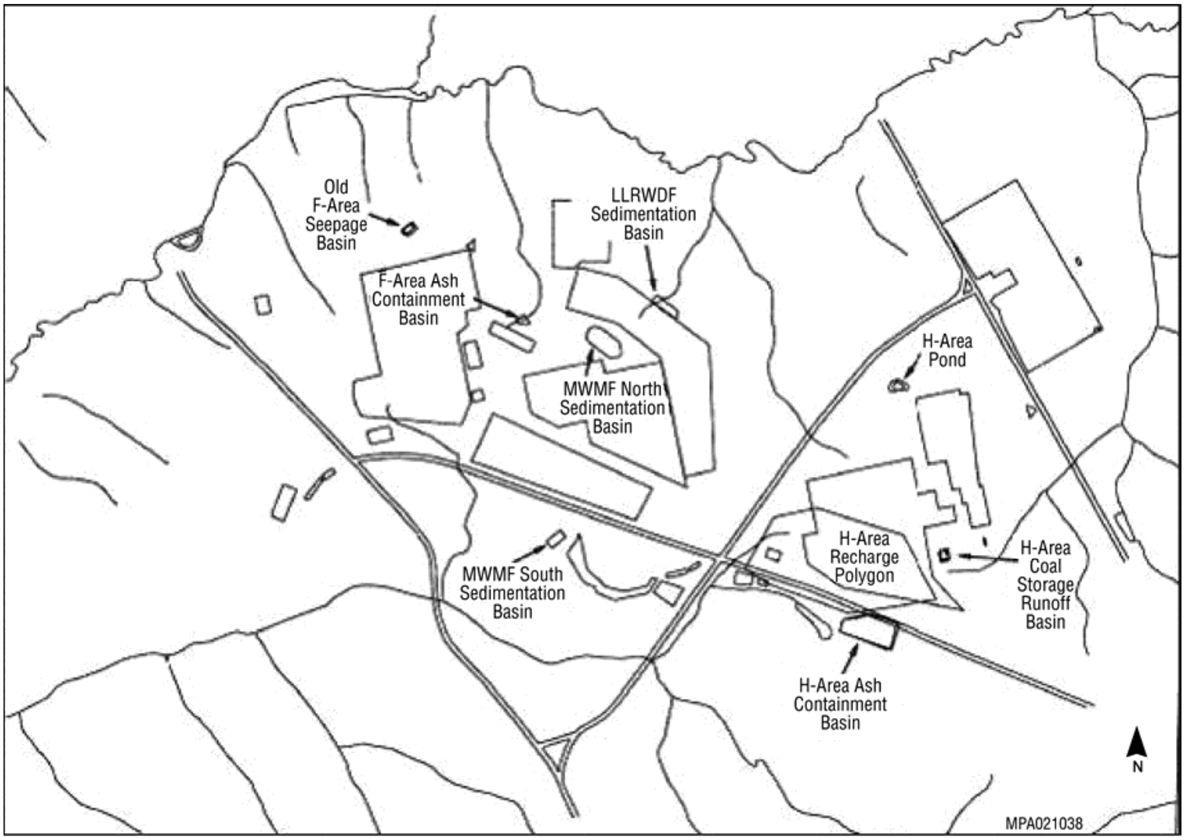


FIGURE 10.1.3-7 Sources of Artificial Groundwater Recharge within the General Separations Area (Source: Flach and Harris 1999)

Industrial solvents, metals, tritium, and other constituents used or generated at SRS have contaminated the shallow aquifers beneath 5% to 10% of SRS. Groundwater contamination has not been detected outside SRS boundaries. In the general separations and waste management areas (E-, F-, H-, S-, and Z-Areas), located in the center of the site, groundwater is contaminated with VOCs (mainly TCE and PCE), radionuclides, metals, and other constituents. These areas encompass many smaller and, in some cases, overlapping groundwater plumes. The shallow groundwater in the southern portion of the E-, F-, and H-Areas discharges to Four Mile Creek and its tributaries; in the northern portion of these areas, the shallow groundwater discharges to Upper Three Runs Creek and its tributaries. The S- and Z-Areas are located on the groundwater divide between Upper Three Runs Creek and its tributaries to the west (ATSDR 2007). Groundwater flow below the Z-Area is to the northeast toward McQueen Branch (DOE 2002). Table 10.1.3-2 lists maximum groundwater concentration exceedances for the Z-Area prior to 2002.

TABLE 10.1.3-2 Summary of Groundwater Exceedances for Z-Area Prior to 2002

Analyte	Concentration (µCi/mL)	Regulatory Limit (µCi/mL)
Gross alpha	9.77×10^{-8}	1.5×10^{-8}
Nonvolatile beta	5.26×10^{-8}	5.0×10^{-8}
Ra-226	7.78×10^{-9}	5.0×10^{-9}
Ra-228	8.09×10^{-9}	5.0×10^{-9}
Radium, total alpha emitting	5.55×10^{-8}	5.0×10^{-9}
Ruthenium-106	3.08×10^{-8}	3.0×10^{-8}

Source: DOE (2002)

10.1.3.3 Water Use

SRS is the largest self-supplied industrial consumer of groundwater in South Carolina; it used about 14.8 million L/d (3.9 million gal/d) in 2006. Drinking and process water are supplied by a network of approximately 40 wells across the site; 8 of these wells are dedicated to the domestic water system (there are treatment facilities at A-, D-, and K-Areas). The wells range in capacity from 760 to 5,700 L/min (200 to 1,500 gpm). Most groundwater production is from the deep Crouch Branch and McQueen Aquifers, with a few lower-capacity wells pumping from the shallower Gordon Aquifer and the lower zone of the Upper Three Runs Aquifer. Every major operating area at SRS has groundwater-producing wells. The amount of water pumped at SRS has decreased significantly since 1986, when the pump rate was as high as 41 million L/d (11 million gal/d), owing to the consolidation of the domestic water system completed in 1997 (DOE 2002; WSRC 2007a).

Regional domestic water supplies are primarily drawn from the shallow aquifers, including the Gordon Aquifer and the Upper Three Runs Aquifer. The municipal and industrial water supplies in Aiken County come from the deeper Crouch Branch and McQueen Aquifers. In Barnwell and Allendale Counties, municipal water supplies are drawn from the Gordon Aquifer and overlying units that thicken to the southeast. In 2005, Aiken County ranked as the 16th largest public water suppliers in South Carolina, with an average pump rate of 33.3 million L/d (8.8 million gal/d) and a per capita use of about 890 L/d (235 gal/d) (DOE 2002; Newcome 2005).

10.1.4 Human Health

Potential radiation exposures to the off-site general public residing in the vicinity of SRS would be a relatively small fraction of the dose limit of 100 mrem/yr set by DOE to protect the public from the operations of its facilities (DOE Order 458.1). The dose to the highest-exposed individual is estimated to be less than 0.4 mrem/yr. This dose is composed of the dose from airborne releases of radionuclides (0.044 mrem/yr) (SRNS 2015) and 0.12 mrem contributed by exposures associated with waterborne releases of radionuclides. For the waterborne component, the maximum dose from ingestion of contaminated water is estimated to be 0.011 mrem; the maximum dose from ingestion of fish is 0.03 mrem; and the maximum dose from ingestion of vegetables, meat, and milk contaminated through irrigation is 0.074 mrem (SRNS 2015).

There are other unlikely situations under which the radiation dose incurred by the off-site general public could be higher. For example, an individual could hunt in the Savannah River Swamp on the privately owned Creek Plantation (which contains the highest concentrations of radioactive contamination in soil). If this individual hunted for 120 hours per year at that location, he or she could incur a radiation dose of 2.9 mrem/yr from direct radiation, soil ingestion, and inhalation of resuspended dust particles. If the hunter consumed a deer or hog harvested at that location, which is assumed to be sufficient to meet all of an individual's requirements for meat for a year, the hunter might incur another dose of 3.2 mrem/yr (SRNS 2015). This estimate was obtained by using the average measured Cs-137 concentration in the flesh of all deer and hogs harvested in 2014. Table 10.1.4-1 provides the radiation doses estimated for the different exposure scenarios; the footnotes provide more detailed explanations regarding the methods used to develop these dose estimates.

According to the 2014 worker radiation exposure data published in DOE (2015), a total of 1,584 workers received measurable doses. A collective total dose of 92.8 person-rem was recorded, resulting in an average individual dose of 58 mrem/yr. This collective total dose is based on 0.164 person-rem from internal exposure and 92.636 person-rem from external exposure. Among the workers who registered measurable doses, most received external radiation; only 8 workers had measurable internal doses. The collective internal dose was 0.164 person-rem; if distributed evenly among the 8 workers, the average individual dose was 0.02 mrem/yr (DOE 2015, Exhibit B-4). No radiation worker received a dose greater than the DOE administrative control level of 2 rem/yr in 2014. Use of DOE's ALARA program ensures that worker doses are kept well below applicable standards.

10.1.5 Ecology

A Natural Resources Management Plan (USFS 2005) was prepared for SRS. It covers all natural resource operations, including management, education, and research programs. For natural resource management purposes, SRS is divided into six management areas (USFS 2005). The GTCC LLRW and GTCC-like waste disposal facility would be located within the 15,558-ha (38,444-ac) Industrial Core Management Area. The primary objective in this area is to support facilities and site missions, with other important objectives being promoting conservation and restoration, providing research and educational opportunities, and generating the sale of forest products (USFS 2005). Natural resource management programs conducted within SRS include (1) habitat, population, invasive species, threatened species, and endangered species management; (2) forest products harvesting and silviculture management; (3) secondary roads, boundary, and trails management; (4) watershed management; (5) fire management; (6) DOE

1 **TABLE 10.1.4-1 Estimated Annual Radiation Doses to Workers and the General Public at SRS**

Receptor	Radiation Source	Exposure Pathway	Annual Dose to Individual (mrem/yr)	Annual Dose to Population (person-rem/yr)
On-site workers	Radioactive materials handled in operations	Inhalation and ingestion	0.02[a]	0.164[a]
	Radioactive materials handled in operations	Direct radiation	58[b]	92.636[b]
General public	Airborne release	Submersion; inhalation; ingestion of plant foods (contaminated through deposition), meat, and milk; direct radiation from deposition	0.044[c]	1.7[d]
	Surface water contamination	Ingestion of water	0.011[e]	
		Ingestion of fish	0.028[f]	
		Ingestion of leafy and nonleafy vegetables, meat, and milk (resulting from irrigation)	0.074[g]	
	Swamp soil	External radiation, soil ingestion, and dust inhalation (from hunting activities)	2.9[h]	
	Wildlife animals	Ingestion of deer/hog	3.2[i]	
Worker/public	Natural background radiation and man-made sources		620[j]	484,260[k]

[a] In 2014, among the workers monitored for internal exposure, 8 had measurable doses. A collective dose of 0.164 person-rem was recorded (DOE 2015).

[b] In 2014, 1,584 workers received measurable doses. The total collective dose for these workers was 92.8 person-rem (DOE 2015). After subtracting the collective dose of internal exposure from the total collective dose and distributing the remaining dose evenly among the workers, an average individual external dose of 58 mrem/yr was obtained.

[c] Radiation dose was calculated with MAXDOSE-SR, a computer code developed to demonstrate compliance with DOE environmental orders at SRS. Monitored airborne releases and estimated airborne releases of diffuse and fugitive materials were added, and the sums were used with meteorological data in the calculation (SRNS 2015).

[d] The collective dose was estimated with POPDOSE-SR by using the population data within 80 km (50 mi) around the SRS. The population size is about 781,060 (SRNS 2015). Like MAXDOSE-SR, POPDOSE-SR was developed to demonstrate compliance with DOE environmental orders at SRS.

Footnotes continue on next page.

TABLE 10.1.4-1 (Cont.)

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[e] The dose corresponds to drinking water supplied by the public water treatment plant (BJSWA Chelsea, BJSWA Purrysburg, and Savannah I&D) (SRNS 2015). The potential dose was calculated by using the measured tritium concentration in surface water and calculated concentrations of other radionuclides on the basis of monitored liquid effluent discharge rates along with data on the river flow rate.

[f] The dose corresponds to eating 24 kg (53 lb) of bass caught exclusively from the mouth of Steel Creek (SRNS 2015). The potential dose resulted mainly from Cs-137, of which the concentration in the flesh of fish caught from the creek was measured and used in the dose calculation.

[g] The dose was calculated by assuming that contaminated Savannah River water was used for irrigation. A land area of 400 ha (1,000 ac) was assumed to be devoted to each of the major food types: vegetation, milk, and meat (SRNS 2015).

[h] The dose corresponded to hunting for 120 hours in Savannah River Swamp soil on the privately owned Creek Plantation that had the highest soil contamination measured in 2007 (SRNS 2015). The radiation dose was calculated by using the RESRAD computer code (Yu et al. 2000). The potential dose corresponding to fishing activities would be less; a dose of 0.28 mrem/yr was calculated, assuming an exposure duration of 250 hours per year on the South Carolina bank of the Savannah River near the mouth of Steel Creek (SRNS 2015).

[i] The dose was calculated on the basis of the average concentration of Cs-137 measured in all deer (1.29 pCi/g) or hogs (1.29 pCi/g) harvested from SRS during 2014. The deer or hogs were assumed to constitute the entire meat diet of the hunter (SRNS 2015).

[j] Average dose to a member of the U.S. population as estimated in Report No. 160 of the National Council on Radiation Protection and Measurements (NCRP 2009).

[k] Collective dose to the population of 781,058 within 80 km (50 mi) of the SRS from natural background radiation and man-made sources.

research set-aside areas; and (7) research (USFS 2005). In 1972, SRS was designated as the first NERP. Significant components of the NERP include the 30 DOE research set-aside areas that total 5,568 ha (14,005 ac). These areas are representative habitats that DOE has preserved for ecological research. They are protected from public intrusion and most site-related activities (DOE 2002).

SRS is in the transition area between the northern oak-hickory-pine forest and the southern mixed forest. It therefore contains species common to both forest types. About 90% of SRS contains upland pine, hardwood, and mixed (pines and hardwoods) forests and bottomland hardwood forests. The loblolly-longleaf-slash pine (*Pinus taeda*, *P. palustris*, *P. elliottii*) community covers about 65% of the site (DOE 1997). More than 1,300 plant species have been reported from SRS (Wike et al. 2006).

The GTCC reference location would be situated in an area dominated by stands of loblolly and slash pine. Understory species in the pine stands include black cherry (*Prunus serotina*), oaks (*Quercus* spp.), and persimmon (*Diospyros virginiana*). The site area also has small pockets of upland hardwood stands of white oak (*Quercus alba*), southern red oak (*Quercus falcata*), and hickory (*Carya* spp.). Ground cover at the site includes Japanese honeysuckle (*Lonicera japonica*), greenbrier (*Smilax* spp.), muscadine grape (*Vitis rotundifolia*), spotted wintergreen (*Chimaphila maculata*), and various grasses, legumes, and composites (DOE 1997).

More than 19,830 ha (49,000 ac) of wetlands occur on SRS (DOE 1997). They are widely distributed throughout the site, making up more than 20% of the site. Wetlands present include bottomland hardwood forests, cypress-tupelo swamp forests, floodplains, creeks, impoundments, and more than 300 Carolina bays (naturally occurring pond formations that cover about 445 ha [1,100 ac] of SRS) and wetland depressions. The Savannah River Swamp is a major wetland area that borders the Savannah River and covers about 3,800 ha (9,400 ac) of SRS (DOE 1997). No wetlands occur within the GTCC reference location.

Wildlife species that occur at SRS include 55 species of mammals, 255 species of birds, and 104 species of reptiles and amphibians (Wike et al. 2006). More than 150 species have been documented as using developed areas on SRS, with most species using landscaped areas away from buildings or other structures (Mayer and Wike 1997). White-tailed deer, feral hog, and American beaver populations are controlled through selective harvests, including public hunts for deer and boars. Concern has been expressed that the nine-banded armadillos may disturb and possibly breach waste unit closure caps, which could result in increased rainwater infiltration (Wike et al. 2006).

Bird species likely to occur within the pine-dominated forests of the GTCC reference location include Carolina wren (*Thryothorus ludovicianus*), wood thrush (*Hylocichla mustelina*), northern mockingbird (*Mimus polyglottos*), eastern towhee (*Pipilo erythrophthalmus*), pine warbler (*Dendroica pinus*), prairie warbler (*D. discolor*), red-eyed vireo (*Vireo olivaceus*), red-bellied woodpecker (*Melanerpes carolinus*), yellow-shafted flicker (*Colaptes auratus auratus*), sharp-shinned hawk (*Accipiter striatus*), eastern screech owl (*Megascops asio*), northern bobwhite (*Colinus virginianus*), and wild turkey (*Meleagris gallopavo*) (DOE 1997).

The Savannah River is the major aquatic habitat in the SRS vicinity. SRS also contains more than 50 man-made ponds, including two large water bodies: the 1,012-ha (2,500-ac) Par Pond and the 405-ha (1,000-ac) L Lake. These water bodies were created by damming Lower Three Runs Creek and Steel Creek, respectively. More than 80 species of fish have been identified on SRS, including commercial and recreational species (NRC 2005). The designated area for the GTCC reference location is within Upper Three Runs Creek watershed. Tinker, Mill, and McQueen Creeks are the bodies of water that are closest to the site (Figure 10.1.3-1). Minnow and sunfish species dominate the fish population in Upper Three Runs, while shiners, madtoms, and darters occur within the tributary streams (DOE 1997).

The federally and state-listed species identified from Aiken County are listed in Table 10.1.5-1. No designated critical habitat for any federally threatened or endangered species occurs within the area designated for the GTCC reference location (DOE 1997). The Eastern indigo snake (*Drymarchon couperi*, federally threatened), while not known to occur in Aiken County (SCDNR 2009), may be present in the county. Major natural resource management actions on SRS are aimed at habitat management for the red-cockaded woodpecker (*Picoides borealis*).

10.1.6 Socioeconomics

Socioeconomic data for SRS describes an ROI surrounding the site composed of four counties: Columbia County and Richmond County in Georgia and Aiken County and Barnwell County in South Carolina. More than 80% of SRS workers reside in these counties (NRC 2005).

10.1.6.1 Employment

In 2011, total employment in the ROI stood at 214,636 (U.S. Department of Labor 2012). Employment grew at an annual average rate of 0.4% between 2002 and 2011. The economy of the ROI is dominated by the trade and service industries, with employment in these activities currently contributing more than 70% of all employment (see Table 10.1.6-1). The manufacturing sector is also a significant employer in the ROI, with 12% of total ROI employment. Employment at SRS was 13,616 in 2000 (NRC 2005).

10.1.6.2 Unemployment

Unemployment rates have varied across the counties in the ROI (Table 10.1.6-2). Over the period 2002–2011, the average rate in Barnwell County was 11.7%, with lower rates in Richmond County (7.4%), Aiken County (6.6%), and Columbia County (4.9%). The average rate in the ROI over this period was 6.7%, higher than the average rate for Georgia (6.5%) and lower than the average rate for South Carolina (7.8%). Unemployment rates for 2010 were similar to those for 2011; in Barnwell County, the unemployment rate fell from 17.6% to 15.6%, while in Richmond County, the rate declined from 10.8% to 10.6%. The average rate for the ROI fell from 9.4% to 9.2%; the rate for Georgia fell from 10.2% to 9.8%; and for South Carolina, that rate fell from 11.2% to 10.3%.

TABLE 10.1.5-1 Federally and State-Listed Threatened, Endangered, and Other Special-Status Species in Aiken County, South Carolina

Common Name (Scientific Name)	Status[a] Federal/State
Plants	
Harperella (*Ptilimnium nodosum*)	E/-
Relict trillium (*Trillium reliquum*)	E/-
Smooth coneflower (*Echinacea laevigata*)	E/-
Fishes	
Shortnose sturgeon (*Acipenser brevirostrum*)	E/SE
Amphibians	
Gopher frog (*Rana capito*)	-/SE
Reptiles	
Eastern indigo snake (*Drymarchon couperi*)	T/-
Gopher tortoise (*Gopherus polyphemus*)	-/SE
Spotted turtle (*Clemmys guttata*)	-/ST
Birds	
Bald eagle (*Haliaeetus leucocephalus*)	-/SE
Red-cockaded woodpecker (*Picoides borealis*)	E/SE
Mammals	
Rafinesque's big-eared bat (*Plecotus rafinesquii*)	-/SE

[a] E (endangered): A species in danger of extinction throughout all or a significant portion of its range.

SE (state endangered): An animal species or subspecies whose prospects of survival or recruitment in South Carolina are in jeopardy.

ST (state threatened): An animal species likely to be classified as state endangered within the foreseeable future throughout all or a significant portion of its South Carolina range.

T (threatened): A species likely to become endangered within the foreseeable future throughout all or a significant portion of its range.

-: Not listed.

Source: SCDNR (2006)

10.1.6.3 Personal Income

Personal income in the ROI stood at almost $17 billion in 2009, growing at an annual average rate of growth of 1.4% over the period 2000–2009 (Table 10.1.6-3). ROI personal income per capita also rose, from $32,686 in 2000 to $34,364 in 2009. Per-capita incomes were higher in Columbia County ($41,943 in 2009) than elsewhere in the ROI.

TABLE 10.1.6-1 SRS: County and ROI Employment by Industry in 2009

	Georgia		South Carolina			
Sector	Columbia County	Richmond County	Aiken County	Barnwell County	ROI Total	% of ROI Total
Agriculture[a]	266	105	779	337	1,487	0.9
Mining	10	104	78	0	192	0.1
Construction	2,580	3,318	7,500	109	13,507	8.3
Manufacturing	3,184	7,712	6,964	1,616	19,476	11.9
Transportation and public utilities	335	2,253	3,871	112	6,571	4.0
Trade	6,986	12,610	7,806	913	28,315	17.3
Finance, insurance, and real estate	1,141	3,476	1,747	202	6,566	4.0
Services	12,472	52,296	20,813	1,848	87,429	53.5
Other	10	10	10	10	40	0.0
Total	26,951	81,899	49,445	5,027	163,322	

[a] USDA (2008).

Source: U.S. Bureau of the Census (2012a)

TABLE 10.1.6-2 SRS: Average County, ROI, and State Unemployment Rates (%) in Selected Years

Location	2002–2011	2010	2011
Columbia County, Georgia	4.9	7.0	7.1
Richmond County, Georgia	7.4	10.8	10.6
Aiken County, South Carolina	6.6	8.8	8.8
Barnwell County, South Carolina	11.7	17.6	15.6
ROI	6.7	9.4	9.2
Georgia	6.5	10.2	9.8
South Carolina	7.8	11.2	10.3

Source: U.S. Department of Labor (2012)

10.1.6.4 Population

The population of the ROI was 507,322 in 2010 (U.S. Bureau of the Census 2012b) and was expected to reach 519,503 by 2012 (Table 10.1.6-4). In 2010, 200,549 people were living in Richmond County (40% of the ROI total), and 160,099 people (32% of the total) resided in Aiken County. Over the period 2000–2010, the population in the ROI rate as a whole grew slightly, with an average growth rate of 1.1% and a higher-than-average growth rate in Columbia County (3.3%). The population in Georgia as a whole grew at a rate of 1.7% over the same period; in South Carolina, the population grew at a rate of 1.4%.

TABLE 10.1.6-3 SRS: County, ROI, and State Personal Income in Selected Years

Income	2000	2009	Average Annual Growth Rate (%), 2000–2009
Columbia County			
Total personal income (2011 $ in billions)	3.6	4.7	3.2
Personal income per capita (2011 $)	40,103	41,943	0.5
Richmond County			
Total personal income (2011 $ in billions)	5.9	6.0	0.2
Personal income per capita (2011 $)	29,292	29,907	0.2
Aiken County			
Total personal income (2011 $ in billions)	4.8	5.6	1.8
Personal income per capita (2011 $)	33,460	35,813	0.8
Barnwell County			
Total personal income (2011 $ in billions)	0.7	0.6	–1.5
Personal income per capita (2011 $)	28,667	25,904	–1.1
ROI total			
Total personal income (2011 $ in billions)	14.9	16.9	1.4
Personal income per capita (2011 $)	32,686	34,364	0.6
Georgia			
Total personal income (2011 $ in billions)	306.7	351.7	1.5
Personal income per capita (2011 $)	37,468	35,784	–0.5
South Carolina			
Total personal income (2011 $ in billions)	131.3	155.5	1.8
Personal income per capita (2011 $)	32,856	34,081	0.4

Source: DOC (2012)

10.1.6.5 Housing

Housing stock in the ROI as a whole grew at an annual rate of 1.5% over the period 2000–2010 (Table 10.1.6-5), with the total number of housing units being 217,690 in 2010. A total of 29,879 new units were added to the existing housing stock in the ROI between 2000 and 2010. There were 19,180 vacant housing units in the ROI in 2010, of which 7,515 were rental units that could be available to construction workers at the proposed facility.

TABLE 10.1.6-4 SRS: County, ROI, and State Population in Selected Years

Location	1990	2000	2010	Average Annual Growth Rate (%), 2000–2010	2012[a]
Georgia					
Columbia County	66,031	89,288	124,053	3.3	132,486
Richmond County	189,719	199,775	200,549	0.0	200,704
South Carolina					
Aiken County	120,940	142,552	160,099	1.1	163,860
Barnwell County	20,293	23,478	22,621	–0.4	22,453
ROI total	396,983	455,093	507,322	1.1	519,503
Georgia	6,478,216	8,186,453	9,687,653	1.7	10,019,433
South Carolina	3,486,703	4,012,012	4,625,364	1.4	4,758,857

[a] Argonne National Laboratory projections.

Sources: U.S. Bureau of the Census (2012b)

10.1.6.6 Fiscal Conditions

Construction and operations of a GTCC LLRW and GTCC-like waste disposal facility could result in increased expenditures for local government jurisdictions, including counties, cities, and school districts. Revenues to support these expenditures could come primarily from state and local sales tax revenues associated with employee spending during construction and operations and be used to support additional local community services currently provided by each jurisdiction. Table 10.1.6-6 presents information on expenditures by the various local government jurisdictions and school districts in the ROI.

10.1.6.7 Public Services

Construction and operations of a GTCC LLRW and GTCC-like waste disposal facility could require increases in employment in order to provide public safety, fire protection, community, and educational services in the counties, cities, and school districts likely to host relocating construction workers and operations employees. Additional demands could also be placed on local physician services. Table 10.1.6-7 presents data on employment and levels of service (number of employees per 1,000 population) for public safety and general local government services. Table 10.1.6-8 provides data on teachers and level of service, and Table 10.1.6-9 covers physicians.

TABLE 10.1.6-5 SRS: County and ROI Housing Characteristics in Selected Years

Type of Housing	2000	2010
Columbia County		
Owner occupied	25,557	35,475
Rental	5,563	9,423
Vacant units	2,201	3,728
Total units	33,321	48,626
Richmond County		
Owner occupied	42,840	41,682
Rental	31,080	35,242
Vacant units	8,392	9,407
Total units	82,312	86,331
Aiken County		
Owner occupied	42,036	46,956
Rental	13,551	17,297
Vacant units	6,400	7,996
Total units	61,987	72,249
Barnwell County		
Owner occupied	6,810	6,280
Rental	2,211	2,657
Vacant units	1,170	1,547
Total units	10,191	10,484
ROI total		
Owner occupied	117,243	130,393
Rental	52,405	64,619
Vacant units	18,163	22,678
Total units	187,811	217,690

Source: U.S. Bureau of the Census (2012b)

TABLE 10.1.6-6 SRS: County, ROI, and State Public Service Expenditures in 2006 ($ 2011 in millions)[a]

Location	Local Government	School District
Georgia		
Columbia County	52.7	102.8
Richmond County	122.0	190.4
South Carolina		
Aiken County	88.5	120.1
Barnwell County	20.9	23.9
ROI total	284.1	437.2
Georgia	42,324	13,945
South Carolina	17,299	6,003

[a] Argonne National Laboratory projections.

10.1.7 Environmental Justice

Figures 10.1.7-1 and 10.1.7-2 and Table 10.1.7-1 show the minority and low-income compositions of the total population located in the 80-km (50-mi) buffer around SRS from Census Bureau data for the year 2010 and from CEQ guidelines (CEQ 1997). Persons whose incomes fall below the federal poverty threshold are designated as low income. Minority persons are those who identify themselves as Hispanic or Latino, Asian, Black or African American, American Indian or Alaska Native, Native Hawaiian or other Pacific Islander, or multi-racial (with at least one race designated as a minority race under CEQ). Individuals identifying themselves as Hispanic or Latino are included in the table as a separate entry. However, because Hispanics can be of any race, this number also includes individuals who also identified themselves as being part of one or more of the population groups listed in the table.

A large number of minority and low-income individuals are located in the 50-mi (80-km) area around the boundary of the reference location. Within the 50-mi (80-km) radius in Georgia, 48.1% of the population is classified as minority, while 17.2% is classified as low income. However, the number of minority individuals does not exceed the state average by 20 percentage points or more, and the number of minority individuals does not exceed 50% of the total population in the area; that is, there is no minority population in the Georgia portion of the 50-mi (80-km) area as a whole based on 2010 Census data and CEQ guidelines. The number of low-income individuals does not exceed the state average by 20 percentage points or more and does not exceed 50% of the total population in the area; that is, there are no low-income populations in the Georgia portion of the 50-mi (80-km) area around the reference location as a whole.

Within the 50-mi (80-km) radius in South Carolina, 40.2% of the population is classified as minority, while 18.2% is classified as low income. The number of minority individuals does not exceed the state average by 20 percentage points or more, and the number of minority

TABLE 10.1.6-7 SRS: County, ROI, and State Public Service Employment in 2009

	Columbia County		Richmond County		Aiken County	
Service	No.	Level of Service[a]	No.	Level of Service[a]	No.	Level of Service[a]
Police protection	217	1.9	645	3.2	128	1.8
Fire protection[b]	87	0.8	366	1.8	150	1.0

	Barnwell County		ROI		Georgia[c]	
Service	No.	Level of Service[a]	No.	Level of Service[a]	No.	Level of Service[a]
Police protection	25	1.1	1,015	2.1	19,170	2.0
Fire protection	0	0.0	603	1.2	10,411	1.1

	South Carolina[c]	
Service	No.	Level of Service[a]
Police protection	8,799	2.0
Fire protection	4,680	1.1

[a] Level of service represents the number of employees per 1,000 persons in each county.

[b] Does not include volunteers.

[c] 2006 data.

Sources: U.S. Bureau of the Census (2008a,b, 2012b,c); FBI (2012); Fire Departments Network (2012)

individuals does not exceed 50% of the total population in the area; that is, there is no minority population in the South Carolina portion of the 50-mi (80-km) area as a whole area based on 2010 Census data and CEQ guidelines. The number of low-income individuals does not exceed the state average by 20 percentage points or more and does not exceed 50% of the total population in the area; that is, there are no low-income populations in the South Carolina portion of the 50-mi area (80-km) area around the reference location as a whole.

10.1.8 Land Use

SRS occupies about 80,130 ha (198,000 ac) within a generally rural area. Existing land use at SRS can be characterized under three main categories: (1) 73% is undeveloped/forest, (2) 22% is wetlands/water, and (3) 5% is developed (NRC 2005). The developed areas of the site contain production and support facilities, infrastructure, R&D, and waste management facilities to meet SRS's mission of serving the nation through safe, secure, cost-effective management of the U.S. nuclear stockpile, nuclear materials, and the environment. The remainder of SRS is

TABLE 10.1.6-8 SRS: County, ROI, and State Education Employment in 2011

Location	No. of Teachers	Level of Service[a]
Georgia		
Columbia County	1,470	15.9
Richmond County	2,240	14.5
South Carolina		
Aiken County	1,471	16.7
Barnwell County	276	15.7
ROI total	5,458	15.5
Georgia	115,918	14.4
South Carolina	46,980	15.4

[a] Level of service represents the number of teachers per 1,000 persons in each county.

Sources: National Center for Educational Statistics (2012); U.S. Bureau of the Census (2012b,c)

TABLE 10.1.6-9 SRS: County, ROI, and State Medical Employment in 2010

Location	No. of Physicians	Level of Service[a]
Georgia		
Columbia County	803	6.5
Richmond County	1,315	6.6
South Carolina		
Aiken County	252	1.6
Barnwell County	14	0.6
ROI total	2,384	4.7
Georgia[b]	19,143	2.0
South Carolina[b]	9,100	2.1

[a] Level of service represents the number of physicians per 1,000 persons in each county.

[b] 2006 data.

Sources: AMA (2012); U.S. Bureau of the Census (2008b, 2012b)

primarily forest and wetlands (DOE 2002; USFS 2005). Most of the forested areas are pine forests managed by the USFS through an interagency agreement with DOE. In 1972, the entire site was designated as a NERP. A little more than 5,666 ha (14,000 ac) within 30 set-aside areas have been established on SRS to be used exclusively for nondestructive environmental research coordinated by the University of Georgia's Savannah River Ecology Laboratory (Davis and Janecek 1997). None of the set-aside areas are located near the GTCC reference location. Public use of the site is limited primarily to controlled hunts and science literacy programs (DOE 2002). Fishing also is allowed within the Crackerneck Wildlife Management Area.

The *Savannah River Future Use Plan* (DOE 1998, as cited in DOE 2002) states as policy that (1) SRS boundaries will remain unchanged and the land shall remain under ownership of the federal government, consistent with the site's designation as a NERP; (2) residential use of all SRS land is prohibited; and (3) the integral site model that incorporates three planning zones (industrial, industrial support, and restricted public uses) will be utilized. The land between Upper Three Runs Creek and Fourmile Branch (which includes the designated area for the GTCC reference location) is considered to be within the industrial land use category (DOE 2002).

For natural resources management purposes, SRS has been divided into six management areas on the basis of existing biological and physical conditions, operations capability, and suitability for mission objectives. These areas are the (1) 15,558-ha (38,444-ac) Industrial Core Management Area, (2) 35,289-ha (87,200-ac) Red-Cockaded Woodpecker Management Area, (3) 19,061-ha (47,100-ac) Supplemental Red-Cockaded Woodpecker Management Area,

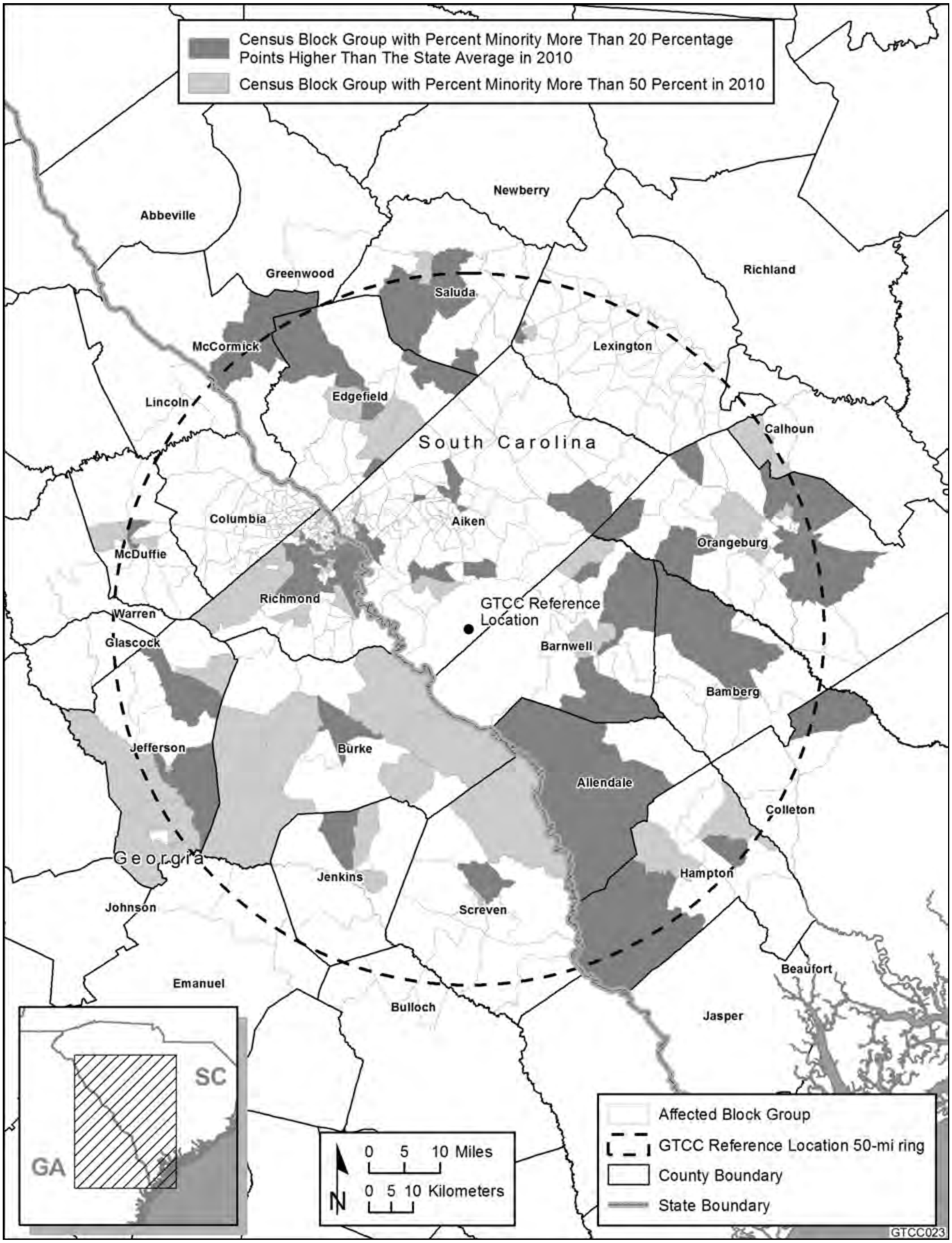

FIGURE 10.1.7-1 Minority Population Concentrations in Census Block Groups within an 80-km (50-mi) Radius of the GTCC Reference Location at SRS (Source: U.S. Bureau of the Census 2012b)

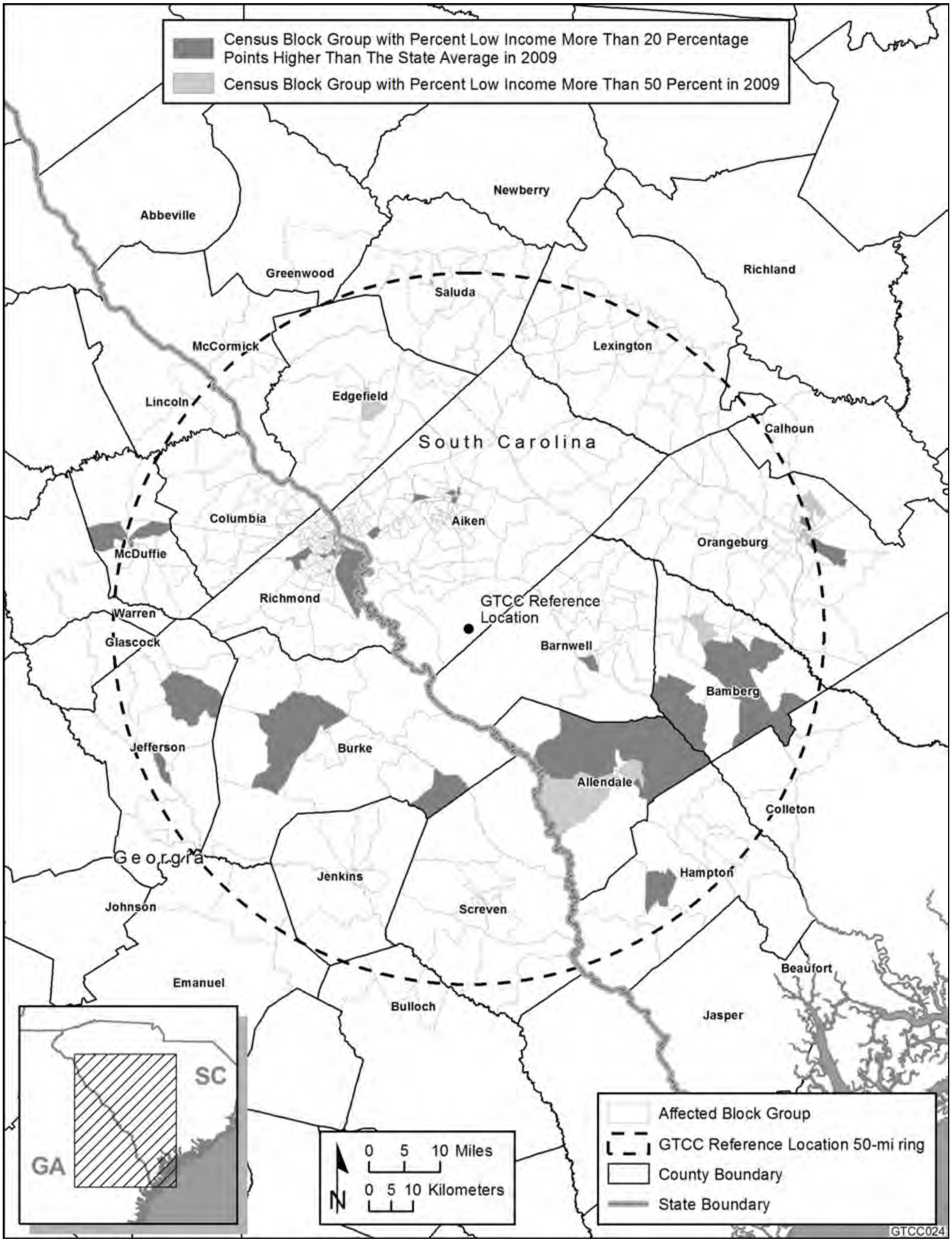

FIGURE 10.1.7-2 Low-Income Population Concentrations in Census Block Groups within an 80-km (50-mi) Radius of the GTCC Reference Location at SRS (Source: U.S. Bureau of the Census 2012b)

TABLE 10.1.7-1 Minority and Low-Income Populations within an 80-km (50-mi) Radius of SRS

Population	Georgia Block Groups	South Carolina Block Groups
Total population	418,463	441,450
White, Non-Hispanic	217,376	263,936
Hispanic or Latino	16,705	19,810
Non-Hispanic or Latino minorities	184,382	157,704
One race	176,406	151,947
Black or African American	165,786	146,919
American Indian or Alaskan Native	1,116	1,609
Asian	8,323	2,891
Native Hawaiian or other Pacific Islander	593	131
Some other race	588	397
Two or more races	7,976	5,757
Total minority	201,087	177,514
Percent minority	48.1%	40.2%
Low-income	25,541	28,689
Percent low-income	17.2%	18.2%
State percent minority	44.1%	35.9%
State percent low-income	16.5%	17.1%

Source: U.S. Bureau of the Census (2012b)

(4) 4,532-ha (11,200-ac) Crackerneck Wildlife Management Area and Ecological Reserve, (5) 4,047-ha (10,000-ac) Savannah River Swamp Management Area, and (6) 1,781-ha (4,400-ac) Lower Three Runs Corridor Management Area (USFS 2005). The GTCC reference location is located within the Supplemental Red-Cockaded Woodpecker Management Area. The goal of protecting the red-cockaded woodpecker has a strong influence on natural resource decisions in this management area. Natural resource management in this area is designed to promote conservation and restoration, provide research and educational opportunities, and generate revenue from the sale of forest products (USFS 2005).

Forest and agricultural lands are the predominant lands bordering the SRS site (NRC 2005). Various industrial, manufacturing, medical, and farming operations occur near SRS (DOE 2005).

10.1.9 Transportation

Vehicular access to SRS is provided by South Carolina SRs 19, 64, and 125 and by US 278. SR 19 runs north from the site through New Ellenton toward Aiken, approximately 16 km (10 mi) from the northern border of SRS. SR 64 runs in an easterly direction from the site toward Barnwell. SR 125 runs through the site in a southeasterly direction between North Augusta and Allendale, passing through Beech Island and Jackson. US 278 also runs through the site between North Augusta and Barnwell in a southeasterly direction. SR 781 connects US 278 with Williston to the northeast of the site. Annual traffic counts for local roads are provided in Table 10.1.9-1.

On-site, SRS has approximately 210 km (130 mi) of primary roads and 1,800 km (1,100 mi) of secondary roads to handle the site's transportation needs (DOE 2005). About 20,000 vehicle trips per day (employees driving to and from work as well as driving between site areas) occur on-site to support shipments of materials and obtain access to test wells, utility lines, research sites, and natural resource management activities (DOE 2005).

The railroad infrastructure at SRS consists of 53 km (33 mi) of track for deliveries of foreign fuel shipments, movement of material and equipment on-site, and deliveries of materials for construction projects (DOE 2005). Rail service to SRS is provided by CSX Transportation.

10.1.10 Cultural Resources

Research on the archaeological resources at SRS has been ongoing since 1973. The Savannah River Archaeological Research Program of the South Carolina Institute of Archaeology and Anthropology, University of South Carolina, has been the primary group involved in the research. The Archaeological Research Program has been involved in identifying cultural resources at the site and developing management documents for maintaining them there. In 1999, the DOE Savannah River Operations Office, South Carolina SHPO, and ACHP developed a Programmatic Agreement to define how the site will consider the resources under its jurisdiction.

Cultural resources at SRS include archaeological sites, historic structures, and traditional cultural properties. Two main prehistoric periods have been defined for the region in which SRS is located. Each of these periods is divided into subsets of early, middle, and late. The older period is the Archaic, which spans the period between 8000 and 1000 B.C. The subsets of the Archaic are Early (8000 to 6000 B.C.), Middle (6000 to 3000 B.C.), and Late (3000 to 1000 B.C.). In general, the Archaic period is characterized by variable weather patterns, which, in turn, greatly affected the density and distribution of people across the continent. The next major period is the Woodland period (1000 B.C to A.D. 1100). The Woodland period is defined by major changes in subsistence strategies, such as the introduction of agriculture and the bow and arrow for more efficient hunting. During the Woodland period, populations continued to grow, and the first large-scale permanent settlements are found. It was during the Woodland Period that pottery was first widely produced. A final prehistoric period noted in the SRS region is the Mississippian period, which extends from A.D. 1100 to 1450.

European settlement of the area began during the colonial period between 1730 and 1780 and was focused along major waterways, such as the Savannah River and its tributaries. During the 1700s and early 1800s, this pattern of concentration of settlements along rivers persisted. Early farms used the richer soils along the rivers and focused on subsistence farming, with only surpluses being sold. During the 19th century, the situation began to change, with more cash crops, such as cotton, being grown. A relatively small amount of slave labor was employed.

TABLE 10.1.9-1 Traffic Counts in the Vicinity of SRS

Location		Average Daily Traffic Volume
US 278	West of SR 302	4,400
	Between SR 125 and SR 302	7,100
	North of the city of Barnwell	6,800
	Between SR 300 and US 301	3,900
SR 3	Near US 278	1,350
	Between SR 125 and US 301	900
SR 19	In the vicinity of US 78	7,200
	North of New Ellenton at Medwell Hill Rd.	13,200
SR 125	In Aiken County near Barnwell County line	3,200
	South of site boundary	2,100
	West of SR 3	1,650
SR 302	SR 125 to US 278	1,150
	North of US 278	5,400
	SR 118 to SR 19	22,400

Source: SCDOT (2007)

Settlement patterns did not begin changing until after the Civil War. The introduction of the railroads, which relieved the dependence on rivers for transportation, was a major factor in the land use changes (Cabak et al. 1996). After the Civil War, the tenant farming and share cropper systems began to take hold in the region. The Depression of the 1930s caused many people to leave the region for urban centers. After World War II, the increased mechanization of farming also resulted in people leaving the region as larger land holdings became common.

The Savannah River Project was established in 1950 by the AEC. The plant was operated by E.I. duPont de Nemours and Company, Inc., to produce basic materials for use in the manufacture of nuclear weapons. The plant site was constructed between 1951 and 1956. The site consisted of five nuclear reactors, two large chemical separation plants, a tritium processing facility, a heavy-water extraction plant, a uranium fuel processing facility, a fuel and target fabrication facility, and a waste management facility. The contract to operate and manage the operations switched to the Westinghouse Savannah River Company in 1989. The name of the facility changed from the Savannah River Project to Savannah River Site in 1989 as well.

There are more than 850 archaeological sites known on the SRS property (NRC 2005). Of these 850 sites, 67 have been determined potentially eligible for listing on the *National Register*. Prehistoric sites at SRS include village sites, base camps, limited activity sites, quarries, and workshops. Historic sites at SRS include farmsteads, tenant dwellings, mills, plantations, slave quarters, rice farm dikes, dams, cattle pens, ferry locations, churches, schools, towns, cemeteries, commercial buildings, and roads. Roughly 400 historic sites have been documented at SRS. No architectural surveys have been conducted at SRS. Numerous specialized facilities at SRS have the potential to be considered eligible for the NRHP.

A predictive model for the presence of cultural resources was developed during the 1970s for SRS. The model identifies three zones of archaeological sensitivity. Zone 1 has the highest potential for having numerous large archaeological sites. Zone 2 has moderate potential, and Zone 3 has the lowest potential (DOE 1997). The GTCC reference location is in Zone 3.

Traditional cultural properties are locations that are important to a group for maintaining its cultural identity. While these resources are most often related to Native Americans, they can be associated with other groups as well. The Apalachee, Cherokee, Chicksaw, Creek, Shawnee, Westo, and Yuchi all have traditional ties to the SRS property. The Yuchi Tribal Organization, the National Council of Muskogee Creek, and the Indian People's Muskogee Tribal Town Confederacy have expressed interest in the SRS property with regard to it containing traditional religious locations. The Yuchi Tribal Organization and the National Council of Muskogee Creek expressed concern about plants that they use in traditional ceremonies that can be found on SRS land.

10.1.11 Waste Management

Site management of the waste types generated by the land disposal methods for Alternatives 4 and 5 are discussed in Section 5.3.11.

10.2 ENVIRONMENTAL AND HUMAN HEALTH CONSEQUENCES

The potential impacts from the construction, operations, and post-closure of the trench (Alternative 4) and vault (Alternative 5) disposal methods are presented in this section for the resource areas evaluated. The affected environment for each resource area is described in Section 10.1. The GTCC reference location for SRS is shown in Figure 10.1-1.

10.2.1 Climate and Air Quality

This section discusses potential climate and air quality impacts from the construction and operations of each of the two disposal methods (trench and vault) at SRS. Noise impacts are presented in Section 5.3.1.

10.2.1.1 Construction

During the construction period, emissions of criteria pollutants (SO_2, NO_x, CO, PM_{10}, and $PM_{2.5}$), VOCs, and the primary greenhouse gas CO_2 would be caused by fugitive dust emissions from earth-moving activities and engine exhaust emissions from heavy equipment and commuter, delivery, and support vehicles. Typically, the potential impacts from exhaust emissions on ambient air quality would be smaller than those from fugitive dust emissions. Accordingly, only the potential impacts of fugitive PM_{10} and $PM_{2.5}$ emissions from construction activities on ambient air quality are discussed.

Air emissions of criteria pollutants, VOCs, and CO_2 from construction activities were estimated for the peak year when site preparation and construction of the support facility and some disposal cells would take place. Estimates for PM_{10} and $PM_{2.5}$ include diesel particulate emissions. The estimates are provided in Table 10.2.1-1 for each disposal method. Detailed information on emission factors, assumptions, and emission inventories is available in Appendix C. As shown in the table, total peak-year emission rates are estimated to be rather small when compared with emission totals for all three counties encompassing SRS (Aiken, Allendale, and Barnwell Counties). Peak-year emissions for all criteria pollutants and VOCs would be higher for the vault method, which would consume more materials and resources for vault construction and disturb more areas than would the trench method. In terms of absolute value and contribution to the emissions total, the peak-year emissions of NO_x for the vault method would be the highest, about 0.18% of the three-county emissions total, while it is estimated that other criteria pollutants and VOCs would be less than 0.03% of the three-county emissions total.

The highest background concentration levels for $PM_{2.5}$ in the area approached the standards (around 97%) (see Table 10.1.1-3). Construction activities would occur at least 14 km (9 mi) from the site boundary and thus would not be likely to result in exceedances of the standards. However, construction activities would still be conducted in a manner that would minimize potential impacts of construction-related emissions on ambient air quality. Also, construction permits typically require fugitive dust control by means of established standard dust control practices, primarily by watering unpaved roads, disturbed surfaces, and temporary stockpiles.

Although O_3 levels in the area exceeded the standard (about 109%) (see Table 10.1.1-3), the three counties encompassing SRS are currently in attainment for O_3 (40 CFR 81.341). O_3 precursor emissions from the proposed GTCC LLRW and GTCC-like waste disposal facility for both methods would be relatively small (less than 0.18% and 0.02% of the three-county total NO_x and VOC emissions, respectively), and they would be much lower than those for the regional air shed in which emitted precursors are transported and formed into O_3. Accordingly, potential impacts of O_3 precursor releases from construction on regional O_3 would not be of concern.

The major air quality concern with respect to emissions of CO_2 is that it is a greenhouse gas, which traps solar radiation reflected from the earth, keeping it in the atmosphere. The combustion of fossil fuels makes CO_2 the most widely emitted greenhouse gas worldwide. CO_2 concentrations in the atmosphere have continuously increased from approximately 280 ppm in preindustrial times to 379 ppm in 2005, a 35% increase, and most of this increase has occurred in the last 100 years (IPCC 2007).

The climatic impact of CO_2 does not depend on the geographic location of its sources because CO_2 is stable in the atmosphere and is essentially uniformly mixed; that is, the global total is the important factor with respect to global warming. Therefore, a comparison between U.S. and global emissions and the total emissions from the construction of a disposal facility is useful in understanding whether CO_2 emissions from the site would be significant with respect to global warming. As shown in Table 10.2.1-1, the highest peak-year amount of CO_2 emissions

TABLE 10.2.1-1 Peak-Year Emissions of Criteria Pollutants, Volatile Organic Compounds, and Carbon Dioxide from Construction of the Trench and Vault Disposal Facilities at SRS

Pollutant	Total Emissions (tons/yr)[a]	Construction Emissions (tons/yr)			
		Trench (%)[b]		Vault (%)[b]	
SO_2	20,700	0.90	(<0.01)	3.2	(0.02)
NO_x	17,336	8.1	(0.05)	31	(0.18)
CO	74,159	3.3	(<0.01)	11	(0.01)
VOCs	15,095	0.90	(0.01)	3.6	(0.02)
PM_{10}[c]	13,678	5.0	(0.04)	8.6	(0.06)
$PM_{2.5}$[c]	3,960	1.5	(0.04)	3.6	(0.09)
CO_2		670		2,300	
County[d]	4.25×10^6		(0.02)		(0.05)
South Carolina[e]	9.62×10^7		(0.0007)		(0.002)
U.S.[e]	6.54×10^9		(0.00001)		(0.00004)
World[e]	3.10×10^{10}		(0.000002)		(0.000007)

[a] Total emissions in 2002 for all three counties encompassing SRS (Aiken, Allendale, and Barnwell Counties). See Table 10.1.1-1 for criteria pollutants and VOCs.

[b] Numbers in parentheses are percent of total emissions.

[c] Estimates for GTCC construction include diesel particulate emissions.

[d] Emission data for the year 2005. Currently, data on CO_2 emissions at the county level are not available, so county-level emissions were estimated from available state total CO_2 emissions on the basis of population distribution.

[e] Annual CO_2 emissions in South Carolina, the United States, and worldwide in 2005.

Source: EIA (2008); EPA (2008b, 2009)

from construction would be less than 0.05%, 0.002% and 0.00004%, respectively, of 2005 county, state, and U.S. CO_2 emissions. In 2005, CO_2 emissions in the United States were about 21% of worldwide emissions (EIA 2008). Emissions from construction would be less than 0.00001% of global emissions. Potential impacts on climate change from construction emissions would be small.

Appendix D assumes an initial construction period of 3.4 years. The disposal units would be constructed as the waste became available for disposal. The construction phase would extend over more years; thus, emissions in nonpeak years would be lower than peak-year emissions in the table. In addition, construction activities would occur only during daytime hours, when air dispersion is most favorable. Accordingly, potential impacts from construction activities on ambient air quality would be minor and intermittent in nature.

General conformity applies to federal actions taking place in nonattainment or maintenance areas and is not applicable to the proposed action at SRS because the area is classified as being in attainment for all criteria pollutants (40 CFR 81.341).

10.2.1.2 Operations

Criteria pollutants, VOCs, and CO_2 would be released into the atmosphere during operations. These emissions would include fugitive dust emissions from emplacement activities and exhaust emissions from heavy equipment and commuter, delivery, and support vehicles. Estimated annual emissions of criteria pollutants, VOCs, and CO_2 at the facility are presented in Table 10.2.1-2. Detailed information on emission factors, assumptions, and emission inventories is available in Appendix C. As shown in the table, annual emissions from operations are estimated to be higher than those from construction under the trench method; estimates for PM_{10} and $PM_{2.5}$ include diesel particulate emissions. Except for PM_{10} emissions, the emission estimates for the vault method are about the same for the construction and operations phases. Compared with annual emissions for counties encompassing SRS, annual NO_x emissions for both the trench and vault methods are about 0.15% of the total emissions, while emissions of other criteria pollutants and VOCs are about 0.02% of the total.

Concentration levels from operational activities, except O_3 and $PM_{2.5}$ concentrations, are expected to remain well below the standards. Estimates for PM_{10} and $PM_{2.5}$ include diesel particulate emissions. As discussed in the construction section, established fugitive dust control measures (primarily the watering of unpaved roads, disturbed surfaces, and temporary stockpiles) would be implemented to minimize potential impacts on ambient air quality.

With regard to regional O_3, precursor emissions of NO_x and VOCs would be comparable to those resulting from construction activities (about 0.16% and 0.02% of the three-county emission totals, respectively) and are not anticipated to contribute much to regional O_3 levels. The highest emissions of CO_2 among the disposal methods would be comparable to the highest construction-related emissions; thus, their potential impacts on climate change would also be negligible.

PSD regulations are not applicable to the proposed action because the proposed action is not a major stationary source.

10.2.2 Geology and Soils

Direct impacts from land disturbance would be proportional to the total area of land disturbed during site preparation activities (e.g., grading and backfilling) and construction of the GTCC LLRW and GTCC-like waste disposal facility and related infrastructure (e.g., roads). Land disturbance would include the surface area covered for both the trench and vault disposal methods and the vertical displacement of geologic materials for the trench disposal method (the borehole disposal method is not evaluated for SRS). The increased potential for soil erosion would be an indirect impact from land disturbance at the construction site. Indirect impacts

TABLE 10.2.1-2 Annual Emissions of Criteria Pollutants, Volatile Organic Compounds, and Carbon Dioxide from Operations of the Trench and Vault Disposal Facilities at SRS

Pollutant	Total Emissions (tons/yr)[a]	Operation Emissions (tons/yr)			
		Trench (%)[b]		Vault (%)[b]	
SO_2	20,700	3.3	(0.02)	3.3	(0.02)
NO_x	17,336	27	(0.16)	27	(0.16)
CO	74,159	15	(0.02)	15	(0.02)
VOCs	15,095	3.1	(0.02)	3.1	(0.02)
PM_{10}[c]	13,678	2.5	(0.02)	2.5	(0.02)
$PM_{2.5}$[c]	3,960	2.2	(0.06)	2.2	(0.06)
CO_2		3,200		3,300	
County[d]	4.25×10^6		(0.08)		(0.08)
South Carolina[e]	9.62×10^7		(0.003)		(0.003)
U.S.[e]	6.54×10^9		(0.00005)		(0.00005)
World[e]	3.10×10^{10}		(0.00001)		(0.00001)

[a] Total emissions in 2002 for all three counties encompassing SRS (Aiken, Allendale, and Barnwell Counties). See Table 10.1.1-1 for criteria pollutants and VOCs.

[b] Numbers in parentheses are percent of total emissions.

[c] Estimates for GTCC operations include diesel particulate emissions.

[d] Emission data for the year 2005. Currently, data on CO_2 emissions at the county level are not available, so county-level emissions were estimated from available state total CO_2 emissions on the basis of population distribution.

[e] Annual CO_2 emissions in South Carolina, the United States, and worldwide in 2005.

Source: EIA (2008); EPA (2008b, 2009)

would also result from the consumption of geologic materials (e.g., aggregate) for facility and other associated infrastructure construction. The impact analysis also considers whether the proposed action would preclude the future extraction and use of mineral materials or energy resources.

10.2.2.1 Construction

Impacts from disturbing the land surface area would be a function of the disposal method (trench or vault) implemented at the site, but the impacts from the two methods would be comparable. Geologic and soil material requirements are listed in Table 5.3.2-1. The vault facility would require the most material since it would involve the installation of interim and final cover systems. This material would be considered permanently lost. However, neither of the disposal methods is expected to result in adverse impacts on geologic and soil resources at SRS, since these resources are in abundant supply in South Carolina.

No significant changes in surface topography or natural drainages are anticipated in the construction area. However, the disturbance of soil during the construction phase would increase the potential for erosion in the immediate vicinity. Mitigation measures would be implemented to avoid or minimize the risk of erosion.

The GTCC LLRW and GTCC-like waste disposal facility would be sited and designed with safeguards to avoid or minimize the risks associated with seismic hazards. SRS is in a seismically active region, and small-magnitude earthquakes occur regularly. There is no volcanic risk for SRS. The potential for other hazards (e.g., subsidence and liquefaction) is considered to be low.

10.2.2.2 Operations

The disturbance of soil and the increased potential for soil erosion would continue throughout the operations phase as waste was delivered to the site for disposal over time. Mitigation measures would be implemented to avoid or minimize the risk of erosion.

Impacts related to the extraction and use of valuable geologic materials are expected to be low, since mineral and energy development does not occur within the boundary of SRS.

10.2.3 Water Resources

Direct and indirect impacts on water resources could result from water use at the proposed GTCC LLRW and GTCC-like waste disposal facility during construction and operations. Table 5.3.3-1 provides an estimate of the water consumption and discharge volumes for the land disposal methods; Tables 5.3.3-2 and 5.3.3-3 summarize the water use impacts (in terms of change in annual water use) on water resources from construction and operations, respectively. A discussion of potential impacts during each project phase is presented in the following sections. In addition, contamination due to potential leaching of radionuclides from the waste inventory into groundwater could occur, depending on the post-closure performance of the trench and vault disposal facilities discussed in Section 10.2.4.2.

10.2.3.1 Construction

Of the two land disposal methods considered for SRS, construction of a vault facility would have the higher water requirement (Table 5.3.3-1). Water demands for construction at SRS would be met by using groundwater from on-site wells. (Wells at the SRS currently draw from the deep Crouch Branch and McQueen Aquifers, with a few lower-capacity wells pumping from the shallower Gordon Aquifer and the lower zone of the Upper Three Runs Aquifer.) No surface water would be used at the site during construction. As a result, no direct impacts on surface water resources are expected. The potential for indirect surface water impacts on the Savannah River and its tributaries related to soil erosion, contaminated runoff, and sedimentation would be reduced by implementing good industry practices and mitigation measures. The GTCC reference location is not within the 100-year floodplain of Fourmile Branch or Upper Three Run Creek.

Currently, SRS uses about 5.3 billion L (1.4 billion gal) of groundwater per year. Construction of the proposed GTCC LLRW and GTCC-like waste disposal facility would increase the annual water use at SRS by a maximum of about 0.06% (vault method) over the 20-year period that construction would occur. Because withdrawals of groundwater would be relatively small, they would not significantly lower the water table or change the direction of groundwater flow at SRS. As a result, impacts due to groundwater withdrawals are expected to be negligible.

Construction activities could potentially change the infiltration rate at the site of the proposed GTCC LLRW and GTCC-like waste disposal facility, first by increasing the rate as ground would be disturbed in the initial stages of construction and then by decreasing the rate as impermeable materials (e.g., the clay material and geotextile membrane assumed for the cover or cap in the land disposal facility designs) would cover the surface. These changes are expected to be negligible since the area of land associated with the proposed GTCC LLRW and GTCC-like waste disposal facility (up to 25 ha [60 ac], depending on the disposal method) is small relative to the SRS land area.

Disposal of waste (including sanitary waste) generated during construction of the trench or vault disposal facility would have a negligible impact on the quality of water resources at SRS (see Sections 5.3.11 and 10.2.11). The potential for indirect surface water or groundwater impacts related to spills at the surface would be reduced by implementing good industry practices and mitigation measures.

10.2.3.2 Operations

The two land disposal methods considered for SRS would have the same water requirement (Table 5.3.3-1). Water demands for operations at SRS would be met by using groundwater from on-site wells. No surface water would be used at the site during operations. As a result, no direct impacts on surface water resources are expected. The potential for indirect surface water impacts related to soil erosion, contaminated runoff, and sedimentation would be reduced by implementing good industry practices and mitigation measures.

Operations of the proposed GTCC LLRW and GTCC-like waste disposal facility would increase the annual water use at SRS by a maximum of about 0.1% (trench or vault method). Because withdrawals of groundwater would be relatively small, they would not significantly lower the water table or change the direction of groundwater flow at SRS. As a result, impacts due to groundwater withdrawals are expected to be small.

Disposal of waste (including sanitary waste) generated during operations of the trench or vault disposal facility would have a negligible impact on the quality of water resources at SRS (see Sections 5.3.11 and 10.2.11). The potential for indirect impacts on surface water or groundwater related to spills at the surface would be reduced by implementing good industry practices and mitigation measures.

10.2.4 Human Health

Potential impacts on members of the general public and on involved workers from the construction and operations of the waste disposal facilities are expected to be comparable for all of the sites evaluated in this EIS for the land disposal methods, and these impacts are described in Section 5.3.4. The following sections discuss the impacts from hypothetical facility accidents associated with waste handling activities and the impacts during the post-closure phase. They address impacts on members of the general public who might be affected by these waste disposal activities at the SRS GTCC reference location, since these impacts would be site dependent.

10.2.4.1 Facility Accidents

Data on the estimated human health impacts from hypothetical accidents at a GTCC LLRW and GTCC-like waste disposal facility located at SRS are provided in Table 10.2.4-1. The accident scenarios are discussed in Section 5.3.4.2.1 and Appendix C. A reasonable range of accidents that includes operational events and natural causes is analyzed. The impacts presented for each accident scenario are for the sector with the highest impacts, and no protective measures are assumed; therefore, they represent maximum impacts expected for such an accident.

The collective population dose includes exposure from inhalation of airborne radioactive material, external exposure from radioactive material deposited on the ground, and ingestion of contaminated crops. The exposure period is considered to last for 1 year immediately following the accidental release. It is recognized that interdiction of food crops would likely occur if a significant release did occur, but this assessment conservatively addresses what could happen without interdiction. For the accidents involving CH waste (Accidents 1–9, 11, 12), the ingestion dose accounts for approximately 20% of the collective population dose shown in Table 10.2.4-1. External exposure is negligible in all cases. All exposures are dominated by the inhalation dose from the passing plume of airborne radioactive material downwind of the hypothetical accident immediately following release.

The highest estimated impact on the general public, 45 person-rem, would be from a hypothetical release from a SWB caused by a fire in the WHB (Accident 9). This dose is not expected to lead to any additional LCFs in the population. This dose would be released to the 263,000 people living to the west-northwest of the facility, resulting in an average dose of less than 0.0002 rem per person. Because this dose would be from internal intake (primarily inhalation, with some ingestion) and because the DCFs used in this analysis are for a 50-year CEDE, this dose would be accumulated over the course of 50 years.

TABLE 10.2.4-1 Estimated Radiological Human Health Impacts from Hypothetical Facility Accidents at SRS[a]

		Off-Site Public		Individual[b]	
Accident Number	Accident Scenario	Collective Dose (person-rem)	Latent Cancer Fatalities[c]	Dose (rem)	Likelihood of LCF[c]
1	Single drum drops, lid failure in Waste Handing Building	0.001	<0.00001	0.0001	<0.00001
2	Single SWB drops, lid failure in Waste Handing Building	0.002	<0.00001	0.0002	<0.00001
3	Three drums drop, puncture, lid failure in Waste Handling Building	0.002	<0.00001	0.0002	<0.00001
4	Two SWBs drop, puncture, lid failure in Waste Handling Building	0.003	<0.00001	0.0003	<0.00001
5	Single drum drops, lid failure outside	1	0.0006	0.095	0.00006
6	Single SWB drops, lid failure outside	2.2	0.001	0.22	0.0001
7	Three drums drop, puncture, lid failure outside	1.8	0.001	0.17	0.0001
8	Two SWB drops, puncture, lid failure outside	3.1	0.002	0.3	0.0002
9	Fire inside the Waste Handling Building, one SWB assumed to be affected	45	0.03	4.3	0.003
10	Single RH waste canister breach	<0.001	<0.00001	<0.00001	<0.00001
11	Earthquake, affects 18 pallets, each with 4 CH drums	29	0.02	2.7	0.002
12	Tornado, missile hits one SWB, contents released	8.9	0.005	0.86	0.0005

[a] CH = contact-handled, RH = remote-handled, LCF = latent cancer fatality, SWB = standard waste box.

[b] The individual receptor is assumed to be 100 m (330 ft) downwind from the release point. This individual is expected to be a noninvolved worker because there would be no public access within 100 m (330 ft) of the GTCC reference location.

[c] LCFs are calculated by multiplying the dose by the health risk conversion factor of 0.0006 fatal cancer per person-rem (see Section 5.2.4.3). Values are rounded to one significant figure.

The dose to an individual (expected to be a noninvolved worker because there would be no public access within 100 m [330 ft] of the GTCC reference location) includes exposure from inhalation of airborne radioactive material and 2 hours of exposure to radioactive material deposited on the ground. As shown in Table 10.2.4-1, the highest estimated dose to an individual, 4.3 rem, would result from Accident 9 from inhalation exposure immediately after the postulated release. This estimated dose is for a hypothetical individual located 100 m (330 ft) to the north of the accident location. As discussed above, the estimated dose of 4.3 rem would be accumulated over a 50-year period after intake and would not result in any symptoms of acute radiation syndrome. A maximum annual dose of about 5% of the total dose would occur in the first year. The increased lifetime probability of a fatal cancer for this individual is approximately 0.3% on the basis of a total dose of 4.3 rem.

10.2.4.2 Post-Closure

The potential radiation dose from airborne releases of radionuclides to the off-site public after the closure of either the trench or vault disposal facility would be small. RESRAD-OFFSITE calculation results indicate that the potential inhalation dose at a distance of 100 m (330 ft) from the disposal facility is estimated to be less than 1.8 mrem/yr for trench disposal and 0.52 mrem/yr for vault disposal. The potential radiation exposure would be caused mainly by inhalation of radon gas and its short-lived progeny.

At SRS, the climate is generally humid, with an average annual precipitation rate of about 1.2 m/yr (3.9 ft/yr). The natural water infiltration rate to deeper soils is estimated to be about 0.38 m/yr (1.2 ft/yr), which is much larger than the natural infiltration rate estimated for other sites considered in this EIS. As a result, more radionuclides would be carried to the groundwater table in a shorter period of time. It is estimated that within 10,000 years, the peak annual radiation dose associated with the use of contaminated groundwater from disposal of the entire GTCC LLRW and GTCC-like waste inventory at SRS by a hypothetical resident farmer living 100 m (330 ft) from the disposal facility would be 1,300 mrem/yr for the vault method and 1,700 mrem/yr for the trench method (see Table 10.2.4-2).

The peak annual doses are calculated to occur quite quickly for SRS because the water infiltration rate is so high there. The maximum annual dose would occur about 54 years (for the vault method) and 29 years (for the trench method) after failure of the engineered cover and barriers. These times represent the time after failure of the engineered barriers (including the cover), which is assumed to begin 500 years after closure of the disposal facility. The exposure pathways related to the use of contaminated groundwater considered in this analysis include the ingestion of contaminated groundwater, soil, plants, meat, and milk; external radiation; and the inhalation of radon gas and its short-lived progeny.

The peak annual doses and LCF risks given in Tables 10.2.4-2 and 10.2.4-3 to the hypothetical resident farmer (from use of potentially contaminated groundwater within the first 10,000 years after closure of the disposal facility) are those associated with the disposal of the entire GTCC LLRW and GTCC-like waste inventory by using the vault and trench disposal methods. In these tables, the annual doses and LCF risks contributed by each waste type

TABLE 10.2.4-2 Estimated Peak Annual Doses (in mrem/yr) from the Use of Contaminated Groundwater within 10,000 Years of Disposal at the GTCC Reference Location at SRS[a]

	GTCC LLRW				GTCC-Like Waste				Peak Annual Dose from Entire Inventory
Disposal Technology/ Waste Group	Activated Metals	Sealed Sources	Other Waste - CH	Other Waste - RH	Activated Metals	Sealed Sources	Other Waste - CH	Other Waste - RH	
Vault disposal									1,300[b]
Group 1 stored	2.0	-	0.0	1.3	0.21	0.0	15	1,000	
Group 1 projected	30	0.0	-	0.039	0.53	0.0	4.2	3.6	
Group 2 projected	14	0.0	6.5	230	-	-	8.3	18	
Trench disposal									1,700[b]
Group 1 stored	2.2	-	0.0	1.0	0.24	0.0	31	1,100	
Group 1 projected	33	0.0	-	0.031	0.60	0.0	8.7	2.9	
Group 2 projected	16	0.0	13	460	-	-	17	31	

[a] These annual doses are associated with the use of contaminated groundwater by a hypothetical resident farmer located 100 m (330 ft) from the edge of the disposal facility. All values are given to two significant figures, and a hyphen means there is no inventory for that waste type. The values given in this table represent the annual doses to the hypothetical resident farmer at the time of peak annual dose from the entire GTCC LLRW and GTCC-like waste inventory. These contributions do not represent the maximum doses that could result from each of these waste types separately. Because of the different radionuclide mixes and activities contained in the different waste types, the maximum doses that could result from each waste type individually generally occur at different times than the peak annual dose from the entire inventory. The peak annual doses that could result from each of the waste types are presented in Tables E-22 through E-25 in Appendix E.

[b] The times for the peak annual doses of 1,300 mrem/yr for vaults and 1,700 mrem/yr for trenches were calculated to be about 54 years and 29 years, respectively, for disposal of the entire GTCC LLRW and GTCC-like waste inventory. These times represent the time after failure of the cover and engineered barriers (which is assumed to begin 500 years after closure of the disposal facility). The values reported for the other entries in this table represent the annual doses from the specific waste types at the time of these peak doses. The primary contributors to the dose are GTCC LLRW Other Waste - RH and GTCC-like Other Waste - RH. The primary radionuclides causing this dose would be C-14, Tc-99, I-129, and Np-237.

TABLE 10.2.4-3 Estimated Peak Annual LCF Risks from the Use of Contaminated Groundwater within 10,000 Years of Disposal at the GTCC Reference Location at SRS[a]

	GTCC LLRW				GTCC-Like Waste				
Disposal Technology/ Waste Group	Activated Metals	Sealed Sources	Other Waste - CH	Other Waste - RH	Activated Metals	Sealed Sources	Other Waste - CH	Other Waste - RH	Peak Annual LCF Risk from Entire Inventory
Vault disposal									8E-04[b]
Group 1 stored	1E-06	-	0E+00	8E-07	1E-07	0E+00	9E-06	6E-04	
Group 1 projected	2E-05	0E+00	-	2E-08	3E-07	0E+00	3E-06	2E-06	
Group 2 projected	9E-06	0E+00	4E-06	1E-04	-	-	5E-06	1E-05	
Trench disposal									1E-03[b]
Group 1 stored	1E-06	-	0E+00	6E-07	1E-07	0E+00	2E-05	7E-04	
Group 1 projected	2E-05	0E+00	-	2E-08	4E-07	0E+00	5E-06	2E-06	
Group 2 projected	9E-06	0E+00	8E-06	3E-04	-	-	1E-05	2E-05	

[a] These annual LCF risks are associated with the use of contaminated groundwater by a hypothetical resident farmer located 100 m (330 ft) from the edge of the disposal facility. All values are given to one significant figure, and a hyphen means there is no inventory for that waste type. The values given in this table represent the annual LCF risks to the hypothetical resident farmer at the time of peak annual LCF risk from the entire GTCC LLRW and GTCC-like waste inventory. These contributions do not represent the maximum LCF risks that could result from each of these waste types separately. Because of the different radionuclide mixes and activities contained in the different waste types, the maximum LCF risks that could result from each waste type individually generally occur at different times than the peak annual LCF risk from the entire inventory.

[b] The times for the peak annual LCF risks of 8E-04 for vaults and 1E-03 for trenches were calculated to be about 54 years and 29 years, respectively, for disposal of the entire GTCC LLRW and GTCC-like waste inventory. These times represent the time after failure of the cover and engineered barriers (which is assumed to begin 500 years after closure of the disposal facility). The values reported for the other entries in this table represent the annual LCF risks from the specific waste types at the time of peak LCF risks. The primary contributors to the LCF risk are GTCC LLRW Other Waste - RH and GTCC-like Other Waste - RH. The primary radionuclides causing this risk would be C-14, Tc-99, I-129, and Np-237.

(i.e., dose and risk for each waste type at the time or year when the peak dose or risk for the entire inventory is observed) to the peak dose and risk are also tabulated. The doses and LCF risks presented for the various waste types do not necessarily represent the peak dose and LCF risk of the waste type itself when it is considered on its own. Tables E-22 through E-25 in Appendix E present peak doses for each waste type when considered on its own. Because these peak doses generally occur at different times, the results should not be summed to obtain total doses for comparison with those presented in Table 10.2.4-2 (although for some cases, these sums might be close to those presented in the site-specific chapters).

The radiation doses are largely associated with the GTCC-like Other Waste - RH; GTCC LLRW Other Waste - RH contributes about one-fourth of the peak annual dose. Activated metals also contribute a measurable amount to the peak dose and LCF risk for each disposal method.

It is calculated that within 100 years after a breach of the engineered barriers (including cover), C-14, Tc-99, I-129, and Np-237 would reach the groundwater table and a well installed by the hypothetical resident farmer. These radionuclides are highly soluble in water, a characteristic that could lead to potentially significant groundwater concentrations and subsequently high doses and LCF risks to this hypothetical receptor. Additional radionuclides that would contribute to the groundwater dose within 10,000 years include Ni-59, Ni-63, Ra-226, Am-241, and Th-230. Of these five radionuclides, it is calculated that Ni-59, Ni-63, and Ra-226 would reach the groundwater table and a well located 100 m (330 ft) downgradient of the disposal facility, while the radiation doses attributable to Am-241 and Th-230 would largely be those associated with the decay products of these two radionuclides (Np-237 and Ra-226).

Figure 10.2.4-1 is a temporal plot of the doses associated with the use of contaminated groundwater for the vault and trench disposal methods for a period extending to 10,000 years, and Figure 10.2.4-2 shows these results to 100,000 years. Note that the time scale in Figure 10.2.4-1 is logarithmic, while the time scale in Figure 10.2.4-2 is linear. A logarithmic time scale was used in the first figure to better illustrate the projected radiation doses to a hypothetical resident farmer in the first 10,000 years.

As shown in Figure 10.2.4-2, a number of additional actinides (mainly isotopes of uranium, plutonium, and thorium) would contribute to the groundwater dose thousands of years after closure and last over a very long duration. The peak annual doses from these radionuclides would occur about 30,000 years following closure of the trench disposal facility and about 40,000 years following closure of the vault facility. These maximum doses are lower than those that are predicted to occur within the first 10,000 years by the RESRAD-OFFSITE computer code.

The results given here are assumed to be conservative because the location selected for the residential exposure is 100 m (330 ft) from the edge of the disposal facility. Use of a longer distance, which might be more realistic for the sites being evaluated, would significantly lower these estimated doses (i.e., by as much as 70%). A sensitivity analysis performed to determine the effect of a distance longer than 100 m (330 ft) is presented in Appendix E.

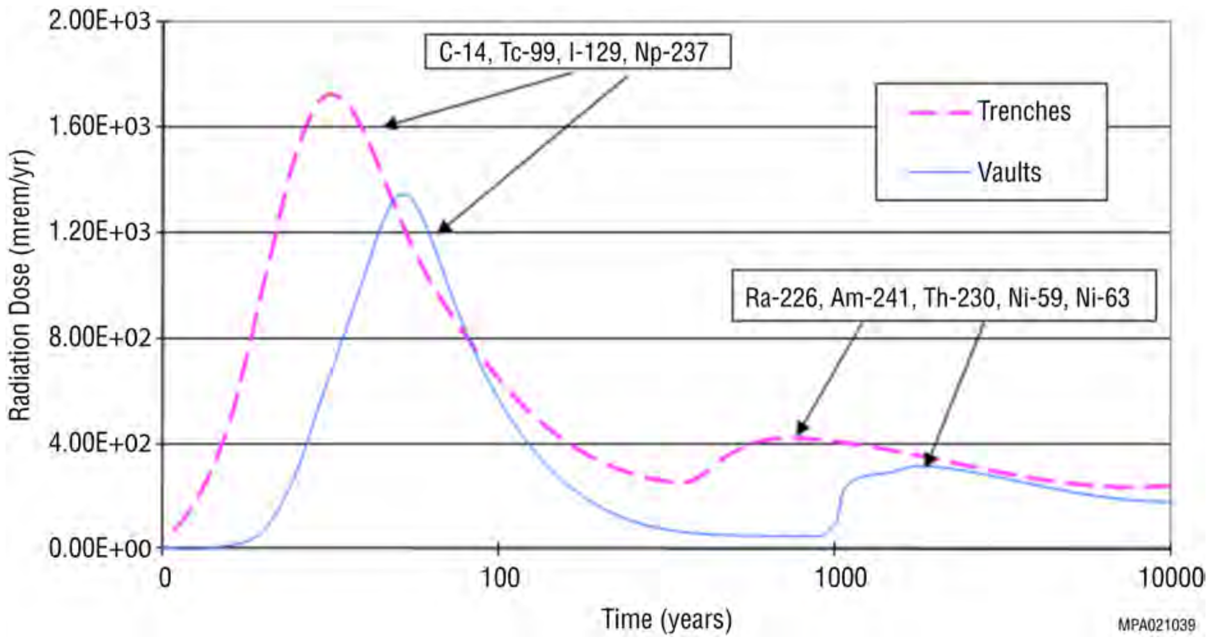

FIGURE 10.2.4-1 Temporal Plot of Radiation Doses Associated with the Use of Contaminated Groundwater within 10,000 Years of Disposal for the Trench and Vault Disposal Methods at SRS

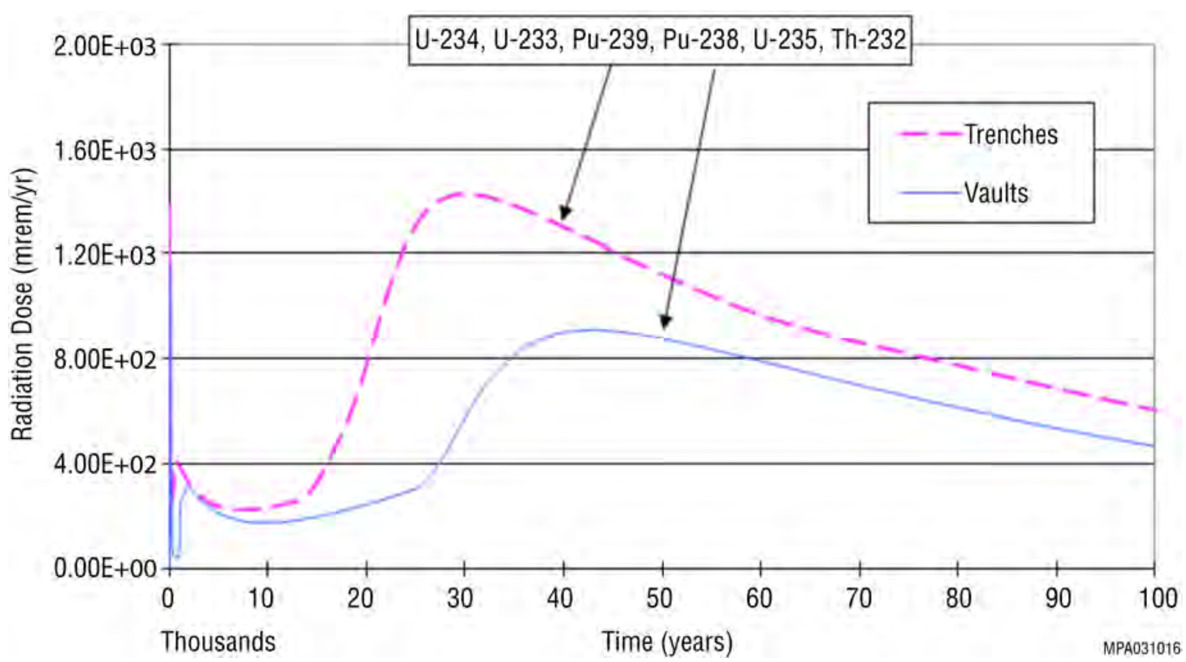

FIGURE 10.2.4-2 Temporal Plot of Radiation Doses Associated with the Use of Contaminated Groundwater within 100,000 Years of Disposal for the Trench and Vault Disposal Methods at SRS

These analyses assume that engineering controls would be effective for 500 years following closure of the disposal facility. This means that essentially no infiltrating water would reach the wastes from the top of the disposal units during the first 500 years. It is assumed that after 500 years, the engineered barriers would begin to degrade, allowing infiltrating water to come in contact with the disposed-of wastes. For purposes of analysis in the EIS, it is assumed that the amount of infiltrating water that would contact the wastes would be 20% of the site-specific natural infiltration rate for the area, and that the water infiltration rate around and beneath the disposal facilities would be 100% of the natural rate for the area. This approach is conservative because it is expected that the engineered systems (including the disposal facility cover) would last longer than 500 years, even in the absence of active maintenance measures.

It is assumed that the Other Waste would be stabilized with grout or other material and that this stabilizing agent would be effective for 500 years. Consistent with the assumptions used for engineering controls, no credit was taken in this analysis for the effectiveness of this stabilizing agent after 500 years. That is, it is assumed that any water that would contact the wastes after 500 years would be able to leach radioactive constituents from the disposed-of materials. These radionuclides could then move with the percolating groundwater to the underlying groundwater system. This assumption is conservative because grout or other stabilizing materials could retain their integrity for longer than 500 years.

Sensitivity analyses performed relative to these assumptions indicate that if a higher infiltration rate to the top of the disposal facilities was assumed, the doses would increase in a linear manner from those presented. Conversely, the doses would decrease in a linear manner with lower infiltration rates. This finding indicates the need to ensure good cover is placed over the closed disposal units. Also, the doses would be lower if it was assumed that the grout would last for a longer time. Because of the long-lived nature of the radionuclides associated with some of the GTCC LLRW and GTCC-like waste, any stabilization effort (such as grouting) would have to be effective for longer than 5,000 years in order to substantially reduce doses that could result from potential future leaching of the disposed-of waste.

The radiation doses presented in the post-closure assessment in this EIS are intended to be used for comparing the performance of each land disposal method at each site evaluated. The results indicate that the use of robust engineering designs and redundant measures (e.g., types and thicknesses of covers and long-lasting grout) in the disposal facility could delay the potential release of radionuclides and could reduce any releases to very low levels, thereby minimizing potential groundwater contamination and associated human health impacts in the future. DOE has considered the potential doses to the hypothetical resident farmer as well as other factors discussed in Section 2.9 in identifying the preferred alternative presented in Section 2.10.

10.2.5 Ecology

Section 5.3.5 presents an overview of the potential impacts on ecological resources that could result from the construction, operations, and post-closure maintenance of the GTCC LLRW and GTCC-like waste disposal facility regardless of the location selected for the facility. This section evaluates the potential impacts of the facility on the ecological resources at SRS.

Initial loss of mostly upland pine and some hardwood forest habitats, followed by eventual establishment of low-growth vegetation on the disposal site, are not expected to create a long-term reduction in the regional ecological diversity. After closure of the GTCC LLRW and GTCC-like waste disposal facility, the cover would be planted with annual and perennial grasses and forbs. As appropriate, regionally native plants would be used to landscape the disposal site in accordance with "Guidance for Presidential Memorandum on Environmentally and Economically Beneficial Landscape Practices on Federal Landscaped Grounds" (EPA 1995).

Clearing of forest habitat for the GTCC LLRW and GTCC-like waste disposal facility could result in a localized loss of wildlife species that occupy forest habitats. White-tailed deer could also lose a source of mast and potential cover against weather extremes. Species that might occur at the GTCC LLRW and GTCC-like waste disposal facility once vegetation became established include species that are currently found on urban areas near SRS. However, fencing (during the institutional control/monitored post-closure period) of the disposal site would lessen the potential for mid- to large-size mammals to enter the area. Some wildlife species might frequent the area between the forest and GTCC reference location (field/forest-edge habitat) (Peterson et al. 2005). Species more dependent on forested habitat or more sensitive to disturbance (e.g., wood warblers and vireos) would probably be permanently displaced from the GTCC reference location (DOE 1997).

Wildlife-vehicle collisions stemming from increased traffic associated with construction and operations of the GTCC LLRW and GTCC-like waste disposal facility would result in mortality of some wildlife species. Population-level impacts are not expected from these losses since these species are common throughout SRS (DOE 1997).

Because no aquatic or wetland habitats occur within the immediate vicinity of the GTCC reference location, direct impacts on aquatic and wetland biota are not expected. DOE would use appropriate erosion control measures to minimize off-site movement of soil. The GTCC LLRW and GTCC-like waste disposal facility retention pond is not expected to become a highly productive aquatic habitat. However, depending on the amount of water and length of time that water would be retained within the pond, aquatic invertebrates could become established within it. Waterfowl, shorebirds, and other birds might also make use of the retention pond, as would amphibian, reptile, and mammal species that might enter the site.

Several of the federally and state-listed or special-status species listed in Table 10.1.5-1 could occur at the GTCC reference location. However, the area of forested habitat that would be disturbed by construction would be small relative to the overall area of such habitat on SRS. Also, mitigation measures would minimize the potential for adverse impacts on these species. Therefore, construction of the GTCC disposal facility would have a small to negligible impact on the populations of special-status species at SRS.

The GTCC reference location does not contain red-cockaded woodpecker nesting or foraging areas that are utilized by the birds; however, it does contain unoccupied habitat approaching suitable age that could be utilized by the species (DOE 1997). Forest removal during construction of the facility would eliminate only about 0.1% of the Supplemental Red-

Cockaded Woodpecker Management Area at SRS. This small reduction is not expected to have an effect on the population of the red-cockaded woodpecker at SRS (USFS 2005).

No other threatened or endangered species occur on the GTCC reference location. The site could establish a vegetative cover that could provide habitat suitable for the smooth coneflower (*Echinacea laevigata*) (i.e., abundant sunlight with little competition in the herbaceous layer). Habitats at SRS that provide suitable habitat for that species include open woods, cedar barrens, roadsides, clearcuts, and transmission line ROWs (DOE 1997). DOE would continue to review the site during construction and operations to ensure that no adverse impacts on listed species were occurring.

Among the goals of the waste management mission at DOE sites is to maintain disposal facilities in a manner that protects the environment and complies with regulations (DOE 2002). Therefore, impacts associated with the GTCC LLRW and GTCC-like waste disposal facility that could affect ecological resources would be minimized and mitigated.

10.2.6 Socioeconomics

10.2.6.1 Construction

The potential socioeconomic impacts from constructing a GTCC LLRW and GTCC-like waste disposal facility and support buildings at SRS would be relatively small for both the trench and vault disposal methods. Construction activities would create direct employment of 62 people (trench method) to 145 people (vault method) in the peak construction year and an additional 64 indirect jobs (trench method) to 168 indirect jobs (vault method) in the ROI (Table 10.2.6-1). Construction activities would constitute less than 1% of the total ROI employment in the peak year. A GTCC LLRW and GTCC-like waste disposal facility would produce between $4.8 million in income (trench method) and $12.7 million in income (vault method) in the peak year of construction.

In the peak year of construction, between 27 people (trench) and 64 people (vault method) would in-migrate to the ROI (Table 10.2.6-1), as a result of employment on-site. In-migration would have only a marginal effect on population growth and would require less than 1% of vacant rental housing in the peak year. No significant impact on public finances would occur as a result of in-migration, and no new local public service employees would be required to maintain existing levels of service in the various local public service jurisdictions in the ROI. In addition, on-site employee commuting patterns would have a small to moderate impact on levels of service in the local transportation network surrounding the site.

10.2.6.2 Operations

The potential socioeconomic impacts from operating a GTCC LLRW and GTCC-like waste disposal facility would be relatively small for both the trench and vault disposal methods.

TABLE 10.2.6-1 Effects of GTCC LLRW and GTCC-Like Waste Disposal Facility Construction and Operations on Socioeconomics at the ROI for SRS[a]

	Trench		Vault	
Impact Category	Construction	Operations	Construction	Operations
Employment (number of jobs)				
Direct	62	48	145	51
Indirect	64	43	168	45
Total	126	91	313	96
Income ($ in millions)				
Direct	2.3	3.2	6.2	3.4
Indirect	2.5	1.6	6.5	1.6
Total	4.8	4.8	12.7	5.0
Population (number of new residents)	27	2	64	2
Housing (number of units required)	14	1	32	1
Public finances (% impact on expenditures)				
Cities and counties[b]	<1	<1	<1	<1
Schools[c]	<1	<1	<1	<1
Public service employment (number of new employees)				
Local government employees[d]	0	0	1	0
Teachers	0	0	1	0
Traffic (impact on current levels of service)	Small	Small	Moderate	Small

[a] Impacts shown are for waste facility and support buildings in the peak year of construction and the first year of operations.

[b] Includes impacts that would occur in the cities of Aiken, Jackson, New Ellenton, North Augusta, Wagener, Barnwell, Blackville, Williston, Grovetown, Harlem, Augusta, Blyth, and Hephzibah; in Aiken and Barnwell Counties in South Carolina; and in Colombia and Richmond Counties in Georgia.

[c] Includes impacts that would occur in Aiken County, Barnwell Additional Voluntary Contribution, Barnwell #19, Barnwell #29, Barnwell #45, Columbia, and Richmond County School Districts.

[d] Includes police officers, paid firefighters, and general government employees.

Operational activities would create about 48 direct jobs (trench method) to 51 direct jobs (vault method) annually and an additional 43 indirect jobs (trench method) to 45 indirect jobs (vault method) in the ROI (Table 10.2.6-1). A GTCC LLRW and GTCC-like waste disposal facility would also produce between $4.8 and $5.0 million in income annually during operations.

Two people would move to the area at the beginning of operations (Table 10.2.6-1). However, in-migration would have only a marginal effect on population growth and would require less than 1% of vacant owner-occupied housing during facility operations. No significant impact on public finances would occur as a result of in-migration, and no new local public service employees would be required to maintain existing levels of service in the various local public service jurisdictions in the ROI. In addition, on-site employee commuting patterns would have a small impact on levels of service in the local transportation network surrounding the site.

10.2.7 Environmental Justice

10.2.7.1 Construction

No radiological risks and only very low chemical exposure and risk are expected during construction of the trench and vault methods. Chemical exposure during construction would be limited to airborne toxic air pollutants at less than standard levels and would not result in any adverse health impacts. Because the health impacts of each facility on the general population within the 80-km (50-mi) assessment area during construction would be negligible, impacts from the construction of each facility on the minority and low-income populations would not be significant.

10.2.7.2 Operations

Because incoming GTCC LLRW and GTCC-like waste containers would only be consolidated for placement in trench and vault facilities, with no repackaging necessary, there would be no radiological impacts on the general public during disposal operations and no adverse health impacts on the general population. In addition, no surface releases that might enter local streams or interfere with subsistence activities by low-income or minority populations would occur. Because the health impacts from routine operations on the general public would be negligible, it is expected that there would be no disproportionately high and adverse impact on minority and low-income population groups within the 80-km (50-mi) assessment area. Subsequent NEPA review to support any GTCC implementation would consider any unique exposure pathways (such as subsistence fish, vegetation, or wildlife consumption, or well water use) to determine any additional potential health and environmental impacts.

10.2.7.3 Accidents

An accidental radiological release from any of the land disposal facilities would not be expected to cause any LCFs to members of the public in the surrounding area. In the unlikely event of a release at a facility, the communities most likely to be affected could be minority or low-income, given the demographics within 80 km (50 mi) of the GTCC reference location. However, it is highly unlikely such a release would occur, and the risk to any population, including low-income and minority communities, is considered to be low for the accident with the highest potential impacts, estimated to be less than 0.03 LCF for the population groups residing to the west-northwest of the site.

Although the overall risk would be very small, the greatest short-term risk of exposure following an airborne release and the greatest one-year risk would be to the population groups residing to the west-northwest of the site because of the prevailing wind condition in this case. Airborne releases following an accident would likely have a larger impact on the area than would an accident that released contaminants directly into the soil surface. A surface release entering local steams could temporarily interfere with subsistence activities being carried out by low-income and minority populations within a few miles downstream of the site.

Monitoring of contaminant levels in soil and surface water following an accident would provide the public with information on the extent of any contaminated areas. Analysis of contaminated areas to decide how to control the use of high-health-risk areas would reduce the potential impact on local residents.

10.2.8 Land Use

Section 5.3.8 presents an overview of the potential impacts on land use that could result from the GTCC LLRW and GTCC-like waste disposal facility regardless of the location selected for the facility. This section evaluates the potential impacts from the GTCC LLRW and GTCC-like waste disposal facility on land use at SRS.

The GTCC reference location is situated in an area designated as a forest timber unit (DOE 1997). The site would be redesignated to accommodate the GTCC LLRW and GTCC-like waste disposal facility and be considered a developed site. Marketable timber on the site would be removed and sold. As mentioned in Section 10.2.5, forest removal during construction of the facility would eliminate about 0.1% of the Supplemental Red-Cockaded Woodpecker Management Area at SRS. Land use on areas surrounding SRS would not be affected. Future land use activities that would be permitted within or immediately adjacent to the GTCC LLRW and GTCC-like waste disposal facility would be limited to those that would not jeopardize the integrity of the facility, create a security risk, or create a worker or public safety risk.

10.2.9 Transportation

The transportation of GTCC LLRW and GTCC-like waste necessary for the disposal of all waste at SRS was evaluated. As discussed in Section 5.3.9, transportation of all cargo is considered for both truck and rail modes of transport as separate options for the purposes of this EIS. Transportation impacts are expected to be the same for disposal in trenches or vaults because the same type of transportation packaging would be used regardless of the disposal method.

As discussed in Appendix C, the impacts of transportation were calculated in three areas: (1) collective population risks during routine conditions and accidents (Section 10.2.9.1), (2) radiological risks to individuals receiving the highest impacts during routine conditions (Section 10.2.9.2), and (3) consequences to individuals and populations after the most severe accidents involving a release of a radioactive or hazardous chemical material (Section 10.2.9.3).

Radiological impacts during routine conditions are a result of human exposure to the low levels of radiation near the shipment. The regulatory limit established in 49 CFR 173.441 (Radiation Level Limitations) and 10 CFR 71.47 (External Radiation Standards for All Packages) to protect the public is 0.1 mSv/h (10 mrem/h) at 2 m (6 ft) from the outer lateral sides of the transport vehicle. This dose rate corresponds roughly to 14 mrem/h at 1 m (3 ft). As discussed in Appendix C, Section C.9.4.4, the external dose rates for CH shipments to SRS are assumed to be 0.5 and 1.0 mrem/h at 1 m (3 ft) for truck and rail shipments, respectively. For shipments of RH waste, the external dose rates are assumed to be 2.5 and 5.0 mrem/h at 1 m (3 ft) for truck and rail shipments, respectively. These assignments are based on shipments of similar types of waste. Dose rates from rail shipments are approximately double the rates for truck shipments because rail shipments are assumed to have twice the number of waste packages as a truck shipment. Impacts from accidents depend on the amount of radioactive material in a shipment and the fraction that is released if an accident occurs. The parameters used in the transportation accident analysis are described further in Appendix C, Section C.9.4.3.

10.2.9.1 Collective Population Risk

The collective population risk is a measure of the total risk posed to society as a whole by the actions being considered. For a collective population risk assessment, the persons exposed are considered as a group, without specifying individual receptors. Exposures to four different groups are considered: (1) persons living and working along the transportation routes, (2) persons sharing the route, (3) persons at stops along the route, and (4) transportation crew members. The collective population risk is used as the primary means of comparing various options. Collective population risks are calculated for cargo-related causes for routine transportation and accidents. Vehicle-related risks are independent of the cargo in the shipment and are calculated only for traffic accidents (fatalities caused by physical trauma).

Estimated impacts from the truck and rail options are summarized in Tables 10.2.9-1 and 10.2.9-2, respectively. For the truck option, it is estimated that about 12,600 shipments resulting in about 18 million km (11 million mi) of travel would cause no LCFs in the truck crew members

TABLE 10.2.9-1 Estimated Collective Population Transportation Risks for Shipment of GTCC LLRW and GTCC-Like Waste by Truck for Disposal at SRS[a]

			Cargo-Related[b] Radiological Impacts								Vehicle-Related Impacts[c]
			Dose Risk (person-rem)						Latent Cancer Fatalities[d]		
				Routine Public							
Waste	No. of Shipments	Total Distance (km)	Routine Crew	Off-Link	On-Link	Stops	Total	Accident[e]	Crew	Public	Physical Accident Fatalities
Group 1											
GTCC LLRW											
Activated metals - RH											
Past BWRs	20	39,000	0.41	0.023	0.067	0.072	0.16	0.00022	0.0002	<0.0001	0.0011
Past PWRs	143	331,000	3.4	0.18	0.56	0.61	1.3	0.0015	0.002	0.0008	0.0082
Operating BWRs	569	778,000	8.1	0.44	1.3	1.4	3.2	0.0035	0.005	0.002	0.023
Operating PWRs	1,720	2,500,000	26	1.3	4.2	4.6	10	0.01	0.02	0.006	0.069
Sealed sources - CH	209	283,000	0.12	0.063	0.19	0.2	0.45	0.039	<0.0001	0.0003	0.0078
Cesium irradiators - CH	240	325,000	0.14	0.073	0.21	0.23	0.52	0.0044	<0.0001	0.0003	0.0089
Other Waste - CH	5	11,200	0.0047	0.0018	0.0068	0.008	0.017	<0.0001	<0.0001	<0.0001	0.00027
Other Waste - RH	54	39,700	0.41	0.026	0.065	0.073	0.16	<0.0001	0.0002	<0.0001	0.0016
GTCC-like waste											
Activated metals - RH	38	107,000	1.1	0.039	0.17	0.2	0.4	<0.0001	0.0007	0.0002	0.003
Sealed sources - CH	1	1,350	0.00057	0.0003	0.00089	0.00097	0.0022	<0.0001	<0.0001	<0.0001	<0.0001
Other Waste - CH	69	110,000	0.046	0.022	0.068	0.079	0.17	0.001	<0.0001	0.0001	0.0036
Other Waste - RH	1,160	1,570,000	16	0.84	2.5	2.9	6.3	0.0019	0.01	0.004	0.053

TABLE 10.2.9-1 (Cont.)

			Cargo-Related[b] Radiological Impacts								Vehicle-Related Impacts[c]
			Dose Risk (person-rem)						Latent Cancer Fatalities[d]		
				Routine Public							
Waste	No. of Shipments	Total Distance (km)	Routine Crew	Off-Link	On-Link	Stops	Total	Accident[e]	Crew	Public	Physical Accident Fatalities
Group 2											
GTCC LLRW											
Activated metals - RH											
New BWRs	202	293,000	3	0.15	0.48	0.54	1.2	0.0012	0.002	0.0007	0.0075
New PWRs	833	1,160,000	12	0.54	1.9	2.1	4.5	0.0043	0.007	0.003	0.032
Additional commercial waste	1,990	2,940,000	31	1.6	4.7	5.4	12	<0.0001	0.02	0.007	0.1
Other Waste - CH	139	205,000	0.086	0.043	0.13	0.15	0.32	0.0026	<0.0001	0.0002	0.0071
Other Waste - RH	3,790	5,170,000	53	2.8	8.3	9.5	21	0.00056	0.03	0.01	0.18
GTCC-like waste											
Other Waste - CH	44	44,800	0.019	0.01	0.029	0.032	0.072	0.00035	<0.0001	<0.0001	0.0015
Other Waste - RH	1,400	1,920,000	20	1	3.1	3.5	7.7	0.0016	0.01	0.005	0.066
Total Groups 1 and 2	12,600	17,800,000	170	9.2	28	32	69	0.072	0.1	0.04	0.57

a BWR = boiling water reactor, PWR = pressurized water reactor, CH = contact-handled, RH = remote-handled.

b Cargo-related impacts are impacts attributable to the radioactive nature of the material being transported.

c Vehicle-related impacts are impacts independent of the cargo in the shipment.

d LCFs were calculated by multiplying the dose by the health risk conversion factor of 6×10^{-4} fatal cancer per person-rem (see Section 5.2.4.3).

e Dose risk is a societal risk and is the product of accident probability and accident consequence.

TABLE 10.2.9-2 Estimated Collective Population Transportation Risks for Shipment of GTCC LLRW and GTCC-Like Waste by Rail for Disposal at SRS[a]

			Cargo-Related[b] Radiological Impacts								Vehicle-Related Impacts[c]
			Dose Risk (person-rem)						Latent Cancer Fatalities[d]		
				Routine Public							
Waste	No. of Shipments	Total Distance (km)	Routine Crew	Off-Link	On-Link	Stops	Total	Accident[e]	Crew	Public	Physical Accident Fatalities
Group 1											
GTCC LLRW											
Activated metals - RH											
Past BWRs	7	16,600	0.14	0.07	0.0037	0.069	0.14	0.00054	<0.0001	<0.0001	0.0019
Past PWRs	37	92,700	0.79	0.38	0.021	0.38	0.78	0.0025	0.0005	0.0005	0.0074
Operating BWRs	154	234,000	2.4	1	0.05	1.2	2.3	0.0039	0.001	0.001	0.018
Operating PWRs	460	734,000	7.4	3	0.15	3.6	6.7	0.01	0.004	0.004	0.054
Sealed sources - CH	105	187,000	0.53	0.29	0.012	0.34	0.64	0.0021	0.0003	0.0004	0.0087
Cesium irradiators - CH	120	214,000	0.6	0.33	0.014	0.39	0.73	0.00024	0.0004	0.0004	0.01
Other Waste - CH	3	7,800	0.019	0.013	0.00058	0.013	0.026	<0.0001	<0.0001	<0.0001	0.00051
Other Waste - RH	27	29,000	0.35	0.11	0.0037	0.17	0.29	<0.0001	0.0002	0.0002	0.0032
GTCC-like waste											
Activated metals - RH	11	33,000	0.27	0.09	0.0046	0.12	0.21	<0.0001	0.0002	0.0001	0.003
Sealed sources - CH	1	1,780	0.005	0.0027	0.00011	0.0033	0.0061	<0.0001	<0.0001	<0.0001	<0.0001
Other Waste - CH	35	65,500	0.18	0.11	0.0051	0.12	0.24	<0.0001	0.0001	0.0001	0.0046
Other Waste - RH	579	936,000	9.3	3.8	0.17	4.2	8.2	0.00019	0.006	0.005	0.066

TABLE 10.2.9-2 (Cont.)

Waste	No. of Shipments	Total Distance (km)	Cargo-Related[b] Radiological Impacts: Dose Risk (person-rem): Routine Crew	Routine Public: Off-Link	Routine Public: On-Link	Routine Public: Stops	Routine Public: Total	Accident[e]	Latent Cancer Fatalities[d]: Crew	Latent Cancer Fatalities[d]: Public	Vehicle-Related Impacts[c]: Physical Accident Fatalities
Group 2											
GTCC LLRW											
Activated metals - RH											
New BWRs	54	86,000	0.86	0.35	0.015	0.4	0.77	0.00059	0.0005	0.0005	0.006
New PWRs	227	341,000	3.5	1.2	0.056	1.7	3	0.0029	0.002	0.002	0.021
Additional commercial waste	498	883,000	8.5	3.7	0.17	3.8	7.7	<0.0001	0.005	0.005	0.067
Other Waste - CH	70	124,000	0.35	0.22	0.01	0.23	0.46	0.00029	0.0002	0.0003	0.0094
Other Waste - RH	1,900	3,160,000	31	13	0.57	14	28	<0.0001	0.02	0.02	0.25
GTCC-like waste											
Other Waste - CH	22	26,300	0.088	0.05	0.0022	0.058	0.11	<0.0001	<0.0001	<0.0001	0.0018
Other Waste - RH	702	1,150,000	11	4.8	0.22	5.1	10	0.00017	0.007	0.006	0.085
Total Groups 1 and 2	5,010	8,320,000	78	33	1.5	36	70	0.024	0.05	0.04	0.62

a BWR = boiling water reactor, PWR = pressurized water reactor, CH = contact-handled, RH = remote-handled.

b Cargo-related impacts are impacts attributable to the radioactive nature of the material being transported.

c Vehicle-related impacts are impacts independent of the cargo in the shipment.

d LCFs were calculated by multiplying the dose by the health risk conversion factor of 6×10^{-4} fatal cancer per person-rem (see Section 5.2.4.3).

e Dose risk is a societal risk and is the product of accident probability and accident consequence.

or members of the public. One fatality directly related to accidents is expected. No LCFs are estimated for the rail option, with approximately 5,010 railcar shipments resulting in about 8 million km (5 million mi) of travel. However, one fatality from accidents could occur.

10.2.9.2 Highest-Exposed Individuals during Routine Conditions

During the routine transportation of radioactive material, specific individuals might be exposed to radiation in the vicinity of a shipment. Risks to these individuals for a number of hypothetical exposure-causing events were estimated. The receptors included transportation workers, inspectors, and members of the public exposed during traffic delays, while working at a service station, or while living and/or working near a destination site. The assumptions about exposure are given in Appendix C, and transportation impacts are provided in Section 5.3.9. The scenarios for exposure are not meant to be exhaustive; they were selected to provide a range of representative potential exposures. On a site-specific basis, if someone was living or working near the SRS entrance and present for all 12,600 truck or 5,010 rail shipments projected, that individual's estimated dose would be approximately 0.5 or 1.0 mrem, respectively, over the course of more than 50 years. The individual's associated lifetime LCF risk would then be 3×10^{-7} or 6×10^{-7} for truck or rail shipments, respectively.

10.2.9.3 Accident Consequence Assessment

Whereas the collective accident risk assessment considers the entire range of accident severities and their related probabilities, the accident consequence assessment assumes that an accident of the most severe category has occurred. The consequences, in terms of committed dose (rem) and LCFs for radiological impacts, were calculated for both exposed populations and individuals in the vicinity of an accident. Because the exact location of such a transportation accident is impossible to predict and thus not specific to any one site, generic impacts were assessed, as presented in Section 5.3.9.

10.2.10 Cultural Resources

The GTCC reference location at SRS is situated northeast of Zone Z along the Aiken and Barnwell County line. The location is in Archaeological Zone 3, which means it has a low potential for containing cultural resources. The project area was partially examined for the presence of archaeological material in 1986, and no materials were found at that time (Brooks et al. 1986). The remaining portion was examined in 1996 by the Savannah River Archaeological Research Program. The survey identified seven archaeological sites: one prehistoric lithic scatter and six late 19th and early 20th century homesteads. It is not known if any of these sites have been evaluated for listing on the NRHP. The seven archaeological sites found in the project area would require evaluation for listing on the NRHP. If any archaeological site was found to be eligible for listing and could not be avoided, then appropriate mitigation would be developed. Mitigation would be determined through consultation with the South Carolina SHPO and the appropriate Native American tribes. Before projects could begin, Native

American tribes would need to be contacted to determine if they had any concerns about the location chosen for the project. Native Americans have indicated that resources of concern to them are present on SRS.

The land disposal methods evaluated (trench and vault) have the potential to affect cultural resources as a result of the ground clearing needed for construction. Potential impacts from the trench method would be less than those from the vault method. The vault method also requires large amounts of soil to cover the waste. The location for soil extraction has not been chosen. Potential impacts on cultural resources could occur during the removal and hauling of the soil required for this method. Depending on the location chosen for excavating the soil for the cover, the impacts could be greater from this component of the project than from construction of the disposal facility. Impacts on cultural resources would need to be considered for the soil extraction locations. The NHPA Section 106 process would be followed for all project locations.

Minimal impacts are expected from operational and post-closure activities because no new ground-disturbing activities are anticipated; most impacts would occur during construction. If any of the eligible archaeological sites were avoided during construction, they would require consideration during any operational or post-closure activities. In the event that any post-construction activities would affect an eligible archaeological site, mitigation for the impacts would be developed in consultation with the SHPO and the appropriate Native American tribes. Tribal consultation might be necessary, depending on the status of resources of concern to the tribe near the project area.

10.2.11 Waste Management

The construction of either of the land disposal facilities (trench or vault) would generate small quantities of hazardous and nonhazardous solids and hazardous and nonhazardous liquids. Waste generated from operations would include small quantities of solid LLRW (e.g., spent HEPA filters) and nonhazardous solid waste (including recyclable wastes). These waste types would either be disposed of on-site or sent off-site for disposal. It is likely that no impacts on waste management programs at SRS would result from the waste that might be generated from the construction and operation of the land disposal methods. Section 5.3.11 provides a summary of the waste handling programs at SRS for the waste types generated.

10.3 SUMMARY OF POTENTIAL ENVIRONMENTAL CONSEQUENCES AND HUMAN HEALTH IMPACTS

The potential environmental consequences from the disposal of GTCC LLRW and GTCC-like waste under Alternatives 3 and 4 are summarized by resource area as follows:

Air quality. The potential impacts from construction and operations at SRS on ambient air quality would be negligible. Under the trench method, peak-year emissions of all criteria pollutants, VOCs, and CO_2 would be lowest during construction but highest during operations. The highest emissions associated with the trench and vault methods would be about 0.18% of the three-county emissions total for NO_x. O_3 levels in the three counties encompassing SRS are currently in attainment; O_3 precursor emissions from construction and operational activities would be relatively small — less than 0.18% and 0.03% of NO_x and VOC emissions, respectively, and much lower than those for the regional air shed. CO_2 emissions during construction and operations would be negligible. All construction and operational activities would occur at least 14 km (9 mi) from the site boundary and would not contribute much to concentrations at the boundary or the nearest residence.

Noise. The highest composite noise during construction would be about 91 dBA at 15 m (50 ft) from the source. Noise levels at 610 m (2,000 ft) from the source would be below the EPA guidelines. This distance is well within the SRS boundary, and there are no residences within this distance. Noise generated during operations would be less than noise during construction.

Geology. No adverse impacts from the extraction and use of geologic and soil resources are expected, nor are any significant changes in surface topography or natural drainages expected. The potential for erosion would be reduced by best management practices.

Water resources. Construction of a vault facility would have a higher water requirement than the trench option. Water demands for construction at SRS would be met by using groundwater from on-site wells. No surface water would be used at the site during construction; therefore, no direct impacts on surface water are expected. Indirect impacts on surface water would be reduced by implementing good industry practices and mitigation measures. Construction of the proposed GTCC LLRW and GTCC-like waste disposal facility would increase the annual water use at SRS by a maximum of about 0.06% (vault method), and operations would increase it by a maximum of about 0.1% (trench or vault method). Since these increases would not significantly lower the water table or change the direction of groundwater flow, impacts due to groundwater withdrawals are expected to be negligible. Water demands during the decommissioning phase at SRS would be smaller than those during construction, and there would be no water demands during the post-closure period. Groundwater could become contaminated with some radionuclides during the post-closure period; indirect impacts on surface water could occur as a result of aquifer discharges to springs and rivers.

Human health. The impacts on workers from operations would be mainly those from the radiation doses associated with handling the wastes. It is estimated that the annual radiation dose would be 4.6 person-rem/yr for the trench method and 5.2 person-rem/yr for the vault method. Neither of these doses is expected to result in any LCFs (see Section 5.3.4.1.1). The maximum dose to any individual worker would not exceed the DOE administrative control level (2 rem/yr) for site operations. It is expected that the maximum dose to any individual workers over the entire project would not exceed a few rem.

The worker impacts from accidents would be associated with the physical injuries and possible fatalities that could result from construction and waste handling accidents. It is estimated that the annual number of lost workdays due to injuries and illnesses would be 2 for both the trench and vault methods, and no fatalities would result from construction and waste handling accidents (see Section 5.3.4.2.2). These injuries would not be associated with the radioactive nature of the wastes but would simply be those expected to occur in any construction project of this size.

It is not expected that the general public would receive any measurable doses during waste disposal operations, given the solid nature of the wastes and the distance of waste handling activities from potential affected individuals. The highest dose to an individual from an accident involving the waste packages prior to disposal (from a fire affecting an SWB) is estimated to be 4.3 rem and to not result in any LCFs. The total dose to the affected population from such an event is estimated to be 45 person-rem. The peak annual dose to a hypothetical nearby receptor (resident farmer) who resides 100 m (330 ft) from the edge of the disposal site in the first 10,000 years after closure of the disposal facility is estimated to be 1,700 mrem/yr under the trench method and 1,300 mrem/yr under the vault method. These doses would be mainly from GTCC LLRW Other Waste - RH and GTCC-like Other Waste - RH and would occur about 29 years (for the trench method) and 54 years (for the vault method) following failure of the engineered cover and barriers.

Ecological resources. The initial loss of upland pine and some hardwood forest habitats, followed by eventual establishment of low-growth vegetation, would not create a long-term reduction in the local or regional ecological diversity. Wildlife-vehicle collisions stemming from increased traffic associated with the facility would contribute to losses; however, population-level impacts are not expected. After closure, the cover would become vegetated with annual and perennial grasses and forbs. Clearing of forest habitat for construction of the GTCC LLRW and GTCC-like waste disposal facility could result in localized loss of wildlife species. White-tailed deer could also lose a source of mast and potential cover against weather extremes. Fences (during the institutional control/monitored post-closure period) at the site would lessen the potential for mid-sized to large mammals to enter the site. There are no natural aquatic habitats within the immediate vicinity of the GTCC reference location; however, depending on the amount of water in the retention pond and length of retention, certain species (e.g., aquatic invertebrates, waterfowl, shorebirds, and mammals) could become established. Several state-listed and special-status species occur within the project area. Impacts on these species would likely be small, since the area of habitat disturbance would be small relative to the overall area of such habitat at SRS. Forest removal during construction would eliminate about 0.1% of the Supplemental Red-Cockaded Woodpecker Management Area; population-level impacts are not expected.

Socioeconomics. Impacts would be small. Construction would create direct employment for 145 people (vault method) in the peak construction year and 168 indirect jobs (vault method) in the ROI; the annual average employment growth rate would increase by less than 0.1 of a percentage point. The waste facility would produce up to $12.7 million in income (vault method) in the peak construction year. Up to 64 people would in-migrate to the ROI as a result of employment on-site; in-migration would have only a marginal effect on population growth and require less than 1% of vacant housing in the peak year. Impacts from operating the facility would also be small, creating up to 51 direct jobs (vault method) and up to 45 indirect jobs (vault method) in the ROI annually. The disposal facility would produce up to $5 million in income annually during operations.

Environmental justice. Health impacts on the general population within the 80-km (50-mi) assessment area during construction and operations would be negligible, and no impacts on minority and low-income populations as a result of the construction and operations of a GTCC LLRW and GTCC-like waste disposal facility are expected. If analyses that accounted for any unique exposure pathways (such as subsistence fish, vegetation, or wildlife consumption or well-water consumption) determined that health and environmental impacts would not be significant, then there would be no high and adverse impacts on minority and low-income populations. If impacts were found to be significant, disproportionality would be determined by comparing the proximity of high and adverse impacts to the location of low-income and minority populations.

Land use. The GTCC reference location would be in an area designated as a forest timber unit. This area could be reclassified to accommodate the GTCC LLRW and GTCC-like waste disposal facility and be considered a developed site. Marketable timber on the site would have to be removed and could be sold.

Transportation. Shipment of all waste to SRS by truck would result in approximately 12,600 shipments involving a total distance of 18 million km (11 million mi). To ship all waste by rail would require 5,010 railcar shipments involving 8 million km (5 million mi) of travel. It is estimated that no LCFs would occur to the public or crew members for either mode of transportation, but one fatality from accidents could occur.

Cultural resources. There are seven archaeological sites within the GTCC reference location area at SRS; these sites would require evaluation for listing on the NRHP. Mitigation for eligible sites would be determined through consultation with the South Carolina SHPO and appropriate tribes. Of the two disposal methods considered, the trench method has the least potential to affect cultural resources (especially during the construction phase) because it has the smallest land requirement. Impacts at the source location for soil to cover a vault facility would also be considered.

Waste management. The waste that could be generated from the construction and operations of the land disposal methods is not expected to affect current waste management programs at SRS.

10.4 CUMULATIVE IMPACTS

Section 5.4 presents the methodology for the cumulative impacts analysis. In the analysis that follows, impacts of the proposed action are considered in combination with the impacts of past, present, and reasonably foreseeable future actions. This section begins with a description of reasonably foreseeable future actions at SRS, including those that are ongoing, under construction, or planned for future implementation. Past and present actions are generally accounted for in the affected environment section (Section 10.1).

10.4.1 Reasonably Foreseeable Future Actions

Reasonably foreseeable actions at SRS are summarized in the following sections. These actions were identified primarily from a review of the EIS on the construction and operation of the proposed Mixed Oxide (MOX) Fuel Fabrication Facility at SRS (NRC 2005). The actions listed are planned, under construction, or ongoing and may not be inclusive of all actions at the site. However, they should provide an adequate basis for determining potential cumulative impacts at SRS.

10.4.1.1 Mixed Oxide Fuel Fabrication Facility

In 1999, DOE signed a contract with a consortium (now called Shaw AREVA MOX Services, LLC) to design, build, and operate a MOX Fuel Fabrication Facility in the F-Area at the center of SRS. The facility is a major component of a U.S. program to dispose of surplus weapons-usable plutonium. The 55,742-m^2 (600,000-ft^2) facility consists of two major sections. The first is a five-level section where weapons-usable material will be cleaned and purified via aqueous polishing; the second section is where fabrication will take place. Current material needs for the facility's construction include 129,974 m^3 (170,000 yd^3) of concrete, 31,751 metric tons or t (35,000 tons) of reinforcing steel, 914,400 linear m (3 million linear ft) of power and control cable, and 128 km (80 mi) of piping. Once operational, the facility will be capable of converting 3.5 t (3.9 tons) of weapons-grade plutonium into MOX fuel assemblies each year (NNSA 2008).

The NRC is responsible for licensing the facility. On March 30, 2005, it issued a construction authorization (NRC 2008). As of 2008, the $4.8 billion facility employed more than 1,000 workers, and it will employ at least 1,000 workers for the next two decades. Construction is expected to last into 2016 (Blanchard 2008).

10.4.1.2 Spent Nuclear Fuel Management

SRS, as an important component of the U.S. nonproliferation program, provides for the safe receipt and interim storage of irradiated SNF assemblies from domestic and foreign test and research reactors. The first off-site fuel was received and stored in February 1997. Since then, fuel has been stored in wet storage facilities. Disassembly basins are located in all five of SRS's reactor areas. Currently, only L-Basin still contains and receives fuel material. Thousands more assemblies are expected to be received and stored in L-Basin in the coming decade. The SNF stored and received at L-Basin may be transferred to H-Canyon for disposition off-site or to the INL Site for storage pending disposition (SRS 2007; DOE 2008).

10.4.1.3 Highly Enriched Uranium

In 1996, DOE published a ROD (61 FR 40619, August 1996) to blend HEU at SRS to 4% low-enriched uranium (LEU). Processing the uranium from weapons-usable HEU to LEU makes the material less attractive and supports U.S. nuclear nonproliferation goals. In its HEU blend-down program, SRS blended down approximately 16.7 t (18.4 tons) of HEU into 260.5 t (287.2 tons) of LEU through the site's H-canyon chemical separation facility. This material was provided to the Tennessee Valley Authority (TVA) via an Interagency Agreement with DOE. The TVA processed the material into reactor fuel for use in two commercial reactors at the Browns Ferry Nuclear Plant, which produces commercial electrical power in Athens, Alabama. DOE and TVA intend to extend the Interagency Agreement and continue downblending weapons-usable uranium to a non-proliferable form for use in power reactors (DOE 1996, 2002; Savannah River Operations Office 2006).

10.4.1.4 Tritium Extraction Facility

The SRS's Tritium Extraction Facility (TEF) became fully operational in 2007. The facility, located in H-Area, extracts tritium from target-bearing rods irradiated in commercial light water reactors. Its purpose is to ensure a sustainable supply of tritium for the U.S. nuclear weapons stockpile (WSRC 2008).

The TEF consists of three major structures: the Remote Handling Building (RHB), Tritium Processing Building (TPB), and Tritium Support Building (TSB). The RHB is approximately 18-m (60-ft) high, 26-m (86-ft) wide, and 66-m (215-ft) long. It has a truck receiving area, cask decontamination area, tritium-producing burnable absorber rods, waste preparation area, furnaces, hot maintenance area, and glove boxes for extraction pumps and tanks. It also has an overhead crane and RH equipment. The TBP provides preliminary purification of the extracted gases. It is a single-story facility, approximately 38-m (125-ft) wide by 47-m (155-ft) long, and is built above ground. The TPB houses the main control room, crane control room, and miscellaneous rooms for gas analysis and radiation control activities. The TSB houses management and support staff; it also has change rooms, maintenance support areas, and a loading dock (WSRC 2008).

The facility was staffed by about 600 workers during construction and has an operations staff of about 100 permanent employees. Shipments of the irradiated rods are received at TEF. In addition, the NNSA is evaluating the optimum mode of operations for the TEF; it will be based on the most efficient use of SRS resources and the changing demands for new tritium to support the nuclear weapons stockpile (WSRC 2008).

10.4.1.5 Salt Waste Processing Facilities

Salt waste processing facilities at SRS use two removal processes: the actinide removal process (ARP) and the modular caustic side solvent extraction unit (MCU). Removing the salt waste, which fills approximately 90% of the tank space in the SRS tank farms, is a major step toward closing SRS's 47 high-level radioactive waste tanks that currently contain about 136 million L (36 million gal) of waste. ARP and MCU together make up the interim salt disposal processing system, which separates the high-activity fraction from the low-activity fraction from SRS's waste storage tanks to be safely dispositioned. The low-activity fraction is stabilized with cement in the Saltstone Production Facility and disposed of in on-site vaults.

The high-activity fraction is vitrified in the Defense Waste Processing Facility (DWPF; see Section 10.4.1.7). SRS first received radioactive salt waste solution for processing at the ARP and MCU facilities in April 2008, and it completed a successful test run as the facilities were brought on line in a deliberate, sequenced process to ensure safe operations. In combination with the Saltstone Production Facility and Saltstone Disposal Facility, this approach treats, decontaminates, and disposes of radioactive salt waste removed from SRS storage tanks (SRS 2008). The Salt Waste Processing Facility is currently being constructed at SRS to replace the interim treatment described above. The Salt Waste Processing Facility can treat a higher volume of waste with greater decontamination than can the interim process.

10.4.1.6 Tank Closure

DOE has considered alternatives for closing the 49 high-level radioactive waste tanks and associated equipment at SRS, such as evaporator systems, transfer pipelines, diversion boxes, and pump pits. DOE needs to close these tanks to reduce human health and safety risks at and near the waste tanks and to reduce the eventual introduction of contaminants into the environment. DOE has selected the preferred alternative identified in its waste tank closure EIS (DOE 2002), "Stabilize Tanks — Fill with Grout," to help develop and implement the process for closing the tanks and associated equipment at SRS. Following bulk waste removal (as described in Section 11.4.12.5 of DOE 2002), DOE cleans the tanks to meet the performance objectives contained in the general closure plan and the tank-specific closure module and then fills the tanks with grout (DOE 2002; WSRC 2007b).

10.4.1.7 Defense Waste Processing Facility

The DWPF converts the high-activity fraction of liquid waste from the storage tanks into a solid glass form suitable for long-term storage and disposal. It is the largest such plant in the world. The glassification process, called vitrification, immobilizes radioactivity in glass, thereby reducing the risks associated with the continued storage of liquid nuclear wastes at SRS, and it prepares the waste for ultimate disposal in a federal repository. About 136 million L (37 million gal) of liquid nuclear wastes (in sludge and salt forms) are now stored in 47 underground waste tanks at SRS; the majority of the high-activity portion of this waste will be vitrified at the DWPF (WSRC 2007c).

The DWPF vitrifies sludge from waste by mixing a sandlike borosilicate glass, called frit, with the waste and then heating it in a ceramic melter. The molten glass-waste mixture is poured into stainless-steel canisters to cool and harden. Each canister is 3-m (10-ft) tall and 0.6 m (2 ft) in diameter; a filled canister weighs about 2.3 t (5,000 lb). Canisters are welded shut and then sent to storage buildings at SRS, where they are lowered into an underground, reinforced, concrete vault. SRS has the capacity to safely store about 4,400 canisters, a number that represents about 16 to 20 years of canisters at current production rates (although more storage buildings could be built if necessary) (WSRC 2007c).

Construction of the DWPF began in late 1983, and operations began in March 1996. The DWPF is projected to produce more than 5,000 canisters by the year 2019 (WSRC 2007c).

10.4.2 Cumulative Impacts from the GTCC Proposed Action at SRS

Potential impacts of the proposed action are considered in combination with the impacts of past, present, and reasonably foreseeable future actions. The summary of environmental impacts in Section 10.3 indicates that the potential impacts from the GTCC EIS proposed action (construction and operations of either a trench or vault disposal facility) would be small for all the resource areas evaluated. On the basis of the total impacts (including the reasonably foreseeable future actions summarized in Section 10.4.1) reported in NUREG 1767 (NRC 2005), the additional potential impacts from a GTCC proposed action would not result in the exceedance of any of the thresholds discussed in that report. For example, the annual levels of the criteria pollutants related to air quality reported in NUREG 1767 ranged from 32% (NO_2) to 52% (PM_{10}) of the SAAQS standards. It is estimated that the GTCC proposed action would result in no more than 0.16% of the total emissions in the surrounding counties. The highest NO_2 level reported for the surrounding counties of 0.004 ppm is 7.5% of the 0.053-ppm SAAQS standard, and the county level at 56 $\mu g/m^3$ is 37% of the 150-$\mu g/m^3$ PM_{10} SAAQS standard.

A potential long-term impact from a GTCC action would be the groundwater radionuclide concentrations that could result if the integrity of the facility did not remain intact in the distant future. The human health evaluation for the post-closure phase of the proposed action indicates that as much as 1,700 mrem/yr could be incurred by the hypothetical resident farmer assumed to be 100 m (330 ft) from the edge of the disposal facility in about 29 years (trench method) to 54 years (vault method) after failure of the cover and engineered barrier, which is assumed to begin 500 years after the closure of the disposal facility. The estimates are primarily attributable to the GTCC-like RH waste (primary radionuclide contributors include C-14, Tc-99, I-129, and Np-237). The analysis took credit for engineered barriers incorporated to prolong the protectiveness of the facility. The sensitivity analysis that was performed for this EIS indicates that the doses could be reduced more if the receptor was assumed to be farther away from the facility. An annual review of the performance assessment and composite analysis for the E-Area low-level waste facility indicated that the calculated maximum dose to a hypothetical future member of the public would be about 14 mrem/yr (Millings 2009; Swingle 2008). Finally, follow-on NEPA evaluations and documents prepared to support any further considerations of siting a new trench or vault disposal facility at SRS would provide more detailed analyses of site-specific issues, including cumulative impacts.

10.5 SETTLEMENT AGREEMENTS AND CONSENT ORDERS FOR SRS

A review of existing settlement agreements and consent orders for SRS did not identify any that would contain requirements that would be affected by Alternatives 4 and 5 for this EIS.

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11 WASTE ISOLATION PILOT PLANT VICINITY: AFFECTED ENVIRONMENT AND CONSEQUENCES OF ALTERNATIVES 3, 4, AND 5

This chapter provides an evaluation of the affected environment, environmental and human health consequences, and cumulative impacts from the disposal of GTCC LLRW and GTCC-like waste under Alternative 3 (in a new borehole disposal facility), Alternative 4 (in a new trench disposal facility), and Alternative 5 (in a new vault disposal facility) at the WIPP Vicinity reference locations. Alternatives 3 to 5 are described in Section 5.1. Environmental consequences common to the sites for which Alternatives 3 to 5 are evaluated (including the WIPP Vicinity locations) are discussed in Chapter 5 and not repeated in this chapter. Impact assessment methodologies used for this EIS are described in Appendix C. Federal and state statutes and regulations and DOE Orders relevant to the WIPP Vicinity locations are discussed in Chapter 13 of this EIS.

11.1 AFFECTED ENVIRONMENT

This section discusses the affected environment for the various environmental resource areas evaluated for the GTCC reference locations at the WIPP Vicinity. One reference location is in Section 27 (inside the WIPP Land Withdrawal Boundary [WIPP LWB]), and the other is in Section 35 (on a parcel of land managed by the BLM just outside the WIPP LWB) (see Figure 11.1-1). Both the reference locations are located within T22S, R31E. These reference locations were selected primarily for evaluation purposes for this EIS. The actual location or locations would be identified on the basis of follow-on evaluations if and when it is decided to locate a land disposal facility at the WIPP Vicinity.

11.1.1 Climate, Air Quality, and Noise

Climate, air quality, and noise conditions at the WIPP Vicinity reference locations (within Sections 27 and 35) are similar to the conditions at the WIPP site described in Section 4.2.1 because of their proximity to each other, so the descriptions are not repeated here.

11.1.2 Geology and Soils

The WIPP Vicinity reference locations occupy two 2.6-km^2 (1-mi^2) or 260-ha (640-ac) parcels: Section 27, which is inside the WIPP LWB, and Section 35, which is outside and immediately adjacent to the southeast corner of the WIPP repository site. Given the close proximity of the WIPP Vicinity reference locations to the WIPP repository site, their regional geologic setting and stratigraphy at the reference locations can be inferred from the extensive data on the WIPP site that are summarized in Section 4.2.2. The text that follows summarizes the site stratigraphy on the basis of the work discussed in Powers (2009), with an emphasis on near-surface formations (above the Rustler Formation) in the vicinity of Sections 27 and 35.

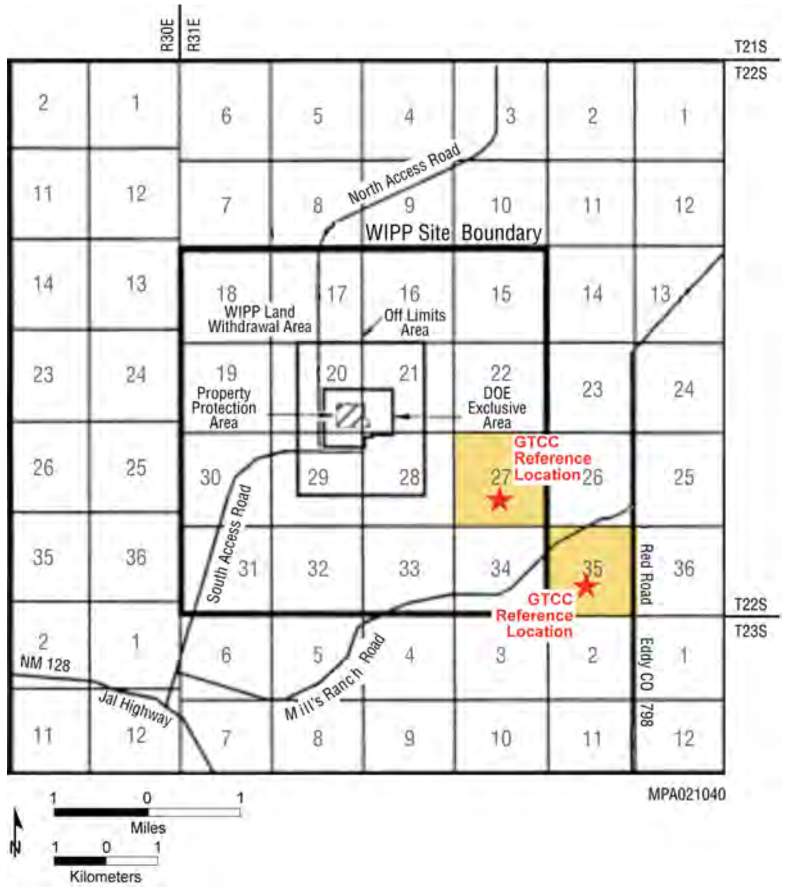

FIGURE 11.1-1 WIPP Vicinity GTCC Reference Locations

The topography across the WIPP Vicinity reference locations exhibits some broad valley forms, possibly indicating areas of concentrated surface runoff and integrated drainages during prolonged rainfall events. Sand dunes are present, but likely thinner and more uniform than local dune fields. Calcrete[1] exposures appear as heavily vegetated semicircular features on aerial photos of Section 35. These are thought to represent intradune areas that focus water drainage and enhance vegetation growth, causing degradation of the underlying calcrete and creating slight topographic depressions. These surface features, however, have no relationship to dissolution or subsidence of deeper evaporite units.

The WIPP Vicinity reference locations are situated on Quaternary age alluvium, playa lake deposits, and semi-stabilized and active dune sands. These deposits compose the majority of surface exposures and most of the shallow subsurface sediments in the WIPP Vicinity region. Just below these deposits is a fairly continuous mantle of caliche (called the Mescalero). The Mescalero caliche is a well-lithified alluvial deposit of chalky, finely crystalline limestone that is fairly continuous across the WIPP site and can be up to 1.8-m (6-ft) thick. It thickens and is more indurated to the east of the site near Sections 27 and 35. There is a caliche borrow pit

1 Calcrete is a conglomerate of surficial gravel and sand that is cemented by carbonate material.

near the southeast corner of Section 35; deposits in the pit indicate the Mescalero is thick and indurated enough to be quarried. Overlying the Mescalero is the Berino soil, a thick, reddish, semiconsolidated sand containing little carbonate, ranging in thickness from centimeters (inches) to 0.3 to 0.6 m (1 to 2 ft).

The top of the Dewey Lake Formation is at least 15-m (50-ft) deep across both Sections 27 and 35, with depths of more than 30 m (100 ft) expected in Section 27. The overlying Santa Rosa Formation likely occurs within 11 m (35 ft) of the ground surface across both sections, with shallower depths (less than 3 m [10 ft]) expected along the eastern portion of Section 27 and possibly all of Section 35. The Gatuña Formation thins to the east and may be absent along much of the eastern portion of both sections.

No natural factors within the WIPP Vicinity reference locations that would affect the engineering aspects of slope stability or subsidence have been reported. The presence of the Mescalero caliche is generally considered to be an indicator of surface stability (DOE 1997).

Liquefaction of saturated sediments is a potential hazard during or immediately following large earthquakes. Whether soils will liquefy depends on several factors, including the magnitude of the earthquake, peak ground velocity, susceptibility of soils to liquefaction, and depth to groundwater. No surface displacement or faulting younger than early Permian has been reported at WIPP, indicating that tectonic movement since then, if any, has not been noteworthy. No mapped Quaternary (last 1.9 million years) or Holocene (last 10,000 years) faults exist closer to the site than the western escarpment of the Guadalupe Mountains, about 100 km (60 mi) to the west-southwest (DOE 1997). The strongest earthquake on record within 290 km (180 mi) of the site was the Valentine, Texas, earthquake of August 16, 1931 (DOE 1997), with an estimated Richter magnitude of 6.4. From 1974 to 2006, recorded earthquakes within a 300-km (184-mi) radius of WIPP ranged from magnitude 2.3 to 5.7 (USGS 2010).

11.1.3 Water Resources

Given the close proximity of the WIPP Vicinity reference locations to the WIPP repository site, the hydrological conditions at the reference locations can be inferred from the extensive amount of information available on the WIPP site, which is summarized in Section 4.2.3. The discussions that are most relevant to the WIPP Vicinity reference locations are those on surface water (Section 4.2.3.1) and those on the aquifer units above the Salado Formation (Section 4.2.3.2.1).

11.1.4 Human Health

The two WIPP Vicinity GTCC reference locations are Section 27 (within the WIPP LWB) and Section 35 (adjacent to the WIPP LWB). The following discussion is based on operations at WIPP and assumed to be applicable to both reference locations.

Radiation exposures of the off-site general public could occur as a result of three pathways: (1) air transport, (2) water ingestion, and (3) ingestion of game animals. Of these three pathways, only the air pathway is considered to be credible. Elevated concentrations of radionuclides have not been detected in groundwater or game animals in the site vicinity. In 2014, the whole body dose to the highest-exposed individual from airborne releases was estimated to be 5.86×10^{-3} mrem/yr (DOE 2015). This individual was assumed to reside 7.5 km (4.6 mi) west–northwest of the site. A hypothetical individual residing at the site fence line in the northwest sector was estimated to receive a whole body dose of 2.38×10^{-1} mrem/yr. These values are well below the dose limit of 100 mrem/yr from all exposure pathways set by DOE to protect the general public from the operation of its facilities.

In 2010, the collective dose to the population living within 80 km (50 mi) of WIPP was calculated to be 7.99×10^{-3} person-rem/yr (DOE 2015). If this dose was distributed uniformly to all individuals living within 80 km (50 mi) of the site – a total of 92,599 people (DOE 2015) – the average dose to each person would be about 8.63×10^{-5} mrem/yr. This is an extremely small fraction of the average dose of 620 mrem/yr to members of the general public from exposure to natural background and man-made sources of radiation (NCRP 2009).

11.1.5 Ecology

The description of ecological resources at the WIPP Vicinity reference locations is similar to the description of these resources at the WIPP site, which is provided in Section 4.2.5.

11.1.6 Socioeconomics

Socioeconomic data for the WIPP Vicinity cover the ROI surrounding the reference locations, which is composed of two counties in New Mexico: Eddy County and Lea County. The majority of workers associated with the waste disposal facility at either of the WIPP Vicinity reference locations would reside in these counties (DOE 1997). The socioeconomic data are the same as the data presented in Section 4.2.6 for the WIPP repository.

11.1.7 Environmental Justice

Because of the proximity of the WIPP Vicinity reference locations to the WIPP repository, the effects on environmental justice are the same as those presented for the WIPP repository site under Alternative 2. Figures 4.2.7-1 and 4.2.7-2 and Table 4.2.7-1 show the minority and low-income compositions of the total population located in the 80-km (50-mi) buffer from Census Bureau data for the year 2010 (U.S. Bureau of the Census 2012) and from CEQ guidelines (CEQ 1997). Persons whose incomes fall below the federal poverty threshold are designated as low income. Minority persons are those who identify themselves as Hispanic or Latino, Asian, Black or African American, American Indian or Alaska Native, Native Hawaiian or other Pacific Islander, or multi-racial (with at least one race designated as a minority race under CEQ). Individuals who identify themselves as Hispanic or Latino are included in the table as a separate entry. However, because Hispanics can be of any race, this number also includes individuals who also identify themselves as being part of one or more of the population groups listed in the table.

A large number of minority and low-income individuals are located in the 50-mi (80-km) area around the boundary of the reference location. Within the 50-mi (80-km) radius in New Mexico, 53.0% of the population is classified as minority, while 15.5% is classified as low income. Although the number of minority individuals does not exceed the state average by 20 percentage points or more, the number of minority individuals exceeds 50% of the total population in the area; that is, there is a minority population in the New Mexico portion of the 50-mi (80-km) area based on 2010 Census data and CEQ guidelines. The number of low-income individuals does not exceed the state average by 20 percentage points or more and does not exceed 50% of the total population in the area; that is, there are no low-income populations in the New Mexico portion of the 50-mi (80-km) area around the reference location as a whole.

Within the 50-mi (80-km) radius in Texas, 45.3% of the population is classified as minority, while 15.4% is classified as low income. The number of minority individuals does not exceed the state average by 20 percentage points or more, and the number of minority individuals does not exceed 50% of the total population in the area; that is, there is no minority population in the Texas portion of the 50-mi (80-km) area as a whole area based on 2010 Census data and CEQ guidelines. The number of low-income individuals does not exceed the state average by 20 percentage points or more and does not exceed 50% of the total population in the area; that is, there are no low-income populations in the Texas portion of the 50-mi area (80-km) area around the reference location as a whole.

11.1.8 Land Use

The primary land use within the WIPP Vicinity reference location Section 35 is for oil and gas production. The land use description for the WIPP site contains further information applicable to land use within the WIPP site area (including for Section 27) (see Section 4.2.8). Figures 11.1.8-1 and 11.1.8-2 show potash leases in the vicinity of WIPP and the WIPP Vicinity reference locations, and a map of oil wells within 1.6 km (1 mi) of the WIPP LWB, respectively. There are no potash leases on Sections 27 and 35. There is an oil well on Section 35.

11.1.9 Transportation

Highway access to the WIPP region is by US 285 (north-south) or US 62/180 (northeast-southwest). Both highways pass through Carlsbad, New Mexico. Situated 40 km (25 mi) east of Carlsbad, WIPP can be reached from US 62/180 to the north and from New Mexico SR 128 to the south. The North Access Road from US 62/180 is about 21 km (13 mi) in length and is restricted to official WIPP business or to DOE and BLM personnel, permittees, licensees, or lessees (DOE 2002a). The South Access Road is Eddy County Road 802 originating at SR 128. General public access on Eddy County Road 802 can be restricted at the Off-Limits Area boundary if it is determined that there would be a significant safety risk to WIPP personnel

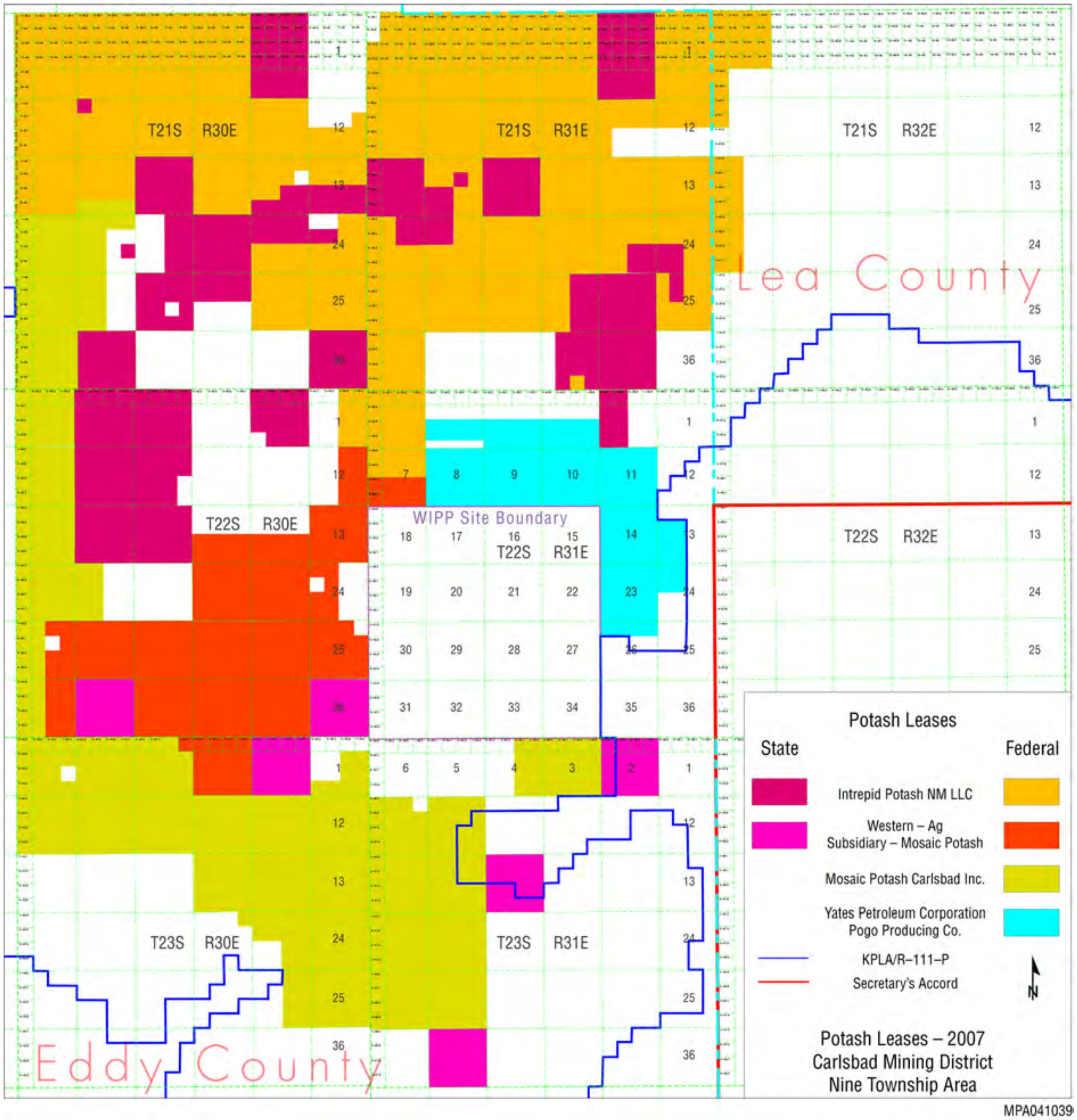

FIGURE 11.1.8-1 Potash Leases in the Vicinity of WIPP (as of 2007)

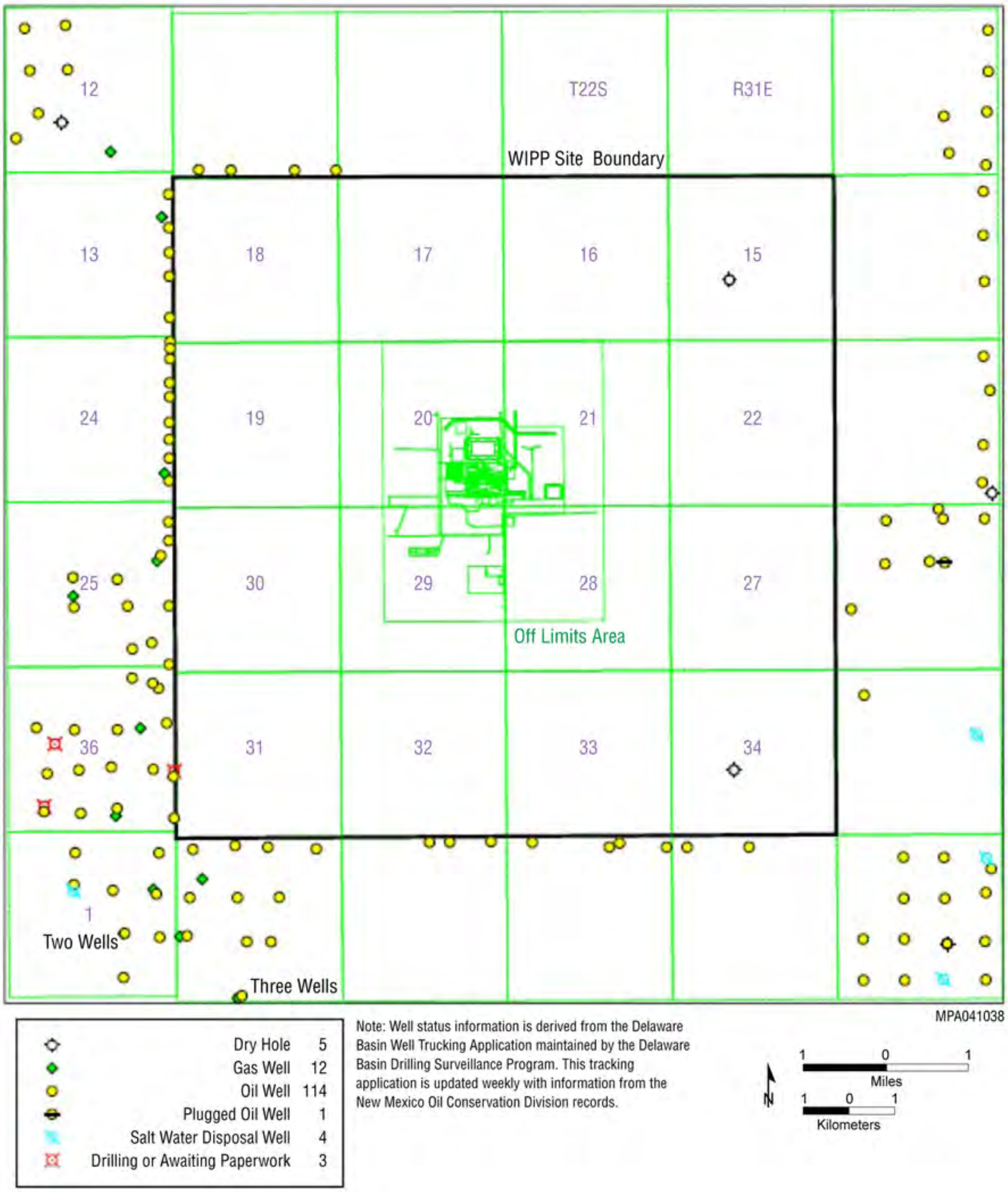

FIGURE 11.1.8-2 Map of Oil Wells within 1.6 km (1 mi) of WIPP Land Withdrawal Boundary

(DOE 2002a). Average daily traffic on the access roads is estimated to be 800 vehicles on the North Access Road and 400 vehicles on the South Access Road (NMED 2007).

Rail access to the WIPP Vicinity locations is provided by a rail line that connects with a spur of the BNSF Railroad near Mosaic Potash's Nash Draw Mine, 10 km (6 mi) southwest of the site (DOE 2002a).

11.1.10 Cultural Resources

Roughly 1,370 ha (3,380 ac) of the 4,140 ha (10,240 ac) managed by WIPP have been surveyed for cultural resources. The surveys identified approximately 60 archaeological sites and 90 isolated finds (DOE 2006). The largest survey was done in 1987 by Mariah and Associates. The 1987 survey examined portions of 45 sections surrounding the WIPP facility (DOE 2002a).

People have been living in the desert southwest for more than 10,000 years. Prehistoric people tended to live nomadic lifestyles, collecting resources from different areas at different times of the year (DOE 2002a). Most prehistoric archaeological sites in the WIPP area represent short-term use. In the mid 1500s, the Jumano and Apachean people used the area. They collected goods seasonally and traded with nearby Puebloan people. The Spanish were the first Europeans to cross what would become southeastern New Mexico. In historic times, the region was only lightly populated because of a lack of resources. Some ranching took place on the WIPP property during the 1940s and 1950s. Evidence of these activities is still visible in some locations.

The WIPP Vicinity reference location in Section 27 is in the WIPP LWB, and Section 35 is located on BLM-managed land just to the southeast of the WIPP LWB. The majority of Section 27 (T22S, R31E) and the majority of Section 35 (T22S, R31E) have not been examined for the presence of cultural resources. However, some cultural resource surveys were undertaken, and archaeological sites were found in both sections. In Section 27, a cultural resource survey was done for a proposed haul road. The survey identified Site 32632. The site consists of a surface artifact scatter of prehistoric materials. The site appears to represent a short-term occupation site that was revisited several times. On the basis of the potsherds found at the site, the resource dates to the Jornada Mogollon period (A.D. 900 to 1450) (Hunt 1994). Site 32632 was recommended as being potentially eligible for listing on the NRHP. Site 32632 is the only cultural resource currently known to be within Section 27.

Section 35 was surveyed on several occasions in anticipation of development. Currently there are seven known cultural resources located in Section 35. Of the seven resources, only one, 54373, is currently recommended as being potentially eligible for listing on the NRHP. Another site, 83670, has been very heavily impacted by past activities and no longer requires consideration.

A review of cultural resource information for the region revealed that the Maroon Cliffs Archaeological District is located northeast of WIPP. It is the closest archaeological district to the reference locations. The 4,770-ha (11,780-ac) district contains evidence of habitation ranging from the Archaic period (5000 B.C.) to the Jornada Mogollon (A.D. 900 to 1450) (BLM 1988).

Pit houses have been reported among the archaeological sites documented at this location. The district includes a wide variety of topographic features. The district is located roughly 11 km (7 mi) northwest of the project area.

11.1.11 Waste Management

Currently no waste management activities are being conducted at the WIPP Vicinity reference location in Section 35. It is expected that at the WIPP Vicinity reference location in Section 27, the waste management activities for the WIPP repository could accommodate the waste types generated by the land disposal methods (Alternatives 3 to 5), as discussed in Section 5.3.11.

11.2 ENVIRONMENTAL AND HUMAN HEALTH CONSEQUENCES

The potential impacts from the construction, operations, and post-closure of the land disposal methods (borehole, trench, and vault) are presented in this section for the resource areas evaluated. The discussion of the affected environment for the WIPP Vicinity locations is presented in Section 11.1 (and Section 4.2 for some resource areas, as indicated). The WIPP Vicinity locations are shown in Figure 11.1-1. The following sections address the potential environmental and human health consequences for each resource area discussed in Section 11.1.

11.2.1 Climate and Air Quality

This section presents potential climate and air quality impacts that could result from construction, operations, decommissioning, and post-closure of each of the three land disposal alternatives (borehole, trench, and vault) at either of the WIPP Vicinity locations. Noise impacts are presented in Section 5.3.1.

11.2.1.1 Construction

During the construction period, emissions of criteria pollutants (such as SO_2, NO_x, CO, PM_{10}, and $PM_{2.5}$), VOCs, and the primary greenhouse gas CO_2 would be caused by fugitive dust emissions from earth-moving activities and engine exhaust emissions from heavy equipment and commuter, delivery, and support vehicles. Typically, potential impacts from exhaust emissions on ambient air quality would be smaller than those from fugitive dust emissions.

Air emissions of criteria pollutants, VOCs, and CO_2 from construction activities were estimated for the peak year, when site preparation and construction of support facilities and some disposal cells would take place. The estimates are provided in Table 11.2.1-1 for each disposal method. Detailed information on emission factors, assumptions, and emission inventories is presented in Appendix D. As shown in the table, it is estimated that total peak-year emission rates would be rather small when compared with the Eddy County emissions total. Peak-year

TABLE 11.2.1-1 Peak-Year Emissions of Criteria Pollutants, Volatile Organic Compounds, and Carbon Dioxide from Construction of the Three Land Disposal Facilities at the WIPP Vicinity

Pollutant	Total Emissions (tons/yr)[a]	Construction Emissions (tons/yr)					
		Trench		Borehole		Vault	
SO_2	7,783	0.90	(0.01)[b]	3.0	(0.04)	3.2	(0.04)
NO_x	8,437	8.1	(0.10)	26	(0.31)	31	(0.37)
CO	25,725	3.3	(0.01)	11	(0.04)	11	(0.04)
VOCs	8,222	0.90	(0.01)	2.7	(0.03)	3.6	(0.04)
PM_{10}[c]	27,327	5.0	(0.02)	13	(0.05)	8.6	(0.03)
$PM_{2.5}$[c]	4,744	1.5	(0.03)	4.1	(0.09)	3.6	(0.08)
CO_2		670		2,200		2,300	
County[d]	1.85×10^6		(0.04)		(0.12)		(0.12)
New Mexico[e]	6.50×10^7		(0.001)		(0.003)		(0.004)
U.S.[e]	6.54×10^9		(0.00001)		(0.00003)		(0.00004)
Worldwide[e]	3.10×10^{10}		(0.000002)		(0.000007)		(0.000007)

a Total emissions in 2002 for Eddy County, in which WIPP is located. See Table 4.2.1-1 for criteria pollutants and VOCs.

b As percent of total emissions.

c Estimates for GTCC construction include diesel particulate emissions.

d Emission data for the year 2005. Currently, data on CO_2 emissions at the county level are not available, so county-level emissions were estimated from available state total CO_2 emissions on the basis of the population distribution.

e Annual CO_2 emissions in New Mexico, the United States, and worldwide in 2005.

Sources: EIA (2008); EPA (2008, 2009)

emissions for all criteria pollutants (except PM_{10} and $PM_{2.5}$) and VOCs would be the highest for the vault method, the construction of which would consume more materials and resources than would construction of the other two methods. The borehole method would disturb more area, so its fugitive dust emissions are estimated to be the highest. Peak-year emissions of all pollutants would be the lowest for the trench method, which would disturb the smallest area among the disposal methods. In terms of contribution to the emissions total, the peak-year emissions of NO_x under the vault method would be the highest, about 0.37% of the total county emissions, while emissions of other criteria pollutants and VOCs would be 0.08% or less of the county emissions total.

Background concentration levels for PM_{10} and $PM_{2.5}$ at the WIPP Vicinity reference locations are well below the standards (less than 59% of SAAQS); estimates for PM_{10} and $PM_{2.5}$ include diesel particulate emissions (Table 4.2.1-2). Construction at the WIPP Vicinity locations could occur within a few tens of meters of the boundary of both sections. Under unfavorable dispersion conditions, high concentrations of PM_{10} or $PM_{2.5}$ are expected and could exceed the standards at the location boundaries, although such exceedances would be rare. Construction activities would not contribute much to concentrations at the expected nearest residence. These activities would be conducted to minimize the potential impacts of related emissions on ambient air quality. In so doing, where appropriate, fugitive dust would be controlled by established, standard dust control practices, primarily by watering unpaved roads, disturbed surfaces, and temporary stockpiles, as stipulated in the construction permits.

Although O_3 levels in Carlsbad, about 42 km (26 mi) west of the WIPP site area, have exceeded the standard (see Table 4.2.1-2), Eddy County, including the WIPP Vicinity GTCC reference locations, is currently in attainment for O_3 (40 CFR 81.332). The WIPP Vicinity GTCC reference locations are located far from any major cities, and O_3 precursor emissions from a disposal facility under all three methods would be relatively small, 0.37% or less and 0.04% or less of the county total NO_x and VOC emissions, respectively. The O_3 precursor emissions would be much lower than those from the regional air shed in which emitted precursors are transported and formed into O_3. Accordingly, potential impacts of O_3 precursor releases from construction on regional O_3 would not be of concern.

The major air quality concern with respect to emissions of CO_2 is that it is a greenhouse gas, which traps solar radiation reflected from the earth, keeping it in the atmosphere. The combustion of fossil fuels makes CO_2 the most widely emitted greenhouse gas worldwide. CO_2 concentrations in the atmosphere have continuously increased, going from approximately 280 ppm in preindustrial times to 379 ppm in 2005, a 35% increase. Most of this increase has occurred in the last 100 years (IPCC 2007).

The climatic impact of CO_2 does not depend on the geographic location of its sources because CO_2 is stable in the atmosphere and is essentially uniformly mixed; that is, the global total is the important factor with respect to global warming. Therefore, a comparison between U.S. and global emissions and the total emissions from the construction of a disposal facility is useful in understanding whether CO_2 emissions from the site are significant with respect to global warming. As shown in Table 11.2.1-1, the highest peak-year amount of CO_2 emissions from construction would be under 0.12%, 0.004%, and 0.00004% of 2005 county, state, and U.S. CO_2 emissions, respectively. In 2005, CO_2 emissions in the United States were about 21% of worldwide emissions (EIA 2008). Potential impacts on climate change from construction emissions would be small.

An initial construction period of 3.4 years is assumed (see Appendix D). Because the disposal units would be constructed as the waste became available for disposal, the construction phase would be extended over more years. Emissions would thus be lower in nonpeak years than in the peak year, as presented in Table 11.2.1-1. In addition, construction activities would occur only during daytime hours, when air dispersion is most favorable. Accordingly, potential impacts from construction activities on ambient air quality would be minor and intermittent.

General conformity applies to federal actions taking place in nonattainment or maintenance areas and is not applicable to the proposed action at the WIPP Vicinity locations because the area is classified as being in attainment for all criteria pollutants (40 CFR 81.332).

11.2.1.2 Operations

Criteria pollutants, VOCs, and CO_2 would be released into the atmosphere during operations. These emissions would include fugitive dust emissions from emplacement activities and exhaust emissions from heavy equipment and commuter, delivery, and support vehicles. Estimates of annual emissions of criteria pollutants, VOCs, and CO_2 at the facility are presented in Table 11.2.1-2. Detailed information on emission factors, assumptions, and emission inventories is available in Appendix D. As shown in the table, annual operational emissions are estimated to be lower than those from construction under the borehole method. Annual emissions from operations are about the same for the trench and vault methods but higher than those for the borehole method. Compared with annual emissions for Eddy County, annual emissions of NO_x for the trench and vault methods would be the highest, about 0.32% of the county total, while emissions of other criteria pollutants and VOCs would be about 0.06% or less.

TABLE 11.2.1-2 Annual Emissions of Criteria Pollutants, Volatile Organic Compounds, and Carbon Dioxide from Operations of the Three Land Disposal Facilities at the WIPP Vicinity

		Operation Emissions (tons/yr)					
Pollutant	Total Emissions (tons/yr)[a]	Trench		Borehole		Vault	
SO_2	7,783	3.3	(0.04)[b]	1.2	(0.02)	3.3	(0.04)
NO_x	8,437	27	(0.32)	10	(0.12)	27	(0.32)
CO	25,725	15	(0.06)	6.7	(0.03)	15	(0.06)
VOCs	8,222	3.1	(0.04)	1.2	(0.01)	3.1	(0.04)
PM_{10}[c]	27,327	2.5	(0.01)	0.91	(0.003)	2.5	(0.01)
$PM_{2.5}$[c]	4,744	2.2	(0.05)	0.81	(0.02)	2.2	(0.05)
CO_2		3,200		1,700		3,300	
County[d]	1.85×10^6		(0.17)		(0.09)		(0.18)
New Mexico[e]	6.50×10^7		(0.005)		(0.003)		(0.005)
U.S.[e]	6.54×10^9		(0.00005)		(0.00003)		(0.00005)
Worldwide[e]	3.10×10^{10}		(0.00001)		(0.00001)		(0.00001)

[a] Total emissions in 2002 for Eddy County, in which WIPP is located. See Table 4.2.1-1 for criteria pollutants and VOCs.

[b] As percent of total emissions.

[c] Estimates for GTCC operations include diesel particulate emissions.

[d] Emission data for the year 2005. Currently, data on CO_2 emissions at the county level are not available, so county-level emissions were estimated from available state total CO_2 emissions on the basis of the population distribution.

[e] Annual CO_2 emissions in New Mexico, the United States, and worldwide in 2005.

Sources: EIA (2008); EPA (2008, 2009)

Except for O_3 and particulates, concentration levels from operational activities are expected to remain well below the standards. Estimates for PM_{10} and $PM_{2.5}$ include diesel particulate emissions. However, although lower than their impacts during construction, fugitive dust emissions during operations (emplacement of waste) could exceed the standards under unfavorable meteorological conditions. Established fugitive dust control measures (primarily watering unpaved roads, disturbed surfaces, and temporary stockpiles) would be implemented to minimize potential impacts on ambient air quality.

With regard to regional O_3, precursor emissions of NO_x and VOCs during operations would be comparable to those during construction (about 0.32% and 0.04% of the county total, respectively) and are not anticipated to contribute much to regional O_3 levels. The highest emissions of CO_2 among the three disposal methods would be comparable to the highest construction-related emissions, and thus their potential impacts on climate change would also be negligible. PSD regulations are not applicable to the proposed action because the proposed action is not a major stationary source.

11.2.2 Geology and Soils

Direct impacts from land disturbance would be proportional to the total area of land disturbed during site preparation activities (e.g., grading and backfilling) and construction of the waste disposal facility and related infrastructure. Land disturbance would include the surface area covered for each disposal method and the vertical displacement of geologic materials for the borehole and trench disposal methods. The increased potential for soil erosion would be an indirect impact of land disturbance at the construction site. Indirect impacts would also result from the consumption of geologic materials (e.g., aggregate) for facility and new road construction. The impact analysis also considers whether the proposed action would preclude the future extraction and use of mineral materials or energy resources.

11.2.2.1 Construction

Land surface area disturbance impacts would be a function of the disposal method implemented at the site (Table 5.1-1). Of the three disposal facility layouts, the borehole facility layout would result in the greatest impact in terms of land area disturbed (44 ha or 110 ac). It also would result in the greatest disturbance with depth 40 m (130 ft), with boreholes completed in unconsolidated sand, silt, clay, caliche, and evaporites.

Geologic and soil material requirements are provided in Table 5.3.2-1. Of the three disposal facilities, the vault facility would require the most material since it would involve the installation of cover systems that use soil material. This material would be considered permanently lost. However, none of the three disposal methods are expected to result in adverse impacts on geologic and soil resources in the WIPP Vicinity reference locations, since these resources are in abundant supply at the site and in the surrounding area.

No significant changes in surface topography or natural drainages are anticipated in the construction area. However, the disturbance of soil during the construction phase would increase the potential for erosion in the immediate vicinity. This potential would be greatly reduced by the low precipitation rates in the WIPP Vicinity. Mitigation measures also would be implemented to avoid or minimize the risk of erosion.

The GTCC LLRW and GTCC-like waste disposal facility would be sited and designed with safeguards to avoid or minimize the risks associated with seismic and volcanic hazards. The WIPP Vicinity is in a seismically active region, and small-magnitude earthquakes (usually less than 3 on the Richter scale) occur frequently. Larger-magnitude earthquakes are probable at the site. New facilities in the WIPP Vicinity would be sited and designed with safeguards to avoid or minimize the risks associated with seismic hazards. The annual probability of a volcanic event is considered to be very low, since the nearest volcanic field is in northwestern New Mexico, and the volcanoes within this field are dormant. The potential for liquefaction and subsidence are also considered to be low, given the deep water table and low precipitation rates in the area.

11.2.2.2 Operations

The disturbance of soil and the increased potential for soil erosion would continue throughout the operational phase, because waste would be delivered to the site for disposal over time. The potential for soil erosion would be greatly reduced by the low precipitation rates at the WIPP Vicinity reference locations. Mitigation measures would also be implemented to avoid or minimize the risk of erosion.

Impacts related to the extraction and use of valuable geologic materials are expected to be low, since only the area within the facility itself would be unavailable for mining or drilling. The WIPP Vicinity reference locations are currently closed to commercial mineral development; however, oil and gas production is currently taking place in Section 35, and potash mining does occur at other sections (especially to the north and southwest). Waste disposal activities in Section 35 would not have adverse impacts on the extraction of economic minerals in the surrounding region.

11.2.3 Water Resources

Direct and indirect impacts on water resources could occur as a result of water use at the proposed GTCC LLRW and GTCC-like waste disposal facility during construction and operations. Table 5.3.3-1 provides an estimate of the water consumption and discharge volumes for the three land disposal methods; Tables 5.3.3-2 and 5.3.3-3 summarize the impacts from water use (in terms of change in annual water use) on water resources that would occur during construction and normal operations, respectively. A discussion of potential impacts during each project phase is presented in the following sections. In addition, contamination due to potential leaching of radionuclides from the waste inventory into groundwater could occur, depending on the post-closure performance of the land disposal facilities discussed in Section 11.2.4.2.

11.2.3.1 Construction

Of the three types of land waste disposal facilities considered for the WIPP Vicinity reference locations, a vault facility would require the greatest amount of water during construction (Table 5.3.3-1). Water demands for construction at the WIPP Vicinity reference locations would be met by using groundwater piped in from off-site wells within the city of Carlsbad's water supply system. There are no surface water bodies at the site, and no surface water would be used during construction. As a result, no direct or indirect impacts on surface water resources are expected. The WIPP Vicinity reference locations are not located within 100-year or 500-year floodplains.

Currently, no water is used at the WIPP Vicinity reference locations. The Carlsbad Double Eagle South Well Field supplies water to the WIPP repository site to the south; its annual water production is about 1.4 million L (360 million gal). Construction of the proposed GTCC LLRW and GTCC-like waste disposal facility would increase the pumpage for the Double Eagle water system by a maximum of about 0.24% (vault method) (Table 5.3.3-2). Because increased withdrawals of groundwater would be relatively small, they would be easily accommodated by the Double Eagle water system. The 61-cm (24-in.) pipeline that carries water from this water system to the WIPP repository site has the capacity to transport the increased volume of water effectively. The increase in the water volume needed would be relatively small, and impacts on the water table elevation and any change in the direction of groundwater flow would be negligible.

Disposal of waste (including sanitary waste) generated during construction of the land disposal facilities would have a negligible impact on the quality of water resources at the WIPP Vicinity locations. The potential for indirect surface water or groundwater impacts related to spills at the surface would be reduced by implementing good industry practices and mitigation measures.

11.2.3.2 Operations

Of the three land waste disposal facilities considered for the WIPP Vicinity reference locations, the trench and vault facilities would require the most water during operations (Table 5.3.3-1). Water demands for operations at the WIPP Vicinity reference locations would be met by using groundwater from the Carlsbad water supply system. There are no surface water bodies at the site, and no surface water would be used during operations. As a result, no direct or indirect impacts on surface water resources are expected. The GTCC WIPP Vicinity reference locations are not located within 100-year or 500-year floodplains.

Operations of the proposed GTCC LLRW and GTCC-like waste disposal facility would increase the overall demand on the Double Eagle water system by about 0.39% (Table 5.3.3-3). Because withdrawals of groundwater would be relatively small, they would be easily accommodated by the Double Eagle water system. The increased water demand would slightly lower the existing water table below the well fields. However, because the volume increase would be relatively small, impacts on the water table elevation and any change in the direction of groundwater flow would be negligible.

Disposal of waste (including sanitary waste) generated during operations of the land disposal facilities would have a negligible impact on the quality of water resources at the WIPP Vicinity reference locations. The potential for indirect surface water or groundwater impacts related to spills at the surface would be reduced by implementing good industry practices and mitigation measures.

11.2.4 Human Health

Potential impacts on members of the general public and the involved workers from the construction and operations associated with the land disposal facilities are expected to be comparable for all of the sites evaluated in this EIS for the land disposal methods. These impacts are discussed in Section 5.3.4. The following sections discuss the impacts from hypothetical facility accidents associated with waste handling activities and the impacts during the long-term post-closure phase. They address impacts on members of the general public who might be affected by these waste disposal activities at the WIPP Vicinity reference locations, since these impacts would be site dependent but are expected to be the same for both sections (27 and 35).

11.2.4.1 Facility Accidents

Data on the estimated human health impacts from hypothetical accidents at a land GTCC LLRW and GTCC-like waste disposal facility located at a WIPP Vicinity reference location are provided in Table 11.2.4-1. The accident scenarios are discussed in Section 5.3.4.2.1 and Appendix C. A reasonable range of accidents that included operational events and natural causes was analyzed. The impacts presented for each accident scenario are for the sector with the highest impacts, and no protective measures are assumed; therefore, the impacts represent the maximum expected for such an accident.

The collective population dose includes exposure from inhalation of airborne radioactive material, external exposure from radioactive material deposited on the ground, and ingestion of contaminated crops. The exposure period is considered to last for 1 year immediately following the accidental release. It is recognized that interdiction of food crops would likely happen if a significant release did occur, but many stakeholders are interested in what could happen without interdiction. For the accidents involving CH waste (see Accidents 1–9, 11, and 12 on Table 11.2.4-1), the ingestion dose accounted for about 20% of the collective population dose shown in Table 11.2.4-1. External exposure was found to be negligible in all cases. All exposures were dominated by the inhalation dose from the passing plume of airborne radioactive material downwind of the hypothetical accident immediately following release.

The highest estimated impact on the general public, 7.0 person-rem, would be from a hypothetical release from an SWB caused by a fire in the WHB (Accident 9). The WHB discussed in Chapter 11 is hypothetical and does not refer to the WHB that currently exists at the nearby WIPP geologic repository facility. Such a dose is not expected to lead to any additional LCFs in the population. This dose would be to the 28,800 people living west of the facility, resulting in an average dose of about 0.0002 rem per person. Because this dose would be from internal intake (primarily inhalation, with some ingestion) and because the DCFs used in this analysis are for a 50-year CEDE, this dose would be accumulated over the course of 50 years.

The dose to an individual (expected to be a noninvolved worker) includes exposure from inhalation of airborne radioactive material and 2 hours of exposure to radioactive material deposited on the ground. As shown in Table 11.2.4-1, the highest estimated dose to an individual, 7.5 rem, would be for Accident 9 from inhalation exposure immediately after the postulated release. This estimated dose would be to a hypothetical individual located 100 m (330 ft) north-northeast or east-southeast of the accident location. As discussed above, the estimated dose of 7.5 rem would be accumulated over a 50-year period after intake; it is not expected that it would result in symptoms of acute radiation syndrome. A maximum annual dose of about 5% of the total dose would occur in the first year. The increased lifetime probability of a fatal cancer for this individual would be about 0.5% on the basis of a total dose of 7.5 rem.

11.2.4.2 Post-Closure

The potential radiation dose from airborne releases of radionuclides to the off-site public after the closure of a waste disposal facility would be small. RESRAD-OFFSITE calculation results indicate that there would be no measurable exposure from this pathway from a borehole facility. Small radiation exposures are estimated to occur from use of the trench and vault disposal methods. The potential inhalation dose at a distance of 100 m (330 ft) from the disposal facility is estimated to be less than 1.8 mrem/yr for trench disposal and 0.52 mrem/yr for vault disposal. The potential radiation exposures would be caused mainly by inhalation of radon gas and its short-lived progeny.

The use of boreholes would provide better protection against potential exposures from airborne releases of radionuclides because of the greater depth of cover material involved. The top of the waste placement zone of the boreholes would be 30 m (100 ft) bgs, and this depth of overlying soil would inhibit the diffusion of radon gas, CO_2 gas (containing C-14), and tritium (H-3) water vapor to the atmosphere above the disposal area. However, because the distance to the groundwater table would be closer under the borehole method than under the trench and vault methods, radionuclides that leached out from wastes in the boreholes would reach the groundwater table in a shorter time than would radionuclides that leached out from a trench or vault disposal facility.

On the basis of the RESRAD-OFFSITE calculation results, within 10,000 years, no radiation exposure would be incurred by a hypothetical resident farmer living 100 m (330 ft) from the disposal facility as a result of using groundwater. Potential exposure could occur after 10,000 years and would be caused mainly by I-129 and Tc-99 that reached the groundwater table. Transport times needed by other radionuclides to reach the groundwater table would be longer than 100,000 years as a result of their greater retardation in the soil.

TABLE 11.2.4-1 Estimated Radiological Human Health Impacts from Hypothetical Facility Accidents at the WIPP Vicinity Reference Locations[a]

		Off-Site Public		Individual[b]	
Accident No.	Accident Scenario	Collective Dose (person-rem)	Latent Cancer Fatalities[c]	Dose (rem)	Likelihood of LCF[c]
1	Single drum drops, lid failure in Waste Handing Building	0.00015	<0.0001	0.00017	<0.0001
2	Single SWB drops, lid failure in Waste Handing Building	0.00035	<0.0001	0.00038	<0.0001
3	Three drums drop, puncture, lid failure in Waste Handling Building	0.00027	<0.0001	0.0003	<0.0001
4	Two SWBs drop, puncture, lid failure in Waste Handling Building	0.00049	<0.0001	0.00053	<0.0001
5	Single drum drops, lid failure outside	0.15	<0.0001	0.17	<0.0001
6	Single SWB drops, lid failure outside	0.35	0.0002	0.38	0.0002
7	Three drums drop, puncture, lid failure outside	0.27	0.0002	0.3	0.0002
8	Two SWBs drop, puncture, lid failure outside	0.49	0.0003	0.53	0.0003
9	Fire inside the Waste Handling Building, one SWB assumed to be affected	7	0.004	7.5	0.005
10	Single RH waste canister breach	<0.0001	<0.0001	<0.0001	<0.0001
11	Earthquake affects 18 pallets, each with 4 CH drums	4.3	0.003	4.8	0.003
12	Tornado, missile hits one SWB, contents released	1.4	0.0008	1.5	0.0009

a CH = contact-handled, RH = remote-handled, LCF = latent cancer fatality, SWB = standard waste box. The WHB discussed in this chapter is hypothetical and does not refer to the Waste Handling Building or WHB that currently exists at the nearby WIPP geologic repository facility.

b The individual receptor is assumed to be 100 m (330 ft) downwind from the release point. This individual is expected to be a noninvolved worker.

c LCFs are calculated by multiplying the dose by the health risk conversion factor of 0.0006 fatal cancer per person-rem (see Section 5.2.4.3). LCF values are rounded to one significant figure.

Figure 11.2.4-1 shows the temporal plot of the radiation doses associated with the use of contaminated groundwater for a time frame extended to 100,000 years under the three land disposal methods. The late occurrence of radiation exposure associated with the use of contaminated groundwater is attributed to a small natural water infiltration rate (0.2 cm/yr or 0.08 in./yr) and a deep groundwater table of about 150 m (500 ft). The peak annual doses are calculated to be 84 mrem/yr for use of boreholes, 99 mrem/yr for use of trenches, and 110 mrem/yr for use of the vault disposal method. These peak annual doses are estimated to occur in about 11,000 years, 14,000 years, and 15,000 years for the borehole, trench, and vault methods, respectively. Most of this dose would be from Tc-99 and associated with the GTCC LLRW activated metal waste and GTCC-like Other Waste - RH. There is a high degree of uncertainty associated with results like these, which are for such a long time of analysis.

The results given here are assumed to be conservative because the location selected for the residential exposure is 100 m (330 ft) from the edge of the disposal facility. Use of a longer distance, which might be more realistic for the sites being evaluated, would significantly lower these estimated doses (i.e., by as much as 70%). A sensitivity analysis performed to determine the effect of a distance longer than 100 m (330 ft) is presented in Appendix E.

These analyses assume that engineering controls would be effective for 500 years following closure of the disposal facility. This means that essentially no infiltrating water would reach the wastes from the top of the disposal units during the first 500 years. It is assumed that after 500 years, the engineered barriers would begin to degrade, allowing infiltrating water to come in contact with the disposed-of wastes. For purposes of analysis in the EIS, it is assumed

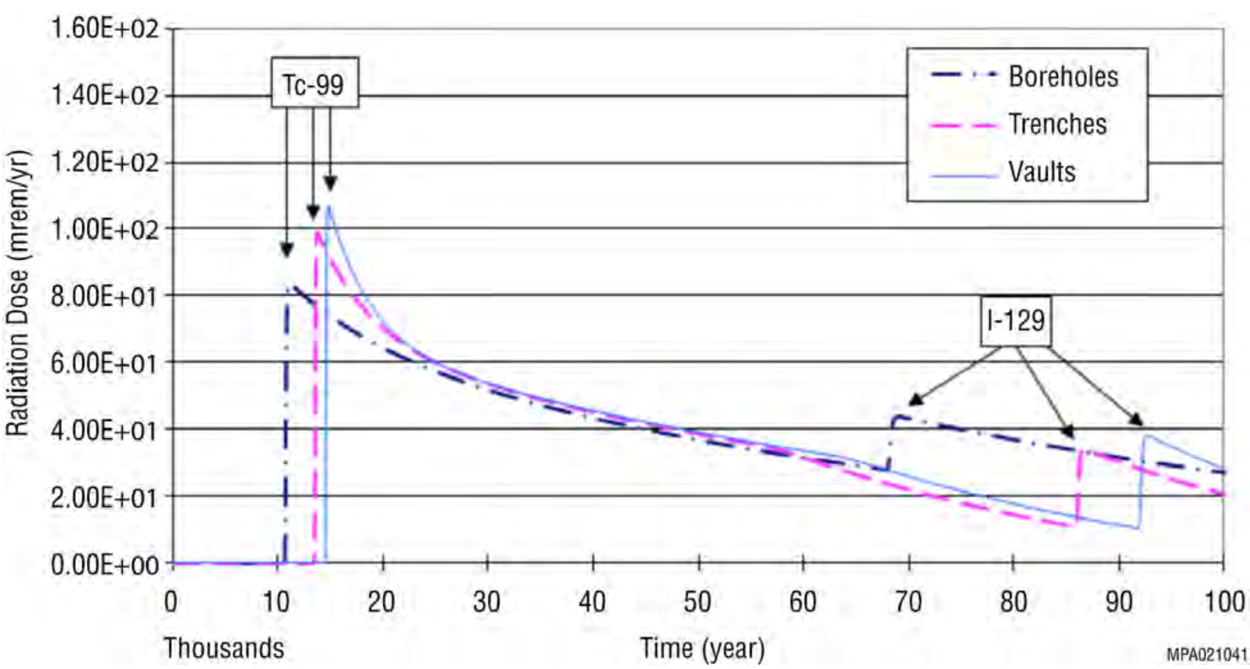

FIGURE 11.2.4-1 Temporal Plot of Radiation Doses Associated with the Use of Contaminated Groundwater within 100,000 Years of Disposal for the Three Land Disposal Methods at the WIPP Vicinity

that the amount of infiltrating water that would contact the wastes would be 20% of the site-specific natural infiltration rate for the area, and that the water infiltration rate around and beneath the disposal facilities would be 100% of the natural rate for the area. This approach is assumed to be conservative because it is expected that the engineered systems (including the disposal facility cover) would last longer than 500 years, even in the absence of active maintenance measures.

It is assumed that the Other Waste would be stabilized with grout or other material and that this stabilizing agent would be effective for 500 years. Consistent with the assumptions used for engineering controls, no credit was taken for the effectiveness of this stabilizing agent after 500 years in this analysis. That is, it is assumed that any water that would contact the wastes after 500 years would be able to leach radioactive constituents from the disposed-of materials. These radionuclides could then move with the percolating groundwater to the underlying groundwater system. This scenario is assumed to be conservative because grout or other stabilizing materials could retain their integrity for longer than 500 years.

The radiation doses presented in the post-closure assessment in this EIS are intended to be used for comparing the performance of each land disposal method at each site evaluated. The results indicate that the use of robust engineering designs and redundant measures (e.g., types and thicknesses of covers and long-lasting grout) in the disposal facility could delay the potential release of radionuclides and could reduce any releases to very low levels, thereby minimizing potential groundwater contamination and associated human health impacts in the future. DOE has considered the potential doses to the hypothetical resident farmer as well as other factors discussed in Section 2.9 in identifying the preferred alternative presented in Section 2.10.

11.2.5 Ecology

Section 5.3.5 presents an overview of the potential impacts on ecological resources from the construction, operations, and post-closure maintenance of the GTCC LLRW and GTCC-like waste disposal facility, regardless of the location selected for the facility. This section evaluates the potential impacts of the GTCC LLRW and GTCC-like waste disposal facility on the ecological resources at the WIPP Vicinity reference locations at Sections 27 and 35.

It is not expected that the initial loss of shrub-dominated sand dune habitat, followed by the eventual establishment of low-growth vegetation on the disposal site, would create a long-term reduction in the local or regional ecological diversity. After closure of the GTCC LLRW and GTCC-like waste disposal site, the cover would be planted with annual and perennial grasses and forbs. As appropriate, regionally native plants would be used to landscape the disposal site in accordance with “Guidance for Presidential Memorandum on Environmentally and Economically Beneficial Landscape Practices on Federal Landscaped Grounds” (EPA 1995). Priority would be given to native plant species that are conducive to soil stabilization and to wildlife needs. A revegetation program would also be recommended in order to minimize the potential for nonnative species to become established at the site.

Since wetlands do not occur within the area of the WIPP Vicinity reference locations, direct impacts on wetlands from construction, operations, and post-closure of the GTCC LLRW and GTCC-like waste disposal facility would not occur. However, wetland plants could potentially develop along the borders of the GTCC LLRW and GTCC-like waste disposal facility retention pond, and depending on the slope of the pond margins and the amount and length of time that the pond would retain water, the shoreline areas of the pond might function in a manner similar to that of a natural emergent wetland.

DOE’s objectives for managing wildlife habitat within the WIPP land withdrawal area include the protection and maintenance of (1) crucial habitats for big game, upland game birds, and raptors; (2) crucial habitats for nongame species of special interest and concern to state or federal agencies; and (3) habitats for federally or state-listed species identified as inhabiting the land within the WIPP LWB (DOE 2002a). DOE’s objectives for managing wildlife habitat at the WIPP Vicinity reference locations would be similar.

Because no aquatic habitats occur within the immediate area of the WIPP Vicinity reference locations, impacts on aquatic biota are not expected. DOE would use appropriate erosion control measures to minimize off-site movement of soils. The GTCC LLRW and GTCC-like waste disposal facility stormwater retention pond is not expected to become a highly productive aquatic habitat. However, depending on the amount of water and length of time that water would be retained in the pond, aquatic invertebrates could become established within it. Waterfowl, shorebirds, and other birds might also make use of the retention pond, as would mammal species that might enter the site.

None of the endangered, threatened, and other special-status species listed in Table 4.2.5-1 have been observed in the WIPP Vicinity (DOE 1997). However, favorable habitat for the lesser prairie-chicken (*Tympanuchus pallidicinctus*), a federal candidate species, does occur within the WIPP Vicinity reference locations, although Section 35 appears to provide a less favorable habitat than do the sections north of it (BLM 2008). One measure for minimizing potential impacts on wildlife is the establishment of periods during which off-site field activities may not be performed during the species’ breeding season. Also, special seed mixes for replanting disturbed areas identified by BLM are used where possible to preserve lesser prairie-chicken habitat (BLM 2008). Similar measures would be enacted for the GTCC LLRW and GTCC-like waste disposal facility. Because only a small proportion of the sand dune habitat within the area would be affected by the GTCC LLRW and GTCC-like waste disposal facility, it is not expected that there would be a population-level impact on the lesser prairie-chicken.

Among the goals of the waste management mission at DOE sites is to maintain disposal facilities in a manner that protects the environment and complies with regulations (DOE 2002b). Therefore, potential impacts on ecological resources from the GTCC LLRW and GTCC-like waste disposal facility would be minimized and mitigated.

11.2.6 Socioeconomics

11.2.6.1 Construction

The potential socioeconomic impacts from constructing a GTCC LLRW and GTCC-like waste disposal facility would be small for all disposal methods. Construction activities would create direct employment of 47 people (borehole method) to 145 people (vault method) in the peak construction year and an additional 58 indirect jobs (trench method) to 152 indirect jobs (vault method) in the ROI (Table 11.2.6-1). Construction activities would constitute less than 1% of the total ROI employment in the peak year. A GTCC LLRW and GTCC-like waste disposal facility would produce between $4.4 million in income (trench method) and $11.7 million in income (vault method) in the peak year of construction.

In the peak year of construction, between 41 people (borehole method) and 127 people (vault method) would in-migrate to the ROI (Table 11.2.6-1) as a result of employment on-site. In-migration would have only a marginal effect on population growth and would require up to 2% of vacant housing in the peak year. No significant impact on public finances would occur as a result of in-migration; up to four local public service employees would be required to maintain existing levels of service in the various local public service jurisdictions in the ROI. In addition, on-site employee commuting patterns would have a small to moderate impact on levels of service in the local transportation network surrounding the site.

11.2.6.2 Operations

The potential socioeconomic impacts from operating a GTCC LLRW and GTCC-like waste disposal facility would be small for all disposal methods. Operational activities would create about 38 direct jobs (borehole method) to 51 direct jobs (vault method) annually and an additional 32 indirect jobs (borehole method) to 38 indirect jobs (vault method) in the ROI (Table 11.2.6-1). A GTCC LLRW and GTCC-like waste disposal facility would also produce between $3.8 million in income (borehole method) and $4.8 million in income (vault method) annually during operations.

Three to four people would move to the area at the beginning of operations (Table 11.2.6-1). However, in-migration would have only a marginal effect on population growth and would require less than 1% of vacant owner-occupied housing during facility operations. No significant impact on public finances would occur as a result of in-migration, and no new local public service employees would need to be hired in order to maintain existing levels of service in the various local public service jurisdictions in the ROI. In addition, on-site employee commuting patterns would have only a small impact on levels of service in the local transportation network surrounding the site.

TABLE 11.2.6-1 Effects of GTCC LLRW and GTCC-Like Waste Disposal Facility Construction and Operations on Socioeconomics at the ROI for the WIPP Vicinity[a]

	Trench		Borehole		Vault	
Impact Category	Construction	Operations	Construction	Operations	Construction	Operations
Employment (number of jobs)						
Direct	62	48	47	38	145	51
Indirect	58	37	78	32	152	38
Total	120	85	125	70	297	89
Income ($ in millions)						
Direct	2.2	3.2	1.9	2.6	6.0	3.4
Indirect	2.2	1.3	3.3	1.2	5.7	1.4
Total	4.4	4.5	5.2	3.8	11.7	4.8
Population (number of new residents)	55	4	41	3	127	4
Housing (number of units required)	27	2	21	2	63	2
Public finances (% impact on expenditures)						
Cities and counties[b]	<1	<1	<1	<1	<1	<1
Schools[c]	<1	<1	<1	<1	<1	<1
Public service employment (number of new employees)						
Local government employees[d]	1	0	1	0	2	0
Teachers	1	0	1	0	2	0
Traffic (impact on current levels of service)	Small	Small	Small	Small	Moderate	Small

[a] Impacts shown are for waste facility and support buildings in the peak year of construction and the first year of operation.

[b] Includes impacts that would occur in the cities of Artesia, Carlsbad, Loving, Eunice, Hobbs, Jal, Lovington, and Tatum and in Eddy and Lea Counties.

[c] Includes impacts that would occur in the Artesia, Carlsbad, Loving, Eunice, Hobbs, Jal, Lovington, and Tatum school districts.

[d] Includes police officers, paid firefighters, and general government employees.

11.2.7 Environmental Justice

11.2.7.1 Construction

No radiological risks and only very low chemical exposure and risk are expected during construction of a trench, borehole, or vault facility. Chemical exposure during construction would be limited to airborne toxic air pollutants at less than standard levels and would not result in any adverse health impacts. Since the health impacts from each facility on the general population within the 80-km (50-mi) assessment area during construction would be negligible, impacts from construction of each facility on the minority and low-income population would not be significant.

11.2.7.2 Operations

Because incoming GTCC LLRW and GTCC-like waste containers would only be consolidated for placement in trench, borehole, and vault facilities, with no repackaging necessary, there would be no radiological impacts on the general public during operations, nor would there be any adverse health effects on the general population. In addition, no surface releases that might enter local streams or interfere with subsistence activities by low-income or minority populations would occur. Because the health impacts of routine operations on the general public would be negligible, it is expected that here would be no disproportionately high and adverse impacts on minority or low-income population groups within the 80-km (50-mi) assessment area. Subsequent NEPA review to support any GTCC implementation would consider any unique exposure pathways (such as subsistence fish, vegetation, or wildlife consumption or well water use) to determine any additional potential adverse health and environmental impacts.

11.2.7.3 Accidents

An accidental radiological release from any of the land disposal facilities would not be expected to cause any LCFs to members of the public in the surrounding area. In the unlikely event of a release at a facility, the communities most likely to be affected could be minority or low-income, given the demographics within 80 km (50 mi) of the GTCC reference location. However, it is highly unlikely such a release would occur, and the risk to any population, including low-income and minority communities, is considered to be low for the accident with the highest potential impacts, estimated to be less than 0.004 LCF for the population groups residing to the west of the site.

Although the overall risk would be very small, the greatest short-term risk of exposure following an airborne release and the greatest one-year risk would be to the population groups residing to the west of the site because of the prevailing wind condition in this case. Airborne releases following an accident would likely have a larger impact on the area than would an accident that released contaminants directly into the soil surface.

Monitoring of contaminant levels in soil and surface water following an accident would provide the public with information on the extent of any contaminated areas. Analysis of contaminated areas to decide how to control the use of high-health-risk areas would reduce the potential impact on local residents.

11.2.8 Land Use

Section 5.3.8 presents an overview of the potential land use impacts that could result from the GTCC LLRW and GTCC-like waste disposal facility, regardless of the location selected for the facility. This section evaluates the potential impacts from the GTCC LLRW and GTCC-like waste disposal facility on land use at the WIPP Vicinity reference locations.

Use of the WIPP Vicinity reference location Section 27 would have to be considered against requirements described in the WIPP LWA as amended (P.L. 102-579 as amended by P.L. 104-201). Use of the WIPP Vicinity reference location Section 35 for disposal of GTCC LLRW and GTCC-like waste would alter the current land use of up to 44 ha (110 ac) from multiple use to use by a waste disposal facility. DOE would consider existing lease holders in determining implementability at Section 35. A loss of about 0.2% of a 22,493-ha (55,581-ac) grazing allotment would also occur.

As was the case for the WIPP repository, the land (in Section 35) would be permanently withdrawn from all forms of entry, appropriation, and disposal under the public land laws and reserved for uses associated with the purposes of the GTCC LLRW and GTCC-like waste disposal facility. DOE would prepare a land management plan, as appropriate, and provide opportunities for the public and for federal, state, and local agencies to participate in the land use planning. Land use on areas surrounding the WIPP Vicinity locations is not expected to be affected. Future land use activities that would be permitted within or immediately adjacent to the GTCC LLRW and GTCC-like waste disposal facility would be limited to those that would not jeopardize the integrity of the facility, create a security risk, or create a worker or public safety risk.

11.2.9 Transportation

The transportation impacts of all GTCC LLRW and GTCC-like waste for disposal at the WIPP Vicinity reference locations was evaluated. As discussed in Section 5.2.9, transportation of all cargo is considered for both truck and rail modes of transport as separate options for the purposes of this EIS. Transportation impacts are expected to be the same for the borehole, trench, and vault methods because the same type of transportation packaging would be used regardless of the disposal method. In addition, it is expected that impacts for both Sections 27 and 35 would be the same because the transportation routes would be similar.

As discussed in Appendix C, Section C.9, the impacts of transportation were calculated in three areas: (1) collective population risks during routine conditions and accidents (Section 11.2.9.1), (2) radiological risks to individuals receiving the highest impacts during routine conditions (Section 11.2.9.2), and (3) consequences to individuals and populations after the most severe accidents involving a release of radioactive or hazardous chemical material (Section 11.2.9.3).

Radiological impacts during routine conditions are a result of human exposure to the low levels of radiation near the shipment. The regulatory limit established in 49 CFR 173.441 (Radiation Level Limitations) and 10 CFR 71.47 (External Radiation Standards for All Packages) to protect the public is 0.1 mSv/h (10 mrem/h) at 2 m (6 ft) from the outer lateral sides of the transport vehicle. This dose rate corresponds roughly to 14 mrem/h at 1 m (3 ft). As discussed in Appendix C, Section C.9.4.4, the external dose rates for CH shipments to the WIPP Vicinity locations are assumed to be 0.5 and 1.0 mrem/h at 1 m (3 ft) for truck and rail shipments, respectively. For shipments of RH waste, the external dose rates are assumed to be 2.5 and 5.0 mrem/h at 1 m (3 ft) for truck and rail shipments, respectively. These assignments are based on shipments of similar types of waste. Dose rates from rail shipments are approximately double the rates for truck shipments because rail shipments are assumed to have twice the number of waste packages as a truck shipment. Impacts from accidents depend on the amount of radioactive material in a shipment and the fraction that is released if an accident occurs. The parameters used in the transportation accident analysis are described further in Appendix C, Section C.9.4.3.

11.2.9.1 Collective Population Risk

The collective population risk is a measure of the total risk posed to society as a whole by the actions being considered. For a collective population risk assessment, the persons exposed are considered as a group, without specifying individual receptors. Exposures to four different groups are considered: (1) persons living and working along the transportation routes, (2) persons sharing the route, (3) persons at stops along the route, and (4) transportation crew members. The collective population risk is used as the primary means of comparing various options. Collective population risks are calculated for cargo-related causes for routine transportation and accidents. Vehicle-related risks are independent of the cargo in the shipment and are only calculated for traffic accidents (fatalities caused by physical trauma).

Estimated impacts from the truck and rail options are summarized in Tables 11.2.9-1 and 11.2.9-2, respectively. For the truck option, it is estimated that approximately 12,600 shipments involving about 36 million km (23 million mi) of travel would cause no LCFs to truck crew members or members of the general public. One fatality related to accidents is expected. No LCFs are estimated for the rail option, involving approximately 5,010 railcar shipments and about 14 million km (9 million mi) of travel. However, one fatality from accidents could occur.

TABLE 11.2.9-1 Estimated Collective Population Transportation Risks for Shipment of GTCC LLRW and GTCC-Like Waste by Truck for Disposal at the WIPP Vicinity Reference Locations[a]

			Cargo-Related[b] Radiological Impacts								Vehicle-Related Impacts[c]
			Dose Risk (person-rem)						Latent Cancer Fatalities[d]		
				Routine Public							
Waste	No. of Shipments	Total Distance (km)	Routine Crew	Off-Link	On-Link	Stops	Total	Accident[e]	Crew	Public	Physical Accident Fatalities
Group 1											
GTCC LLRW											
Activated metals - RH											
Past BWRs	20	63,300	0.66	0.027	0.1	0.12	0.24	0.00022	0.0004	0.0001	0.0015
Past PWRs	143	407,000	4.2	0.16	0.64	0.75	1.5	0.0012	0.003	0.0009	0.0091
Operating BWRs	569	1,550,000	16	0.57	2.4	2.8	5.8	0.0039	0.01	0.003	0.035
Operating PWRs	1,720	4,170,000	43	1.5	6.4	7.7	16	0.011	0.03	0.009	0.095
Sealed sources - CH	209	360,000	0.15	0.031	0.2	0.26	0.49	0.017	<0.0001	0.0003	0.0091
Cesium irradiators - CH	240	413,000	0.17	0.036	0.23	0.3	0.56	0.0028	0.0001	0.0003	0.01
Other Waste - CH	5	603	0.00025	<0.0001	0.00032	0.00043	0.00077	<0.0001	<0.0001	<0.0001	<0.0001
Other Waste - RH	54	150,000	1.5	0.062	0.23	0.28	0.57	<0.0001	0.0009	0.0003	0.0034
GTCC-like waste											
Activated metals - RH	38	85,800	0.89	0.021	0.12	0.16	0.3	<0.0001	0.0005	0.0002	0.0035
Sealed sources - CH	1	1,720	0.00072	0.00015	0.00096	0.0012	0.0023	<0.0001	<0.0001	<0.0001	<0.0001
Other Waste - CH	69	211,000	0.088	0.029	0.12	0.15	0.3	0.00097	<0.0001	0.0002	0.0044
Other Waste - RH	1,160	3,370,000	35	1.2	5.1	6.2	12	0.0022	0.02	0.007	0.07

TABLE 11.2.9-1 (Cont.)

			Cargo-Related[b] Radiological Impacts								Vehicle-Related Impacts[c]
			Dose Risk (person-rem)						Latent Cancer Fatalities[d]		
				Routine Public							
Waste	No. of Shipments	Total Distance (km)	Routine Crew	Off-Link	On-Link	Stops	Total	Accident[e]	Crew	Public	Physical Accident Fatalities
Group 2											
GTCC LLRW											
Activated metals - RH											
New BWRs	202	348,000	3.6	0.099	0.51	0.64	1.3	0.00077	0.002	0.0008	0.0083
New PWRs	833	1,940,000	20	0.7	3	3.6	7.2	0.0049	0.01	0.004	0.044
Additional commercial waste	1,990	6,200,000	64	2.2	9.4	11	23	<0.0001	0.04	0.01	0.13
Other Waste - CH	139	433,000	0.18	0.06	0.26	0.31	0.63	0.003	0.0001	0.0004	0.009
Other Waste - RH	3,790	11,500,000	120	4.2	17	21	43	0.0008	0.07	0.03	0.24
GTCC-like waste											
Other Waste - CH	44	117,000	0.049	0.016	0.069	0.084	0.17	0.0004	<0.0001	0.0001	0.0025
Other Waste - RH	1,400	4,210,000	43	1.5	6.4	7.7	16	0.0022	0.03	0.009	0.088
Total Groups 1 and 2	12,600	35,600,000	350	12	52	64	130	0.051	0.2	0.08	0.76

a BWR = boiling water reactor, PWR = pressurized water reactor, CH = contact-handled, RH = remote-handled.

b Cargo-related impacts are impacts attributable to the radioactive nature of the material being transported.

c Vehicle-related impacts are impacts independent of the cargo in the shipment.

d LCFs were calculated by multiplying the dose by the health risk conversion factor of 6×10^{-4} fatal cancer per person-rem (see Section 5.2.4.3).

e Dose risk is a societal risk and is the product of accident probability and accident consequence.

TABLE 11.2.9-2 Estimated Collective Population Transportation Risks for Shipment of GTCC LLRW and GTCC-Like Waste by Rail for Disposal at the WIPP Vicinity Reference Locations[a]

			Cargo-Related[b] Radiological Impacts								Vehicle-Related Impacts[c]
			Dose Risk (person-rem)						Latent Cancer Fatalities[d]		Physical Accident Fatalities
				Routine Public							
Waste	No. of Shipments	Total Distance (km)	Routine Crew	Off-Link	On-Link	Stops	Total	Accident[e]	Crew	Public	
Group 1											
GTCC LLRW											
Activated metals - RH											
Past BWRs	7	21,300	0.17	0.056	0.0033	0.077	0.14	0.00035	0.0001	<0.0001	0.0017
Past PWRs	37	103,000	0.86	0.27	0.016	0.39	0.67	0.0014	0.0005	0.0004	0.006
Operating BWRs	154	422,000	3.5	1.1	0.062	1.7	2.8	0.0025	0.002	0.002	0.018
Operating PWRs	460	1,200,000	10	3.4	0.18	4.8	8.4	0.0081	0.006	0.005	0.055
Sealed sources - CH	105	190,000	0.53	0.16	0.0085	0.38	0.56	0.00095	0.0003	0.0003	0.0062
Cesium irradiators - CH	120	217,000	0.61	0.19	0.0097	0.44	0.64	0.00013	0.0004	0.0004	0.0071
Other Waste - CH	3	2,740	0.011	0.0025	0.00017	0.0083	0.011	<0.0001	<0.0001	<0.0001	<0.0001
Other Waste - RH	27	85,600	0.68	0.27	0.012	0.33	0.61	<0.0001	0.0004	0.0004	0.0025
GTCC-like waste											
Activated metals - RH	11	23,400	0.21	0.051	0.0028	0.1	0.16	<0.0001	0.0001	<0.0001	0.0024
Sealed sources - CH	1	1,810	0.0051	0.0016	<0.0001	0.0037	0.0053	<0.0001	<0.0001	<0.0001	<0.0001
Other Waste - CH	35	99,700	0.24	0.11	0.0066	0.18	0.29	0.00011	0.0001	0.0002	0.0036
Other Waste - RH	579	1,670,000	14	4.5	0.25	6.7	11	0.00024	0.008	0.007	0.061

TABLE 11.2.9-2 (Cont.)

			Cargo-Related[b] Radiological Impacts								Vehicle-Related Impacts[c]
			Dose Risk (person-rem)						Latent Cancer Fatalities[d]		
				Routine Public							
Waste	No. of Shipments	Total Distance (km)	Routine Crew	Off-Link	On-Link	Stops	Total	Accident[e]	Crew	Public	Physical Accident Fatalities
Group 2											
GTCC LLRW											
Activated metals - RH											
New BWRs	54	113,000	1	0.32	0.017	0.5	0.84	0.00058	0.0006	0.0005	0.0052
New PWRs	227	569,000	4.9	1.7	0.08	2.3	4.1	0.0033	0.003	0.002	0.026
Additional commercial waste	498	1,450,000	12	3.8	0.23	6	10	<0.0001	0.007	0.006	0.054
Other Waste - CH	70	203,000	0.49	0.23	0.014	0.36	0.6	0.00035	0.0003	0.0004	0.0076
Other Waste - RH	1,900	5,550,000	45	15	0.85	23	38	<0.0001	0.03	0.02	0.2
GTCC-like waste											
Other Waste - CH	22	64,300	0.15	0.078	0.0039	0.11	0.19	<0.0001	<0.0001	0.0001	0.0023
Other Waste - RH	702	2,040,000	17	5.4	0.31	8.3	14	0.00022	0.01	0.008	0.076
Total Groups 1 and 2	5,010	14,000,000	110	36	2.1	55	94	0.018	0.07	0.06	0.53

a BWR = boiling water reactor, PWR = pressurized water reactor, CH = contact-handled, RH = remote-handled.

b Cargo-related impacts are impacts attributable to the radioactive nature of the material being transported.

c Vehicle-related impacts are impacts independent of the cargo in the shipment.

d LCFs were calculated by multiplying the dose by the health risk conversion factor of 6×10^{-4} fatal cancer per person-rem (see Section 5.2.4.3).

e Dose risk is a societal risk and is the product of accident probability and accident consequence.

11.2.9.2 Highest-Exposed Individuals during Routine Conditions

During the routine transportation of radioactive material, specific individuals might be exposed to radiation in the vicinity of a shipment. Risks to these individuals for a number of hypothetical exposure-causing events were estimated. The receptors include transportation workers, inspectors, and members of the public exposed during traffic delays, while working at a service station, or while living and or working near a destination site. The assumptions about exposure are given in Appendix C, and transportation impacts are provided in Section 5.3.9. The scenarios for exposure are not meant to be exhaustive; they were selected to provide a range of representative potential exposures. On a site-specific basis, if someone was living or working near the entrance to the WIPP Vicinity locations and present for all 12,600 truck or 5,010 rail shipments projected, that individual's estimated dose would be approximately 0.5 or 1.0 mrem, respectively, over the course of more than 50 years. The individual's associated lifetime LCF risk would then be 3×10^{-7} or 6×10^{-7} for truck or rail shipments, respectively.

11.2.9.3 Accident Consequence Assessment

Whereas the collective accident risk assessment considers the entire range of accident severities and their related probabilities, the accident consequence assessment assumes that an accident of the highest severity category has occurred. The consequences, in terms of committed dose (rem) and LCFs for radiological impacts, were calculated for both exposed populations and individuals in the vicinity of an accident. Because the exact location of such a transportation accident is impossible to predict and thus is not specific to any one site, generic impacts were assessed, as presented in Section 5.3.9.

11.2.10 Cultural Resources

Eight cultural resources have been identified in Section 27 (T22S, R31E) and Section 35 (T22S, R31E); one is in Section 27, and seven are in Section 35. Neither section has been fully examined for the presence of cultural resources. Most of the cultural resources being discovered appear to be the remains of camps that show the evidence of food preparation.

If this location was chosen for development, the NHPA Section 106 process for considering the impact of the project on significant cultural resources would be followed. The Section 106 process requires the facility location and any ancillary locations that would be affected by the project to be investigated for the presence of cultural resources prior to disturbance. If the project occurred near one of the known resources, additional research would be needed to determine if the resource was eligible for listing on the NRHP. If it was, all impacts on the resource would need to be mitigated. Avoidance is always the preferred mitigation measure.

The borehole method has the greatest potential to affect cultural resources because of its 44-ha (110-ac) land requirement. The amount of land needed to employ this method is almost twice the amount needed to construct the vault or the trench method. The majority of the impacts on cultural resources are expected to occur during the construction phase. On the basis of previous research in the region, it is expected that some isolated prehistoric artifacts and possibly some larger prehistoric cultural resources would be found in the project area. One prehistoric site is known within the project area, and it has yet to be evaluated for listing on the NRHP. If additional archaeological sites were identified, they would require evaluation for listing on the NRHP.

Unlike the other two methods being considered, the vault method requires large amounts of soil to cover the waste. Impacts on cultural resources could occur during the removal and hauling of the soil required for this method. Impacts on cultural resources would need to be considered for the soil extraction locations. The NHPA Section 106 process would be followed for all locations. Potential impacts on cultural resources from the operations of the vault method could be comparable to those expected from the borehole method. While the actual footprint would be smaller for the vault method, additional land would be disturbed to obtain the soil for the cover. Most impacts on significant cultural resources could be mitigated through data recovery, but avoidance is the preferred mitigation. The appropriate mitigation would be determined through consultation with the New Mexico SHPO and the appropriate Native American tribes. These tribes would be consulted to ensure that no traditional cultural properties that could be disturbed were located in the project area.

It is expected that activities associated with construction, operations, and post-closure would have a minimal impact on cultural resources. No new ground-disturbing activities are expected to occur in association with operations and post-closure activities.

11.2.11 Waste Management

The construction of the land disposal facilities would generate small quantities of hazardous and nonhazardous solids and hazardous and nonhazardous liquids. Waste generated from operations would include small quantities of solid LLRW (e.g., spent HEPA filters) and nonhazardous solid waste (including recyclable wastes). These wastes could be sent off-site for disposal; therefore, no impacts from the waste generated from the construction and operations of the land disposal methods are expected. Section 5.3.11 summarizes the management and handling procedures that could be followed for the waste that might be generated by the land disposal facilities at the WIPP Vicinity.

11.3 SUMMARY OF POTENTIAL ENVIRONMENTAL CONSEQUENCES AND HUMAN HEALTH IMPACTS

The potential environmental consequences from Alternatives 3, 4, and 5 discussed in Section 11.2 are summarized by resource area as follows:

Air quality. Total peak-year emission rates are estimated to be rather small when compared with the Eddy County total emissions. Peak-year emissions for all criteria pollutants (except PM_{10} and $PM_{2.5}$) would be small. Construction at the WIPP Vicinity GTCC reference locations could occur within less than 100 m (330 ft) of the site boundary. Under unfavorable dispersion conditions, high concentrations of PM_{10} or $PM_{2.5}$ could occur and exceed the standards at the site boundary, although such exceedances would be rare. Compared with annual emissions for Eddy County, annual emissions of NO_x for the vault method during construction would be the highest, about 0.37% of the county total, while emissions of other criteria pollutants and VOCs would be about 0.06% or less. Except for O_3 and particulates, concentration levels from operational activities are expected to remain well below the standards. During operations, fugitive dust emissions could exceed the standards under unfavorable meteorological conditions.

Noise. The highest composite noise level during construction would be about 92 dBA at 15 m (50 ft) from the source. Noise levels at 690 m (2,300 ft) from the source would be below the EPA guideline of 55 dBA as L_{dn} for residential zones. There would be no residences within this distance. Noise generated during operations would be less than noise during construction. No impacts from ground-borne vibration are anticipated because the generating equipment would not be high-vibration equipment and because there are no residences or vibration-sensitive buildings nearby.

Geology. During the construction phase, the borehole facility footprint would result in the greatest impact in terms of land area disturbed (44 ha or 110 ac). It also would result in the greatest disturbance with depth, 40 m (130 ft), with boreholes being completed in unconsolidated sand, silt, clay, caliche, and evaporites. No adverse impacts from extraction or use of geologic and soil resources are expected. No significant changes in surface topography or natural drainages would occur. The potential for erosion would be reduced because of the low precipitation rates at the WIPP Vicinity and further reduced by best management practices.

Water resources. Construction of a vault facility and operations of a vault or trench facility would have the highest water requirement. Water demands for construction at the WIPP Vicinity reference locations would be met by using groundwater from the Carlsbad Double Eagle water system. There are no surface water bodies at the site, and no surface water would be used during construction; therefore, no direct or indirect impacts on surface water are expected. Construction and operations of the proposed GTCC LLRW and GTCC-like waste disposal facility would increase the pumpage for the Double Eagle water system by a maximum of about 0.24% and 0.39%, respectively. This volume increase would be relatively small, and impacts would be negligible. It is expected that there would be no water demands during the post-closure period. Because of the low infiltration rates and deep water table, groundwater would not likely become contaminated with radionuclides for more than 50,000 years for all three disposal methods.

Human health. The worker impacts from operations would mainly be those from the radiation doses associated with handling and disposing of the wastes. The annual radiation dose would be 2.6 person-rem/yr for boreholes, 4.6 person-rem/yr for trenches, and 5.2 person-rem/yr for vaults. These worker doses are not expected to result in any LCFs (Section 5.3.4.1.1). The maximum dose to any individual worker would not exceed the DOE administrative control level (of 2 rem/yr) for site operations. It is expected that the maximum dose to any individual workers over the entire project would not exceed a few rem.

The worker impacts from accidents would be associated with the injuries and illnesses during disposal operations and possible fatalities that could occur from construction and waste handling activities. The annual number of lost workdays due to injuries and illnesses would range from 1 (for boreholes) to 2 (for trenches and vaults), and no fatalities would occur from construction and waste handling accidents (see Section 5.3.4.2.2). These injuries would not be associated with the radioactive nature of the wastes but would simply be those that are expected to occur in any construction project of this size.

For the general public, no measurable doses are expected to occur during waste disposal at the site during operations, given the solid nature of the wastes and the distance of waste handling activities from potentially affected individuals. The highest dose to an individual from an accident involving the waste packages prior to disposal (from a fire impacting an SWB) is estimated to be 7.5 rem and would not result in any LCFs. The total dose to the affected population from such an event is estimated to be 7.0 person-rem (see Table 11.2.4-1). Groundwater contamination is not projected to reach a nearby hypothetical resident farmer located 100 m (330 ft) from the edge of the disposal facility within the first 10,000 years, so this individual would receive no incremental radiation dose from disposal of these wastes from this potential exposure pathway.

Ecology. Initial loss of shrub-dominated sand dune habitat, followed by the eventual establishment of low-growth vegetation on the disposal site, is not expected to create a long-term reduction in the local or regional ecological diversity. No aquatic habitats occur within the immediate vicinity of the GTCC reference locations at the WIPP Vicinity; hence, impacts on aquatic biota are not expected. No endangered, threatened, and other special-status species have been observed in the WIPP Vicinity area (DOE 1997). However, favorable habitat for the lesser prairie-chicken (*Tympanuchus pallidicinctus*), a federal candidate species, does occur within the WIPP Vicinity area (BLM 2008).

Socioeconomics. Impacts associated with construction and operations of the land disposal facilities would be small. Construction would create direct employment for up to 145 people (vault method) in the peak construction year and up to 152 additional indirect jobs (vault method) in the ROI; the annual average employment growth rate would increase by less than 0.1 of a percentage point. The waste facility would produce up to $11.7 million in income in the peak construction year (vault method). Up to 127 people would in-migrate to the ROI as a result of employment on-site; in-migration would have only a marginal effect on population growth and require less than 2% of vacant housing in the peak year. Impacts from operating the facility would also be small, creating up to 51 direct jobs annually (vault method) and up to 38 additional indirect jobs (vault method) in the ROI. The disposal facility would produce up to $4.8 million in income annually during operations.

Environmental justice. Health impacts on the general population within the 80-km (50-mi) assessment area during construction and operations would be negligible, and no impacts on minority and low-income populations as a result of the construction and operations of a GTCC LLRW and GTCC-like waste disposal facility are expected. If analyses that accounted for any unique exposure pathways (such as subsistence fish, vegetation, or wildlife consumption or well-water consumption) determined that health and environmental impacts would not be significant, then there would be no high and adverse impacts on minority and low-income populations. If impacts were found to be significant, disproportionality would be determined by comparing the proximity of high and adverse impacts to the location of low-income and minority populations.

Land use. The GTCC WIPP Vicinity Section 27 reference location is located within the WIPP LWB and is therefore subject to the WIPP LWA as amended (P.L. 102-579 as amended by P.L. 104-201) requirements. WIPP Vicinity Section 35 reference location is located within a multiple use area and contains oil and gas leases. A loss of 0.2% of a 22,493-ha (55,581-ac) grazing allotment would occur, and a portion of Section 35 would be altered to a waste disposal area.

Transportation. Shipment of all waste to the WIPP Vicinity by truck would result in approximately 12,600 shipments involving a total distance of 36 million km (23 million mi). Shipment of all waste by rail would involve 5,010 railcar shipments totaling 14 million km (9 million mi) of travel. It is estimated that no LCFs would occur to the public or crew members for either mode of transportation, but one fatality from an accident could occur. For comparison, since starting operations in 1999, WIPP has received more than 8,500 truck shipments of defense TRU waste.

Cultural resources. The majority of the impacts on cultural resources are expected to occur during the construction phase. On the basis of previous research in the region, it is expected that some isolated prehistoric artifacts and possibly some larger prehistoric cultural resources would be found in the project area. One known prehistoric site is within the WIPP Vicinity reference location and has yet to be evaluated for listing on the NRHP. If additional archaeological sites were identified, they would require evaluation for listing on the NRHP. Section 106 of the NHPA would be followed to determine the impacts of disposal facility activities on significant cultural resources, as needed. Local tribes would be consulted to ensure that no traditional cultural properties were affected by the project.

Waste management. The wastes that might be generated from the construction and operations of the land disposal methods could be sent off-site for disposal as commercial waste management facilities became available.

11.4 CUMULATIVE IMPACTS

Potential impacts of the proposed action are considered in combination with the impacts of past, present, and reasonably foreseeable future actions. Section 5.4 presents the methodology for the cumulative impacts analysis. The analysis provided below begins with a description of reasonably foreseeable future actions at the WIPP Vicinity locations, including those that are ongoing, under construction, or planned for future implementation. Past and present actions are generally accounted for in the affected environment section (Section 11.1). Impacts of the proposed action are considered in combination with the impacts of past, present, and reasonably foreseeable future actions.

Aside from the adjacent operating WIPP repository, the primary use of land within 16 km (10 mi) of the WIPP Vicinity locations is grazing, with lesser amounts of land used for oil and gas extraction and potash mining. Most of this land is managed and owned by BLM. Two ranches are located within 16 km (10 mi) of the WIPP site. The closest town, Loving, New Mexico, is about 29 km (18 mi) away. Most of the land within 50 km (30 mi) of the WIPP Vicinity locations is owned by either the federal government or the State of New Mexico. At the time of the preparation of this EIS, there were no known plans for large actions on BLM land.

The land use described above, in combination with the low potential impacts discussed in Section 11.2, indicate that the contribution from the construction, operations, and post-closure phases of the proposed action to cumulative impacts at the WIPP Vicinity locations and the nearby WIPP geologic repository would be small and would not have a significant cumulative impact on area air quality, geology and soils, water resources, ecology, socioeconomics, environmental justice, cultural resources, and land use. The post-closure performance analysis incorporating the emplacement of the GTCC LLRW and GTCC-like waste at the adjacent WIPP repository (as discussed in Section 4.3.4) indicated that releases to the environment (if any) would be negligible. Combining these releases with the results discussed in Section 11.2.4, which indicates that potential post-closure radionuclide releases to the groundwater in Sections 27 and 35 would also be small, indicates that cumulative human health impacts at the WIPP Vicinity would not be significant.

On June 15, 2005, the NRC staff issued the *Environmental Impact Statement for the Proposed National Enrichment Facility in Lea County, New Mexico* (NRC 2005). This facility was constructed and is now in operation. It is located about 60 km (37 mi) east of the WIPP Vicinity reference locations (town of Eunice). The distance from the WIPP Vicinity reference locations – in combination with NRC staff findings (as reported in the EIS for that action [NRC 2005]) that stated that environmental impacts from this enrichment facility would be small to moderate – indicate that cumulative impacts from the possible GTCC LLRW and GTCC-like waste disposal activities at the WIPP Vicinity reference locations in combination with the enrichment facility operations would be small and not result in significant cumulative impacts for all resource areas evaluated (including human health and transportation).

On June 5, 2012 (*Federal Register*, Vol. 77, No. 108), DOE proposed to evaluate two additional locations for a long-term mercury storage facility. These two locations are both near WIPP, but the first is located within and the second is located outside the land subject to the WIPP LWA (P.L. No. 102-579), as amended. The first is located in Section 20, Township 22 South, Range 31 East (across the WIPP access road from the WIPP facility), and the second is located in Section 10, Township 22 South, Range 31 East, approximately 3.5 mi (5.6 km) north of the WIPP facility. The impacts on the various resource areas from construction and operation of a long-term mercury storage facility would range from none to minor, including impacts on land use and visual resources, surface water or groundwater resources, air emissions, engine exhaust emissions from transporting mercury, noise levels, ecological resources, cultural and paleontological resources, the site's waste management infrastructure, human health, socioeconomics, and vehicle trips during construction. There would be minor, short-term (6-month) air quality impacts involving construction of a new storage facility. There would be no disproportionately high and adverse effects on minority or low-income populations.

Transportation accidents are predicted to pose a negligible to low risk to human health. The impacts from the proposed construction and operation of a long-term mercury storage facility discussed above, in combination with the potential impacts summarized in Section 11.2 for the GTCC proposed action, would not have a significant cumulative impact on any of the resource areas evaluated for the WIPP and the WIPP Vicinity.

Finally, follow-on NEPA evaluations and documents prepared to support any further considerations of siting a new borehole, trench, or vault disposal facility at the WIPP Vicinity reference locations would provide more detailed analyses of site-specific issues, including cumulative impacts.

11.5 STATUTORY AND REGULATORY PROVISIONS RELEVANT TO THE EIS

Siting a vault, trench, or borehole facility for GTCC LLRW and GTCC-like waste inside the WIPP LWB (i.e., Section 27) would be subject to the limits of the WIPP LWA as amended (P.L. 102-579 as amended by P.L. 104-201), as discussed for WIPP in Section 4.7; therefore, federal legislation to develop such facilities would be required. Siting a vault, trench, or borehole facility on BLM-administered land outside the WIPP LWB (i.e., Section 35) would require a land withdrawal in accordance with DOI regulations at 40 CFR Part 2300, "Land Withdrawals."

11.6 REFERENCES FOR CHAPTER 11

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12 GENERIC DISPOSAL FACILITIES ON NONFEDERAL LANDS

This chapter provides an evaluation of the human health consequences from the disposal of GTCC LLRW and GTCC-like waste under Alternative 3 (use of a new borehole disposal facility), Alternative 4 (use of a new trench disposal facility), and Alternative 5 (use of a new vault disposal facility) at generic nonfederal (commercial) sites in the United States. The evaluation focuses on the human health consequences after closure of the disposal facilities in order to provide information for comparison with the other alternatives presented in this EIS.

DOE solicited technical capability statements from commercial vendors that might be interested in constructing and operating a GTCC LLRW and GTCC-like waste disposal facility in a request for information in the *FedBizOpps* on July 1, 2005. Although at that time, several commercial vendors expressed an interest, no vendors provided specific information on disposal locations and methods for analysis in the EIS. On June 20, 2014 Waste Control Specialists, LLC, (WCS), filed (and resubmitted on July 21, 2014) a Petition for Rulemaking with the Texas Commission on Environmental Quality (TCEQ) requesting the State of Texas to revise certain provisions of the Texas Administrative Code to remove prohibitions on disposal of GTCC LLRW, GTCC-like waste and TRU waste at its TCEQ licensed facilities. On January 30, 2015, TCEQ sent a letter to the NRC requesting guidance on the State of Texas's authority to license disposal of GTCC LLRW, GTCC-like waste and TRU waste. This matter is under review by NRC. Including a generic commercial facility in this EIS would allow DOE to make a programmatic determination regarding the disposal of GTCC LLRW and GTCC-like waste at such a facility. DOE has included analysis of generic commercial facilities in the event that a facility could become available in the future. In that case, before making a decision to use a commercial facility, DOE would conduct further NEPA reviews, as appropriate.

Because the evaluation is for generic sites, an evaluation of impacts on the remaining environmental resource areas (including potential human health impacts from disposal facility accidents; see list in Section 2 and Figure 2.1) is not included; it is more appropriate that the analyses of these resource areas be based on site-specific information. That is, region-wide input parameters would not result in meaningful information on which subsequent decisions could be based when determining where to implement a GTCC LLRW and GTCC-like waste disposal facility. However, it can be gleaned from the results of Alternatives 3 to 5 for the federal sites (found in Chapters 6 to 11 of this EIS) that the potential impacts on these environmental resource areas from using the borehole, trench, or vault methods for disposing of GTCC LLRW and GTCC-like waste at a commercial site could be similar and that the potential long-term impacts on human health could provide a differentiating factor when deciding among alternatives for GTCC LLRW and GTCC-like waste disposal. These impacts are thus the focus of this chapter.

Alternatives 3 to 5 are described in Section 5.1, and the environmental consequences from these alternatives that are common to the federal sites are evaluated in Chapter 5. These impacts would also be generally applicable to commercial facility sites and thus are not repeated here. Impact assessment methodologies used for this EIS are described in Appendix C.

12.1 APPROACH FOR ANALYZING THE GENERIC COMMERCIAL SITES

The analysis here covers four generic sites, one in each of the four major geographic regions of the country coinciding with the four NRC regions (see Figure 1.4-2). These four generic sites are referred to as Regions I, II, III and IV, and they include the same states as those addressed by the corresponding NRC regions. That is, Region I covers the Northeastern states, Region II the Southeastern states, Region III the Midwestern states, and Region IV the Western states.

The RESRAD-OFFSITE computer code was used to address the post-closure impacts at the four generic sites in a manner similar to that done for the federal sites. This allows for a direct comparison of the results given in this chapter with those given in Chapters 6 through 11. The RESRAD-OFFSITE input parameters describing the setting for each of the four generic sites, including its soil properties and hydrological characteristics, were developed from information used in similar analyses (Poe 1998; Toblin 1998, 1999), and these are presented in Appendix E (see Tables E-19 and E-20).

One of the most important parameters in this evaluation is the depth to groundwater in these four regions. These depths were determined to be as follows from using the references given above (see Table E-19 in Appendix E): Region I (3.4 m or 11 ft), Region II (13 m or 44 ft), Region III (2.2 m or 7 ft), and Region IV (55 m or 180 ft). On the basis of these groundwater depths, a vault facility could be used in each of the four regions, while trenches could be used in only two regions (II and IV), and boreholes could be used only in Region IV. Note that using this combination of disposal methods and geographic regions allows for a comparison of using trenches in the two regions in which the DOE sites considered in this EIS are located (i.e., in Regions II and IV). None of the federal sites considered in this EIS are located in Regions I or III.

The choice of disposal methods assessed in this chapter for the four geographic regions is meant to provide additional information to allow for an informed decision on the best approach for disposing of GTCC LLRW and GTCC-like waste. There may be locations in Regions I, II, and III that could accommodate use of the borehole method. However, without specific sites and characterization information, this EIS limits the evaluation to Region IV, where the depth to groundwater would be generally compatible with use of the borehole method on a regional basis. The same limitation applies with regard to the use of trenches, but in this case, the evaluation is limited to Regions II and IV. There are likely to be some locations in Regions I and III where the depth to groundwater is greater, so that the trench method could be used to effectively dispose of GTCC LLRW and GTCC-like waste, should any proposals for a commercial facility in those regions be identified at a later time. However, these two regions generally have shorter distances to groundwater than do Regions II and IV. The vault method is considered to be applicable in all four regions, since this method is largely above grade and involves the greatest distance between the bottom of the disposed-of wastes and the groundwater.

It is assumed that all of the GTCC LLRW and GTCC-like waste would be disposed of at each regional site/disposal method combination, as was assumed for the analyses conducted at the federal sites. The results are presented in the same manner as that used for the federal sites in order to provide information that could be useful for comparison.

For this analysis, it is assumed that the conceptual designs of the disposal facilities (borehole, trench, and vault) would be the same as those presented in Section 5.1. Hence, the assumptions about the engineered controls and waste stabilization practices are also similar to those assumptions for the federal sites evaluated in this EIS (in Chapters 6 through 11). The natural water infiltration rates were taken to be those assumed in the *Draft Environmental Impact Statement on 10 CFR Part 61 "Licensing Requirements for Land Disposal of Radioactive Waste"* (Vol. 4, Appendix J, Table J.5, in NUREG-0782; see NRC 1981). They are 0.074 m/yr for Region I, 0.18 m/yr for Region II, 0.05 m/yr for Region III, and 0.001 m/yr for Region IV. In addition, it is assumed that the integrity of the engineered covers and waste containers would begin to degrade after 500 years. At that time, an amount of water that is equivalent to 20% of the natural infiltration rate would enter the waste containers and leach radionuclides from the waste materials. The assumption of a water infiltration rate that is 20% of the natural infiltration rate for the area is consistent with the assumption used in the analyses of waste disposal at the federal sites evaluated in this EIS. A summary of the assumptions used to generate the results presented in this chapter is presented in Appendix E.

12.2 HUMAN HEALTH IMPACTS FROM CONSTRUCTION AND OPERATION OF THE LAND DISPOSAL FACILITIES AT THE GENERIC COMMERCIAL SITES

The human health impacts on workers and the general public at these generic commercial facilities during disposal facility construction and waste disposal operations are expected to be similar to those at the federal sites considered in this EIS. These impacts are expected to be mainly the occupational doses from waste disposal operations; no off-site releases are expected because the waste packages would contain the radioactive materials and because monitoring of the site and nearby vicinity would identify the need for any corrective actions. It is possible that the public could be exposed to external gamma radiation from wastes being stored at the site prior to disposal if individuals were to venture close enough to these wastes, but such exposures are expected to be low and not result in any significant LCF risk. In addition, there would be security measures at the facility to ensure that an individual could not gain unauthorized or inadvertent access to the wastes.

It is expected that the doses to the general public in the vicinity of a hypothetical commercial disposal facility during disposal operations would be well below the dose limit of 100 mrem/yr set by DOE and the NRC for radiation protection purposes for reasons described below. Engineering controls would likely be effective in limiting releases of contaminants to the environment, and the site perimeter would be monitored to ensure the effectiveness of these controls. Even though the commercial disposal facility would be licensed by the NRC or an Agreement State, it is expected that the facility would adhere to limits that are comparable to those set by DOE for its operations to control radiation exposures. The DOE radiation dose limits for members of the general public are given in DOE Order 5400.5, and the NRC requirements are given in Subpart D of 10 CFR Part 20.

Individuals working at a commercial disposal facility would be routinely monitored for radiation exposure. The worker doses would be kept below applicable radiation dose standards. DOE has established a primary radiation dose standard of 5 rem/yr to workers for its operations

(10 CFR Part 835), and the NRC has the same occupational dose limit in Subpart C of 10 CFR Part 20. In addition, DOE has set an administrative control level of 2 rem/yr for all DOE activities, and it requires contractors to develop a similar level for specific activities that is consistent with this requirement. The contractor administrative control level is generally not expected to exceed 1.5 rem/yr, and for many activities, the level should be 500 mrem/yr or less. The NRC would be expected to impose similar limits to control occupational doses at a hypothetical commercial site for disposing of GTCC LLRW and GTCC-like waste. External gamma exposure would be the primary exposure pathway for workers.

The specific monitoring and maintenance program to be used at a commercial GTCC LLRW and GTCC-like waste disposal site would be prescribed by the NRC or Agreement State as part of the licensing process. Such a program would be designed to provide effective control of any releases from the site and would include ALARA considerations. The potential impacts on members of the general public and involved workers from the construction and operations of land disposal facilities for GTCC LLRW and GTCC-like waste are discussed in Section 5.3.4. The impacts at a commercial disposal facility are expected to be comparable to those at a DOE site, because similar procedures are expected to be used to operate the facility. The impacts presented in Section 5.3.4 for construction and operations are therefore applicable to commercial disposal facilities as well as to DOE sites, and these are not repeated here.

Although all appropriate health and safety procedures and requirements for use of a commercial GTCC LLRW and GTCC-like waste disposal facility would be met, it is possible that accidents could occur that could injure workers and result in the off-site release of radioactive materials. It is expected that the impacts on workers from accidents would be similar to those estimated for use of federal sites, as given in Table 5.3.4-2. That is, less than one fatality is predicted to occur during construction and operations, but a number of injuries could occur. The numbers of lost workdays due to nonfatal injuries and illness during construction activities are estimated to be 16 for use of boreholes, 49 for use of trenches, and 150 for use of vaults. About one to two lost workdays could occur annually during operational activities.

The impact from accidents involving the release of radioactive materials to off-site locations would depend on the local meteorology and location of nearby individuals. While these factors are very much site-dependent, the radiation doses and LCF risks to a nearby individual would generally be expected to be comparable to those predicted for use of federal sites. The highest dose to an individual (expected to be a noninvolved worker) for the various federal sites evaluated in the EIS ranges from 2.4 to 16 rem, with the highest LCF risk being 0.009. This individual is assumed to be located 100 m (330 ft) from an accident involving a fire to an SWB. The dose to the impacted population in the downwind sector from such an accident would not result in any LCFs.

12.3 POST-CLOSURE PERIOD HUMAN HEALTH IMPACTS FROM THE LAND DISPOSAL FACILITIES AT THE GENERIC COMMERCIAL SITES

The major differentiating factor for these four geographic regions is related to the impacts that could occur during the post-closure period. These are related to the potential release of contaminants to the environment and the subsequent exposure to nearby individuals. Because it is assumed that the site would not be monitored post-closure, there would be no worker doses during this time period. Also, although airborne releases could occur, it is expected that the overlying cover system and the dispersion of any released radionuclides by the wind would greatly decrease the air concentrations. Hence, the highest doses are expected to be those associated with the migration of radionuclides to groundwater and their subsequent use by members of the general public. For this assessment, the exposed individual is assumed to be a hypothetical resident farmer located 100 m (330 ft) downgradient from the disposal facility. This assessment is the same as that done for the federal sites considered in this EIS.

It is assumed that following closure of the disposal facility, the engineering controls incorporated into the disposal facility design would degrade and begin to fail, allowing water to infiltrate into the wastes. This infiltration could result in the leaching of contaminants from the packaged wastes over time. These contaminants could move downward with the infiltrating water to the underlying groundwater system and eventually migrate to a well being used to supply potable water. Should this scenario occur, it is possible that an individual could be exposed to relatively high concentrations of radionuclides and incur significant radiation doses. This scenario, which was developed by using the RESRAD-OFFSITE computer code, is evaluated in this section, and it represents an upper bound to the long-term doses and LCF risks that are reasonably expected to occur if a commercial facility was constructed for disposal of GTCC LLRW and GTCC-like waste.

The potential radiation dose from the airborne release of radionuclides to off-site members of the public after closure of a disposal facility would be small. Estimates developed by using RESRAD-OFFSITE indicate that there would be no measurable exposure from this pathway for the borehole method. Small radiation exposures are estimated for the trench and vault methods. The potential inhalation dose at a distance of 100 m (330 ft) from the disposal facility is estimated to be less than 1.8 mrem/yr for trench disposal and 0.52 mrem/yr for vault disposal. The potential radiation exposures would result mainly from the inhalation of radon gas and its short-lived progeny.

The borehole method would provide better protection against potential exposures from airborne releases of radionuclides because of the greater depth of the cover material. For the use of boreholes, the wastes would be emplaced 30 to 40 m (100 to 130 ft) bgs, and the depth of overlying soil would inhibit the diffusion of radon gas, CO_2 gas (containing C-14), and tritium (H-3) water vapor to the atmosphere above the disposal area. However, because the distance to the groundwater table from boreholes would be shorter than the distance from trenches or vaults, radionuclides that leached out from the wastes in boreholes would reach the groundwater table in a shorter time than those from wastes in trenches or vaults. This would mean there would be less time for radioactive decay to occur before the radionuclides reached the environment.

For this assessment, the entire GTCC LLRW and GTCC-like waste inventory is assumed to be disposed of at a single commercial facility in each of the four geographic regions. Representative parameters were chosen for each site so that the RESRAD-OFFSITE computer code could be used to address the movement of radioactive contaminants from these GTCC LLRW and GTCC-like waste to the nearby environment (see Appendix E). It is assumed that engineering controls (the integrity of stabilizing agents in the Other Waste type and the disposal facility cover) would prevent or minimize water infiltration into the wastes for the first 500 years following closure of the disposal facility. This practice would allow time for the short-lived radionuclides to decay to innocuous levels. It is further assumed that after the first 500 years, the facility covers would still be effective in reducing water infiltration to the top of the facility (i.e., 80% reduction is assumed).

Calculations indicate that within 10,000 years, radionuclides would reach the groundwater table and a well installed by a hypothetical resident farmer located a distance of 100 m (330 ft) from the downgradient edge of a disposal facility in Regions I, II, and III. Radionuclides are not predicted to reach this hypothetical well within 10,000 years in Region IV for any of the three disposal methods. This assumption reflects the more arid climate and greater depth to groundwater in the Western United States. However, calculations indicate that radionuclides would reach the groundwater table and this hypothetical well after 10,000 years, and these results are discussed below.

The results of these modeling calculations are given in Tables 12.3-1 through 12.3-6 and in Figures 12.3-1 through 12.3-7. The tables provide the peak annual doses and LCF risks associated with use of contaminated groundwater resulting from the disposal of the entire GTCC LLRW and GTCC-like waste inventory at a commercial disposal facility in Regions I, II, and III. The tables show the contributions from the different waste types to the peak annual doses and LCFs at the time of peak impact, and the figures illustrate the radionuclides that provide most of the annual dose and LCF risk. Since the calculations indicate that disposal of GTCC LLRW and GTCC-like waste in a borehole, trench, or vault facility in Region IV would not reach the groundwater table in 10,000 years, tables summarizing the peak annual doses and LCF risks are not provided for this region. However, the radiation doses out to 100,000 years for these three disposal methods in Region IV are shown in Figure 12.3-7. The major dose contributor in all four regions is GTCC-like Other Waste - RH. The primary radionuclides causing this dose are generally C-14, I-129, and isotopes of uranium and plutonium.

Because the radionuclide mixes are different for each waste type (i.e., activated metals, sealed sources, and Other Waste), the peak annual doses and LCF risks do not necessarily occur at the same time for each waste type. In addition, the peak annual doses and LCF risks for the entire GTCC LLRW and GTCC-like waste inventory considered as a whole could be different from those for the individual waste types. The results presented in Tables 12.3-1 through 12.3-6 are for the entire GTCC LLRW and GTCC-like waste inventory, and the contributions of the individual waste types given in these tables are those that occur at the time of the peak annual doses and LCF risks for the entire inventory.

The estimated doses and LCF risks for the hypothetical resident farmer scenario evaluated to assess the post-closure impacts for GTCC LLRW and GTCC-like waste disposal at a commercial facility are presented in two ways in this EIS. The first presents the peak annual doses and LCF risks when disposal of the entire GTCC LLRW and GTCC-like waste inventory is considered. These are provided in Tables 12.3-1 through 12.3-6. The second presents the peak annual doses for each waste type considered on its own. These results are presented in Tables E-22 through E-25 in Appendix E. The first set of results could be used as the basis for

TABLE 12.3-1 Estimated Peak Annual Dose (in mrem/yr) from the Use of Contaminated Groundwater within 10,000 Years of Disposal in a Commercial Vault Disposal Facility in Region I[a]

	GTCC LLRW				GTCC-Like Waste				
Disposal Technology/Waste Group	Activated Metals - RH	Sealed Sources - CH	Other Waste - CH	Other Waste - RH	Activated Metals - RH	Sealed Sources - CH	Other Waste - CH	Other Waste - RH	Peak Annual Dose from Entire Inventory
Vault disposal									12,000[b]
Group 1 stored	0.0	–	0.0	7.2	0.026	0.0	400	370	
Group 1 projected	2.8	400	–	0.22	0.065	0.0	110	9,700	
Group 2 projected	1.3	0.0	71	210	–	–	230	440	

[a] These annual doses are associated with the use of contaminated groundwater by a hypothetical resident farmer located 100 m (330 ft) from the edge of the vault disposal facility. All values are given to two significant figures, and a dash means there is no inventory for that waste type. The values given in this table represent the annual doses to the hypothetical resident farmer at the time of peak annual dose from the entire GTCC LLRW and GTCC-like waste inventory. These contributions do not represent the maximum doses that could result from each of these waste types separately. Because of the different radionuclide mixes and activities contained in the different waste types, the maximum doses that could result from each waste type individually generally occur at different times than the peak annual dose from the entire inventory. The peak annual doses that could result from each of the waste types are presented in Tables E-22 through E-25 in Appendix E. Region I is composed of the Northeastern states (see Figure 1.4-2).

[b] The time for the peak annual dose of 12,000 mrem/yr for disposal of the entire GTCC LLRW and GTCC-like waste inventory was calculated to be about 49 years after failure of the cover and engineered barriers (which is assumed to begin 500 years after closure of the disposal facility). The values reported for the other entries in this table represent the annual doses from the specific waste types at the time of the peak annual dose (i.e., at 49 years following failure of the cover and engineered barriers). The primary contributor to the dose is GTCC-like Other Waste - RH, and the primary radionuclides causing this dose are C-14, I-129, and uranium and plutonium isotopes.

TABLE 12.3-2 Estimated Peak Annual LCF Risk from the Use of Contaminated Groundwater within 10,000 Years of Disposal in a Commercial Vault Disposal Facility in Region I[a]

	GTCC LLRW				GTCC-Like Waste				
Disposal Technology/Waste Group	Activated Metals - RH	Sealed Sources - CH	Other Waste - CH	Other Waste - RH	Activated Metals - RH	Sealed Sources - CH	Other Waste - CH	Other Waste - RH	Peak Annual LCF Risk from Entire Inventory
Vault disposal									7E-03[b]
Group 1 stored	0E+00	–	0E+00	4E-06	2E-08	0E+00	2E-04	2E-04	
Group 1 projected	2E-06	2E-04	–	1E-07	4E-08	0E+00	7E-05	6E-03	
Group 2 projected	8E-07	0E+00	4E-05	1E-04	–	–	1E-04	3E-04	

[a] These annual LCF risks are associated with the use of contaminated groundwater by a hypothetical resident farmer located 100 m (330 ft) from the edge of the vault disposal facility. All values are given to one significant figure, and a dash means there is no inventory for that waste type. The values given in this table represent the annual LCF risks to the hypothetical resident farmer at the time of peak annual LCF risk from the entire GTCC LLRW and GTCC-like waste inventory. These contributions do not represent the maximum LCF risks that could result from each of these waste types separately. Because of the different radionuclide mixes and activities contained in the different waste types, the maximum LCF risks that could result from each waste type individually generally occur at different times than the peak annual LCF risk from the entire inventory. Region I is composed of the Northeastern states (see Figure 1.4-2).

[b] The time for the peak annual LCF risk of 7E-03 for disposal of the entire GTCC LLRW and GTCC-like waste inventory was calculated to be about 49 years after failure of the cover and engineered barriers (which is assumed to begin 500 years after closure of the disposal facility). The values reported for the other entries in this table represent the annual LCF risks from the specific waste types at the time of the peak annual LCF risk (i.e., at 49 years following failure of the cover and engineered barriers). The primary contributor to the LCF risk is GTCC-like Other Waste - RH, and the primary radionuclides causing this risk are C-14, I-129, and uranium and plutonium isotopes.

TABLE 12.3-3 Estimated Peak Annual Dose (in mrem/yr) from the Use of Contaminated Groundwater within 10,000 Years of Disposal in a Commercial Vault or Trench Disposal Facility in Region II[a]

	GTCC LLRW				GTCC-Like Waste				
Disposal Technology/Waste Group	Activated Metals - RH	Sealed Sources - CH	Other Waste - CH	Other Waste - RH	Activated Metals - RH	Sealed Sources - CH	Other Waste - CH	Other Waste - RH	Peak Annual Dose from Entire Inventory
Vault disposal									1,200[b]
Group 1 stored	0.86	–	0.0	0.0	0.12	0.0	11	940	
Group 1 projected	13	0.0	–	0.0	0.29	0.0	3.1	0.0	
Group 2 projected	6.2	0.0	5.3	210	–	–	6.2	13	
Trench disposal									1,200[b]
Group 1 stored	1.1	–	0.0	0.0	0.15	0.0	14	950	
Group 1 projected	17	0.0	–	0.0	0.38	0.0	0.39	0.0	
Group 2 projected	8.1	0.0	6.6	210	–	–	7.8	12	

[a] These annual doses are associated with the use of contaminated groundwater by a hypothetical resident farmer located 100 m (330 ft) from the edge of the disposal facility. All values are given to two significant figures, and a dash means there is no inventory for that waste type. The values given in this table represent the annual doses to the hypothetical resident farmer at the time of peak annual dose from the entire GTCC LLRW and GTCC-like waste inventory. These contributions do not represent the maximum doses that could result from each of these waste types separately. Because of the different radionuclide mixes and activities contained in the different waste types, the maximum doses that could result from each waste type individually generally occur at different times than the peak annual dose from the entire inventory. The peak annual doses that could result from each of the waste types are presented in Tables E-22 through E-25 in Appendix E. Region II is composed of the Southeastern states (see Figure 1.4-2).

[b] The times for the peak annual doses of 1,200 mrem/yr for disposal of the entire GTCC LLRW and GTCC-like waste inventory using the vault and trench methods were calculated to be about 100 and 34 years, respectively, after failure of the cover and engineered barriers (which is assumed to begin 500 years after closure of the disposal facility). The values reported from the other entries in this table represent the annual doses for the specific waste types at the time of the peak annual dose (i.e., at 100 and 34 years following failure of the cover and engineered barriers for the vault and trench methods, respectively). For both cases, the primary contributor to the dose is GTCC-like Other Waste - RH, and the primary radionuclides causing this dose are C-14 and I-129.

TABLE 12.3-4 Estimated Peak Annual LCF Risk from the Use of Contaminated Groundwater within 10,000 Years of Disposal in a Commercial Vault or Trench Disposal Facility in Region II[a]

	GTCC LLRW				GTCC-Like Waste				Peak Annual LCF Risk from Entire Inventory
Disposal Technology/Waste Group	Activated Metals - RH	Sealed Sources - CH	Other Waste - CH	Other Waste - RH	Activated Metals - RH	Sealed Sources - CH	Other Waste - CH	Other Waste - RH	
Vault disposal									7E–04[b]
Group 1 stored	5E-07	–	0E+00	0E+00	7E-08	0E+00	7E-06	6E–04	
Group 1 projected	8E-06	0E+00	–	0E+00	2E-07	0E+00	2E-06	0E+00	
Group 2 projected	4E-06	0E+00	3E-06	1E-04	–	–	4E-06	8E–06	
Trench disposal									7E–04[b]
Group 1 stored	7E-07	–	0E+00	0E+00	9E-08	0E+00	8E-06	6E–04	
Group 1 projected	1E-05	0E+00	–	0E+00	2E-07	0E+00	2E-07	0E+00	
Group 2 projected	5E-06	0E+00	4E-06	1E-04	–	–	5E-06	7E-06	

[a] These annual LCF risks are associated with the use of contaminated groundwater by a hypothetical resident farmer located 100 m (330 ft) from the edge of the vault disposal facility. All values are given to one significant figure, and a dash means there is no inventory for that waste type. The values given in this table represent the annual LCF risks to the hypothetical resident farmer at the time of peak annual LCF risk from the entire GTCC LLRW and GTCC-like waste inventory. These contributions do not represent the maximum LCF risks that could result from each of these waste types separately. Because of the different radionuclide mixes and activities contained in the different waste types, the maximum LCF risks that could result from each waste type individually generally occur at different times than the peak annual LCF risk from the entire inventory. Region II is composed of the Southeastern states (see Figure 1.4-2).

[b] The time for the peak annual LCF risk of 7E-04 for disposal of the entire GTCC LLRW and GTCC-like waste inventory was calculated to be about 100 and 34 years, respectively, after failure of the cover and engineered barriers (which is assumed to begin 500 years after closure of the disposal facility). The values reported for the other entries in this table represent the annual LCF risks from the specific waste types at the time of the peak annual LCF risk (i.e., at 100 and 34 years following failure of the cover and engineered barriers for the vault and trench methods, respectively). The primary contributor to the LCF risk is GTCC-like Other Waste - RH, and the primary radionuclides causing this risk are C-14 and I-129.

TABLE 12.3-5 Estimated Peak Annual Dose (in mrem/yr) from the Use of Contaminated Groundwater within 10,000 Years of Disposal in a Commercial Vault Disposal Facility in Region III[a]

	GTCC LLRW				GTCC-Like Waste				
Disposal Technology/Waste Group	Activated Metals - RH	Sealed Sources - CH	Other Waste - CH	Other Waste - RH	Activated Metals - RH	Sealed Sources - CH	Other Waste - CH	Other Waste - RH	Peak Annual Dose from Entire Inventory
Vault disposal									530[b]
Group 1 stored	11	–	0.0	0.0	0.16	0.0	4.7	410	
Group 1 projected	18	0.0	–	0.0	0.39	0.0	1.4	0.017	
Group 2 projected	7.8	0.0	2.1	83	–	–	2.5	5.2	

[a] These annual doses are associated with the use of contaminated groundwater by a hypothetical resident farmer located 100 m (330 ft) from the edge of the vault disposal facility. All values are given to two significant figures, and a dash means there is no inventory for that waste type. The values given in this table represent the annual doses to the hypothetical resident farmer at the time of peak annual dose from the entire GTCC LLRW and GTCC-like waste inventory. These contributions do not represent the maximum doses that could result from each of these waste types separately. Because of the different radionuclide mixes and activities contained in the different waste types, the maximum doses that could result from each waste type individually generally occur at different times than the peak annual dose from the entire inventory. The peak annual doses that could result from each of the waste types are presented in Tables E-22 through E-25 in Appendix E. Region III is composed of the Midwestern states (see Figure 1.4-2).

[b] The time for the peak annual dose of 530 mrem/yr for disposal of the entire GTCC LLRW and GTCC-like waste inventory was calculated to be about 69 years after failure of the cover and engineered barriers (which is assumed to begin 500 years after closure of the disposal facility). The values reported for the other entries in this table represent the annual doses from the specific waste types at the time of the peak annual dose (i.e., at 69 years following failure of the cover and engineered barriers). The primary contributor to the dose is GTCC-like Other Waste - RH, and the primary radionuclides causing this dose are C-14 and I-129.

TABLE 12.3-6 Estimated Peak Annual LCF Risk from the Use of Contaminated Groundwater within 10,000 Years of Disposal in a Commercial Vault Disposal Facility in Region III[a]

	GTCC LLRW				GTCC-Like Waste				
Disposal Technology/Waste Group	Activated Metals - RH	Sealed Sources - CH	Other Waste - CH	Other Waste - RH	Activated Metals - RH	Sealed Sources - CH	Other Waste - CH	Other Waste - RH	Peak Annual LCF Risk from Entire Inventory
Vault disposal									3E-04[b]
Group 1 stored	7E-07	–	0E+00	0E+00	9E-08	0E+00	3E-06	2E-04	
Group 1 projected	1E-05	0E+00	–	0E+00	2E-07	0E+00	8E-07	1E-08	
Group 2 projected	5E-06	0E+00	1E-06	5E-05	–	–	2E-06	3E-06	

[a] These annual LCF risks are associated with the use of contaminated groundwater by a hypothetical resident farmer located 100 m (330 ft) from the edge of the vault disposal facility. All values are given to one significant figure, and a dash means there is no inventory for that waste type. The values given in this table represent the annual LCF risks to the hypothetical resident farmer at the time of peak annual LCF risk from the entire GTCC LLRW and GTCC-like waste inventory. These contributions do not represent the maximum LCF risks that could result from each of these waste types separately. Because of the different radionuclide mixes and activities contained in the different waste types, the maximum LCF risks that could result from each waste type individually generally occur at different times than the peak annual LCF risk from the entire inventory. Region III is composed of the Midwestern states (see Figure 1.4-2).

[b] The time for the peak annual LCF risk of 3E-04 for disposal of the entire GTCC LLRW and GTCC-like waste inventory was calculated to be about 69 years after failure of the cover and engineered barriers (which is assumed to begin 500 years after closure of the disposal facility). The values reported for the other entries in this table represent the annual LCF risks from the specific waste types at the time of the peak annual LCF risk (i.e., at 69 years following failure of the cover and engineered barriers). The primary contributor to the LCF risk is GTCC-like Other Waste - RH, and the primary radionuclides causing this risk are C-14 and I-129.

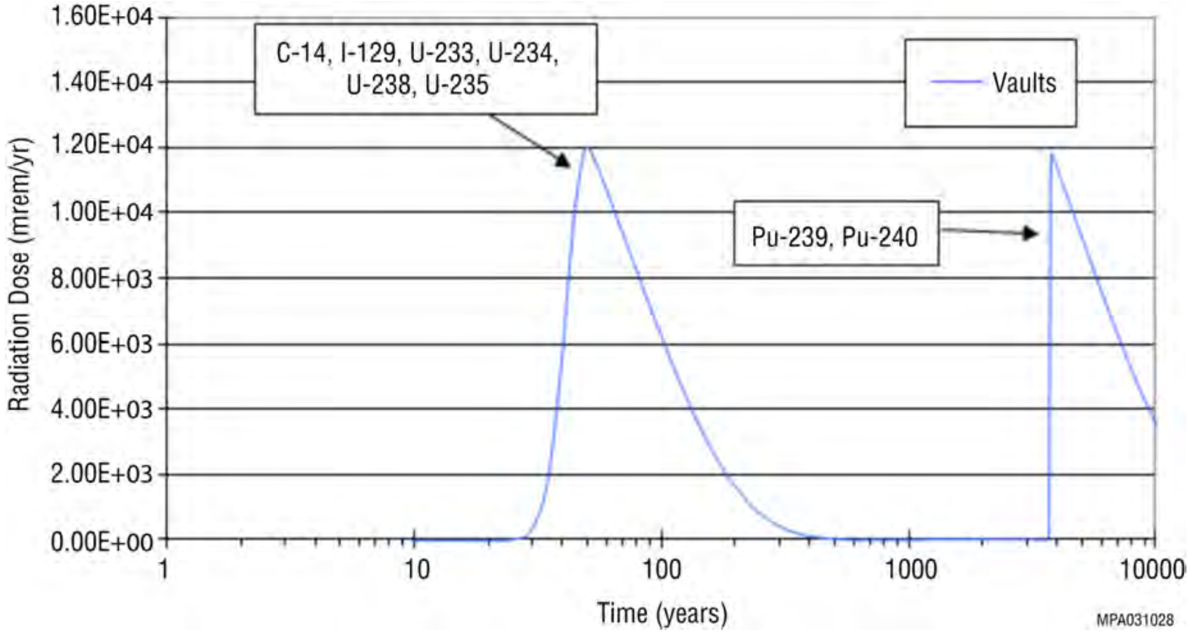

FIGURE 12.3-1 Temporal Plot of Radiation Doses Associated with the Use of Contaminated Groundwater within 10,000 Years of Disposal in a Commercial Vault Disposal Facility in Region I

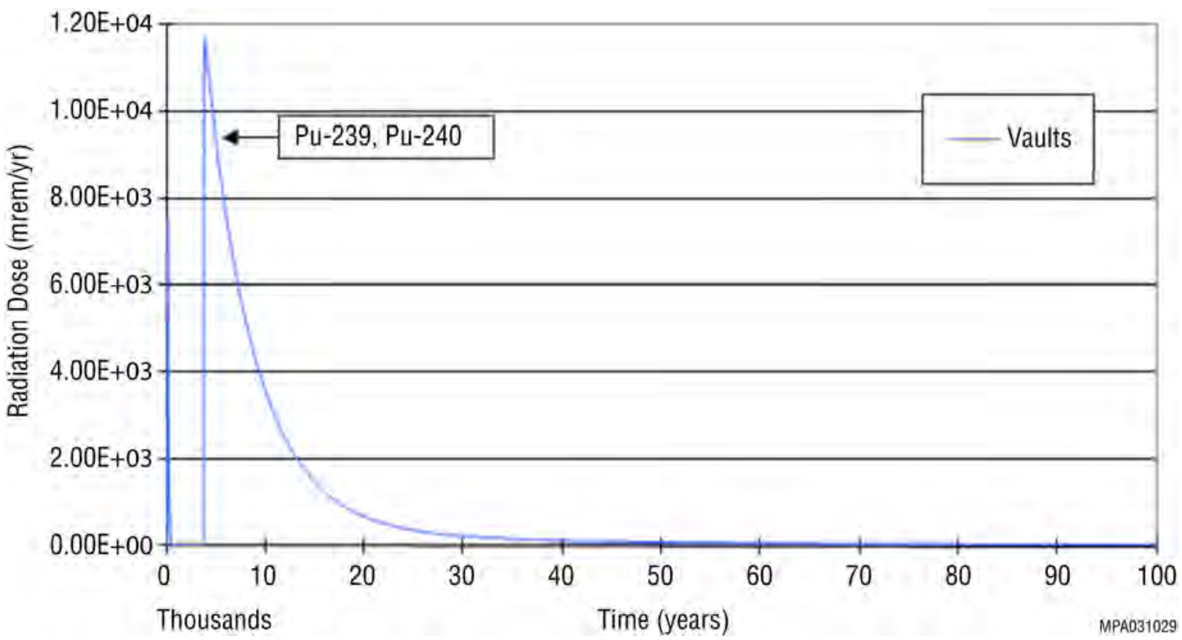

FIGURE 12.3-2 Temporal Plot of Radiation Doses Associated with the Use of Contaminated Groundwater within 100,000 Years of Disposal in a Commercial Vault Disposal Facility in Region I

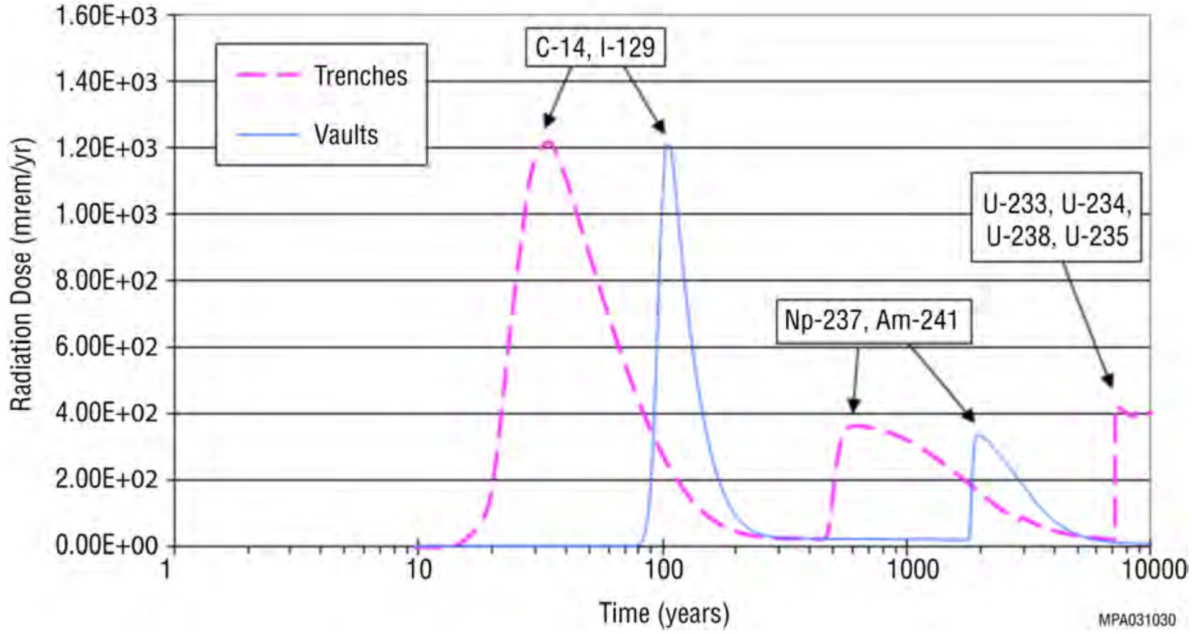

FIGURE 12.3-3 Temporal Plot of Radiation Doses Associated with the Use of Contaminated Groundwater within 10,000 Years of Disposal in a Commercial Vault or Trench Disposal Facility in Region II

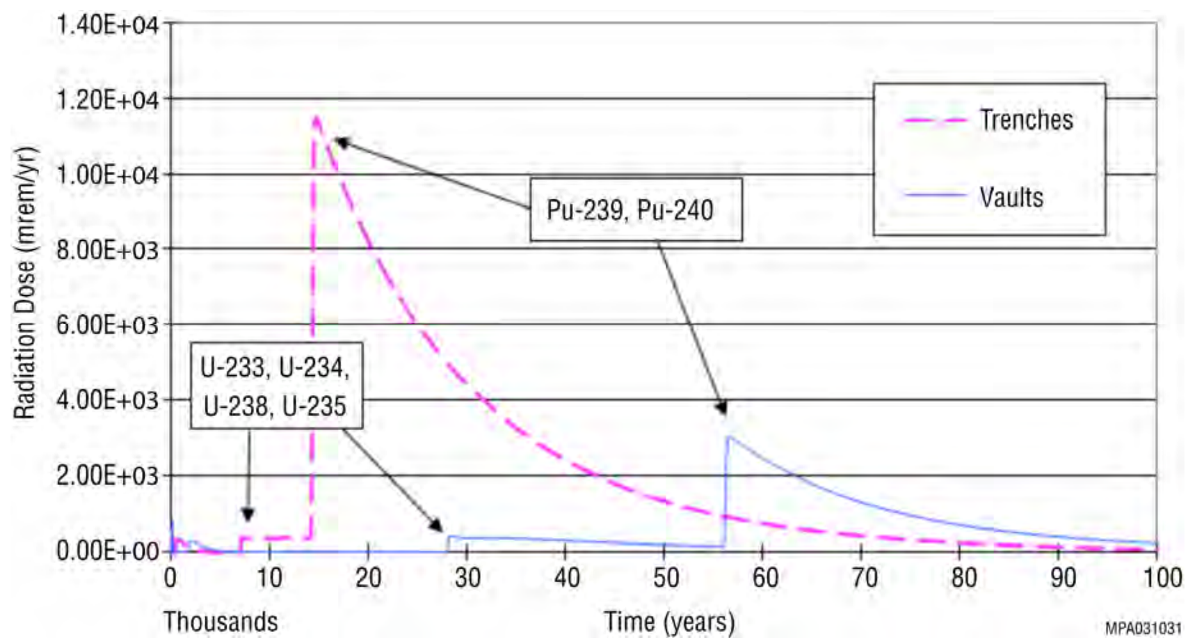

FIGURE 12.3-4 Temporal Plot of Radiation Doses Associated with the Use of Contaminated Groundwater within 100,000 Years of Disposal in a Commercial Vault or Trench Disposal in Region II

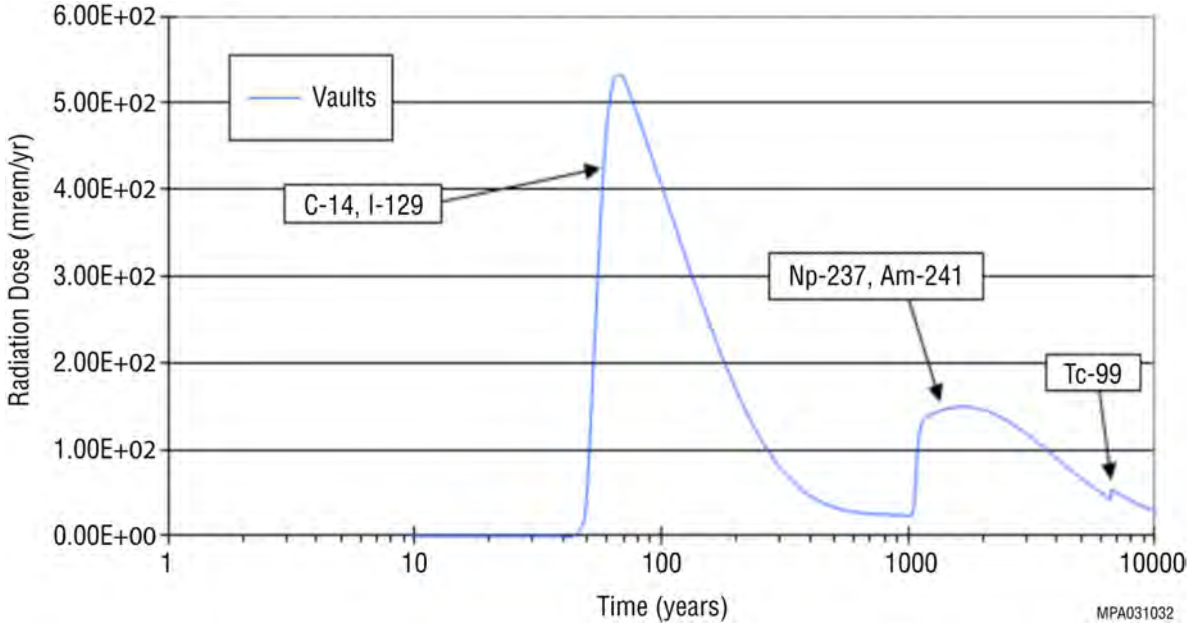

FIGURE 12.3-5 Temporal Plot of Radiation Doses Associated with the Use of Contaminated Groundwater within 10,000 Years of Disposal in a Commercial Vault Disposal Facility in Region III

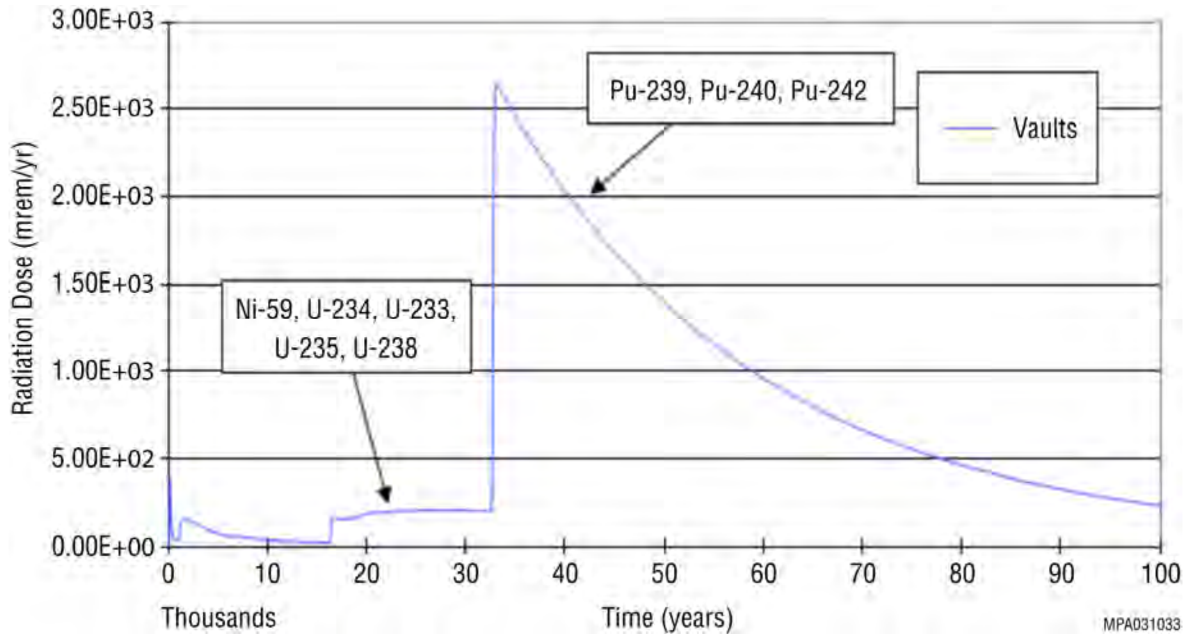

FIGURE 12.3-6 Temporal Plot of Radiation Doses Associated with the Use of Contaminated Groundwater within 100,000 Years of Disposal in a Commercial Vault Disposal Facility in Region III

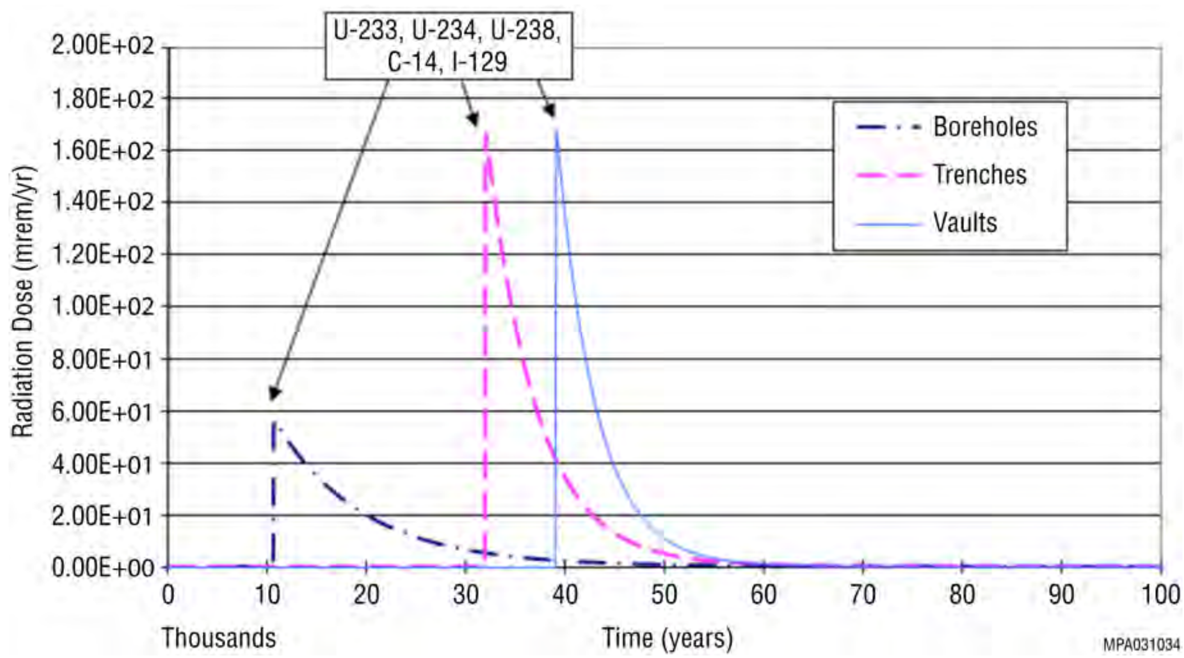

FIGURE 12.3-7 Temporal Plot of Radiation Doses Associated with the Use of Contaminated Groundwater within 100,000 Years of Disposal in a Commercial Borehole, Trench, or Vault Disposal Facility in Region IV

comparing the performance of each site and land disposal method if the entire GTCC LLRW and GTCC-like waste inventory was going to be disposed of at one site by using one method. The second set could be used as the basis for comparing the performance of each site and each land disposal method when the disposal of each of the three waste types is being considered.

Figures 12.3-1, 12.3-3, and 12.3-5 are temporal plots of the annual doses associated with the use of contaminated groundwater for a time period that extends to 10,000 years in Regions I, II, and III, respectively. Figures 12.3-2, 12.3-4, 12.3-6, and 12.3-7 show these results for a period that extends to 100,000 years in all four geographic regions. Note that the time scale in the figures illustrating the results to 10,000 years is logarithmic, while it is linear in the figures illustrating the results to 100,000 years. A logarithmic time scale was used in the figures that extend the results to 10,000 years to better show the projected radiation doses to a hypothetical resident farmer shortly after closure of the disposal facility.

The highest estimated annual doses and LCF risks associated with the use of a commercial disposal facility for GTCC LLRW and GTCC-like waste were calculated to occur in Region I. The peak annual dose within 10,000 years from the use of a vault disposal facility in this region was calculated to be 12,000 mrem/yr, and this dose would occur about 49 years after failure of the cover and engineered barriers (which is assumed to begin 500 years after closure of the disposal facility). This dose would be largely due to C-14, I-129, and uranium isotopes (see Figure 12.3-1). A comparable annual dose was calculated to occur at about 3,800 years from plutonium isotopes.

C-14, I-129, and uranium are relatively soluble in water. (All are assumed to have a distribution coefficient [K_d] value of 0 cm^3/g; K_d measures the partitioning of radionuclides to the soil particles relative to the liquid in soil columns.) This solubility could lead to potentially significant groundwater doses to the resident farmer. The exposure pathways considered in this analysis include the ingestion of contaminated groundwater, soil, plants, meat, and milk; external radiation; and the inhalation of radon gas and its short-lived progeny. Except for the ingestion of contaminated groundwater, all pathways result from using the contaminated groundwater for irrigation and feeding livestock. The doses in Region I are the highest of the doses in the four regions, largely because of (1) the more humid environment there, (2) the generally shorter distance to groundwater there than in the other three regions, and (3) the assumed low K_ds for several important radionuclides.

Two disposal methods (vault and trench) are evaluated for Region II. The peak annual dose within 10,000 years from the use of either of these two methods to dispose of the entire GTCC LLRW and GTCC-like waste inventory was calculated to be 1,200 mrem/yr. This dose would occur at about 100 years for the vault method and 34 years for the trench method after failure of the cover and engineered barriers (which is assumed to begin 500 years after closure of the disposal facility). These doses would be largely due to C-14 and I-129 (see Figure 12.3-3). A larger annual dose was calculated to occur after 10,000 years from plutonium isotopes. This dose was calculated to be 12,000 mrem/yr at 15,000 years in the future for trenches, and 3,000 mrem/yr at 57,000 years for vaults (see Figure 12.3-4).

The peak annual doses in Region III from vault disposal of the entire GTCC LLRW and GTCC-like waste inventory are lower than those in Regions I and II. The peak annual dose within 10,000 years was calculated to be 530 mrem/yr, and this dose occurs about 69 years after failure of the cover and engineered barriers (which is assumed to begin 500 years after closure of the disposal facility). This dose would also be largely due to C-14 and I-129 (see Figure 12.3-5). A larger annual dose was calculated to occur in Region III after 10,000 years from plutonium isotopes. This dose was calculated to be 2,600 mrem/yr and to occur about 33,000 years in the future (see Figure 12.3-6).

The peak annual doses are lowest in Region IV. It is predicted that radionuclides would not reach the groundwater table and the well of a hypothetical resident farmer within the first 10,000 years following disposal because of the much lower water infiltration rate assumed for this region than for the other three regions. However, it was calculated that radionuclides would reach the groundwater table after 10,000 years. The peak annual doses were calculated to be 170 mrem/yr for use of vaults and trenches, and 57 mrem/yr for use of boreholes. These peak doses are estimated to occur at about 39,000, 32,000, and 11,000 years in the future for these three disposal methods, respectively. These doses would mainly result from uranium isotopes, C-14, and I-129 (see Figure 12.3-7). These results illustrate that as the distance to the groundwater table increases (from boreholes to trenches to vaults), the length of time it takes for the radionuclides to reach the groundwater table also increases.

As can be seen by these results, the maximum radiation doses are relatively high for all regions except Region IV. This result is expected because the use of an arid site would likely result in lower doses from the groundwater pathway than would the use of a more humid site.

The modeling approach used here is assumed to be conservative; the use of a longer distance to a hypothetical receptor might be more realistic and would be evaluated as part of the NRC or Agreement State licensing process.

The highest radiation doses and LCF risks occur in Region I. A disposal facility in this region is expected to be in a generally humid environment, and the distance to the groundwater table is expected to be relatively short. These properties of a humid site are expected to result in higher radiation doses, higher LCF risks, and doses and risks that would occur at an earlier time than those at more arid sites, such as those expected in Region IV.

The results given here are assumed to be conservative because the location selected for the residential exposure is 100 m (330 ft) from the edge of the disposal facility. Use of a longer distance, which might be more realistic for the sites being evaluated, would significantly lower the estimated doses (i.e., by as much as 70%). A sensitivity analysis performed to determine the effect of a distance longer than 100 m (330 ft) is presented in Appendix E.

These analyses assume that engineering controls would be effective for 500 years following closure of the disposal facility. This means that essentially no infiltrating water would reach the wastes from the top of the disposal units during the first 500 years. It is assumed that after 500 years, the engineered barriers would begin to degrade, allowing infiltrating water to come in contact with the disposed-of wastes. For purposes of analysis in this EIS, it is assumed that the amount of infiltrating water that would contact the wastes would be 20% of the site-specific natural infiltration rate for the area, and that the water infiltration rate around and beneath the disposal facilities would be 100% of the natural rate for the area. This approach is considered to be conservative because the engineered systems (including the disposal facility cover) are expected to last significantly longer than 500 years, even in the absence of active maintenance measures.

It is assumed that the Other Waste would be stabilized with grout or other material and that this stabilizing agent would be effective for 500 years. Consistent with the assumptions used for engineering controls, no credit was taken for the effectiveness of this stabilizing agent after 500 years in this analysis. That is, it is assumed that any water that would contact the wastes after 500 years would be able to leach radioactive constituents from the disposed-of materials. These radionuclides could then move with the percolating groundwater to the underlying groundwater system. This assumption is considered to be conservative because grout or other stabilizing materials could retain their integrity for longer than 500 years.

Sensitivity analyses performed relative to these assumptions indicate that if a higher infiltration rate to the top of the disposal facilities was assumed, the doses would increase in a linear manner from those presented. Conversely, they would decrease in a linear manner with lower infiltration rates. This finding indicates the need to ensure a good cover over the closed disposal units. Also, the doses would be lower if the grout was assumed to last for a longer time. Because of the long-lived nature of the radionuclides associated with the GTCC LLRW and GTCC-like waste, any stabilization effort (such as grouting) would have to be effective for longer than 5,000 years in order to substantially reduce doses that could result from potential future leaching of the disposed-of waste.

The radiation doses presented in the post-closure assessment in this EIS are intended to be used for comparing the performance of each land disposal method at each site evaluated. The results indicate that the use of robust engineering designs and redundant measures in the disposal facility could delay the potential release of radionuclides and could reduce the release to very low levels, thereby minimizing potential groundwater contamination and associated human health impacts in the future. DOE has considered the potential doses to the hypothetical farmer as well as other factors discussed in Section 2.9 in identifying the preferred alternative presented in Section 2.10.

12.4 REFERENCES FOR CHAPTER 12

NRC (U.S. Nuclear Regulatory Commission), 1981, *Draft Environmental Impact Statement on 10 CFR Part 61 "Licensing Requirements for Land Disposal of Radioactive Waste,"* NUREG-0782, Vol. 4, Appendices G–Q.

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Toblin, A.L., 1998, *Near Field Groundwater Transport and Gardener Dose Consequence*, Tetra Tech NUS, Gaithersburg, Md.

Toblin, A.L., 1999, *Radionuclide Transport and Dose Commitment from Drinking Water from Continued Storage and Degradation of Spent Nuclear Fuel and High Level Waste Materials under Loss of Institutional Control*, Tetra Tech NUS, Gaithersburg, Md.

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13 APPLICABLE LAWS, REGULATIONS, AND OTHER REQUIREMENTS

This chapter presents the laws, regulations, and other requirements that could impact implementation of the GTCC LLRW and GTCC-like waste disposal alternatives and the No Action Alternative described in this EIS. Federal environmental, cultural, and health and safety laws and regulations are summarized in Section 13.3; Executive Orders in Section 13.4; DOE Orders in Section 13.5; and state environmental laws, regulations, and agreements in Section 13.6. Radioactive material packaging and transportation laws and regulations are discussed in Section 13.7. Consultations with federal, state, and local agencies and federally recognized American Indian Nations are discussed in Section 13.8.

13.1 INTRODUCTION

The NOI announcing the preparation of this EIS states that DOE, in the EIS, will describe the statutory and regulatory requirements for the disposal alternatives and whether legislation or regulatory modifications may be needed for their implementation. This chapter identifies and summarizes the major federal and state laws and environmental requirements that could impact the implementation of the No Action Alternative and the alternatives for disposing of GTCC LLRW and GTCC-like wastes as described in the EIS and the NOI, and it describes some of the statutory or regulatory modifications that may be necessary to implement the disposal alternatives.

A number of federal environmental laws affect environmental protection, health, safety, compliance, and consultation at every location discussed in this EIS. In addition, certain environmental requirements have been delegated to state authorities for enforcement and implementation. Furthermore, state legislatures have adopted laws to protect health and safety and the environment. It is DOE policy to conduct its operations in a manner that ensures the protection of public health, safety, and the environment through compliance with all applicable federal and state laws, regulations, orders, and other requirements.

The various disposal alternatives analyzed in this EIS involve either the operation of an existing DOE facility or the construction and operation of new DOE or commercial facilities, and the transportation of materials. Actions required to comply with statutes, regulations, and other federal and state requirements may depend on whether a facility is newly built or is incorporated in whole or in part into an existing facility and whether a facility is owned and operated by DOE or by a commercial entity. Requirements vary among alternatives and states. The disposal sites considered in this EIS are located in the following states: Idaho (the INL Site), Nevada (NNSS), New Mexico (LANL, WIPP, and WIPP Vicinity), South Carolina (SRS), and Washington (the Hanford Site). Disposal could also occur on land withdrawn for the WIPP, land in the public domain, or privately held land not yet identified.

13.2 BACKGROUND

Requirements governing the management of radioactive waste arise primarily from the following sources: Congress, federal agencies, Executive Orders, legislatures of the affected states, and state agencies. In general, federal statutes establish national policies, create broad legal requirements, and authorize federal agencies to create regulations that conform to the statutes. Detailed implementation of these statutes is delegated to various federal agencies such as DOE, the U.S. Department of Transportation (DOT), and the EPA. For many environmental laws under EPA jurisdiction, state agencies may be delegated responsibility for the majority of program implementation activities, such as permitting and enforcement, but the EPA usually retains oversight of the delegated program.

Some applicable laws, such as NEPA, ESA, and the Emergency Planning and Community Right-to-Know Act, require specific reports and/or consultations rather than permits. Other applicable laws, such as CERCLA and the Federal Insecticide, Fungicide, and Rodenticide Act, establish general requirements that must be satisfied during site operation and closeout.

Executive Orders establish policies and requirements for federal agencies. They do not have the general applicability of statutes or regulations.

State statutes implement and supplement federal laws for protection of air and water quality and may address solid waste management programs; locally rare or endangered species; and local resource, historic, and cultural values.

Except for generic disposal facilities on nonfederal lands, the sites being considered for the disposal of GTCC LLRW and GTCC-like wastes are located on property controlled by DOE or other agencies of the federal government. DOE has authority to regulate the health and safety aspects of its nuclear facilities operations and certain environmental activities at its sites. The Atomic Energy Act of 1954, as amended, is the principal authority for DOE’s regulatory activities. DOE exercises its regulatory authority primarily through the use of DOE directives and regulations.

13.3 APPLICABLE FEDERAL LAWS AND REGULATIONS

This section describes the federal environmental, cultural, safety, and health laws and several regulations that could apply to the No Action Alternative and the alternatives for disposal of GTCC LLRW and GTCC-like wastes described in the EIS. Section 13.3.1 describes the federal laws that could apply; Section 13.3.2 describes the federal laws and regulations specific to each disposal alternative and whether statutory or regulatory modifications may be necessary to effectuate the alternative. Section 13.3.3 provides descriptions of the federal laws and regulations applicable to the No Action Alternative.

13.3.1 Laws of General Applicability

The laws described in this section are those that could be applicable to the disposal methodologies and sites assessed in this EIS and the No Action Alternative.

American Indian Religious Freedom Act of 1978 (42 USC 1996). The AIRFA reaffirms American Indian religious freedom under the First Amendment and sets U.S. 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 tribal religions.

Antiquities Act of 1906, as amended (16 USC 431 to 433). This Act protects historic and prehistoric ruins, monuments, and antiquities, including paleontological resources, on federally controlled lands from appropriation, excavation, injury, and destruction without permission.

Archaeological and Historic Preservation Act of 1974, as amended (16 USC 469 to 469c). This Act provides for the preservation of historical and archaeological data (including relics and specimens) that might otherwise be irreparably lost or destroyed as the result of federal actions. Under the law, federal agencies must notify the Secretary of Interior whenever they find that a federal project may cause loss or destruction of significant scientific, prehistoric, or archeological data.

Archaeological Resources Protection Act of 1979, as amended (16 USC 470 et seq.). This Act requires a permit for any excavation or removal of archaeological resources from federal or American Indian lands. Excavations must be undertaken for the purpose of furthering archaeological knowledge in the public interest, and resources removed remain the property of the United States.

Atomic Energy Act of 1954, as amended (P.L. 83-703, 42 USC 2011 et seq.). The AEA as amended provides the statutory framework for DOE and NRC regulation of nuclear material and activities, including management of radioactive waste. DOE exercises regulatory authority over activities conducted by DOE or on its behalf. NRC and Agreement States exercise regulatory authority over activities conducted in the commercial sector through licensing regulations. The AEA as amended authorizes DOE to set radiation protection standards for itself and its contractors at DOE nuclear facilities. An extensive system of standards and requirements has been established through DOE regulations and directives to protect health and minimize danger to life and property from activities under DOE's jurisdiction. Requirements for environmental protection, safety, and health are implemented at DOE sites primarily through contractual mechanisms that establish the applicable DOE requirements for management and operating contractors.

Under the respective authorities of the AEA as amended granted to the DOE and the NRC, radioactive waste generated or owned by DOE and disposed of at DOE facilities is not subject to the NRC's classification system for low-level radioactive waste or its definition of GTCC LLRW. Except as specifically provided by law, DOE facilities are not subject to NRC licensing requirements.

Bald and Golden Eagle Protection Act of 1973, as amended (16 USC 668 through 668d). The Bald and Golden Eagle Protection Act, as amended, makes it unlawful to take, pursue, molest, or disturb bald (American) and golden eagles, their nests, or their eggs anywhere in the United States. The U.S. Department of Interior (DOI) regulates activities that might adversely affect bald and golden eagles.

Clean Air Act of 1970, as amended (42 USC 7401 et seq.). The CAA 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 Act requires that each federal agency with jurisdiction over any property or facility engaged in any activity 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.

Section 109 directs the EPA to set NAAQS for criteria pollutants. These standards were established for PM, SO_2, CO, O_3, NO_2, and lead. Section 111 of the CAA requires the establishment of national standards of performance for new or modified stationary sources of atmospheric pollutants, and Section 160 requires that specific emission increases be evaluated prior to permit approval to prevent significant deterioration of air quality. Specific standards for releases of hazardous air pollutants (including radionuclides) are required per Section 112. Radionuclide emissions from DOE facilities are regulated under the NESHAP Program under 40 CFR Part 61.

Clean Water Act of 1972, as amended (33 USC 1251 et seq.). The CWA provides water quality standards for the nation's waterways, guidelines and limitations for effluent discharges from point-source discharges, and the NPDES permit program that is administered by the EPA. Sections 401 through 405 of the Water Quality Act of 1987 added Section 402(p) to the CWA, which requires the EPA to establish regulations for permits for stormwater discharges associated with industrial activities. Section 404 of the CWA requires permits for the discharge of dredge or fill materials into navigable waters.

Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (42 USC 9604; also known as Superfund). The CERCLA provides authority for federal and state governments to respond directly to hazardous substance incidents. The Act requires reporting of spills, including radioactive spills, to the National Response Center.

Endangered Species Act of 1973, as amended (16 USC 1531 et seq.). The ESA provides a program for the conservation of threatened and endangered species and the ecosystems on which those species rely. The Act is intended to prevent the further decline of endangered and threatened species and to restore those species and their critical habitats. Section 7 requires federal agencies to ensure that any action authorized, funded, or carried out by them is not likely to jeopardize the continued existence of listed species or modify their critical habitat.

Emergency Planning and Community Right-to-Know Act of 1986 (USC 11001 et seq.; also known as SARA Title III). This Act requires emergency planning and notice to communities and government agencies concerning the presence and release of specific chemicals. Under Subtitle A of the Act, federal facilities are required to provide 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.

Energy Policy Act of 2005 (P.L. 109-58). This Act requires DOE to prepare a report on the cost and schedule to complete an EIS and ROD for permanent disposal of GTCC. It also requires DOE to, prior to making a final decision on the disposal alternative or alternatives to be implemented, submit to Congress a report that describes all disposal alternatives under consideration and includes all information required in a 1987 DOE report to Congress related to the safe disposal of GTCC. The Act further requires that DOE await action by Congress before making a final decision on the disposal alternative or alternatives to be implemented.

Federal Insecticide, Fungicide, and Rodenticide Act of 1947, as amended (7 USC 136 et seq.). This Act regulates the use, registration, and disposal of several classes of pesticides to ensure that they are applied in a manner that protects the public, workers, and the environment. Implementing regulations include recommended procedures for the disposal and storage of pesticides and worker protection standards.

Fish and Wildlife Coordination Act of 1934, as amended (16 USC 661 et seq.). The Fish and Wildlife Coordination Act promotes effective planning and cooperation among federal, state, public, and private agencies for the conservation and rehabilitation of the nation's fish and wildlife. The Act requires consultation with the USFWS and state authorities whenever a federal action involves impounding, diverting, channel deepening, or otherwise controlling or modifying the waters of any stream or other body of water.

Low-Level Radioactive Waste Policy Amendments Act of 1985 (P.L. 99-240, 42 USC 2021 et seq.). The LLRWPAA provides in section 3(b)(1)(D) that the federal government is responsible for the disposal of LLRW with concentrations of radionuclides that exceed the NRC-established limits for Class C radioactive waste (i.e., greater-than-Class C or GTCC LLRW). The Act specifies that GTCC LLRW designated a federal responsibility under section 3(b)(1)(D) that results from activities licensed by the NRC is to be disposed of in an NRC-licensed facility that has been determined to be adequate to protect public health and safety. However, unless specifically provided by law, NRC does not have authority to license and regulate facilities operated by or on behalf of DOE. Further, the LLRWPAA does not limit DOE to using only non-DOE facilities for GTCC LLRW disposal. Accordingly, if DOE selects a facility operated by or on behalf of DOE for disposal of GTCC LLRW for which it is responsible under section 3(b)(1)(D), clarification from Congress would be needed to address NRC's role in licensing such a facility and related issues. In addition, clarification from Congress may be needed on NRC's role if DOE selects a commercial GTCC LLRW disposal facility licensed by an Agreement State, rather than by NRC.

Migratory Bird Treaty Act of 1918, as amended (16 USC 703 et seq.). This Act, as amended, is intended to protect birds that have common migration patterns between the United States and Canada, Mexico, Japan, and Russia. The Act stipulates that it is unlawful at any time, by any means, or in any manner to "kill any migratory bird unless and except as permitted by regulation."

National Environmental Policy Act of 1969, as amended (42 USC 4321 et seq.). The NEPA establishes a national policy promoting awareness of the consequences of human activity on the environment and consideration of environmental impacts during the planning and decision-making stages of a project. It requires federal agencies to prepare an EIS for "major Federal actions significantly affecting the quality of the human environment."

National Historic Preservation Act of 1966, as amended (16 USC 470 et seq.). The NHPA provides that sites with significant national historic value be placed on the NRHP, maintained by the Secretary of the Interior. Section 106 of the Act requires a federal agency to determine whether its proposed undertaking is the type of activity that could affect historic properties. If so, the agency must consult with the appropriate SHPO or Tribal Historic Preservation Officer. If an adverse effect is found, the consultation often ends with the execution of an MOA that indicates how the adverse effect will be resolved.

Native American Graves Protection and Repatriation Act of 1990 (25 USC 3001). The NAGPRA establishes a means for American Indians to request the return or repatriation of human remains and other cultural items presently held by federal agencies or federally assisted museums or institutions. The Act also contains provisions regarding the intentional excavation and removal of, inadvertent discovery of, and illegal trafficking in American Indian human remains and cultural items. The law requires the establishment of a review committee with monitoring and policymaking responsibilities, the development of regulations for repatriation, and the development of procedures to handle unexpected discoveries of graves or grave goods during activities on federal or tribal lands. All federal agencies that manage land and/or are responsible for archaeological collections obtained from their lands or generated by their activities must comply with the Act.

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 jeopardizing health and welfare.

Paleontological Resources Preservation Act of 2009 (16 USC 470aaa et seq.). This Act promotes the preservation and use of paleontological resources on federal lands by prohibiting the following: (1) taking or damaging paleontological resources located on federal lands without a permit or permission, (2) selling or purchasing such resources received from federal lands, and (3) submitting false records or identification for such resources removed from federal lands.

Pollution Prevention Act of 1990 (42 USC 13101 et seq.). This Act establishes a national policy for waste management and pollution control. Source reduction is given first preference, followed by environmentally safe recycling, then by treatment, and finally by disposal.

Resource Conservation and Recovery Act of 1976, as amended (42 USC 6901 et seq.). Under the RCRA, which amended the Solid Waste Disposal Act of 1965, the EPA defines and identifies hazardous waste; establishes standards for its transportation, treatment, storage, and disposal; and requires permits for persons engaged in hazardous waste activities. Section 3006 of RCRA allows states to establish and administer these permit programs with EPA approval. The Federal Facility Compliance Act of 1992 (42 USC 6961 et seq.) amended RCRA to require that all federal agencies having jurisdiction over a solid waste facility or disposal site, or engaged in the management of solid or hazardous waste, are subject to all applicable federal, state, and local laws, regulations, and ordinances addressing solid and hazardous waste.

Safe Drinking Water Act of 1974, as amended (42 USC 300(f) et seq.). The primary objective of the Safe Drinking Water Act (SDWA) is to protect the quality of public drinking water supplies and sources of drinking water. The implementing regulations, administered by the EPA unless delegated to states, establish standards applicable to public water systems. These regulations include maximum contaminant levels (including those for radioactivity) in public water systems that have at least 15 service connections used by year-round residents or that regularly serve at least 25 year-round residents.

Toxic Substances Control Act of 1976 (15 USC 2601 et seq.). The TSCA provides the EPA with the authority to require testing of chemical substances entering the environment and to regulate them as necessary. The law complements and expands existing toxic substance laws such as Section 112 of the CAA and Section 307 of the CWA. TSCA requires compliance with inventory reporting and chemical control provisions of the legislation to protect the public from the risks of exposure to chemicals.

13.3.2 Statutes and Regulations Specific to the Disposal Alternatives

This section describes the major statutes and regulations that impact implementation of the geologic and nongeologic disposal alternatives considered in this EIS. It also describes statutory or regulatory modifications that might be necessary for GTCC LLRW and GTCC-like waste disposal to occur.

13.3.2.1 Geologic Disposal

The statute that governs disposal at the Waste Isolation Pilot Plant is the WIPP Land Withdrawal Act as amended.

Waste Isolation Pilot Plant Land Withdrawal Act as amended (P.L. 102-579 as amended by P.L. 104-201). The WIPP LWA as amended withdrew land from the public domain for the purpose of creating and operating WIPP, the geologic repository in New Mexico designated as the national disposal site for TRU waste generated by atomic energy defense activities. The WIPP LWA as amended defines the characteristics and amount of waste that will be disposed of at the facility and stipulates that TRU waste must be transported to WIPP in NRC-certified shipping containers. The WIPP LWA as amended exempts waste to be disposed at WIPP from the RCRA land disposal restrictions.

The WIPP LWA as amended authorizes the EPA to issue regulations regarding the disposal of TRU radioactive waste at WIPP. The EPA exercises this regulatory authority through 40 CFR Part 191, "Environmental Radiation Protection Standards for Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Wastes." WIPP-specific disposal regulations are specified in 40 CFR Part 194, "Criteria for the Certification and Re-Certification of the Waste Isolation Pilot Plant's Compliance with the 40 CFR Part 191 Disposal Regulations."

The WIPP LWA as amended limits the use of WIPP to the disposal of TRU waste generated by atomic energy defense activities. In addition, it established certain limits on the surface dose rate, total volume, total radioactivity (curies), and maximum activity level (curies per liter averaged over the volume of the canister) for waste received at WIPP. The total capacity for disposal of TRU waste established under the WIPP LWA as amended is 175,675 m^3 (6.2 million ft^3). The Consultation and Cooperative Agreement with the State of New Mexico (1981) established a total RH TRU capacity of 7,080 m^3 (250,000 ft^3), with the remaining capacity for CH TRU at 168,500 m^3 (5.95 million ft^3). In addition, the WIPP LWA as amended limits the total radioactivity of RH waste to 5.1 million curies. For comparison, the GTCC LLRW and GTCC-like waste CH volume, RH volume, and RH total radioactivity are approximately 6,650 m^3 (235,000 ft^3), 5,050 m^3 (178,000 ft^3), and 157 million curies, respectively. On the basis of emplaced and anticipated waste volumes, the disposal of all GTCC LLRW and GTCC-like waste at WIPP would exceed the limits for RH volume and RH total activity. The majority of the GTCC LLRW and GTCC-like RH volume is from the Other Waste category (e.g., DOE non-defense-generated TRU), and activated metal waste contributes most of the RH activity. Implementation of the WIPP alternative for disposal of GTCC LLRW and GTCC-like waste would require legislation to authorize disposal of waste other than TRU waste generated by atomic energy defense activities at WIPP and an increase in the disposal capacity limit for RH total curies. It will also be necessary to revise the Consultation and Cooperative Agreement to authorize an increase in the total volume of all RH TRU waste. In addition, a corresponding modification of the facility's RCRA permit with the New Mexico Environment Department, a modification to the Agreement for Consultation and Cooperation between U.S. Department of Energy and the State of New Mexico for the Waste Isolation Pilot Plant (updated April 18, 1988), which sets limits (identified above) on the total volume of RH TRU received at WIPP, and compliance certification with the EPA might be required. RH GTCC LLRW and GTCC-like waste would be packaged in shielded containers and would not exceed the surface dose and curies-per-liter limits for RH waste in the WIPP LWA as amended. The Low-Level Radioactive Waste Policy Amendments Act (LLRWPAA, P.L. 99-240) requires that GTCC LLRW and GTCC-like waste be disposed of in a facility licensed by the NRC. Because the LLRWPAA specifies that GTCC LLRW be disposed of in a facility licensed by the NRC, implementation of the WIPP alternative may also require legislative changes in order for WIPP to be utilized as a disposal facility for GTCC LLRW consistent with the LLRWPAA.

13.3.2.2 Nongeologic Disposal

Statutes applicable to nongeologic disposal of GTCC LLRW and GTCC-like wastes include the Low-Level Radioactive Waste Policy Amendments Act of 1985; Atomic Energy Act of 1954, as amended; Waste Isolation Pilot Plant Land Withdrawal Act as amended; and Federal Land Policy and Management Act.

Low-Level Radioactive Waste Policy Amendments Act of 1985 (P.L. 99-240, 42 USC 2021 et seq.). The LLRWPAA in section 3(b)(1)(D) that the federal government is responsible for the disposal of LLRW with concentrations of radionuclides that exceed the NRC-established limits for Class C radioactive waste (i.e., greater-than-Class C or GTCC LLRW). The Act specifies that GTCC LLRW designated a federal responsibility under section 3(b)(1)(D) that results from activities licensed by the NRC is to be disposed of in an NRC-licensed facility that has been determined to be adequate to protect public health and safety. However, unless specifically provided by law, NRC does not have authority to license and regulate facilities operated by or on behalf of DOE. Further, the LLRWPAA does not limit DOE to using only non-DOE facilities for GTCC LLRW disposal. Accordingly, if DOE selects a facility operated by or on behalf of DOE for disposal of GTCC LLRW for which it is responsible under section

3(b)(1)(D), clarification from Congress would be needed to address NRC's role in licensing such a facility and related issues. In addition, clarification from Congress may be needed on NRC's role if DOE selects a commercial GTCC LLRW disposal facility licensed by an Agreement State, rather than by NRC.

Atomic Energy Act of 1954, as amended (P.L. 83-708, 42 USC 2011 et seq.). The AEA as amended provides the statutory framework for DOE and NRC regulation of nuclear material and activities, including management of radioactive waste. DOE exercises regulatory authority over activities conducted by DOE or on its behalf. NRC and Agreement States exercise regulatory authority over activities conducted in the commercial sector through licensing regulations. The AEA as amended authorizes DOE to set radiation protection standards for itself and its contractors at DOE nuclear facilities. An extensive system of standards and requirements has been established through DOE regulations and directives to protect health and minimize danger to life and property from activities under DOE's jurisdiction. Requirements for environmental protection, safety, and health are implemented at DOE sites primarily through contractual mechanisms that establish the applicable DOE requirements for management and operating contractors.

Waste Isolation Pilot Plant Land Withdrawal Act as amended (P.L. 102-579 as amended by P.L. 104-201). Two locations in the WIPP Vicinity are considered for the disposal of GTCC LLRW and GTCC-like waste in an above-grade vault, near-surface trench, or intermediate-depth borehole: (1) property inside the WIPP LWB and (2) property on BLM-administered land outside and adjacent to the WIPP LWB. Siting a vault, trench, or borehole facility for GTCC LLRW and GTCC-like waste inside the WIPP LWB would be subject to the limits of the WIPP LWA as amended (as discussed for WIPP); therefore, federal legislation to develop such facilities would be required. Siting a vault, trench, or borehole facility on BLM-administered land outside the WIPP LWB would require a land withdrawal in accordance with DOI regulations at 40 CFR 2300, "Land Withdrawals."

Federal Land Policy and Management Act as amended (43 USC 1701 et seq.*).* This Act is applicable to the alternatives to dispose of GTCC LLRW and GTCC-like wastes in a new trench facility or borehole facility on government property in the vicinity of WIPP. Use of that land for a permanent radioactive waste disposal facility would require that it be withdrawn from the public domain, under the FLPMA, as was done for the WIPP land withdrawal.

13.3.2.3 Laws and Regulations Specific to the No Action Alternative

Atomic Energy Act of 1954, as amended (P.L. 83-708, 42 USC 2011 et seq.). The AEA as amended provides the statutory framework for DOE and NRC regulation of nuclear material and activities, including management of radioactive waste. DOE exercises regulatory authority over activities conducted by DOE or on its behalf. NRC and Agreement States exercise regulatory authority over activities conducted in the commercial sector through licensing regulations. The AEA as amended authorizes DOE to set radiation protection standards for itself and its contractors at DOE nuclear facilities. An extensive system of standards and requirements has been established through DOE regulations and directives to protect health and minimize danger to life and property from activities under DOE's jurisdiction. Requirements for environmental protection, safety, and health are implemented at DOE sites primarily through contractual mechanisms that establish the applicable DOE requirements for management and operating contractors.

Under the No Action Alternative, GTCC LLRW from commercial nuclear reactors would continue to be stored on-site at NRC-licensed facilities pursuant to 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities." These licenses are issued for a 40-year term and can be renewed. Alternatively, or in the event that a facility with a Part 50 license is going through decommissioning or has been decommissioned, GTCC LLRW would be stored in an ISFSI licensed in accordance with 10 CFR Part 72, "Licensing Requirements for the Independent Storage of Spent Nuclear Fuel, High-Level Radioactive Waste, and Reactor-Related Greater-Than-Class C Waste." Licenses issued for ISFSIs have a 20-year term and can be renewed. Sealed sources would remain at generator or other licensee sites. Other Waste would continue to be stored and managed at generator or other interim storage sites.

Under the No Action Alternative, GTCC-like wastes would continue to be stored in accordance with DOE's existing authorities and DOE directives.

Low-Level Radioactive Waste Policy Amendments Act of 1985 (P.L. 99-240, 42 USC 2021 et seq.). The LLRWPAA in section 3(b)(1)(D) that the federal government is responsible for the disposal of LLRW with concentrations of radionuclides that exceed the NRC-established limits for Class C radioactive waste (i.e., greater-than-Class C or GTCC LLRW). The Act specifies that GTCC LLRW designated a federal responsibility under section 3(b)(1)(D) that results from activities licensed by the NRC is to be disposed of in an NRC-licensed facility that has been determined to be adequate to protect public health and safety. However, unless specifically provided by law, NRC does not have authority to license and regulate facilities operated by or on behalf of DOE. Further, the LLRWPAA does not limit DOE to using only non-DOE facilities for GTCC LLRW disposal. Accordingly, if DOE selects a facility operated by or on behalf of DOE for disposal of GTCC LLRW for which it is responsible under section 3(b)(1)(D), clarification from Congress would be needed to address NRC's role in licensing such a facility and related issues. In addition, clarification from Congress may be needed on NRC's role if DOE selects a commercial GTCC LLRW disposal facility licensed by an Agreement State, rather than by NRC.

13.4 APPLICABLE EXECUTIVE ORDERS

This section identifies environmental-, health-, and safety-related Executive Orders applicable to the GTCC LLRW and GTCC-like waste disposal alternatives and the No Action Alternative discussed in this EIS.

Executive Order 11514 (Protection and Enhancement of Environmental Quality, March 5, 1970), as amended by Executive Order 11991 (May 24, 1977). This Order requires federal agencies to continually monitor and control their activities in order to (1) protect and enhance the quality of the environment and (2) develop procedures to ensure the fullest practicable provision of timely public information and understanding of the federal plans and programs that might have potential environmental impacts so that the views of interested parties can be obtained. DOE issued regulations at 10 CFR Part 1021 and DOE Order 451.1B to ensure compliance with this Order.

Executive Order 11593 (Protection and Enhancement of the Cultural Environment, May 13, 1971). This Order directs federal agencies to locate, inventory, and nominate qualified properties under their jurisdiction or control to the NRHP. The federal agencies are also to initiate procedures to provide for the maintenance, rehabilitation, or restoration of sites on the NRHP.

Executive Order 11988 (Floodplain Management, May 24, 1977). This Order, implemented by DOE in 10 CFR Part 1022, requires 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, May 24, 1977). This Order directs federal agencies to avoid new construction in wetlands unless there is no practicable alternative and unless the proposed action includes all practicable measures to minimize harm to wetlands that might result from such use. DOE requirements for complying with procedures for reviewing wetlands activity are in 10 CFR Part 1022.

Executive Order 12088 (Federal Compliance with Pollution Control Standards, October 13, 1978, as amended by Executive Order 12580, Superfund Implementation, January 23, 1987). This Order directs federal agencies to comply with applicable administrative and procedural pollution control standards established by, but not limited to, the CAA, Noise Control Act, CWA, SDWA, TSCA, and RCRA.

Executive Order 12656 (Assignment of Emergency Preparedness Responsibilities, November 18, 1988). This Order assigns emergency preparedness responsibilities to federal departments and agencies.

Executive Order 12699 (Seismic Safety of Federal and Federally Assisted or Regulated New Building Construction, January 5, 1990). This Order requires federal agencies to reduce risks to occupants of buildings owned, leased, or purchased by the federal government or buildings constructed with federal assistance and to persons who would be affected by failures of federal buildings in earthquakes; improve the capability of existing federal buildings to function during or after an earthquake; and reduce earthquake losses of public buildings, all in a cost-effective manner. Each federal agency responsible for the design and construction of a federal building shall ensure that the building is designed and constructed in accordance with appropriate seismic design and construction standards.

Executive Order 12898 (Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations, February 11, 1994). This Order requires each federal agency to identify and address any disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority and low-income populations.

Executive Order 13007 (Indian Sacred Sites, May 24, 1996). This Order directs federal agencies that are managing federal lands — to the extent that is practicable, permitted by law, and not clearly inconsistent with essential agency functions — to (1) accommodate access to and ceremonial use of Indian sacred sites by Indian religious practitioners and (2) avoid adversely affecting the physical integrity of such sacred sites.

Executive Order 13045 (Protection of Children from Environmental Health Risks and Safety Risks, April 21, 1997), as amended by Executive Order 13229 (October 9, 2001). This Order requires each federal agency to make it a high priority to identify and assess environmental health risks and safety risks that may disproportionately affect children and to ensure that its policies, programs, activities, and standards address disproportionate risks to children that result from environmental health risks or safety risks.

Executive Order 13112 (Invasive Species, February 3, 1999). This Order requires federal agencies to prevent the introduction of invasive species; to provide for their control; and to minimize their economic, ecological, and human health impacts.

Executive Order 13175 (Consultation and Coordination with Indian Tribal Governments, November 6, 2000). This Order requires federal agencies to consult, to the greatest extent practicable and to the extent permitted by law, with tribal governments prior to taking actions that affect federally recognized tribal governments. Federal agencies must also assess the impact of federal government plans, projects, programs, and activities on tribal trust resources and assure that tribal government rights and concerns are considered during the development of such plans, projects, programs, and activities.

Executive Order 13186 (Responsibilities of Federal Agencies to Protect Migratory Birds, January 10, 2001). This Order requires each federal agency that takes actions that have, or are likely to have, a measurable negative effect on migratory bird populations to develop and implement, by 2003, an MOU with the USFWS that shall promote the conservation of migratory bird populations.

Executive Order 13423 (Strengthening Federal Environmental, Energy, and Transportation Management, January 26, 2007). This Order requires federal agencies to lead by example in advancing the nation's energy security and environmental performance by achieving specific goals in the following areas: energy efficiency, greenhouse gas reduction, renewable energy use, reduction in water consumption, acquisition of environmentally preferable products, reduction in the use of toxic and hazardous chemicals and materials, high-performance and sustainable building, reduction in petroleum use, use of alternative fuel, and electronics management. Federal agencies are also required to maintain cost-effective waste prevention and recycling programs at their facilities.

Executive Order 13514 (Federal Leadership in Environmental, Energy, and Economic Performance, October 5, 2009). This Order builds upon Executive Order 13423 by establishing quantitative goals for water use reduction, waste diversion, and the purchase of environmentally preferable products and services and by requiring that federal agencies develop and achieve agency-specific targets for reducing greenhouse gas emissions.

13.5 APPLICABLE U.S. DEPARTMENT OF ENERGY DIRECTIVES

The AEA authorizes DOE to establish standards to protect health and minimize the dangers to life or property from activities under DOE's jurisdiction. The major DOE directives pertaining to the alternatives in this EIS are described below.

DOE Order 144.1, *American Indian Tribal Government Interactions and Policy* (January 16, 2009). This order communicates departmental, programmatic, and field responsibilities for interacting with American Indian governments; transmits DOE's American Indian and Alaska Native Tribal Government Policy, including its guiding principles; and transmits the framework for implementation of the policy.

DOE Order 151.1C, ***Comprehensive Emergency Management System*** **(November 2, 2005).** This Order establishes policy and assigns and describes roles and responsibilities for the DOE Emergency Management System. The Emergency Management System provides the framework for development, coordination, control, and direction of all emergency planning, preparedness, readiness assurance, response, and recovery actions.

DOE Order 231.1A, ***Environment, Safety, and Health Reporting*** **(August 19, 2003; Change 1, June 3, 2004).** This Order establishes responsibilities and requirements to ensure the timely collection, reporting, analysis, and dissemination of information on environmental, safety, and health issues as required by law or regulations or as needed to ensure that DOE is kept fully informed on a timely basis about events that could adversely affect the health and safety of the public or the workers, the environment, the intended purpose of DOE facilities, or the credibility of DOE.

DOE Order 413.3A, ***Program and Project Management for the Acquisition of Capital Assets*** **(July 28, 2006).** This Order provides project management direction for the acquisition of capital assets that are delivered on schedule, within budget, and fully capable of meeting mission performance standards; safeguards and security standards; and environmental, safety, and health standards.

DOE Order 414.1C, ***Quality Assurance*** **(June 17, 2005).** The Order establishes principles to ensure that products and services meet or exceed customers' expectations and to achieve quality assurance for all work.

DOE Order 420.1B ***Facility Safety*** **(December 22, 2005).** This Order establishes facility safety requirements related to nuclear safety design, criticality safety, fire protection, and the mitigation of hazards related to natural phenomena.

DOE Order 425.1C, ***Startup and Restart of Nuclear Facilities*** **(March 13, 2003).** This Order establishes requirements for the startup of new nuclear facilities and for the restart of existing nuclear facilities that have been shut down. The requirements specify a readiness review process that must demonstrate that it is safe to start (or restart) the subject facility. The facility must be started (or restarted) only after documented independent reviews of readiness have been conducted and after the approvals specified in the Order have been received.

DOE Order 430.1B, ***Real Property Asset Management*** **(September 24, 2003; Change 1, February 8, 2008).** This Order establishes a corporate, holistic, and performance-based approach to real property life-cycle asset management that links real property asset planning, programming, budgeting, and evaluation to program mission projections and performance outcomes. This Order also identifies requirements and establishes reporting mechanisms and responsibilities for real property asset management.

DOE Order 430.2B, *Departmental Energy, Renewable Energy and Transportation Management* (February 27, 2008). The Order implements Executive Order 13423 and provides the goals, requirements, and responsibilities for managing DOE energy use, buildings, and vehicle fleets.

DOE Order 433.1A, *Maintenance Management Program for DOE Nuclear Facilities* (February 13, 2007). This Order defines the safety management program required for the maintenance and reliable performance of structures, systems, and components that are part of the safety basis required at DOE Hazard Category 1, 2, and 3 nuclear facilities.

DOE Order 435.1, *Radioactive Waste Management* (July 9, 1999, Change 1, August 28, 2001, Certified, January 1, 2007). This Order and its associated manual and guidance establish responsibilities and requirements for the management of DOE high-level radioactive waste, TRU waste, LLRW, and the radioactive component of mixed waste. These documents provide detailed radioactive waste management requirements, including those related to waste that is incidental to reprocessing determinations; waste characterization, certification, treatment, storage, and disposal; and radioactive waste facility design and closure.

DOE Order 440.1B, *Worker Protection Program for DOE (Including National Nuclear Security Administration) Federal Employees* (May 17, 2007). This Order establishes the framework for an effective worker protection program that reduces or prevents injuries, illnesses, and accidental losses by providing DOE and NNSA federal employees with safe and healthful workplaces.

DOE Order 450.1A, *Environmental Protection Program* (June 4, 2008). This Order requires implementation of sound stewardship practices that are protective of the air, water, land, and other natural and cultural resources impacted by DOE operations, and by which DOE cost-effectively meets or exceeds compliance with applicable environmental, public health, and resource protection requirements.

DOE Order 451.1B, *National Environmental Policy Act Compliance Program* (October 26, 2000; Change 1, September 28, 2001). This Order establishes internal requirements and responsibilities for implementing NEPA, the CEQ Regulations Implementing the Procedural Provisions of NEPA (40 CFR Parts 1500–1508), and the DOE NEPA Implementing Procedures (10 CFR Part 1021). Establishing these requirements and responsibilities ensures efficient and effective implementation of DOE's NEPA responsibilities through teamwork, controlling the cost and time for the NEPA process, and maintaining quality.

DOE Order 460.1C, *Packaging and Transportation Safety* (May 14, 2010). This Order establishes safety requirements for the proper packaging and transportation of DOE off-site shipments and on-site transfers of radioactive and other hazardous materials and for modal transport.

DOE Order 460.2A, *Departmental Materials Transportation and Packaging Management* (December 22, 2004). This Order requires DOE operations to be conducted in compliance with all applicable international, federal, state, local, and tribal laws, rules, and regulations governing materials transportation that are consistent with federal regulations, unless exemptions or alternatives are approved. This Order also states that it is DOE policy that shipments comply with the DOT regulations at 49 CFR Parts 100 through 185, except those that infringe upon maintenance of classified information.

DOE Order 470.2B, *Independent Oversight and Performance Assurance Program* (October 31, 2002). This Order establishes the Independent Oversight Program that is designed to enhance DOE safeguards and security; cyber security; emergency management; and environment, safety, and health programs by providing DOE and contractor managers, Congress, and other stakeholders with an independent evaluation of the adequacy of DOE policy and the effectiveness of line management performance in these and other critical functions.

DOE Order 470.4A, *Safeguards and Security Program* (May 25, 2007). This Order establishes responsibilities for the DOE Safeguards and Security Program and the managerial framework for implementing DOE policy on integrated safeguards and security management.

DOE Order 5400.5, *Radiation Protection of the Public and the Environment* (February 8, 1990; Change 2, January 7, 1993). This Order establishes standards and requirements for DOE operations for protection of members of the public and the environment against undue risk from radiation. It is DOE policy to implement legally applicable radiation protection standards and to consider and adopt, as appropriate, recommendations by authoritative organizations, such as NCRP and ICRP. It is also DOE policy to adopt and implement standards generally consistent with those of the NRC for DOE facilities and activities not subject to NRC licensing authority.

DOE Order 5480.20A, *Personnel Selection, Qualification, and Training Requirements for DOE Nuclear Facilities* (November 15, 1994; Change 1, July 12, 2001). This Order establishes the selection, qualification, and training requirements for DOE contractor personnel involved in the operation, maintenance, and technical support of DOE nuclear reactors and nonreactor nuclear facilities. DOE objectives under this Order are to ensure the development and implementation of contractor-administered training programs that provide consistent and effective training for personnel at DOE nuclear facilities. The Order contains minimum requirements that must be included in training and qualification programs.

13.6 STATE ENVIRONMENTAL LAWS, REGULATIONS, AND AGREEMENTS

Certain environmental requirements have been delegated to state authorities for implementation and enforcement. It is DOE policy to conduct its operations in an environmentally safe manner that complies with all applicable laws, regulations, and standards, including state laws and regulations. A list of state environmental laws, regulations, and agreements potentially applicable to the GTCC LLRW disposal alternatives and the No Action Alternative discussed in this EIS is provided in Table 13.6-1.

13.7 RADIOACTIVE MATERIAL PACKAGING AND TRANSPORTATION REGULATIONS

DOE has broad authority under the AEA to regulate all aspects of activities involving radioactive materials that are undertaken by DOE or on its behalf, including the transportation of radioactive materials. DOE exercises this authority to regulate certain DOE shipments, such as shipments undertaken by governmental employees or shipments involving special circumstances. In most cases that do not involve national security, DOE utilizes commercial carriers that undertake shipments of DOE material under the same terms and conditions as commercial shipments. These shipments are subject to regulation by DOT and NRC, as appropriate.

DOT and NRC have the primary responsibility for federal regulations governing commercial radioactive material transportation. The Hazardous Materials Transportation Act of 1975, as amended (49 U.S.C. 5105, et seq.), requires DOT to establish regulations for the safe transportation of hazardous materials in commerce (including radioactive materials). Title 49 of the CFR contains DOT standards and requirements for the packaging, transporting, and handling of radioactive materials for all modes of transportation. DOT's Hazardous Materials Regulations, or HMR, on the transportation of hazardous and radioactive materials can be found in 49 CFR Parts 171 through 180. In addition, the requirements for motor carrier transportation can be found in 49 CFR Parts 350 through 399, and the requirements for transportation by rail can be found in 49 CFR Parts 200 through 268. The NRC sets additional design and performance standards for packages that carry materials with higher levels of radioactivity. The NRC regulations pertaining to radioactive materials transportation are found in 10 CFR Part 71. These regulations include detailed requirements for certification testing of packaging designs. This certification testing involves a variety of conditions such as heating, free dropping onto an unyielding surface, immersing in water, dropping the package onto a vertical steel bar, and checking gas tightness.

The transportation casks used to transport radioactive material are subject to numerous inspections and tests. These tests are designed to ensure that cask components are properly assembled and meet applicable safety requirements. Tests and inspections are clearly identified in the Safety Analysis Report for Packaging and/or the Certificate of Compliance for each cask. Casks are loaded and inspected by registered users in compliance with approved quality assurance programs. Operations involving the casks are conducted in compliance with 10 CFR 71.91. Reports of defects or accidental mishandling are submitted to the NRC.

TABLE 13.6-1 State Requirements That Might Apply to GTCC LLRW and GTCC-Like Waste Disposal

Law/Regulation/Agreement	Citation	Requirements
Idaho		
Idaho Environmental Protection and Health Act	*Idaho Code* (IC), Title 39, Health and Safety, Chapter 1, Department of Health and Welfare, Sections 39–105	Provides for development of air pollution control permitting regulations.
Rules for the Control of Air Pollution in Idaho	Idaho Administrative Procedures Act (IDAPA) 58, Department of Environmental Quality, Title 1, Chapter 1 (58.01.01)	Enforces national ambient air quality standards.
Idaho Water Pollution Control Act	IC, Title 39, Chapter 36, Water Quality	Establishes a program to enhance and preserve the quality and value of water resources.
Water Quality Standards and Wastewater Treatment Requirements	IDAPA 58.01.02	Establishes water quality standards and wastewater treatment requirements.
Transportation of Hazardous Waste	IC, Title 18, Crimes and Punishment, Chapter 39, Highways and Bridges, Section 18-3905; IC, Title 49, Motor Vehicles, Chapter 22, Hazardous Materials/Hazardous Waste Transportation Enforcement	Regulates transportation of hazardous materials/hazardous waste on highways.
Idaho Hazardous Waste Management Act	IC, Title 39, Chapter 44, Hazardous Waste Management	Requires permit prior to construction or modification of a hazardous waste disposal facility.
Rules and Standards for Hazardous Waste	IDAPA 58.01.05	Requires permit prior to construction or modification of a hazardous waste disposal facility.
Various Acts Regarding Fish and Game	IC, Title 36, Fish and Game, Chapter 9, Protection of Fish, Chapter 11, Protection of Animals and Birds, and Chapter 24, Species Conservation	Requires consultation with responsible agency.
Endangered Species Act	IC, Title 67, State Government and State Affairs, Chapter 8, Executive and Administrative Officers, Section 67-818	Requires consultation with the Department of Fish and Game.
Rules for Classification and Protection of Wildlife	IDAPA 13, Department of Fish and Game, 13.01.06	Requires consultation with the Department of Fish and Game.

1 **TABLE 13.6-1 (Cont.)**

Law/Regulation/Agreement	Citation	Requirements
Idaho Historic Preservation Act	IC, Title 67, Chapter 46, Preservation of Historic Sites	Requires consultation with responsible local governing body.
Agreement in Principle between the Western Shoshone-Bannock Tribes and DOE	December 10, 2002	Establishes understanding and commitment between the tribes and DOE.
Idaho Site Treatment Plan and Consent Order for Federal Facility Compliance Plan	November 1, 1995 (issued to INEEL [now INL] and Argonne National Laboratory-West [now Materials and Fuels Complex])	Addresses compliance with the Federal Facility Compliance Act issues by implementing the INL Site Treatment Plan.
Nevada		
Nevada Revised Statutes: Air Emission Controls	Chapter 445B	Addresses operating permits for the control of gaseous and particulate emissions from construction and operations.
Nevada Revised Statutes: Water Controls	Chapter 445A	Sets conditions for issuance of variances and exemptions, temporary permits, stormwater discharge permits, and NPDES permits.
Nevada Revised Statutes: Adjudication of Vested Water Rights, Appropriation of Public Waters, Underground Water and Wells	Chapter 534	Sets requirements for establishing state water rights for use of public waters of the state, which include underground waters.
Nevada Revised Statutes: State Fire Marshal	Chapter 477	Addresses permits for storage of hazardous materials in quantities above those the Uniform Fire Code specifies.
Nevada Revised Statutes: Hazardous Materials	Chapter 459	Sets requirements for management and disposal of hazardous waste.
Nevada Revised Statutes: Protection and Preservation of Timbered Lands, Trees, and Flora	Chapter 527	Protects the indigenous flora of the State of Nevada.
Nevada Revised Statutes: Hunting, Fishing, and Trapping; Miscellaneous Protective Measures	Chapter 503	Addresses procedures for the classification and protection of wildlife.

TABLE 13.6-1 (Cont.)

Law/Regulation/Agreement	Citation	Requirements
New Mexico		
New Mexico Air Quality Control Act	*New Mexico Statutes Annotated* (NMSA), Chapter 74, Environmental Improvement, Article 2, Air Pollution, and Implementing Regulations at *New Mexico Administrative Code* (NMAC) Title 20, Environmental Protection, Chapter 2, Air Quality	Establishes air quality standards and requires a permit prior to construction or modification of an air contaminant source. Also requires an operating permit for major producers of air pollutants and imposes emission standards for hazardous air pollutants.
New Mexico Radiation Protection Act	NMSA, Chapter 74, Article 3, Radiation Control	Establishes state requirements for worker protection.
New Mexico Water Quality Act	NMSA, Chapter 74, Article 6, Water Quality, and Implementing Regulations found in NMAC, Title 20, Chapter 6, Water Quality	Establishes water quality standards and requires a permit prior to the construction or modification of a water discharge source.
New Mexico Groundwater Protection Act	NMSA, Chapter 74, Article 6B, Groundwater Protection	Establishes state standards for protection of groundwater from leaking underground storage tanks.
New Mexico Solid Waste Act	NMSA, Chapter 74, Article 9, Solid Waste Act, and Implementing Regulations found in NMAC Title 20, Environmental Protection, Chapter 9, Solid Waste	Requires a permit prior to construction or modification of a solid waste disposal facility.
New Mexico Hazardous Waste Act	NMSA, Chapter 74, Article 4, Hazardous Waste, and Implementing Regulations found in NMAC Title 20, Environmental Protection, Chapter 4, Hazardous Waste	Establishes permit requirements for construction, operation, modification, and closure of a hazardous waste management facility and establishes state standards for cleanup of releases from leaking underground storage tanks.
Endangered Plant Species	NMAC, Title 19, Chapter 21, Endangered Plants (Revised December 3, 2001)	Establishes plant species list and rules for collection.
Environmental Oversight and Monitoring Agreement	Agreement in Principle (AIP) between DOE and the State of New Mexico	Provides DOE support for state activities in environmental oversight, monitoring, access, and emergency response.

TABLE 13.6-1 (Cont.)

Law/Regulation/Agreement	Citation	Requirements
Environmental Improvement Act	NMSA 1978, Sections 74-1-1 through 74-1-15; NMAC, 20.5.1 through 20.5.17, August 15, 2003	Modifies aboveground tank regulations to include requirements for the registration, installation, modification, repair, closure, or removal of aboveground storage tanks, as well as for detecting releases, recordkeeping, and financial responsibility in the State of New Mexico.
Environmental Oversight and Monitoring Agreement	Agreement in Principle between DOE and the State of New Mexico	Provides DOE support for state activities in environmental oversight, monitoring, access, and emergency response.
New Mexico Cultural Properties Act	NMSA, Chapter 18, Libraries and Museums, Article 6, Cultural Properties	Establishes the State Historic Preservation Office and requirements to prepare an archaeological and historic survey and consult with the State Historic Preservation Office.
New Mexico Hazardous Chemicals Information Act	NMSA, Chapter 74, Article 4E-1, Hazardous Chemicals Information	Implements the hazardous chemical information and toxic release reporting requirements of the Emergency Planning and Community Right-to-Know Act of 1986 (SARA Title III) for covered facilities.
South Carolina		
South Carolina Pollution Control Act	*South Carolina (SC) Code Annotated*, Section 48-1-10, et seq.	Addresses permits for construction and alteration of wastewater treatment facilities; PSD permits; and Title V Operating Permits for new or existing sources that are major, subject to NESHAP, New Source Performance Standards (NSPS), or affected under the Acid Rain Program.
Safe Drinking Water Act	*SC Code*, Section 44-55-10	Addresses public Water System Permits for the construction, modification, expansion, and operation of public water systems.
Hazardous Waste Management Act	*SC Code*, Section 44-56-10	Addresses permits for facilities that will store hazardous wastes beyond the allowed accumulation periods, treat hazardous wastes, or dispose of hazardous wastes.

TABLE 13.6-1 (Cont.)

Law/Regulation/Agreement	Citation	Requirements
South Carolina Atomic Energy and Radiation Control Act	SC Regulations R.61-63	Addresses license to receive, use, possess, transfer, or dispose of radioactive material.
Underground Storage Tank Control Regulations	SC RCRA Regulations R.61-92	Addresses underground storage tank installation and operation permits.
South Carolina Occupational Safety and Health Standards for General Industry and Public Sector Marine Terminals	Chapter 71	Addresses identification, evaluation, and control of the hazards of processes involving a flammable liquid or gas, hydrocarbon fuel, or highly hazardous chemical at or above the specified threshold quantity.
Washington		
Washington State Hazardous Waste Management Act	*Revised Code of Washington* (RCW) 70.105	Regulates the disposal of hazardous wastes; implements waste reduction and prevention programs.
Washington Clean Air Act	RCW 70.94	Authorizes an operating permit program, civil penalties, administrative enforcement provisions; covers toxics and hazardous air pollutants for new sources and modifications to existing sources.
The Washington State Department of Health regulations, Radiation Protection — Air Emissions	*Washington Administrative Code* (WAC) 246–247	Provides standards and permit requirements for the emission of radionuclides to the atmosphere from DOE facilities.
Washington State Environmental Policy Act	RCW 43.21C	Provides for the evaluation of proposals, which may be conditioned or denied through the permit process, on the basis of environmental considerations.
Model Toxics Control Act	RCW 70.105D	Regulates releases of hazardous substances caused by past activities and potential and ongoing releases of hazardous substances from current activities.
Water Pollution Control Act	RCW 90.48	Establishes a permit system to license and control the discharge of pollutants into waters of the state.

TABLE 13.6-1 (Cont.)

Law/Regulation/Agreement	Citation	Requirements
Washington State Department of Health licensing requirements	WAC 246–247	Provides licensing requirements for new sources of radioactive emissions.

The routes selected for these shipments will meet the requirements of DOT for using the interstate highway system or a state-designated alternative route. In addition, DOE will follow other routes that have been identified through agreements with local, tribal, or state governments for transport of radioactive waste. As a matter of policy, all DOE shipments are undertaken in accordance with the requirements and standards that apply to comparable commercial shipments, except where there is a determination that national security or another critical interest requires different action. In implementing this policy, DOE cooperates with federal, state, local, and tribal entities and utilizes existing expertise and resources to the extent practicable. In all cases, DOE will achieve a level of protection that meets or exceeds the level of protection associated with comparable commercial shipments.

13.8 CONSULTATIONS

Certain laws, such as the ESA, Fish and Wildlife Coordination Act, and NHPA, require consultation and coordination by DOE with other governmental entities, including other federal agencies, state and local agencies, and federally recognized American Indian governments. In addition, the DOE American Indian and Alaska Native Government Policy requires DOE to consult with any American Indian or Alaska Native Tribal Government with regard to any property to which the tribe attaches religious or cultural importance that might be affected by a DOE action.

Most of these consultations are related to biotic resources, cultural resources, and American Indian rights. Biotic resource consultations generally pertain to the potential for activities to disturb sensitive species or habitats. Cultural resource consultations relate to the potential for disruption of important cultural resources and archaeological sites. American Indian consultations are concerned with the potential for impacts on any rights and interests, including the disturbance of ancestral American Indian sites, and sacred sites, traditional and religious practices of American Indians, and natural resources of importance to American Indians.

DOE consults with the appropriate SHPOs, as required by NEPA and Section 106 of NHPA; the USFWS, as required by the ESA of 1973, the Bald and Golden Eagle Protection Act, and the Migratory Bird Treaty Act; and the appropriate state regulators, as required by state laws or regulations.

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No entries

APPENDIX A:

CONTRACTOR DISCLOSURE STATEMENT

Argonne National Laboratory is the contractor assisting the U.S. Department of Energy (DOE) in preparing the environmental impact statement (EIS) for the disposal of greater-than-Class C (GTCC) low-level radioactive waste and GTCC-like waste. DOE is responsible for reviewing and evaluating the information and determining the appropriateness and adequacy of incorporating any data, analyses, or results in the EIS. DOE determines the scope and content of the EIS and supporting documents and will furnish direction to Argonne, as appropriate, in preparing these documents.

The Council on Environmental Quality's regulations (40 CFR 1506.5(c)), which have been adopted by DOE (10 CFR Part 1021), require contractors who will prepare an EIS to execute a disclosure specifying that they have no financial or other interest in the outcome of the project. The term "financial interest or other interest in the outcome of the project" for the purposes of this disclosure is defined in the March 23, 1981, "Forty Most Asked Questions Concerning CEQ's National Environmental Policy Act Regulations," 46 *Federal Register* 18026–18028 at Questions 17a and 17b. Financial or other interest in the outcome of the project includes "any financial benefit such as promise of future construction or design work on the project, as well as indirect benefits the consultant is aware of (e.g., if the project would aid proposals sponsored by the firm's other clients)," 46 *Federal Register* 18026–18038.

In accordance with these regulations, Argonne National Laboratory hereby certifies that it has no financial or other interest in the outcome of the project.

Certified by:

____
Signature

John R. Krummel
Name

Director, Environmental Science Division
Title

7/27/2012
Date

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APPENDIX B:

GTCC LLRW AND GTCC-LIKE WASTE INVENTORIES

This appendix provides detailed information on the inventories (volumes and radionuclide activities) of the wastes addressed in this environmental impact statement (EIS) for disposal alternatives for greater-than-Class C (GTCC) low-level radioactive waste (LLRW) and GTCC-like waste. Preliminary inventories were provided in the July 23, 2007, Notice of Intent (NOI) to prepare this EIS, and the bases of these estimates were described in a report prepared by Sandia National Laboratories entitled *Greater-Than-Class C Low-Level Radioactive Waste and DOE Greater-Than-Class C-Like Waste Inventory Estimates* (Sandia 2007). This report was issued in July 2007. Additional details on this inventory are provided in a subsequent report entitled *Basis Inventory for Greater-Than-Class-C Low-Level Radioactive Waste Environmental Impact Statement Evaluations*, Task 3.2 Report, Revision 1, which was issued in May 2008 (Sandia 2008).

These two reports were prepared to update GTCC LLRW estimates previously developed for the U.S. Department of Energy (DOE 1994). The inventory estimates reported in 1994 were limited to GTCC LLRW and did not consider GTCC-like waste. A third report was prepared by Argonne National Laboratory (Argonne) to summarize the information in these two documents and supplement or update information. This report is entitled *Supplement to Greater-Than-Class C (GTCC) Low-Level Radioactive Waste and GTCC-Like Waste Inventory Reports* (Argonne 2010). This appendix provides a summary of the waste inventory data needed for this EIS on the basis of information contained in the three inventory reports described above.

As described in Section 1.4.1 of the EIS, wastes are placed in one of two groups for purposes of analysis. Group 1 consists of wastes that were already generated and are in storage or projected to be generated by existing facilities, such as commercial nuclear power plants. Group 2 consists of wastes that might be generated from proposed future activities, including several DOE projects, two planned molybdenum-99 (Mo-99) production projects, and new nuclear power plants that have not yet been licensed by the U.S. Nuclear Regulatory Commission (NRC) or constructed.

The estimated waste volumes and total radionuclide activities for the wastes in Groups 1 and 2 are shown in Table B-1 and are summarized as follows. The total waste volume in Group 1 is estimated to be 5,300 m^3 (190,000 ft^3) and contains a total of 110 megacuries (MCi) of radionuclide activity, mainly from the decommissioning of commercial nuclear power reactors currently in operation.

Group 2 has an estimated waste volume of 6,400 m^3 (230,000 ft^3) and contains a total activity of 49 MCi. Some of this waste is associated with the West Valley Site. A total of 980 m^3 (35,000 ft^3) of GTCC-like wastes are associated with decommissioning the West Valley Site (exclusive of the NRC-licensed disposal area [NDA] and state-licensed disposal area [SDA]), and an additional 4,300 m^3 (150,000 ft^3) of GTCC LLRW could be generated should a decision be made to exhume the NDA and SDA. As for Group 1 GTCC LLRW and GTCC-like waste, the

TABLE B-1 Summary of Group 1 and Group 2 GTCC LLRW and GTCC-Like Waste Packaged Volumes and Radionuclide Activities[a]

	In Storage		Projected		Total Stored and Projected	
Waste Type	Volume (m^3)	Activity (MCi)[b]	Volume (m^3)	Activity (MCi)	Volume (m^3)	Activity (MCi)
Group 1						
GTCC LLRW						
Activated metals (BWRs)[c] - RH	7.1	0.22	200	30	210	31
Activated metals (PWRs) - RH	51	1.1	620	76	670	77
Sealed sources (Small)[d] - CH	–[e,f]		1,800	0.28	1,800	0.28
Sealed sources (Cs-137 irradiators) - CH	–	–	1,000	1.7	1,000	1.7
Other Waste[g] - CH	42	0.000011	–	–	42	0.000011
Other Waste - RH	33	0.0042	1.0	0.00013	34	0.0043
Total	130	1.4	3,700	110	3,800	110
GTCC-like waste						
Activated metals - RH	6.2	0.23	6.6	0.0049	13	0.24
Sealed sources (Small) - CH	0.21	0.0000060	0.62	0.000071	0.83	0.000077
Other Waste - CH	430	0.016	310	0.0062	740	0.022
Other Waste - RH	520	0.096	200	0.17	720	0.26
Total	960	0.34	510	0.18	1,500	0.52
Total Group 1	1,100	1.7	4,200	110	5,300	110
Group 2						
GTCC LLRW						
Activated metals (BWRs) - RH	–	–	73	11	73	11
Activated metals (PWRs) - RH	–	–	300	37	300	37
Activated metals (Other) - RH[h]	–	–	740	0.14	740	0.14
Sealed sources - CH[h]	–	–	23	0.000020	23	0.000020
Other Waste - CH[h]	–	–	1,600	0.024	1,600	0.024
Other Waste - RH[h]	–	–	2,300	0.51	2,300	0.51
Total	–	–	5,000	49	5,000	49
GTCC-like waste						
Activated metals - RH	–	–	–	–	–	–
Sealed sources - CH	–	–	–	–	–	–
Other Waste - CH	–	–	490	0.012	490	0.012
Other Waste - RH	–	–	870	0.48	870	0.48
Total	–	–	1,400	0.49	1,400	0.49
Total Group 2	–	–	6,400	49	6,400	49

TABLE B-1 (Cont.)

Waste Type	In Storage		Projected		Total Stored and Projected	
	Volume (m^3)	Activity (MCi)[b]	Volume (m^3)	Activity (MCi)	Volume (m^3)	Activity (MCi)
Groups 1 and 2						
GTCC LLRW						
Activated metals - RH	59	1.4	1,900	160	2,000	160
Sealed sources - CH	–	–	2,900	2.0	2,900	2.0
Other Waste - CH	42	0.00091	1,600	0.024	1,600	0.024
Other Waste - RH	33	0.0042	2,300	0.51	2,300	0.51
Total	130	1.4	8,700	160	8,800	160
GTCC-like waste						
Activated metals - RH	6.2	0.23	6.6	0.0049	13	0.24
Sealed sources - CH	0.21	0.0000060	0.62	0.000071	0.83	0.000077
Other Waste - CH	430	0.016	800	0.02	1,200	0.036
Other Waste - RH	520	0.096	1,100	0.65	1,600	0.75
Total	960	0.34	1,900	0.67	2,800	1.0
Total Groups 1 and 2	1,100	1.7	11,000	160	12,000	160

[a] All values have been rounded to two significant figures. Some totals may not equal sum of individual components because of independent rounding. BWR = boiling water reactor, CH = contact-handled (waste), PWR = pressurized water reactor, RH = remote-handled (waste). Includes waste in storage as of 2008 and projected through 2083. Waste quantity data obtained in 2008 had verification updates made in 2010 as needed, see Argonne (2010). In performing its due diligence in the preparation of this final EIS, DOE reviewed the waste quantity data and has determined that the expected waste quantity estimates remain valid and are conservative and bounding.

[b] MCi means megacurie or 1 million curies.

[c] There are two types of commercial nuclear reactors in operation in the United States, BWRs and PWRs. Different factors were used to estimate the volumes and activities of activated metal wastes for these two types of reactors.

[d] Sealed sources may be physically small but have high concentration of radionuclides.

[e] There are sealed sources currently possessed by NRC licensees that may become GTCC LLRW when no longer needed by the licensee. Due to the lack of information on the current status of the sources (i.e., whether they are in use, waste, etc.), the estimated volume and activity of these sources are included in the projected inventory.

[f] A dash means that there is no value for that entry.

[g] Other Waste consists of those wastes that are not activated metals or sealed sources; it includes contaminated equipment, debris, scrap metals, filters, resins, soil, solidified sludges, and other materials.

[h] Wastes from the West Valley Site NDA and SDA are reflected in the inventories listed under Group 2 activated metals, sealed sources, and Other Waste - RH/CH. Of the 740 m^3 under activated metals, 210 m^3 is from the NDA and 525 m^3 is from the SDA; 23 m^3 of sealed sources is from the SDA; 1,600 m^3 of Other Waste - CH is from the SDA; and 1,950 m^3 of Other Waste - RH included 1,943 m^3 from the NDA and 7.34 m^3 from the SDA.

radionuclide activity in the Group 2 wastes results mainly from the decommissioning of new commercial nuclear power reactors.

The GTCC LLRW and GTCC-like waste associated with decontamination and decommissioning of the West Valley Site are in both Group 1 and Group 2. Group 1 wastes are all GTCC-like wastes and result from past and ongoing decontamination activities at the site. Some of the wastes are already in storage, and others are being generated by decontamination of the Main Plant Process Building (MPPB) to make it ready for demolition. Group 2 wastes are all projected wastes from potential future decommissioning activities. These wastes include GTCC-like wastes from decommissioning of the MPPB and the Waste Tank Farm (WTF). West Valley Demonstration Project transuranic (TRU) wastes include debris generated during the decontamination (cleanout) of the mechanical processing cells of the former Nuclear Fuel Services, Inc., reprocessing plant as well as wastes determined to be TRU. Group 2 GTCC LLRW and GTCC-like waste would also be generated should a decision be made to exhume the wastes from the NDA and SDA as part of future decommissioning activities. Because waste generated at the West Valley site is not considered defense waste and therefore are currently not permitted to be disposed in the WIPP, GTCC LLRW and GTCC-like wastes have been included in the volume estimates of waste requiring a disposition pathway for this GTCC EIS. Some of this waste may be subject to a determination that would result in it being classified as Waste Incidental to Reprocessing (WIR). The analysis associated with this determination evaluates the radionuclide content of the waste, rather than merely relying on how the waste was originally generated.

The volume of GTCC-like wastes associated with the West Valley Site from wastes already in storage, ongoing decontamination of the MPPB, and the future decommissioning of the MPPB and WTF is estimated to be about 2,200 m^3 (78,000 ft^3). Of this total, about 1,300 m^3 (46,000 ft^3) is in Group 1 and 980 m^3 (35,000 ft^3) is in Group 2. An additional 4,300 m^3 (150,000 ft^3) of GTCC LLRW and GTCC-like wastes could be generated by the exhumation of the NDA and SDA at the site as part of future decommissioning activities. Most of the GTCC LLRW and GTCC-like waste from these disposal areas would be GTCC LLRW, with 31 m^3 (1,100 ft^3) from the NDA being GTCC-like waste. The 31 m^3 (1,100 ft^3) of GTCC-like waste is included with the volume of GTCC LLRW from the NDA and SDA for purposes of analysis in the EIS.

The total estimated volume of mixed waste in Group 1 is about 170 m^3 (6,000 ft^3), which represents less than 4% of the total volume Group 1 waste. About 120 m^3 (4,200 ft^3) of this total is GTCC-like mixed waste currently in storage at the West Valley Site. Current information is insufficient to allow a reasonable estimate of the amount of Group 2 waste that could be mixed waste. Most of the Group 1 mixed waste is GTCC-like waste; only 4 m^3 (140 ft^3) is GTCC LLRW (Sandia 2007). Available information indicates that much of this waste is characteristic hazardous waste as regulated under the Resource Conservation and Recovery Act (RCRA); therefore, this EIS assumes that for the land disposal methods, the generators will treat the waste to render it nonhazardous under federal and state laws and requirements. The Waste Isolation Pilot Plant (WIPP), however, can accept mixed waste, as provided in the WIPP Land Withdrawal Act (LWA) as amended (P.L. 102-579 as amended by P.L. 104-201).

The DOE planned plutonium-238 (Pu-238) production project is estimated to produce 380 m^3 (13,000 ft^3) of Group 2 GTCC-like wastes with a total activity of 0.094 MCi. Many of the radionuclides in these wastes have short half-lives (three years or less) that will not have an impact on long-term management decisions. For purposes of analysis in the EIS, it is assumed that the Pu-238 production wastes will be stored for three years at the facilities generating these wastes prior to shipment to the disposal site. The total activity in these wastes given here includes radioactive decay for three years.

Waste associated with the future domestic production of Mo-99 is also included in the GTCC EIS inventory. The Mo-99 producers are in preliminary stages of developing Mo-99 domestically, and therefore the quantities of waste considered in this analysis are estimates. For purposes of analysis in this EIS, DOE considered use of the following technologies for the production of Mo-99: 1) a particle accelerator-based neutron source that emits neutrons ; 2) open pool reactor technology.

For purposes of analysis in the EIS, it is assumed that these Mo-99 producers will begin operation in the next few years and to operate for 71 years (to 2083). The total volume of GTCC LLRW produced over this time frame for the Mo-99 production facilities in the United States is estimated to be about 390 m^3 (14,000 ft^3) and contain 0.48 MCi of activity.[1] The total volume and activity amounts are estimates and have been developed based on of information received from the Mo-99 producers.

As discussed in Section 1.4.1, the GTCC LLRW and GTCC-like wastes are considered to be in one of three waste types: activated metals, sealed sources, or Other Waste. The waste inventory includes wastes already generated and in storage (stored inventory), as well as wastes estimated to be generated in the future (projected inventory). All three types of waste (activated metals, sealed sources, and Other Waste) are currently in storage at sites licensed by the NRC or Agreement States and at certain DOE sites.

B.1 SUMMARY OF WASTE VOLUMES

Table B-1 provides a summary of the packaged waste volumes for the Group 1 and 2 wastes being addressed in this EIS. Some of the Group 1 wastes have already been generated and are in storage, and the rest would be generated in the future. All Group 2 wastes would be generated in the future. Table B-2 identifies the locations where GTCC LLRW and GTCC-like wastes are currently being stored or would be generated in the future. Additional information for GTCC-like wastes is presented in Table B-3. This information is described in more detail in Argonne (2010).

[1] Waste from Mo-99 production will be generated by NRC and Agreement State licensees and is therefore, for purposes of analysis in this EIS, considered to be GTCC LLRW. In the event Mo-99 producers enter into Uranium Lease and Take-Back Contracts with DOE pursuant to applicable provisions in the American Medical Isotopes Production Act of 2012 (Title XXXI, Subtitle F, National Defense Authorization Act for Fiscal Year 2013, Public Law 112-239), it is possible that waste resulting from Mo-99 production included in the current estimates of GTCC LLRW may be determined to be waste for which DOE is responsible for final disposition.

TABLE B-2 Storage and Generator Locations of the GTCC LLRW and GTCC-Like Wastes Addressed in This EIS[a]

Waste Type	GTCC LLRW	GTCC-Like
Group 1		
Activated metals - RH	Various states (see Figure 3.1-1)	INL Site (Idaho) ORR (Tennessee)
Sealed sources - CH	Various states	LANL (New Mexico)
Other Waste - CH	Babcock and Wilcox (Virginia) Waste Control Specialists (Texas)	West Valley Site (New York) INL Site (Idaho) Babcock and Wilcox (Virginia)
Other Waste - RH	Virginia and Texas	West Valley Site (New York) INL Site (Idaho) ORR (Tennessee) Babcock and Wilcox (Virginia)
Group 2		
Activated metals - RH	Various states	–
Sealed sources - CH	West Valley Site (New York)	–
Other Waste - CH	West Valley Site (New York)	West Valley Site (New York) ORR (Tennessee)
Other Waste - RH	West Valley Site (New York) Missouri University Research Reactor (Missouri) Babcock and Wilcox (Virginia)	West Valley Site (New York) ORR (Tennessee)

[a] Other waste consists of those wastes that are not activated metals or sealed sources; it includes contaminated equipment, debris, scrap metal, filters, resins, soil, solidified sludges, and other materials. A dash means no volume for that waste type. INL = Idaho National Laboratory, LANL = Los Alamos National Laboratory, ORR = Oak Ridge Reservation.

The GTCC LLRW is stored at NRC or Agreement State licensee locations, including at commercial storage facilities at a number of sites across the United States. Most of the activated metal GTCC LLRW is stored at commercial nuclear power plants. Figure 3.1-1 shows the locations of the currently operating nuclear power plants, most of which are located east of the Mississippi River. GTCC LLRW sealed sources are stored at medical facilities and hospitals, industrial facilities, universities, and commercial storage and staging locations. Two facilities are currently being used to store GTCC LLRW Other Waste (in Virginia and Texas). All of these facilities are operated in accordance with applicable requirements.

A comparison of the volumes and radionuclide activities of GTCC LLRW and GTCC-like waste with the annual volumes and activity of LLRW generated in the United States and with high-level waste and spent nuclear fuel is shown in Figure B-1. As can be seen in this figure, GTCC LLRW and GTCC-like waste represents a very small fraction of the total volume of LLRW generated annually, but it has significantly greater activity.

This information is presented in detail in a number of tables that describe the types of waste packages that were used to evaluate waste handling and transportation impacts. These tables do not mean to imply that these waste packages would actually be used for such purposes once a disposal site was selected. Rather, these packages are representative of those that could be

1 **TABLE B-3 Sources of the GTCC-Like Wastes Addressed in This EIS[a]**

Waste Type	Site[b]	Stored Volume (m^3)	Projected Volume (m^3)
Group 1			
Activated metals - RH	INL Site	3.3	6.6
	ORR	2.9	–[c]
Sealed sources - CH	LANL	0.21	0.62
Other Waste - CH	West Valley Site[d]	400	310
	INL Site	31	–
	B&W	3.4	–
Other Waste - RH	West Valley Site[d]	480	63
	INL Site	19	–
	ORR	4.0	130
	B&W	15	0.60
Total		960	510
Group 2			
Activated metals - RH	–	–	–
Sealed sources - CH	–	–	–
Other Waste - CH	West Valley Site[d]	–	220
	ORR	–	260
Other Waste - RH	West Valley Site[d]	–	760
	ORR	–	120
Total		–	1,400

[a] All values have been rounded to two significant figures. Some totals may not equal sum of individual components because of independent rounding. B&W = Babcock & Wilcox Company (Lynchburg, Va.), CH = contact-handled (waste), INL = Idaho National Laboratory, LANL = Los Alamos National Laboratory, ORR = Oak Ridge Reservation, RH = remote-handled (waste). Includes waste in storage as of 2008 and projected through 2083. Waste quantity data obtained in 2008 had verification updates made in 2010 as needed, see Argonne (2010). In performing its due diligence in the preparation of this final EIS, DOE reviewed the waste quantity data and has determined that the expected waste quantity estimates remain valid and are conservative and bounding.

[b] These are the sites where the wastes are currently being stored or would be generated in the future.

[c] A dash means that there is no value for that entry.

[d] These volumes were provided by the DOE Waste Valley Site Office and assumed waste repackaging with volume reduction prior to disposal. These wastes are associated with decontamination activities at the West Valley Site. Because of the assumed volume reduction, the volumes presented in this GTCC EIS are less than those presented in the Final EIS for the West Valley Site (DOE 2010a).

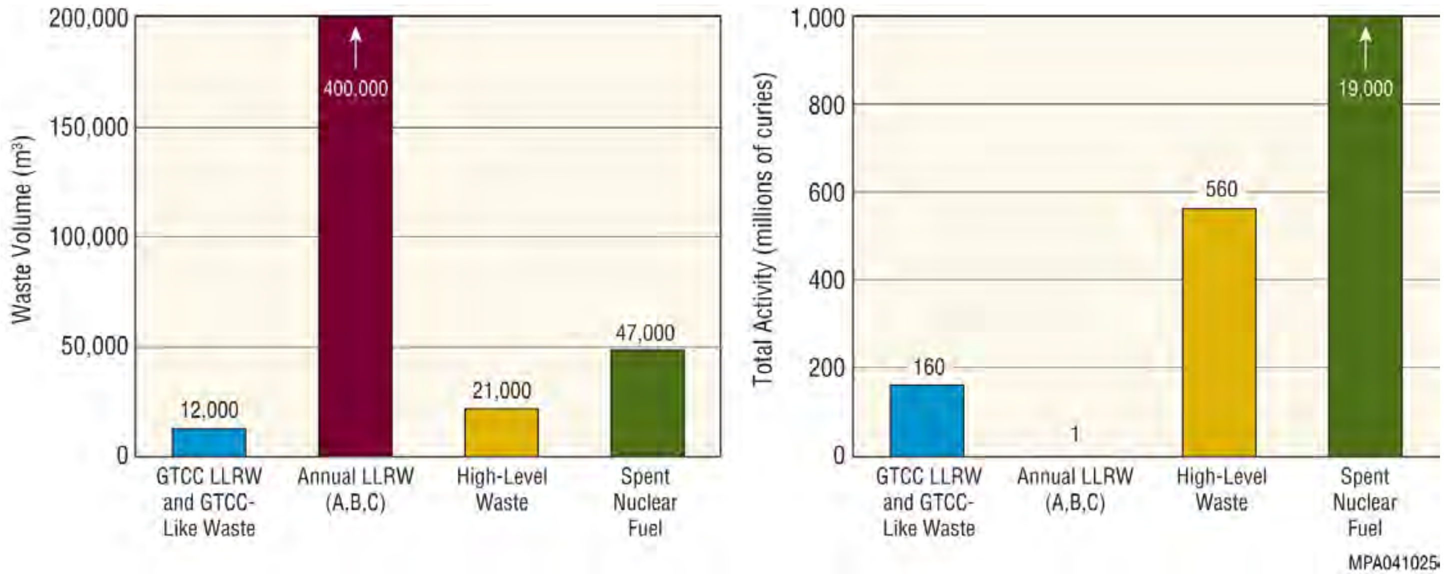

FIGURE B-1 Comparison of GTCC LLRW and GTCC-Like Waste with Other Radioactive Wastes

used, and they were chosen herein solely for the purpose of evaluating environmental impacts associated with the various disposal alternatives being addressed in this EIS.

B.2 SUMMARY OF RADIONUCLIDE ACTIVITIES

The radionuclide activities in the wastes were developed by using information provided by the DOE Operations and Field Offices in response to a data call, using information provided in databases, and conducting a review of documents on GTCC LLRW and TRU waste prepared by DOE and NRC. Radionuclide information for the two planned Mo-99 projects and the DOE Pu-238 production project was provided by the organizations planning to implement these projects in the future.

The radionuclides present in GTCC LLRW and GTCC-like waste can generally be placed in three categories: neutron activation products, radioactive fission products, and actinides (i.e., radionuclides that are higher than actinium in the Chart of the Nuclides). The main source of activity in activated metals is neutron activation products, while fission products and actinides are the main radionuclides present in sealed sources and Other Waste. Fission products and some actinides are also present in relatively low concentrations in activated metals. The actinides include TRU radionuclides, and many of these are present in GTCC-like Other Waste.

Radionuclide profiles were used to develop estimates of the total curies of each radionuclide that would be present in the various waste streams, and then the individual waste streams were summed to obtain estimates of the total activities in the various GTCC LLRW and GTCC-like waste types. The three reports identified on page B-1 (Sandia 2007, 2008; Argonne 2010) can be consulted to evaluate these results in more detail for the individual waste streams. This information was used to address the impacts associated with the handling, transportation, and disposal of these wastes in this EIS.

A summary of the radionuclide activities in the Group 1 and Group 2 GTCC LLRW and GTCC-like waste is provided in Tables B-4 through B-7. The radionuclides in these tables are those expected to be most prevalent or significant in evaluating the radiological impacts from the various disposal alternatives considered in the EIS. The radionuclide activities given in this appendix for stored wastes account for radioactive decay to 2019, while the activities for projected wastes are those expected to be present when the wastes are generated and available for disposal. In addition, the radionuclide activities for the GTCC LLRW and GTCC-like waste in the two disposal areas at the West Valley Site were decay-corrected to 2019 for purposes of analysis in this EIS.

The radionuclide activities for Group 1 GTCC LLRW and GTCC-like waste are summarized in Tables B-4 through B-6. Table B-4 contains the total (stored and projected) activities for GTCC LLRW and GTCC-like waste, which are divided into the stored activities (Table B-5) and projected activities (Table B-6). The Group 2 activities are given separately in the same format in Table B-7. All of the Group 2 wastes would be generated in the future; there are no stored Group 2 wastes.

TABLE B-4 Radionuclide Activity (in curies) of Group 1 GTCC LLRW and GTCC-Like Waste[a]

	GTCC LLRW					GTCC-Like Waste				
		Sealed Sources[c]		Other Waste			Sealed Sources[c]		Other Waste	
Radionuclide	Activated Metals[b]	Actinides	Nonactinides	CH	RH	Activated Metals[b]	Actinides	Nonactinides	CH	RH
Hydrogen-3	$\times 10^{3}$	–	–	–	–	2.3×10^{5}	–	–	1.7×10^{-1}	1.6×10^{1}
Carbon-14	2.3×10^{4}		–	–	5.8×10^{-3}	6.8×10^{2}		–	1.3×10^{1}	$\times 10^{2}$
Manganese-54	$\times 10^{4}$	–	–	–	9.6×10^{-3}	2.8×10^{-5}	–	–	4.7×10^{-3}	$\times 10^{1}$
Iron-55 6.8	4.0×10^{7}		–	–	6.3×10^{-4}	1.7×10^{2}		–	5.7 1.0	8.2
Nickel-59 4.9	1.3×10^{5}–	–	–	–	1.1×10^{-1}	3.1 _	–	–	7.6×10^{-2}4.8	1.6×10^{2}
Cobalt-60	5.0×10^{7}	–	–	–	8.7	4.7×10^{3}	–	–	4.1×10^{-3}	1.2×10^{3}
Nickel-63	1.8×10^{7}–	–	–	–	5.3	8.0×10^{2} _	–	–	2.5×10^{-2}	9.4×10^{3}
Strontium-90	1.2×10^{4}	–	–	–	1.5×10^{3}	–	–	–	6.6×10^{1}	3.6×10^{4}
Molybdenum-93	$\times 10^{2}$	–	–	–	–	–	–	–	–	–
Niobium-94	6.0×10^{2}		–	–	–	1.3×10^{-2}		–	5.2×10^{-5}	$\times 10^{-2}$
Technetium-99 1.1	4.5×10^{3}	–	–	–	7.6×10^{-1}	–	–	–	3.2×10^{-1}	1.7×10^{2}
Iodine-129	1.9	–	–	–	–	–	–	–	9.7×10^{-5}9.8	2.7
Cesium-137	1.3×10^{4}–	–	1.7×10^{6}	5.7	2.0×10^{3}	– _	–	–	6.5×10^{1}	3.9×10^{4}
Promethium-147	–	–	–	–	–	–	–	–	1.4×10^{-3}	5.6
Samarium-151	–	–	–	–	–	–	–	–	2.9×10^{-3}	1.7×10^{-1}
Europium-152	–	–	–	–	–	6.6×10^{2}		–	3.1×10^{-3}	6.8×10^{2}
Europium-154	–	–	–	–	–	6.0	–	–	1.9×10^{-1}	$\times 10^{2}$
Europium-155	–	–	–	–	–	7.1×10^{-1}		–	3.1×10^{-4}	$\times 10^{1}$
Lead-210		–	–	–	5.1×10^{-9}	– _	–	–	3.6×10^{-6}2.2	$\times 10^{-9}$
Radium-226	–	–	–	–	–	–	–	–	4.3 9.2	–
Actinium-227	–	–	–	–	–	– _	–	–	3.3×10^{-2}2.3	1.6×10^{-9}
Radium-228	–	–	–	–	–	–	–	–	2.3×10^{-1}	–
Thorium-229	–	–	–	–	8.8×10^{-4}	–	–	–	2.2	7.4×10^{-2}
Thorium-230	–	–	–	–	8.9×10^{-6}	–	–	–	4.1×10^{-1}	2.7×10^{-2}
Protactinium-231	–	–	–	–	–	–	–	–	1.1×10^{-5}	1.3×10^{-8}
Thorium-232	–	–	–	–	–	–	–	–	2.8×10^{-1}	6.8×10^{-1}
Uranium-232	–	–	–	–	–	–	–	–	2.3×10^{1}	1.9
Uranium-233	–	–	–	–	6.0×10^{-1}	–	–	–	9.4	7.9×10^{2}
Uranium-234	–	–	–	–	–	–	–	–	4.4×10^{1}	1.6
Uranium-235	–	–	–	–	5.2×10^{-3}	–	–	–	1.6×10^{-1}	3.5×10^{-1}
Uranium-236	–	–	–	–	–	–	–	–	5.4×10^{-2}	7.9×10^{-1}
Neptunium-237	–	–	–	–	3.2×10^{-3}	–	–	–	1.1	1.5

TABLE B-4 (Cont.)

	GTCC LLRW					GTCC-Like Waste				
		Sealed Sources[c]		Other Waste			Sealed Sources[c]		Other Waste	
Radionuclide	Activated Metals[b]	Actinides	Nonactinides	CH	RH	Activated Metals[b]	Actinides	Nonactinides	CH	RH
Uranium-238	–	–	–	–	–	–	–	–	9.1×10^{-2}	1.1×10^{1}
Plutonium-238	8.8×10^{-1}	1.2×10^{5}	–	–	1.8×10^{1}	–	–	–	1.3×10^{3}	1.5×10^{3}
Plutonium-239	4.5×10^{3}	8.4×10^{3}	–	–	2.5×10^{1}	–	–	–	9.0×10^{2}	2.9×10^{3}
Plutonium-240	–	–	–	–	7.5	–	2.2×10^{1}	–	7.1×10^{2}	1.8×10^{3}
Plutonium-241	2.5×10^{1}	–	–	–	6.2×10^{2}	–	–	–	1.4×10^{4}	1.7×10^{4}
Americium-241	6.4×10^{1}	1.5×10^{5}	–	5.0	6.6×10^{1}	–	–	–	4.4×10^{3}	5.3×10^{3}
Plutonium-242	–	–	–	–	2.3×10^{-3}	–	–	–	4.5	3.9
Americium-243	–	–	–	–	4.7×10^{-3}	–	3.5×10^{-1}	–	3.4×10^{1}	8.6×10^{1}
Curium-243	–	–	–	–	–	–	–	–	7.6×10^{-2}	2.2
Curium-244	–	2.2×10^{1}	–	–	5.2	–	5.4×10^{1}	–	1.8	1.1×10^{3}
Curium-245	–	–	–	–	–	–	–	–	2.0×10^{-9}	3.4×10^{2}
Curium-246	–	–	–	–	–	–	–	–	1.9×10^{-11}	5.4×10^{1}

[a] The approach used to develop these activities is given in Argonne (2010) and the references cited therein. The activities represent values at the time the wastes are projected to be available for disposal and are given to two significant figures. Separate estimates were developed for GTCC LLRW and GTCC-like waste. A dash means there is no value for that entry. CH = contact-handled (waste), RH = remote-handled (waste).

[b] All of the activated metal wastes are expected to be RH waste.

[c] All of the sealed source wastes are expected to be CH waste, with the possible exception of two americium-241/beryllium sources.

TABLE B-5 Radionuclide Activity (in curies) of Stored Group 1 GTCC LLRW and GTCC-Like Waste[a]

	GTCC LLRW					GTCC-Like Waste				
		Sealed Sources[c]		Other Waste			Sealed Sources[c]		Other Waste	
Radionuclide	Activated Metals[b]	Actinides	Nonactinides	CH	RH	Activated Metals[b]	Actinides	Nonactinides	CH	RH
Hydrogen-3	1.6×10^{2}	–	–	–	–	2.3×10^{5}	–	–	1.1×10^{-1}	1.6×10^{1}
Carbon-14	1.4×10^{3}	–	–	–	5.6×10^{-3}	2.0×10^{2}	–	–	1.0×10^{1}	1.0×10^{2}
Manganese-54	9.2×10^{-3}	–	–	–	9.4×10^{-3}	2.8×10^{-5}	–	–	2.3×10^{-6}	4.2×10^{-3}
Iron-55	3.4×10^{4}	–	–	–	6.1×10^{-4}	1.7×10^{2}	–	–	9.9×10^{-1}	8.2
Nickel-59	7.8×10^{3}	–	–	–	1.1×10^{-1}	6.0×10^{-1}	–	–	5.9×10^{-2}	1.6×10^{2}
Cobalt-60	3.5×10^{5}	–	–	–	8.4	8.5×10^{2}	–	–	4.0×10^{-3}	3.1×10^{2}
Nickel-63	9.6×10^{5}	–	–	–	5.2	1.9×10^{2}	–	–	2.5×10^{-2}	9.4×10^{3}
Strontium-90	4.7×10^{2}	–	–	–	1.5×10^{3}	–	–	–	8.6	2.9×10^{4}
Molybdenum-93		–	–	–	–	–	–	–	–	–
Niobium-94	4.1×10^{1}	–	–	–	–	1.8×10^{-3}	–	–	5.2×10^{-5}	$\times 10^{-2}$
Technetium-99	2.8×10^{2}	–	–	–	7.3×10^{-1}	–	–	–	2.4×10^{-1}	1.7×10^{2}
Iodine-129 7.4	1.2×10^{-1}	–	–	–	–	–	–	–	4.9×10^{-5} 9.8	2.7
Cesium-137	5.5×10^{2}	–	–	5.7	2.0×10^{3}	–	–	–	5.0	3.0×10^{4}
Promethium-147	–	–	–	–	–	–	–	–	1.4×10^{-3}	5.6
Samarium-151	–	–	–	–	–	–	–	–	2.9×10^{-3}	1.7×10^{-1}
Europium-152	–	–	–	–	–	6.6×10^{2}	–	–	3.1×10^{-3}	6.0×10^{-4}
Europium-154	–	–	–	–	–	6.0	–	–	1.1×10^{-1}	1.7×10^{1}
Europium-155	–	–	–	–	–	7.1×10^{-1}	–	–	3.1×10^{-4}	7.9×10^{-1}
Lead-210	–	–	–	–	4.9×10^{-9}	–	–	–	3.6×10^{-6}	2.2×10^{-9}
Radium-226	–	–	–	–	–	–	–	–	3.4	–
Actinium-227	–	–	–	–	–	–	–	–	2.4×10^{-2}	1.6×10^{-9}
Radium-228	–	–	–	–	–	–	–	–	1.1×10^{-1}	–
Thorium-229	–	–	–	–	8.5×10^{-4}	–	–	–	1.7	7.4×10^{-2}
Thorium-230	–	–	–	–	8.6×10^{-6}	–	–	–	3.2×10^{-1}	2.7×10^{-2}
Protactinium-231	–	–	–	–	–	–	–	–	1.1×10^{-5}	1.3×10^{-8}
Thorium-232	–	–	–	–	–	–	–	–	2.2×10^{-1}	6.8×10^{-1}
Uranium-232	–	–	–	–	–	–	–	–	1.8×10^{1}	1.9
Uranium-233	–	–	–	–	5.8×10^{-1}	–	–	–	7.3	1.7×10^{1}
Uranium-234	–	–	–	–	–	–	–	–	3.4×10^{1}	1.6
Uranium-235	–	–	–	–	5.0×10^{-3}	–	–	–	1.5×10^{-1}	3.5×10^{-1}
Uranium-236	–	–	–	–	–	–	–	–	4.2×10^{-2}	7.9×10^{-1}

TABLE B-5 (Cont.)

	GTCC LLRW					GTCC-Like Waste				
		Sealed Sources[c]		Other Waste			Sealed Sources[c]		Other Waste	
Radionuclide	Activated Metals[b]	Actinides	Nonactinides	CH	RH	Activated Metals[b]	Actinides	Nonactinides	CH	RH
Neptunium-237	–	–	–	–	3.1×10^{-3}	–	–	–	1.0	1.5
Uranium-238	–	–	–	–	–	–	–	–	7.0×10^{-2}	1.8
Plutonium-238	4.7×10^{-2}	–	–	–	1.8×10^{1}	–	–	–	1.0×10^{3}	7.5×10^{2}
Plutonium-239	2.8×10^{2}	–	–	–	2.4×10^{1}	–	–	–	7.0×10^{2}	2.7×10^{3}
Plutonium-240	–	–	–	–	7.3	–	–	–	5.6×10^{2}	1.7×10^{3}
Plutonium-241	6.4×10^{-1}	–	–	–	6.0×10^{2}	–	–	–	9.6×10^{3}	1.6×10^{4}
Americium-241	3.8	–	–	5.0	6.4×10^{1}	–	–	–	3.6×10^{3}	5.3×10^{3}
Plutonium-242	–	–	–	–	2.2×10^{-3}	–	–	–	3.5	3.9
Americium-243	–	–	–	–	4.6×10^{-3}	–	–	–	2.7×10^{1}	8.6×10^{1}
Curium-243	–	–	–	–	–	–	–	–	5.3×10^{-2}	1.8
Curium-244	–	–	–	–	5.0	–	6.0	–	1.2	3.8×10^{1}
Curium-245	–	–	–	–	–	–	–	–	2.0×10^{-9}	3.4×10^{2}
Curium-246	–	–	–	–	–	–	–	–	1.9×10^{-11}	5.4×10^{1}

[a] The approach used to develop these activities is given in Argonne (2010) and the references cited therein. The activities represent values at the time the wastes are projected to be available for disposal and are given to two significant figures. Separate estimates were developed for GTCC LLRW and GTCC-like waste. A dash means there are no values for that entry. CH = contact-handled (waste), RH = remote-handled (waste).

[b] All of the activated metal wastes are expected to be RH waste.

[c] All of the sealed source wastes are expected to be CH waste, with the possible exception of two americium-241/beryllium sources.

TABLE B-6 Radionuclide Activity (in curies) of Projected Group 1 GTCC LLRW and GTCC-Like Waste[a]

	GTCC LLRW					GTCC-Like Waste				
		Sealed Sources[c]		Other Waste			Sealed Sources[c]		Other Waste	
Radionuclide	Activated Metals[b]	Actinides	Nonactinides	CH	RH	Activated Metals[b]	Actinides	Nonactinides	CH	RH
Hydrogen-3	6.7×10^{3}	–	–	–	–	–	–	–	5.7×10^{-2}	–
Carbon-14	2.1×10^{4}	–	–	–	1.7×10^{-4}	4.9×10^{2}	–	–	3.0	1.4×10^{-2}
Manganese-54	4.9×10^{4}	–	–	–	2.9×10^{-4}	–	–	–	4.7×10^{-3}	4.8×10^{1}
Iron-55	4.0×10^{7}	–	–	–	1.9×10^{-5}	–	–	–	4.7	1.1×10^{-5}
Nickel-59	1.2×10^{5}	–	–	–	3.3×10^{-3}	2.5	–	–	1.7×10^{-2}	2.0×10^{-3}
Cobalt-60	5.0×10^{7}	–	–	–	2.6×10^{-1}	3.8×10^{3}	–	–	9.8×10^{-5}	8.8×10^{2}
Nickel-63	1.7×10^{7}	–	–	–	1.6×10^{-1}	6.1×10^{2}	–	–	–	9.5×10^{-2}
Strontium-90	1.1×10^{4}	–	–	–	4.6×10^{1}	–	–	–	5.7×10^{1}	7.3×10^{3}
Molybdenum-93	1.0×10^{2}	–	–	–	–	–	–	–	–	–
Niobium-94	5.5×10^{2}	–	–	–	–	1.1×10^{-2}	–	–	–	–
Technetium-99	4.2×10^{3}	–	–	–	2.3×10^{-2}	–	–	–	8.7×10^{-2}	2.1
Iodine-129	1.8	–	–	–	–	–	–	–	4.8×10^{-5}	6.6×10^{-5}
Cesium-137	1.3×10^{4}	–	1.7×10^{6}	–	6.0×10^{1}	–	–	–	6.0×10^{1}	9.5×10^{3}
Promethium-147	–	–	–	–	–	–	–	–	–	–
Samarium-151	–	–	–	–	–	–	–	–	–	–
Europium-152	–	–	–	–	–	–	–	–	–	6.8×10^{2}
Europium-154	–	–	–	–	–	–	–	–	7.5×10^{-2}	2.0×10^{2}
Europium-155	–	–	–	–	–	–	–	–	–	9.1×10^{1}
Lead-210	–	–	–	–	1.5×10^{-10}	–	–	–	–	9.1×10^{-11}
Radium-226	–	–	–	–	–	–	–	–	9.5×10^{-1}	–
Actinium-227	–	–	–	–	–	–	–	–	9.5×10^{-3}	–
Radium-228	–	–	–	–	–	–	–	–	1.2×10^{-1}	–
Thorium-229	–	–	–	–	2.6×10^{-5}	–	–	–	4.9×10^{-1}	1.6×10^{-5}
Thorium-230	–	–	–	–	2.7×10^{-7}	–	–	–	8.8×10^{-2}	1.6×10^{-7}
Protactinium-231	–	–	–	–	–	–	–	–	–	–
Thorium-232	–	–	–	–	–	–	–	–	6.2×10^{-2}	–
Uranium-232	–	–	–	–	–	–	–	–	5.5	5.6×10^{-3}
Uranium-233	–	–	–	–	1.8×10^{-2}	–	–	–	2.1	7.8×10^{2}
Uranium-234	–	–	–	–	–	–	–	–	9.6	2.4×10^{-3}
Uranium-235	–	–	–	–	1.5×10^{-4}	–	–	–	4.1×10^{-3}	3.1×10^{-4}
Uranium-236	–	–	–	–	–	–	–	–	1.2×10^{-2}	–

TABLE B-6 (Cont.)

	GTCC LLRW					GTCC-Like Waste				
		Sealed Sources[c]		Other Waste			Sealed Sources[c]		Other Waste	
Radionuclide	Activated Metals[b]	Actinides	Nonactinides	CH	RH	Activated Metals[b]	Actinides	Nonactinides	CH	RH
Neptunium-237	–	–	–	–	9.5×10^{-5}	–	–	–	1.1×10^{-2}	3.1×10^{-2}
Uranium-238	–	–	–	–	–	–	–	–	2.2×10^{-2}	8.8
Plutonium-238	8.3×10^{-1}	1.2×10^{5}	–	–	5.4×10^{-1}	–	–	–	2.9×10^{2}	7.5×10^{2}
Plutonium-239	4.2×10^{3}	8.4×10^{3}	–	–	7.4×10^{-1}	–	–	–	2.0×10^{2}	2.0×10^{2}
Plutonium-240	–	–	–	–	2.2×10^{-1}	–	2.2×10^{1}	–	1.6×10^{2}	3.4×10^{1}
Plutonium-241	2.4×10^{1}	–	–	–	1.8×10^{1}	–	–	–	4.6×10^{3}	1.0×10^{2}
Americium-241	6.0×10^{1}	1.5×10^{5}	–	–	2.0	–	–	–	7.1×10^{2}	6.0×10^{1}
Plutonium-242	–	–	–	–	6.8×10^{-5}	–	–	–	9.8×10^{-1}	4.1×10^{-5}
Americium-243	–	–	–	–	1.4×10^{-4}	–	3.5×10^{-1}	–	7.5	8.4×10^{-5}
Curium-243	–	–	–	–	–	–	–	–	2.3×10^{-2}	3.4×10^{-1}
Curium-244	–	2.2×10^{1}	–	–	1.5×10^{-1}	–	4.8×10^{1}	–	5.9×10^{-1}	1.1×10^{3}
Curium-245	–	–	–	–	–	–	–	–	–	–
Curium-246	–	–	–	–	–	–	–	–	–	–

[a] The approach used to develop these activities is given in Argonne (2010) and the references cited therein. The activities represent values at the time the wastes are projected to be available for disposal and are given to two significant figures. Separate estimates were developed for GTCC LLRW and GTCC-like waste. A dash means there are not values for that entry. CH = contact-handled (waste), RH = remote-handled (waste).

[b] All of the activated metal wastes are expected to be RH waste.

[c] All of the sealed source wastes are expected to be CH waste, with the possible exception of two americium-241/beryllium sources.

TABLE B-7 Radionuclide Activity (in curies) of Group 2 GTCC LLRW and GTCC-Like Waste[a]

	GTCC LLRW					GTCC-Like Waste				
		Sealed Sources[c]		Other Waste			Sealed Sources		Other Waste	
Radionuclide	Activated Metals[b]	Actinides	Nonactinides	CH	RH	Activated Metals[b]	Actinides	Nonactinides	CH	RH
Hydrogen-3	3.6×10^{3}	–	–	2.0×10^{2}	1.9×10^{2}	–	–	–	1.1×10^{-1}	1.7×10^{-1}
Carbon-14	1.0×10^{4}	–	–	4.4	1.5×10^{2}	–	–	–	5.9	9.0
Manganese-54	2.3×10^{4}	–	–	–	1.8×10^{-7}	–	–	–	9.4×10^{-3}	1.4×10^{-2}
Iron-55	1.8×10^{7}	–	–	3.9×10^{-1}	3.1	–	–	–	9.4	1.4×10^{1}
Nickel-59	5.4×10^{4}	–	–	3.3×10^{-2}	2.1	–	–	–	3.3×10^{-2}	5.1×10^{-2}
Cobalt-60	2.3×10^{7}	–	–	6.5	4.8×10^{1}	–	–	–	2.0×10^{-4}	3.0×10^{-4}
Nickel-63	7.5×10^{6}	–	–	3.7	1.8×10^{2}	–	–	–	–	–
Strontium-90	1.3×10^{4}	–	–	2.8	1.0×10^{5}	–	–	–	6.1	5.1×10^{4}
Molybdenum-93	4.7×10^{1}	–	–	–	5.5×10^{-5}	–	–	–	–	–
Niobium-94	2.7×10^{2}	–	–	1.0×10^{-3}	2.8×10^{-2}	–	–	–	–	–
Technetium-99	1.9×10^{3}	–	–	1.0×10^{-3}	1.7×10^{1}	–	–	–	1.3×10^{-1}	3.2
Iodine-129	2.1	–	–	2.9×10^{-3}	5.4×10^{-2}	–	–	–	–	3.8×10^{-3}
Cesium-137	2.3×10^{4}	–	–	2.2×10^{1}	1.1×10^{5}	–	–	–	3.3	3.4×10^{5}
Promethium-147	1.1×10^{-1}	–	–	–	1.7×10^{5}	–	–	–	–	4.4×10^{3}
Samarium-151	1.7×10^{2}	–	–	–	2.4×10^{3}	–	–	–	–	–
Europium-152	3.3×10^{-1}	–	–	–	1.1	–	–	–	–	–
Europium-154	1.8×10^{1}	–	–	–	5.9×10^{1}	–	–	–	1.5×10^{-1}	2.3×10^{-1}
Europium-155	7.0×10^{-1}	–	–	–	2.0×10^{3}	–	–	–	–	–
Lead-210	3.3×10^{-7}	–	–	–	5.1×10^{-7}	–	–	–	–	–
Radium-226	1.5×10^{-6}	–	–	–	2.5×10^{-6}	–	–	–	1.9	2.9
Actinium-227	1.1×10^{-2}	–	–	–	1.8×10^{-2}	–	–	–	1.9×10^{-2}	2.9×10^{-2}
Radium-228	3.2×10^{-4}	–	–	–	5.6×10^{-4}	–	–	–	2.4×10^{-1}	3.6×10^{-1}
Thorium-229	1.2×10^{-2}	–	–	–	2.2×10^{-2}	–	–	–	9.8×10^{-1}	1.5
Thorium-230	1.3×10^{-4}	–	–	–	2.4×10^{-4}	–	–	–	1.8×10^{-1}	2.7×10^{-1}
Protactinium-231	3.0×10^{-2}	–	–	–	5.2×10^{-2}	–	–	–	–	–
Thorium-232	3.2×10^{-3}	–	–	–	5.6×10^{-3}	–	–	–	1.2×10^{-1}	1.9×10^{-1}
Uranium-232	1.4	–	–	–	2.9	–	–	–	1.1×10^{1}	1.7×10^{1}
Uranium-233	3.8	–	–	–	7.4	–	–	–	4.1	6.4
Uranium-234	2.0×10^{-1}	–	–	9.7×10^{-3}	3.9×10^{-1}	–	–	–	1.9×10^{1}	2.9×10^{1}
Uranium-235	7.2×10^{-2}	–	–	4.8×10^{-4}	3.7	–	–	–	8.0×10^{-3}	1.4×10^{-2}
Uranium-236	1.1×10^{-1}	–	–	–	4.4×10^{-1}	–	–	–	2.4×10^{-2}	3.6×10^{-2}

TABLE B-7 (Cont.)

	GTCC LLRW					GTCC-Like Waste				
		Sealed Sources[c]		Other Waste			Sealed Sources		Other Waste	
Radionuclide	Activated Metals[b]	Actinides	Nonactinides	CH[d]	RH	Activated Metals[b]	Actinides	Nonactinides	CH	RH
Neptunium-237	6.7×10^{-2}	–	–	3.4×10^{-9}	9.9×10^{-2}	–	–	–	2.2×10^{-2}	2.3
Uranium-238	8.4×10^{-1}	–	–	1.0×10^{-2}	3.1	–	–	–	3.9×10^{-2}	7.3×10^{-2}
Plutonium-238	1.3×10^{2}	–	–	2.1×10^{4}	2.1×10^{2}	–	–	–	5.7×10^{2}	1.9×10^{3}
Plutonium-239	2.1×10^{3}	–	–	4.9×10^{1}	4.5×10^{2}	–	–	–	4.0×10^{2}	6.4×10^{2}
Plutonium-240	1.6×10^{2}	–	–	4.5×10^{1}	2.4×10^{2}	–	–	–	3.2×10^{2}	5.1×10^{2}
Plutonium-241	2.5×10^{3}	–	–	2.7×10^{3}	3.9×10^{3}	–	–	–	9.3×10^{3}	1.5×10^{4}
Americium-241	7.2×10^{2}	–	–	1.2×10^{-2}	1.0×10^{3}	–	–	–	1.4×10^{3}	2.6×10^{3}
Plutonium-242	1.4×10^{-1}	–	–	4.4×10^{-2}	2.0×10^{-1}	–	–	–	2.0	3.0
Americium-243	1.1	–	–	6.8×10^{-4}	6.8×10^{-1}	–	–	–	1.5×10^{1}	2.3×10^{1}
Curium-243	1.4×10^{-1}	–	–	7.4×10^{-6}	2.4×10^{-1}	–	–	–	3.9×10^{-2}	3.9
Curium-244	8.0	–	–	4.9×10^{-3}	5.3	–	–	–	1.0	9.1×10^{1}
Curium-245	8.0×10^{-4}	–	–	–	1.3×10^{-3}	–	–	–	–	–
Curium-246	6.4×10^{-5}	–	–	–	1.1×10^{-4}	–	–	–	–	–

[a] There is a large degree of uncertainty in the schedules and plans for the projects that will generate these wastes. The approach used to develop these activities is given in Argonne (2010) and the references cited therein. The activities represent values at the time the wastes are projected to be available for disposal and are given to two significant figures. Separate estimates were developed for GTCC LLRW and GTCC-like waste. All of these wastes will be generated in the future, and there are no Group 2 GTCC-like activated metal and sealed source wastes. A dash means there is no value for that entry. CH = contact-handled (waste), RH = remote-handled (waste).

[b] All of the activated metal wastes are expected to be RH waste.

[c] The radionuclide activities for the small volume of sealed sources in the SDA are included with the activities reported for the GTCC LLRW Other Waste - RH category.

Most of the radionuclide activity in the wastes being addressed in this EIS is associated with the neutron activation products in commercial nuclear reactors (i.e., GTCC LLRW activated metals). The sealed sources contribute a relatively small amount to the total radionuclide activity, with the exception of cesium-137 (Cs-137), which has a half-life of about 30 years. While the total activity of the Other Waste is significantly lower than that of the activated metal waste, much of this activity is attributable to long-lived TRU radionuclides. These long-lived radionuclides are important in evaluating the viability of various disposal alternatives in this EIS.

To provide additional perspective on these radionuclide activities, the key properties of the major radionuclides discussed in this appendix are given in Table B-8. This table identifies the major modes of decay for the 44 radionuclides given in Tables B-4 through B-7, along with the half-lives and radiation energies of the alpha and beta particles and photons (gamma rays and x-rays) emitted by these radionuclides. Also indicated are the short-lived radionuclides that accompany these 44 radionuclides.

The information in Tables B-4 through B-7 is useful in assessing the long-term impacts associated with disposing of these wastes at the various sites evaluated in this EIS. The impacts associated with waste handling and transportation were developed by using radionuclide profiles specific to the various waste streams. As noted previously, the activities given here represent information from available sources, and they were decay-corrected to provide a common basis for the EIS analysis.

B.3 PHYSICAL CHARACTERISTICS OF THE WASTES

Following is a description of the physical characteristics of the three waste types (i.e., activated metals, sealed sources, and Other Waste).

B.3.1 Activated Metals

The activated metal waste consists of steel, stainless-steel, and a number of specialty alloys used in nuclear reactors. Portions of the reactor assembly and other components near the nuclear fuel are activated by high fluxes of neutrons during reactor operations for long periods of time, and high concentrations of some radionuclides are produced. Many of these radionuclides have very short half-lives and decay rapidly, while others have longer half-lives and remain radioactive for an extended period of time. Most of the activated metal waste will be generated in the future from the decommissioning of commercial nuclear power reactors.

Only a very small fraction of the metallic waste generated from decommissioning commercial nuclear power plants will be GTCC LLRW. Most of the waste will be Class A, B, or C LLRW that can be disposed of at existing commercial radioactive waste disposal sites. For purposes of analysis in the EIS, all of the GTCC LLRW activated metal waste is considered to be remote-handled (RH) waste on the basis of the expected high concentrations of gamma-emitting radionuclides in this material. This waste will need a significant amount of shielding to reduce the levels of radiation to acceptable levels and/or will have to be handled remotely. RH waste is

TABLE B-8 Key Properties of the Major Radionuclides Addressed in This EIS[a]

				Radiation Energy per Decay (MeV)		
Radionuclide	Half-Life	Specific Activity (Ci/g)	Decay Mode	Alpha (α)	Beta (β)	Photon (γ)
Actinium-227[b]	22 yr	73	α, β	0.068	0.016	<0.001
Thorium-227 (99%)	*19 days*	*31,000*	*α*	*5.9*	*0.053*	*0.11*
Francium-223 (1%)	*22 min*	*39 million*	*β*	*-*	*0.40*	*0.059*
Radium-223	*11 days*	*52,000*	*α*	*5.7*	*0.076*	*0.13*
Radon-219	*4.0 s*	*13 billion*	*α*	*6.8*	*0.0063*	*0.056*
Polonium-215	*0.0018 s*	*30 trillion*	*α*	*7.4*	*<0.001*	*<0.001*
Lead-211	*36 min*	*25 million*	*β*	*-*	*0.46*	*0.051*
Bismuth-211	*2.1 min*	*420 million*	*α*	*6.6*	*0.010*	*0.047*
Thallium-207	*4.8 min*	*190 million*	*β*	*-*	*0.49*	*0.0022*
Americium-241	430 yr	3.5	α	5.5	0.052	0.033
Americium-243	7,400 yr	0.20	α	5.3	0.022	0.056
Neptunium-239	*2.4 days*	*230,000*	*β*	*-*	*0.26*	*0.17*
Carbon-14	5,700 yr	4.5	β	-	0.049	-
Cesium-137	30 yr	88	β	-	0.19	-
Barium-137m (95%)[c]	*2.6 min*	*540 million*	*IT*	*-*	*0.065*	*0.60*
Cobalt-60	5.3 yr	1,100	β	-	0.097	2.5
Curium-243	29 yr	52	α	5.8	0.14	0.13
Curium-244	18 yr	82	α	5.8	0.086	00017
Curium-245	8,500 yr	0.17	α	5.4	0.065	0.096
Curium-246	4,700 yr	0.31	α	5.4	0.0080	0.0015
Europium-152	13 yr	180	β, EC	-	0.14	1.2
Europium-154	8.8 yr	270	β	-	0.29	1.2
Europium-155	5.0 yr	470	β	-	0.063	0.061
Hydrogen-3	12 yr	9,800	β	-	0.0057	-
Iodine-129	16 million yr	0.00018	β	-	0.064	0.025
Iron-55	2.7 yr	2,400	EC	-	0.0042	0.0017
Lead-210	22 yr	77	β	-	0.038	0.0048
Bismuth-210	*5.0 days*	*130,000*	*β*	*-*	*0.39*	*-*
Polonium-210	*140 days*	*4,500*	*α*	*5.3*	*<0.001*	*<0.001*
Manganese-54	310 days	7,700	EC	-	0.0042	0.84
Molybdenum-93	3,500 yr	1.1	EC	-	0.0055	0.011
Niobium-93m	*14 yr*	*280*	*IT*	*-*	*0.028*	*0.0019*
Neptunium-237	2.1 million yr	0.00071	α	4.8	0.070	0.035
Protactinium-233	*27 days*	*21,000*	*β*	*-*	*0.20*	*0.20*
Nickel-59	75,000 yr	0.082	EC	-	0.0046	0.0024
Nickel-63	96 yr	60	β	-	0.17	-
Niobium-94	20,000 yr	0.19	β	-	0.17	1.6
Plutonium-238	88 yr	17	α	5.5	0.011	0.0018
Plutonium-239	24,000 yr	0.063	α	5.1	0.0067	<0.001
Plutonium-240	6,500 yr	0.23	α	5.2	0.011	0.0017
Plutonium-241	14 yr	100	β	<0.001	0.0052	<0.001
Plutonium-242	380,000 yr	0.0040	α	4.9	0.0087	0.0014
Promethium-147	2.6 yr	940	β	-	0.062	<0.001
Samarium-147	*110 billion yr*	*0.000000023*	*α*	*2.2*	*-*	*-*
Protactinium-231	33,000 yr	0.048	α	5.0	0.065	0.048
Radium-226	1600 yr	1.0	α	4.8	0.0036	0.0067
Radon-222	*3.8 days*	*160,000*	*α*	*5.5*	*<0.001*	*<0.001*
Polonium-218	*3.1 min*	*290 million*	*α*	*6.0*	*<0.001*	*<0.001*
Lead-214	*27 min*	*33 million*	*β*	*-*	*0.29*	*0.25*
Bismuth-214	*20 min*	*45 million*	*β*	*-*	*0.66*	*1.5*
Polonium-214	*0.00016 s*	*330 trillion*	*α*	*7.7*	*<0.001*	*<0.001*

TABLE B-8 (Cont.)

				Radiation Energy per Decay (MeV)		
Radionuclide	Half-Life	Specific Activity (Ci/g)	Decay Mode	Alpha (α)	Beta (β)	Gamma (γ)
Radium-228	5.8 yr	280	β	-	0.017	<0.001
Actinium-228	*6.1 h*	*2.3 million*	*β*	-	*0.48*	*0.97*
Thorium-228	*1.9 yr*	*830*	*α*	*5.4*	*0.021*	*0.0033*
Samarium-151	90 yr	27	β	-	0.020	<0.001
Strontium-90	29 yr	140	β	-	0.20	-
Yttrium-90	*64 h*	*550,000*	*β*	-	*0.94*	*<0.001*
Technetium-99	210,000 yr	0.017	β	-	0.10	-
Thorium-229	7,300 yr	0.22	α	4.9	0.12	0.096
Radium-225	*15 days*	*40,000*	*β*	-	*0.11*	*0.014*
Actinium-225	*10 days*	*59,000*	*α*	*5.8*	*0.022*	*0.018*
Francium-221	*4.8 min*	*180 million*	*α*	*6.3*	*0.010*	*0.031*
Astatine-217	*0.032 s*	*1.6 trillion*	*α*	*7.1*	*<0.001*	*<0.001*
Bismuth-213	*46 min*	*20 million*	*α, β*	*0.13*	*0.44*	*0.13*
Polonium-213 (98%)	*0.0000042 s*	*13,000 trillion*	*α*	*8.4*	-	-
Thallium-209 (2%)	*2.2 min*	*410 million*	*β*	-	*0.69*	*2.0*
Lead-209	*3.3 h*	*4.7 million*	*β*	-	*0.20*	-
Thorium-230	77,000 yr	0.020	α	4.7	0.015	0.0016
Thorium-232	14 billion yr	0.00000011	α	4.0	0.012	0.0013
Uranium-232	72 h	22	α	5.3	0.017	0.0022
Uranium-233	160,000 yr	0.0098	α	4.8	0.0061	0.0013
Uranium-234	240,000 yr	0.0063	α	4.8	0.013	0.0017
Uranium-235	700 million yr	0.0000022	α	4.4	0.049	0.16
Thorium-231	*26 h*	*540,000*	*β*	-	*0.17*	*0.026*
Uranium-236	23 million yr	0.000065	α	4.5	0.011	0.0016
Uranium-238	4.5 billion yr	0.00000034	α	4.2	0.010	0.0014
Thorium-234	*24 days*	*23,000*	*β*	-	*0.060*	*0.0093*
Protactinium-234m	*1.2 min*	*690 million*	*β*	-	*0.82*	*0.012*

[a] This table provides a summary of the key radioactive properties of the major radionuclides addressed in this EIS. Many of these radionuclides have short-lived decay products, which will accompany them in the wastes or be present in the future as a result of ingrowth. These associated radionuclides are indicated in italics following the parent radionuclide. A hyphen means the entry is not applicable. EC = electron capture, IT = isomeric transition, Ci = curie, g = gram, and MeV = million electron volts. Values are given to two significant figures and were obtained from Appendix G of Federal Guidance Report Number 13 issued by the U.S. Environmental Protection Agency (EPA 1999) and Publication 38 of the International Commission on Radiological Protection (ICRP 1983).

[b] Some radionuclides, such as actinium-227 and bismuth-213, decay by more than one mode. Where this occurs and the resultant decay products are also radioactive, the relative percentages of the decay products are indicated in the table.

[c] An “m” following the isotopic number, such as barium-137m, indicates that this radionuclide is metastable and reaches a more stable energy configuration by isomeric transition, generally accompanied with one or more gamma rays.

defined to be radioactive waste with contact dose rates greater than 200 millirem per hour (mrem/h). The physical form of this waste is solid metal, which is both physically and chemically inert.

B.3.2 Sealed Sources

Sealed sources typically consist of concentrated radioactive material encapsulated in relatively small containers made of titanium, stainless-steel, or other metals. These sources are commonly used to sterilize medical products, detect flaws and failures in pipelines and metal welds, determine the moisture content in soil and other materials, and diagnose and treat illnesses such as cancer. Only a small fraction of the sealed sources are GTCC LLRW, depending upon the quantity (curies) and half-life of the specific radionuclide present in the source. Most sealed sources are Class A, B, or C LLRW and can be disposed of at existing commercial LLRW disposal facilities, subject to facility waste acceptance criteria and state/compact requirements. The sealed sources that are GTCC LLRW are those that represent a long-term hazard to human health and the environment and exceed the radionuclide concentrations for classification as Class C LLRW given in Title 10, Section 61.55, of the *Code of Federal Regulations* (10 CFR 61.55).

Essentially all of the sealed sources being addressed in this EIS are in Group 1. There are two categories of sealed sources considered in this EIS: small sealed sources and large Cs-137 irradiators. For purposes of analysis, it is assumed that the small GTCC LLRW sealed sources will be packaged in 208-L (55-gal) drums by radionuclide on the basis of packaging factor limits developed by the DOE Global Material Security/Off-Site Source Recovery Project (GMS/OSRP) at Los Alamos National Laboratory (LANL). About 8,700 drums are estimated to be required to dispose of these packaged sealed sources.

In addition to these small sealed sources, there are 1,435 large Cs-137 irradiators in the waste inventory, each with an assumed volume of 0.71 m^3 (25 ft^3). These irradiators cannot be packaged in 208-L (55-gal) drums and are assumed to be disposed of individually in their original shielded devices. In these irradiators, the Cs-137 source is contained within a very robust shielded device, which is expected to retain its integrity for many years following disposal.

Sealed sources can encompass several physical forms, including ceramic oxides, salts, or metals. Cesium chloride salt was generally used in older Cs-137 sources, and newer small sources typically have the radionuclide bonded in a ceramic. Of these two forms, cesium chloride salt is much more water soluble. For this EIS, all of the Cs-137 sources are assumed to be present as cesium chloride salt. For the rest of the sealed sources, the radionuclides are assumed to be in the form of oxides. These oxide sources are likely to be in the form of pellets (Sandia 2008). While there are some sealed sources currently in storage, most of this waste will be generated in the future.

Sealed sources generally have relatively low dose rates when packaged for disposal. As noted in Sandia (2008), all of the packaged sealed sources are expected to be contact-handled (CH) waste, with the exception of two americium-241/beryllium sources. For purposes of analysis in this EIS, CH waste is waste for which the contact dose rates on the surface of the package are less than 200 mrem/h. If RH sealed-source wastes are generated, appropriate precautions will be taken to protect workers during waste handling and disposal operations.

B.3.3 Other Waste

Other Waste consists of a wide variety of materials, including contaminated equipment, debris, scrap metal, glove boxes, filters, resins, soil, solidified sludges, and other materials. This type of waste includes those GTCC LLRW and GTCC-like wastes that do not fall into one of the other two types (activated metals or sealed sources). Other Waste can come in a number of physical forms, and a range of radionuclides may be present. About 58% of the Other Waste is RH waste, and 42% is CH waste.

Much of the waste in this category is associated with the West Valley Site. Decontamination and decommissioning activities at the West Valley Site would generate both GTCC LLRW and GTCC-like wastes, with the possible exhumation of the NDA and SDA generating all of the GTCC LLRW at this site. It is expected that most of the GTCC-like Other Waste associated with the West Valley Site would meet the DOE definition of TRU waste. This waste might have originated from non-defense activities and therefore might not be authorized for disposal at WIPP under the WIPP LWA as amended (P.L. 102-579 as amended by P.L. 104-201). In addition to the Other Waste associated with the West Valley Site, this waste type includes GTCC LLRW from two commercial Mo-99 production projects and GTCC-like waste from a planned DOE Pu-238 production project.

It is assumed for purposes of analysis in this EIS that the radionuclides in Other Waste can leach out somewhat readily when exposed to water. Therefore, it is assumed that the Other Waste would be stabilized with grout or another matrix prior to being shipped to the disposal facilities considered in this EIS, as appropriate.

B.4 ASSUMED WASTE GENERATION TIMES

The waste generation times assumed for purposes of analysis in the EIS are shown in Figure 3.4.2-1. As shown in this figure, much of the waste is assumed to be generated and received at the alternative disposal facilities before 2035.

The GTCC LLRW and GTCC-like waste disposal facility is assumed to be available to receive wastes in 2019, and at that time, the GTCC LLRW and GTCC-like waste in storage would begin to be transported to the disposal facility. The actual start date for operations is uncertain at this time and dependent upon, among other things, the alternative or alternatives selected, additional NEPA review as required, characterization studies, and other actions necessary to initiate and complete construction and operation of a GTCC LLRW and GTCC-like waste disposal facility. For purposes of analysis in the EIS, DOE assumed a start date of disposal operations in 2019. However, given these uncertainties, the actual start date could vary. As shown in Table B-1, the current volume of stored GTCC LLRW and GTCC-like waste is about

1,100 m^3 (39,000 ft^3), and this volume is expected to increase somewhat over the next nine years. While very little additional activated metal from decommissioning commercial nuclear reactors would be generated before 2019, the volumes of sealed sources and Other Waste would increase as sealed sources would continue to become disused and a number of ongoing projects that would generate GTCC-like waste would be completed.

A number of assumptions were made in developing the assumed generation and waste receipt rates. For the Group 1 wastes, future inventory estimates are projected to 2035 for Other Waste, 2062 for activated metals, and 2083 for sealed sources. The time period used for activated metal waste accounts for the decommissioning of all currently NRC-licensed commercial nuclear power plants, which will produce most of the radionuclide activity for Group 1 wastes. Many nuclear utilities are currently seeking and being granted extensions to their operating licenses from NRC. These extensions are generally for about 20 years. Assuming that all commercial nuclear power reactors receive 20-year license extensions, the last currently operating nuclear power plant will cease operation in 2056. It is assumed that a 6-year cooling period occurs before decommissioning operations commence and these wastes become available for disposal. When one year is allowed for disposal, all such waste will be disposed of by 2062 (Sandia 2008).

The time period for Group 1 Other Waste reflects a reasonable amount of time for addressing the indicated wastes. Many of these wastes are associated with the West Valley Site, and activities that could generate Group 1 wastes at this site are expected to be completed before 2035. The waste volumes and activities for the Other Waste generated by other sources are comparatively small and well defined. The time period for Group 1 sealed sources is consistent with the assumption used to address the future decommissioning of Group 2 commercial nuclear power reactors.

All of the wastes in Group 2 will be generated in the future. Some of these facilities may or may not be constructed and operated as currently envisioned, so these projections have a high degree of uncertainty associated with them. This situation contrasts with that of the Group 1 wastes, some of which are already in storage and the rest of which are expected to be generated from currently operating facilities.

The same approach as that used for the Group 1 activated metal wastes from commercial nuclear reactors was used for comparable Group 2 wastes from proposed new reactors. Although the schedules for new commercial reactors are subject to change, it is projected that activated metal wastes from decommissioning these reactors would be generated to 2083. A total of 33 new reactors were assumed to estimate the volumes and radionuclide activities for these wastes, consistent with information provided by the NRC (NRC 2009). As was the case for the Group 1 activated metal wastes, it is assumed that the new reactors would have a 60-year operational life and that a 6-year cooling period would occur before decommissioning operations would commence and these wastes would become available for disposal.

All other GTCC LLRW and GTCC-like waste in Group 2 are expected to be disposed of shortly after generation. Most of the Group 2 GTCC LLRW is associated with the assumed exhumation of the NDA and SDA at the West Valley Site. For purposes of analysis in the EIS, it is assumed that a decision to exhume these wastes would be made within 10 years of the *Record* *of Decision: Final Environmental Impact Statement for Decommissioning and/or Long-Term Stewardship at the West Valley Demonstration Project and Western New York Nuclear Service Center* (DOE 2010b) and that these wastes would be exhumed from 2020 to 2035. This is a conservative approach, because if the wastes were exhumed later, additional radioactive decay would occur prior to generation of this GTCC LLRW and GTCC-like waste. As noted previously, it is assumed that the interim on-site storage of wastes from the two planned commercial Mo-99 production projects and the planned DOE Pu-238 production project would allow for decay of the short-lived radionuclides in these wastes.

B.5 PACKAGING ASSUMPTIONS

Packaging and shipment configurations vary among Alternatives 2, 3, 4, and 5. Section B.5.1 provides the assumptions used for the land disposal alternatives (3, 4, and 5). The assumptions for disposal at WIPP (Alternative 2) are discussed in Section B.5.2.

B.5.1 Land Disposal

For the purpose of this EIS, GTCC LLRW and GTCC-like waste are assumed to be transported by truck and rail to a disposal facility in Type B shipping packages. There are more truck casks readily available for shipping CH waste than for shipping RH waste, especially RH waste with external radiation dose rates on the order of 1,000 rem/h at the container surface. Rates this high are characteristic of the activated metal waste discussed in Section B.3.1. On the other hand, a number of rail casks can accommodate waste containers and payloads that are larger than those handled by truck casks, and the rail casks also have sufficient shielding for waste with high external radiation dose rates. Table B-9 provides examples of shipping packages that could be used for the transport of GTCC LLRW and GTCC-like waste, some of which are discussed further in Sections B.5.1.1 and B.5.1.2. Note that not all GTCC LLRW or GTCC-like waste would necessarily require shipment in Type B packaging as discussed in Section C.9.4.2. Because the levels of radioactivity of the CH waste (including the sealed sources) in their Type A containers (i.e., 208-L [55-gal] drums and SWBs) are assumed to be near the upper limits specified in 10 CFR Part 71, with multiple drums or SWBs per shipment, Type B shipping packaging is assumed for this analysis. However, at the time of actual shipment, all GTCC LLRW and GTCC-like waste would be packaged in compliance with applicable radioactive material transportation safety regulations, and Type B packaging might not be required, depending on the characteristics of the waste to be transported.

B.5.1.1 Contact-Handled Waste

A common container for the storage and disposal of CH and RH GTCC LLRW and GTCC-like waste is the 208-L (55-gal) drum (referred to as drum(s) in the remainder of this appendix). In addition, some stored and projected CH wastes may be packaged for disposal in standard waste boxes (SWBs). This EIS assumes that the disposal of CH waste, with the exception of Cs-137 irradiators, will be in drums and SWBs. The Transuranic Package

TABLE B-9 Representative Sample of Type B Shipping Packages with the Potential for Transporting GTCC LLRW and GTCC-Like Waste[a]

Package	Internal Diameter in m (in.)	Internal Length in m (in.)	Maximum Payload in kg (lb)	Maximum Gross Weight in kg (lb)	Waste Type		Transport Mode	
					CH	RH[b]	Truck[c]	Rail
TRUPACT-II	1.85 (73)	1.91 (75)	3,300 (7,265)	8,700 (19,250)	X		X	
HalfPACT	1.85 (73)	1.14 (45)	3,400) (7,600)	8,200 (18,100)	X		X	
CNS 10-160B	1.73 (68)	1.96 (77)	6,600 (14,500)	32,700 (72,000)		X	X	
RH 72-B	0.79 (31)	3.30 (130)	3,600 (8,000)	15,200 (33,500)		X	X	
CNS 3-55[d]	0.91 (36)	2.82 (111)	4,200 (9,220)	31,800 (70,000)		X	X	
3-60B[e]	0.89 (35)	2.82 (111)	4,300 (9,500)	36,300 (80,000)		X	X	
TN-RAM	0.89 (35)	2.82 (111)	4,300 (9,500)	36,300 (80,000)		X	X	
NAC STC	1.80 (71)	4.19 (165)	8,500 (18,700)[f]	118,000 (260,000)		X		X
NAC UMS	1.73 (68)	4.90 (193)	9,100 (20,000)[f]	113,000 (250,000)		X		X
125-B	1.30 (51)	4.90 (193)	20,000 (44,000)	82,300 (181,500)		X		X
TS 125	1.70 (67)	4.90 (193)	38,000 (85,000)	129,000 (285,000)		X		X

[a] The packages' internal dimensions and weight limits were taken from NRC (2006).

[b] Casks designed to handle RH waste may also transport CH waste.

[c] Truck casks may also be used for rail transport.

[d] The certificate of compliance expired in October 2008 and will not be renewed.

[e] Proposed design intended for replacement of the CNS 3-55 cask (Carlson et al. 2006; NRC 2007).

[f] Listed payload weight is that specified for the transport of GTCC LLRW and GTCC-like waste.

Transporter-II (TRUPACT-II) Type B package (DOE 2005) is an example of what can be used to transport the CH waste for disposal. This package is in widespread use for similar types of waste and can be used for both truck and rail transport. Two common shipping configurations of waste used with the TRUPACT-II are two stacked 7-drum packs (seven 208-L [55-gal] drums in a close-packed hexagonal unit) or two stacked SWBs.

For the purposes of this EIS, the external volume occupied by a drum is assumed to be 0.267 m^3 (9.43 ft^3), which assumes a right circular cylinder with an outside diameter of 0.610 m (2.0 ft) and a length of 0.914 m (3.0 ft). This external volume is in the upper range of 0.226 to

0.283 m^3 (8 to 10 ft^3) (DOE 2006a) that is expected for these types of drums at an LLRW disposal site but is not considered to be overly conservative. The internal volume of a 208-L (55-gal) drum is 0.208 m^3 (7.34 ft^3). The outside dimensions of an SWB are 1.80 m (71 in.) in length, 1.37 m (54 in.) in width, and 0.94 m (37 in.) in height (DOE 2004). The approximate internal and external volumes of an SWB are 1.88 m^3 (66.4 ft^3) and 2.08 m^3 (73.4 ft^3), respectively. SWBs are rounded on the ends for use as shipping containers within TRUPACT-II shipping casks, with two SWBs to a cask in a stacked configuration.

While other shipping configurations (e.g., 321- and 378-L [85- and 100-gal] drums, as well as 10-drum overpacks) might be possible with the TRUPACT-II or other casks, their use is not considered in this EIS, but the use of other types of containers could be accommodated in the current disposal facility designs discussed in Appendix D. Also, GTCC LLRW and GTCC-like CH waste may be found in storage in containers larger than SWBs at some sites, but there are currently no viable casks available for transport. Packing arrangements in the CH disposal units could be modified accordingly in the future if such packages became available (e.g., the TRUPACT-III [DOE 2007]).

B.5.1.2 Remote-Handled Waste

A number of Type B casks are available for the transport of RH waste. Selection of the proper cask will depend on the external dose rate and the use of the appropriate shipping container or canister for a given cask. Except for activated metal waste (which has a high external dose rate similar to spent nuclear fuel), the majority of the RH wastes being considered for disposal can be packaged in drums and shipped in truck casks, such as the RH 72-B (DOE 2006b) and 10-160B (NRC 2005), or in a rail cask (such as the Nuclear Assurance Corp. [NAC] STC). This EIS assumes that all RH waste, except for activated metal waste, is packaged for disposal in drums. If shipped in the RH 72-B cask, three drums can be packaged in an RH canister (DOE 1995) that is designed for use with this cask. The RH canister has a length of 3.07 m (121 in.), a diameter of 0.66 m (26 in.), a wall that is 0.64-cm (0.25-in.) thick, and an internal volume of 0.89 m^3 (31.4 ft^3). As an alternative, RH waste can be loaded directly into the canister for disposal (DOE 2006c). The proposed land disposal facility designs in Appendix D can accommodate both drums and RH canisters.

Activated metal is assumed to be packaged in unshielded right circular stainless-steel canisters (activated metal canisters ([AMCs]). To facilitate potential shipment by truck as well as rail and to provide flexibility in the facility design as discussed in Appendix D, the size and weight of these canisters were selected to be compatible with existing containers and weight limitations of truck casks. AMCs are assumed to have an external length of 1.22 m (48 in.), an outside diameter of 0.66 m (26 in.), an external volume of 0.418 m^3 (14.8 ft^3), and an internal volume of 0.370 m^3 (13.1 ft^3), with a wall thickness of 1.27 cm (0.5 in.) and an end plate thickness of 2.54 cm (1 in.). The external diameter of 0.66 m (26 in.) was chosen to match that of the RH canister (DOE 1995) and remain close to the 0.61-m (24-in.) diameter of drums used for RH waste disposal. A loaded AMC is estimated to weigh approximately 2,600 kg (5,800 lb). This weight was based on a fill fraction of 75% (Sandia 2007). Additional discussion on the size of the AMCs in relation to RH disposal is presented in Appendix D.

Most Type B casks would need to be recertified to transport activated metals. A recent investigation of appropriate truck and rail casks for the transport of activated metals showed that few options are available, primarily because of the cargo's high external radiation dose rates (Carlson et al. 2006). The certificate of compliance for the heavily shielded CNS 3-55 truck cask is no longer valid (it expired in October 2008). However, Energy Solutions may be in the process of supplying an equivalent replacement, the 3-60B cask (NRC 2007). The TN-RAM is also a candidate truck cask, but only one cask is in existence (Carlson et al. 2006). On the other hand, the TN-RAM and/or the CNS 3-55 design could be used as the basis for another certificate of compliance submittal. Both the 3-60B and TN-RAM designs have a payload capacity of 4,300 kg (9,500 lb) and internal dimensions that could support a longer AMC.

The present length of the AMC was selected to keep it compatible with the RH 72-B and 10-160B packages. For containers with lower dose rates, an AMC could be shipped with spacers in the RH 72-B, which has a 3,600-kg (8,000-lb) payload. The 10-160B is certified to transport activated metal and has a 6,580-kg (14,500-lb) payload. However, additional shielding would be needed for any AMCs with radiation dose rates on the order of 1,000 rem/h at contact. The payload limit includes any additional shielding and bracing that would be needed, which would likely require recertification of the package.

B.5.2 Waste Isolation Pilot Plant

The assumptions about the packaging used to dispose of CH waste are the same for disposal at WIPP and for the land disposal options. However, it is assumed that RH waste would be packaged in one of the two shielded containers discussed below, so it could be handled as CH waste in order to optimize disposal space at WIPP (Sandia 2007, 2008). Both truck and rail transport modes are considered for shipment of GTCC LLRW and GTCC-like waste to WIPP.

For activated metal and RH waste with higher external dose rates, packaging in canisters with a diameter of 0.71 m (28 in.), height of 1.4 m (55 in.), and inner cavity dimensions of 0.47 m (18.4 in.) in diameter and 1.15 m (45.4 in.) in length is assumed. The canister is fitted with a 9.71-cm (3.825-in.) lead shield to reduce radiation rates at the surface to less than 200 mrem/h (Sandia 2007). The canister is based on an older AMC design and should not be confused with the AMCs used in this EIS as described in Section B.5.1.2; it is referred to as a half-shielded activated metal canister (h-SAMC) in this EIS. A loaded canister is estimated to weigh 4,190 kg (9,220 lb). For truck transport, only one h-SAMC is assumed per shipment; there is one h-SAMC per truck Type B package. Three h-SAMCs are assumed per rail Type B package.

RH waste with lower external dose rates is assumed to be packaged in lead-shielded containers currently undergoing certification for use at WIPP (DOE undated). These containers are roughly the size of 208-L (55-gal) drums with a 2.54-cm (1-in.) lead liner designed to hold a 113-L (30-gal) drum of RH waste. One HalfPACT type B package can transport one three-pack (DOE undated).

B.6 SITE INVENTORIES AND SHIPMENTS

The number of shipments from a generator site to a disposal facility depends on the type of waste, the amount of waste, the packaging used, and the transport mode. Sections B.6.1 and B.6.2 summarize this information for disposal at land disposal sites and WIPP, respectively. Table B-10 summarizes the shipment loading assumptions used for the alternatives considered.

B.6.1 Land Disposal

It is assumed that approximately 12,600 truck shipments or 5,000 rail shipments of all GTCC LLRW and GTCC-like waste considered in Groups 1 and 2 would be needed if the land disposal methods were used. For the purposes of this EIS, Table B-11 summarizes waste volumes generated, disposal containers, and number of shipments estimated.

B.6.2 Deep Geologic Disposal at WIPP

It is assumed that approximately 33,700 truck shipments or 11,800 rail shipments would be needed to dispose of all Group 1 and 2 GTCC LLRW and GTCC-like waste at WIPP, as summarized in Table B-12. The number of shipments is more than double the number estimated

TABLE B-10 Number of Waste Containers per Shipment

Waste Container	Number of Containers per Vehicle	Comments
Truck shipments		
AMC	1	One AMC per Type B shipping package
h-SAMC	1	One h-SAMC per Type B shipping package
CH drum	42	Two 7-drum packs per TRUPACT-II, three TRUPACT-IIs per truck
SWB	6	Two SWBs per TRUPACT-II, three TRUPACT-IIs per truck
Cs-137 irradiator	6	Two irradiators per TRUPACT-II, three TRUPACT-IIs per truck
RH drum	3	Three drums per one RH canister in an RH 72-B
Lead-shielded container	9	Three containers per HalfPACT, three HalfPACTs per truck
Rail shipments		
AMC	4	The weight of the number of AMCs is limited by the Type B shipping package
h-SAMC	3	The weight of the number of h-SAMCs is limited by the Type B shipping package
CH drum	84	Two 7-drum packs per TRUPACT-II, six TRUPACT-IIs per railcar
SWB	12	Two SWBs per TRUPACT-II, six TRUPACT-IIs per railcar
Cs-137 irradiator	12	Two SWBs per TRUPACT-II, six TRUPACT-IIs per railcar
RH drum	6	Three drums per RH canister, two RH canisters/RH 72-Bs per railcar
Lead-shielded container	18	Three containers per HalfPACT, six HalfPACTs per railcar

TABLE B-11 Estimated Number of Radioactive Material Shipments for Disposal of GTCC LLRW and GTCC-Like Waste at Potential Land Disposal Sites[a]

Shipment Site	Waste Type	Volume (m^3)	Container Type	No. of Containers	No. of Truck Shipments	No. of Railcar Shipments[b]
Group 1						
GTCC LLRW						
Activated metals						
Past/present commercial reactors[c]	RH	882.4	AMC	2,452	2,452	660
Sealed sources[d]						
Small	CH	1,810.0	55-gal drum	8,702	209	105
Cs-137 irradiators	CH	1,018.9	Self-contained	1,435	240	120
Other Waste						
CH	CH	42.1	55-gal drum	203	5	3
RH	RH	33.6	55-gal drum	162	54	27
GTCC-like waste						
Activated metals						
RH	RH	12.8	AMC	38	38	11
Sealed sources[d]						
Small	CH	0.8	55-gal drum	4	1	1
Other Waste						
CH drum	CH	33.9	55-gal drum	173	5	3
CH SWB	CH	708.8	SWB	381	64	32
RH	RH	716.3	55-gal drum	3,462	1,155	579
Group 1 total		5,259.5		17,012	4,223	1,541

TABLE B-11 (Cont.)

Shipment Site	Waste Type	Volume (m^3)	Container Type	No. of Containers	No. of Truck Shipments	No. of Railcar Shipments[b]
Group 2						
GTCC LLRW						
Activated metals						
New BWRs	RH	72.6	AMC	202	202	54
New PWRs	RH	303.4	AMC	833	833	227
Additional commercial waste	RH	735.3	AMC	1,990	1,990	498
Other Waste						
CH	CH	1,551.0	SWB	829	139	70
RH	RH	2,361.8	55-gal drum	11,365	3,789	1,896
GTCC-like waste						
Other Waste						
CH	CH	488.3	SWB	261	44	22
RH	RH	874.4	55-gal drum	4,207	1,403	702
Group 2 total		6,386.8		19,687	8,400	3,469
Total Groups 1 and 2		11,646.2		36,699	12,623	5,010

[a] AMC = activated metal canister, BWR = boiling water reactor, CH = contact-handled, PWR = pressurized water reactor, RH = remote-handled, SWB = standard waste box.

[b] Rail shipments are assumed to consist of one railcar as part of a general freight train.

[c] Sum of shipments from the individual commercial reactor site locations. Approximate reactor locations are listed in Table 3.4-1 in Chapter 3.

[d] For purposes of this EIS, commercial and DOE sealed sources are assumed to be shipped from the population-weighted center of the United States. These sources are distributed throughout the country and are projected waste.

TABLE B-12 Estimated Number of Radioactive Material Shipments for Disposal of GTCC LLRW and GTCC-Like Waste at WIPP[a]

Shipment Site	Waste Type	Volume (m^3)	Container Type	No. of Containers	No. of Truck Shipments	No. of Railcar Shipments[b]
Group 1						
GTCC LLRW						
Activated metals						
Past/present commercial reactors[c]	RH	882.4	h-SAMC	12,595	12,595	4,237
Sealed sources[d]						
Small	CH	1,810.0	55-gal drum	8,702	209	105
Cs-137 irradiators	CH	1,018.9	Self-contained	1,435	240	120
Other Waste						
CH	CH	42.1	55-gal drum	203	5	3
RH	RH	33.6	h-SAMC	172	172	58
GTCC-like						
Activated metals						
RH	RH	12.8	h-SAMC	70	70	24
Sealed sources[d]						
Small	CH	0.8	55-gal drum	4	1	1
Other Waste						
CH drum	CH	33.9	55-gal drum	173	5	3
CH SWB	CH	708.8	SWB	381	64	32
RH	RH	716.3	h-SAMC	3,654	3,654	1,221
Group 1 total		5,259.5		27,389	17,015	5,804

TABLE B-12 (Cont.)

Shipment Site	Waste Type	Volume (m^3)	Container Type	No. of Containers	No. of Truck Shipments	No. of Railcar Shipments[b]
Group 2						
GTCC LLRW						
Activated metals						
New BWRs	RH	72.6	h-SAMC	956	956	320
New PWRs	RH	303.4	h-SAMC	4,789	4,789	1,607
Additional commercial waste	RH	735.3	h-SAMC	3,736	3,736	1,246
Other Waste						
CH	CH	1,551.0	SWB	829	139	70
RH container	RH	2,298.9	Shielded container	20,348	2,262	1,131
RH h-SAMC	RH	62.9	h-SAMC	323	323	109
GTCC-like waste						
Other Waste						
CH	CH	488.3	SWB	261	44	22
RH	RH	874.4	h-SAMC	4,441	4,441	1,481
Group 2 total		6,386.8		35,683	16,690	5,986
Total Groups 1 and 2		11,646.2		63,072	33,705	11,790

[a] BWR = boiling water reactor, CH = contact-handled, h-SAMC = half-shielded activated metal canister, PWR = pressurized water reactor, RH = remote-handled, SWB = standard waste box.

[b] Rail shipments are assumed to consist of one railcar as part of a general freight train.

[c] Sum of shipments from the individual commercial reactor site locations. Approximate reactor locations are listed in Table 3.4-1 in Chapter 3.

[d] For purposes of this EIS, commercial and DOE sealed sources are assumed to be shipped from the population-weighted center of the United States. These sources are distributed throughout the country and are projected waste.

for the land disposal sites because of the use of the lead-shielded containers to transport the RH waste. The h-SAMC and lead-shielded containers have less internal volume than the AMCs and 208-L (55-gal) drums, respectively.

B.7 ACCIDENT CONSEQUENCE SHIPMENT INVENTORIES

For the transportation accident consequence analysis discussed in Section 5.3.9.3 and in Appendix C, Section C.9.3.3, the potentially worst-case shipment inventories (radionuclide source terms) were used in the analysis. In the case of sealed sources, if all shipments were grouped according to the radionuclides present, shipments of Am-241 sealed sources were found to have the highest potential impacts. Truck shipments were assumed to carry 1,470 Ci of Am-241 based on a limit of 35 Ci per 208-L (55-gal) drum, with 14 drums per TRUPACT-II and three TRUPACT-IIs per truck. Rail shipments were assumed to contain double the volumes of truck shipments. Table B-13 presents the estimated shipment inventories used for activated metals from commercial nuclear power plants, Other Waste - CH, and Other Waste - RH. The values in Table B-13 for the activated metals and Other Waste - RH represent shipments to enhanced near-surface disposal facilities using the AMC for the activated metals in a Type B shipping package and 208-L (55-gal) drums in an RH 72-B for the Other Waste - RH. For shipments to WIPP, the corresponding inventories for the activated metals and Other Waste - RH would be approximately one-third the values in Table B-13 because the assumed shielded containers for these wastes can only accommodate about one-third the volume of the AMC and 208-L (55-gal) drum configurations.

TABLE B-13 Shipment Inventories Assumed for the Transportation Accident Consequence Assessment

	Activity (Ci)	
Radionuclide	Truck	Rail
Activated Metals		
Americium-241	2.30E-02	9.20E-02
Carbon-14	8.32E+00	3.33E+01
Cobalt-60	2.34E+04	9.35E+04
Cesium-137	4.95E+00	1.98E+01
Hydrogen-3	2.58E+00	1.03E+01
Iodine-129	6.85E-04	2.74E-03
Iron-55	1.53E+04	6.13E+04
Manganese-54	2.62E+01	1.05E+02
Nickel-59	4.44E+01	1.78E+02
Nickel-63	6.44E+03	2.58E+04
Niobium-94	2.67E-01	1.07E+00
Plutonium-238	3.20E-04	1.28E-03
Plutonium-239	1.62E+00	6.48E+00

TABLE B-13 (Cont.)

	Activity (Ci)	
Radionuclide	Truck	Rail
Activated Metals (Cont.)		
Plutonium-241	9.18E-03	3.67E-02
Strontium-90	4.36E+00	1.75E+01
Technetium-99	1.62E+00	6.48E+00
Other Waste - CH		
Americium-241	2.95E+02	5.90E+02
Cobalt-60	9.85E-04	1.97E-03
Cesium-137	9.18E-02	1.84E-01
Nickel-63	6.15E-03	1.23E-02
Neptunium-237	2.53E-01	5.06E-01
Plutonium-238	2.08E+01	4.16E+01
Plutonium-239	2.78E-01	5.56E-01
Plutonium-240	2.22E-03	4.44E-03
Plutonium-241	1.08E+00	2.16E+00
Strontium-90	8.43E-02	1.69E-01
Thorium-230	1.11E-03	2.22E-03
Uranium-235	3.50E-02	7.00E-02
Other Waste - RH		
Cesium-134	1.84E+00	3.68E+00
Cesium-137	4.29E+01	8.58E+01
Cobalt-60	4.12E+00	8.24E+00
Curium-242	1.47E+00	2.94E+00
Curium-244	5.14E+00	1.03E+01
Europium-152	3.19E+00	6.38E+00
Europium-154	9.30E-01	1.86E+00
Europium-155	4.24E-01	8.48E-01
Manganese-54	2.22E-01	4.44E-01
Plutonium-238	3.45E+00	6.90E+00
Plutonium-239	9.02E-01	1.80E+00
Plutonium-240	1.45E-01	2.90E-01
Ruthenium-106	2.47E-01	4.94E-01
Scandium-46	4.21E+00	8.42E+00
Strontium-90	1.71E+01	3.42E+01
Uranium-233	3.62E+00	7.24E+00
Tungsten-185	1.10E+02	2.20E+02
Tungsten-188	2.78E+02	5.56E+02

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APPENDIX C:

IMPACT ASSESSMENT METHODOLOGIES

This appendix summarizes the methodologies used in evaluating the various environmental resource areas discussed in this environmental impact statement (EIS). The environmental resource areas evaluated are as follows:

- Climate, air quality, and noise;
- Geology and soils;
- Water resources;
- Human health (including accidents and intentional destructive acts);
- Ecological resources;
- Socioeconomics;
- Environmental justice;
- Land use;
- Transportation (including accidents);
- Cultural resources; and
- Waste management.

In addition to the above resource areas, DOE evaluated inadvertent human intrusion and cumulative impacts that could result from implementation of the proposed GTCC action at each of the sites evaluated in combination with past, present, and planned activities (including federal and nonfederal activities) at or in the vicinity of each of the sites.

C.1 AIR QUALITY AND NOISE

C.1.1 Air Quality

Potential air quality impacts under each alternative were evaluated by estimating potential air pollutant emissions from the activities associated with facility construction and operations. Potential air emission sources were obtained from Appendix D. Air emissions of criteria pollutants, volatile organic compounds (VOCs), and carbon dioxide (CO_2, a primary greenhouse gas) that would result from the activities associated with construction (e.g., engine exhaust and fugitive dust emissions from heavy equipment and vehicles) and operations (e.g., boiler and emergency generator stack emissions) were estimated by using emission factors available in the standard reference (EPA 2004) and by using activity-level data obtained from Appendix D. Information previously developed for other similar projects was also obtained and used to the extent possible. The significance of project-related emissions to overall air quality was determined by comparing the estimated project-related emissions with the sitewide/countywide emissions or statewide/worldwide emissions of CO_2.

C.1.2 Noise

Potential noise impacts under each alternative were assessed by estimating the noise levels from noise-emitting sources associated with facility construction and operations, then performing noise propagation modeling. First, all potential noise-emitting sources were identified, as described in Appendix D. Examples of noise-emitting sources include heavy equipment used in earth-moving activities during construction, process equipment, emergency generators used during operations, and both the on-site and off-site vehicles used throughout the project. Sound power or sound pressure levels of individual noise sources were obtained from the literature (e.g., Hanson et al. 2006; Menge et al. 1998; Wood and Barnes 2006). For a general assessment of industrial activities, this EIS adopted a simplified but conservative approach to estimate noise levels at sensitive receptors. For a general assessment, it is adequate to assume that only the two noisiest pieces of equipment would operate simultaneously and continuously at full power (Hanson et al. 2006). Potential noise impacts at the nearest sensitive receptors (e.g., residences) were estimated by using a simple noise propagation formula (e.g., considering geometric spreading of sound energy only). If other attenuation mechanisms, such as air absorption or ground effects, are included, more decreases of sound levels would occur. Assuming a 10-hour daytime shift, estimated potential noise levels were assessed by comparing them to the U.S. Environmental Protection Agency (EPA) noise guideline (EPA 1974), which is more stringent than the state or local guidelines.

In addition, a ground-borne vibration impact analysis was performed in the same way as was the noise impact analysis. Common ground-borne vibration sources include construction and operational activities (e.g., use of heavy equipment). The distances at which vibration levels are below the threshold of perception for humans and interference with vibration-sensitive activities were estimated (Hanson et al. 2006).

C.2 GEOLOGY AND SOILS

The main elements considered when assessing impacts on geologic and soil resources were the location and extent of land disturbed during construction and operations. Activities that could result in land disturbance include excavating for the trench and vault facilities, drilling for boreholes, and staging of equipment in designated areas. Geologic and soil conditions within each of the greater-than-Class C (GTCC) reference locations and at the Waste Isolation Pilot Plant (WIPP) are described in the affected environment section. Surveys in the vicinity of the candidate sites, including soil surveys, topographic surveys, and geologic and seismic hazard maps, were reviewed as an initial step in the assessment. Well log data from on-site (or near-site) wells and boreholes were also reviewed.

The impact analysis for geologic resources evaluated effects on critical geologic attributes, including access to mineral or energy resources, destruction of unique geologic features, and mass movement induced by construction. The impact analysis also evaluated regional geologic conditions, such as earthquake potential. The impact analysis for soil resources evaluated effects on specific soil attributes, including the potential for soil erosion and compaction by construction activities.

The determination of the relative magnitude of an impact for each evaluated site was based on an analysis of both the context of the action and the intensity of the impact on a particular resource.

C.3 WATER RESOURCES

Water resources that could be affected by the GTCC LLRW and GTCC-like waste disposal facility include rivers, streams, and groundwater. Hydrologic conditions (including hydrologic parameters, such as flow volumes [surface water] and hydraulic conductivity [groundwater]) in the vicinity of each site evaluated in this GTCC EIS and are described in the affected environment sections.

Impacts on surface water were evaluated in terms of runoff and water quality. Changes in runoff were assessed by comparing runoff conditions with and without the GTCC LLRW and GTCC-like waste disposal facility. The potential for impacts on surface water quality was assessed on the basis of the site's location relative to rivers and streams, local runoff rates, and groundwater discharge.

The impact analysis for groundwater resources evaluated effects on underlying aquifers in terms of changes in groundwater depth, direction of groundwater flow, groundwater velocity, groundwater quality, and recharge rates. Impacts on groundwater depth and direction of flow were assessed by comparing existing water use with water demand under the proposed action. For the land disposal alternatives (borehole, trench, and vault), the RESRAD-OFFSITE (Yu et al. 2007) model was used to estimate the concentrations and migration rates of contaminants from source areas to groundwater (i.e., changes in groundwater quality over time). Changes in recharge rates were assessed by estimating the impermeable area that would result from GTCC LLRW and GTCC-like waste disposal facility construction and operations and comparing it to the recharge area currently available at each of the sites evaluated (see Appendix E).

C.4 HUMAN HEALTH RISK

This section describes the approach used for assessing the human health impacts from disposal of GTCC low-level radioactive waste (LLRW) and GTCC-like waste under normal and accident conditions. For normal operations (Section C.4.1), potential impacts are evaluated for the short term (during construction and disposal operations) and long term (post-closure of the facility). Facility accidents are considered in Section C.4.2.

C.4.1 Operations

The GTCC LLRW and GTCC-like waste would arrive at the disposal facility prepackaged in accordance with appropriate packaging and transportation regulations, and it is expected that the containers would retain their integrity throughout the disposal operations.

Leakage of the waste containers is not expected to occur under routine operations; hence, airborne emissions or wastewater discharges are likewise not expected. As a result, human health impacts during the operational phase would be limited to external radiation exposure, which could occur without direct contact with the waste. The release of contaminants from the waste material could occur after the closure of the disposal facility, as a result of the degradation of the waste containers in the environment over time. Only after the release of the contaminants could human health risks result from direct contact with the contaminants as a result of inhalation and ingestion through potentially available pathways and subsequent transport in the environment.

C.4.1.1 Receptors and Exposure Pathways

Human health impacts are estimated for three categories of receptors in this EIS: involved workers, noninvolved workers, and the off-site general public. Both involved workers and noninvolved workers would be employed by the waste disposal facility. Involved workers are those workers who conduct waste disposal activities, such as loading and unloading the waste containers and placing them into the disposal cells. Noninvolved workers work at the disposal facility but do not perform hands-on activities. For example, they would be employees who work in the administration building or outside the immediate area of the disposal facility but within the boundary of the disposal facility footprint. The general public consists of residents who live outside the boundary of the disposal facility but within 80 km (50 mi) of the facility boundary.

As noted previously, the release of waste material through airborne emissions or wastewater discharges is not expected during the operation of the disposal facility except as a result of accidents, which are discussed in Section C.4.2. Potential impacts are thus estimated only for the involved workers who, because of their close proximity to the waste material, could incur radiation doses through external exposure. Radiation exposures of the noninvolved workers and the off-site general public would be low because they would be farther away from the waste materials. More details are provided in Sections 5.3.4.1.1 and 5.3.4.1.2.

After the closure of the land disposal facility (i.e., borehole, trench, or vault), exposures could occur from waste material released by airborne emissions (should the cover system fail) and from leaching of radionuclides to the groundwater (which is used for drinking and household activities). Such releases could occur over a long time period, usually following closure of the disposal facility. The potential radiation doses and latent cancer fatality (LCF) risks from the airborne pathway would be low; the pathway of most concern is leaching to groundwater (see Section 5.3.4.3). To assess the potential impact associated with using contaminated groundwater in the future, a well located 100 m (330 ft) from the edge of the disposal facility was assumed to be installed by a hypothetical member of the general public. The potential dose from using the contaminated water was analyzed to provide an indication of the post-closure impact associated with waste disposal. Post-closure analysis for Alternative 2 (disposal at WIPP) is discussed in Chapter 4 (Section 4.3.4.3).

Another scenario that could be used to assess the potential impacts from the closure of a waste disposal facility involves a hypothetical intruder who has no knowledge of the waste disposal history and establishes a residence above the waste disposal area after the institutional control period. While digging soil to build the house, the intruder could exhume radioactive material and place it around the house for fill. This exposure scenario is considered to be very unlikely because there would be an engineered barrier (reinforced concrete slab) and a thick layer of cover material placed above the waste material for Alternatives 3 to 5. This scenario is not relevant for Alternative 2 (disposal at WIPP, a geologic repository). The potential exposure of such an individual would be limited and result from the slow release mechanism of gas diffusion. The radionuclides of concern include carbon-14 (C-14), hydrogen-3 (H-3), and radon isotopes and their progeny. It is assumed that the C-14 and H-3 in the waste material would be converted to CO_2 and tritiated water vapor (HTO) in the environment prior to their diffusion process in soil. Radon gas would be generated in the disposal area through radiological decay of radon precursors (radium-226 and radium-228). It is assumed that because the intruder would live above the waste disposal area, he or she would incur radiation exposure by inhaling the gaseous radionuclides (including radon isotopes and their progeny) that would be released as the waste containers gradually degraded. The intruder scenario was not assessed quantitatively in the EIS because of its low probability of occurrence. Disposal procedures would be conducted in a manner to make this scenario implausible.

C.4.1.2 Radiation Dose and Health Effects

The primary human health impact of concern would be radiation exposure that would occur as a result of the radionuclides contained in the waste material. All radiological exposures are presented in terms of committed dose and associated health effects. The calculated dose is the total effective dose equivalent (TEDE), which is the sum of the effective dose equivalent (EDE) from exposure to external radiation and the 50-year committed effective dose equivalent (CEDE) from exposures to internal radiation. For this EIS, the radiation doses were calculated by using the dose conversion factors (DCFs) for adults developed by the International Commission on Radiological Protection (ICRP) as given in ICRP 72 (ICRP 1996). (See Section 5.2.4 for more discussion on these DCFs). The results are generally given in terms of rem or mrem (0.001 rem) for individuals and in terms of person-rem for collective populations.

The primary adverse health effect from the potential radiation doses resulting from disposal operations would be the potential for the induction of LCFs. The health risk conversion factor (expected LCFs per dose) used to convert radiation doses to LCFs (i.e., 0.0006 per rem or person-rem) is a value identified by the Interagency Steering Committee on Radiation Standards (ISCORS) as a reasonable factor to use in the calculation of potential LCFs associated with radiation doses as given in DOE guidance and recommendations (DOE 2003, 2004). Adverse health effects for individuals are presented in terms of the probability of developing an excess LCF, whereas adverse health effects for collective populations are presented as the number of excess LCFs among the population.

C.4.1.3 Sources of Data and Application of Software

The external exposures incurred by the involved workers for the three land disposal alternatives are estimated on the basis of information on worker activities, the estimated number of workers required to implement each alternative, and an average estimated annual dose of 0.2 rem per full-time equivalent (FTE) employee. This value is higher than but generally consistent with doses incurred by workers performing comparable activities at DOE sites (see Section 5.3.4.1.1) and those associated with storage of activated metal wastes at commercial nuclear reactors (see Section 3.5.1.1). Actual worker dose information was used for waste disposal activities at WIPP. This approach was used because there is considerable uncertainty about the procedures workers would use to dispose of these wastes. The exact approach workers would use to dispose of these wastes would be determined after the disposal site and detailed facility design had been approved. This approach for addressing involved worker impacts is considered reasonable for this EIS and is described in more detail in Section 5.3.4.1.1.

The radiological impacts from inhaling gaseous radionuclides are estimated by using the RESRAD-OFFSITE computer code (Yu et al. 2007). The inhalation rate of the individual is assumed to be 20 m^3/d, with an exposure duration of 24 hours per day for 365 days per year. The outdoor air concentrations are used for these calculations, and the time spent indoors, where concentrations would be less than they are outdoors, is not accounted for. Site-specific wind speed and contamination source data are used in these calculations; the data are based on information contained in the post-closure performance analysis report for the waste disposal facility (Argonne 2010). This approach ensures consistency with the assumptions used for the groundwater impact analysis.

The assessment of the potential impacts from groundwater contamination for the land disposal alternatives was conducted by using the same computer code (RESRAD-OFFSITE), as summarized in the post-closure performance analysis report (Argonne 2010). The maximum radiation doses associated with using the contaminated groundwater as the source of drinking water are analyzed for a resident farmer scenario for time frames of 10,000 years and 100,000 years. The ingestion rate of drinking water for the groundwater receptor is assumed to be 730 L/yr (190 gal/yr), which is the ingestion rate for adults recommended by the EPA (EPA 1997). See Appendix E for more details on this evaluation.

The nonradiological impacts on workers are calculated as the number of lost workdays that could occur from occupational accidents and illnesses. Data from the National Safety Council are used to develop these estimates, as described in Section 5.3.4.2.2.

C.4.2 Facility Accidents

The methodology for analyzing the range of potential accidents that could result in a release of radioactive material to the environment and that could occur at the land disposal facilities is discussed in this section. The accident analysis considers potential events involving the different GTCC LLRW and GTCC-like waste types considered in the EIS. Accidents could be initiated during facility operations, such as those that result from equipment or operator failure, or they could be caused by external events, including natural phenomena (earthquake, flood, wind, or tornado). Reasonably foreseeable accidents were screened to identify the accidents that would have the greatest consequences on workers and the public. These "bounding" accidents provide an envelope for the consequences of the other potential accidents that would have less impact on workers and the public.

Because the disposal options involve similar operations and the same waste packages, the accidents evaluated are applicable to all three land disposal options. Because of the differences in the local weather patterns and the location of the potential receptors, the radiological impacts for Alternatives 3 to 5 are site-dependent and are discussed in Chapters 6 through 11 for the Hanford Site, the Idaho National Laboratory (INL) Site, Los Alamos National Laboratory (LANL), Nevada National Security Site (NNSS), Savannah River Site (SRS), and the Waste Isolation Pilot Plant (WIPP) Vicinity, respectively.

The output from the disposal facility accident analyses consists of (1) identification of the accidents potentially important with regard to human health risk for each waste type, (2) assessment of the frequencies of these accidents, (3) evaluation of the source terms resulting from these accidents, and (4) identification of the human health impacts associated with the release and atmospheric dispersion of the source term.

C.4.2.1 Accidents Evaluated

An accident is an event or series of unexpected or undesirable events leading to a loss of waste containment or shielding that could result in radiological exposure to workers or members of the general public. The accidents considered fall under two broad categories (operational events and natural phenomena) that had been previously evaluated for similar types of waste and packaging (DOE 1997a, 2006, 2007). Table C-1 summarizes the accident scenarios analyzed. Table C-2 provides more details for each potential accident considered.

C.4.2.1.1 Operational Events. It is not expected that any waste would be repackaged at the disposal facility; therefore, the only way an operational event could release radioactive material to the environment would be if a disposal container ruptured during handling or temporary storage operations. Handling operations would include (1) transfer of the disposal containers from their Type B shipping packages as received at the Waste Handling Building (WHB) to temporary storage, (2) transfer from temporary storage to an on-site transport cask (if waste is remote-handled [RH]) or to a vehicle, and (3) transfer from the transport vehicle into the disposal unit. All such operations are expected to involve the use of forklifts and/or cranes.

Physical damage to waste containers could result from low-speed vehicle collisions, being dropped, or being crushed by falling objects. Only minor releases would be likely should such accidents happen. High-speed impacts are not anticipated at the disposal facility because of the operational procedures that are followed (e.g., the on-site maximum speed limits are low, waste disposal operations are separated from worker vehicular transport, and access to disposal operations is limited).

Accidents involving contact-handled (CH) waste containers (208-L [55-gal] drums and standard waste boxes [SWBs]) are expected to result in higher impacts because these Type A containers, although fairly robust, are not as sturdy as the cesium irradiators and the RH canisters

TABLE C-1 Accidents Evaluated for the Land Disposal Facilities

Accident Number	Accident Scenario	Accident Description	Frequency Range: $>10^{-2}$/yr	Frequency Range: 10^{-4} to 10^{-2}/yr	Frequency Range: 10^{-6} to 10^{-4}/yr	Frequency Range: $<10^{-6}$/yr
1	Single drum drops, lid failure in Waste Handing Building	A single CH drum is damaged by a forklift and spills its contents onto the ground inside the Waste Handling Building.		X		
2	Single SWB drops, lid failure in Waste Handing Building	A single CH SWB is damaged by a forklift and spills its contents onto the ground inside the Waste Handling Building.		X		
3	Three drums drop, puncture, lid failure in Waste Handling Building	Three CH drums are damaged by a forklift and spill their contents onto the ground inside the Waste Handling Building.		X		
4	Two SWBs drop, puncture, lid failure in Waste Handling Building	Two CH SWBs are damaged by a forklift and spill their contents onto the ground inside the Waste Handling Building.		X		
5	Single drum drops, lid failure outside	A single CH drum is damaged by a forklift and spills its contents outside.				
6	Single SWB drops, lid failure outside	A single CH SWB is damaged by a forklift and spills its contents outside.	X			
7	Three drums drop, puncture, lid failure outside	Three CH drums are damaged by a forklift and spill their contents outside.	X			
8	Two SWBs drop, puncture, lid failure outside	Two CH SWBs are damaged by a forklift and spill their contents outside.	X			
			X			

TABLE C-1 (Cont.)

Accident Number	Accident Scenario	Accident Description	Frequency Range: $>10^{-2}$/yr	10^{-4} to 10^{-2}/yr	10^{-6} to 10^{-4}/yr	$<10^{-6}$/yr
9	Fire inside the Waste Handling Building, one SWB assumed to be affected	A fire within the Waste Handling Building affects the contents of a single CH SWB.			X	
10	Single RH waste canister breach	A single RH waste canister is breached during a fall in the Waste Handling Building.			X	
11	Earthquake affects 18 pallets, each with four CH drums	The Waste Handling Building is damaged during a design basis earthquake, and the structure and confinement systems fail.			X	
12	Tornado, missile hits one SWB, contents released	A major tornado and associated tornado missiles result in failure of the Waste Handling Building structure and its confinement systems.			X	
13	Flood	The facility would be sited in a location that would preclude severe flooding.				X

TABLE C-2 Hypothetical Facility Accident Descriptions

Accident Number	Accident Scenario Description
1	A package (either a 7-drum pack or 4-drum pallet of CH transuranic [TRU] waste) is dropped from a forklift or crane while being handled in the Waste Handling Building. Because the waste containers are Type A packages, per U.S. Nuclear Regulatory Commission (NRC) requirements, they are designed to withstand a 1-m (3.3-ft) drop onto an unyielding surface without damage. However, because the vertical lift can exceed this design rating, it is assumed that the container drop and subsequent crushing cause the lid of a single container to be knocked off. No inner plastic liner is assumed to be present. A fraction of the respirable-sized particulates in the drum are assumed to be suspended inside the drum during the fall and to be released when a lid fails. Spilled contents are released, and the respirable particles are resuspended from this material. Facility high-efficiency particulate air (HEPA) filtration is considered for releases to the atmosphere.
2	Same as Accident 1, except that a single, direct-loaded SWB with CH waste is involved in a drop from a forklift or crane.
3	An error made by the Waste Handling Building forklift operator causes a forklift to strike and puncture two drums. An additional drum is knocked off, and the lid fails. Because the waste containers are Type A packages, per NRC requirements, they are designed to withstand a 1-m (3.3-ft) drop onto an unyielding surface without damage. However, because the vertical lift can exceed this design rating, it is assumed that the container drop and subsequent crushing cause the lid of a single container to be knocked off. No inner plastic liner is assumed to be present. A fraction of the respirable-sized particulates in the drum are assumed to be suspended inside the drum during the fall. A fraction of these are released when the lid fails, or the contents may be released and the respirable particles may be resuspended from this material. Facility HEPA filtration is considered for releases to the atmosphere.
4	An error made by the Waste Handling Building forklift operator causes a forklift to strike and puncture a single, direct-loaded SWB. An additional SWB is knocked off, and the lid fails. Because the waste containers are Type A packages, per NRC requirements, they are designed to withstand a 1-m (3.3-ft) drop onto an unyielding surface without damage. However, because the vertical lift can exceed this design rating, it is assumed that the container drop and subsequent crushing cause the lid of a single container to be knocked off. No inner plastic liner is assumed to be present. A fraction of the respirable-sized particulates in the SWB are assumed to be suspended inside the SWB during the fall. A fraction of these are released when the lid fails, or the contents may be released and the respirable particles may be resuspended from this material. Facility HEPA filtration is considered for releases to the atmosphere.
5	Same as Accident 1, except that it occurs outdoors during disposal operations.
6	Same as Accident 2, except that it occurs outdoors during disposal operations.
7	Same as Accident 3, except that it occurs outdoors during disposal operations.
8	Same as Accident 4, except that it occurs outdoors during disposal operations.
9	A fire in the WHB is caused by the malfunction or overheating of electrical equipment. This fire subsequently ignites nearby combustibles and is assumed to involve one SWB with CH waste.

TABLE C-2 (Cont.)

Accident Number	Accident Scenario Description
10	During the unloading of an RH shipping cask or the loading of an on-site transfer cask, the crane, grapples, or lift fixtures fail, and an RH canister is dropped, resulting in the canister being crushed or punctured.
11	The Waste Handling Building is assumed to be damaged during a design basis earthquake, and the structure and confinement systems fail. The roof is assumed to collapse onto 18 4-drum pallets of CH waste that are in the storage area awaiting final internment. Although four 4-drum pallets are assumed for disposal in trenches, the same number of drums could be involved as 7-drum packs for disposal in 40-m (130-ft) boreholes or above-grade vaults. In either case, the number of drums involved (72) is less than two full truck shipments of CH waste (84 drums).
12	A major design basis tornado is assumed to damage the Waste Handling Building to the extent that a wind-driven missile is able to hit a single SWB containing CH waste. Missiles might be produced from nearby trees, poles, cranes, parts of the facility structure, or various pieces of equipment or material (e.g., pallets).
13	The facility would be sited in a location that would preclude severe flooding.

or activated metal canisters (AMCs) and their shielding casks. As a consequence, the CH waste containers would be more prone to release a portion of their contents. CH drum and SWB radionuclide inventories that had the highest impacts were used in this facility accident analysis for Accidents 1–9, 11, and 12. Accident 10 was also evaluated to provide that perspective should an RH canister fail during an accident. A preliminary screening analysis, in which equivalent release fractions were assumed both for GTCC Other Waste - CH and for GTCC Other Waste - RH released from their containers, showed greater impacts for the CH waste. In addition, if an AMC somehow became breached, the airborne radioactive contamination from material such as activated metal waste would be minimal compared to that from Other Waste, because of the relatively immobile nature of the contamination. Before sealed sources are packaged in drums for disposal, they are relatively immune to collisions and physical impacts because it is assumed that sealed sources are already encased in their own sealed cases or shields; thus, releases from sealed sources are expected to be less than those from the Other Waste - CH.

Fire from internal or external causes is another potential reason for radioactive contamination. Internal causes would be minimized by properly treating the waste before it was packaged and received at the facility. External causes, which are primarily linked to vehicle or equipment fires, would be minimized through proper maintenance and use. Accident 9 considers the impacts from a short-term fire in the WHB.

C.4.2.1.2 Natural Hazards. Potential releases of radioactive material could also occur as a result of natural hazards. Such releases are anticipated only before emplacement (i.e., while the waste is at the WHB). However, it is assumed that the disposal facility would be sited in an area that is not prone to flooding, and depending on the area of the country in which it would be situated, the facility would be built to meet local standards for earthquakes. Other natural hazards (such as tornadoes) in certain areas of the country could cause releases. Accidents 11 and 12 look at potential scenarios involving earthquakes and tornadoes, respectively.

A flood is not considered to be a credible hazard because it is assumed that the facility would be sited to preclude severe flooding. It is assumed that the location and design of the disposal facility would bring the frequency below 1×10^{-6}/yr. For example, the U.S. Nuclear Regulatory Commission's (NRC's) regulations in Title 10, Section 61.50 of the *Code of Federal Regulations* (10 CFR 61.50) require, in part, that waste disposal shall not take place in a 100-year floodplain. U.S. Department of Energy (DOE) guidance (DOE M 435.1-1) also indicates that floodplains should be avoided.

High winds and tornadoes could cause extensive damage, including collapse of a structure. For this accident analysis, it is assumed that the WHB could be damaged if a major tornado, with associated tornado debris missiles, would sweep through the area. Missiles could be produced from nearby trees, poles, cranes, parts of the facility structure, or various pieces of equipment or material (e.g., pallets). The radiological dose would be much lower for a tornado than a high wind because the tornado's higher wind would disperse releases more widely, but credit is not taken in the dispersion analysis for this effect. It is assumed that a missile driven by the wind from a tornado would hit and break an SWB, causing it to release some of its radioactive contents.

The major earthquake assumed would be severe enough to cause the WHB roof to collapse. The earthquake analysis assumes that 18 4-drum pallets of CH waste in the storage area awaiting final internment would be affected. While it is assumed that 4-drum pallets would be disposed of in trenches, the same number of drums could be involved as 7-drum packs for disposal in 40-m (130-ft) boreholes or above-grade vaults. In either case, the number of drums involved (72) is less than two full truck shipments of CH waste (84 drums).

C.4.2.1.3 Accident Frequency. The annual frequency of occurrence for waste handling accidents is the product of the number of drums received per year, number of operations per drum, and probability that a mishandling accident would damage a drum so it would release radioactive material to the surrounding environment. Table C-3 summarizes the development of the accident frequencies.

Seismic design guidelines for DOE facilities are based on facility usage categories. For each category, an earthquake hazard level is specified by using site-specific seismic hazard data. This process ensures that facilities are designed on a uniform basis to address the effects of seismic events, regardless of their locations (DOE 1997b). A beyond-design-basis earthquake, regardless of accident frequency, must be assumed to defeat all building confinement functions. Buildings are typically constructed to withstand earthquakes. Therefore, the frequency of the beyond-design-basis earthquake scenario is assumed to be equal at all of the disposal sites considered. A similar process applies to the hardening of facilities to the potential impacts from high winds and tornados.

TABLE C-3 Determination of Frequencies of Occurrence of Hypothetical Facility Accidents

Accident Number	Accident Scenario	Number of Containers per Year[a]	Number of Operations per Container	Frequency per Operation	Accident Frequency[b] (1/yr)
1	Single drum drops, lid failure in Waste Handing Building	330	2	1.1E-05[c]	7.3E-03
2	Single SWB drops, lid failure in Waste Handing Building	83	2	1.1E-05	1.8E-03
3	Three drums drop, puncture, lid failure in Waste Handling Building	330	2	0.25 × 1.1E-05	1.8E-03
4	Two SWBs drop, puncture, lid failure in Waste Handling Building	83	2	0.25 × 1.1E-05	4.6E-04
5	Single drum drops, lid failure outside	330	2	1.1E-05	7.3E-03
6	Single SWB drops, lid failure outside	83	2	1.1E-05	1.8E-03
7	Three drums drop, puncture, lid failure outside	330	2	0.25 × 1.1E-05	1.8E-03
8	Two SWBs drop, puncture, lid failure outside	83	2	0.25 × 1.1E-05	4.6E-04
9	Fire inside the Waste Handling Building, one SWB assumed to be affected[d]	NA[e]	NA	NA	1.0E-05
10	Single RH waste canister breach	1,150	NA	NA	1.0E-05
11	Earthquake affects 18 pallets, each with four CH drums[f]	NA	NA	NA	1.0E-05
12	Tornado, missile hits one SWB, contents released[f]	NA	NA	NA	1.0E-05
13	Flood	NA	NA	NA	< 1e-6

[a] Based on postulated receipt rates, with the majority of the waste being disposed of by 2035.

[b] Calculated as the product of the number of containers times the number of handling events per container times the accident frequency per handling event.

[c] Drop frequency of 1.1×10^{-5} per operation taken from page 6.13-7-5 of Dubrin et al. (1997).

[d] Annual frequency of 1×10^{-5} per year taken from page G-69 of DOE (1997b).

[e] NA = not applicable, since the number of affected containers is defined in the accident scenario.

[f] Natural phenomena frequency of 1×10^{-5} per year assuming disposal facilities would be constructed as DOE Hazard Category 2 facilities, as per pages G-6 and G-10 of DOE (1997b).

C.4.2.1.4 Source Terms. In analyzing the potential consequences of postulated facility accidents, the source term, which is the amount of radioactive material released, is evaluated. The source term is the product of five factors (DOE 1994):

$$Q = MAR * DR * ARF * RF * LPF$$

where:

Q = source term (Ci);

MAR = material at risk, the maximum amount and type of material present that may be acted upon by the potentially dispersive energy source (Ci);

DR = damage ratio, the fraction of the MAR actually affected by the accident condition;

ARF = airborne release fraction, the fraction of radioactive material actually affected by the accident condition that is suspended in air;

RF = respirable fraction, the fraction of the airborne radioactive particles that are in the respirable size range (i.e., less than 10 μm); and

LPF = leak path factor, the cumulative fraction of airborne material that escapes to the atmosphere from the postulated accident.

Table C-4 summarizes the values used in the EIS facility accident analysis.

The source term should represent a reasonable maximum for a given waste stream. A screening analysis identified the CH waste stream that is the most hazardous to human health. For CH waste assumed to be packaged in 208-L (55-gal) drums, waste from the INL Site is expected to pose the highest risk. For CH waste packaged in SWBs, DOE waste from the West Valley Site is expected to pose the highest risk. For RH packaged in 208-L (55-gal) drums, DOE waste from the West Valley Site is expected to pose the highest risk. Note that three RH drums are contained within the RH canister evaluated in Accident 10.

Because of the uncertainties involved in waste type characterization at the present time, container activity inventories were averaged by taking the total activity for a given waste type from a specific generator and dividing that by the number of containers necessary to hold the waste (discussed further in Appendix B). This information was developed from the waste inventory database established for this EIS. Table C-5 lists the estimated inventories for a CH drum (Accidents 1, 3, 5, 7, and 11), CH SWB (Accidents 2, 4, 6, 8, 9, and 12), and RH drum (Accident 10) as used in this analysis. The actual respirable amount (Ci) released to the environment, the source term, is obtained by multiplying the value in the “Release Factor” column in Table C-4 by the activity from the appropriate container (Table C-4) for a given accident.

TABLE C-4 Estimated Release Fractions for Hypothetical Facility Accidents[a]

Accident Number	Container Type	Number of Containers	DR	ARF[b]	RF[b]	LPF[c]	Release Factor[d]
1	CH drum	1	0.25[e]	0.001	0.1	0.001	2.5E-08
2	CH SWB	1	0.25	0.001	0.1	0.001	2.5E-08
3	CH drum	3	(2 × 0.1 + 1 × 0.25)/3[f]	0.001	0.1	0.001	4.5E-08
4	CH SWB	2	(1 × 0.1 + 1 × 0.25)/2[g]	0.001	0.1	0.001	3.5E-08
5	CH drum	1	0.25	0.001	0.1	1	0.000025
6	CH SWB	1	0.25	0.001	0.1	1	0.000025
7	CH drum	3	(2 × 0.1 + 1 × 0.25)/3	0.001	0.1	1	0.000045
8	CH SWB	2	(1 × 0.1 + 1 × 0.25)/2	0.001	0.1	1	0.000035
9	CH SWB	1	1	0.0005[h]	1	1	0.0005
10	RH canister	1	0.01[e]	0.001	0.1	0.001	1E-09
11	CH drum	72	0.1[i]	0.001	0.1	1	0.00072
12	CH SWB	1	1	0.001[j]	0.1[j]	1	0.0001
13	Sited to preclude severe flooding, no release assumed						

[a] DR = damage ratio, ARF = airborne release fraction, RF = respirable fraction, LPF = leakpath factor; CH = contact-handled, SWB = standard waste box, RH = remote-handled.

[b] For direct loaded containers (DOE 2006).

[c] The values for LPF are explained on page C-17.

[d] The release factor is the product of the number of containers × DR × ARF × RF × LPF. Multiplication of this factor by the appropriate container inventory in Table C-5 provides the source term for each accident.

[e] Source: DOE (1997b).

[f] Damage ratio of 0.1 for each punctured drum and 0.25 for dropped drum with lid failure (DOE 1997b).

[g] Damage ratio of 0.1 for the punctured SWB and 0.25 for the dropped SWB with lid failure (DOE 1997b).

[h] Based conservatively on packaged cellulosic or plastic materials (DOE 2007).

[i] Assumed to behave similarly to a postulated collapse of the Waste Handling Building at WIPP (DOE 2006).

[j] Release fractions associated with tornado missiles are assumed to resemble the fractions associated with mechanical spills (DOE 2007).

Values for the damage ratio, airborne release fraction, and respirable fraction as given in Table C-4 were identified through a review of similar past analyses (DOE 1997b, 2006) and current recommendations (DOE 2007). A leak path factor of 0.001 represents containment by the WHB and assumes continuous operation of the building's heating, ventilation, and air-conditioning (HVAC) system, with high-efficiency particulate air (HEPA) filters removing 99.9% of the airborne particulates. A leak path factor of 1 represents an accident that occurs outdoors or an accident whose conditions have negated the WHB containment.

TABLE C-5 Waste Container Inventories (Ci) for Use in the Facility Accident Analysis[a]

	Container Type		
Element	CH Drum	CH SWB	RH Drum
Ac-227	1.0E-08	1.0E-04	4.6E-06
Am-241	7.5E+00	9.1E+00	1.2E+00
Am-242m	6.3E-10	–	–
Am-243	2.9E-08	9.9E-02	1.7E-02
Bi-212		5.9E-03	4.7E-04
C-14	8.4E-09	3.8E-02	1.8E-02
Cd-113m	2.0E-07	–	–
Ce-144	5.9E-12	5.9E-04	4.7E-05
Cm-242		3.3E-03	2.7E-04
Cm-243	9.7E-10	2.3E-04	9.6E-04
Cm-244	9.5E-07	5.7E-03	2.1E-02
Cm-245	1.3E-11	–	5.4E-02
Cm-246	1.2E-13	–	8.6E-03
Co-57	2.3E-13	–	–
Co-60	2.5E-05	7.5E-07	4.9E-02
Cs-134	4.9E-08	3.2E-05	4.2E-06
Cs-135	4.0E-08	–	–
Cs-137	2.3E-03	1.3E-01	5.6E+01
Eu-152	2.0E-05	–	–
Eu-154	5.4E-06	6.8E-04	2.7E-03
Eu-155	1.9E-06	–	1.2E-04
Fe-55	2.2E-06	3.0E-02	3.6E-03
H-3	1.0E-06	5.6E-04	2.6E-03
I-129	3.1E-07	9.5E-08	4.3E-04
K-40	–	2.2E-03	8.1E-05
Mn-54	9.7E-15	2.8E-05	2.3E-06
Ni-59	–	2.2E-04	–
Nb-94	3.3E-07	–	1.6E-05
Ni-59	1.7E-06	–	2.5E-02
Ni-63	1.6E-04	–	1.5E+00
Np-237	6.4E-03	1.4E-04	3.4E-04
Pa-231	6.8E-08	–	–
Pb-210	2.3E-08	–	–
Pb-212	–	4.1E-03	3.3E-04
Pd-107	7.5E-10	–	–
Pm-146	7.0E-10	–	–
Pm-147	–	–	8.9E-04
Pu-236	7.0E-11	1.6E-04	1.2E-05
Pu-238	5.3E-01	3.5E+00	2.8E-01
Pu-239	7.0E-03	2.6E+00	5.3E-01
Pu-240	5.6E-05	2.0E+00	3.6E-01
Pu-241	2.7E-02	4.7E+01	5.0E+00
Pu-242	1.4E-08	1.3E-02	1.1E-03
Ra-226	1.6E-07	1.2E-02	4.6E-04
Ra-228	–	9.2E-04	5.7E-05

TABLE C-5 (Cont.)

	Container Type		
Element	CH Drum	CH SWB	RH Drum
Ru-106	6.1E-11	2.9E-04	2.4E-05
Sb-125	3.6E-07	–	–
Se-79	2.0E-08	–	–
Sm-147	3.2E-14	–	–
Sm-151	1.8E-05	–	–
Sn-121m	2.8E-09	–	–
Sn-126	1.9E-12	–	–
Sr-90	2.1E-03	1.4E-01	1.2E+01
Tc-99	5.5E-07	9.1E-04	2.7E-02
Th-228	2.3E-10	1.3E-02	1.0E-03
Th-229	2.6E-07	6.4E-03	2.5E-04
Th-230	2.8E-05	1.2E-03	4.7E-05
Th-232	5.2E-09	8.1E-04	3.3E-05
U-232	7.0E-07	6.8E-02	3.0E-03
U-233	2.5E-07	2.7E-02	1.8E-03
U-234	1.5E-05	1.3E-01	4.9E-03
U-235	8.9E-04	5.3E-05	5.3E-05
U-236	5.0E-08	1.5E-04	1.3E-04
U-238	5.7E-08	2.6E-04	3.0E-04
Zr-93	1.0E-07	–	–

[a] CH = contact-handled, RH = remote-handled, SWB = standard waste box. A dash means not applicable, since this radionuclide was not identified as being present for the waste packaged in this type of container.

C.4.2.2 Human Health Impacts

The consequences to the collective off-site general public and individuals receiving the highest impacts are estimated by using an air dispersion model to predict the downwind air concentrations following a release. A number of factors are considered, including the amount of the material released (as discussed in Section C.4.2.1), location of the release, and meteorological conditions. The air concentrations are used to estimate the radiation doses and the potential LCFs associated with these doses. The consequences are estimated on the basis of the assumption that the wind is blowing in the direction that would yield the greatest impacts. For accidents involving releases of radioactive material, the consequences are expressed in the same way as are the consequences from routine operations (i.e., as radiation doses and LCFs for the exposed population and individual receiving the highest dose for all important exposure pathways).

C.4.2.2.1 General Public. The general public consists of the population living within 80 km (50 mi) of the GTCC reference location. The radiation exposure estimates include potential doses from inhalation, groundshine, cloudshine, and ingestion of contaminated crops for 1 year following a hypothetical accidental release of radioactive material, as discussed above.

The GENII computer code (Napier et al. 1988) was used to assess the radiological impacts to the collective off-site population (members of the public) for each accident considered. The off-site population distributions used for the accident analysis were determined by using the latest geographic information (2007 population estimates) available for the land disposal reference locations (ESRI 2008). Future population projections were not used because they are considered too speculative for the time frame covered in the EIS.

The meteorological data used in GENII are joint frequencies of wind speed, wind direction, and atmospheric stability class. The joint-frequency weather data for the Hanford Site (Duncan 2007), LANL (Fuehne 2008), NNSS (DOE 2002a), SRS (NRC 2005), and the WIPP Vicinity (DOE 1997b) were obtained from published reports. Weather data for the INL Site were based on the weather file data (for Idaho Falls, Idaho) originally provided with CAP88-PC (Clean Air Act Assessment Package 1988-Personal Computer) (EPA 1992).

A ground-level release (1-m [3.3-ft] release height) is assumed for all accidents. To provide a conservative estimate for the impacts, the sector with the highest exposure (highest population dose, which is dependent on the number and location of people as well as the weather conditions) was selected, but 50% meteorology (weather conditions that produce impacts that are not exceeded 50% of the time) is used so as not to be overly conservative. For the 1-year exposure period, the length of time of external exposure to contaminated soil is 0.5 year (NRC 1977b), and no credit is given for shielding for inhalation exposure and external exposure to the passing airborne plume. The highest potential ingestion doses, from the autumn period, are incorporated in the reported exposures.

The radiological impacts on the general public for Alternatives 3 to 5 are discussed in Chapters 6 through 11 for the Hanford Site, the INL Site, LANL, NNSS, SRS, and the WIPP Vicinity, respectively.

C.4.2.2.2 Highest-Exposed Individuals. The risk to involved workers would be very sensitive to the specific circumstances of the accident and depend on how rapidly the accident developed, the exact location and response of the workers, the direction and amount of the release, the physical and thermal forces causing or caused by the accident, meteorological conditions, and the characteristics of the building if the accident occurred indoors. Impacts on involved workers under accident conditions would likely be dominated by physical forces from the accident itself, so the radiological impacts (radiation doses and LCFs) on such workers would not be meaningful and are not quantified in the EIS. However, it is recognized that injuries and fatalities among involved workers would be possible as a result of the radiological and physical forces if an accident did occur.

Accident impacts to the individual receiving the highest potential dose were determined by using the GENII code. The same release height and meteorological conditions as those used for the population accident impacts were used for this analysis. The accident analysis evaluated the potential exposure of a hypothetical individual located 100 m (330 ft) downwind of an accident (radiation doses and LCFs). The exposure estimates are reported for the sector (wind direction) with the highest impacts that include potential doses from inhalation, groundshine, and cloudshine for 2 hours following a hypothetical accidental release of radioactive material. The 2-hour exposure accounts for plume passage and potential delays in relocation, if necessary. No mitigative actions are assumed. The individual receiving the highest dose is expected to be a noninvolved worker at the disposal facility. The radiological impacts for Alternatives 3 to 5 are discussed in Chapters 6 through 11 for the Hanford Site, the INL Site, LANL, NNSS, SRS, and the WIPP Vicinity, respectively.

C.5 ECOLOGICAL RESOURCES

Impacts on ecological resources consider the effects of facility construction, operations, and post-closure on terrestrial, wetland, aquatic, and special-status species and their habitats at and in the vicinity of each GTCC reference location or disposal facility site. Special attention was paid to resources protected by regulations (e.g., federally listed species, migratory birds, bald and golden eagles, and wetlands). Section 5.3.5 presents a discussion of the methodology used to determine the potential impacts of the GTCC disposal options on ecological resources. Direct and indirect impacts on ecological resources are evaluated on the basis of the:

- Nature and quality of habitats within and adjacent to the construction footprint,
- Potential magnitude of changes to habitat quality and quantity,
- Temporal characteristics of when impacts could occur,
- Expected duration of impacts,
- Sensitivity of biological resources that could be affected by changes in habitat quality or quantity,
- Rarity and importance of affected resources, and
- Regulatory requirements (wetlands, threatened and endangered species, migratory birds).

Factors considered in evaluating impacts from the GTCC disposal facility include:

- Habitat loss, modification, and fragmentation;
- Barriers to movement;

- Changes in hydrology and water quality;
- Erosion and sedimentation;
- Air quality and fugitive dust;
- Introduction of invasive species;
- Exposure to contaminants (including radionuclides);
- Mortality and injury; and
- Noise and disturbance.

A quantitative assessment of the impacts on the large number of species found at each alternative site was not practical. The approach used for this EIS consisted of gathering land use and land cover data to identify areas of potential habitat and how it would be affected. Thus, impacts on plants and wildlife primarily addressed the effects of facility construction on habitat loss and fragmentation. The potential impacts on wetlands were based on the direct impacts that could result from construction (e.g., filling) or indirect impacts (e.g., changes in water quality, hydrologic regime, or soil compaction and runoff). Impacts on threatened and endangered species were investigated by using a species-specific approach. Consultations with regulatory agencies (e.g., U.S. Fish and Wildlife Service [USFWS] and state fish and game departments) were undertaken to assist with the identification of threatened, endangered, and other special-status species to be considered at each site (see Appendix F for consultation letters).

An overview of the potential impacts that could occur on ecological resources regardless of the GTCC reference location or method is presented in Section 5.3.5. The implementation of mitigation measures to minimize the impacts described in Section 5.3.5 would help to limit the potential impacts on ecological resources.

C.6 SOCIOECONOMICS

The analysis of socioeconomic impacts from the construction of additional rooms and waste disposal operations at WIPP and the construction and waste disposal operations at the land disposal facilities assesses impacts in a region of influence (ROI) at each of the sites evaluated in this EIS. The ROI includes the counties in which the majority (up to 90%) of employees reside at each of the sites. The ROI includes county governments, city governments, and school districts. Within the ROI at each site, there are also various jurisdictions that could be affected by GTCC LLRW and GTCC-like waste disposal facility construction and operations. The assessment of the impacts from GTCC LLRW and GTCC-like waste disposal facilities covers impacts on employment, income, population, housing, community services, and traffic.

C.6.1 Impacts on Regional Employment and Income

The assessment of impacts from a GTCC LLRW and GTCC-like waste disposal facility on regional employment and income is based on the use of regional economic multipliers in association with project expenditure data for the construction and operational phases. Multipliers capture the indirect (off-site) effects of on-site activities associated with the construction and operational activities or events. Expenditure data associated with the construction and operations of a GTCC LLRW and GTCC-like waste disposal facility are derived from numerous sources. These sources provide the relevant data on construction and operating costs for labor and materials, in various general cost categories.

Cost data for each cost category are then mapped into the relevant North American Industry Classification System (NAICS) codes for use with multipliers from an IMPLAN model specified for each state (MIG, Inc. 2008). IMPLAN input-output economic accounts show the flow of commodities to industries from producers and institutional consumers. The accounts also show consumption activities by workers, owners of capital, and imports from outside the region. The IMPLAN model contains 528 sectors representing industries in agriculture, mining, construction, manufacturing, the wholesale and retail trade, utilities, finance, insurance and real estate, and consumer and business services. The model also includes information for each sector on employee compensation; proprietary and property income; personal consumption expenditures; federal, state, and local expenditures; inventory and capital formation; and imports and exports.

Impacts on employment are described in terms of the total number of jobs created in the region in the peak year of construction and in the first year of operations. The relative impact of the increase in employment in the ROI is calculated by comparing total GTCC LLRW and GTCC-like waste facility construction employment over the period in which construction occurs with baseline ROI employment forecasts over the same period. Impacts are expressed in terms of the percentage point difference in the average annual employment growth rate with and without GTCC project construction. Forecasts are based on data provided by the U.S. Department of Commerce.

C.6.2 Impacts on Population

An important consideration in the assessment of the impacts from a GTCC LLRW and GTCC-like waste disposal facility is the number of workers, families, and children who would migrate into the ROI, either temporarily or permanently, to construct and operate the facility. The capacity of regional labor markets to supply workers in the occupations required for facility construction and operations in sufficient numbers is closely related to the occupational profile of the ROI and occupational unemployment rates. To estimate the in-migration that would occur to satisfy direct labor requirements, the analysis develops estimates of the available labor in each direct labor category based on ROI unemployment rates applied to each occupational category. In-migration associated with indirect labor requirements are derived from estimates of the available labor supply in the ROI economy as a whole that is able to satisfy the demand for labor by industry sectors in which GTCC LLRW and GTCC-like waste disposal facility spending initially occurs. The national average household size is used to calculate the number of additional family members who would accompany direct and indirect in-migrating workers.

Impacts on population are described in terms of the total number of in-migrants arriving in the region in the peak year of construction and in the first year of operations. The relative impact of the increase in population in the ROI is calculated by comparing total GTCC LLRW and GTCC-like waste disposal facility construction in-migration over the period in which construction occurs with baseline ROI population forecasts over the same period. Impacts are expressed in terms of the percentage point difference in the average annual population growth rate with and without project construction. Forecasts are based on data provided by the U.S. Bureau of the Census.

C.6.3 Impacts on Housing

The in-migration of workers during construction and operations has the potential to substantially affect the housing market in the ROI. The analysis considers these impacts by estimating the increase in demand for rental housing units in the peak year of construction and for owner-occupied housing in the first year of operations, resulting from the in-migration of both direct and indirect workers into the ROI. The impacts on housing are described in terms of the number of rental units required in the peak year of construction and the number of owner-occupied units required in the first year of operations. The relative impact on the existing housing in the ROI is estimated by calculating the impact of GTCC-related housing demand on the forecasted number of vacant rental housing units in the peak year of construction and the forecasted number of vacant owner-occupied units in the first year of operations. Forecasts are based on data provided by the U.S. Bureau of the Census.

C.6.4 Impacts on Community Services

In-migration associated with the construction and operations of a GTCC facility could translate into increased demand for educational services and public services (police, fire protection, health services, etc.) in the ROI. Estimates of the total number of in-migrating workers and their families are used to calculate the impact of GTCC LLRW and GTCC-like waste disposal facility construction and operations for the ROI counties in which the majority of new workers would locate. Impacts of the facility on county, city, and school district revenues and expenditures are calculated by using baseline data provided in the relevant jurisdictions' annual comprehensive financial reports forecasted for the peak year of construction and first year of operations, based on per-capita revenues and expenditures for each jurisdiction. Population forecasts are based on data provided by the U.S. Bureau of the Census.

Impacts of GTCC LLRW and GTCC-like waste disposal facility in-migration on community service employment are also calculated for the ROI counties in which the majority of new workers would locate. By using estimates of the number of in-migrating workers and families, the analysis calculates the number of new sworn police officers, firefighters, and general government employees required to maintain the existing levels of service for each community service. Calculations are based on the existing number of employees per 1,000 population for each community service. The analysis of the impact on educational employment estimates the number of teachers in each school district who would be required to maintain the existing teacher-student ratios across all student age groups. Information on existing employment and levels of service is collected from the individual jurisdictions providing each service.

C.6.5 Impacts on Traffic

Impacts on traffic in the ROI are described in terms of the impact of the increase in traffic caused by the GTCC LLRW and GTCC-like waste disposal facility on the major road segments used to commute to and from the site by existing site employees. The analysis allocates trips made by construction workers to individual road segments on the basis of the residential distribution of existing site workers. The impact on the existing annual average number of daily trips is then calculated, and the impact on the level of service provided by each individual segment is estimated. Traffic information is collected from state and county transportation departments.

C.7 ENVIRONMENTAL JUSTICE

Executive Order 12898 (February 16, 1994) formally requires federal agencies to incorporate environmental justice as part of their missions. Specifically, it directs them to address, as appropriate, any disproportionately high and adverse human health or environmental effects of their actions, programs, or policies on minority and low-income populations.

The analysis of the impacts of a GTCC LLRW and GTCC-like waste disposal (i.e., construction of additional rooms and waste operations at WIPP, and construction and operation of a new borehole, trench, or vault disposal facility at the GTCC reference location evaluated) on environmental justice issues follows Council on Environmental Quality (CEQ) guidelines described in *Environmental Justice Guidance under the National Environmental Policy Act* (CEQ 1997). The analysis method (1) describes the geographic distribution of low-income and minority populations in the affected area; (2) assesses whether the impacts of construction and operations would be high and adverse; and (3) if impacts are high and adverse, determines whether these impacts would disproportionately affect minority and low-income populations.

Construction and operations associated with GTCC LLRW and GTCC-like waste disposal could affect environmental justice if any adverse health and environmental impacts resulting from either phase of development were significantly high and if these impacts disproportionately affected minority and low-income populations. If an analysis that accounted for any unique exposure pathways (such as subsistence fish, vegetation or wildlife consumption, or well-water consumption) determined that health and environmental impacts would not be significant, there could be no high and adverse impacts on minority and low-income populations. If impacts were found to be significant, disproportionality would be determined by comparing the proximity of high and adverse impacts to the location of low-income and minority populations. Information needed to conduct the analysis would be collected and developed to support future evaluations that would be included in follow-on documents for the selected alternative(s).

The analysis of environmental justice issues considers impacts in an 80-km (50-mi) buffer around the site in order to include any potential adverse human health or socioeconomic impacts related to the GTCC LLRW and GTCC-like waste disposal (i.e., construction of additional rooms and waste disposal operations at WIPP, and construction and operation of a new borehole, trench, or vault disposal facility). Accidental radiological releases, for example, could affect minority and low-income population groups located some distance from the site, depending on the size and nature of potential releases and on the meteorological conditions. Any accidental release to the environment could also affect fish and other natural resources that might be used for subsistence by low-income and minority population groups some distance from the site, the extent of which also would depend on the size and nature of any potential release at the site.

The description of the geographic distribution of minority and low-income groups is based on demographic data from the 2010 Census (U.S. Bureau of the Census 2012). Definitions of minority and low-income population groups are as follows:

- *Minority*. Persons are included in the minority category if they identify themselves as belonging to any of the following racial groups: (1) Hispanic, (2) Black (not of Hispanic origin) or African American, (3) American Indian or Alaska Native, (4) Asian, or (5) Native Hawaiian or other Pacific Islander.

  Beginning with the 2000 Census, where appropriate, the census form allows individuals to designate multiple population group categories to reflect their ethnic or racial origin. In addition, persons who classify themselves as being of multiple racial origins may choose up to six racial groups. The term minority includes all persons, including those classifying themselves in multiple racial categories, except those who classify themselves as "White" (U.S. Bureau of the Census 2012).

  The CEQ guidance proposes that minority populations should be identified in locations where either (1) the minority population of the affected area exceeds 50% or (2) the minority population percentage of the affected area is meaningfully greater than the minority population percentage in the general population or other appropriate unit of geographic analysis.

  The EIS applies both criteria in using the Census Bureau data for census block groups, in that consideration is given to the minority population that is more than 50% or 20 percentage points higher in the relevant location than it is in the state (the reference geographic unit).

- *Low-income.* These are individuals who fall below the poverty line. The poverty line takes into account the family size and the age of individuals in the family. In 1999, for example, the poverty line for a family of five with three children below the age of 18 was $19,882. For any given family below the poverty line, all family members are considered as being below the poverty line for the purposes of analysis in this EIS.

C.8 LAND USE

Land use impacts are identified changes in land use categories and alternative or conflicting uses caused by a proposed action. Potential impacts on land use were evaluated for each alternative site by examining the characteristics and size of the land required for GTCC LLRW and GTCC-like waste disposal and the compatibility of current land use designations with the GTCC LLRW and GTCC-like waste disposal facility. The analyses considered potential land use impacts that could be incurred during the construction, operations, and post-closure phases of the project at each alternative site. An impact on land use would occur if the facility would change land use in the area in which the facility was located (i.e., the facility would not conform to existing DOE land use plans and policies) or in surrounding areas. Therefore, the GTCC LLRW and GTCC-like waste disposal facility was considered to have a potential impact on land use only if it would:

- Conflict with existing land use plans;

- Conflict with existing recreational, educational, scientific, or other uses of the area;

- Conflict with existing conservation goals for the area; or

- Require a conversion from existing commercial land use of the area (e.g., timber harvest, mineral extraction, livestock grazing).

C.9 TRANSPORTATION RISK ANALYSIS

This section provides the methodology and key input parameters used for the transportation risk analysis performed in support of the GTCC EIS. The methodology follows the common approach identified in DOE (2002b). The analysis evaluated the transportation of the waste from its assumed or known location of generation or storage to each of the proposed disposal facility locations. Transportation impacts were estimated for shipment by both truck and rail modes for the three GTCC LLRW and GTCC-like waste types.

C.9.1 Overview

The transportation risk assessment considered human health risks both from routine (normal, incident-free) transport of radiological materials and from potential accidents. In both cases, risks associated with the nature of the cargo itself (“cargo-related” impacts) were considered. Risks related to the transportation vehicle regardless of type of cargo (“vehicle-related" impacts) were considered for potential accidents. Transportation of hazardous chemicals was not part of this analysis because no hazardous chemicals have been identified as being part of the waste disposal operations. Figure C-1 depicts the overall approach.

C.9.1.1 Routine Transportation Risk

The radiological risk associated with routine transportation would be cargo-related and result from the potential exposure of people to low levels of external radiation near a loaded shipment. No direct physical exposure to radioactive material would occur during routine transport because these materials would be in packages designed and maintained to ensure that their contents were contained and shielded during normal transport. Any leakage or unintended release would be considered under accident risks.

C.9.1.2 Accident Transportation Risk

The cargo-related radiological risk from transportation-related accidents would come from the potential release and dispersal of radioactive material into the environment during an accident and the subsequent exposure of people through multiple exposure pathways (e.g., exposure to contaminated soil, inhalation, or the ingestion of contaminated food).

Vehicle-related accident risks refer to the potential for transportation-related accidents that would result in fatalities caused by physical trauma unrelated to the cargo.

C.9.2 Routine Risk Assessment Methodology

The RADTRAN 5 computer code (Neuhauser and Kanipe 2003; Weiner et al. 2006) was used in the routine and accident cargo-related risk assessments to estimate the radiological impacts on collective populations. RADTRAN 5 was developed by Sandia National Laboratories to calculate population risks associated with the transportation of radioactive materials by truck, rail, air, ship, or barge. The code has been used extensively for transportation risk assessments since it was originally issued in the late 1970s as RADTRAN (RADTRAN 1) and has been reviewed and updated periodically. RADTRAN 1 was originally developed to facilitate the calculations presented in NUREG-0170 (NRC 1977a).

C.9.2.1 Collective Population Risk

The radiological risk associated with routine transportation would result from the potential exposure of people to low-level external radiation in the vicinity of loaded shipments. Even under routine transportation, some radiological exposure could occur. Because the radiological consequences (dose) would occur as a direct result of normal operations, the probability of routine consequences is taken to be 1 in the RADTRAN 5 code. Therefore, the dose risk is equivalent to the estimated dose.

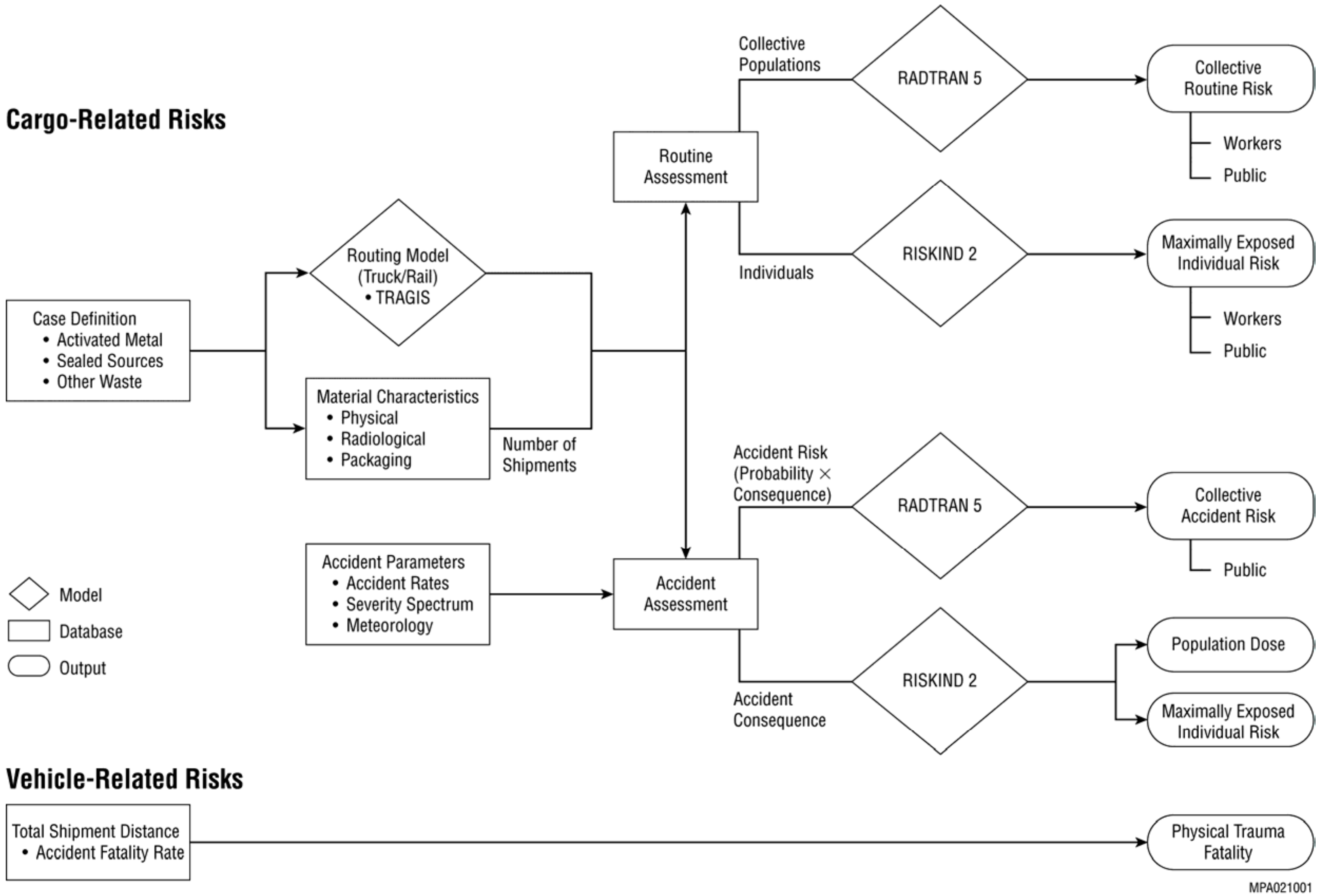

FIGURE C-1 Technical Approach for the Transportation Risk Assessment

For routine transportation, the RADTRAN 5 computer code considers major groups of potentially exposed persons. The RADTRAN 5 calculations of risk for routine highway and rail transportation include exposures of the following population groups:

- *Persons along the route (off-link population)*. Collective doses were calculated for all persons living or working within 0.8 km (0.5 mi) of each side of a transportation route. The total number of persons within the 1.6-km (1-mi) corridor was calculated separately for each route considered in the assessment.

- *Persons sharing the route (on-link population)*. Collective doses were calculated for persons in all vehicles sharing the transportation route. This group includes persons traveling in the same or opposite directions as the shipment, as well as persons in vehicles passing the shipment.

- *Persons at stops*. Collective doses were calculated for people who might be exposed while a shipment was stopped en route. For truck transportation, these stops would include those for refueling, food, and rest. For rail transportation, it was assumed that stops would occur for purposes of classification.

- *Crew members*. Collective doses were calculated for truck transportation crew members involved in the actual shipment of material. Workers involved in loading or unloading were not considered. The doses calculated for the first three population groups were added together to yield the collective dose to the public. The dose calculated for the fourth group represents the collective dose to workers.

The RADTRAN 5 calculations for routine dose generically compute the dose rate as a function of distance from a point or line source (Neuhauser and Kanipe 2003). Associated with the calculation of routine doses for each exposed population group are parameters such as the radiation field strength, source-receptor distance, duration of exposure, vehicular speed, stopping time, traffic density, and route characteristics (such as population density). The RADTRAN manual contains derivations of the equations used and descriptions of these parameters (Neuhauser and Kanipe 2003).

C.9.2.2 Highest-Exposed Individual Risk

In addition to assessing the routine collective population risk, the risks to individuals receiving the highest impacts were estimated for a number of hypothetical exposure scenarios by using the RISKIND model (Yuan et al. 1995; Biwer et al. 1997). Receptors included transportation crew members, departure inspectors, and members of the public exposed during traffic delays, while working at a service station, or while living near a facility, as summarized in Table C-6.

TABLE C-6 Individual Exposure Scenarios

Receptor	Exposure Event	Source
Workers		
Inspector (truck and rail)	1 m for 1 hour	DOE 2008
Railyard crew member	10 m for 2 hours	DOE 1997a, 2008
Public		
Resident near route	18 m (rail), 30 m (truck)	DOE 2008 (rail), DOE 1997a (truck)
Person in traffic jam	1.2 m for 1 hour	DOE 2008
Person at service station	16 m for 49 minutes	DOE 2008
Resident near railyard	200 m for 20 hours	DOE 1997a

RISKIND was used to calculate the dose to each individual considered for an exposure scenario defined by an exposure distance, duration, and frequency specific to that receptor. The distances and durations of exposure were similar to those given in previous transportation risk assessments (DOE 1990, 1995, 1996, 1997a, 1999). The scenarios were not meant to be exhaustive but were selected to provide a range of potential exposure situations.

The RISKIND external dose model considers direct external exposure and exposure from radiation scattered from the ground and air. RISKIND was used to calculate the dose as a function of distance from a shipment on the basis of the dimensions of the shipment (millirem per hour for stationary exposures and millirem per event for moving shipments). The code approximates the shipment as a cylindrical volume source, and the calculated dose includes contributions from secondary radiation scattering from buildup (scattering by the material contents), cloudshine (scattering by the air), and groundshine (scattering by the ground). As a conservative measure, credit for potential shielding between the shipment and the receptor was not considered.

C.9.3 Accident Assessment Methodology

The radiological transportation accident risk assessment used the RADTRAN 5 code for estimating collective population risks and the RISKIND code for estimating individual and population consequences. The collective accident risk for each type of shipment was determined in a manner similar to that described for routine collective population risks.

C.9.3.1 Radiological Accident Risk Assessment

The risk analysis for potential accidents differs fundamentally from the risk analysis for routine transportation because occurrences of accidents are statistical in nature. The accident risk assessment is treated probabilistically in RADTRAN 5 for radiological risk. Accident risk is defined as the product of the accident consequence (dose or exposure) and the probability of the accident occurring. In this respect, RADTRAN 5 estimates the collective accident risk to populations by considering a spectrum of transportation-related accidents. The spectrum of accidents was designed to encompass a range of possible accidents, including low-probability accidents that have high consequences and high-probability accidents that have low consequences (such as “fender benders”). For radiological risk, the results for collective accident risk can be directly compared with the results for routine collective risk because the latter results implicitly incorporate a probability of occurrence of 1 if the shipment takes place.

The RADTRAN 5 calculation of collective accident risk uses models that quantify the range of potential accident severities and the responses of transported packages to accidents. The spectrum of accident severity is divided into several categories, each of which is assigned a conditional probability of occurrence (i.e., the probability that if an accident does occur, it will be of a particular severity). Release fractions, defined as the fraction of the material in a package that could be released in an accident, are assigned to each accident severity category on the basis of the physical and chemical form of the material. The model takes into account the mode of transportation and the type of packaging by selecting the appropriate accident probabilities and release fractions, respectively. The accident rates, the definitions of accident severity categories, and the release fractions used in this analysis are discussed further in Section C.9.4.4.

For accidents involving the release of radioactive material, RADTRAN 5 assumes that the material is dispersed in the environment according to standard Gaussian diffusion models. For the risk assessment, default data for atmospheric dispersion were used, representing an instantaneous ground-level release and a small-diameter source cloud (Neuhauser and Kanipe 2003). The calculation of the collective population dose following the release and dispersal of radioactive material includes the following exposure pathways:

- External exposure to the passing radioactive cloud,
- External exposure to contaminated ground,
- Internal exposure from inhalation of airborne contaminants, and
- Internal exposure from the ingestion of contaminated food.

For the ingestion pathway, state-average food transfer factors, which relate the amount of radioactive material ingested to the amount deposited on the ground, were calculated in accordance with the methods described by NRC Regulatory Guide 1.109 (NRC 1977b) and were used as input to the RADTRAN code. Doses of radiation from the ingestion or inhalation of radionuclides were calculated by applying standard dose conversion factors (DCFs) (EPA 1999; ICRP 1996).

C.9.3.2 Vehicle-Related Accident Risk Assessment

The vehicle-related accident risk refers to the potential for transportation accidents that could result directly in fatalities not related to the nature of the cargo in the shipment. This risk represents fatalities from physical trauma. State-average rates for transportation fatalities are used in the assessment, as discussed in Section C.9.4.1.3. Vehicle-related accident risks were calculated by multiplying the total distance traveled by the rates for transportation fatalities. In all cases, the vehicle-related accident risks were calculated on the basis of distances for round-trip shipment, since the presence or absence of cargo would not be a factor in accident frequency.

C.9.3.3 Accident Consequence Assessment

The RISKIND code is used to provide a scenario-specific assessment of radiological consequences from severe transportation-related accidents for each waste type. The RADTRAN accident risk assessment considers the entire range of accident severities and their related probabilities, whereas the RISKIND accident consequence assessment focuses on accidents that result in the largest releases of radioactive material to the environment.

For each waste type, accident consequences are presented for a shipment of waste that represents the highest potential radiological risk if an accident was to occur. This “maximum reasonably foreseeable accident” is identified for each waste type by screening the site-specific radiological waste characteristics (that is, activity concentrations) developed for this EIS, taking into account the physical forms of waste and the relative hazards of individual radionuclides. For most waste shipments, the consequences of severe accidents would be less than those presented for the maximum reasonably foreseeable case. The accident consequence assessment is intended to provide an estimate of the maximum potential impacts posed by a severe transportation-related accident involving a particular waste type.

The severe accidents considered in the consequence assessment are characterized by extreme mechanical and thermal forces. In all cases, these accidents result in a release of radioactive material to the environment. The accidents correspond to those within the highest accident severity category, as described previously. These accidents represent low-probability, high-consequence events. Therefore, accidents of this severity are expected to be extremely rare. However, the overall probability that such an accident could occur depends on the potential accident rates for this severity category and the shipping distance for each case.

For each waste type, RISKIND is used to calculate the accident consequences for local populations and for the highest-exposed individual. The population dose includes the population within 80 km (50 mi) of the accident site. The exposure pathways considered are similar to those discussed previously for the accident risk assessment. Although remedial activities after the accident (for example, evacuation or ground cleanup) would reduce the consequences, these activities are not considered in the consequence assessment.

Because predicting the exact location of a severe transportation-related accident is impossible when estimating population impacts, separate accident consequences are calculated for accidents occurring in three population density zones: rural, suburban, and urban. Moreover, to address the effects of the atmospheric conditions existing at the time of an accident, two atmospheric conditions are considered: neutral and stable.

The highest-exposed individual for severe transportation accidents would be located at the point that would have the highest concentration of hazardous material that would be accessible to the general public. This location is assumed to be 30 m (100 ft) or farther from the release point at the location of highest air concentration. Only the shipment accident that would result in the highest contaminant concentration is evaluated for individual exposures.

C.9.4 Input Parameters and Assumptions

The principal input parameters and assumptions used in the transportation risk assessment are discussed in this section. DOE has broad authority under the Atomic Energy Act to regulate all aspects of activities involving radioactive materials that are undertaken by DOE or on its behalf, including the transportation of radioactive materials. DOE exercises this authority to regulate certain DOE shipments, such as shipments undertaken by governmental employees or shipments involving special circumstances. In most cases that do not involve national security, DOE utilizes commercial carriers that undertake shipments of DOE material under the same terms and conditions as those of commercial shipments. These shipments are subject to regulation by the U.S. Department of Transportation (DOT) and other entities, as appropriate. As a matter of policy, all DOE shipments are undertaken in accordance with the requirements and standards that apply to comparable commercial shipments, except where there is a determination that national security or another critical interest requires different action. In implementing this policy, DOE cooperates with federal, state, local, and tribal entities and utilizes existing expertise and resources to the extent practicable. In all cases, DOE will achieve a level of protection that meets or exceeds the level of protection associated with comparable commercial shipments.

DOT and the NRC have the primary responsibility for federal regulations governing commercial radioactive material transportation. The Hazardous Materials Transportation Act of 1975, as amended (49 *United States Code* [U.S.C.] 5105, et seq.), requires DOT to establish regulations for the safe transportation of hazardous materials in commerce (including radioactive materials). Title 49 of the *Code of Federal Regulations* (CFR) contains DOT standards and requirements for the packaging, transporting, and handling of radioactive materials for all modes of transportation. DOT's Hazardous Materials Regulations, or HMRs, on the transportation of hazardous and radioactive materials can be found in 49 CFR Parts 171 through 180. In addition, the requirements for motor carrier transportation can be found in 49 CFR Parts 350 through 399, and the requirements for transportation by rail can be found in 49 CFR Parts 200 through 268. The NRC sets additional design and performance standards for packages that carry materials with higher levels of radioactivity. The NRC regulations pertaining to transportation of radioactive materials are found in 10 CFR Part 71. These regulations include detailed requirements for certification testing of packaging designs. This certification testing involves a variety of conditions, such as heating, free dropping onto an unyielding surface, immersing in water, dropping the package onto a vertical steel bar, and checking gas tightness.

C.9.4.1 Route Characteristics

The transportation route selected for a shipment determines the total population of potentially exposed individuals and the expected frequency of transportation-related accidents. For truck and rail transportation, the route characteristics most important for a risk assessment include the total shipping distance between each origin site and destination site and the population density along the route.

C.9.4.1.1 Route Selection. The DOT routing regulations concerning radioactive materials on public highways are prescribed in 49 CFR 397.101 (Requirements for Motor Carriers and Drivers). The objectives of the regulations are to reduce the impacts from transporting radioactive materials, establish consistent and uniform requirements for route selection, and identify the role of state and local governments in routing radioactive materials. The regulations attempt to reduce potential hazards by prescribing that populous areas be avoided and that travel times be minimized. In addition, the regulations require the carrier of radioactive materials to ensure (1) that the vehicle is operated on routes that minimize radiological risks and (2) that accident rates, transit times, population density and activity, time of day, and day of week are considered in determining risk. The final determination of the route is left to the discretion of the carrier unless the shipment contains a "highway route controlled quantity" (HRCQ) of radioactive material, as defined in 49 CFR 173.403 (Definitions). Many potential shipments evaluated for this EIS, such as shipments of activated metal from commercial reactors, fall under this category.

A vehicle transporting an HRCQ of radioactive materials is required to use the interstate highway system except when moving from the point of origin to the interstate or from the interstate to a destination point, when making a necessary repair or rest stop, or when emergency conditions make continued use of the interstate unsafe or impossible. Carriers are required to use interstate circumferential or bypass routes, if available, to avoid populous areas. Any state or Native American tribe may designate alternative preferred routes to replace or supplement the interstate system, in accordance with 49 CFR 397.103. DOT highway routing requirements preempt any conflicting routing requirements issued by state, local, or tribal governments, such as prohibitions on radioactive waste shipments through local nuclear-free zones (49 CFR 397.203).

Railroad routes are generally fixed by the location of rail lines, and urban areas typically cannot be readily bypassed. However, DOT's Pipeline and Hazardous Materials Safety Administration regulations in 49 CFR 172.820(c) require each rail carrier annually to "analyze the safety and security risks for the transportation route(s)" it uses to transport shipments of HRCQ quantities of radioactive material, among other commodities. The route analysis must include the 27 factors related to safety and security identified in Appendix D to 49 CFR Part 172. Carriers are then required to use the analysis to "select the practicable route posing the least overall safety and security risk," in accordance with 49 CFR 172.820(e).

For this analysis, representative shipment routes were identified by using the Transportation Routing Analysis Information System (TRAGIS) (Version 1.5.4) routing model

(Johnson and Michelhaugh 2003) for truck and rail shipments. The routes were selected to be reasonable and consistent with routing regulations and general practice, but they are representative routes only because the actual routes will be chosen in the future. At the time of shipment, the route would be selected on the bases of current road or railroad track conditions, including repairs and traffic congestion.

The highway data network in TRAGIS is a computerized road atlas that includes a complete description of the interstate highway system and of all U.S. highways. In addition, most principal state highways and many local and community highways are identified. The code is periodically updated to reflect current road conditions and has been compared with reported mileages and observations of commercial trucking firms. The TRAGIS highway database version used was Highway Data Network 4.0.

Truck routes are calculated within the model by minimizing the total impedance between origin and destination. The impedance is basically defined as a function of distance and driving time along a particular segment of highway. The HRCQ option in the model was used to select routes for all shipments. The population densities along a route are derived from 2000 Census data.

The rail network used in TRAGIS consists of numerous subnetworks and represents various competing rail companies in the United States. The network was originally based on data from the Federal Railroad Administration and reflected the U.S. railroad system in 1974. The database has been expanded and modified over the past three decades. The code is updated periodically to reflect current track conditions and has been compared with reported mileages and observations of commercial rail firms. A 1:100,000-scale rail network is now incorporated into TRAGIS. The TRAGIS rail database version used was Railroad Data Network 3.2.

Rail routes are calculated by using a “shortest-route” algorithm that finds the path of minimum impedance within an individual subnetwork. A separate method is used to find paths along the subnetworks. The routes chosen for this study were selected by using the standard assumptions in the model, which simulate the process of selection that railroads would use to direct shipments of radioactive waste. The population densities along a route are derived from 2000 Census data.

The actual routes selected for GTCC LLRW and GTCC-like waste shipments at the time of implementation will meet the requirements of DOT for using the interstate highway system or a State-designated alternative route as appropriate. In addition, DOT will follow other routes that have been identified through agreements with local, tribal, or state governments for transport of radioactive waste.

C.9.4.1.2 Population Density. Three population density zones — rural, suburban, and urban — were used for the population risk assessment. The fractions of travel and average population density in each zone were determined with the TRAGIS routing model. Rural, suburban, and urban areas are characterized according to the following breakdown: Rural population densities range from 0 to 54 persons/km^2 (0 to 139 persons/mi^2); suburban densities range from 55 to 1,284 persons/km^2 (140 to 3,326 persons/mi^2); and urban densities cover all population densities greater than 1,284 persons/km^2 (3,326 persons/mi^2). Use of these three population density zones is based on an aggregation of the 11 population density zones provided in the TRAGIS model output. For calculation purposes, information about population density was generated at the state level and used as RADTRAN input for all routes.

C.9.4.1.3 Accident and Fatality Rates. For calculating accident risks, vehicle accident involvement and fatality rates were taken from data provided in Saricks and Tompkins (1999). For each transport mode, accident rates are generically defined as the number of accident involvements (or fatalities) in a given year per unit of travel by that mode in the same year. Therefore, the rate is a fractional value: The accident-involvement count is the numerator, and vehicular activity (total traveled distance) is the denominator. Accident rates are derived from multiple-year averages that automatically account for such factors as heavy traffic and adverse weather conditions. For assessment purposes, the total number of expected accidents or fatalities is calculated by multiplying the total shipping distance for a specific case by the appropriate accident or fatality rate.

For truck transportation, the rates presented in Saricks and Tompkins (1999) are specifically for heavy combination trucks involved in interstate commerce. Heavy combination trucks are rigs composed of a separable tractor unit containing the engine and one to three freight trailers connected to each other and the tractor. Heavy combination trucks are typically used for shipping radioactive wastes. Truck accident rates are computed for each state on the basis of statistics for 1994 to 1996 compiled by the DOT Office of Motor Carriers. Saricks and Tompkins (1999) present accident involvement and fatality counts, estimated kilometers of travel by state, and the corresponding average accident involvement and fatality rates for the three years investigated. Fatalities (including of crew members) are deaths that are attributable to the accident and that occurred within 30 days of the accident.

The truck accident assessment presented in this EIS uses state-specific accident and fatality rates for travel on interstate highways. The total accident risk for a case depends on the total distance traveled in various states and does not rely on national average accident statistics. For comparative purposes, the national average truck accident rate on interstate highways presented in Saricks and Tompkins (1999) is 3.15×10^{-7} accidents/truck-km (5.07×10^{-7} accidents/mi). Likewise, the national average truck fatality rate was reported as 8.9×10^{-9} fatalities/truck-km (1.4×10^{-8} fatalities/mi).

Rail accidents rates are computed and presented in a manner similar to truck accident rates in Saricks and Tompkins (1999). However, for rail transport, the unit of haulage is the railcar. State-specific rail accident involvements and fatality rates are based on statistics for 1994 to 1996 compiled by the Federal Railroad Administration. Rail accidents include both mainline accidents and those occurring in rail yards.

The rail accident assessment presented in this EIS uses accident and fatality rates for travel on mainline (Class 1 and 2) railroads. The total accident risk for a case depends on the total distance traveled in various states and does not rely on national average accident statistics.

For comparative purposes, the national rail accident rate on mainline railroads presented in Saricks and Tompkins (1999) is 2.74×10^{-7} accidents/railcar-km (4.41×10^{-7} accidents/mi). Likewise, the national average rail fatality rate was reported as 7.82×10^{-8} fatalities/railcar-km (1.26×10^{-7} fatalities/km).

Note that the accident rates used in this assessment were computed by considering all interstate shipments, regardless of the cargo. Saricks and Kvitek (1994) points out that shippers and carriers of radioactive material generally have a higher-than-average awareness of transportation risk and prepare cargoes and drivers for such shipments accordingly. This preparation should have the twofold effect of reducing component and equipment failure and mitigating the contribution of human error to accident causation. However, these mitigating effects are not considered in the accident assessment.

C.9.4.2 Packaging

The packaging used for shipping radioactive materials must be designed, constructed, and maintained to ensure that it will contain and shield the contents during normal transportation. For more highly radioactive material, the packaging must contain and shield the contents in severe accidents. The type of packaging used is determined by the radioactive hazard associated with the packaged material. The basic types of packaging required by the applicable regulations are designated as Type A, Type B, or industrial packaging (generally for low-specific-activity material). All shipments evaluated in this analysis are assumed to use Type B packaging for transportation.

The 208-L (55-gal) drums and SWBs that are assumed to contain the CH waste (as discussed in Appendix B, Section B.4) are Type A packaging. This type of packaging must withstand the conditions of normal transportation without the loss or dispersal of the radioactive contents, as specified in 49 CFR 173.413 (Additional Design Requirements for Type A Packages). "Normal" transportation refers to all transportation conditions except those resulting from accidents or sabotage. Approval of Type A packaging is obtained by demonstrating that the packaging can withstand specified testing conditions intended to simulate normal transportation. Type A packaging usually does not require special handling, packaging, or transportation equipment. Because the levels of radioactivity in many of these Type A containers containing CH GTCC LLRW or GTCC-like waste would be near the upper limits specified in 10 CFR Part 71, with multiple drums or SWBs per shipment, the use of Type B packaging is assumed for CH waste shipments. At the time of actual shipment, all GTCC LLRW and GTCC-like waste would be packaged in compliance with radioactive material transportation safety regulations, and Type B packaging might not be required, depending on the characteristics of the waste to be transported.

In addition to meeting all the Type A standards, Type B packaging must also provide a high degree of assurance that the package integrity will be maintained even during severe accidents, with essentially no loss of the radioactive contents or serious impairment of the shielding capability. Type B packaging is required for shipping large quantities of radioactive material and must satisfy stringent testing criteria (as specified in 10 CFR Part 71). The testing criteria were developed to simulate conditions of severe hypothetical accidents, including impact, puncture, fire, and immersion in water. The most widely recognized Type B packaging is the massive casks used to transport highly radioactive spent nuclear fuel (SNF) from nuclear power stations. Large-capacity cranes and mechanical lifting equipment are usually necessary for handling Type B packaging. Many Type B packages are transported on trailers specifically designed for that purpose.

The CH waste considered in this EIS, while it is placed in Type A packaging, is assumed to be transported in Type B containers referred to as the Transuranic Package Transporter-II (TRUPACT-II). TRUPACT-IIs are being used for the shipment of similar types of waste to WIPP. One TRUPACT-II can accommodate either 14 208-L (55-gal) drums (two stacked 7-drum packs [hexagonal arrays with one in the middle]) or two stacked SWBs. For the purposes of this EIS, four cesium irradiators are assumed to be shipped in one TRUPACT-II.

A discussion of the RH waste packaging assumed for this EIS is provided in Section B.4.1.2 in Appendix B. Section B.5 in Appendix B summarizes the shipment configurations and number of shipments used in the transportation analysis.

C.9.4.3 Accident Characteristics

The assessment of transportation accident risk takes into account the fraction of material in a package that would be released or spilled to the environment during an accident, commonly referred to as the release fraction. The release fraction is a function of the severity of the accident and the material packaging. For instance, a low-impact accident, such as a fender-bender, is not expected to cause any release of material. Conversely, a very severe accident is expected to release nearly all of the material in the shipment into the environment. The method used to characterize accident severities and the corresponding release fractions for estimating radioactive risks are described below.

C.9.4.3.1 Accident Severity Categories. A method to characterize the potential severity of transportation-related accidents is described in NUREG-0170 (NRC 1977a). The NRC method divides the spectrum of transportation accident severities into eight categories. Other studies have divided the same accident spectrum into six categories (Wilmot 1981), 20 categories (Fischer et al. 1987), or more (Sprung et al. 2000); however, these latter studies focused primarily on accidents involving shipments of SNF. In this analysis, the NUREG-0170 scheme is used for all shipments.

The NUREG-0170 scheme for accident classification is shown in Figures C-2 and C-3 for truck and rail transportation, respectively. Severity is described as a function of the magnitudes of the mechanical forces (impact) and thermal forces (fire) to which a package might 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 package is subjected to forces within a certain range of values is assigned to the accident severity category associated with that range. The scheme for accident

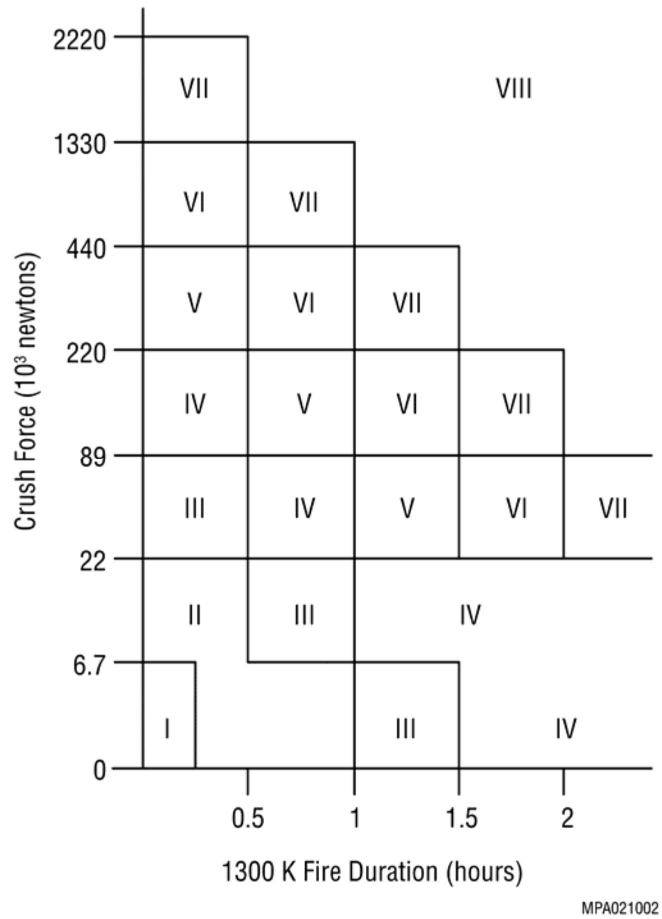

FIGURE C-2 Scheme for NUREG-0170 Classification by Accident Severity Category for Truck Accidents (Source: NRC 1977a)

severity is designed to take into account all credible transportation-related accidents, including those accidents with a low probability but high consequences and those with a high probability but low consequences.

Each severity category represents a set of accident scenarios defined by a combination of mechanical and thermal forces. A conditional probability of occurrence (i.e., the probability that if an accident occurs, it is of a particular severity) is assigned to each category. The fractional occurrences for accidents by accident severity category and population density zone are shown in Table C-7 and are used for estimating the radioactive risks.

Category I accidents are the least severe but the most frequent. Category VIII accidents are very severe but very infrequent. To determine the expected frequency of an accident of a given severity, the conditional probability in the category is multiplied by the baseline accident rate. Each population density zone has a distinct distribution of accident severities related to differences in average vehicular velocity, traffic density, location (rural, suburban, or urban), and other factors.

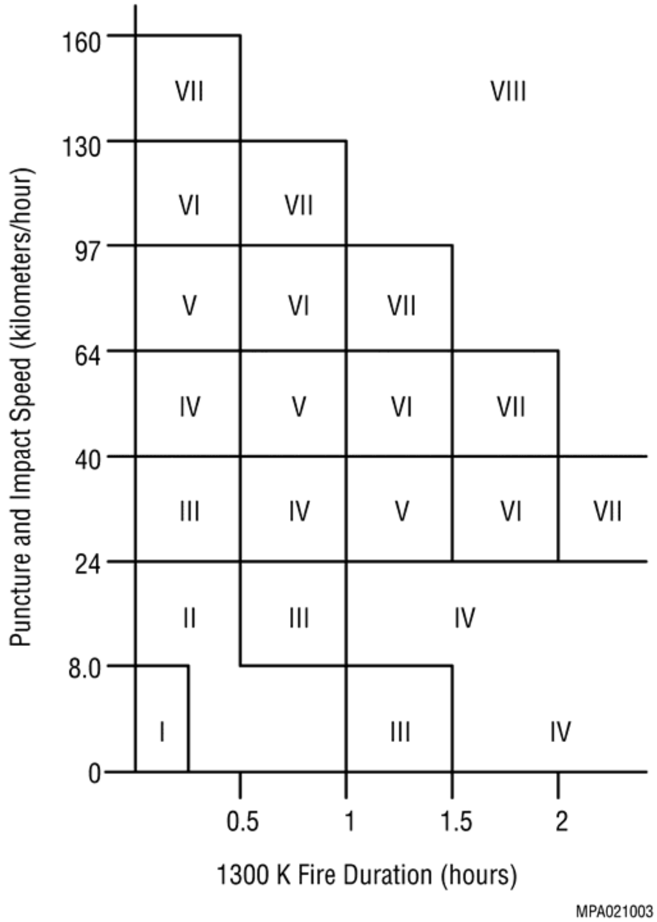

FIGURE C-3 Scheme for NUREG-0170 Classification by Accident Severity Category for Rail Accidents (Source: NRC 1977a)

C.9.4.3.2 Package Release Fractions. In NUREG-0170, radiological and chemical consequences are calculated by assigning package release fractions to each accident severity category. The release fraction is defined as the fraction of the material in a package that could be released from the package as the result of an accident of a given severity. Release fractions take into account all the mechanisms necessary to release material from a damaged package into the environment. Release fractions vary according to the type of package and the physical form of the material.

Representative release fractions for accidents involving activated metal shipments were taken from NUREG-0170 (NRC 1977b). The recommendations in NUREG-0170 are based on best engineering judgments and have been shown to provide conservative estimates of material releases following accidents. Release fractions for accidents of each severity category are given in Table C-8. As shown in that table, the amount of material released from the package ranges from zero for minor accidents to 100% for the most severe accidents. Important for the purposes of risk assessment are the fraction of the released material that can be entrained in an aerosol

TABLE C-7 Fractional Occurrences for Truck and Rail Accidents by Severity Category and Population Density Zone

Accident Severity Category	Fractional Occurrence	Fractional Occurrence by Population Density Zone		
		Rural	Suburban	Urban
Truck				
I	5.5E-01	1.0E-01	1.0E-01	8.0E-01
II	3.6E-01	1.0E-01	1.0E-01	8.0E-01
III	7.0E-02	3.0E-01	4.0E-01	3.0E-01
IV	1.6E-02	3.0E-01	4.0E-01	3.0E-01
V	2.8E-03	5.0E-01	3.0E-01	2.0E-01
VI	1.1E-3	7.0E-01	2.0E-01	1.0E-01
VII	8.5E-05	8.0E-01	1.0E-01	1.0E-01
VIII	1.5E-05	9.0E-01	5.0E-02	5.0E-02
Rail				
I	5.0E-01	1.0E-01	1.0E-01	8.0E-01
II	3.0E-01	1.0E-01	1.0E-01	8.0E-01
III	1.8E-01	3.0E-01	4.0E-01	3.0E-01
IV	1.8E-02	3.0E-01	4.0E-01	3.0E-01
V	1.8E-03	5.0E-01	3.0E-01	2.0E-01
VI	1.3E-04	7.0E-01	2.0E-01	1.0E-01
VII	6.0E-05	8.0E-01	1.0E-01	1.0E-01
VIII	1.0E-05	9.0E-01	5.0E-02	5.0E-02

Source: NRC (1977a)

(part of an airborne contaminant plume) and the fraction of the aerosolized material that is also respirable (of a size that can be inhaled into the lungs). These fractions depend on the physical form of the material. Most solid materials are difficult to release in particulate form and are therefore relatively nondispersible. Conversely, liquid or gaseous materials are relatively easy to release if the container is breached in an accident.

The aerosolized fraction and the respirable fraction were taken to be 1×10^{-6} and 0.05, respectively, for the activated metal that is expected to behave as immobile material (Neuhauser and Kanipe 1992). The release fractions used for the CH and other RH waste shipments with the TRUPACT-II and RH-72B Type B packages, respectively, are also provided in Table C-8.

C.9.4.3.3 Atmospheric Conditions during Accidents. Hazardous material released to the atmosphere is transported by the wind. The amount of dispersion, or dilution, of the contaminant material in the air depends on the meteorological conditions at the time of the accident. Because predicting the specific location of an off-site transportation-related accident

TABLE C-8 Estimated Release Fractions for Type B Packages under Various Accident Severity Categories

Accident Severity Category	Release Fraction[a]	TRUPACT-II[b]		RH-72B[c]	
		Truck	Rail	Truck	Rail
I	0	0	0	0	0
II	0	0	0	0	0
III	0.01	8×10^{-9}	2×10^{-8}	6×10^{-9}	2×10^{-8}
IV	0.1	2×10^{-7}	7×10^{-7}	2×10^{-7}	7×10^{-7}
V	1	8×10^{-5}	8×10^{-5}	1×10^{-4}	1×10^{-4}
VI	1	2×10^{-4}	2×10^{-4}	1×10^{-4}	1×10^{-4}
VII	1	2×10^{-4}	2×10^{-4}	2×10^{-4}	2×10^{-4}
VIII	1	2×10^{-4}	2×10^{-4}	2×10^{-4}	2×10^{-4}

[a] Source*:* NRC (1977b), used for all activated metal shipments. Aerosolized and respirable fractions for activated waste in Type B packages for all accident severity categories are assumed to equal 1×10^{-6} and 0.05, respectively.

[b] Source*:* DOE (1997b), used for CH waste shipments. Both aerosolized and respirable fractions are assumed to equal 1.0.

[c] Source*:* DOE (1990), used for RH waste shipments. Both aerosolized and respirable fractions are assumed to equal 1.0.

and the exact meteorological conditions at the time of an accident is impossible, generic atmospheric conditions were selected for the accident risk assessment. National average weather conditions (Weiner et al. 2006) were used in the analysis.

C.9.4.4 Radiological Risk Assessment Input Parameters and Assumptions

The dose (and, correspondingly, the risk) to populations during routine transportation of radioactive materials is directly proportional to the assumed external dose rate from the shipment. The actual dose rate from the shipment is a complex function of the composition and configuration of shielding and containment materials used in the packaging, the geometry of the loaded shipment, and the characteristics of the radioactive material itself.

Table C-9 lists the external dose rates developed for this transportation analysis. The dose rates are presented as the dose rate at 1 m (3.3 ft) from the lateral sides of the transport vehicle. These values are well below the regulatory limit established in 49 CFR 173.441 (Radiation Level Limitations) and 10 CFR 71.47 (External Radiation Standards for All Packages) to protect the public. The regulatory limit is set at is 0.1 mSv/h (10 mrem/h) at 2 m (6 ft) from the outer lateral sides of the transport vehicle. This dose rate corresponds to approximately 14 mrem/h at 1 m (3 ft) from the shipment. Previous estimates of external dose rates at 1 m from CH and RH wastes similar to GTCC LLRW and GTCC-like waste have ranged up to 3.3 mrem/h for CH

TABLE C-9 External Dose Rates, Package Sizes, and Distances Used in RADTRAN

Shipment	Dose Rate at 1 m (3.3 ft) from Side of the Transport Vehicle (mrem/h)	Package Size (m)	Crew Distance (m)	Crew View (m)
Activated metal and RH waste				
Truck	2.5[a]	3.6[b]	3.2	0.66
Rail	5.0	7.2[c]	NA[d]	NA
CH waste				
Truck	0.5	7.4[e]	10	1.85
Rail	1.0	14.8[f]	NA	NA

[a] Source: Sandia (2008).

[b] One RH-72B package.

[c] Two RH-72B packages.

[d] NA = not applicable.

[e] Three TRUPACT-II packages.

[f] Six TRUPACT-II packages.

waste and up to 9.2 mrem/h for RH waste (DOE 1997b). By using a DOE-complex-wide average radionuclide profile of similar waste, a more recent dose rate estimate of 0.5 mrem/h for CH waste truck shipments and 2.5 mrem/h for RH waste truck shipments was calculated (Sandia 2008). Because of the high activities associated with the GTCC LLRW and GTCC-like waste, especially for the activated metals, these estimates could be lower than the actual values for some specific shipments in the future, but they represent a more realistic overall average external dose rate than the use of an excessive bounding estimate, and they are consistent across alternatives. Once an alternative is selected for disposal of specific waste, further analysis may be required to optimize waste packaging and shipment configurations to minimize impacts on the basis of the characteristics of the actual waste to be transported.

In addition to the specific parameters discussed previously, values for a number of general parameters must be specified within the RADTRAN code to calculate radiological risks. Standard values were used in most cases. These general parameters define basic characteristics of the shipment and traffic and are specific to the mode of transportation. The user's manual for the RADTRAN code (Neuhauser and Kanipe 2003; Weiner et al. 2006) contains derivations and descriptions of these parameters. The general RADTRAN input parameters used in the radiological transportation risk assessment are summarized in Table C-10.

TABLE C-10 General RADTRAN Input Parameters[a]

Parameter	Truck	Rail
Number of crew members	2	5
Average vehicular speed (km/h)[b]		
Rural	88.49	64.37
Suburban	40.25	40.25
Urban	24.16	24.16
Stop time (h/km)	0.0015	0.033
Number of people exposed while stopped	25	Route-specific suburban population average density
Distance for exposure while stopped (m)	20	10 to 400
Number of people per vehicle sharing route	2	3
Population density (persons/km^2)[c]	Route specific	Route specific
One-way traffic count (vehicles/h)[d]		
Rural	530	1
Suburban	760	1
Urban	2,400	5
Fraction of farmland[e]	Route specific	Route specific

[a] Accident conditional probabilities are listed by severity category in Table C-7. Accident release fractions are given in Table C-8. External dose rates are given in Table C-9.

[b] Fraction of rural and suburban travel on freeways is assumed to be 1. Thus, the rural speed is used for both urban and suburban zones in RADTRAN for truck transport.

[c] Route-specific population densities are from the TRAGIS route outputs.

[d] Source: DOE (2002b).

[e] State-specific fraction of farmland was taken from Table 8, pp. 291–299, in USDA (2004).

C.9.5 Uncertainties and Conservatism in Estimated Impacts

The sequence of analyses performed to generate estimates of risk from transporting radioactive waste is as follows: (1) determine the waste inventory and characteristics at each site, (2) estimate the shipment requirements, (3) determine the route characteristics, (4) calculate the radiation doses to exposed individuals (including estimating environmental transport and uptake of radionuclides), and (5) estimate health effects. Uncertainties are associated with each step. Uncertainties exist in the (1) way that the physical systems being analyzed are represented by the computational models; (2) data required to apply the models (because of measurement errors, sampling errors, natural variability, or unknown factors caused simply because the actions being analyzed will occur in the future; and (3) calculations themselves (e.g., the approximation algorithms used in the computer programs).

In principle, one could estimate the uncertainty associated with each input or computational source and predict the resultant uncertainty in each subsequent set of calculations. Thus, one could propagate the uncertainties from one set of calculations to the next and estimate the uncertainty in the final, or absolute, result. However, conducting such a full-scale quantitative uncertainty analysis is often impractical and sometimes impossible, especially for actions that would be initiated at an unspecified time in the future. Instead, the risk analysis is designed to ensure — through uniform and judicious selection of scenarios, models, and input parameters — that relative comparisons of risk among the various alternatives are meaningful. In the transportation risk assessment, this objective is accomplished by uniformly applying input parameters and assumptions to all alternatives for each waste type. Therefore, although considerable uncertainty is inherent in the absolute magnitude of the transportation risk for each alternative, much less uncertainty is associated with the relative differences among the alternatives in a given measure of risk.

In the following sections, areas of uncertainty are discussed for each assessment step enumerated previously, with the exception of health effects. Special emphasis is placed on identifying whether the uncertainties affect relative or absolute measures of risk. Where practical, the parameters that most significantly affect the risk assessment results are identified, and quantitative estimates of uncertainty are provided.

C.9.5.1 Uncertainties in the Waste Inventory and Characterization

The site-specific waste inventories and the physical and radiological waste characteristics are important input parameters for the transportation risk assessment. The potential amount of transportation required for any alternative is determined primarily by the projected waste inventory at each site and assumptions about shipment configurations (packaging and shipment capacities). The physical and radiological characteristics of the waste are important in determining the amount of waste that would be released during an accident and the subsequent doses to exposed individuals through multiple environmental exposure pathways.

In general, the uncertainties in the data specific to the site and waste type could affect the relative and absolute measures of transportation risk, and they are difficult to quantify. For example, there is a large amount of uncertainty associated with the amount of GTCC activated metal waste that would come from commercial reactors, in terms of reactor availability (when a given reactor would shut down) and in terms of the time decommissioning would actually occur (e.g., if there were years between shutdown and decommissioning, it is possible that little or no activated metal waste would be classified as GTCC LLRW and GTCC-like waste). Precisely defining the impact of these uncertainties on the transportation risk is difficult, given the large number of sites.

The uncertainties in the waste characterization data are reflected to some degree in the transportation risk results. If the waste inventories are consistently overestimated (or underestimated), the resulting transportation risk estimates are also overestimated (or underestimated) by roughly the same factor. In terms of relative risk comparisons, such uncertainties have little effect, since the majority of the waste would require shipment under all disposal alternatives (i.e., none of the sites being considered for disposal are also large generators of GTCC LLRW or GTCC-like waste).

C.9.5.2 Uncertainties in Defining the Shipment Configurations

As stated previously, the amount of transportation required for each disposal alternative is partly based on assumptions about the packaging and shipment configurations for each waste type. Representative shipment configurations have been defined for each waste type on the basis of either historical or potential future shipment capacities. (For example, all truck shipments of activated metal could be made in RH-72B or similar Type B packages because of the hypothetical design used for the activated metal canisters). In reality, the actual shipment capacities might differ from the predicted capacities, so the projected number of shipments and consequently the total transportation risk would change. (For example, some GTCC activated metal is already stored in large transportation, storage, and disposal canisters that are suitable only for rail transport). However, although the predicted transportation risks would increase or decrease accordingly (decrease in this case), the relative differences in risks among alternatives would generally remain unchanged.

C.9.5.3 Uncertainties in Determining the Route

Representative routes between all origin sites and destination sites considered for the disposal alternatives have been determined. The routes chosen were consistent with current guidelines, regulations, and practices but may not be the actual routes that will be used in the future. In reality, the actual routes may differ from the representative ones in terms of the lengths of the routes and total populations along them. Moreover, because the assessment considers wastes generated over the next 50 to 70 years, the highway and rail infrastructures and the demographics along the routes could also change over time. Although these effects are not accounted for in the transportation assessment, it is anticipated that any changes would not significantly affect the comparisons of risk among the disposal alternatives considered in the EIS.

C.9.5.4 Uncertainties in Calculating Radiation Doses

The models used to calculate radiation doses from transportation activities introduce additional uncertainty into the risk assessment process. Estimating the accuracy, or absolute uncertainty, of the risk assessment results is generally difficult. The accuracy of the calculated results is closely related to the limitations of the computational models and to the uncertainties in each of the input parameters that the model requires. The single greatest limitation facing users of RADTRAN, RISKIND, or any computer code of this type is the scarcity of data for certain input parameters.

Uncertainties associated with the computational models are minimized by using state-of-the-art computer codes that have been extensively reviewed. However, because numerous uncertainties are recognized but are difficult to quantify, assumptions are made at each step of the risk assessment process. These assumptions are intended to produce conservative results (that is, overestimate the calculated dose and radiological risk). Because parameters and assumptions are applied equally to all disposal alternatives for a waste type, this model bias is not expected to affect the meaningfulness of the risk comparisons; however, the results may not represent risks in an absolute sense.

Incident-free transportation risks are the dominant component of the total transportation risk for both truck and rail modes. The most important parameter in calculating incident-free doses is the shipment external dose rate (i.e., incident-free doses are directly proportional to the shipment external dose rate). For calculation purposes, average dose rates were applied to each waste type because information is not available to predict shipment dose rates accurately on a site-by-site and waste-stream basis. In practice, the external dose rates will vary not only from one site to another and one waste type to another but also from one shipment to another for a given site; the rates are expected to range near the levels assumed for this assessment.

C.9.5.5 Uncertainties in Comparing Truck and Rail Transportation Modes

The transportation risk assessment results presented in this EIS indicate that rail transportation would pose a lower overall risk to workers and the public than would truck transportation of the same quantity of waste. However, it is important to recognize that although rail shipments were found to result in no expected fatalities, the risks from transportation operations for both modes are, in general, small. Moreover, comparisons between truck and rail shipment risks need to consider the uncertainties inherent in the risk assessment process. As discussed above, in most cases, the calculational uncertainties are difficult to quantify and may, in fact, not be the same for truck transport as they are for rail transport. Some important issues that should be considered while comparing truck and rail shipment risks are discussed below.

In this EIS, transportation risks are estimated for the shipment of all waste by 100% truck or by 100% rail mode for each disposal alternative and waste type. The intent of this approach is to bound the transportation impacts for any possible mix of truck and rail shipments, recognizing that both modes would likely take place in the future. Therefore, all facilities were assumed to have rail access. However, a number of the generator sites and some disposal sites do not have direct rail access. For those sites lacking direct rail access, the risks associated with shipping waste by truck to a rail siding are not considered in detail; however, preliminary evaluations indicate that these activities generally contribute only a small amount to the overall transportation risk (DOE 1997a).

Although subject to calculational uncertainties, a number of factors that contribute to the assessment results indicate that rail shipments have lower impacts than truck shipments for the same alternative. These factors include the following:

- Rail shipments are larger than truck shipments; thus, fewer total rail shipments are needed. Consequently, impacts from rail shipment tend to be lower because overall transportation impacts tend to be proportional to shipment mileage.

- On a per-shipment basis, rail shipments have lower radiological impacts than do truck shipments. The radiological impacts from rail shipments tend to be

> lower because fewer members of the public are exposed during rail transport (primarily because there are fewer people at railroad stops and because fewer people share the routes). In addition, rail crew members tend to be much farther from the radioactive material packages than are truckers. However, the differences in radiological risk between the two transport modes for all disposal alternatives lie within the uncertainty of the estimates on the number and location of exposed persons.

Although rail impacts were found to be less than truck impacts, a number of considerations were not specifically addressed in the representative assessment conducted for the purposes of the EIS. First, rail shipments may require additional handling and preparation, especially for sites lacking rail access, and this handling would contribute to the overall rail shipment risk. Second, to be cost effective, rail shipments generally require a large inventory of waste. Rail may thus not be a cost-effective option at smaller generating sites. Finally, rail operations in general are not as flexible and responsive to individual site needs and capabilities as are truck operations.

C.10 CULTURAL RESOURCES

Cultural resources are the physical remains of past human activity or natural features that have significant historical or cultural meaning. These resources include archaeological sites, historic structures, cultural landscapes, and traditional cultural properties.

The analysis of impacts on cultural resources relied on similar types of information for each site and alternative. The area potentially affected was determined for each site and included the areas needed for both construction and operations. To the extent possible, these areas included some buffer to allow for any minor changes during implementation. Information on the presence of cultural resources within the area that might be affected was compiled. This task relied on cultural and historical background data that provided an overarching context for the types of cultural resources that could be present in each region. Previous cultural resource studies were reviewed to determine if specific resources exist within the area potentially affected. A records search was done to determine if any of the cultural resources that are present are eligible for listing on the *National Register of Historic Places* (NRHP).

DOE initiated consultation and communication activities on the GTCC EIS with 14 participating American Indian tribal governments that have cultural or historical ties to the DOE sites being analyzed in this EIS. The consultation activities are being conducted in accordance with President Obama’s Memorandum on Tribal Consultation (dated November 5, 2009); Executive Order 13175 (dated November 6, 2000) entitled “Consultation and Coordination with American Indian Tribal Governments”; Executive Memorandum (dated September 23, 2004) entitled “Government-to-Government Relationship with Tribal Governments” (White House 2004); and DOE Order 144.1, “American Indian Tribal Government Interaction and Policy” (dated January 2009). The consultation activities include technical briefings, the development of the written tribal narrative included in this EIS related to the specific site affiliated with the tribe, and/or discussions with elected tribal officials, based on individual tribal preferences and mutually agreed-upon protocols.

Once the baseline for the types of cultural resources present was established, the assessment considered the activities that would be required for the proposed action and their potential for affecting cultural resources. Of greatest concern were activities that would require ground disturbance because these activities would have the greatest impact on cultural resources. If archeological surveys had not been completed for the project area, the analysis assumed that the distribution of resources was the same as the distribution known for the surrounding region. Once the potential for impacts from each alternative was determined, the effects of each alternative were compared. Tribal perspectives, comments, and concerns identified during the consultation process will be considered by DOE in the decision-making process for selecting and implementing (a) disposal alternatives(s) for GTCC LLRW and GTCC-like waste.

C.11 WASTE MANAGEMENT

Potential impacts on waste management programs at the various sites considered in this EIS were evaluated. Wastes that could be generated from the construction of the land disposal options evaluated in this EIS include small quantities of hazardous solids, nonhazardous solids (concrete and steel spoilage, excavated materials), hazardous liquids, and nonhazardous (sanitary waste) liquids. Wastes that could be generated from the operation of the land disposal methods include small quantities of solid LLRW, such as spent HEPA filters, and nonhazardous solid waste (including recyclable wastes). Some liquid LLRW would also be generated from truck washdown water. A compilation of the waste volumes that could be generated from the construction and operations of the land disposal facilities is presented in Appendix D and in Table 5.3.11-1. For the assessment of waste management impacts in this EIS, annualized construction waste data were derived from the information presented in Appendix D. An initial construction period of 3.4 years was assumed in the derivation.

At all the sites evaluated for the land disposal options, the waste management programs for the waste categories generated were reviewed to determine potential impacts from the additional waste that could be generated. All the waste categories are routinely handled at all the DOE sites evaluated. Waste generated at the WIPP Vicinity could be sent off-site for disposal; commercial disposal options are available for the waste categories that would be generated.

Disposal operations would generate types of waste similar to those currently generated (i.e., liquid nonhazardous, solid nonhazardous, and hazardous waste); it is expected that existing handling procedures and capacities would accommodate the additional waste.

C.12 CUMULATIVE IMPACTS

Cumulative effects or impacts result from the incremental impact of the action alternatives when added to other past, present, and reasonably foreseeable future actions, regardless of what government agency or private entity undertakes such actions. Cumulative effects may result from impacts that are minor individually but that, when viewed collectively over space and time, can produce significant impacts. The approach used for cumulative impacts analysis in this EIS was based on the principles outlined in CEQ (1997) and on the guidance developed by the EPA in EPA (1999) for independent reviewers of EISs.

The cumulative impact analysis for this EIS was not meant to be a review of all potential environmental impacts at and near a site, nor was it meant to be a sitewide impact analysis. For this EIS, past and present impacts at a given site are generally addressed in the affected environment discussion for each resource area. Reasonably foreseeable future actions at a given site were gleaned primarily from a review of various National Environmental Policy Act (NEPA) documents available for the site. In addition, the latest EIS (draft or final, as appropriate) available for the site was reviewed to identify total cumulative impact values reported for the site (with the reasonably foreseeable future actions considered). The potential impacts from this EIS were then compared to those reported values in order to gain perspective on the potential contribution from the GTCC EIS alternatives to overall cumulative impacts at the sites.

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APPENDIX D:

CONCEPTUAL DISPOSAL FACILITY DESIGNS

This appendix presents information on the conceptual facility designs and layouts, modes of transportation, waste packaging, facility resource requirements, and facility emissions associated with the three land disposal methods that the U.S. Department of Energy (DOE) is considering for disposal of greater-than-Class C (GTCC) low-level radioactive waste (LLRW) and GTCC-like waste: (1) borehole disposal, (2) trench disposal, and (3) vault disposal. Each conceptual facility is designed to provide the disposal capacity needed for the entire inventory described in Appendix B. In addition, this appendix provides supporting information for estimating incremental air emissions from waste to be disposed of at the Waste Isolation Pilot Plant (WIPP).

D.1 SCOPE

Two enhanced near-surface methods for disposing of GTCC LLRW and GTCC-like waste were evaluated: a trench and an above-grade vault. One intermediate-depth method — the borehole disposal method — was also evaluated. The level of detail of the proposed designs that is presented in this appendix is sufficient for use in this environmental impact statement (EIS). Further studies, including a site-specific safety analysis report, would be necessary to support further decision-making with regard to implementing any of the three methods.

The disposal facility designs are sized to accommodate the disposal of approximately 12,000 m^3 (420,000 ft^3) of GTCC LLRW and GTCC-like wastes that are expected to be generated through the year 2083. Information on the waste types and their radionuclide activities, volumes, and packaging is provided in Appendix B. The disposal facilities are designed as stand-alone operations. Depending on the final location of such a facility, certain components, such as buildings, equipment, or personnel, could be shared with or obtained from existing facilities, thus lowering anticipated costs.

Section D.2 presents a summary of the assumed disposal packages. Section D.3 provides descriptions of the three land disposal methods considered. Conceptual designs of the proposed facilities are presented in Section D.4. Section D.5 discusses the number of and the cost associated with the personnel required for the construction of and operations at each facility. Estimates of the resource materials and utilities needed to construct and operate the facility are provided in Section D.6. Estimated construction and operation emissions and wastes are discussed in Section D.7, and data on emissions from material deliveries and worker vehicles are provided in Section D.8. Section D.9 provides additional estimates of air emissions related to the expansion and operation of the WIPP facility to accommodate the GTCC LLRW and GTCC-like waste considered in this EIS.

The number of construction workers required at any one time during site preparation and facility construction will vary because of the temporary nature of the work and because certain tasks can be accomplished concurrently while others must occur consecutively. A minimum number of workers are necessary to operate the facility, and that number depends on the waste receipt rate, as discussed further in Section D.5.2. Thus, the estimated resources and emissions from facility operations presented in Sections D.6, D.7, and D.8 are based on the personnel estimates given in Section D.5.2.

D.2 TRANSPORTATION AND PACKAGING

This section provides information on the assumptions about waste transportation and packaging for the borehole, trench, and vault disposal alternatives. Information on the transportation and packaging assumptions for the deep geologic disposal alternative (WIPP) is found in Appendix B. It is assumed that GTCC LLRW and GTCC-like waste would be shipped to the disposal facility in their final disposal containers. Thus, the disposal facilities would be designed to most efficiently accommodate the types of containers that would most likely be used to transport and dispose of this waste. It is assumed that GTCC LLRW and GTCC-like waste would be transported by truck and rail to the disposal facility in Type B shipping packages, as discussed in Section 5. The waste to be disposed of would include sealed sources, contact-handled (CH) Other Waste (Other Waste - CH), remote-handled (RH) Other Waste (Other Waste - RH), and activated metals, as discussed in Appendix B.

D.2.1 Contact-Handled Waste

A common container for the storage of CH and RH GTCC LLRW and GTCC-like waste is the 208-L (55-gal) drum (referred to as drum(s) in the remainder of this appendix). In addition, it is assumed that some stored and projected CH wastes would be packaged for disposal in standard waste boxes (SWBs). As discussed in Appendix B, this EIS explicitly assumes that the disposal of CH waste, except for cesium (Cs) irradiator sources, would be in drums and SWBs. The Cs irradiators are self-contained and would be disposed of in their original shielded container. The size of these irradiators is assumed to be 150 × 65 × 67 cm (59 × 26 × 27 in.) (Sandia 2008a).

Although the use of other shipping and disposal configurations (e.g., 320-L and 380-L [85-gal and 100-gal] drums) might be possible, their use is not explicitly considered; however, the use of other container types could be accommodated in the current disposal facility designs. Also, GTCC LLRW and GTCC-like CH waste might be found in storage in containers larger than SWBs at some sites, but there are currently no viable casks available for transport. Stacking arrangements in the CH disposal cells could be modified accordingly in the future if such packages became available.

D.2.2 Remote-Handled Waste

It is assumed that all RH waste, except for the activated metal waste types, would be packaged for disposal in drums. As discussed in Appendix B, three drums could be packaged in an RH canister (DOE 1995) that is designed for use with the RH-72B shipping cask. As an alternative, RH waste could be loaded directly into the canister for disposal (DOE 2006). The proposed facility designs can accommodate both drums and RH canisters, as discussed further in Sections D.3.1.2.2, D.3.2.2.2, and D.3.3.2.2.

It is assumed that activated metals would be packaged in right circular stainless-steel canisters (activated metal canisters [AMCs]). To facilitate potential shipment by truck as well as rail and to provide flexibility in the facility design, the size and weight of these canisters were selected to be compatible with existing containers and weight limitations of truck casks. Additional discussion on the size of the AMCs is presented in Section B.4.1.2.

D.3 LAND DISPOSAL METHODS

D.3.1 Trench Disposal

D.3.1.1 Conceptual Trench Design

The basic design for the trench disposal facility utilizes trenches that are 3-m (10-ft) wide, 11-m (36-ft) deep, and 100-m (330-ft) long. The trench width and depth were selected to optimize disposal capacity per trench within the limits of excavation equipment that is readily available and shoring equipment that is commercially available. The conceptual drawing of a cross section of the basic trench design (Figure D-1) illustrates the trench design features and dimensions. In addition, the conceptual design for a trench facility is deeper and narrower than it is for conventional near-surface LLRW disposal facilities in order to minimize the potential for inadvertent human intrusion during the post-closure period.

The side walls of the trench would be vertically constructed. A well-compacted material would be placed on top of the native material in the floor of the trench. A layer of sand or gravel (0.3 m [1 ft]) would be placed on top of the compacted material to improve stability. The nature of the compacted material would be selected to be compatible with the surrounding geologic material. The trench sidewalls would be constructed with temporary metal shoring. The metal shoring would be removed when the trench was closed.

The waste packages would be placed into the trench about 5 to 10 m (15 to 30 ft) bgs, and a fine-grained cohesionless fill (sand) would be used to backfill around the waste containers to fill voids. After the trench was filled with the waste containers and backfilled, a reinforced concrete layer would be placed over the waste packages to help mitigate any future inadvertent intrusion. Use of 6-in. (15-cm) on-center steel reinforcement (rebar), in two perpendicular layers, would strengthen the concrete. In addition to adding strength to the concrete layer, the spacing of the rebar would provide protection against inadvertent drilling straight down into the trenches. For this reason, the concrete would have two sets of perpendicular steel reinforcement, one near the top face and the other near the bottom face of the barrier. With a spacing of 6 in. (15 cm), most drill bits would not pass into the trench without encountering the steel reinforcement first (discouraging further penetration), if they had not initially been stopped by the concrete itself.

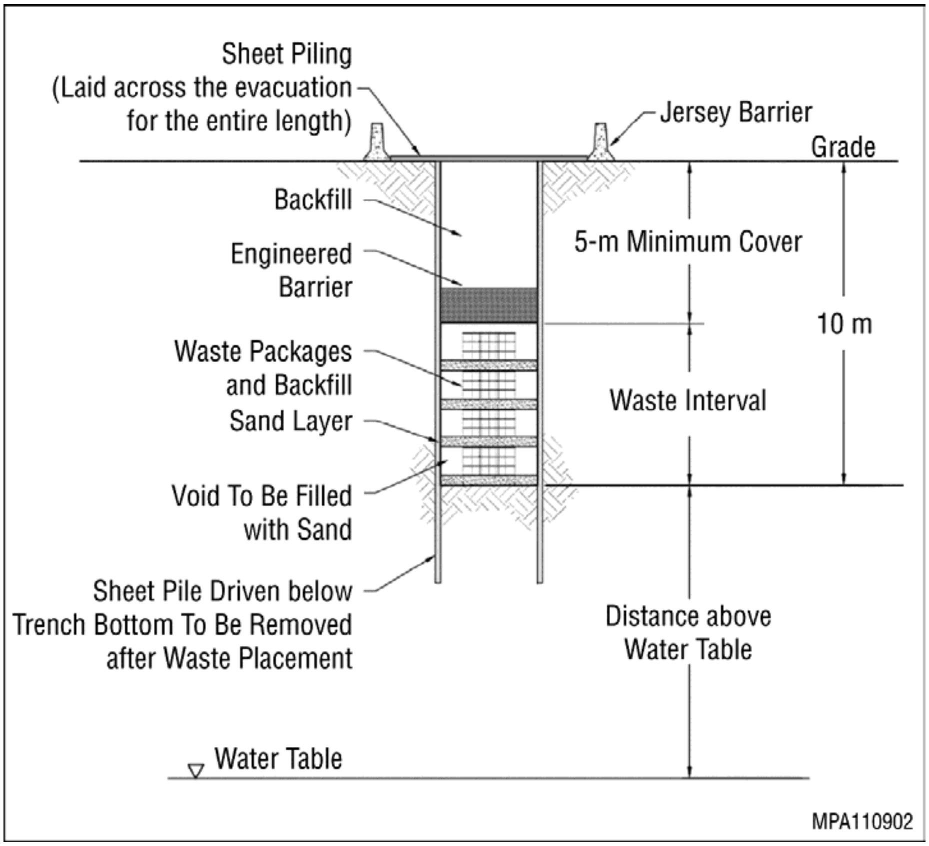

FIGURE D-1 Cross Section of a Conceptual Trench Disposal Unit

It is anticipated that clean fill from construction would be used to backfill the trench above the concrete layer. Each trench could be capped with a cover system consisting of a geotextile membrane overlain by gravel, sand, and topsoil layers (similar to that shown for the vault design final cover system depicted later in Figure D-8). In the case of the trench, the top of the cover system would be flush with or slightly elevated above the surrounding ground surface, depending on the final design.

D.3.1.2 Disposal Package Configurations

D.3.1.2.1 Contact-Handled Waste. The assumed packing arrangement for 208-L (55-gal) drums and SWBs in a 10-m (33-ft) section of trench is shown in Figure D-2. Up to five layers of drums or SWBs could be accommodated with approximately 0.3 m (1 ft) of fill above and below each layer, for a total of 3,000 drums or 500 SWBs per trench. For the larger cesium sources, it is assumed that there would be 560 units per layer (four across the trench width) and three layers, for a total of 1,680 cesium sources per trench. During disposal operations for CH waste, one end of a trench would have a ramp to the surface for entry by a forklift carrying CH waste packages (a pallet of four drums, four cesium sources, or one SWB) for emplacement.

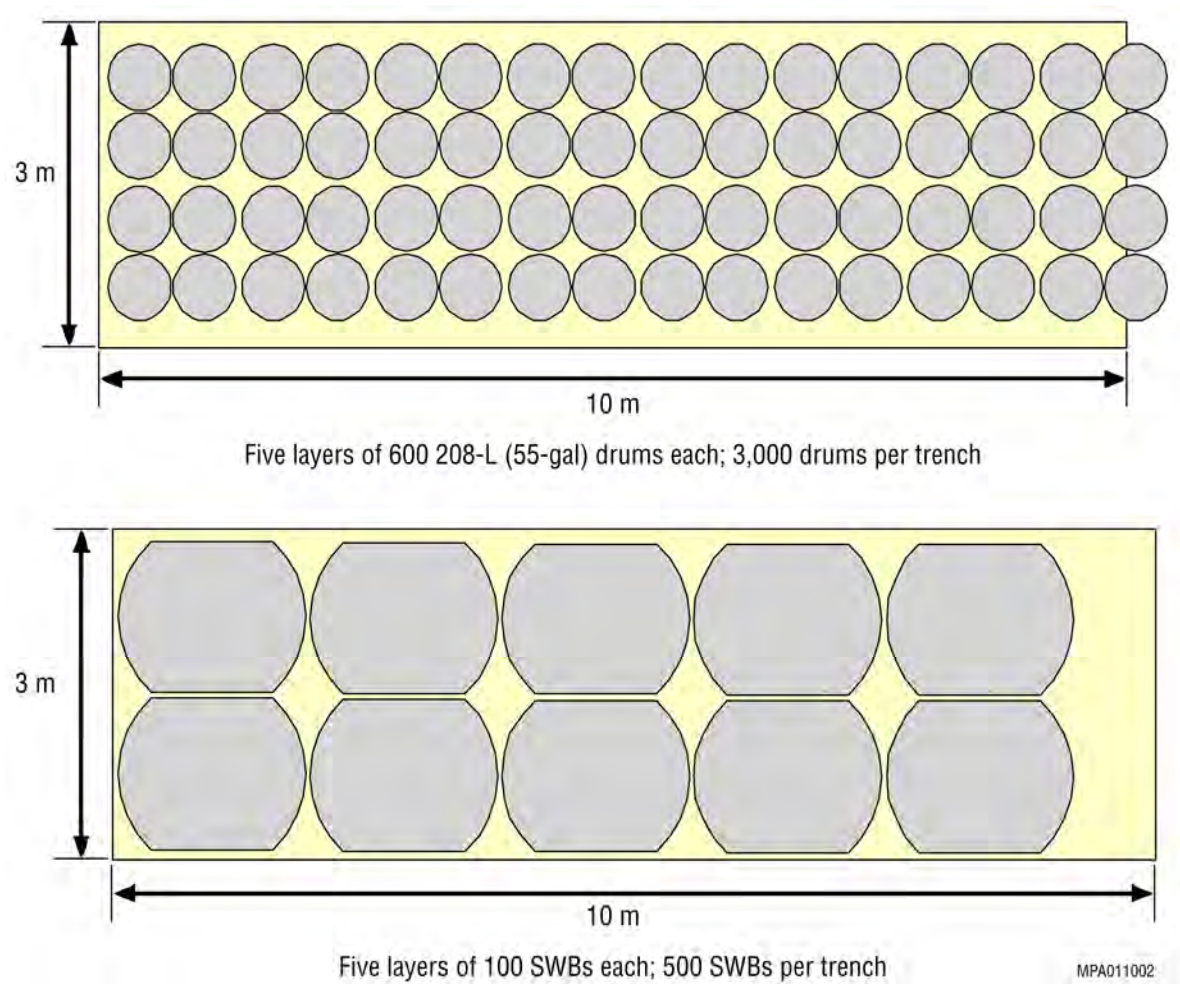

FIGURE D-2 Top View of a 10-m (33-ft) Section of a Trench Packed with Contact-Handled Waste

D.3.1.2.2 Remote-Handled Waste. Additional features are needed in the trenches where RH waste would be buried to provide shielding for the workers once the waste was in place. The RH waste packages (AMCs, drums, and RH canisters) would be disposed of in vertical reinforced concrete cylinders with concrete shield plugs (1.2-m [4-ft] thick) on the top of each cylinder. This design is similar to that proposed for activated metal disposal (Harvego 2007). A mating flange would enable coupling of the bottom-loading transfer cask to a given cylinder for transfer of the waste package into the disposal unit. The transfer cask would be moved off an on-site transport truck into position by an overhead crane. Figure D-3 shows a top view of a 10-m (33-ft) section of an RH waste disposal trench. Each cylinder would be capable of holding up to three AMCs, four individual 208-L (55-gal) drums, or one RH canister. With 302 cylinders per trench, as many as 906 AMCs, 1,208 drums, or 302 RH canisters could be emplaced in one trench.

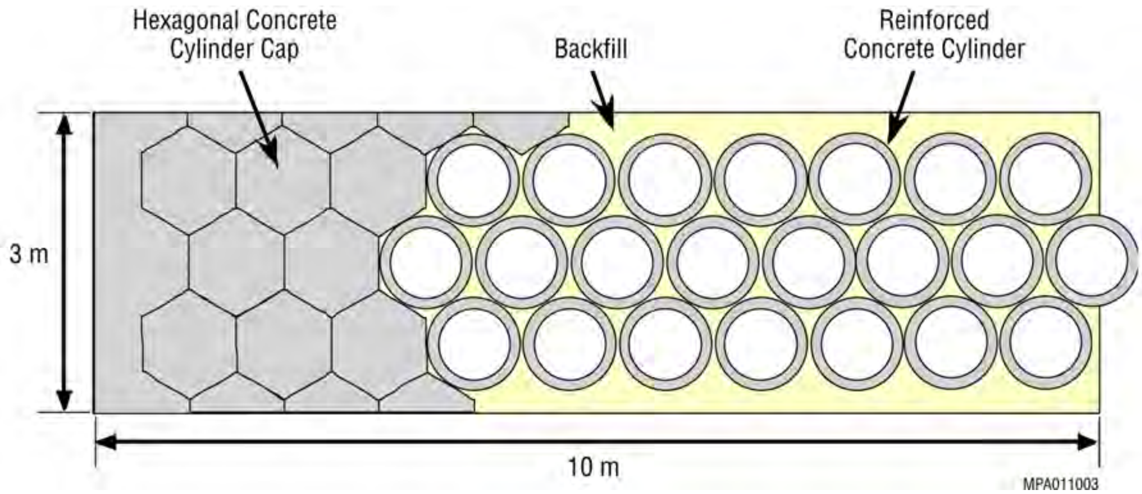

FIGURE D-3 Top View of a 10-m (33-ft) Section of a Trench for Disposal of Remote-Handled Waste

D.3.2 Borehole Disposal

D.3.2.1 Conceptual Borehole Design

Borehole disposal would entail the emplacement of waste in boreholes at depths below 30 m (100 ft) but above 300 m (1,000 ft). Boreholes can vary widely in diameter (from 0.3 to 3.7 m [1 to 12 ft]), and the proximity of one borehole to another can vary depending on the design of the facility. The technology for drilling larger-diameter boreholes is simple and widely available. The current conceptual design employs boreholes that are 2.4 m (8 ft) in diameter and 40-m (130-ft) deep in unconsolidated to semiconsolidated soils, as shown in Figure D-4, with GTCC LLRW and GTCC-like waste emplacement assumed to be about 30 to 40 m (100 to 130 ft) bgs.

A bucket auger would be used to drill the large-diameter borehole (see Figure D-5), and a smooth steel casing would be advanced to the depth of the borehole during the drilling and construction of the borehole. The casing would provide stability to the borehole walls and ensure that waste packages would not snag and plug the borehole as they were lowered and would not sit in an upright position when they reached the bottom. The upper 30 m (100 ft) of smooth steel casing would be removed upon closure of the borehole. In some cases where consolidated materials might be encountered, a more robust drilling technology would be required. A casing would also be used in this latter case as an aid in placing waste packages.

The waste packages would be placed into the borehole, and a fine-grained cohesionless fill (sand) would be used to backfill around the waste containers to fill voids. After the borehole was filled with the waste containers and backfill, a reinforced concrete layer would be placed over the waste packages to help mitigate any future inadvertent intrusion. Use of 6-in. (15-cm) on-center steel reinforcement (rebar), in two perpendicular layers, would strengthen the concrete. In addition to adding strength to the concrete layer, the spacing of the rebar would provide

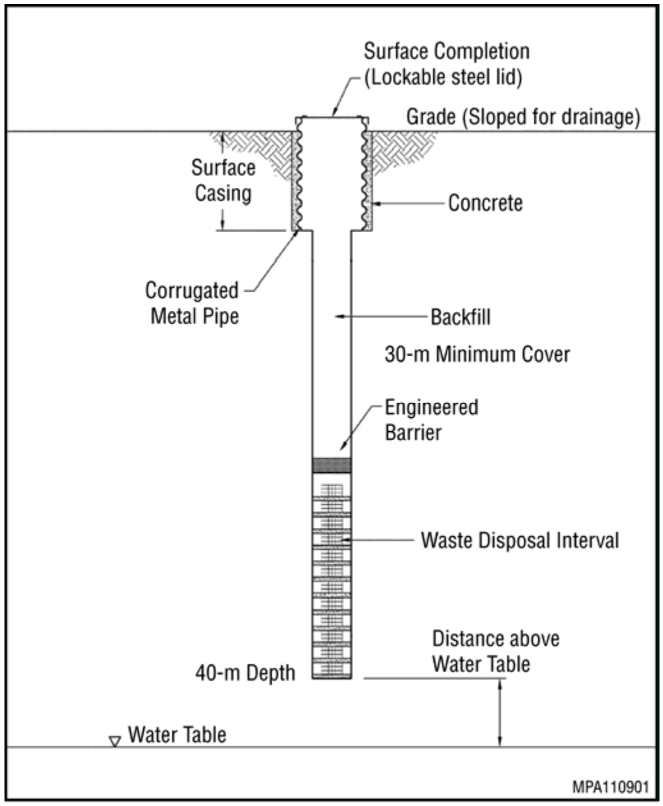

FIGURE D-4 Cross Section of a Conceptual 40-m (130-ft) Borehole

protection against inadvertent drilling straight down into a borehole. For this reason, the concrete would have two sets of perpendicular steel reinforcement, one near the top face and the other near the bottom face of the barrier. With a spacing of 6 in. (15 cm), most drill bits would not pass into the borehole without encountering the steel reinforcement first (discouraging further penetration), if they had not initially been stopped by the concrete itself.

It is anticipated that clean fill from the construction of the facility would be used to backfill the borehole above the concrete layer. Each borehole could be capped with a cover system consisting of a geotextile membrane overlain by gravel, sand, and topsoil layers, similar to that discussed for trench disposal in Section D.3.1.1 and shown for the vault design final cover system depicted later in Figure D-8. In the case of the borehole, the top of the cover system would be flush with or slightly elevated above the surrounding ground surface, depending on the final design.

D.3.2.2 Disposal Package Configurations

D.3.2.2.1 Contact-Handled Waste. CH waste would be taken off the on-site transport vehicle and lowered by crane into a borehole for emplacement. For a borehole, assumed packing

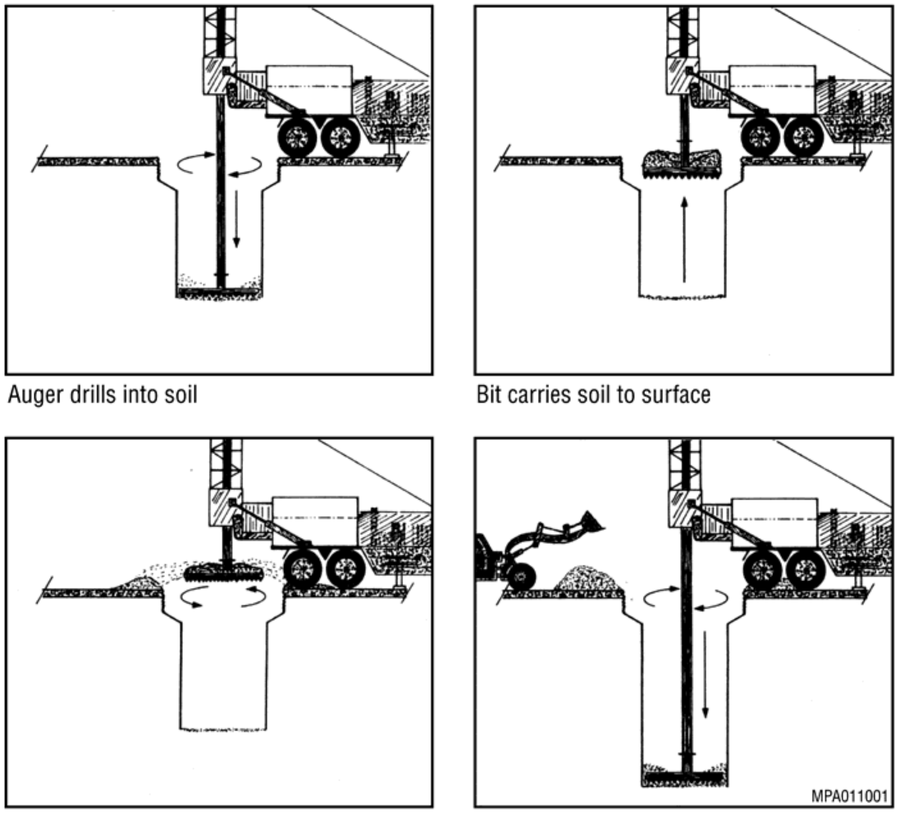

FIGURE D-5 Process Schematic for Drilling a Large-Diameter Borehole by Using a Bucket Auger (Source: Sandia 2007b)

arrangements for CH waste are eight intervals (levels) of 208-L (55-gal) drum 7-packs (56 drums), five intervals of cesium-source 4-packs (20 cesium sources), or eight intervals of one SWB (eight SWBs). Approximately 0.3 m (1 ft) of fill would be used between intervals. Single-interval packing arrangements are shown in Figure D-6.

D.3.2.2.2 Remote-Handled Waste. For RH waste, three intervals of two 3-packs of RH canisters or six intervals of two 3-packs of AMCs are assumed. Thus, 18 RH canisters or 36 AMCs could be emplaced in a borehole. Boreholes for disposal of RH waste would have a shielded cover once the RH waste was emplaced, prior to being full and backfilled. On-site transport of RH waste would occur in shielded bottom-loading transfer casks (e.g., smaller versions of the type used at independent spent fuel storage installations for the movement of spent nuclear fuel [SNF]) that would mate with ports on a borehole cover. Once the transfer cask was mated to the borehole cover, the RH waste would be lowered into place.

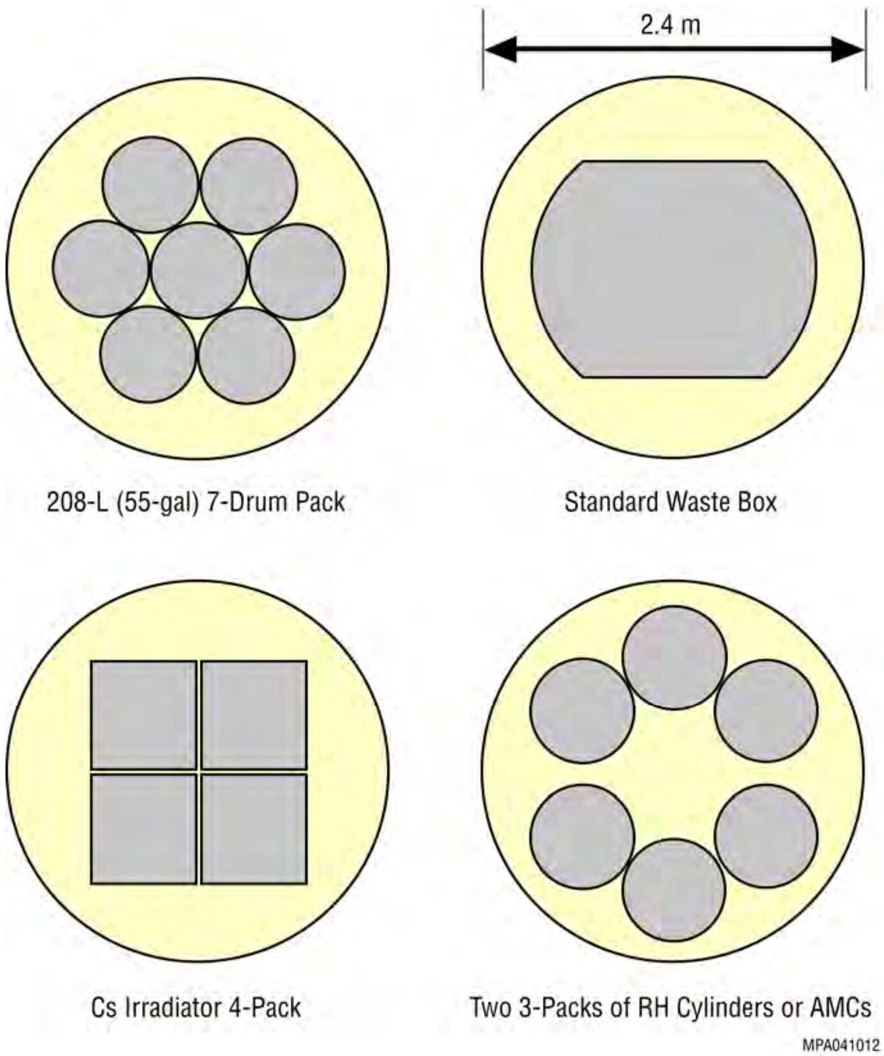

FIGURE D-6 Top View of Single-Interval Packing Arrangements in 2.4-m-Diameter (8-ft-Diameter) Boreholes for Different Container Types

D.3.3 Vault Disposal

D.3.3.1 Conceptual Vault Design

The conceptual design for the vault disposal of GTCC LLRW is a reinforced concrete vault constructed near grade level, with the footings and floors of the vault situated in a slight excavation just below grade. The design is a modification of one disposal concept proposed by Henry (1993) for GTCC LLRW and is similar to a belowground (Denson et al. 1987) vault LLRW disposal method previously investigated by the U.S. Army Corps of Engineers. A similar below-grade concrete vault structure is currently in use for disposal of higher-activity LLRW at the Savannah River Site (SRS) (MMES et al. 1994).

D.3.3.1.1 Vault System. Each vault would be 11-m (35-ft) wide, 94-m (310-ft) long, and 7.9-m (26-ft) tall, with 11 disposal cells situated in a linear array. Interior cell dimensions would be 8.2-m (27-ft) wide, 7.5-m (25-ft) long, and 5.5-m (18-ft) high, with an internal volume of 340 m^3 (12,000 ft^3) per cell. Double interior walls with an expansion joint would be included after every second cell. GTCC LLRW and GTCC-like waste disposal placement is assumed to be about 4.3 to 5.5 m (14 to 18 ft) above ground surface. Figure D-7 shows a schematic cross section of a vault cell.

The exterior walls and roof would be composed of 1.1-m (3.8-ft)-thick reinforced concrete. In addition to adding strength and durability to the vault, the thick concrete would attenuate the radiation emanating from the RH waste component of the material destined for disposal. The most hazardous of the wastes in this respect would be the activated metals from reactor decommissioning; their external radiation rates, primarily from cobalt-60 (Co-60), could be a few thousand roentgens per hour at the waste package surface (Sandia 2007a). With an attenuation of Co-60 gamma rays of one-half for about every 6.2 cm (2.4 in.) of concrete (Shleien 1992), a reduction in radiation (by a factor of more than 260,000) to near background levels is expected.

Use of 6-in. (15-cm) on-center steel reinforcement (rebar), in two perpendicular layers, would strengthen the concrete in the floor, walls, and vault cap (ceiling). In addition to adding strength to the vault construction, the spacing of the rebar would provide protection against inadvertent drilling into the disposal cells. For this reason, the vault cap would have two sets of perpendicular steel reinforcement, one near the exterior face and the other near the interior face of the cap. With a spacing of 6 in. (15 cm), most drill bits would not pass into the vault without encountering the steel reinforcement first (discouraging further penetration), if they had not initially been stopped by the concrete itself. Steel reinforcement in the walls was included because of the increased prevalence of using directional drilling at deeper depths for utility work, which can expose the walls as well as the top of the vault to drilling.

D.3.3.1.2 Engineered Cover Systems. An engineered cover would be used to aid in the isolation of the waste from the environment over the long term. In addition to the protection afforded by the vault and its internal backfill, the thickness of the cover would assure that external exposure rates remained at background levels. The design would direct surface water away from the waste and help deter intrusion by humans, plants, and animals. Minimum and maximum slope requirements would be incorporated to ensure adequate drainage and to reduce erosion/maintain slope stability, respectively.

Two engineered cover systems are included in the design for the vaults, as shown in Figure D-8. The first would be put in place after a vault was filled with waste and permanently closed, or it could be implemented incrementally as the vault was filled (the interim cover with a rise-to-run of 1:3 from the vault edge to ground level). The second cover system would partially replace the interim cover prior to closure of the disposal facility (the final cover with a rise-to-run of 1:5 from the vault edge to ground level). A graded slope of 3% would be used over the combined cover of all of the vaults. Both covers would have a minimum depth of 5.0 m (17 ft) over any portion of a vault, with a 15-cm (0.5-ft) layer of gravelly sand over a vault followed by a layer of clay 0.9-m (3-ft) thick, as shown in Figure D-8. The next layer in the interim cover

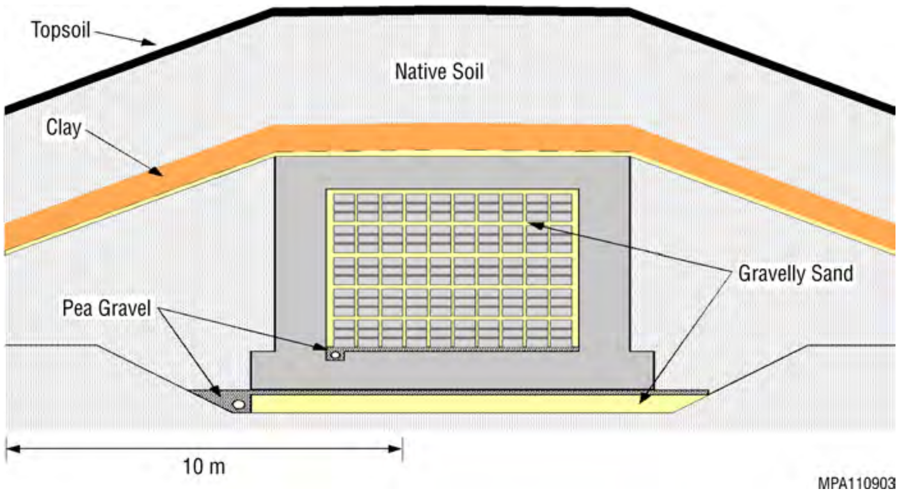

FIGURE D-7 Cross Section of a Conceptual Above-Grade Vault Design (drawn to scale)

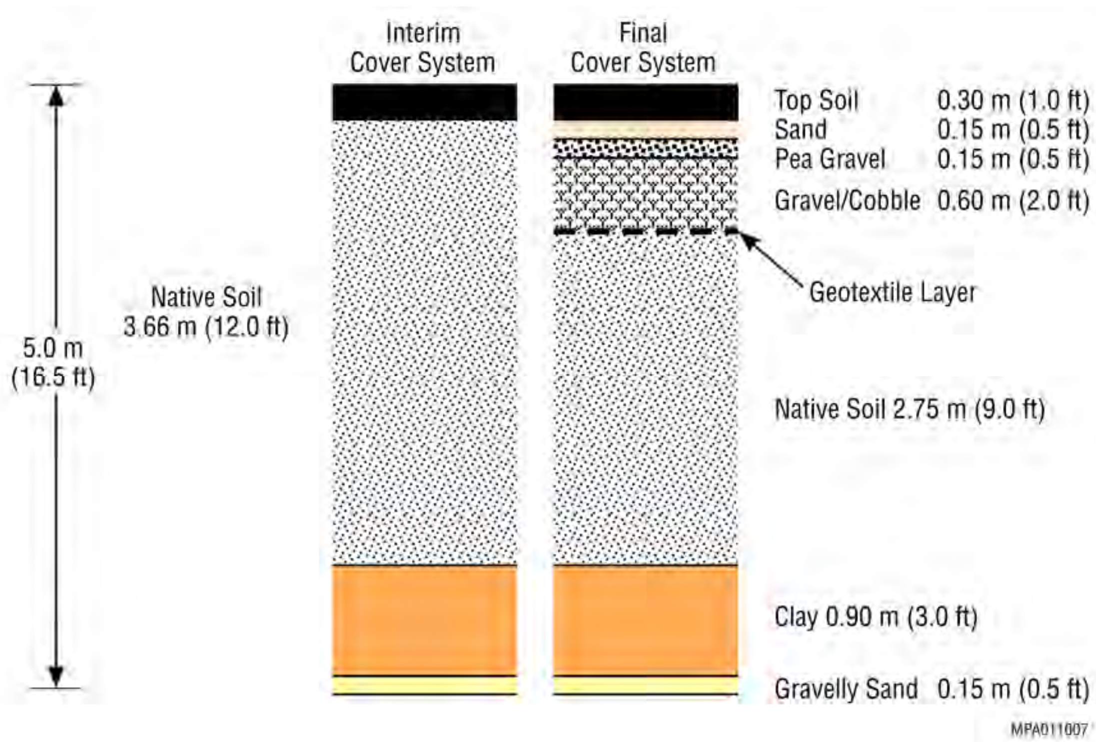

FIGURE D-8 Conceptual Cover Systems for a Vault Disposal Facility (Source: Modified from Henry 1993)

would consist of 3.7 m (12.0 ft) of native soil followed by 0.3 m (1 ft) of topsoil. In the final cover, the next layer over the clay layer would have 2.8 m (9.0 ft) of native soil, followed by a geotextile layer, 0.6 m (2 ft) of gravel, 15 cm (0.5 ft) of pea gravel, 15 cm (0.5 ft) of sand, and 0.3 m (1 ft) of topsoil (Henry 1993). If needed, rock armor could also be incorporated into the final cover to further protect against erosion.

D.3.3.2 Disposal Package Configurations

D.3.3.2.1 Contact-Handled Waste. The packing arrangement of CH 208-L (55-gal) drums in a cell assumes placement of 7-drum packs as received at the facility in a Transuranic Package Transporter-II (TRUPACT-II) Type B transportation package. Figure D-9 shows the arrangement for the CH drums, with 18 7-packs used per layer. With five layers, 630 drums could be accommodated in each cell. For SWBs, 20 could be arranged in one layer (see Figure D-10), with five layers for 100 SWBs in one vault cell. In addition, it is estimated that about 300 cesium irradiators (three layers of 10 × 10) would fit in one cell. A layer of fill would be used between layers of disposal containers to minimize void spaces. SWBs, 7-drum packs, and 4-packs of irradiators would be taken off an on-site transport truck and loaded into the vault cell by an overhead crane.

D.3.3.2.2 Remote-Handled Waste. Vault cells for disposal of RH waste would be similar in design to the trench approach as discussed in Section D.3.1.2.2. RH AMCs, 208-L (55-gal) drums, or canisters would be loaded from a bottom-loading transfer cask into vertical reinforced concrete cylinders with thick concrete shield plugs within each cell. Figure D-11 provides a view from the top of a vault cell. The cylinder loading would be the same as that for the trench approach — three AMCs, four 208-L (55-gal) drums, or one RH canister per cylinder. With 72 cylinders per cell, 216 AMCs, 288 drums, or 72 RH canisters could be emplaced in each vault cell.

D.4 CONCEPTUAL FACILITY LAYOUTS

For all methods, an outside fence would maintain a minimum 30-m (100-ft) buffer around the site, with a larger buffer where the stormwater retention pond and site support facilities could be located. A guard house would restrict access to the site. An administration building would provide the base for site operations, with waiting areas, offices, record storage, and personnel support facilities (e.g., meeting rooms, locker rooms). A receipt and storage (waste handling) building would provide space for inspecting newly received waste for disposal, offloading the waste, and temporarily storing the waste before its emplacement in the disposal units. Vehicles, equipment, and supplies necessary to site operations would be maintained, repaired, and stored in a maintenance and storage building. A laboratory building would provide space for analysis of sample monitoring swipes taken from the exterior of waste packages and equipment. A utilities building would house a boiler and refrigeration system, as well as pump equipment for maintaining proper water levels for an on-site water tank to support potable and sanitary water systems, fire protection systems, and dust suppression. A washdown pad would provide an area for cleaning vehicles and equipment.

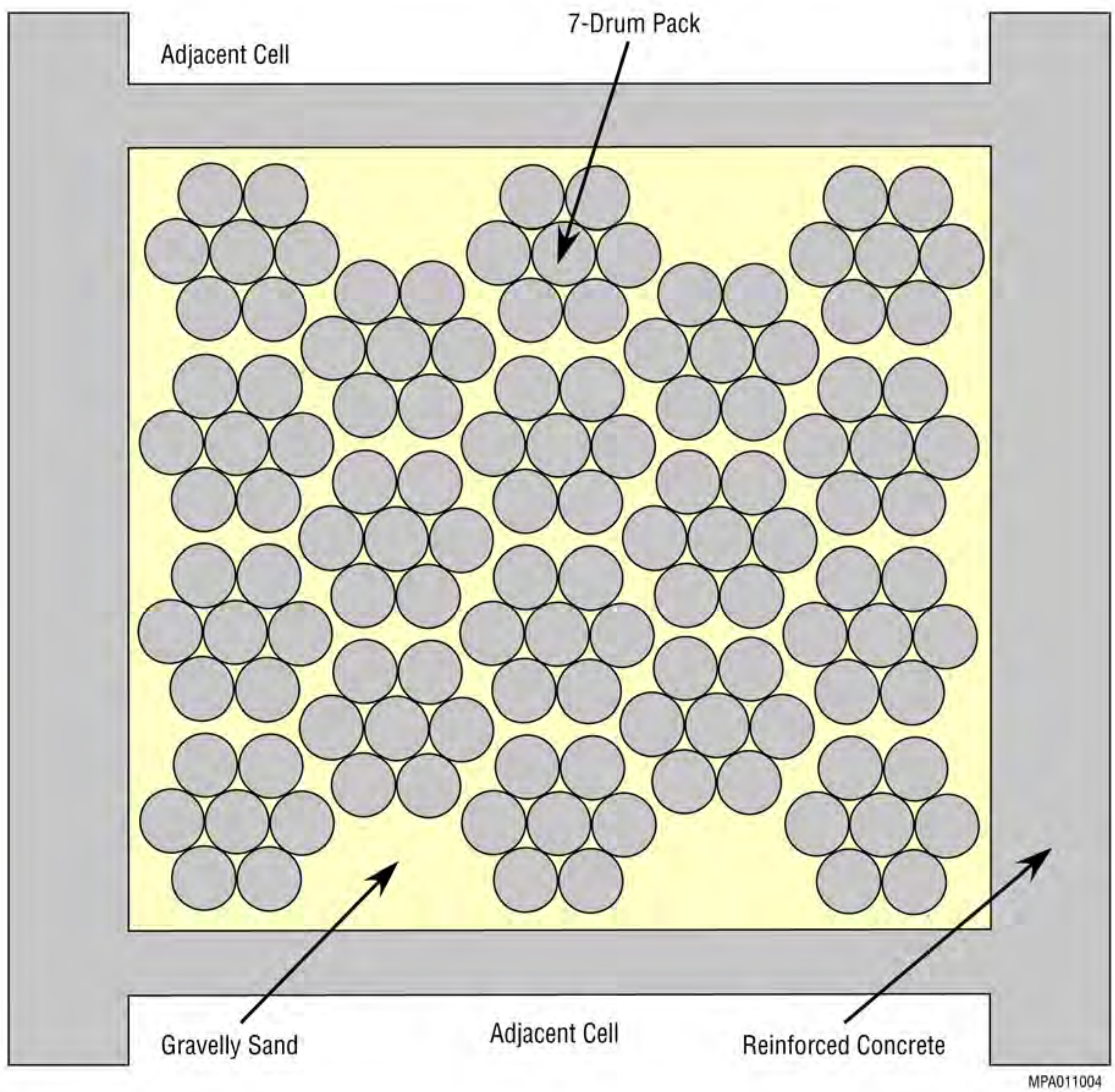

FIGURE D-9 Top View of a Single-Layer Packing Arrangement of Contact-Handled Waste in 208-L (55-gal) 7-Drum Packs in Vault Cells

D.4.1 Trench Disposal

Figure D-12 shows the layout of a conceptual enhanced near-surface trench waste disposal facility. It is estimated that approximately 29 trenches would be required for the disposal of the 12,000 m^3 (420,000 ft^3) of waste currently under consideration. Trenches would be spaced 30 m (100 ft) apart within a facility footprint of about 50 ac (20 ha) with dimensions of 550 × 330 m (1,800 × 1,100 ft) at the fence line.

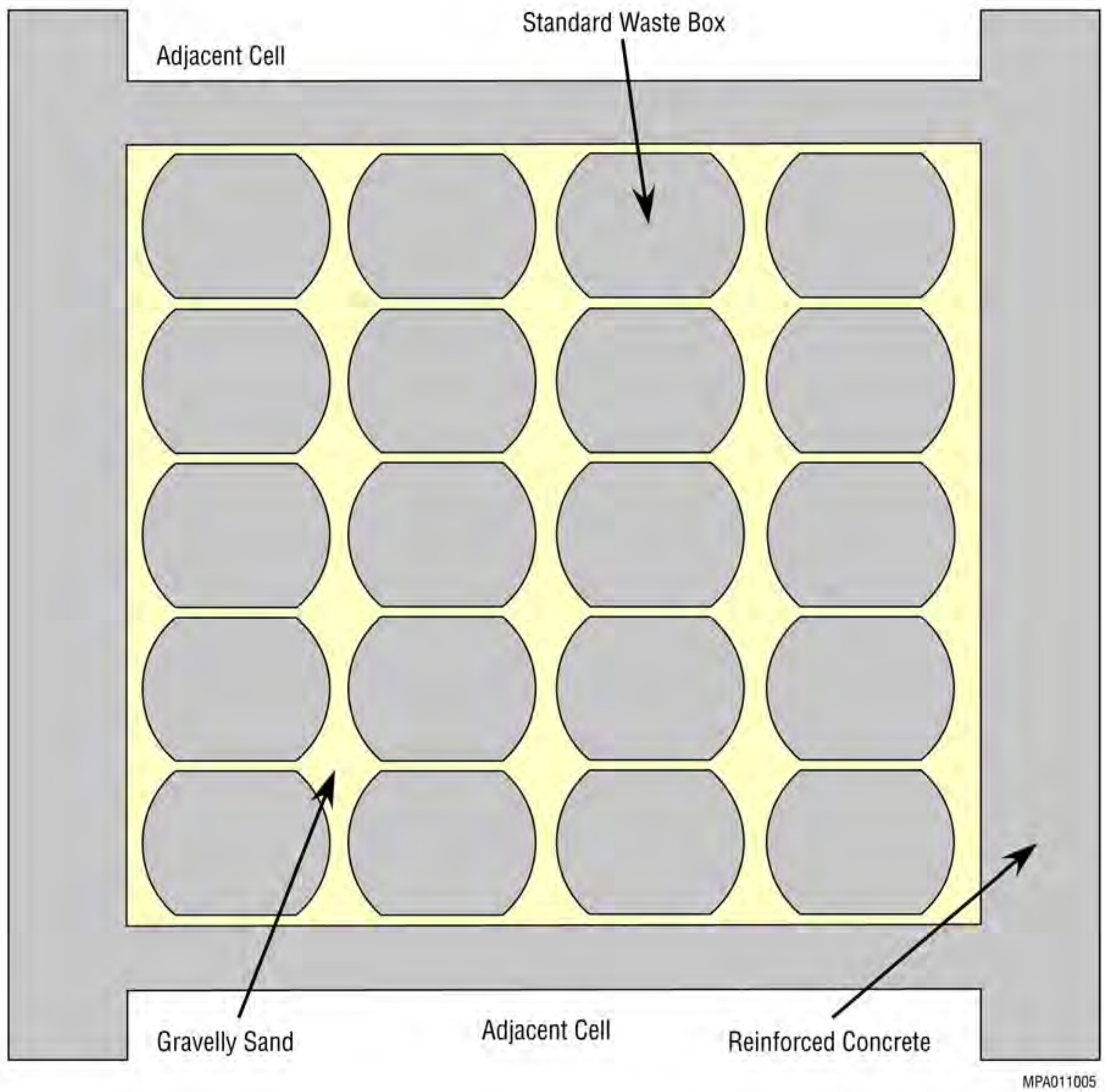

FIGURE D-10 Top View of a Single-Layer Packing Arrangement of Contact-Handled Waste in Standard Waste Boxes in Vault Cells

D.4.2 Borehole Disposal

Figure D-13 shows the layout of a conceptual intermediate-depth borehole waste disposal facility that covers about 110 acres (44 ha). It is estimated that approximately 930 40-m (130-ft) boreholes would be required for the disposal of the 12,000 m^3 (420,000 ft^3) of waste currently under consideration. Boreholes would be spaced 10 m (33 ft) apart on-center with a 30-m (98-ft) space between rows. The facility footprint dimensions would be about 510 × 870 m (1,700 × 2,800 ft) at the fence line.

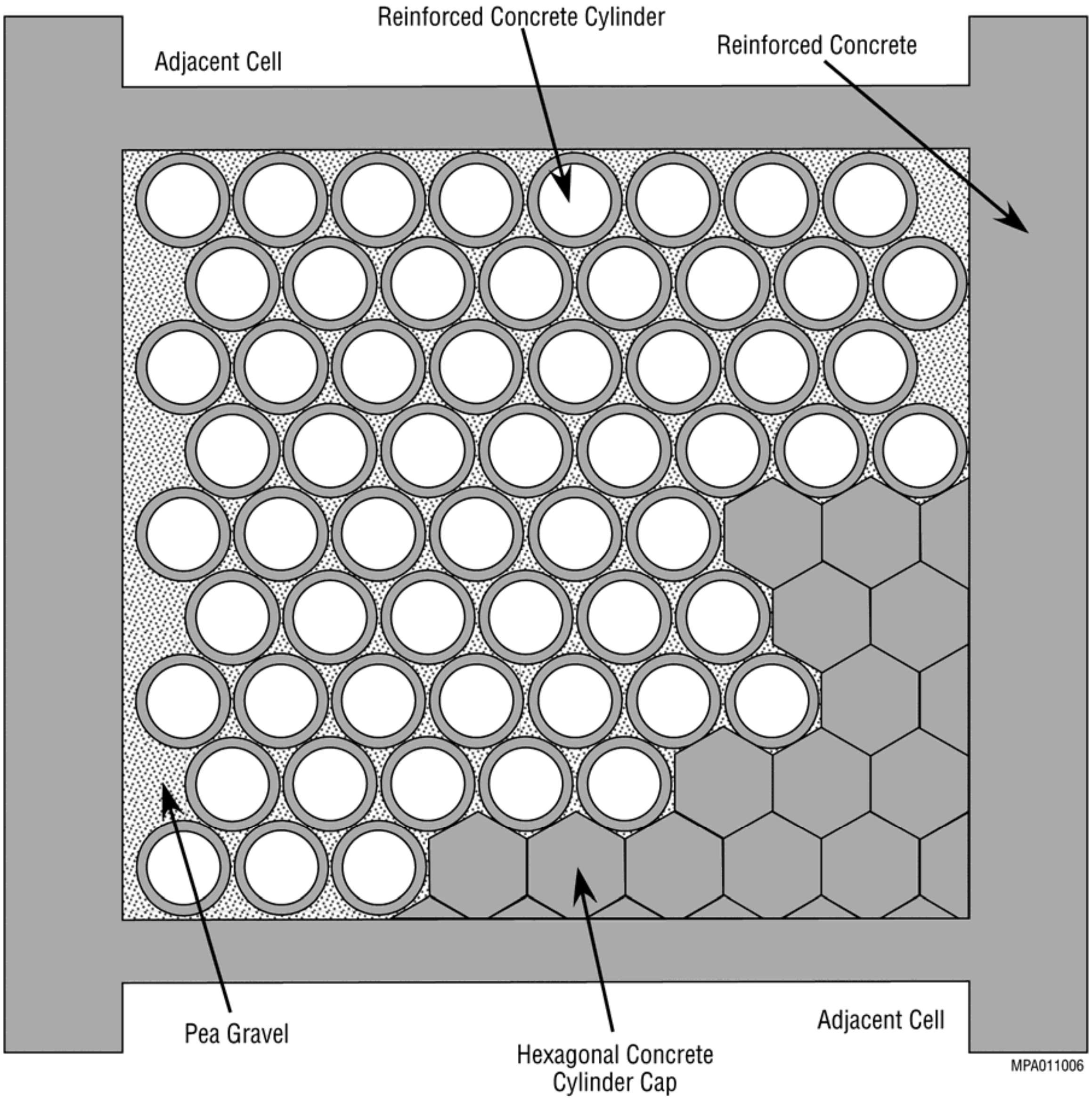

FIGURE D-11 Top View of a Vault Cell for Disposal of Remote-Handled Waste

D.4.3 Vault Disposal

The conceptual above-grade vault system design incorporates 12 vaults with a total land use requirement of about 60 ac (25 ha) within the outer perimeter fence, as shown by the layout of a conceptual facility presented in Figure D-14. Approximately 40 ac (16 ha) would be required for the 12 disposal vaults and their final cover system. The vaults would be spaced to (1) provide adequate room for the interim cover systems (2.1 ac or 0.8 ha each) to be emplaced as each vault was completely filled, (2) protect site workers, and (3) isolate the waste before decommissioning and emplacement of the final cover system prior to facility closure. The facility footprint dimensions would be about 420 × 610 m (1,400 × 2,000 ft) at the fence line.

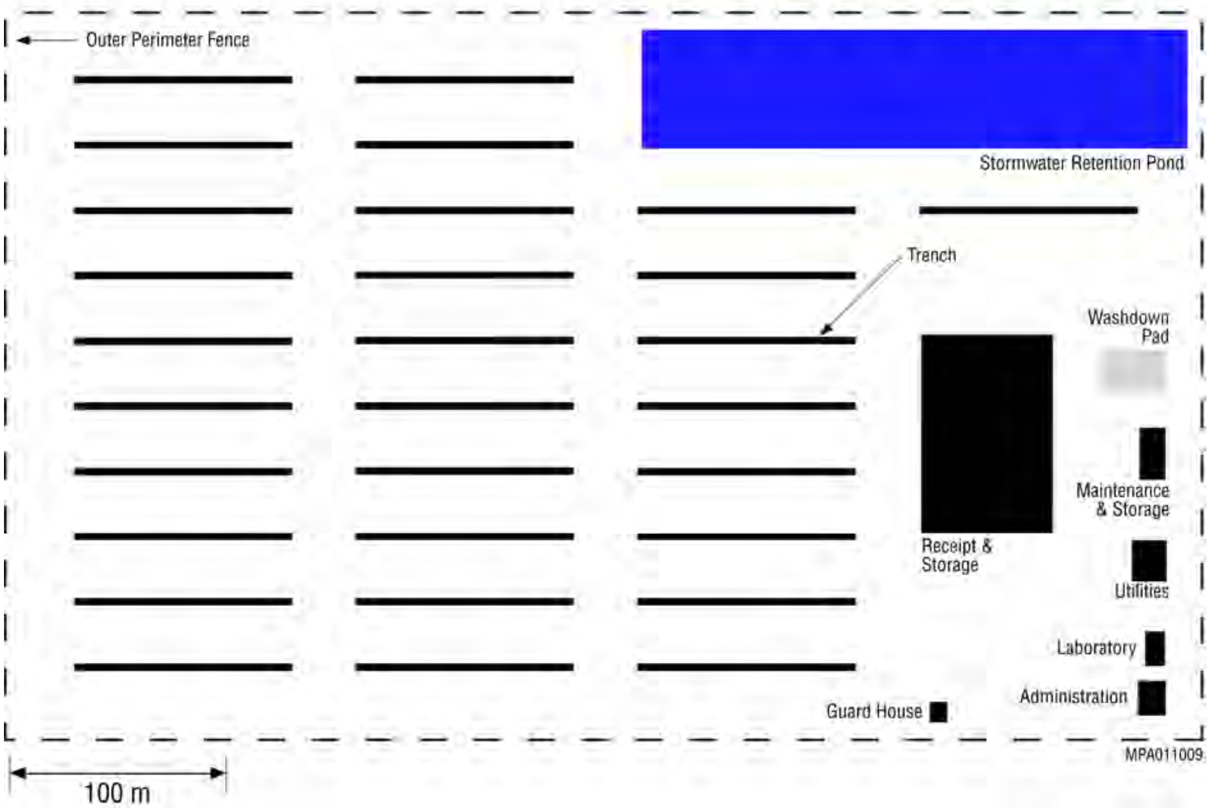

FIGURE D-12 Layout of a Conceptual Trench Disposal Facility

Ditches would separate the vaults with their interim cover systems to minimize standing water and provide site drainage. The conceptual design incorporates a retention pond that is 180 × 110 × 0.30 m (580 × 350 × 1 ft) to manage stormwater runoff. The proposed size of the pond might need to be modified on the basis of site-specific conditions, including precipitation.

D.5 STAFFING AND COST ESTIMATES

D.5.1 Construction

The construction labor force could be organized into five groups:

1. *Management, engineering, design, permitting (Home Office).* This group includes management, planning, engineering, and permitting personnel. Permitting includes licensing activities and National Environmental Policy Act (NEPA) documentation. This group is typically located at the contractors' home or regional office rather than in the field.

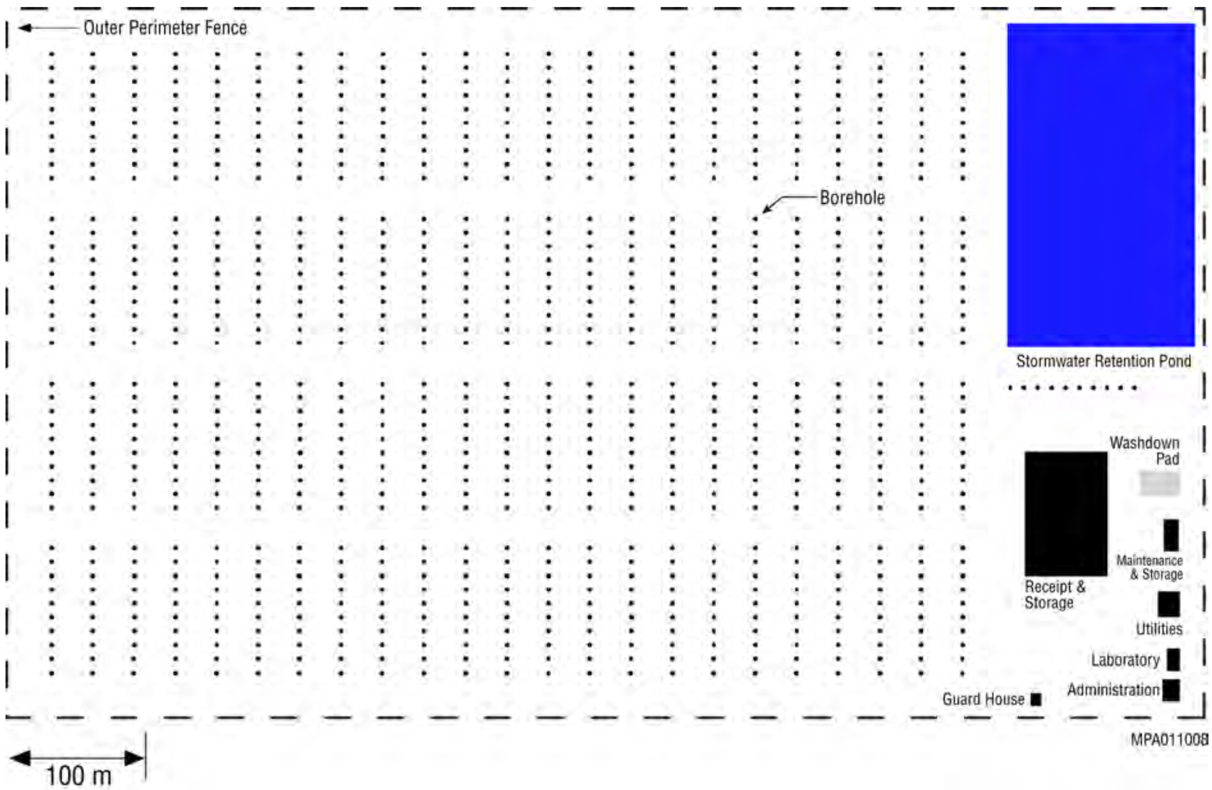

FIGURE D-13 Layout of a Conceptual Borehole Disposal Facility

2. *Management and supervision at the construction site (Field Office).* This group represents overall field management and supervision during actual construction and excavation. Personnel would be stationed in trailers initially. They would relocate to finished buildings (e.g., administration building) upon their completion. This group would remain at one relatively constant level for initial construction of the disposal facility and the initial disposal units. Other levels would be used for intermittent construction of the other disposal units and installation of the final cover system.

3. *Site preparation.* This group includes the surveyors, operating engineers, truck drivers, and laborers who would provide the initial construction entrance, temporary (gravel) roads, stormwater management, initial grubbing, installation of utility services, and associated activities. The level of effort for this group would be greatest during site preparation leading up to construction of the first disposal unit.

4. *Construction.* This group includes those who would be involved in building the trenches, boreholes, or vaults and constructing the support buildings.

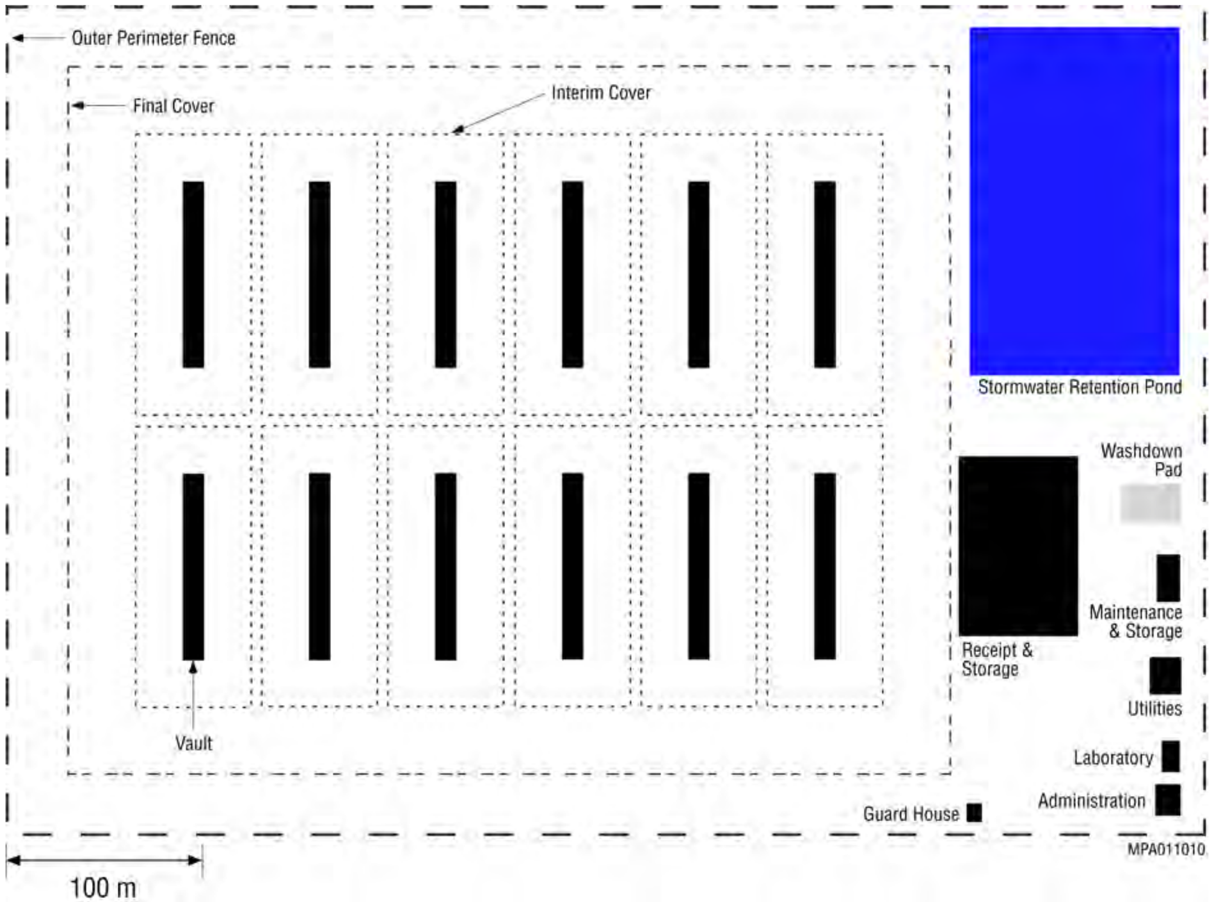

FIGURE D-14 Layout of a Conceptual Vault Disposal Facility

5. *Checkout and startup.* This group includes those involved in readiness assessments, final licensing and permitting activities, and training and certification of the operating staff.

Summaries of labor and cost estimates are provided in Tables D-1 through D-4 for construction of the disposal facility. All cost estimates are based on R.S. Means construction data (R.S. Means 2004, 2006).

D.5.2 Operations

D.5.2.1 Staffing-Level Methodology

To assure that trained personnel would be available at a stand-alone facility, the estimates presented here assume that a disposal facility would remain open on a continuous basis; that is, the facility would not open periodically to receive a short shipping campaign and then close again until a sufficient amount of waste required disposal. This continuous operation would

TABLE D-1 Estimated Person-Hours and Direct Costs Associated with the Construction of the Conceptual Disposal Facilities

Activity	Person-Hours	Material Cost ($)	Labor Cost ($)	S/C[a] Cost ($)	Total Cost ($)
Trench					
Geotechnical investigation	256	16,700	11,600	0	28,300
Shoring placement	1,790	264,000	80,400	0	345,000
Drilling deflector	1,070,000	9,400,000	33,100,000	0	42,500,000
Site prep	44,500	1,020,000	1,210,000	3,360,000	5,600,000
Earthwork grading	1,470	88,800	58,600	0	147,000
RH trenches	155,000	7,680,000	5,730,000	0	13,400,000
Trench closure	20,600	869,000	586,000	0	1,460,000
Support facilities	75,400	4,260,000	2,210,000	1,040,000	7,500,000
Total direct costs	1,370,000	23,600,000	43,000,000	4,400,000	71,000,000
Borehole					
Geotechnical investigation	256	16,700	11,600	0	28,300
Borehole	168,000	103,000,000	13,500,000	0	116,000,000
Drilling deflector	92,000	33,100,000	2,100,000	0	35,200,000
Site prep	81,500	1,620,000	2,220,000	1,320,000	5,170,000
Earthwork grading	3,650	220,000	146,000	0	366,000
Support facilities	88,700	5,120,000	2,530,000	1,090,000	8,740,000
Total direct costs	434,000	143,000,000	20,500,000	2,410,000	166,000,000
Vault					
Vault site preparation	69,800	13,700,000	1,910,000	1,660,000	17,300,000
Vault construction	3,570,000	60,800,000	180,000,000	800,000	241,000,000
Vault cap	307,000	12,700,000	8,650,000	0	21,400,000
Support facilities	114,000	4,870,000	3,330,000	1,480,000	9,690,000
Total direct costs	4,060,000	92,100,000	194,000,000	3,950,000	290,000,000

[a] S/C = subcontract.

TABLE D-2 Estimated Total Construction Full-Time Equivalents

	Staff (FTE-yr)		
Construction Phase	Trench	Borehole	Vault
Direct construction	686	217	2,029
Indirect construction (20% of above)	137	43	406
Total construction	824	260	2,434

TABLE D-3 Project Management Labor Staffing

Project Management Labor	Staff (FTE-yr)		
	Trench	Borehole	Vault
Program manager	1.5	0.5	5.6
Project manager	7.2	2.3	21.1
Program QA/QC manager	0.5	0.1	1.2
Construction manager	43.3	13.7	127.6
Project QA inspector	15.1	4.8	44.6
Health and safety officer	43.3	13.7	127.6
Administrative assistant	22.7	7.2	67.0
Accounting clerk	3.8	1.2	11.1

TABLE D-4 Total Estimated Construction Costs

Cost Summary	Cost ($)		
	Trench	Borehole	Vault
Subcontractor costs	71,000,000	166,000,000	290,000,000
Engineering and design fees	2,840,000	6,630,000	11,600,000
Other direct costs (ODC)	533,000	1,240,000	2,170,000
Subtotal ODC, design, and subcontracts	74,400,000	174,000,000	303,000,000
Markup (15%)	11,200,000	26,000,000	45,500,000
Project management labor costs	1,120,000	2,600,000	4,550,000
Estimated construction costs	86,700,000	202,000,000	354,000,000
Professional services contingency	989,000	2,310,000	4,040,000
Total cost[a]	88,000,000	210,000,000	360,000,000

[a] Total cost is rounded off to two significant figures.

ensure that the same trained personnel would be available to operate the facility and that institutional knowledge would not be lost. In addition, a minimum number of personnel would be necessary for proper operation of the facility, but that number would not scale linearly as the receipt rate increased. Thus, single-value cost estimates or full-time equivalent (FTE) values per shipment or unit volume of waste received are not used.

Coupled with the assumptions on waste receipt rates at the facility, the assumption that the disposal facility would operate on a continuous basis provides for conservative estimates of staffing levels and associated impacts. As discussed below, the number of staff members required to operate the facility is based on potential waste receipt rates in the years following the opening of the facility, which is the time when the majority of the waste would be emplaced. The remaining years of operation would likely require lower staffing levels. Depending on the actual schedules of when the waste could be delivered, the facility could operate on an interim-type basis. In such a case, a pool of trained workers would need to be available when required.

The number of personnel and their functions were estimated on the basis of the functions of the facility, waste volume receipt rates at the facility, and on-site movements of waste packages for final disposal. Details of the time-motion information (unit operations) used to determine the average number of workers required for operations are presented in Argonne (2010). The time period through 2035 was used to estimate the size of the workforce because the majority of the waste under consideration (approximately 75%) would be available for disposal by that time. The annual average receipt rate between 2019 and 2035 is estimated to be 570 truck shipments. As a conservative measure, this receipt rate was used to estimate impacts from operations for the entire period a disposal facility would be open, from 2019 to 2083.

D.5.2.2 Operational Data

Table D-5 provides information on the number and function of personnel required to operate the facility. Annual costs for labor, consumables, and equipment are provided in Tables D-6 through D-8 for trench, borehole, and vault disposal, respectively. More detailed supporting information on operating equipment costs can be found in Argonne (2010).

TABLE D-5 Detailed Worker Breakdown for Disposal Facility Operations[a]

	Number of FTEs		
Labor Category	Trench	Borehole	Vault
Officials and managers	1	1	1
Professionals	1.1	0.6	1.1
Technicians	8	5	8
Security	11	11	11
Craft workers (maintenance)	2	3	2
Office and clerical	6	6	6
Line supervisors	4	4	4
Operators	15	8	18
Total personnel	48	38	51

[a] Values are rounded to appropriate significant figure.

TABLE D-6 Annual Operating and Maintenance Costs for a Conceptual Trench Disposal Facility

Description	Quantity	Unit	Unit Cost ($)	Total Cost ($)
Consumables				
Diesel fuel	210,000	gal/yr	2.49	522,900
Electricity	1,160	MWh/yr	89.00	103,240
Water	1,100,000	gal/yr	0.002	2,498
Natural gas	11,200	Mcf/yr	12.00	134,400
Total consumables cost				763,038
Equipment				
Tractor trailers	3	Each	7,500.00	22,500
Emplacement cranes	1	Each	11,000.00	11,000
Forklift trucks	3	Each	1,500.00	4,500
Vibratory compactor	1	Each	8,500.00	8,500
End-loaders	1	Each	7,950.00	7,950
Pickup trucks	5	Each	1,100.00	5,500
Miscellaneous tools	1	Year	8,805.87	8,806
Maintenance allowance	1	Year	19,000.00	19,000
Total equipment cost				87,756
Labor				
Officials and managers	1.0	FTE	160,000.00	160,000
Professionals	1.1	FTE	130,000.00	142,544
Technicians	7.7	FTE	100,000.00	774,351
Security	10.7	FTE	100,000.00	1,066,611
Craft workers (maintenance)	2.4	FTE	100,000.00	237,500
Office and clerical	6.0	FTE	80,000.00	480,000
Line supervisors	4.0	FTE	100,000.00	400,014
Operators	15.2	FTE	100,000.00	1,523,673
Indirect costs (at 12%)				574,163
Total labor cost				5,358,856

Summary	Subtotal ($)	Contingency (%)	Contingency ($)	Total ($)
Consumables	763,038	40	305,215	1,068,254
Equipment	87,756	30	26,327	114,083
Labor	5,358,856	25	1,339,714	6,698,570
Total	6,209,651		1,671,256	7,880,907[a]

[a] Value rounded to $8 million as annual operating cost. Assuming 20 years of operation, the total cost to operate a trench disposal facility is assumed to be about $160 million.

TABLE D-7 Annual Operating and Maintenance Costs for a Conceptual Borehole Disposal Facility

Description	Quantity	Unit	Unit Cost ($)	Total Cost ($)
Consumables				
Diesel fuel	80,000	gal/yr	2.49	199,200
Electricity	970	MWh/yr	89.00	86,330
Water	410,000	gal/yr	0.002	931
Natural gas	11,200	Mcf/yr	12.00	134,400
Total consumables cost				420,861
Equipment				
Tractor trailers	3	Each	7,500.00	22,500
Emplacement cranes	1	Each	11,000.00	11,000
Fork lift trucks	3	Each	1,500.00	4,500
Vibratory compactor	1	Each	8,500.00	8,500
End-loaders	1	Each	7,950.00	7,950
Pick up trucks	4	Each	1,100.00	4,400
Miscellaneous tools	1	Year	5,133.60	5,134
Maintenance allowance	1	Year	19,000.00	19,000
Total equipment cost				82,984
Labor				
Officials and managers	1.0	FTE	160,000.00	160,000
Professionals	0.6	FTE	130,000.00	78,419
Technicians	5.5	FTE	100,000.00	545,135
Security	10.7	FTE	100,000.00	1,066,611
Craft workers (maintenance)	2.7	FTE	100,000.00	265,000
Office and clerical	6.0	FTE	80,000.00	480,000
Line supervisors	4.0	FTE	100,000.00	400,078
Operators	7.6	FTE	100,000.00	761,721
Indirect costs (at 12%)				450,836
Total labor cost				4,207,799

Summary	Subtotal ($)	Contingency (%)	Contingency ($)	Total ($)
Consumables	420,861	40	168,344	589,206
Equipment	82,984	30	24,895	107,879
Labor	4,207,799	25	1,051,950	5,259,748
Total	4,711,644		1,245,189	5,956,833[a]

[a] Value rounded to $6 million as annual operating cost. Assuming 20 years of operation, the total cost to operate a borehole disposal facility is assumed to be about $120 million.

TABLE D-8 Annual Operating and Maintenance Costs for a Conceptual Above-Grade Vault Facility

Description	Quantity	Unit	Unit Cost ($)	Total Cost ($)
Consumables				
Diesel fuel	210,000	gal/yr	2.49	522,900
Electricity	1,150	MWh/yr	89.00	102,350
Water	1,090,000	gal/yr	0.002	2,476
Natural gas	11,200	Mcf/yr	12.00	134,400
Total consumables cost				762,126
Equipment				
Tractor trailers	3	Each	7,500.00	22,500
Emplacement cranes	1	Each	11,000.00	11,000
Fork lift trucks	3	Each	1,500.00	4,500
Vibratory compactor	1	Each	8,500.00	8,500
End-loaders	1	Each	7,950.00	7,950
Pick up trucks	6	Each	1,100.00	6,600
Miscellaneous tools	1	Year	10,009.12	10,009
Maintenance allowance	1	Year	19,000.00	19,000
Total equipment cost				90,059
Labor				
Officials and managers	1.0	FTE	160,000.00	160,000
Professionals	1.1	FTE	130,000.00	141,606
Technicians	7.7	FTE	100,000.00	770,803
Security	10.7	FTE	100,000.00	1,066,611
Craft workers (maintenance)	2.3	FTE	100,000.00	225,000
Office and Clerical	6.0	FTE	80,000.00	480,000
Line supervisors	4.0	FTE	100,000.00	400,015
Operators	17.8	FTE	100,000.00	1,776,823
Indirect costs (at 12%)				602,503
Total labor cost				5,623,360

Summary	Subtotal ($)	Contingency (%)	Contingency ($)	Total ($)
Consumables	762,126	40	304,850	1,006,976
Equipment	90,059	30	27,018	117,077
Labor	5,623,360	25	1,405,840	7,029,201
Total	6,475,545		1,737,708	8,213,253[a]

[a] Value rounded to $8 million as annual operating cost. Assuming 20 years of operation, the total cost to operate a vault disposal facility is assumed to be about $160 million.

D.6 RESOURCE ESTIMATES

Resources needed for the construction and operations of a GTCC LLRW and GTCC-like waste disposal facility can be divided into two classes: materials and utilities. Materials are the substances used to construct the disposal trenches, boreholes, or vaults and support buildings, such as sand, clay, gravel, and concrete. This category also includes the excavated materials. Utilities include electricity, natural gas or propane, water, and diesel fuel. Materials would be consumed primarily during construction activities. Utilities would be consumed during both construction and operations.

D.6.1 Construction

Table D-9 summarizes materials and resources consumed during construction of a GTCC LLRW and GTCC-like waste disposal facility. The large amount of soil required for vault disposal is necessary for the final 5-m (16-ft) cover depth. More detailed supporting information on resources required for construction can be found in Argonne (2010).

D.6.2 Operations

Operational activities would include receiving the packages of waste, inspecting them, possibly storing them temporarily, possibly reconfiguring them for disposal (e.g., bundling RH canisters into 3-packs for borehole disposal), transporting the waste containers to the disposal cells, and emplacing them. To some extent, construction activities and operational activities would be concurrent. For example, one or more trenches, boreholes, or vaults would be being filled while others were being constructed. Once all the GTCC LLRW and GTCC-like waste had been emplaced and the facility had undergone closure, a period of institutional control would follow. An institutional control program would include physical control of access to the site, an environmental monitoring program, periodic surveillance, and custodial care. The use of utilities would be much greater during the operational period than the institutional control period, so utility use during the institutional control period is not considered here.

D.6.2.1 Materials

The only major consumable materials used during operations would be pallets for potential bundling operations, sand for backfill, and chemicals used to treat the water used on-site, as shown in Table D-10.

D.6.2.2 Utilities

The utilities required for operations are summarized in Table D-11 and D-12. Water and sewage usage are based on the staffing requirements discussed in Section D.5.2.1. Gas, oil, and electricity would be consumed primarily to keep the facility buildings operational, with minor

TABLE D-9 Estimates of the Materials and Resources Consumed during Construction of the Conceptual Disposal Facilities

Construction Materials and Resources	Total Consumption		
	Trench	Borehole	Vault
Utilities			
Water (gal)[a]	5,300,000	2,800,000	17,100,000
Electricity (MWh)[b,c]	34,200	10,800	101,000
Solids[c]			
Concrete (yd^3)	25,600	18,600	88,200
Steel (tons)	2,000	1,400	7,960
Gravel (yd^3)	36,100	25,300	156,400
Sand (yd^3)	3,600	27,900	198,300
Clay (yd^3)	12,900	5,180	56,000
Soil (off-site) (yd^3)	–[d]	–	254,000
Liquids			
Diesel fuel (gal)[b]	750,000	2,030,000	3,380,000
Oil and grease (gal)	18,000	48,000	86,000
Gases			
Industrial gases (propane) (gal)[b]	5,400	4,300	13,600

a Water requirement estimates are based on DOE (1997), in which each FTE requires 20 gal/d, and cementation requires 26.1 lb of water per 100 lb of cement.

b Scaling methodology is based on LLNL (1997).

c Peak demand is 1.71, 0.54, or 5.05 MWh for the trench, borehole, and vault disposal facilities, respectively.

d Dash means not applicable.

amounts of electricity required to operate the overhead cranes during unloading. More information on utility demand can be found in Argonne (2010).

D.7 FACILITY EMISSIONS AND WASTES

D.7.1 Construction

Wastes generated during construction of the disposal facility would be typical of large construction projects. Wastes would consist primarily of construction debris, including concrete fragments, and sanitary wastes generated by the labor force. Emissions would result primarily from the use of fuels in constructing the facility, removing construction debris, and disturbing the

TABLE D-10 Materials Consumed Annually during Operations[a]

Material and Chemical[b]	Quantity (lb/yr) Trench	Borehole	Vault
Sand	2.59E+05	5.20E+04	9.80E+03
Standard pallet (trench = 48-in. × 48-in. × 7.5-in. tall, borehole = steel pallet)	140	5.84E+05	–
Hydrochloric acid (37% HCl)	277	103	275
Sodium hydroxide (50% NaOH)	227	85	225
Sodium hypochlorite	107	40	106
Copolymers	150	56	149
Phosphates	17	6	17
Phosphonates	16	6	15

[a] See Kemmer (1988) for water treatment.

[b] The chemicals are used to treat the raw water used during waste operations.

[c] Dash means not applicable.

TABLE D-11 Average-Day Utility Consumption during Disposal Operations

Utility[a]	Average-Day Consumption Trench	Borehole	Vault
Potable water (USG/d)	1,300	1,000	1,300
Raw water (USG/d)[b]	4,600	1,700	4,500
Sanitary sewer (USG/d)	1,300	1,000	1,300
Natural gas (Mcf/d)	47	47	47
Diesel fuel (USG/d)	900	300	900
Electricity (MWh)[c]	4.8	4.0	4.8

[a] USG/d = U.S. gallons per day, Mcf = million cubic feet.

[b] Includes potable water and water used in truck washdown. Estimate assumes that on average, 605 gal are used to wash down the truck that transports the GTCC LLRW and GTCC-like waste. The estimate is based on Table 6-1 in EPA (2001).

[c] Peak-day demand is 0.5, 0.5, and 0.5 MWh for the trench, borehole, and vault disposal facilities, respectively.

TABLE D-12 Annual Utility Consumption during Disposal Operations

	Annual Consumption[b]		
Utility[a]	Trench	Borehole	Vault
Potable water (USG/yr)	310,000	240,000	310,000
Raw water (USG/yr)[b,c]	1,100,000	410,000	1,090,000
Sanitary sewer (USG/yr)	310,000	240,000	320,000
Natural gas (Mcf/yr)	11,200	11,200	11,200
Diesel fuel (USG/yr)	210,000	80,000	210,000
Electricity (MWh)	1,160	970	1,150

[a] USG/yr = U.S. gallons per year, Mcf = million cubic feet.

[b] Based on 240 operations-days per year.

[c] Includes potable water and water used in truck washdown. Estimate assumes that, on average, 605 gal (2,300 L) are used to wash down the truck that transports the GTCC LLRW and GTCC-like waste. The estimate is based on Table 6-1 in EPA (2001).

land (fugitive dust). The amount of concrete waste was estimated on the basis of the assumption that 0.65% of the concrete usage would be spoilage. The other solid wastes, which would include construction debris and rock cuttings, were taken to be eight times the volume of the concrete spoilage. Steel waste was taken to be 0.5% of the steel requirements. These solid nonhazardous wastes would be disposed of in a municipal solid waste landfill. The amount of sanitary waste was estimated on the basis of the total construction workforce. Liquid (sanitary) nonhazardous wastes would be treated in a portable system or hauled off-site for treatment and disposal. Table D-13 summarizes the amount of waste that would be generated during construction.

Estimates of criteria pollutant emissions generated during construction were based on the estimated amounts of fuel used by the trucks, cranes, and other heavy equipment during construction. Standard U.S. Environmental Protection Agency (EPA) emission factors from the WebFire database (http://cfpub.epa.gov/oarweb/index.cfm?action=fire.main) were used in these calculations. Emissions were calculated from the total quantity of diesel fuel consumed. Dust was estimated from the amount of disturbed land area and the length of time that the disturbed area would be under construction. National Ambient Air Quality Standards (NAAQS) for criteria air pollutants are given in Table D-14. Estimates of construction emissions are given in Table D-15 for the disposal facilities. The initial construction period was assumed to be 3.4 years (824 days for site preparation and construction of support facilities at 240 working days per year). Although disposal unit construction might span more than 60 years because it is assumed that the disposal units would be constructed as the waste became available for disposal, a total of 20 years of actual time for construction operations was assumed, which corresponds to the period when most of the GTCC LLRW and GTCC-like waste is expected to be received for disposal. Emissions of the following criteria air pollutants were estimated: sulfur oxides (SO_x) as sulfur

TABLE D-13 Total Wastes Generated during Construction

Waste Generation by Category	Trench	Borehole	Vault
Hazardous solids (yd^3)	57	18	168
Hazardous liquids (gal)	23,000	7,300	68,000
Nonhazardous solids (yd^3)[a]	62,000	300,000	5,200
Nonhazardous liquids (gal)[b]	4,800,000	1,500,000	14,000,000

[a] Includes concrete and other excavated materials. Excavated materials (if clean) could be used as backfill during operations and would reduce the volume that could be considered as waste.

[b] Includes sanitary and other nonhazardous liquids.

TABLE D-14 National Ambient Air Quality Standards (NAAQS) for Criteria Air Pollutants

Criteria Air Pollutant	Averaging Time	Primary Standard
CO	1 hour	40 mg/m^3
	8 hours	10 mg/m^3
Hydrocarbons	3 hours	160 $\mu g/m^3$
NO_x (as NO_2)	Annual	100 $\mu g/m^3$
SO_x (as SO_2)	24-hours[a]	365 $\mu g/m^3$
	Annual	80 $\mu g/m^3$
PM_{10}	24 hours	150 $\mu g/m^3$
$PM_{2.5}$	24 hours	35 $\mu g/m^3$
	Annual	15 $\mu g/m^3$

[a] Not to be exceeded more than once a year.

Source: 40 CFR Part 50.0 et seq.

TABLE D-15 Estimated Air Emissions during Construction[a]

	Total Emissions (tons)			Peak-Year Emissions (tons/yr)		
Criteria Pollutant[b]	Trench	Borehole	Vault	Trench	Borehole	Vault
VOCs[b]	13	31	62	0.9	2.7	3.6
NO_x	110	270	540	8.1	26	31
SO_2	12	32	53	0.9	3.0	3.2
CO	39	110	190	3.3	11	11
PM_{10}[c]	25	60	65	5.0	13	8.6
$PM_{2.5}$[d]	12	30	44	1.5	4.1	3.6
CO_2	8,400	29,000	38,000	670	2,200	2,300

a Excludes delivery and commuter vehicles.

b VOCs = volatile organic compounds.

c Assumes construction emission factor for fugitive dust PM_{10} of 0.22 tons/acre-month (average conditions) (URBEMIS2007 2007).

d Assumes 21% of fugitive dust PM_{10} is $PM_{2.5}$ and that 89% of combustion PM_{10} is $PM_{2.5}$ (www.aqmd.gov/CEQA/handbook/PM2_5/handout1.doc).

dioxide (SO_2), nitrogen oxides (NO_x) as nitrogen dioxide (NO_2), carbon monoxide (CO), particulate matter with a diameter of less than or equal to 10 micrometers (PM_{10}), and particulate matter with a diameter of less than or equal to 2.5 micrometers ($PM_{2.5}$). The construction equipment fuel use, emission factors, and other supporting information can be found in Argonne (2010).

D.7.2 Operations

Data on annual facility wastes are provided in Table D-16. Data on emissions from fixed facility sources and from mobile sources are provided in Tables D-17 and D-18, respectively. A fixed facility source would be the process steam boiler used for space and water heating and periodic testing of backup diesel generators for electrical power. Mobile emission sources would include tractor trailers, end-loaders, cranes, and forklifts.

D.8 TRANSPORTATION

D.8.1 Construction

Local transportation of workers and materials could lead to significant amounts of vehicle emissions that could affect the local air quality. Large volumes of materials, especially sand and backfill, would be required for the construction of the GTCC LLRW and GTCC-like waste

TABLE D-16 Annual Wastes during Operations

Waste Category	Treatability Category	Average Annual Generation Rate: Trench	Borehole	Vault
Radioactive waste				
Liquid LLRW (water from truck washdown[a]) (gal)	Liquid LLRW	790,000	170,000	780,000
Solid LLRW (including HEPA filters[b]) (yd^3)	Combustible and noncombustible solid LLRW	16	10	16
Nonradioactive waste				
Liquid nonhazardous (sanitary) wastes (gal)	NA[c]	310,100	240,000	320,000
Solid nonhazardous wastes[d] (yd^3)	NA	120	95	120

[a] The water used to wash down the truck after it delivered the LLRW to the disposal facility could be contaminated (but that is not likely). This analysis conservatively assumes that the washdown water would be considered liquid LLRW until determined otherwise.

[b] HEPA = high-efficiency particulate air.

[c] NA = not applicable.

[d] Solid nonhazardous wastes include domestic trash and office waste.

TABLE D-17 Estimated Annual Emissions of Criteria Pollutants from Fixed Facility Emission Sources

	Mission-Critical Equipment Emissions (tons/yr)			Process Steam Boiler Emissions (tons/yr)		
Criteria Pollutant	Trench	Borehole	Vault	Trench	Borehole	Vault
SO_2	3.57E-02	3.57E-02	3.57E-02	3.4E-03	3.4E-03	3.4E-03
NO_x	5.44E-01	5.44E-01	5.44E-01	2.8E-01	2.8E-01	2.8E-01
CO	1.17E-01	1.17E-01	1.17E-01	4.7E-01	4.7E-01	4.7E-01
PM_{10}	1.26E-02	1.26E-02	1.26E-02	4.3E-02	4.3E-02	4.3E-02
$PM_{2.5}$	1.26E-02	1.26E-02	1.26E-02	4.3E-02	4.3E-02	4.3E-02
CO_2	2.03E+01	2.03E+01	2.03E+01	6.7E+02	6.7E+02	6.7E+02

TABLE D-18 Estimated Annual Emissions of Criteria Pollutants from Mobile Sources[a]

Criteria Pollutant	Mobile Equipment Emissions (tons/yr)		
	Trench	Borehole	Vault
SO_2	3.23E+00	1.20E+00	3.27E+00
NO_x	2.58E+01	9.06E+00	2.59E+01
CO	1.25E+01	4.63E+00	1.26E+01
PM_{10}	2.38E+00	8.46E-01	2.39E+00
$PM_{2.5}$	2.12E+00	7.53E-01	2.12E+00
CO_2	2.34E+03	8.73E+02	2.37E+03

[a] Mobile emission sources include forklifts and mobile cranes.

disposal facility. Approximately 9,200, 36,600, or 74,200 truck shipments for trench, borehole, or vault disposal, respectively, would be required, as summarized in Table D-19. Estimated emissions from these shipments are provided in Table D-20. The emission factors used in the calculations are given in Table D-21. Additional vehicles required for worker intrasite transportation would also result in some emissions during construction, as shown in Table D-20, which also provides estimates for emissions as a result of worker commuter trips.

D.8.2 Operations

Estimated emissions for local transportation of disposal site workers (i.e., daily commutes) are provided in Table D-22.

D.9 WASTE ISOLATION PILOT PLANT

The primary source of information for estimating the impacts of disposing of the GTCC LLRW and the GTCC-like waste at the Waste Isolation Pilot Plan (WIPP) (Alternative 2) is Sandia (2008b). The following text provides supplemental information for estimating the incremental air emissions during construction of the additional underground rooms required to emplace the waste and during disposal operations.

D.9.1 Construction

Emissions from construction of the underground rooms would result from underground haul trucks taking the mined salt to the waste hoist and surface haul trucks taking the mined salt from the waste hoist to the Salt Storage Area. The miner itself is powered by electricity and thus

TABLE D-19 Rough Order-of-Magnitude Estimate of the Number of Truck Shipments of Construction Materials[a]

Resource	Truck Capacity	Total Consumption: Trench	Total Consumption: Borehole	Total Consumption: Vault	No. of Truck Shipments: Trench	No. of Truck Shipments: Borehole	No. of Truck Shipments: Vault
Portland cement (yd^3)[b]	10	2,816	2,046	9,702	282	205	971
Gravel (yd^3)[b]	10	46,596	32,926	192,562	4,660	3,293	19,257
Sand (yd^3)[b]	10	10,256	32,736	221,232	1,026	3,274	22,124
Clay (yd^3)	10	12,900	5,180	56,000	1,290	518	5,600
Steel (tons)[c]	21	2,000	1,400	7,960	96	67	380
Asphalt paving (tons)[d]	20	600	900	700	30	45	35
Backfill (yd^3)[e]	10	–	–	254,000	–	–	25,400
Diesel fuel (gal)[f]	9,000	7.5E+05	2.0E+06	3.4E+06	84	226	376
Excavated materials	10	62,000	294,400	–	6,200	29,440	–
Total (rounded up)					13,700	37,100	74,200

[a] Calculation neglects truck deliveries of process equipment and related items (which should be low in comparison with other shipments). A dash means not applicable.

[b] Assumes that concrete is composed of 11% Portland cement, 41% gravel, and 26% sand and is shipped to the site in a standard 10-yd^3 (7.6-m^3) end-dump truck.

[c] Assumes that the net payload for steel transport to site is 42,000 lb (19,000 kg).

[d] Assumes hot mix asphalt is loaded into the 20-ton-capacity tri-axle trucks for transport to the paving site.

[e] Assumes that shipment uses standard 10-yd^3 (7.6-m^3) end-dump trucks.

[f] Assumes that shipment uses a U.S. Department of Transportation (DOT) 406/MC-306 atmospheric-pressure tank truck with a 9,000-gal (34,000-L) capacity.

TABLE D-20 Estimated Annual Emissions from Construction Vehicles[a]

	Delivery Vehicle Emissions (tons)[b]			Support Vehicle Emissions (tons)[c]			Worker Commuter Vehicle Emissions (tons)[d]		
Criteria Pollutant	Trench	Borehole	Vault	Trench	Borehole	Vault	Trench	Borehole	Vault
SO_x	1.09E-04	2.96E-04	5.92E-04	1.66E-04	5.35E-05	4.87E-04	2.62E-03	8.26E-04	7.73E-03
NO_x	6.85E-03	1.86E-02	3.71E-02	1.04E-02	3.36E-03	3.06E-02	6.15E-02	1.94E-02	1.82E-01
CO	2.62E-02	7.09E-02	1.42E-01	3.99E-02	1.28E-02	1.17E-01	1.63E+00	5.16E-01	4.82E+00
PM_{10}	1.43E-03	3.88E-03	7.77E-03	2.19E-03	7.02E-04	6.40E-03	1.26E-02	3.99E-03	3.74E-02
$PM_{2.5}$	7.63E-04	2.07E-03	4.13E-03	1.16E-03	3.74E-04	3.41E-03	6.10E-03	1.93E-03	1.80E-02
VOCs	4.28E-03	1.16E-02	2.32E-02	6.52E-03	2.10E-03	1.91E-02	7.85E-02	2.48E-02	2.32E-01
CO_2	1.59E+01	4.29E+01	8.59E+01	2.42E+01	7.77E+00	7.08E+01	1.66E+02	5.23E+01	4.89E+02

[a] Assumes a construction period of 20 years.

[b] Estimates of 13,700, 37,100, and 74,200 auto one-way trips to the construction site are based on the total number of deliveries for trench, borehole, or vault construction, respectively. One-way trip distance of 20 mi (32 km) is based on DOE (1997). Emissions are based on round-trip distances.

[c] Assumes one support vehicle per 30 construction workers (824, 260, or 2,434 FTEs assumed for trench, borehole, or vault construction, respectively), as taken from LLNL (1997) and NRC (1994). Assumes that 10 mi (16 km) are travelled per day per vehicle, as taken from Table 4.5 on page 4-15 of NRC (1994).

[d] Estimates of 9,885, 3,123, and 29,212 auto one-way trips to the construction site are based on the total construction personpower for trench, borehole, or vault facility construction, respectively. Assumes 240 workdays per year. One-way trip distance of 20 mi (32 km) is based on DOE (1997). Emissions are based on round-trip distance.

TABLE D-21 Criteria Pollutant Vehicle Emission Factors

Criteria Pollutant	Emission Factor (g/mi)[a] Delivery Vehicle	Support Vehicle	Commuter Vehicle
SO_x	0.00225	0.00225	0.006
NO_x	0.141	0.141	0.141
CO	0.539	0.539	3.745
PM_{10}	0.0295	0.0295	0.029
$PM_{2.5}$	0.0157	0.0157	0.014
VOCs	0.0880	0.0880	0.18
CO_2	326	326	380

[a] Emission factors were determined by using Argonne GREET 2.8a Version (version date: August 30, 2007) available at http://www.transportation.anl.gov/software/GREET/greet_2-8a_beta.html.

TABLE D-22 Estimated Annual Emissions from Commuter Vehicles

Criteria Pollutant	Commuter Vehicle Emissions (tons/yr)[a] Trench	Borehole	Vault
SO_x	3.1E-03	2.4E-03	3.2E-03
NO_x	7.2E-02	5.7E-02	7.5E-02
CO	1.9E+00	1.5E+00	2.0E+00
PM_{10}	1.5E-02	1.2E-02	1.5E-02
$PM_{2.5}$	7.1E-03	5.6E-03	7.5E-03
VOCs	9.2E-02	7.2E-02	9.6E-02
CO_2	1.9E+02	1.5E+02	2.0E+02

[a] Estimates of 11,548, 9,117, and 12,116 one-way auto trips to the disposal facility are based on the total operational personpower for trench, borehole, or vault facility construction, respectively. Assumes 240 workdays per year. One-way trip distance of 20 mi (32 km) is based on DOE (1997). Emissions are based on round-trip distance.

would not produce any direct emissions. The assumed construction period for the additional 26 rooms is 20 years. The estimated annual emissions, based on 23,700 tons of salt mined per room (Sandia 2008b), are shown in Table D-23 for the criteria pollutants. Estimates are based on the fuel consumption of the haul trucks given in Table D-24 and the vehicle emission factors provided in Table D-25.

TABLE D-23 Air Emissions during Construction at WIPP

Criteria Pollutant	Total Emissions (tons)	Annual Emissions (tons/yr)
VOCs	2.9	0.14
NO_x	28.7	1.4
SO_2	4.7	0.23
CO	19.4	0.97
PM_{10}[b]	36.5	1.8
$PM_{2.5}$[c]	28.1	1.4
CO_2	3,734	186.7

[a] Calculated by using EPA methodology for coal mining (http://www.epa.gov/ttn/chief/ap42/ch11/final/c11s09.pdf).

[b] Assumes 89% of combustion PM_{10} is $PM_{2.5}$ (www.aqmd.gov/CEQA/handbook/PM2_5/handout1.doc).

D.9.2 Operations

The estimated emissions from operations at WIPP to dispose of the GTCC LLRW and GTCC-like waste would result from the equipment that moves disposal packages underground. For CH waste, a waste transporter moves the package from the waste hoist to a disposal room, where a 20-ton forklift subsequently moves the waste to its emplacement location. For RH waste, it is assumed that a 41-ton forklift would move the disposal package from the hoist to its emplacement location (Sandia 2008b). Table D-26 summarizes the effort involved on an annual basis.

From Table D-26, the average annual hours of operation for each piece of equipment were estimated: 539, 941, and 1,432 hours, respectively, for the 20-ton forklift, the waste transporter, and the 41-ton forklift. The annual average emissions were then estimated by using the emission factors given in Table D-27, as shown in Table D-28.

TABLE D-24 Annual Diesel Fuel Use for Construction of the Additional Disposal Rooms at WIPP

Type of Haul Truck	Diesel Fuel Use per Room (gal)[a]	Duration per Room (h)[a]	No. of Rooms per Year[b]	Duration per Year (h)	Diesel Fuel Use per Year (gal)
185-hp underground	11,440	1,082.2	1.3	1,407	14,872
Surface	3,160	105.3	1.3	137	4,108

[a] Source: Sandia (2008b).

[b] Assumes 20-year period to construct the 26 additional rooms required for GTCC LLRW and GTCC-like waste.

TABLE D-25 Construction Equipment Fuel Consumption and Emission Factors

	Consumables (gal/h)		Emission Factor (lb/1,000 gal)					
Type of Haul Truck	Diesel Fuel	Oil and Grease	VOCs	NO_x	SO_2	CO	PM_{10}[a]	CO_2
185-hp underground	10.6	0.2	17.1	171.7	31.2	123.5	16.8	22,600.0
Surface	30.0	0.2	0.2	2.3	0.0	0.8	0.1	272.3

[a] These emission factors are for combustion-derived PM_{10} emissions and do not include the fugitive dust component.

TABLE D-26 Annual Equipment Usage for Disposal of Waste at WIPP

Equipment	Horsepower Rating[a]	Time per Disposal Package (min)[a]	Estimated Diesel Usage (gal)[a]	Average No. of Disposal Packages/yr[b]	Average Diesel Usage (gal/yr)
20-ton forklift (diesel)	94	10	0.9	3,230	2,910
Waste transporter (diesel)	138	20	2.6	2,820	7,340
41-ton forklift (diesel) – RH	231	60	13.2	1,430	18,900
Total					29,200

[a] Source: Sandia (2008b).

[b] Average estimated for operations is based on the assumption that the majority of the waste disposed of annually at WIPP is composed of GTCC LLRW and GTCC-like waste.

TABLE D-27 Equipment Emission Factors

Criteria Air Pollutant	Emission Factor (lb/horsepower per hour) 20-ton Forklift	41-ton Forklift	Waste Transporter
SO_2	1.87E-03	1.87E-03	1.87E-03
NO_x	1.15E-02	9.92E-03	9.92E-03
CO	2.20E-03	2.20E-03	2.20E-03
PM_{10}	1.59E-03	8.82E-04	8.82E-04
$PM_{2.5}$	1.41E-03	7.85E-04	7.85E-04
VOCs	8.82E-04	8.82E-04	8.82E-04
CO_2	1.15E+00	1.15E+00	1.15E+00

Source: www.aqmd.gov/CEQA/documents/2005/nonaqmd/chevron/appB.xls.

TABLE D-28 Estimated Average Annual Emissions of Criteria Pollutants from GTCC LLRW and GTCC-Like Waste Emplacement at WIPP

Criteria Air Pollutant	Annual Average Emissions (tons/yr)
SO_2	4.8E-01
NO_x	2.6E+00
CO	5.6E-01
PM_{10}	2.4E-01
$PM_{2.5}$	2.2E-01
VOCs	2.3E-01
CO_2	2.9E+02

D.10 REFERENCES

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APPENDIX E:

EVALUATION OF LONG-TERM HUMAN HEALTH IMPACTS FOR THE NO ACTION ALTERNATIVE AND THE LAND DISPOSAL ALTERNATIVES

This appendix presents the approach used to evaluate the long-term impacts on human health that could result from the No Action Alternative in Chapter 3 and the land disposal alternatives (via the borehole, trench, or vault disposal methods) in Chapters 6 through 12 considered in the Greater-Than-Class C (GTCC) Environmental Impact Statement (EIS). The approach used to evaluate long-term impacts on human health from use of the Waste Isolation Pilot Plant (WIPP) deep geologic repository is presented in Chapter 4. The RESRAD-OFFSITE computer code (Yu et al. 2007), with site-specific parameters to the extent that this information was available, was used to perform the analyses for the three land disposal methods at the six federal and four generic commercial sites. This computer code was also used to evaluate the long-term human health impacts for the No Action Alternative. The information given in this appendix summarizes the approach and results described in Argonne (2010). A number of simplifying assumptions are made for the purposes of the comparative analysis in this EIS, especially in terms of the long-term performance of engineered materials assumed for the borehole, trench, and vault disposal facilities. It is expected that detailed, site-specific assessments that would include more specific calculations on the physical and chemical performance of different engineered materials would be made before implementation of any alternative.

For the No Action Alternative, it is assumed that the long-term human health impacts would be limited to members of the general public who might be exposed to GTCC LLRW and GTCC-like waste stored in facilities located within the four NRC regions. For the land disposal alternatives, it is assumed that the long-term human health impacts would be limited to members of the general public who might be exposed to radioactive contaminants released from the waste packages after the engineering barriers (including the cover) and waste containers failed. Direct intrusion into the waste disposal units is considered to be a very unlikely event and is not addressed in this appendix; this issue is addressed in Section 5.5. A number of markers and barriers would be placed on, in, and near the closed disposal facility to prevent intrusion into the buried wastes. The impacts from direct intrusion into the disposal facility are therefore addressed qualitatively in the EIS.

There are three release mechanisms considered in RESRAD-OFFSITE that can lead to contamination at off-site locations: airborne releases, surface runoff, and leaching (see Section E.1). However, only two of these mechanisms are considered significant and applicable to storage or disposal of GTCC LLRW and GTCC-like waste in the long term: (1) airborne releases and (2) leaching of radioactive contaminants from the waste containers or packages, with transport to groundwater and migration to an accessible location, such as a groundwater well. These two mechanisms are addressed in this EIS to determine the impacts on off-site members of the general public following closure of the storage or disposal facility. Surface runoff is not considered to be a viable pathway, given the depth of the disposal facility cover and use of good engineering practices during closure of the disposal facility, which would include measures to minimize erosion by surface water.

Airborne releases could include gases (e.g., radon, carbon dioxide [CO_2], and water vapor containing tritium [H-3]) and particulates if the disposal facility cover was completely lost through erosion. Particulate radionuclide emissions are not expected to be significant, because it is very unlikely that the thick disposal facility cover would be completely lost through erosion. In addition, any material removed from the facility surface cover by erosion or weathering could be replaced to some extent by nearby soil similarly removed. Potential radiation doses to individuals from gaseous releases are expected to be small because the gases would have to diffuse through the thick covers placed on top of the waste disposal units.

Standard engineering practices and measures would be taken in designing and constructing the disposal facility to ensure long-term stability and to minimize the likelihood of contaminant migration from the wastes to the surrounding environment. The facility would be sited in a location consistent with applicable requirements, which would include the consideration of geologic characteristics, to minimize events that could compromise the containment characteristics of the disposal facilities in the long term. It is expected that the use of engineering controls in concert with the natural features of the selected site would ensure the long-term viability of this facility.

The groundwater pathway is generally the pathway of most concern with regard to addressing the post-closure impacts on the general public from a disposal facility for GTCC LLRW and GTCC-like waste, and this pathway is the focus of this appendix. Releases to surface water would only occur once the entire engineered cover over the disposed wastes had eroded away. Because of the thick cover layer and the use of very robust engineering techniques to construct it, it was assumed for the analyses in the EIS that the buried GTCC LLRW and GTCC-like waste would always be overlain by some cover material through 10,000 years, eliminating surface water runoff as a potential exposure mechanism for the action alternatives.

Even if releases to surface water were to occur, it is not expected that these releases would be significant or result in higher peak annual doses or latent cancer fatality (LCF) risks than would releases to groundwater. The disposal facility and waste containers are assumed to maintain their integrity for at least 500 years, and this factor would allow many of the shorter-lived radionuclides to decay to innocuous levels prior to any releases to the environment. In addition, it is expected that releases to surface water would be much more diluted in the environment (such as in a river or lake) before being ingested by the hypothetical receptor than would comparable releases to groundwater (in which case the hypothetical receptor would extract water for use from a well). Because of this smaller amount of dilution, the groundwater pathway would likely be much more significant than the surface water pathway.

Since the travel time to a hypothetical receptor would likely be shorter for any releases to surface water than for releases to groundwater, the time at which the peak annual dose and LCF risk would occur could be sooner for the surface water pathway than the groundwater pathway. However, this is not expected to have a significant impact on the peak annual dose or LCF risk, because the radionuclides that would cause most of the dose have very long half-lives. That is, the additional time to reach a hypothetical receptor through groundwater would not result in any appreciable additional reduction in the radionuclide concentrations causing most of the impacts due to radioactive decay. For these reasons, the groundwater pathway is considered to be the most significant pathway in the long term in this EIS.

An analysis similar to that done for the land disposal alternatives was done for the No Action Alternative (see Chapter 3). Under this alternative, no credit is taken for maintenance of the stored GTCC LLRW and GTCC-like waste beyond 100 years. That is, it is assumed for analysis purposes in this EIS that after 100 years, water could contact the radioactive contaminants in the waste packages and leach radionuclides from the wastes, and that these radionuclides could then move toward the underlying groundwater system. While airborne releases from degraded containers could occur, it is expected that the dispersion of any released radionuclides by the wind would greatly decrease the air concentrations. In addition, it is expected that surface runoff would not be a major concern with regard to this alternative in the long term, because the storage sites would probably have berms or other engineered features to minimize water runoff from the site.

The highest doses associated with the No Action Alternative would therefore probably be those associated with the migration of radionuclides to groundwater that would subsequently be used by members of the general public. Focusing on the groundwater pathway for this alternative also allows for a more direct comparison of the long-term impacts from the No Action Alternative with the post-closure impacts given for the action alternatives.

E.1 RESRAD-OFFSITE COMPUTER CODE

The RESRAD-OFFSITE computer code (Yu et al. 2007) is an extension of the original RESRAD code (Yu et al. 2001) developed by Argonne National Laboratory for the U.S. Department of Energy (DOE). The original (on-site) RESRAD code was developed to address exposure pathways relevant to an individual exposed to residual radioactive soil contamination. This focus allowed for the development of soil cleanup criteria for various exposure scenarios, and RESRAD was largely used to develop cleanup criteria for radioactively contaminated soil in support of DOE remedial action projects.

This code was expanded in RESRAD-OFFSITE to address the radiological consequences to a receptor located either on-site or outside the area of primary contamination. The expanded code can be used to calculate the radiological dose and excess lifetime cancer risk to various receptors by using dose coefficients and radionuclide slope factors from the U.S. Environmental Protection Agency (EPA) and International Commission on Radiological Protection (ICRP). Although this code, too, was developed largely to address soil cleanup guidelines corresponding to a specified dose limit, it has a number of features that make it a good choice for use in the analyses done for this EIS.

The following discussion on the use of RESRAD-OFFSITE focuses on the use of this code for the action alternatives. The same general approach that was used for the action alternatives was used for the No Action Alternative. The simulation approach for the action alternatives is described in Section E.2, and the approach used for the No Action Alternative is described in Section E.3.

The RESRAD-OFFSITE computer code allows for the initial radiological contamination to be in environmental settings ranging from those involving surficial contamination to situations in which a clean cover layer overlies a zone of radioactive contamination. This latter situation simulates the closed land disposal facilities for GTCC LLRW and GTCC-like waste addressed in this EIS, in which there is an overlying soil cover over the disposed-of wastes (the zone of radioactive contamination). The RESRAD-OFFSITE computer code can incorporate the presence of up to five partially saturated layers below the contaminated zone, a feature that is advantageous for delineating the various sites addressed in this EIS. The RESRAD-OFFSITE code is more flexible than the original RESRAD code in that it has the capability to not only model the radiation exposure of an individual who spends time directly above the primary zone of radioactive contamination (on-site) but also one who spends time away from the primary contamination (off-site), which is the application that is most useful for this EIS.

As noted previously, there are three types of releases that can lead to contamination at off-site locations (Figure E-1) that are addressed by RESRAD-OFFSITE: airborne releases, surface runoff, and leaching. Airborne releases can lead to the off-site releases of either particulates or gases (such as radon). Particulate releases are limited to sites having surficial soil contamination, while gases can be released from buried materials following their upward movement from the radioactive contamination source through any overlying cover materials. For this EIS, particulate releases are expected to be very unlikely given the thick covers overlying the disposed-of wastes. In addition, any such releases would be greatly diluted in the atmosphere, such that potential doses to members of the general public would be very low. The only radionuclides that would be subject to airborne releases are gases, because the surface soil cover

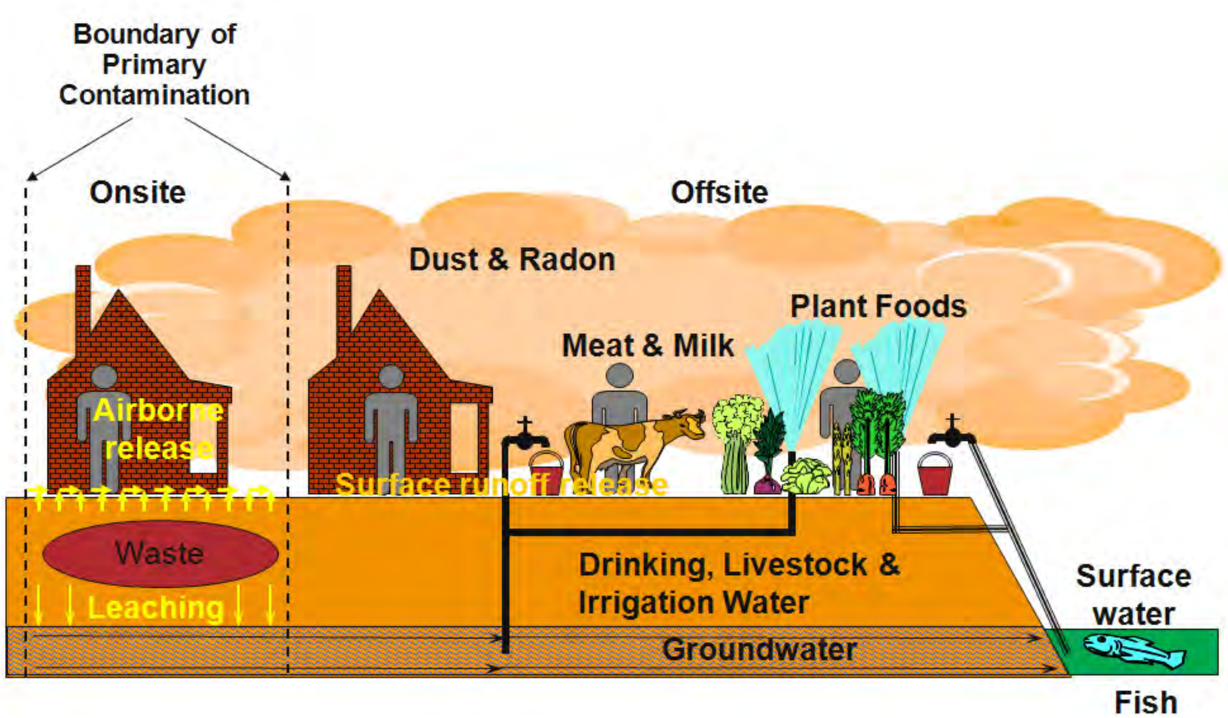

FIGURE E-1 Environmental Release Mechanisms and Exposure Pathways Considered in RESRAD-OFFSITE

is assumed to remain sufficiently intact so as to not expose the buried wastes to the atmosphere. That is, it is assumed in the EIS analyses that the soil cover is not completely removed with regard to all of the sites and disposal methods.

The second release mechanism (surface runoff) is also considered to not be relevant to the analysis conducted for this EIS. This mechanism addresses the loss of surficial contamination by precipitation that flows along the slope of the ground surface to the surrounding area. In the RESRAD-OFFSITE code, any radioactively contaminated material removed by surface runoff is modeled as a release to a nearby surface water body. This exposure pathway is not relevant to this assessment because it is assumed that the disposed-of wastes would always be overlain by some clean soil cover.

The third release mechanism considered by RESRAD-OFFSITE is the leaching of radionuclides by precipitation that percolates through the contaminated waste zone. This is the pathway of most concern in the post-closure assessment of potential human health impacts. For this EIS, it is assumed that once contamination reaches the groundwater, it is removed by a hypothetical individual using a well. Radionuclides in groundwater can also be discharged to a surface water body, but this would result in much lower concentrations of radionuclides due to dilution. For conservatism, groundwater was assumed to be the sole source of potable water for the hypothetical individual for assessing the post-closure impacts.

Since RESRAD-OFFSITE does not contain features to simulate the movement of percolating water over the various layers of an engineered cover or the degradation of waste containers over time, simplifying assumptions were made in this analysis. For example, the engineered barriers and waste containers were assumed to begin to degrade and fail 500 years after closure of the disposal facility. This is a conservative assumption that was used because RESRAD-OFFSITE does not have the capability to calculate a container failure distribution. This adds conservatism to the results presented in this EIS.

However, RESRAD-OFFSITE does have features that allow a reasonable estimate to be made of the release of radioactive contaminants from the GTCC LLRW and GTCC-like waste. Specifically, the code uses a rate-controlled release to model the quantity of contaminants that can be removed by leaching from the wastes as water flows down through the primary zone of contamination. The release rate can be specified to vary as a function of time and is used by RESRAD-OFFSITE to simulate the entry of radionuclides into the percolating water with subsequent transport in the unsaturated zone(s) and groundwater aquifer. This is a very useful feature of this code for use in the EIS analyses, because it allows the source term (GTCC LLRW and GTCC-like waste) to have any physical or chemical form. What needs to be specified is the release rate of the radionuclides from the source.

The RESRAD-OFFSITE groundwater transport model simulates the convection and dispersion of radionuclides in the liquid phase during transport in soils. Some sites have very uniform settings, and parameters can be selected to represent soil properties on the basis of the measurements taken in site soils. Other sites have much more complicated geological settings, and they can include fracture flow. In these cases, it is important to select the parameter values that best represent flow conditions in the local environment so that these conditions can be adequately modeled with the RESRAD-OFFSITE computer code. For example, in the analyses for disposal of GTCC LLRW and GTCC-like waste at the Idaho National Laboratory (INL) Site, a distribution coefficient (K_d) value of zero was specified for all radionuclides for the thick-flow basalt layers. This selection was made to simulate the fracture flow condition in which water flows through the basalt layers quickly, leaving little contact time for dissolved radionuclides to be adsorbed to the solid phase.

In evaluating the movement of radionuclides through the environment, the RESRAD-OFFSITE computer code addresses radioactive decay and ingrowth of progeny radionuclide(s). This capability is one of the major reasons RESRAD-OFFSITE was selected for use in this EIS. Many of the radionuclides in the GTCC LLRW and GTCC-like waste (in particular, the actinide elements) are present in long decay chains, and it is necessary to accurately account for the decay and ingrowth of all radionuclides that could affect a potential receptor in the long-term future. The RESRAD code has been used in a number of situations addressing radionuclide decay and ingrowth during groundwater transport, and it has been shown to provide good estimates of this effect.

In addition to simply accounting for decay and ingrowth of radioactive progeny as the primary radionuclides move through the environment, RESRAD-OFFSITE uses radionuclide-specific retardation factors to address the effects of sorption and desorption on the transport speed through soil. This feature allows the code to simulate the different rates at which radionuclides in the same decay chain move in the environment. Numerical methods are employed in RESRAD-OFFSITE to evaluate the analytical solutions to the differential equations that characterize the behavior of radionuclides being transported in the unsaturated and saturated zones. To increase the precision of the calculation results in this EIS, the saturated zone was further divided to smaller sublayers.

While other computer models have features that could be used to support this analysis, use of these codes would not significantly improve the results presented in the EIS. The results of most interest were the estimated peak annual dose and peak annual LCF risk in the first 10,000 years. If the peak annual impacts did not occur within 10,000 years, the analysis was extended out to 100,000 years. The radionuclides that would cause most of the dose have long half-lives (C-14, Tc-99, I-129, and isotopes of uranium and plutonium), and the peak annual dose, in many cases, would occur in the distant future. Because of this, it was not necessary to know in great detail the exact mechanisms by which the radionuclides from the site would be released in order to perform this comparative assessment.

A number of the computer codes considered for this analysis require detailed information on the engineering design and the specific materials used to construct the facility, which are generally lacking at this point in the process. Also, although these codes might improve the estimates for the first few hundred years, or even a thousand years, they provide no information to address the conditions of the engineered barriers and waste containers and their performances over the very long time frame necessary for this EIS. After radionuclides would be released from the disposal unit, they would travel through the various layers of soils underneath the disposal facility to reach the groundwater table and then travel in the groundwater aquifer to arrive at the receptor location. The time that the radionuclides would spend traveling in soils could be thousands of years or even longer, and the potential radioactive ingrowth and decay and the different transport speeds between parent and progeny radionuclides could significantly affect the groundwater concentrations.

The RESRAD-OFFSITE code has the ability to simulate the transport of radionuclides in the vadose zone and saturated zone, and this capability has been demonstrated in the past. Although the code does not have the ability to estimate distributed container failure over time, it has provisions that allow users to bypass the release rate calculations and accept the input release rates of radionuclides as a function of time.

There are other computer codes with functions similar to those of RESRAD-OFFSITE. Some neglect the ingrowth of progeny nuclides during transport; some consider ingrowth by assuming progeny nuclides are transported at the same speed as are parent nuclides. Others consider both ingrowth of progeny and different transport speeds of parents and progeny but employ numerical analysis methods that would take very long (unrealistic) computation times for simulations that are run over 10,000 or 100,000 years. The precision of results from a numerical analysis can be greatly affected when the analysis is extended to such a long period of time as that required by this EIS.

Given the complexity of the facility design, the various physical and chemical compositions of waste, the complexity of the actual geologic nature and hydrogeologic nature of the candidate sites, and the unknown behavior of the engineered barriers and waste containers over a very long period of time, estimates of the peak annual radiation doses and LCF risks to human health are very difficult to predict over the time periods considered in the EIS. Assumptions were made to simplify the impact analysis, and these were applied in a uniform manner across the different sites. This allows a comparison to be made of the relative merits of the various disposal alternatives and sites considered in the EIS. These results would not be significantly affected if other computer codes were utilized in the analysis.

RESRAD-OFFSITE also accounts for the accumulation of radionuclides at off-site locations through dust deposition and water irrigation. Water irrigation can lead to the accumulation of radionuclides in soil, which is significant for the hypothetical off-site receptor considered in the EIS (i.e., a resident farmer).

The RESRAD-OFFSITE methodology has been used in two model validation studies: the Biospheric Model Validation Study II (BIOMOV II) program and the Environmental Modeling for Radiation Safety (EMRAS) program (BIOMOVS II 1996; IAEA 1996). Both programs were organized by the International Atomic Energy Agency (IAEA). Currently, the EMRAS Naturally Occurring Radioactive Material Working Group is using RESRAD-OFFSITE for a model comparison study with area source scenarios. This level of validation supports the use of this code in performing the comparative evaluation in this EIS.

E.2 SIMULATION APPROACH FOR THE LAND DISPOSAL ALTERNATIVES

Potential long-term impacts on human health that could result from the disposal of GTCC LLRW and GTCC-like waste were analyzed in this EIS by using the RESRAD-OFFSITE computer code, as summarized above. Additional details on this computer code are presented in its user manual, which can be reviewed for more information (Yu et al. 2001). This section discusses the exposure scenario and source term assumptions used for the analyses.

E.2.1 Exposure Scenario and Pathways

The assessment of long-term impacts on human health from the closed disposal facility requires the identification of an appropriate exposure scenario. Proper site selection and proper design, closure, and post-closure monitoring and maintenance of the facility would reduce the likelihood, to the extent possible, that anyone would actually be exposed to the radioactive contaminants in the wastes. A hypothetical resident farmer exposure scenario was selected for performing a comparative analysis in this EIS as a conservative approach. This scenario is unlikely to occur at the federal sites evaluated in this EIS, since current land use designations for the reference locations do not include residential use. The results presented here should not be used for regulatory compliance purposes in the future, and they should not be compared with site-specific performance assessments that have been conducted for existing waste disposal facilities. Such assessments are based on site-specific exposure scenarios and conditions. However, the assessment in this EIS does provide useful information to guide the decision-making process for identifying the most appropriate method to manage these GTCC LLRW and GTCC-like waste.

For the analysis of long-term impacts on human health after closure of the disposal facility, a hypothetical resident farmer is assumed to move near the site and reside in a house located 100 m (330 ft) from the edge of the disposal facility boundary. This location was selected because it is consistent with the minimum buffer zone distance surrounding a DOE LLRW disposal site identified in DOE Manual 435.1-1 (DOE 1999). This DOE *Radioactive Waste Management Manual* notes that a larger or smaller buffer zone for a DOE LLRW disposal facility may be used if adequate justification is provided. No additional distance beyond this minimum buffer zone of 100 m (330 ft) from the edge of the disposal facility is assumed in this analysis. This assumption is conservative since the federal sites considered in this EIS are very large, and a significant buffer zone of greater than 100 m (330 ft) would likely be employed for this disposal facility. An evaluation of the reduction in the potential radiation dose to this hypothetical receptor at greater distances is given in Section E.6.

For this analysis, a hypothetical individual is assumed to move to this location and develop a farm. This resident farmer is then assumed to develop a groundwater well as the sole source of water (for drinking, household use, irrigation, and feeding livestock) and to obtain much of his/her food (fruits, vegetables, meat, and milk) from the farm. A hypothetical resident farmer was selected for this evaluation because this scenario would involve the most intensive use of the land, and this receptor would thus incur the highest dose of any potential receptor in the future. As mentioned previously, the assumption of a resident farmer presents a potentially conservative bias against sites where such a scenario is less likely. However, the use of the same exposure scenario at all sites provides a common basis for comparison of the results for the sites considered in this EIS. DOE has considered the potential doses to the hypothetical resident farmer as well as other factors discussed in Section 2.9 in identifying the preferred alternative presented in Section 2.10.

The hypothetical resident farmer could be exposed to airborne contaminants, including particulates, radon gas and its short-lived decay products, and gaseous radionuclides such as C-14 (in the form of CO_2) and H-3 (in the form of water vapor). These gases could diffuse out of the waste containers and move through the disposal facility cover and then be transported by the wind to the off-site location where the farmer resides. As noted previously, airborne particulates are not expected to be generated, given the presence of the engineered cover over the GTCC LLRW and GTCC-like waste. This individual could also incur a radiation dose through the use of groundwater contaminated as the result of leaching of radionuclides in the waste containers and their transport to the underlying groundwater table.

Secondary soil contamination at off-site locations would be possible if contaminated groundwater was used for irrigation and if this practice was continued for an extended period of time. Potential exposure pathways related to the use of contaminated groundwater include (1) external irradiation; (2) inhalation of dust particulates from irrigated fields, radon gas (and its short-lived decay products), H-3, and C-14; and (3) ingestion of water, soil, plant foods, meat, and milk. Plant foods (fruits and vegetables) could become contaminated through foliar deposition as well as root uptake. Meat and milk could become contaminated if livestock ingested contaminated water (obtained from the well) and fodder contaminated by use of this groundwater. Figure E-2 illustrates the exposure pathways associated with use of contaminated groundwater.

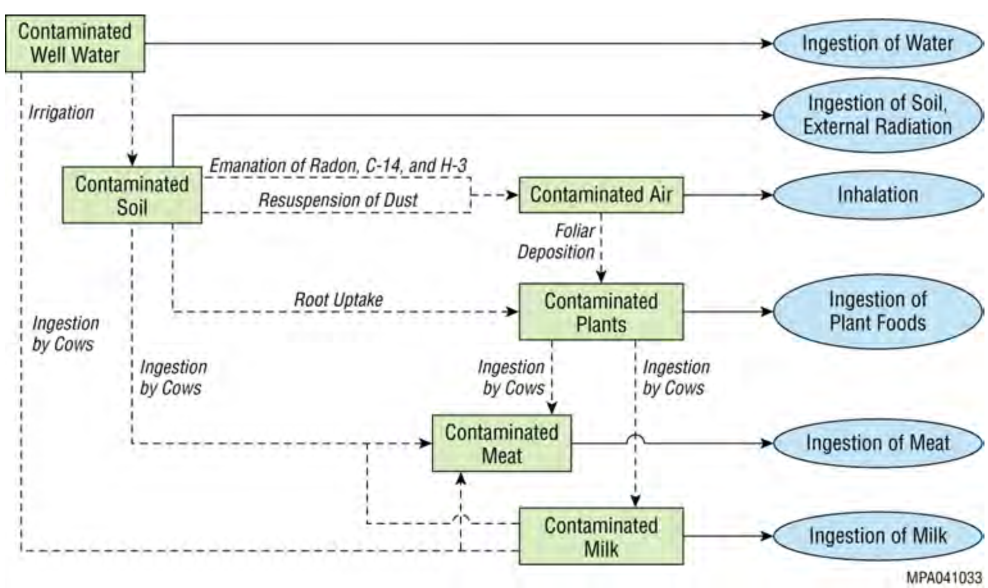

FIGURE E-2 Exposure Pathways Associated with the Use of Contaminated Groundwater

E.2.2 Assumptions Related to Leaching from the Wastes

It is assumed that the only way the hypothetical receptor would be exposed to radiation in the future would be if the radionuclides were released from the waste containers and disposal facility. The most likely mechanism for this to occur would be contact with infiltrating water. Precipitation could infiltrate into the disposal area and contact the waste containers. It is assumed that no releases would occur while the waste containers and engineering barriers (including the cover) remained intact. However, it is expected that over time, the waste packages and engineering barriers would lose their integrity. When this condition occurred, water could contact the waste materials within the packages and move downward to the groundwater table. Although water could also enter the contaminated waste zone as a result of the rising groundwater, this scenario is not considered likely because the disposal facility would be sited in accordance with NRC regulations that should preclude this from occurring.

Data on the performance of waste packages and engineering barriers over an extended time period are limited. Even when data are available, using the data to predict the release rates of radionuclides over a very long time period can be difficult to defend. The potential impacts on groundwater are evaluated over a very long time period in this EIS (10,000 years and longer to obtain peak annual doses and LCF risks). Determining how and when the waste packages and engineering barriers would begin to degrade and how this degradation would progress over time is one of the more challenging and site- and design-specific aspects of the analysis. Thus, for a comparative analysis such as this, simplifying assumptions are made regarding the performance of engineering barriers and waste packages.

The radiation doses presented in the post-closure assessment in this EIS are intended to be used for comparing the performance of each land disposal method at each site evaluated. The results indicate that the use of robust engineering designs and redundant measures in the disposal facility could delay the potential release of radionuclides and could reduce the release to very low levels, thereby minimizing the potential groundwater contamination and associated human health impacts in the future.

For purposes of analysis in this EIS, it is assumed that the engineered barriers would begin to degrade and fail 500 years after the closure of the disposal facility. This assumption is considered to be conservative (i.e., yield greater impacts) since the integrity of the engineered barriers is expected to last longer than 500 years. It is assumed that the radionuclides in the disposed-of wastes (listed in Appendix B) would not be available for leaching until the engineering barriers started to degrade. Many of the radionuclides in the GTCC LLRW and GTCC-like waste have very long half-lives, so this 500-year time period would not result in an appreciable reduction in the total hazard associated with these wastes as a result of radioactive decay. This assumption is more conservative for some sites than others where conditions are more favorable to the long-term performance of waste packages.

In performing these evaluations, the protection provided by a number of engineering measures included in the conceptual facility designs, such as a cover designed to minimize water infiltration, was considered in the analyses. It is assumed that these engineering measures would completely eliminate water infiltration into the waste units for the first 500 years. It is assumed that after that time, the integrity of these engineering measures would begin to degrade and fail, reducing their effectiveness in keeping percolating water out of the waste disposal units. A study at the Savannah River Site (SRS) indicated that after 10,000 years, the closure cap at the F-Area would still shed about 80% of the cumulative precipitation falling on it, with a higher degree of effectiveness occurring before 10,000 years (Phifer et al. 2007). The cover effectiveness would continue to decrease very slowly after 10,000 years. This information was used to estimate the amount of water that could infiltrate into the disposed-of wastes as described in the following text. The assumed effectiveness of a cover system can be a critical factor for distinguishing between facility performance at a humid site and at an arid site.

It is assumed that the water infiltration rate into the top of waste disposal facility would be zero for the first 500 years following closure, and then it would be 20% of the natural rate. This approach is meant to account for the reduction in the integrity of the cover and other engineering barriers as they begin to degrade and fail. This value was used for all future times extending to 10,000 years and longer (to obtain peak annual doses). This reduced water infiltration rate (from the natural rate for the area) is limited to the waste disposal area; at the perimeter of the waste disposal facility, the natural background infiltration rate is used in the EIS analyses.

This is a simplified approach to address the reduction in cover effectiveness over time. The amount of water infiltrating into the disposal facility would increase as the cover effectiveness decreased. It is difficult to model the gradual degradation of the engineered cover; hence, the long-term average effectiveness was simulated in the calculations. A sensitivity analysis was conducted to examine the potential change in off-site doses by using varied values to simulate varying degrees of effectiveness that would yield different water infiltration rates. The results of this sensitivity analysis are given in Section E.6.

This approach of using a reduced water infiltration rate only for the waste disposal area is assumed to be conservative, because with a higher water infiltration rate outside the waste disposal area, the transport time needed for radionuclides to reach the underlying groundwater table after they have been released from the waste disposal area would be shortened. This approach provides less time for radioactive decay to occur during transport, which results in higher groundwater concentrations being estimated at the receptor location.

E.2.3 Assumptions Related to Radionuclide Release Rates

As described in Appendix B, the GTCC LLRW and GTCC-like waste encompass three waste types for purposes of analysis in this EIS: activated metals, sealed sources, and Other Waste. For activated metal wastes, the release of radionuclides was correlated with the corrosion of metals. The radionuclide release fraction for activated metals was taken to be 1.19×10^{-5}/yr in this analysis. This value is assumed to be reasonable for stainless-steel waste forms for the purpose of this comparative analysis on the basis of rates observed in corrosion experiments on stainless-steel coupons conducted at the INL Site (INL 2006; Adler Flitton et al. 2004). However, if the environmental conditions surrounding a specific waste were not controlled and were more conducive to causing corrosion, or if the metal making up a specific waste was more conducive to corrosion, the release fractions could be higher than those used here.

The release rates of radionuclides in sealed sources were simulated on the basis of the assumption that radionuclides would partition between water and the sealed source matrix when coming in contact with water. It is assumed that the partitioning factor of each radionuclide has the same value as the K_d associated with the surface soil at the various sites. Because there would be backfill soil surrounding the waste containers in the disposal units, radionuclides released from the sealed sources would have to travel through the surrounding soils before leaving the disposal area. By using the soil K_d values to calculate the radionuclide release rates, the binding of radionuclides to the sealed source matrix is assumed to be the same as that in the surrounding soil. This approach is conservative, because it tends to overestimate the release rates of radionuclides from sealed sources.

While activated metals and sealed sources are structurally sound and generally resistant to leaching with water, many of the wastes in the Other Waste type are not. For this analysis, it is assumed that the Other Waste would be solidified (e.g., with grout or another similar material) before being placed in the disposal units. This assumption is reasonable and consistent with current disposal practices for such wastes, which include a wide variety of materials that could compact or quickly degrade without such measures. Use of such a stabilizing agent is not assumed for activated metal and sealed source wastes.

The solidification provided by mixing the Other Waste with a stabilizing agent would also reduce the leaching of radionuclides. However, the reduction in leaching might not last over a long period of time, when the nature of the stabilizing agent would change in the environment or the integrity of the stabilizing agent would deteriorate. In this analysis, the effectiveness of solidification in terms of leaching reduction is assumed to last for 500 years following facility closure; after that, the retention of radionuclides by the stabilizing agent is assumed to be the same as that of the surrounding backfill soils. Hence, the release rates of radionuclides from the Other Waste were simulated with soil K_d values after the effective period of the stabilizing agent. The release rates of radionuclides were simulated with the K_d values for a cementitious system during the effective period, assuming cement would be used as the stabilizing agent.

Cement that contains slag has been shown to reduce the leaching of nickel, technetium, and uranium more effectively than cement that does not contain slag. The presence of slag results in an environment that is more reducing and not oxidizing, as opposed to cement alone. Since technetium and uranium are major radionuclides of concern with respect to the GTCC LLRW and GTCC-like waste, it is assumed that slag-containing cement would be used to solidify the Other Waste for purposes of analysis in this EIS. Although the cementitious material could eventually convert to an oxidized form over long periods of time, this effect would be offset by the corrosion of the metal drums in the disposal environment, which would consume oxygen and lead to chemically reducing conditions.

Information on the K_d values in cementitious systems is given in Table E-1 for a number of elements from different sources. (All tables appear before the references at the end of this appendix.) Only one set of values was given in Krupka et al. (2004), which was taken to represent a non-slag-containing cementitious system. Kaplan is a co-author of this 2004 report, as well as the author of a separate study published in 2006 (Kaplan 2006). It is assumed that the second report contains additional information that was not available when the first report was published in 2004. Therefore, when selecting the K_d values for cementitious systems, only data from the second report were used for comparison with data from the other sources.

The last two columns of Table E-1 provide the selected K_d values for oxidizing and reducing cement. These values are generally the lowest (or most conservative in that they allow for the most potential leaching into the groundwater) of the reported values, unless multiple sources provided the same higher value. In addition to the reported values, chemical similarity was also considered in determining the values to use in this analysis. The use of the smallest K_d values would result in more conservative (higher) dose estimates.

The K_d values for reducing cement are used in this analysis to estimate the release rates of radionuclides when water infiltrates into the waste disposal units while the effectiveness of the stabilizing agent still holds. As indicated in Table E-1, the selected values for oxidizing and reducing cement are the same except for nickel, technetium, and uranium. Note that these values are based on specific assumptions regarding the type of cement used and would need to be reconsidered on the basis of the actual cements that could be used in a specific situation. Maintaining local reducing conditions can be an important consideration in designing the final system for specific wastes containing significant amounts of nickel, technetium, and uranium isotopes.

For the analyses in this EIS, the grout is assumed to retain its effectiveness for 500 years following facility closure. After this time period, the leachability of the Other Waste would increase as the grout degraded, which would result in higher off-site doses. The amount of the increase would depend on the rate at which the grout failed. While it is difficult to model the gradual degradation of the grout system, a sensitivity analysis was conducted to examine the potential change in off-site doses that would result from a different effective period for the grout stabilization system. The results of this sensitivity analysis are given in Section E.6.

E.3 SIMULATION APPROACH FOR THE NO ACTION ALTERNATIVE

An analysis of the long-term human health impacts associated with the No Action Alternative (in which the wastes are stored indefinitely) was conducted to provide information for comparison of the post-closure human health impacts associated with the action alternatives. As noted previously, the pathway of most concern in the long term is expected to be radionuclide migration to groundwater underlying the storage facilities. The analysis of the No Action Alternative was also done by using the RESRAD-OFFSITE computer code.

Under the No Action Alternative, it is assumed that a generic site located within each of the four NRC regions would be the storage location for all of the GTCC LLRW and GTCC-like waste within that region. It is assumed that the activated metals and Other Waste would remain within the NRC region in which the facility that generated the wastes was located, and the sealed sources would be divided among the four NRC regions in proportion to the number of NRC-licensed facilities within each region. That is, the potential long-term impacts from the groundwater pathway were analyzed for four different sites with different waste inventories (Table E-2). The characteristics of the generic storage site within each region are assumed to be the same as those of the generic commercial site within the same region for the action alternatives.

It is assumed that the GTCC LLRW and GTCC-like waste would be placed on the ground surface without any protective covers. They would be stacked randomly and would take up more space than they would in the disposal cells for the action alternatives. Monitoring and surveillance of the waste containers are assumed to last for 100 years but would be discontinued after that period. The waste packages are assumed to be left unattended in this manner for the indefinite future (10,000 years and beyond).

This analysis of the No Action Alternative was performed to provide a baseline against which the action alternatives could be compared. This alternative is not a viable long-term management option for the GTCC LLRW and GTCC-like waste, and at some point in the future, a decision would have to be made to dispose of these wastes.

E.3.1 Exposure Scenario and Pathways

The exposure scenario and pathways considered for the No Action Alternative are the same as those considered for the action alternatives described above. That is, a hypothetical resident farmer is assumed to inhabit a site located 100 m (330 ft) from the edge of the storage facility and to obtain water for use at the farm from a groundwater well. The storage area is assumed to cover an area of 90,000 m^2 (970,000 ft^2); that is, 300 × 300 m (1,000 × 1,000 ft).

E.3.2 Assumptions Related to Leaching from the Wastes

The potential long-term human health impacts (peak annual doses and LCF risks) for the No Action Alternative were calculated for each waste type separately. Because there would be no protection against weathering of the waste containers after the monitoring and surveillance period ended (at 100 years), it is assumed that the containers would breach and fail at this time. This would allow precipitation water to enter the containers and contact the waste materials. The precipitation rates assumed for the generic storage sites are 1.07, 1.34, 0.82, and 0.27 m/yr for Regions I, II, III, and IV, respectively (Poe 1998; Toblin 1999). The other assumptions related to leaching of contaminants from the waste packages are generally the same as those given for the action alternatives.

E.3.3 Assumptions Related to Radionuclide Release Rates

The release rates of radionuclides contained in activated metal waste were calculated with an assumed release fraction of 1.19×10^{-5}/yr, which was the same as that assumed for the action alternatives. This release fraction reflects the corrosion rate of metal and was obtained from actual measurements conducted at the INL Site (INL 2006). For the sealed source and Other Waste types, the release rates of radionuclides were calculated by assuming the partitioning of radionuclides between the waste matrix and the precipitation water would be the same as the partitioning of radionuclides between soil particles and water. This assumption was made because the wastes would not be solidified, and the use of soil K_ds for calculating radionuclide release rates is consistent with the approach used for evaluating the action alternatives.

After radionuclides were released from the waste containers, they would accumulate in the surface soil underneath the containers. This contamination could be released from the storage site by runoff water or be carried to deeper soils by infiltration water. The fraction of released radionuclides removed by runoff water would depend on the amount of runoff water, the slope of the ground surface, the adsorption of radionuclides to the surface soil, and engineered site features such as berms. Unlike the design of a disposal facility that would incorporate engineering measures to facilitate surface water runoff away from the disposal area to prevent water from infiltrating to deeper soils, a preferred feature for a storage area would be the capability to reduce surface water runoff to reduce the spread of contamination to the surrounding area.

For this analysis of the No Action Alternative, it is assumed that all released radionuclides accumulating in the surface soil would be carried by infiltration water to deeper soils. The infiltration rate of water is assumed to be the same as that for the generic commercial disposal facility located in the same region. As shown in Table E-19, the water infiltration rates for the generic disposal facilities in Regions I, II, III, and IV are 0.074, 0.18, 0.05, and 0.001 m/yr, respectively. These values are listed as precipitation rates in the table. Because the irrigation rates, runoff coefficients, and evapotranspiration coefficients are all zero, the infiltration rates would be equivalent to the precipitation rates.

E.4 INPUT PARAMETERS FOR RESRAD-OFFSITE EVALUATIONS

As described previously, the RESRAD-OFFSITE computer code (Yu et al. 2007) was used to calculate the potential impacts on a hypothetical resident farmer located 100 m (330 ft) from the edge of the disposal facility. Two potential release mechanisms (associated with airborne emissions and leaching to groundwater) were considered in the assessment for the action alternatives. For the potential radiation doses resulting from airborne releases coming directly from the disposal area, a Gaussian plume dispersion model (which is incorporated into the RESRAD-OFFSITE code along with the default wind speed and stability class frequency data from the weather station that is nearest the site) was used in this evaluation. The doses from this release mechanism were largely from gaseous emissions (principally radon gas and its short-lived decay products). The results of these analyses are provided in the appropriate sections of the EIS and are not repeated in this appendix.

For the groundwater pathway, site-specific input parameters were used to simulate the movement of contaminants from the wastes contained in the disposal unit to the hypothetical resident farmer located 100 m (330 ft) from the edge of the disposal facility in the downgradient direction. These parameters were obtained from published information given in performance assessments, risk assessments, and environmental modeling studies for the various sites. The input parameters relevant to the groundwater pathway are provided in Tables E-3 through E-14 for the six federal sites. Two tables are provided for each of the six sites. The first table provides the values for all of the input parameters except the K_d values; the K_d values for each of the radionuclides addressed for each site are given in the second table.

For example, Table E-3 provides the values used for the RESRAD-OFFSITE parameters for the evaluation at the INL Site except for the K_d values, which are provided in Table E-4. The same is done for the Hanford Site (Tables E-5 and E-6), Los Alamos National Laboratory (LANL, Tables E-7 and E-8), Nevada National Security Site (NNSS, Tables E-9 and E-10), SRS (Tables E-11 and E-12), and the WIPP Vicinity (Tables E-13 and E-14). Additional details on these values (including the selection rationale and sources used in determining these values) are also provided in the tables.

The input parameters most significant in an evaluation of the groundwater migration pathway are given in a comparative manner for these six sites in Tables E-16 through E-18, in order that differences in site characteristics can be more easily compared. These parameters include the water infiltration rates (Table E-15), characteristics of the unsaturated and saturated zones (Tables E-16 and E-17), and K_d values (Table E-18).

Data for the generic commercial sites located in the four regions were obtained from the same sources (NRC 1981; Poe 1998; Toblin 1999). These values are shown in Tables E-19 and E-20 for comparison. Table E-19 provides the values for all input parameters except the K_d values, and Table E-20 provides the K_d values. These same values were also used for the No Action Alternative.

The calculated concentrations of the various radionuclides in groundwater were used to calculate the radiation dose to the hypothetical resident farmer for the relevant exposure pathways. This individual is assumed to be an adult who spends 75% of his/her time at the site in the vicinity of his/her house (50% indoors and 25% outdoors) and 25% of his/her time away from the area. The farmer is assumed to cultivate an agricultural field encompassing 1,000 m^2 (0.25 ac) for growing fruits and vegetables and a grazing area of 10,000 m^2 (2.5 ac) for raising livestock. It is assumed that the yields of fruits, vegetables, meat, and milk would be sufficient to provide 50% of the needs of the farmer and his family. The remainder of the food would be obtained from sources removed from the farm and be free of any radioactive contamination. These assumptions are taken directly from the RESRAD-OFFSITE code for the default residential farmer scenario.

It is assumed that the farmer would drill a well close to his/her house to supply the potable water needs for drinking, household activities, watering livestock, and irrigating the farm fields. The farmer would draw approximately 2,500 m^3 (660,000 gal) of water from the well each year. For the fruit and vegetable fields, an irrigation rate of 0.1 m/yr (0.33 ft/yr) of water applied to the field is used for SRS and the two generic sites located in Regions I and II; a higher value of 0.2 m/yr (0.66 ft/yr) is used for the other federal sites and the two generic sites located in Regions III and IV. Because SRS and the generic sites located in Regions I and II have higher precipitation rates, less irrigation water would be needed to sustain the growth of crops and vegetables. An irrigation rate of 0.1 m/yr (0.33 ft/yr) is used for the livestock grazing field for all sites. Although irrigation water may not actually be needed at all of these sites (or lesser amounts than those indicated here), this assumption has the effect of increasing the cumulative amount of contamination in the agricultural field that could end up in the resident farmer's food supply.

It is assumed that the resident farmer would ingest 730 L (200 gal) of water; 14 kg (31 lb) of leafy vegetables; 160 kg (350 lb) of fruit, grain, and nonleafy vegetables; 63 kg (140 lb) of meat; and 92 L (24 gal) of milk every year. While working in the fields, the farmer would ingest 36.5 g (0.080 lb) of soil every year (or an average of 0.1 g per day for each day of the year). The inhalation rate of the farmer was taken to be 8,400 m^3/yr (297,000 ft^3/yr). Except for the water ingestion rate, which is about the 90th percentile value for the general public (EPA 2000), these values for the consumption and exposure parameters are the same as the RESRAD-OFFSITE default values.

As noted previously, this assessment is meant to provide a comparative evaluation of the relative merits of each of the disposal sites. While the assumption used (that there would be a complete loss of institutional memory and that residential use of the area in the immediate vicinity of a GTCC LLRW and GTCC-like waste disposal facility would occur) provides a uniform basis for evaluating potential impacts, its use does not imply that such a situation is expected to occur. Use of standardized assumptions and input parameters (as was done in this analysis) should help to ensure that the best alternative site is selected for disposal of GTCC LLRW and GTCC-like wastes.

While the health effects addressed in this EIS are limited to LCF risks, additional health effects beyond cancer can occur in individuals exposed to radiation, including cardiovascular disease and hereditary effects. However, these additional health effects are not quantified in this EIS. The risk of cardiovascular disease has been shown to increase in persons exposed to high therapeutic doses and also in atomic bomb survivors exposed to more modest doses (NAS 2006). However, there is no direct evidence of increased risk of noncancer diseases at low doses, such as the doses that could potentially occur to members of the general public under the alternatives evaluated in this EIS.

Also, the risk of hereditary effects from radiation exposure is generally attributable to gamma irradiation of the reproductive organs. In contrast, most of the dose to the hypothetical resident farmer in the long term would be a result of long-lived radionuclides having alpha and beta radiation. As noted in NAS (2006), the risk of heritable disease is sufficiently small that it has not been detected in humans, even in thoroughly studied irradiated populations, such as those of Hiroshima and Nagasaki. The risk of cancer fatality was determined to be a reasonable means of comparing alternatives in the EIS.

The assessment of potential human health impacts resulting from groundwater contamination was conducted for a time period of 10,000 years following facility closure. If the maximum impacts (peak annual doses and LCF risks) were not observed in this time period, the assessment time was extended to 100,000 years, which is the maximum time limit for the RESRAD-OFFSITE code. The results of this assessment are provided in Section E.5. A detailed discussion of this evaluation is provided in Argonne (2010).

E.5 RESULTS

The results of the RESRAD-OFFSITE simulations are summarized in Table E-21 for the No Action Alternative. This table presents the estimated peak annual doses when the storage of each individual waste type in each NRC region is considered. As indicated by the results, storage of the GTCC LLRW and GTCC-like waste in Region I would result in very high radiation exposure to a hypothetical farmer residing 100 m (330 ft) from the edge of the storage facility. The peak annual dose could reach 270,000 mrem/yr for the GTCC-like Other Waste - RH in this region. The peak annual dose for Region II during the first 10,000 years would be much lower, with a maximum value of about 850 mrem/yr for GTCC LLRW Other Waste - RH. However, after 10,000 years, the peak annual dose would increase and could reach as high as 16,000 mrem/yr for GTCC LLRW sealed sources.

A similar tendency was found in the estimated annual doses for Region III. The lowest impacts would occur in Region IV. Within 100,000 years, the estimated peak annual dose would be less than 10 mrem/yr. While the estimated results can largely be explained on the basis of precipitation and infiltration rates as well as the depth to the groundwater table assumed for the storage site at each region, they are also in part due to the different waste inventories assumed to be stored in the different regions.

The results for the action alternatives are summarized in Tables E-22 through E-25. Table E-22 presents the estimated peak annual doses to the hypothetical resident farmer from each individual waste type in the Group 1 stored inventory, and Table E-23 presents the results from each individual waste type in the Group 1 projected inventory. These results are based on the dose conversion factors for an adult in ICRP 72 (ICRP 1996), as discussed in Appendix C. The peak annual doses from each individual waste type in the entire Group 1 waste inventory are given in Table E-24. Table E-25 gives the peak annual doses for the Group 2 inventory (all of which is projected waste). These two groups of wastes are defined in Section 1.4.1 of the EIS. The dose calculations were performed over two time periods — 10,000 years and 100,000 years — following closure of the disposal facility.

The results are provided separately for GTCC LLRW and GTCC-like waste and address the three separate waste types (activated metals, sealed sources, and Other Waste). The estimated peak annual doses are associated with the disposal of each type of waste material, respectively; therefore, they may occur at different times in the future. The results are provided in this format to allow for an evaluation of the post-closure human health impacts associated with disposing of certain types of wastes at specific locations with specific disposal approaches. For example, it is possible to compare the peak annual projected doses for the stored activated metal GTCC LLRW that could result from using the three disposal methods at the different alternate sites by looking at the appropriate column in Table E-22. As noted previously, these results are intended to be viewed in a comparative manner given the uncertainties associated with this analysis.

The results given in these four tables differ from those given in the site-specific chapters of the EIS. The values given in this appendix are the peak annual doses associated with the disposal of each individual waste type in the Group 1 stored inventory (Table E-22), Group 1 projected inventory (Table E-23), Group 1 total inventory (Table E-24), and Group 2 total inventory (Table E-25). The values given in the main body of the EIS represent the peak annual doses to the hypothetical resident farmer at the time of peak annual dose for the entire GTCC LLRW and GTCC-like waste inventory. Because of the different radionuclide mixes and activities contained in the different waste types, the maximum doses that could result from each waste type individually generally occur at different times than the peak annual dose from the entire inventory. The results given in the main body of the EIS could be used to support the decision-making process when disposal of the entire inventory at a single separate location is considered, while those in this appendix would support decision-making for the disposal of individual waste types.

The peak annual doses range from zero (meaning that the radioactive contaminants from that particular waste type do not reach the off-site receptor) up to 2,200 mrem/yr for vault disposal of Group 1 GTCC-like Other Waste at the INL Site in 10,000 years. All annual doses calculated as being less than 0.001 mrem/yr are reported as being "<0.001 mrem/yr," since these doses are much too low to be measured or detected. The highest doses calculated for the federal sites are those from disposing of wastes at the INL Site. For the INL Site, the high doses are due to the low K_d values for several radionuclides, particularly for iodine-129 (I-129) and uranium isotopes (a value of 0 cm^3/g was used for I-129, and for uranium isotopes, a value of 0 cm^3/g was used for part of the basalt layers and a value of 0.66 cm^3/g was use for the saturated zone in this analysis). A low K_d indicates that the radionuclide has a high potential for partitioning to the liquid phase while moving through soil.

The highest dose for the generic commercial facilities located in the four regions ranges from zero up to 10,000 mrem/yr in 10,000 years. On the basis of the results of the RESRAD-OFFSITE modeling, it is estimated that there would be no groundwater dose within 10,000 years for a generic commercial facility located in Region IV because the radioactive contamination would not reach the groundwater table in 10,000 years as a result of the arid conditions at this location. The highest dose estimated is for a commercial facility located in Region I because of the higher water infiltration rate there, in combination with a shallow depth to groundwater table and low K_d values for C-14 and I-129 (a value of 0 cm^3/g was used in the analysis).

The sites with the lowest estimated annual doses are those located in the arid regions of the country. The analyses indicate that the radionuclides are not expected to reach groundwater for any waste type and disposal method at NNSS in 100,000 years, and generally lower doses are projected to occur at the other sites located in the Western United States (except for the INL Site). No radionuclides are expected to reach groundwater at the WIPP Vicinity in 10,000 years, and the maximum annual doses in 100,000 years at this site are low.

The arid sites result in lower doses because of lower water infiltration rates there (due to lower precipitation) and the longer distance to the groundwater table. Of these two factors, the water infiltration rate appears to be more significant than the depth to the groundwater table. The time period of this analysis is very long (longer than 10,000 years), and many of the radionuclides have very long half-lives. Radionuclides released from the disposed-of wastes would eventually reach the groundwater table within this time period, even if the depth to the groundwater table was increased. Reducing the water infiltration rate would not only reduce the radionuclide release rate but would also increase the transport time to reach the hypothetical exposure location.

E.6 SENSITIVITY ANALYSIS

The peak annual doses and LCF risks to a hypothetical resident farmer located 100 m (330 ft) downgradient of the edge of a disposal facility from using contaminated groundwater are presented in Section E.5. The following assumptions were used in the EIS to perform this evaluation:

1. The engineering barriers incorporated in the disposal facility would keep percolating water out of the waste units for 500 years following closure of the disposal facility.

2. After 500 years, the integrity of the barriers and waste containers would begin to degrade, allowing for water infiltration into the top of the disposal units at 20% of the natural infiltration rate for the area.

3. The water infiltration rate around and beneath the disposal facility would remain at 100% of the natural rate for the area at all times.

4. Once water would begin to affect the disposed-of wastes, radionuclides would be leached out at a rate that would depend on the waste type.

5. A stabilizing agent (grout) would be used to solidify the Other Waste type, and this grout would maintain its effectiveness for 500 years.

6. After 500 years, the effectiveness of the grout would be compromised, allowing for more leaching to occur.

7. The activated metal and sealed source wastes would be disposed of without the use of any additional stabilizing material.

These assumptions were applied across various alternate sites so that the peak annual doses and LCF risks for the different sites could be compared on a uniform basis.

The parameters used in these analyses were generally selected to provide conservative estimates (i.e., to overestimate the peak annual doses and LCF risks that would likely occur in the future should one of these alternatives be implemented). Uncertainties are inherent with these types of analyses, especially given the long periods analyzed in this EIS (10,000 years and longer to obtain peak annual doses and LCF risks). To evaluate the uncertainties associated with key assumptions used for the analysis of the long-term human health impacts, a sensitivity analysis was performed to provide information on the effects that key assumptions have on the results. In this sensitivity analysis, the RESRAD-OFFSITE calculations were repeated while the value of only one parameter was varied and the values of the other parameters were kept at their base values. This approach excluded the influence of the other parameters and provides results that can be analyzed to determine which assumptions have the most impact on these estimates.

Two sites were considered in this sensitivity analysis: SRS and WIPP Vicinity. The first site is representative of sites in the Eastern United States (a humid site), and the second site is representative of sites in the Western United States (an arid site). The analysis was limited to trench disposal of the GTCC-like stored Group 1 Other Waste - CH, and it was conducted for a time period of 10,000 years. It is assumed that this waste would be stabilized with grout, and this waste type has a radionuclide mix that is representative of many of the GTCC LLRW and GTCC-like waste. The results of the sensitivity analysis for this waste type and disposal method at these two sites can be used to infer conclusions about different waste streams disposed of at other alternate sites by using the three land disposal methods. This analysis also gives some indication of the level of conservatism in the results, which is useful information for the decision-making process.

Three parameters were addressed in this sensitivity analysis: (1) the water infiltration rate through the disposal facility cover after 500 years following closure of the facility, (2) the effectiveness of the stabilizing agent (grout) used for Other Waste, and (3) the distance to the assumed hypothetical receptor. These three parameters address issues related to disposal facility design, waste form stability, and site selection.

To address the influence of the water infiltration rate on the estimated radiation doses to the hypothetical future farmer, two additional infiltration rates (corresponding to 50% and 100% of the natural infiltration rate for the area) were considered along with the base value of 20%.

The effective period for the stabilizing agent (grout) used for Other Waste is assumed to be 500 years in this EIS. This assumption is considered to be reasonable, but it is likely that the grout could be effective for a longer period of time. To address the significance of this time period assumed for grout, two additional effective periods were addressed for both the SRS and WIPP Vicinity: 2,000 years and 5,000 years.

The exposure distance to the resident farmer is assumed to be 100 m (330 ft) from the edge of the disposal facility. This distance was based on the minimum buffer zone identified for DOE LLRW disposal facilities. This distance would likely be much longer, especially for the federal sites considered in this EIS. To address the significance of the distance to a future hypothetical receptor (which may have a bearing on site selection and development of a buffer zone), this distance was increased to 300 m (980 ft) and 500 m (1,600 ft).

In addition to the Base Case, two additional values were considered for each of the three parameters at the two sites as discussed above. A total of 10 additional cases were constructed and analyzed by using RESRAD-OFFSITE at SRS and WIPP Vicinity. Table E-26 lists the different cases and the parameter values assumed for those cases.

Tables E-27 and E-28 provide the peak annual doses and the times at which they would occur for the Base Case and the 10 sensitivity analysis cases analyzed for the WIPP Vicinity and SRS, respectively. A time period of 10,000 years was used to perform these analyses with the

RESRAD-OFFSITE computer code. Note that the results given here for the Base Case differ from those given in the site-specific chapters in the main body of the EIS. The peak annual doses in this appendix for the Base Case are the peak values when disposal of only the Group 1 stored GTCC-like Other Waste - CH is considered, whereas the values in the main body of the EIS are the peak annual doses when disposal of the entire inventory of GTCC LLRW and GTCC-like waste is considered.

For the WIPP Vicinity, groundwater contamination would not occur within 10,000 years for any of the three water infiltration rates used in this analysis (20%, 50%, or 100% of the natural background rate for this area) after failure of the engineering barriers (including the cover) and waste containers. A higher rate than is naturally present at that site is needed for groundwater contamination to occur. A higher infiltration rate to the disposal units would result in higher release rates of radionuclides, yielding higher peak doses. However, the transport time required for radionuclides to move to the groundwater table after leaving the disposal units would be the same, regardless of the water infiltration rate to the disposal units. The times would be the same because in the analysis, it is assumed that the water infiltration rate to areas outside the waste disposal units would be equivalent to the natural background rate. (This assumption was selected to provide more conservative estimates of the potential doses.) Since groundwater contamination would not occur within 10,000 years in the Base Case, the contamination would not be observed in Cases I or II either.

For Cases III to VIII, the effectiveness of grouting was extended from 500 years to either 2,000 years or 5,000 years, which would reduce the leaching of radionuclides for a longer time when compared with the time for the Base Case. Consequently, at the WIPP Vicinity, no groundwater contamination was observed within 10,000 years for these cases. Increasing the exposure distance of the receptor from 100 m (330 ft) to 300 m (980 ft) in Case IX and to 500 m (1,600 ft) in Case X would postpone the onset of radiation exposure. In addition, because of the extra dilution by clean water coming down from the ground surface, the potential radiation dose would also be lower than that in the Base Case. The maximum dose of 0 mrem/yr within 10,000 years as calculated for Cases IX and X at the WIPP Vicinity is consistent with this expectation.

The results for the Base Case and Cases I and II as calculated for SRS (Table E-28) demonstrate the influence of the water infiltration rate on the GTCC LLRW and GTCC-like waste in the disposal unit. The results provide information on the influence that the performance of the disposal facility cover has on long-term radiation doses through the groundwater pathway. The peak annual dose would increase as the water infiltration rate increased, because when more water would enter the waste packages, more radionuclides would be leached and released from the disposal area. The increase in the peak annual dose would be roughly proportional to the increase in the water infiltration rate. Similar conclusions can be drawn about the results for Cases III, IV, and V or the results for Cases VI, VII, and VIII. Figure E-3 compares the radiation doses as a function of time among the Base Case, Case I, and Case II. Figure E-4 compares the radiation doses among Cases III, IV, and V. Figure E-5 compares the radiation doses among Cases VI, VII, and VIII.

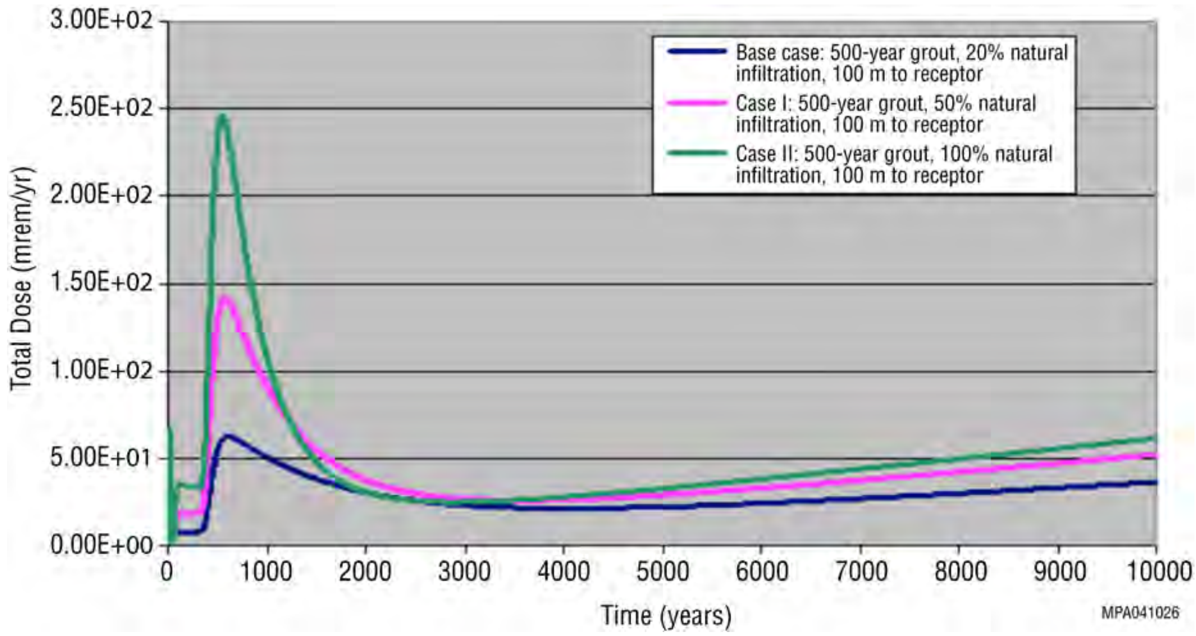

FIGURE E-3 Comparison of Annual Doses for the Base Case and Cases I and II for Trench Disposal of Stored Group 1 GTCC-Like Other Waste - CH at SRS

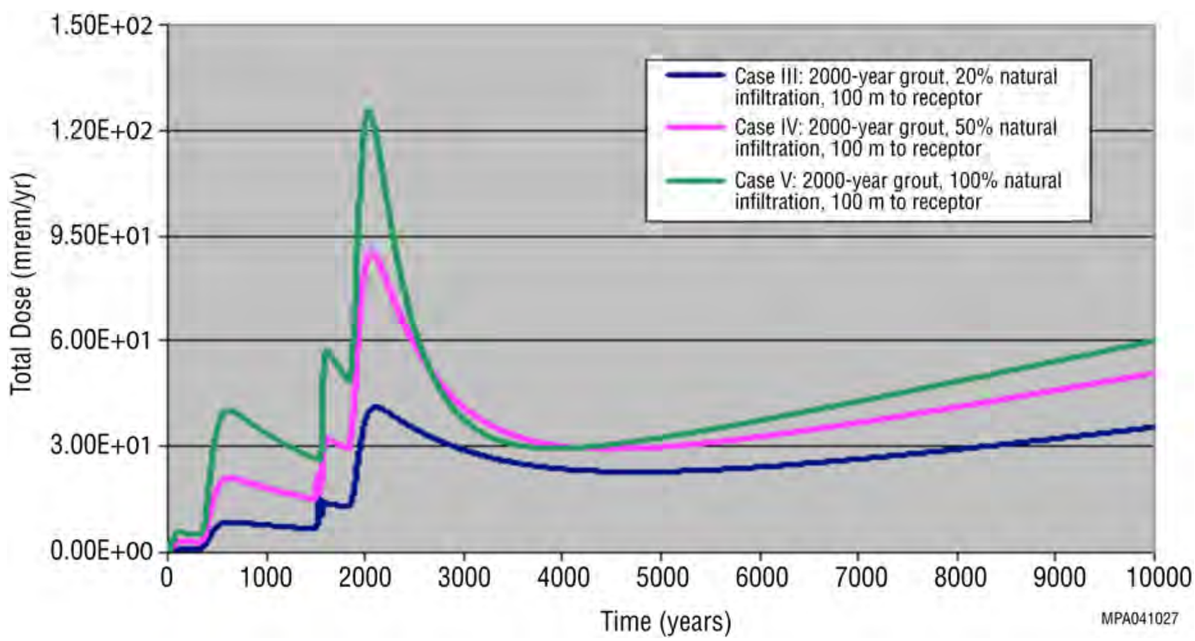

FIGURE E-4 Comparison of Annual Doses for Cases III, IV, and V for Trench Disposal of Stored Group 1 GTCC-Like Other Waste - CH at SRS

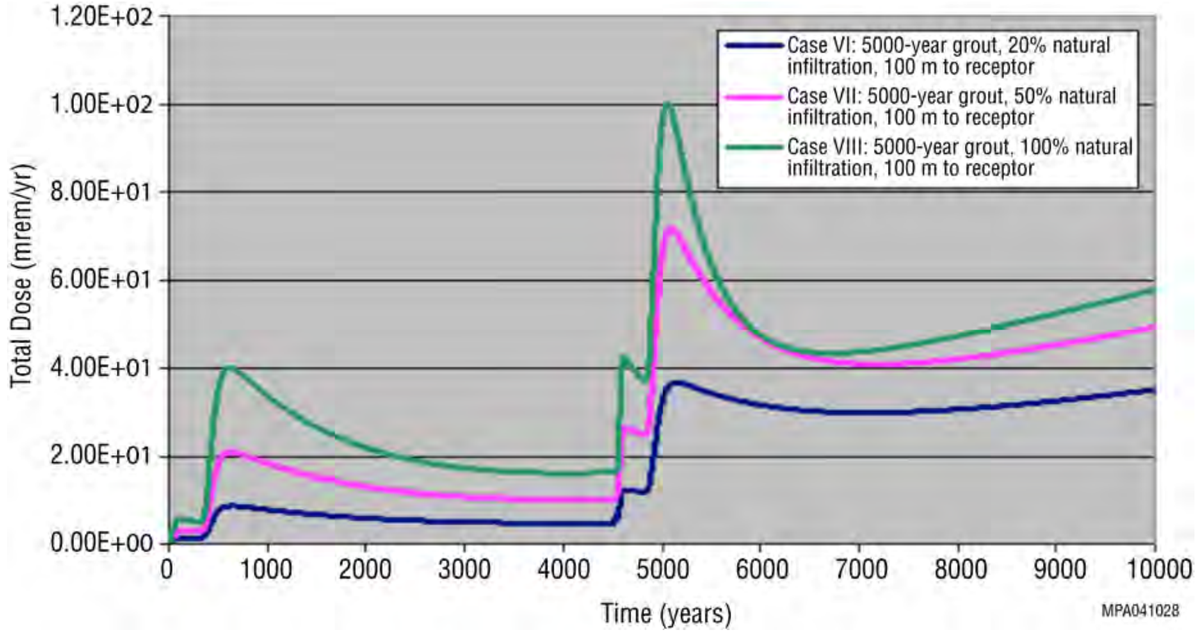

FIGURE E-5 Comparison of Annual Doses for Cases VI, VII, and VIII for Trench Disposal of Stored Group 1 GTCC-Like Other Waste - CH at SRS

In Figure E-3, for all the three cases (Base Case, Case I, and Case II), the sharp peak close to time 0 is caused by C-14, which was assumed to be highly soluble in water (a K_d value of 0 cm^3/g was used in the analyses). After C-14, Np-237 and then Ra-226 would reach the groundwater table. The radiation dose between 100 and 350 years is mainly contributed by Np-237. After 350 years, Ra-226 plays a dominant role in determining the radiation dose. Because of more adsorption to the soil particles during transport to the receptor location, the peaks created by Np-237 and Ra-226 are not as sharp as the peak created by C-14. In addition to the initial inventory in the Group 1 GTCC-like stored Other Waste - CH, Np-237 could be generated by the decay of Am-241, while Ra-226 could be generated by the decay of U-234 and Th-230. The ingrowth of Np-237 and Ra-226 explains the gradual rise of the radiation dose, which continues all the way to 10,000 years after the peak at around 500–600 years. Note that for the RESRAD-OFFSITE analyses, time 0 corresponds to the onset of leaching of radionuclides, which is assumed to occur 500 years after the closure of the disposal facility when the integrity of the barrier materials and waste containers begins to degrade. Therefore, if the reported time is 600 years, it means 1,100 years after the closure of the disposal facility.

The influence of the effectiveness of the stabilizing agent (grout) on the potential radiation doses is demonstrated by comparing the results of the Base Case and Cases III and VI (see Figure E-6). During the effective period, the release rates of radionuclides from the waste disposal area would be reduced, thereby reducing the radiation dose associated with groundwater contamination for the corresponding period. The retention of more radionuclides in the waste containers would allow for more radioactive decay to occur before the release. Hence, the peak annual dose after the effective period would be lower than when there was no waste stabilizing or when the effective period of the stabilizing agent was shorter. The longer the effective period,

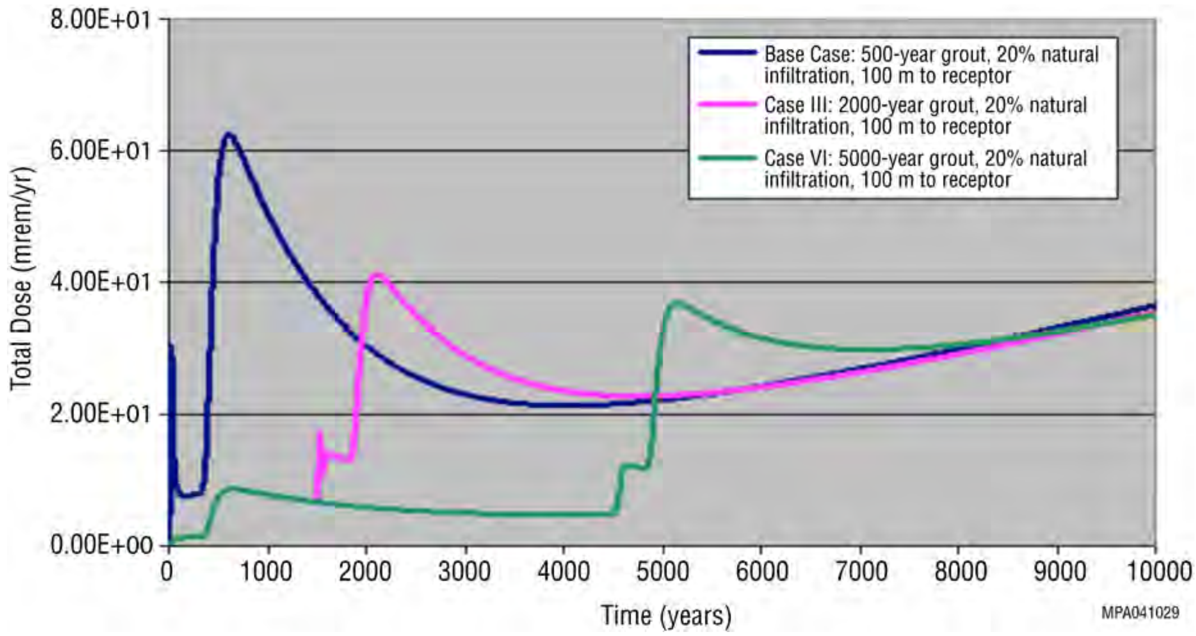

FIGURE E-6 Comparison of Annual Doses for the Base Case and Cases III and VI for Trench Disposal of Stored Group 1 GTCC-Like Other Waste - CH at SRS

the more evident the delay and reduction of the peak dose (compare the dose results for Cases I, IV, and VII in Figure E-7 or the results for Cases II, V, and VIII in Figure E-8).

For Case III in Figure E-6 (the first part of the curve overlaps with the curve for Case VI), the dose results were obtained by assuming the effectiveness of grouting would last for 2,000 years (i.e., the grouting would be effective for 1,500 years after water started to infiltrate into the waste containers). The grouting would reduce the releases of radionuclides and allow for more radioactive decay to take place in the containers. By the time the grout was no longer effective, the partitioning of radionuclides to the water phase would increase simultaneously, resulting in a sudden increase of the release rates, and the corresponding increase in radiation dose would be observed at a later time depending on the travel time required for the radionuclides to reach the receptor location. Because the grouting would have more influence on Np-237 than on Ra-226 (K_ds used for Np-237 and Ra-226 were 300 and 100 cm^3/g, respectively, in the analyses), the radiation dose within the effective period (the first 1,500 years in the RESRAD-OFFSITE analyses) would be largely contributed by Ra-226. After the effective period, the release rates of both Np-237 and Ra-226 would increase. However, because Np-237 (with a K_d of 0.6 cm^3/g) would travel faster than Ra-226 (with a K_d of 5 cm^3/g) in the soil column and groundwater aquifer, its influence on the radiation dose would be observed earlier (the first peak after 1,500 years in the dose profile) than that from Ra-226 (the second peak after 1,500 years in the dose profile). The grouting would also reduce the release rate of C-14 (a K_d of 10 cm^3/g was assumed for the grouting system); therefore, a sharp peak before 1,500 years would no longer be observed. The sharp peak (close to 1,500 years in the dose profiles) would occur after the effective period of the grout; however, the radioactivity of C-14 would have decayed some by then, so the sharp peak would become less obvious.

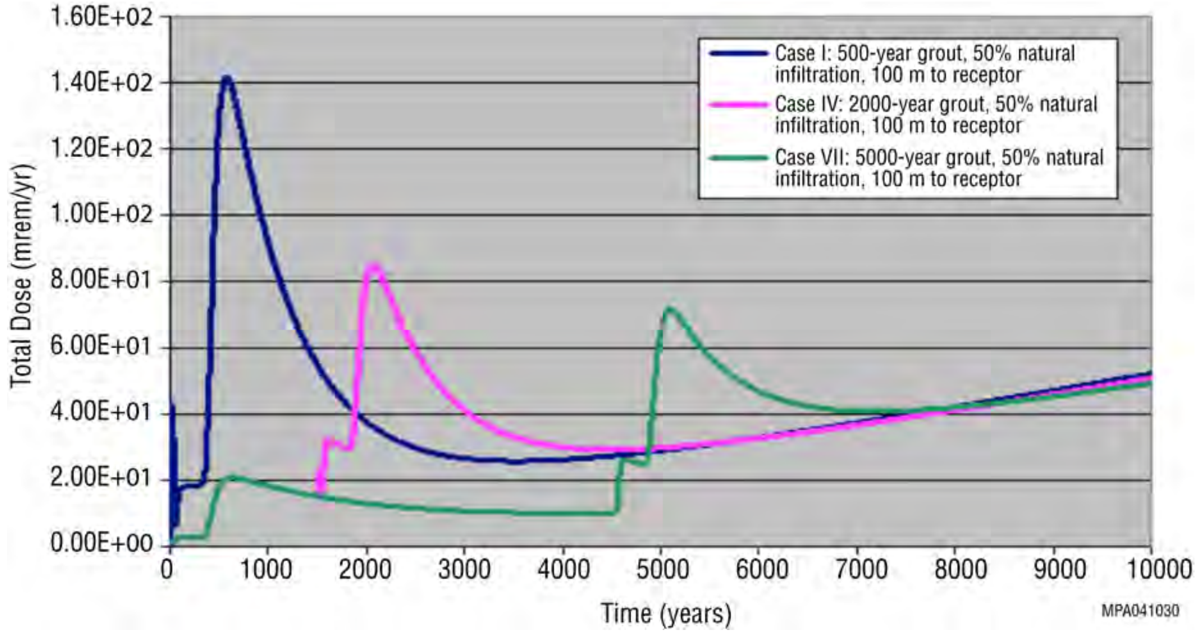

FIGURE E-7 Comparison of Annual Doses for Cases I, IV, and VII for Trench Disposal of Stored Group 1 GTCC-Like Other Waste - CH at SRS

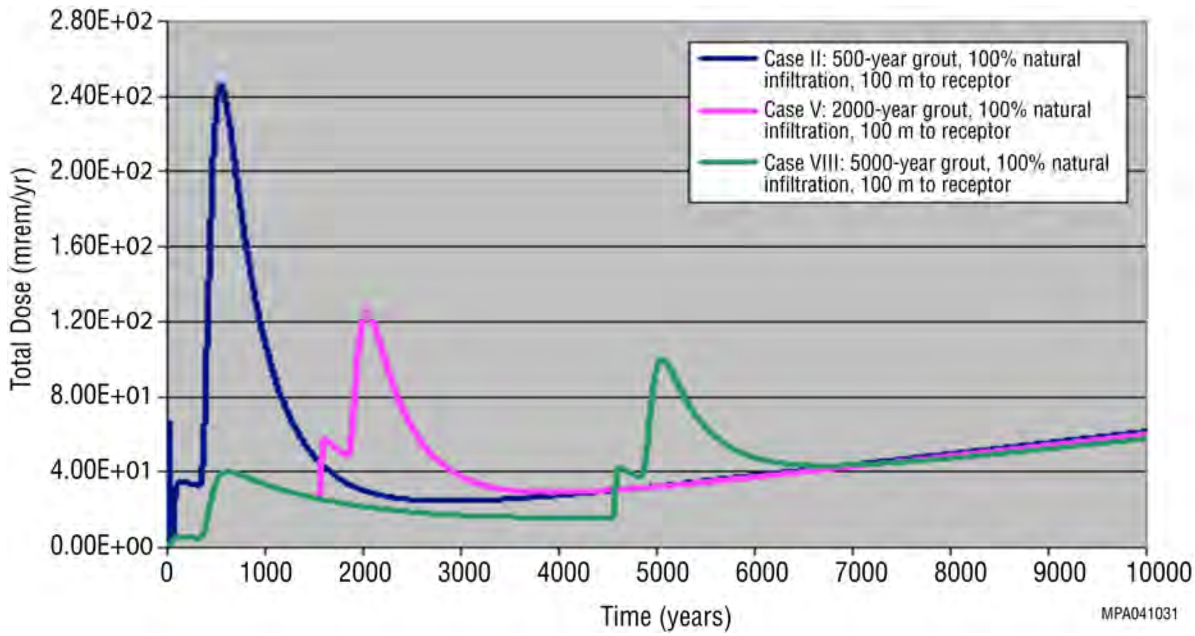

FIGURE E-8 Comparison of Annual Doses for Cases II, V, and VIII for Trench Disposal of Stored Group 1 GTCC-Like Other Waste - CH at SRS

For Case VI in Figure E-6, the dose results were obtained by assuming that the effectiveness of grouting would last for 5,000 years. The dose profiles are similar to that for Case III and can be explained by the same reasons provided in the previous paragraph, except that more decay and ingrowth of radioactivity would occur in the waste containers prior to the loss of grout effectiveness. The increased radioactive decay explains why magnitudes of the peaks after 4,500 years for Case VI are smaller than magnitudes of the peaks after 1,500 years for Case III. The increased ingrowth of progeny radionuclides explains why the difference in the maximum dose between Cases III and VI is less than the difference in the maximum dose between the Base Case and Case III.

The radiation dose incurred by the hypothetical resident farmer considered for post-closure impact analyses would decrease with increasing exposure distance, as demonstrated by the results for the Base Case and Cases IX and X (see also Figure E-9). As mentioned before, this result would occur because additional dilution of radionuclide concentrations in groundwater would result from the additional transport distance toward the location of the off-site well. As the distance would increase from 100 m (330 ft) to 500 m (1,600 ft), the maximum annual radiation dose would decrease by more than 70%.

Although the sensitivity analysis was not conducted with the entire inventory of GTCC LLRW and DOE GTCC-like waste, the results in this appendix provide a good indication of the dose reduction that would occur with the entire inventory under more favorable conditions than those assumed for the Base Case (i.e., a lower water infiltration rate with better engineering of the cover, a longer effective time for the stabilizing agent [grout], and a longer distance to a hypothetical receptor). It is expected that with more robust designs of engineering barriers and waste containment procedures, the actual human health impacts would be much lower than those presented in this EIS.

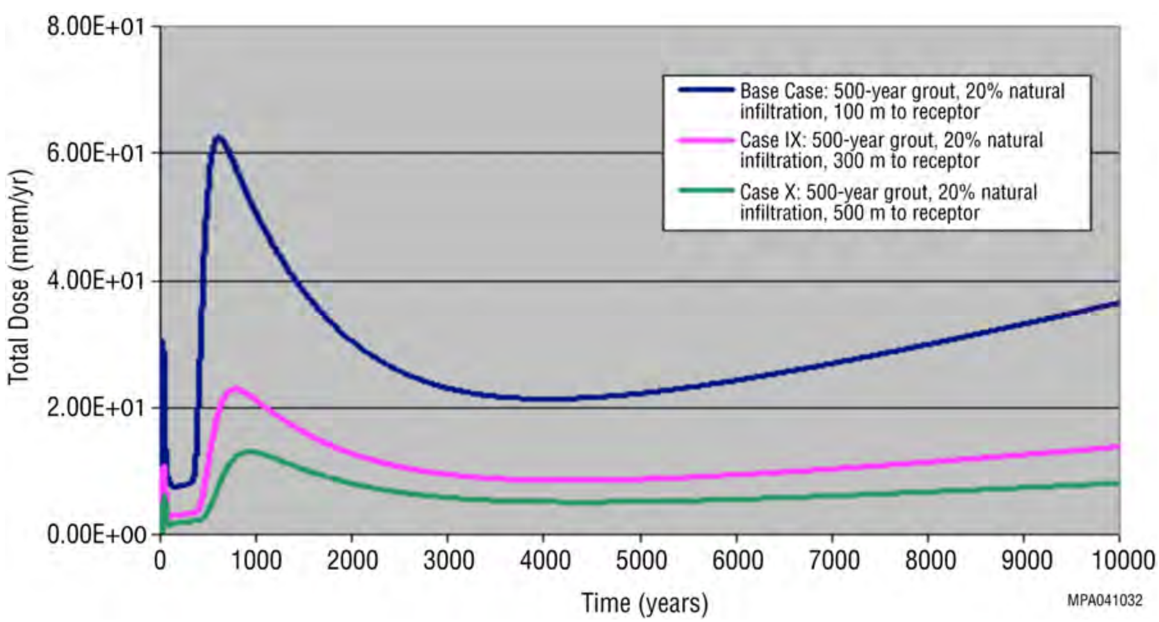

FIGURE E-9 Comparison of Annual Doses for the Base Case and Cases IX and X for Trench Disposal of Stored Group 1 GTCC-Like Other Waste - CH at SRS

TABLE E-1 Distribution Coefficients (cm^3/g) for Cementitious Systems (moderately aged concrete)[a]

Element	PNNL-13037 Rev. 2 (Krupka et al. 2004)	WSRC-TR-2006-0004 Rev. 0 (Kaplan 2006)		SRNL-RPA-2007-00006 (Kaplan 2007)		Mattigod et al. 2002[b]		Mattigod et al. 2002	Selected Value	
		Oxidizing	Reducing	Oxidizing	Reducing	Oxidizing	Reducing	Haddam Neck Samples	Oxidizing	Reducing
Ac	5,000	5,000	5,000	–[c]	–	–	–	–	1,000	1,000
Am	5,000	5,000	5,000	–	–	1,000–5,000	1,000–5,000	>230 – >1,750	1,000	1,000
C	10	10	10	–	–	100	100	–	10	10
Cm	5,000	5,000	5,000	–	–	1,000	1,000	–	1,000	1,000
Co	100	1,000	1,000	–	–	100	100	3,400–32,500, 180–380		100
Cs	30	4	4	–	–	20	20	14,800–26,800, 34–240	100	4
Fe	–	–	–	5,000	1,000	100	100	7–18	12	12
Gd	–	5,000	5,000	–	–	–	–	–	4 1,000	1,000
H	0	0	0	–	–	0	0	–	0	0
I	8	20	20	–	–	–	–	–	20	20
Mn	–	–	–	100	100	–	–	–	100	100
Mo	–	–	–	0.1	0.1	–	–	–	0.1	0.1
Nb	40	1,000	1,000	–	–	1,000	1,000	–	1,000	1,000
Ni	100	1,000	1,000	–	–	100	100	10-61	10	100
Np	2,000	2,000	2,000	–	–	2,000–5,000	5,000	>300 – >510	300	300
Pa	2,000	2,000	2,000	–	–	–	–	–	2,000	2,000
Pb	5,000	500	500	–	–	–	–	–	500	500
Po	–	500	500	–	–	–	–	–	500	500
Pu	5,000	5,000	5,000	–	–	5,000	5,000	>1,300 – >5,600	5,000	5,000
Ra	100	100	100	–	–	–	–	–	100	100
Sm	–	5,000	5,000	–	–	–	–	–	1,000	1,000
Sr	–	1	1	–	–	1–3	1–3		1	1
Tc	0	0	5,000	–	–	0-1	1,000	6–21	0	1,000
Th	5,000	5,000	5,000	–	–	5,000	5,000	–	5,000	5,000
U	1,000	1,000	5,000	–	–	–	–	10–11 –	1,000	5,000

[a] Sources for the K_d values for cementitious systems are Krupka et al. (2004), Kaplan (2006, 2007), and Mattigod et al. (2002).

[b] Values obtained from Table 5 of Mattigod et al. (2002) for Environment II, which considers moderately aged cement that may last from 100–10,000 years to 1,000–100,000 years. The original sources cited by Mattigod et al. (2002) for the K_d values are Krupka and Serne (1998) and Bradbury and Van Loon (1998).

[c] A dash means no information was available.

TABLE E-2 Inventories of the GTCC LLRW and GTCC-Like Waste in the Four NRC Regions for the No Action Alternative[a]

	Waste Volume (m^3)								
	GTCC LLRW				GTCC-Like Waste				
NRC Region	Activated Metals	Sealed Sources	Other Waste - CH	Other Waste - RH	Activated Metals	Sealed Sources	Other Waste - CH	Other Waste - RH	All Waste Types
I	960	520	1,600	2,000	0	0	930	1,300	7,300
II	420	740	0	390	2.9	0	270	270	2,100
III	220	420	0	0	0	0	0	0	640
IV	390	1200	42	33	9.9	0.83	31	19	1,700

	Waste Activity (Ci)								
	GTCC LLRW				GTCC-Like Waste				
NRC Region	Activated Metals	Sealed Sources	Other Waste - CH	Other Waste - RH	Activated Metals	Sealed Sources	Other Waste - CH	Other Waste - RH	All Waste Types
I	3.3E+07	3.7E+05	2.4E+04	3.1E+04	0.0	0.0	3.3E+04	4.9E+05	3.4E+07
II	5.2E+07	5.3E+05	0.0	9.8E+04	2.3E+05	0.0	2.4E+02	4.2E+04	5.3E+07
III	2.4E+07	3.0E+05	0.0	0.0	0.0	0.0	0.0	0.0	2.4E+07
IV	4.7E+07	8.2E+05	1.1E+01	9.5E+04	5.2+03	7.7E+01	1.3E+03	2.0E+02	4.8E+07

[a] All values are given to two significant figures.

TABLE E-3 RESRAD-OFFSITE Input Parameter Values for Groundwater Analysis for the INL Site

Parameter	Value	Value Selection Rationale	Source
Site properties			
Wind speed (m/s)	3.4	Site-specific data.	WRCC 2007
Precipitation (m/yr)	0.22	Site-specific data.	WRCC 2007
Primary contamination area properties			
Irrigation (m/yr)	0	No agricultural activities.	Yu et al. 2007
Evapotranspiration coefficient	0.52	To obtain an infiltration rate of 4 cm/yr, which is close to the value used for the base-case scenario (4.1 cm/yr) in the performance assessment (PA) for the Tank Farm facility.	DOE 2003
Runoff coefficient	0.6212		
Rainfall and runoff	160	To obtain an erosion rate of 1E-5 m/yr for the cover and contamination zone (i.e., would yield more conservative results).	Yu et al. 2007 (applies to the sum of all four parameters at left)
Slope-length-steepness factor	10		
Cover and management factor	0.045		
Support practice factor	1		
Contaminated zone			
Total porosity	0.4		RESRAD-OFFSITE default
Erosion rate (m/yr)	1.00E-05	Chose a small value so that the contaminated zone would not be eroded away (i.e., would yield more conservative results).	Yu et al. 2007
Dry bulk density (g/cm^3)	1.8	Estimated average for different waste types, based on GTCC inventory data.	Sandia 2008
Soil erodibility factor	0.00112	To obtain an erosion rate of 1E-5 m/yr.	Yu et al. 2007
Field capacity	0.3		RESRAD-OFFSITE default
b-parameter	5.3		RESRAD-OFFSITE default
Hydraulic conductivity (m/yr)	10		RESRAD-OFFSITE default
Cover layer			
Total porosity	0.4		RESRAD-OFFSITE default
Erosion rate (m/yr)	1.00E-05	Chose a small value so that the buried waste would remain covered within the time frame considered (i.e., would yield more conservative groundwater results because there would be no losses through surface runoff and erosion).	Yu et al. 2007
Dry bulk density (g/cm^3)	1.5		RESRAD-OFFSITE default
Soil erodibility factor	0.00093	To obtain an erosion rate of 1E-5 m/yr.	Yu et al. 2007
Unsaturated Zone 1		Alluvium (surficial sediment, a coarse-grain unit consisting of predominantly sand and gravel).	
Thickness (m)	9.14	Based on Well USGS-51 strata information.	DOE 2003, p. 2-46
Density (g/cm^3)	1.643	Density for sandy clay/clay.	Yu et al. 2000, Table 3.1-1
Total porosity	0.5		DOE 2003

TABLE E-3 (Cont.)

Parameter	Value	Value Selection Rationale	Source
Effective porosity	0.5	Set to the same value as total porosity.	DOE 2003
Field capacity	0.1	Coarse grain retains less water.	
Hydraulic conductivity (m/yr)	29,200	Corresponds to 80 m/d used in the PA for the Tank Farm facility.	DOE 2003, p. 3-42
b-parameter	4.339	This b-parameter value, along with the hydraulic conductivity and infiltration rate, gives a moisture content of 0.16.	
Longitudinal dispersivity (m)	0	No dispersivity is assumed for all the sites.	
Unsaturated Zone 2		Thick-flow basalt units.	
Thickness (m)	94.64	Sum of thicknesses of thick-flow basalt layers. According to Well USGS-51 strata profile, thick-flow basalt constitutes roughly 90% of the total thickness of all basalt layers above the groundwater table.	
Density (g/cm^3)	2	Density for basalt.	DOE 2007
Total porosity	0.05	Value assumed for the basalt unit.	DOE 2003
Effective porosity	0.05	Set to the same as total porosity.	DOE 2003
Field capacity	0.001	Set to a value less than moisture content.	
Hydraulic conductivity (m/yr)	3,650	Corresponds to 10 m/d.	DOE 2003, p. 3-43
b-parameter	0.76	Selected to give a moisture content of 0.004, which is provided in the INL Site's comments on RESRAD-OFFSITE input parameters.	Wilcox 2008
Longitudinal dispersivity (m)	0	No dispersivity is assumed for all sites.	
Unsaturated Zone 3		Upper interbed sequence with a low permeability.	
Thickness (m)	7.47	Sum of thicknesses of upper interbeds.	
Density (g/cm^3)	1.46	Value for silt loam.	NUREG/CR-6697 (Yu et al. 2000)
Total porosity	0.57	Porosity used for the C-D interbed in the Radioactive Waste Management Complex (RWMC) PA.	DOE 2006a
Effective porosity	0.57	Set to the same as total porosity.	DOE 2006a
Field capacity	0.3		RESRAD-OFFSITE default
Hydraulic conductivity (m/yr)	1.29	Corresponds to 0.0035 m/d, the geometric mean of 0.005 m/d and 0.0025 m/d assumed for the C-CD and D-DE2 interbeds in the Tank Farm facility PA.	DOE 2003

TABLE E-3 (Cont.)

Parameter	Value	Value Selection Rationale	Source
b-parameter	3.6	Calculated mean for silt loam soil. Distribution is log normal (1.28, 0.334). The b-parameter, along with the assumed infiltration rate and hydraulic conductivity, results in a moisture content of 0.414.	NUREG/CR-6697 (Yu et al. 2000)
Longitudinal dispersivity (m)	0	No dispersivity is assumed for all sites.	
Unsaturated Zone 4		Lower sedimentary interbeds.	
Thickness (m)	15.39	The difference between total thickness of the interbeds (estimated to be about 23.35 m according to the Well USGS-51 profile) and the thickness of the upper interbeds, 7.47 m.	
Density (g/cm^3)	1.643	Set to the value for alluvium sediment since they were assumed to have similar hydraulic characteristics in the Tank Farm facility PA.	DOE 2003
Total porosity	0.5		
Effective porosity	0.5	Set to the same as total porosity.	
Field capacity	0.3		RESRAD-OFFSITE default
Hydraulic conductivity (m/yr)	29,200	Set to the same value as for alluvium.	DOE 2003
b-parameter	10.4	Value for silty clay. This b-parameter value, along with the infiltration rate and hydraulic conductivity, results in a moisture content of 0.286.	
Longitudinal dispersivity (m)	0	No dispersivity is assumed for all sites.	
Unsaturated Zone 5		Thin-flow basalt units.	
Thickness (m)	10.52	Sum of thicknesses of thin-flow basalt layers. According to Well USGS-51 strata profile, thin flows basalt constitutes roughly 10% of the total thickness of all basalt layers above the groundwater table.	
Density (g/cm^3)	2	Density for basalt.	DOE 2007
Total porosity	0.05	Value assumed for the basalt unit.	DOE 2003
Effective porosity	0.05	Set to the same as total porosity.	DOE 2003
Field capacity	0.001	Set to a value less than moisture content.	
Hydraulic conductivity (m/yr)	365,000	Corresponds to 1,000 m/d.	DOE 2003, p. 3-43
b-parameter	1.67	Selected to give a moisture content of 0.004, which is provided in the INL Site's comments on RESRAD-OFFSITE input parameters.	Willcox 2008

TABLE E-3 (Cont.)

Parameter	Value	Value Selection Rationale	Source
Longitudinal dispersivity (m)	0	No dispersivity is assumed for all sites.	
Saturated zone hydrology			
Thickness (m)	495	Site-specific average (76−914 m).	Anderson and Lewis 1989
Density of saturated zone (g/cm^3)	2	Density for basalt.	DOE 2007
Total porosity	0.05	Value assumed for basalt.	DOE 2003
Effective porosity	0.05	Set to the same as total porosity.	DOE 2003
Hydraulic conductivity (m/yr)	1,979	Corresponds to 5.42 m/d (the geometric mean of the range from 3.0E-3 to 9.8E+3 m/d, reported as the effective hydraulic conductivity of the basalt and interbedded sediments that compose the Snake River Plain Aquifer at and near the INL Site).	DOE 2003
Hydraulic gradient to well	0.00075	Average for the site (0.00019 to 0.0028), close to the average slope of the water table (4 ft/mi) reported in the Tank Farm facility PA.	McCarthy and McElroy 1995; Anderson and Lewis 1989; DOE 2003
Depth of aquifer contributing to well (m), below the water table	10		RESRAD-OFFSITE default
Longitudinal dispersivity (m)	10% of distance traveled	Assumption used for all sites, which is commonly used for groundwater transport modeling.	
Horizontal lateral dispersivity (m)	10% of longitudinal dispersivity		
Disperse vertically (yes/no)	Yes	To consider dispersion.	Yu et al. 2007
Vertical lateral dispersivity (m)	10% of the horizontal lateral dispersivity	Assumption used for all sites.	

TABLE E-4 Soil/Water Distribution Coefficients (K_d values)[a] for Different Radionuclides for the INL Site

	K_d Value (cm^3/g)							
Element	Unsaturated Zone 1 (alluvium, surficial sediment)	Unsaturated Zone 2 (thick flow basalt units)	Unsaturated Zone 3 (upper interbed sequence with a low permeability)	Unsaturated Zone 4 (lower sedimentary interbeds)	Unsaturated Zone 5 (thin flow basalt units)	Saturated Zone	Value Selection Rationale[b]	Source
Ac	225	0	225	225	0	9	Based on comments from the INL Site, the same K_d value was used for alluvium and interbeds. The basalt K_d was set to 0, and the K_d for the saturated zone was set to 1/25 that of alluvium and interbeds.	DOE 2007
Am	225	0	225	225	0	9	Same as for Ac.	DOE 2007
C	0.4	0	0.4	0.4	0	0.016	Same as for Ac.	DOE 2007
Cm	4,000	0	4,000	4,000	0	160	Same as for Ac.	DOE 2007
Co	10	0	10	10	0	0.40	Same as for Ac.	Jenkins 2001
Cs	500	0	500	500	0	20	Same as for Ac.	Jenkins 2001
Fe	220	0	220	220	0	8.8	Same as for Ac.	Jenkins 2001
Gd	240	0	240	240	0	9.6	Same as for Ac.	Jenkins 2001
H	0	0	0	0	0	0	Same as for Ac.	DOE 2007
I	0	0	0	0	0	0	Same as for Ac.	DOE 2007
Mn	50	0	50	50	0	2	Same as for Ac.	Jenkins 2001
Mo	10	0	10	10	0	0.4	Same as for Ac.	DOE 2007
Nb	500	0	500	500	0	20	Same as for Ac.	DOE 2007
Ni	100	0	100	100	0	4	Same as for Ac.	Jenkins 2001
Np	23	0	23	23	0	0.92	Same as for Ac.	DOE 2007
Pa	8	0	8	8	0	0.32	Same as for Ac.	DOE 2007
Pb	270	0	270	270	0	10.80	Same as for Ac.	DOE 2007
Po	150	0	150	150	0	6	Same as for Ac.	Jenkins 2001
Pu	2,500	0	2,500	2,500	0	100	Same as for Ac.	DOE 2007
Ra	575	0	575	575	0	23	Same as for Ac.	DOE 2007

TABLE E-4 (Cont.)

	K_d Value (cm^3/g)							
Element	Unsaturated Zone 1 (alluvium, surficial sediment)	Unsaturated Zone 2 (thick flow basalt units)	Unsaturated Zone 3 (upper interbed sequence with a low permeability)	Unsaturated Zone 4 (lower sedimentary interbeds)	Unsaturated Zone 5 (thin flow basalt units)	Saturated Zone	Value Selection Rationale[b]	Source
Sm	2,500	0	2,500	2,500	0	100	Same as for Ac.	DOE 2007
Sr	12	0	12	12	0	0.48	Same as for Ac.	Jenkins 2001
Tc	0	0	0	0	0	0	Same as for Ac.	DOE 2007
Th	500	0	500	500	0	20	Same as for Ac.	DOE 2007
U	15.4	0	15.4	15.4	0	0.616	Same as for Ac.	DOE 2007

[a] K_d values are listed for the unsaturated zones and the saturated zone. For the contaminated zone, the release fraction of radionuclides is correlated with the metal corrosion rate for the activated metal wastes, the site-specific soil K_d values for sealed sources, and site-specific soil K_d values and cementitious system K_d values for Other Waste.

[b] For the INL Site's review comments on the RESRAD-OFFSITE input parameters, see Wilcox (2008).

TABLE E-5 RESRAD-OFFSITE Input Parameter Values for Groundwater Analysis for the Hanford Site

Parameter	Value	Value Selection Rationale	Source
Site properties			
Wind speed (m/s)	3.4	Site-specific data at Hanford Meteorology Station (HMS), 50 m above ground.	DOE 2004
Precipitation (m/yr)	0.17	Site-specific data (54.39 in./yr), based on HMS measurements. Consistent with values reported by the Western Regional Climate Center (1948–2005).	DOE 2004, p. 4.16
Primary contamination area properties			
Irrigation (m/yr)	0	No agricultural activities.	Yu et al. 2007
Evapotranspiration coefficient	0.97878	In DOE 2005, the infiltration rate suggested for the post-design life for the sitewide surface barrier is 3.5 mm/yr; the post-design life for the Integrated Disposal Facility (IDF) surface barrier is 0.9 mm/yr. However, for the IDF surface barrier, a sensitivity analysis needs to be conducted for an infiltration rate of 5.0 mm/yr as well. Considering the recharge rate at the 200 E Area, which ranges from 1.5 to 4 mm/yr with shrub covering, and to be consistent with the other sites that use a natural infiltration rate for the GTCC analysis, an infiltration rate of 3.5 mm/yr was chosen for the groundwater analysis. To obtain an infiltration rate of 0.0035 m/yr (3.5 mm/yr), the evapotranspiration coefficient was calculated to be 0.97878.	DOE 2005
Runoff coefficient	0.03	Runoff is about 3% of the total precipitation; most of the remaining precipitation is lost through evapotranspiration.	Duncan et al. 2007
Rainfall and runoff	160	To obtain the desired erosion rates for the cover and contamination zone.	Yu et al. 2007 (applies to sum of all four parameters at left)
Slope-length-steepness factor	0.4		
Cover and management factor	0.003		
Support practice factor	1		

TABLE E-5 (Cont.)

Parameter	Value	Value Selection Rationale	Source
Contaminated zone			
Total porosity	0.4		RESRAD-OFFSITE default
Erosion rate (m/yr)	1.00E-05	Chose a small value so that the contaminated zone would not be eroded away. Will yield more conservative results.	Yu et al. 2007
Dry bulk density (g/cm^3)	1.8	Estimated average for different waste streams, based on preliminary GTCC LLRW and GTCC-like waste inventory data.	Sandia 2008
Soil erodibility factor	0.42	To obtain the desired erosion rate.	Yu et al. 2007
Field capacity	0.3		RESRAD-OFFSITE default
b-parameter	5.3		RESRAD-OFFSITE default
Hydraulic conductivity (m/yr)	10		RESRAD-OFFSITE default
Cover layer			
Total porosity	0.4		RESRAD-OFFSITE default
Erosion rate (m/yr)	1.00E-05	Chose a small value so that the buried waste would remain covered within the time frame considered (i.e., would yield more conservative groundwater results because there would be no losses through surface runoff and erosion).	Yu et al. 2007
Dry bulk density (g/cm^3)	1.5		RESRAD-OFFSITE default
Soil erodibility factor	0.35	To obtain the desired erosion rate.	Yu et al. 2007
Unsaturated Zone 1		Fine sand plus coarse sand-dominated layers in the Hanford Formation. They were considered together because of their similar geological and hydrogeological properties.	
Thickness (m)	58	Average value calculated with the stratigraphic columns data for 200 E area.	Last et al. 2006
Density (g/cm^3)	1.65	For fine sand and coarse sand layers in Hanford Formation.	Last et al. 2006
Total porosity	0.37	Set to the same as effective porosity.	Last et al. 2006
Effective porosity	0.37	For fine sand and coarse sand layers in Hanford Formation.	Last et al. 2006
Field capacity	0.03	Residual moisture content.	Last et al. 2006
Hydraulic conductivity (m/yr)	710	Corresponding to 2.25E-3 cm/s. Selected based on the information presented in Last et al. 2006 for fine and coarse sands in Hanford Formation.	
b-parameter	4.05	Value for sand soil.	Yu et al. 2001
Longitudinal dispersivity (m)	0	No dispersion.	Assumption used for all sites

TABLE E-5 (Cont.)

Parameter	Value	Value Selection Rationale	Source
Unsaturated Zone 2		Gravel-dominated layers in the Hanford Formation plus Ringold Unit E. They were considered together because of their similar geological and hydrogeological properties.	
Thickness (m)	30	Average value calculated with the stratigraphic columns data for 200 E area.	Data presented in Last et al. 2006, Appendix A.
Density (g/cm^3)	1.93	For gravel-dominated layers in Hanford Formation and Ringold Unit E.	Last et al. 2006
Total porosity	0.27	Value for Hanford and Ringold gravel.	DOE 2009
Effective porosity	0.27	Set to the same as total porosity.	DOE 2009
Field capacity	0.024	Residual moisture content.	Last et al. 2006
Hydraulic conductivity (m/yr)	148	Corresponding to 4.68E-4 cm/s. Selected on the basis of information presented in Last et al. 2006 for gravel-dominated layers in Hanford Formation and Ringold Unit E.	Last et al. 2006
b-parameter	7.12	Value for sandy clay loam soil.	Yu et al. 2001, Table E-2
Longitudinal dispersivity (m)	0	No dispersion.	Assumption used for all sites.
Saturated zone hydrology		Consider the combination of the Hanford Formation and Ringold Unit E.	
Thickness (m)	45	Entire aquifer is 45 to 71.7 m thick. Use the lower value.	Horton 2007
Density of saturated zone (g/cm^3)	1.98	Calculated on the basis of a soil particle density of 2.65 g/cm^3 and a total porosity of 0.25.	
Total porosity	0.25	Used for unconfined aquifer.	Page O-91, DOE 2009
Effective porosity	0.25	Set to the same as total porosity.	Page O-91, DOE 2009
Hydraulic conductivity (m/yr)	12,775	Slug tests at five monitoring wells in the IDF location (Reidel 2004) indicate a high-permeability condition, ranging from >25 to >45 m/d. These estimates for the hydraulic conductivity beneath the IDF site are consistent with the unconfined aquifer flow through the gravel-dominated facies of the lower Hanford Formation. Use the average of 35 m/day, which converts to 12,775 m/yr.	Reidel 2004
Hydraulic gradient to well	0.00124	Geometric mean of the range from 0.00073 to 0.00209.	Horton 2007
Depth of aquifer contributing to well (m), below water table	10		RESRAD-OFFSITE default

TABLE E-5 (Cont.)

Parameter	Value	Value Selection Rationale	Source
Longitudinal dispersivity (m)	10% of distance traveled	Assumptions used for all sites. Common practices for groundwater transport modeling.	
Horizontal lateral dispersivity (m)	10% of longitudinal dispersivity		
Disperse vertically (yes/no)	Yes	To consider dispersion.	Yu et al. 2007
Vertical lateral dispersivity (m)	10% of horizontal lateral dispersivity	Assumptions used for all sites.	

TABLE E-6 Soil/Water Distribution Coefficients (K_d values)[a] for Different Radionuclides for the Hanford Site

Source	K_d Value (cm^3/g) Unsaturated Zone 1	Unsaturated Zone 2	Saturated Zone	Value Selection Rationale for Unsaturated Zone 1 and Saturated Zone	Source	Value Selection Rationale for Unsaturated Zone 2	Source
Ac	300	30	300	Best K_d value for far field in sand sequence with natural recharge (no impact from wastes).	Krupka et al. 2004, Table 5.6	Use 10% of the value for sand-dominated soil, an approach used in the groundwater data package.	Thorne et al. 2006
Am	1,900	190	1,900	To be consistent with values used in DOE 2009.	DOE 2009; Beyeler et al. 1999	Same as above.	Thorne et al. 2006
C	4	0.4	4	To be consistent with the values used in DOE 2009.	DOE 2005, 2009	Same as above.	Thorne et al. 2006
Cm	300	30	300	Best K_d value for far field in sand sequence with natural recharge (no impact from wastes).	Table 5.6, Krupka et al. 2004	Same as above.	Thorne et al. 2006
Co	2,000	200	2,000	Best K_d value for far field in sand sequence with natural recharge (no impact from wastes).	Table 5.6, Krupka et al. 2004	Same as above.	Thorne et al. 2006
Cs	80	8	80	To be consistent with the values used in DOE 2009.	DOE 2005, 2009	Same as above.	Thorne et al. 2006
Fe	220	22	220	Generic value for sand soil.	Site-specific value preferred. Sheppard and Thibault 1990; Yu et al. 2000	Same as above.	Thorne et al. 2006

TABLE E-6 (Cont.)

Source	K_d Value (cm^3/g)			Value Selection Rationale for Unsaturated Zone 1 and Saturated Zone	Source	Value Selection Rationale for Unsaturated Zone 2	Source
	Unsaturated Zone 1	Unsaturated Zone 2	Saturated Zone				
Gd	825	82.5	825	Generic value for soil.	Yu et al. 2000	Same as above.	Thorne et al. 2006
H	0	0	0	To be consistent with the values used in DOE 2009.	DOE 2005, 2009	Same as above.	Thorne et al. 2006
I	0	0	0	To be consistent with the values used in DOE 2009.	DOE 2005, 2009	Same as above.	Thorne et al. 2006
Mn	50	5	50	To be consistent with the values used DOE 2009.	Sheppard and Thibault 1990, Yu et al. 2000	Same as above.	Thorne et al. 2006
Mo	10	1	10	To be consistent with the values used DOE 2009.	Sheppard and Thibault (1990); Yu et al. 2000	Same as above.	Thorne et al. 2006
Nb	300	30	300	Best K_d value for far field in sand sequence with natural recharge (no impact from wastes).	Krupka et al. 2004, Table 5.6	Same as above.	Thorne et al. 2006
Ni	400	40	400	To be consistent with the values used in DOE 2009.	DOE 2009; Beyeler et al. 1999	Same as above.	Thorne et al. 2006
Np	2.5	0.25	2.5	To be consistent with the values used in DOE 2009.	DOE 2005, 2009	Same as above.	Thorne et al. 2006
Pa	2.5	0.25	2.5	Set to the same values as Np.	DOE 2005, 2009	Same as above.	Thorne et al. 2006
Pb	80	8	80	To be consistent with the values used in DOE 2009.	DOE 2005, 2009	Same as above.	Thorne et al. 2006

TABLE E-6 (Cont.)

	K_d Value (cm^3/g)						
Source	Unsaturated Zone 1	Unsaturated Zone 2	Saturated Zone	Value Selection Rationale for Unsaturated Zone 1 and Saturated Zone	Source	Value Selection Rationale for Unsaturated Zone 2	Source
Po	150	15	150	Generic value for sand soil.	Sheppard and Thibault 1990; Yu et al. 2000	Same as above.	Thorne et al. 2006
Pu	150	15	150	To be consistent with the values used in DOE 2009.	DOE 2005, 2009	Same as above.	Thorne et al. 2006
Ra	10	1	10	Same as Sr.	DOE 2005	Same as above.	Thorne et al. 2006
Sm	300	30	300	Same as Ac.	Krupka et al. 2004, Table 5.6	Same as above.	Thorne et al. 2006
Sr	10	1	10	To be consistent with the values used in DOE 2009.	DOE 2005, 2009	Same as above.	Thorne et al. 2006
Tc	0	0	0	To be consistent with the values used in DOE 2009.	DOE 2005, 2009	Same as above.	Thorne et al. 2006
Th	3,200	320	3,200	To be consistent with the values used in DOE 2009.	DOE 2009; Beyeler et al. 1999	Same as above.	Thorne et al. 2006
U	0.6	0.06	0.6	To be consistent with the values used in DOE 2009.	DOE 2009; Beyeler et al. 1999	Same as above.	Thorne et al. 2006

[a] K_d values are listed for the unsaturated zones and the saturated zone. For the contaminated zone, the release fraction of radionuclides is correlated with the metal corrosion rate for the activated metal wastes, the site-specific soil K_d values for sealed sources, and the site-specific soil K_d values and cementitious system K_d values for Other Waste.

TABLE E-7 RESRAD-OFFSITE Input Parameter Values for Groundwater Analysis for LANL

Parameter	Value	Value Selection Rationale	Source
Site properties			
Wind speed (m/s)	2.65	Geometric mean of the distribution log normal (2.65, 1.35).	Distribution information from Henckel 2008. The distribution function is based on wind speed data collected at the meteorological tower at TA-54 from January 1992 through April 2005 (http://weather.lanl.gov)
Precipitation (m/yr)	0.356	Site-specific data.	Bowen 1990
Primary contamination area properties			
Irrigation (m/yr)	0	No agricultural activities.	Yu et al. 2007
Evapotranspiration coefficient	0.9	To obtain an infiltration rate of 5 mm/yr, which was determined for use in the analysis on the basis of the histogram shown on p. 23 of Stauffer et al. 2005.	Stauffer et al. 2005
Runoff coefficient	0.8596		
Rainfall and runoff	160	To obtain the erosion rates used as the input values for the cover and contamination zone.	Yu et al. 2007 (applies to the sum of all four parameters at left)
Slope-length-steepness factor	10		
Cover and management factor	0.045		
Support practice factor	1		
Contaminated zone			
Total porosity	0.4		RESRAD-OFFSITE default
Erosion rate (m/yr)	1.00E-05	Chose a small value so that the buried waste would remain covered within the time frame considered (i.e., would yield more conservative groundwater results because there would be no losses through surface runoff and erosion).	Yu et al. 2007
Dry bulk density (g/cm^3)	1.8	Estimated average for different waste streams, on the basis of preliminary GTCC LLRW and GTCC-like waste inventory data.	Sandia 2008
Soil erodibility factor	0.00112	To obtain the erosion rate used for the input value.	Yu et al. 2007
Field capacity	0.3		RESRAD-OFFSITE default
b-parameter	5.3		RESRAD-OFFSITE default
Hydraulic conductivity (m/yr)	10		RESRAD-OFFSITE default
Cover layer			
Total porosity	0.4		RESRAD-OFFSITE default
Erosion rate (m/yr)	1.00E-05	Chose a small value so that the cover material would not be eroded away completely within the time frame considered.	Yu et al. 2007
Dry bulk density (g/cm^3)	1.5		RESRAD-OFFSITE default
Soil erodibility factor	0.00093	To obtain the erosion rate used for the input value.	Yu et al. 2007

TABLE E-7 (Cont.)

Parameter	Value	Value Selection Rationale	Source
Unsaturated Zone 1		Tshirege Member Unit 2.	
Thickness (m)	13	Determined on the basis of as-drilled data for Well R-22.	Stauffer et al. 2005, Table 2
Density (g/cm^3)	1.4	Value for Tshirege Member Unit 2.	Stauffer et al. 2005, Table 4
Total porosity	0.41	Value for Tshirege Member Unit 2.	Stauffer et al. 2005, Table 4
Effective porosity	0.41	Set to the same value as total porosity.	
Field capacity	0.02	Set to a smaller value than 0.024, the moisture content for a saturation of 0.06.	
Hydraulic conductivity (m/yr)	61.81	Corresponds to a permeability of 2.0E-13 m^2 for the Tshirege Member Unit 2.	Stauffer et al. 2005, Table 4
b-parameter	0.175	Selected to give a saturation of 0.06, an approximated value based on the range of site data for Unit 2 presented in Figure 2.1-2 of Birdsell et al. 1999.	Birdsell et al. 1999
Longitudinal dispersivity (m)	0	No dispersion for vadose zone, an assumption applied to all sites.	
Unsaturated Zone 2		Tshirege Units 1v, 1g, and Cerro Toledo interval.	
Thickness (m)	26	Determined based on as-drilled data for Well R-22.	Stauffer et al. 2005, Table 2
Density (g/cm^3)	1.2	Average value for Tshirege Member Unit 5.	Stauffer et al. 2005, Table 4
Total porosity	0.47	Average value for Tshirege Units 1f, 1g, and Cerro Toledo interval.	Stauffer et al. 2005, Table 4
Effective porosity	0.47	Set to the same value as total porosity.	
Field capacity	0.02	Set to a smaller value than 0.094, the moisture content for a saturation of 0.2.	
Hydraulic conductivity (m/yr)	46.36	Corresponds to a permeability of 1.5E-13 m^2, the average for Tshirege Member Units 1v, 1g, and Cerro Toledo interval.	Stauffer et al. 2005, Table 4
b-parameter	1.339	Selected to give a saturation of 0.2, an approximated value based on the range of site data for Unit 2 presented in Figure 2.1-2 of Birdsell et al. 1999.	Birdsell et al. 1999
Longitudinal dispersivity (m)	0	No dispersion for vadose zone, an assumption applied to all sites.	

TABLE E-7 (Cont.)

Parameter	Value	Value Selection Rationale	Source
Unsaturated Zone 3		Otowi Member above Guaje Pumice.	
Thickness (m)	16	Determined based on as-drilled data for Well R-22.	Stauffer et al. 2005, Table 2
Density (g/cm^3)	1.2	Value for Otowi Member above Guaje Pumice.	Stauffer et al. 2005, Table 4
Total porosity	0.44	Value for Otowi Member above Guaje Pumice.	Stauffer et al. 2005, Table 4
Effective porosity	0.44	Set to the same value as total porosity.	
Field capacity	0.04	Set to a smaller value than 0.12; the moisture content corresponds to a saturation of 0.27.	
Hydraulic conductivity (m/yr)	71.08	Corresponds to a permeability of 2.3E-13 m^2 for Otowi Member above Guaje Pumice.	Stauffer et al. 2005, Table 4
b-parameter	2.152	Selected to give a saturation of 0.27, an approximated value based on a range of site data in Figure 2.1-2 of Birdsell et al. 1999.	Birdsell et al. 1999
Longitudinal dispersivity (m)	0	No dispersion for vadose zone, an assumption applied to all sites.	
Unsaturated Zone 4		Otowi Member Guaje Pumice.	
Thickness (m)	3	Determined based on as-drilled data for Well R-22.	Stauffer et al. 2005, Table 2
Density (g/cm^3)	0.8	Value for Otowi Member Guaje Pumice.	Stauffer et al. 2005, Table 4
Total porosity	0.67	Value for Otowi Member Guaje Pumice.	Stauffer et al. 2005, Table 4
Effective porosity	0.67	Set to the same value as total porosity.	
Field capacity	0.00001	Set to a small value so that it is not used to reset the saturation ratio calculated.	
Hydraulic conductivity (m/yr)	46.36	Corresponds to a permeability of 1.5E-13 m^2 for the Otowi Member Guaje Pumice.	Stauffer et al. 2005, Table 4
b-parameter	1.891	Selected to give a saturation of 0.26, an approximated value based on a range of site data presented in Figure 2.1-2 of Birdsell et al. 1999.	Birdsell et al. 1999
Longitudinal dispersivity (m)	0	No dispersion for vadose zone, an assumption applied to all sites.	
Unsaturated Zone 5		Cerros del Rio basalts vadose zone.	
Thickness (m)	211	Determined on the basis of as-drilled data for Well R-22.	Stauffer et al. 2005, Table 2
Density (g/cm^3)	2.7	Value for the basalts.	Stauffer et al. 2005, Table 4

TABLE E-7 (Cont.)

Parameter	Value	Value Selection Rationale	Source
Total porosity	0.001	Value for basalts vadose zone.	Stauffer et al. 2005, Table 4
Effective porosity	0.001	Set to the same value as total porosity.	
Field capacity	0.00001	Set to a small value so that it is not used to reset the saturation ratio calculated.	
Hydraulic conductivity (m/yr)	309.05	Corresponds to a permeability of 1.0E-12 m^2 for the basalts vadose zone.	Stauffer et al. 2005, Table 4
b-parameter	2.713	Selected to give a saturation of 0.27, an approximated value based on the range of site data presented in Figure 2.1-2 of Birdsell et al. 1999.	Birdsell et al. 1999
Longitudinal dispersivity (m)	0	No dispersion for vadose zone, an assumption applied to all sites.	
Saturated zone hydrology		Cerro del Rio basalts saturated zone.	
Thickness (m)	37.5	Used for groundwater modeling.	Stauffer et al. 2005
Density of saturated zone (g/cm^3)	2.7	Value for the basalts.	Stauffer et al. 2005, Table 4
Total porosity	0.05	Value for basalts saturated zone.	Stauffer et al. 2005, Table 4
Effective porosity	0.05	Set to the same value as total porosity.	
Hydraulic conductivity (m/yr)	309.05	Corresponds to a permeability of 1.0E-12 m^2 for the basalts vadose zone.	Stauffer et al. 2005, Table 4
Hydraulic gradient to well	0.013		Stauffer et al. 2005, Section 3.1.4.3
Depth of aquifer contributing to well (m), below water table	10		RESRAD-OFFSITE default
Longitudinal dispersivity (m)	10% of distance traveled	Assumption applied to all sites considered. A common practice used in groundwater modeling.	
Horizontal lateral dispersivity (m)	10% of the longitudinal dispersivity		
Disperse vertically (yes/no)	Yes	To consider dispersion.	Yu et al. 2007
Vertical lateral dispersivity (m)	10% of the horizontal lateral dispersivity	Assumption applied to all sites considered.	

TABLE E-8 Soil/Water Distribution Coefficients (K_d values)[a] for Different Radionuclides for LANL

	K_d Value (cm^3/g)			
Element	Unsaturated Zone	Saturated Zone	Value Selection Rationale	Source
Ac	130	130	Value suggested by French of LANL for use in RESRAD-OFFSITE modeling to develop a GTCC LLRW and GTCC-like waste disposal facility.	French 2008; Wolsberg 1980
Am	2,400	2,400	Most likely value based on the distribution, T (2.0E+02, 2.4E+3, 2.7E+04).	French 2008; Longmire et al. 1996
C	0	0	For volcanic tuff.	Birdsell et al. 1999; Krier et al. 1997; Brookins 1984; French 2008
Cm	50	50	For devitrified volcanic tuff.	Birdsell et al. 1999; Krier et al. 1997; Brookins 1984; French 2008
Co	0.45	0.45	For volcanic tuff.	Birdsell et al. 1999; Krier et al. 1997; Brookins 1984; French 2008
Cs	7.5	7.5	Mean of distribution, U(1.0E+0, 1.5E+01, 7.5E+0).	French 2008; Bechtel/SAIC 2004
Fe	209	209	Value for generic soil.	Yu et al. 2000
Gd	50	50	Value for generic soil.	Krier et al. 1997
H	0	0	Assumed no adsorption.	Krier et al. 1997
I	0	0	For volcanic tuff.	Birdsell et al. 1999; Krier et al. 1997
Mn	158	158	Value for generic soil.	Yu et al. 2000
Mo	4	4	For volcanic tuff.	Birdsell et al. 1999; Krier et al. 1997; Brookins 1984
Nb	100	100	For volcanic tuff.	Birdsell et al. 1999; Krier et al. 1997; Brookins 1984
Ni	50	50	For volcanic tuff.	Birdsell et al. 1999; Krier et al. 1997; Brookins 1984
Np	2.2	2.2	Most likely value based on the distribution, T(1.7E-01, 2.2E+0, 3.1E+0).	French 2008; Longmire et al. 1996
Pa	5,500	5,500	Mean of the distribution, TN(5.5E+03, 1.5E+03, 1.0E+03, 1.0E+04).	French 2008; Bechtel/SAIC 2004
Pb	25	25	For volcanic tuff.	Birdsell et al. 1999; Krier et al. 1997; Brookins 1984
Po	10	10	Value for generic soil.	Yu et al. 2000
Pu	4.10	4.10	Geometric mean for volcanic tuff (4.1-110).	Birdsell et al. 1999, Krier et al. 1997
Ra	500	500	Mean of the distribution, U(1.0E+2, 1.0E+03, 5.0E+02).	French 2008; Bechtel/SAIC 2004
Sm	50	50	Set to the same value as Gd.	Krier et al. 1997; Baes et al. 1984
Sr	40	40	Mean of the distribution, U(1.0E+0, 7.0E+01, 4.0E+01).	French 2008; Bechtel/SAIC 2004
Tc	0	0	Assumed no adsorption.	Birdsell et al. 1999; Krier et al. 1997; French 2008; Longmire et al. 1996
Th	5,000	5,000	Mean of the distribution, U(1.0E+3, 1.0E+04, 5.0E+03).	French 2008; Bechtel/SAIC 2004
U	2.4	2.4	Most likely value based on the distribution, T(1.4E+0, 2.4E+0, 3.5E+0).	French 2008; Longmire et al. 1996

[a] K_d values are listed for the unsaturated zones and the saturated zone. For the contaminated zone, the release fraction of radionuclides is correlated with the metal corrosion rate for the activated metal wastes, the site-specific soil K_d values for sealed sources, and site-specific soil K_d values and cementitious system K_d values for Other Waste.

TABLE E-9 RESRAD-OFFSITE Input Parameter Values for Groundwater Analysis for NNSS

Parameter	Value	Value Selection Rationale	Source
Site properties			
Wind speed (m/s)	2.6	Site-specific data.	Bechtel Nevada 2006
Precipitation (m/yr)	0.13	Site-specific data.	National Security Technologies, LLC 2008
Primary contamination area properties			
Irrigation (m/yr)	0	No agricultural activities.	Yu et al. 2007
Evapotranspiration coefficient	0.99	Selected to give an infiltration rate of 0.00003 m/yr, which is the site-specific hydraulic conductivity for the vadose zone.	Shott et al. 1998
Runoff coefficient	0.977		
Rainfall and runoff	160	To obtain the erosion rates used as the input values for the cover and contamination zone.	Yu et al. 2007 (applies to sum of all four parameters at left)
Slope-length-steepness factor	0.4		
Cover and management factor	0.003		
Support practice factor	1		
Contaminated zone			
Total porosity	0.4		RESRAD-OFFSITE default
Erosion rate (m/yr)	1.00E-05	Chose a small value so that the buried waste would remain covered within the time frame considered (i.e., would yield more conservative groundwater results because there would be no losses through surface runoff and erosion).	Yu et al. 2007
Dry bulk density (g/cm^3)	1.8	Estimated average for different waste streams, based on preliminary GTCC LLRW and GTCC-like waste inventory data.	Sandia 2008
Soil erodibility factor	0.42	To obtain the erosion rate used as the input value.	Yu et al. 2007
Field capacity	0.3		RESRAD-OFFSITE default
b-parameter	5.3		RESRAD-OFFSITE default
Hydraulic conductivity (m/yr)	10		RESRAD-OFFSITE default
Cover layer			
Total porosity	0.4		RESRAD-OFFSITE default
Erosion rate (m/yr)	1.00E-05	Chose a small value so that the cover material would not be eroded away completely within the time frame considered. Would yield more conservative results.	Yu et al. 2007
Dry bulk density (g/cm^3)	1.5		RESRAD-OFFSITE default
Soil erodibility factor	0.35	To obtain the erosion rate used as the input value.	Yu et al. 2007

TABLE E-9 (Cont.)

Parameter	Value	Value Selection Rationale	Source
Unsaturated Zone 1			
Thickness (m)	246	Average of the range from 235.3 to 256.6 m.	Bechtel Nevada 2001, 2002
Density (g/cm^3)	1.65	Site-specific data.	Shott et al. 1998
Total porosity	0.36	Site-specific data.	Shott et al. 1998
Effective porosity	0.36	Site-specific data.	Shott et al. 1998
Field capacity	0.3		RESRAD-OFFSITE default
Hydraulic conductivity (m/yr)	0.00003	Site-specific data.	Shott et al. 1998
b-parameter	5.3		RESRAD-OFFSITE default
Longitudinal dispersivity (m)	0	No dispersivity was assumed for the unsaturated zone.	Assumption used for all sites.
Saturated zone hydrology			
Thickness (m)	220	Average value from well monitoring data.	Reynolds Electrical & Engineering Company, Inc. 1994
Density of saturated zone (g/cm^3)	1.6	Site-specific data.	Shott et al. 1998
Total porosity	0.36	Site-specific data.	Shott et al. 1998
Effective porosity	0.36	Site-specific data.	Shott et al. 1998
Hydraulic conductivity (m/yr)	439	Site-specific data.	Shott et al. 1998
Hydraulic gradient to well	9.70E-05	Site-specific data.	National Security Technologies, LLC 2008
Depth of aquifer contributing to well (m), below water table	10		RESRAD-OFFSITE default
Longitudinal dispersivity (m)	10% of the distance traveled	Assumption used for all sites. Common practice for groundwater modeling.	
Horizontal lateral dispersivity (m)	10% of the longitudinal dispersivity	Assumption used for all sites. Common practice for groundwater modeling.	
Disperse vertically (yes/no)	Yes	To consider dispersion.	Yu et al. 2007
Vertical lateral dispersivity (m)	10% of the horizontal lateral dispersivity	Assumption used for all sites.	

TABLE E-10 Soil/Water Distribution Coefficients for Different Radionuclides for NNSS[a]

Element	K_d Value (cm^3/g) Unsaturated Zone	Saturated Zone	Value Selection Rationale	Source
Ac	7,000	7,000	Mean value of the distribution used in the Area 5 Radioactive Waste Management Site (RWMS) performance assessment (PA) model.	Bechtel Nevada 2006
Am	7,000	7,000	Same as Ac.	Bechtel Nevada 2006
C	0	0	Same as Ac.	Bechtel Nevada 2006
Cm	4,000	4,000	Suggested value for sandy soil.	Yu et al. 2000
Co	60	60	Suggested value for sandy soil.	Yu et al. 2000
Cs	280	280	Suggested value for sandy soil.	Yu et al. 2000
Fe	209	209	Suggested value for generic soil.	Yu et al. 2000
Gd	825	825	Suggested value for generic soil.	Yu et al. 2000
H	0	0	Value used in the Area 5 RWMS PA model.	Bechtel Nevada 2006
I	0	0	Value used in the Area 5 RWMS PA model.	Bechtel Nevada 2006
Mn	50	50	Suggested value for sandy soil.	Yu et al. 2000
Mo	10	10	Suggested value for sandy soil.	Yu et al. 2000
Nb	7,000	7,000	Mean value of the distribution used in the Area 5 RWMS PA model.	Bechtel Nevada 2006
Ni	100	100	Same as Nb.	Bechtel Nevada 2006
Np	5	5	Same as Nb.	Bechtel Nevada 2006
Pa	5	5	Same as Nb.	Bechtel Nevada 2006
Pb	300	300	Same as Nb.	Bechtel Nevada 2006
Po	300	300	Set to the same value as Pb.	Bechtel Nevada 2006
Pu	7.5	7.5	Same as Nb.	Bechtel Nevada 2006
Ra	185	185	Same as Nb.	Bechtel Nevada 2006
Sm	245	245	Set to the same value as Eu used in the Area 5 RWMS PA model.	Bechtel Nevada 2006
Sr	420	420	Same as Nb.	Bechtel Nevada 2006
Tc	0	0	Same as Nb.	Bechtel Nevada 2006
Th	7,000	7,000	Same as Nb.	Bechtel Nevada 2006
U	0.8	0.8	Same as Nb.	Bechtel Nevada 2006

[a] K_d values are listed for the unsaturated zones and the saturated zone. For the contaminated zone, the release fraction of radionuclides is correlated with the metal corrosion rate for the activated metal wastes, the site-specific soil K_d values for sealed sources, and site-specific soil K_d values and cementitious system K_d values for Other Waste.

1 **TABLE E-11 RESRAD-OFFSITE Input Parameter Values for Groundwater Analysis for SRS**

Parameter	Value	Value Selection Rationale	Source
Site properties			
Wind speed (m/s)	3	Site-specific data.	SRCC 2007a
Precipitation (m/yr)	1.2	Site-specific data.	SRCC 2007b; Cook et al. 2004
Primary contamination area properties			
Irrigation (m/yr)	0	No agricultural activities.	Yu et al. 2007
Evapotranspiration coefficient	0.598	On the basis of both coefficients, an infiltration rate of 0.376 m/yr (14.8 in./yr) was derived. The Flach et al. 2005 estimate for trenches covered with a 4-ft operational soil cover and topsoil is 14.8 in./yr. The Young and Pohlmann 2003 study shows an infiltration rate ranging from 9 to 16 in./yr with a median value of 14.8 in./yr, or 1/3 of the yearly rainfall of approximately 48 in. The above information is cited in WSRC 2008, Part C, pp. 68 and 69.	WSRC 2008 (applies to both parameters at left)
Runoff coefficient	0.221		
Rainfall and runoff	160	To obtain the desired erosion rates for the cover and contamination zone.	Yu et al. 2007 (applies to sum of all four parameters at left)
Slope-length-steepness factor	10		
Cover and management factor	0.045		
Support practice factor	1		
Contaminated zone			
Total porosity	0.4		RESRAD-OFFSITE default
Erosion rate (m/yr)	1.01E-05	Chose a small value so that the contaminated zone would not be eroded away. Will yield more conservative results.	Yu et al. 2007
Dry bulk density (g/cm^3)	1.8	Estimated average for different waste streams, based on preliminary GTCC LLRW and GTCC-like waste inventory data.	Sandia 2008
Soil erodibility factor	0.00112	To obtain the desired erosion rate.	Yu et al. 2007
Field capacity	0.3		RESRAD-OFFSITE default
b-parameter	5.3		RESRAD-OFFSITE default
Hydraulic conductivity (m/yr)	10		RESRAD-OFFSITE default

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TABLE E-11 (Cont.)

Parameter	Value	Value Selection Rationale	Source
Cover layer			
Total porosity	0.4		RESRAD-OFFSITE default
Erosion rate (m/yr)	1.00E-05	Chose a small value so that the buried waste would remain covered within the time frame considered (i.e., would yield more conservative groundwater results because there would be no losses through surface runoff and erosion).	Yu et al. 2007
Dry bulk density (g/cm^3)	1.5		RESRAD-OFFSITE default
Soil erodibility factor	0.00093	To obtain the desired erosion rate.	Yu et al. 2007
Unsaturated Zone 1			
Thickness (m)	6.1	According to Part B, Figure 1-6, of WSRC 2008, the thickness of the upper vadose zone can be calculated as the sum of the thicknesses of the soil fill (4 ft), upper waste zone (2.5 ft), and lower waste zone (13.5 ft). The total is 20 ft, (i.e., 6.1 m).	WSRC 2008, Figure 1-6
Density (g/cm^3)	1.65	Calculated with a soil particle density of 2.70 g/cm^3 and an effective porosity of 0.39.	WSRC 2008, Part B, Table 1-14
Total porosity	0.39		WSRC 2008, Part B, Table 1-14, p. 1-55
Effective porosity	0.39	Set to the same value as total porosity.	
Field capacity	0.3		RESRAD-OFFSITE default
Hydraulic conductivity (m/yr)	2.7	For upper vadose zone.	WSRC 2008, Part B, Table 1-14, Appendix G, Table G-2
b-parameter	6.62	Mean of distribution, log normal (LN) (1.89, 0.260) for sandy clay soil.	Yu et al. 2000
Longitudinal dispersivity (m)	0		WSRC 2008, p. 2-43
Unsaturated Zone 2			
Thickness (m)	16.9	The water table in the E-Area and Z-Area is approximately 20 to 25 m below the ground surface.	Kaplan 2006
Density (g/cm^3)	1.62	Calculated with a soil particle density of 2.66 g/cm^3 and an effective porosity of 0.39.	WSRC 2008, Table 1-14
Total porosity	0.39	Used for PORFLOW transport analysis for lower vadose zone.	WSRC 2008, p. 2043
Effective porosity	0.39	For lower vadose zone.	WSRC 2008, Table 1-14
Field capacity	0.3		RESRAD-OFFSITE default
Hydraulic conductivity (m/yr)	29	For lower vadose zone.	WSRC 2008, Tables 1-14, G-2
b-parameter	4.1	Mean of distribution, LN (1.41, 0.275), for sandy clay loam.	Yu et al. 2000
Longitudinal dispersivity (m)	0		WSRC 2008, p. 2-43

TABLE E-11 (Cont.)

Parameter	Value	Value Selection Rationale	Source
Saturated zone hydrology			
Thickness (m)	27.85	Mean of the range of site-specific data (15.5–40.2 m), including thicknesses from the upper and lower aquifer zones and the tan clay confining zone.	For E Area, Cook et al. 2004
Density of saturated zone (g/cm^3)	1.39	Considering the distribution of local clayey sediments throughout the sandy aquifer.	WSRC 2008, p. 1-67
Total porosity	0.38	For sandy material associated with aquifers.	WSRC 2008, p. 1-57
Effective porosity	0.25	Considering the distribution of local clayey sediments throughout the sandy aquifer.	WSRC 2008, p. 1-67
Hydraulic conductivity (m/yr)	1,265	Geometric mean of the values for Upper Three Runs aquifer and Lower Three Runs aquifers.	WSRC 2008, p. 1-57 and Table G-1
Hydraulic gradient to well	0.0079	Geometric mean of the site-specific range for Aquifer Unit IIB, 0.0035–0.018.	MMES et al.1994
Depth of aquifer contributing to well (m), below water table	10		RESRAD-OFFSITE default
Longitudinal dispersivity (m)	10% of the distance traveled	Assumption used for all sites. Common practice for groundwater modeling.	
Horizontal lateral dispersivity (m)	1% of distance traveled	Assumption used for all sites. Common practice for groundwater modeling.	
Disperse vertically (yes/no)	Yes	To consider dispersion.	Yu et al. 2007
Vertical lateral dispersivity (m)	0.1% of distance traveled	Assumption used for all sites.	

TABLE E-12 Soil/Water Distribution Coefficients for Different Radionuclides for SRS[a]

	K_d Value (cm^3/g)				
Element	Unsaturated Zone 1	Unsaturated Zone 2	Saturated Zone	Value Selection Rationale	Source
Ac	8,500	1,100	1,100	Clay/sand material best estimated K_d. Clay material K_d for unsaturated Zone 1. Sand material K_d for unsaturated Zone 2 and saturated zone.	WSRC 2008, Table 2-33; Kaplan 2006
Am	8,500	1,100	1,100	Same as above.	Same as above
C	0	0	0	Same as above.	Same as above
Cm	8,500	1,100	1,100	Same as above.	Same as above
Co	30	7	7	Best value for clayey/sandy sediment.	Kaplan 2006, Table 10
Cs	250	50	50	Best value for sandy/clayey sediment.	Kaplan 2006, Table 10
Fe	400	200	200	Best value for clayey/sandy soil.	Kaplan 2007
Gd	8,500	1,100	1,100	Best value for clayey/sandy sediment.	Kaplan 2006, Table 10
H	0	0	0	Clay/sand material best estimated K_d. Clay material K_d for unsaturated Zone 1. Sand material K_d for unsaturated Zone 2 and saturated zone.	WSRC 2008, Table 2-33; the values listed were obtained from Kaplan 2006
I	0.6	0	0	Same as above.	Same as above
Mn	200	15	15	Best value for clayey/sandy soil.	Kaplan 2007
Mo	120	6	6	Best value for clayey/sandy soil.	Kaplan 2007
Nb	0	0	0	Same as above.	WSRC 2008, Table 2-33; the values listed were obtained from Kaplan 2006
Ni	30	7	7	Same as above.	Same as above
Np	35	0.6	0.6	Same as above.	Same as above
Pa	35	0.6	0.6	Same as above.	Same as above
Pb	5,000	2,000	2,000	Same as above.	Same as above
Po	5,000	2,000	2,000	Best value for clayey/sandy soil.	Kaplan 2006
Pu	5,900	270	270	Clay/sand material best estimated K_d. Clay material K_d for unsaturated Zone 1. Sand material K_d for unsaturated Zone 2 and saturated zone.	WSRC 2008, Table 2-33; the values listed were obtained from Kaplan 2006
Ra	17	5	5	Same as above.	Same as above
Sr	17	5	5	Same as above.	Same as above
Sm	8,500	1,100	1,100	Same as above.	Same as above
Tc	0.2	0.1	0.1	Same as above.	Same as above
Th	2,000	900	900	Same as above.	Best value for sandy soil, Kaplan 2006
U	300	200	200	Same as above.	Same as above

[a] K_d values are listed for the unsaturated zones and the saturated zone. For the contaminated zone, the release fraction of radionuclides is correlated with the metal corrosion rate for the activated metal wastes, the site-specific soil K_d values for sealed sources, and site-specific soil K_d values and cementitious system K_d values for Other Waste.

TABLE E-13 RESRAD-OFFSITE Input Parameter Values for Groundwater Analysis for WIPP Vicinity

Parameter	Value	Value Selection Rationale	Source
Site properties			
Wind speed (m/s)	3.71	Site-specific data, low end of the most prevalent range.	DOE 2006b
Precipitation (m/yr)	0.3048	Site-specific data (about 12 in.).	DOE 2006b
Primary contamination area properties			
Irrigation (m/yr)	0	No agricultural activities.	Yu et al. 2007
Evapotranspiration coefficient	0.9934	To obtain an infiltration rate of 0.002 m/yr, which is indicated in the source suggested by WIPP staff for reference.	Campbell et al. 1996
Runoff coefficient	0.0125	Because of the flat ground surface, the annual runoff is typically 0.1 to 0.2 in. The average value of 0.15 in. converts to a runoff coefficient of 0.0125.	For annual runoff — DOE 2006b
Rainfall and runoff	160	To obtain the erosion rates used as input values for the cover and contamination zone.	Yu et al. 2007 (applies to sum of all four parameters at left)
Slope-length-steepness factor	0.4		
Cover and management factor	0.003		
Support practice factor	1		
Contaminated zone			
Total porosity	0.4		RESRAD-OFFSITE default
Erosion rate (m/yr)	1.00E-05	Chose a small value so that the contaminated zone would not be eroded away. Will yield more conservative results.	Yu et al. 2007
Dry bulk density (g/cm^3)	1.8	Estimated average for different waste streams, based on GTCC LLRW and GTCC-like waste inventory data.	Sandia 2008
Soil erodibility factor	0.42	To obtain the erosion rate used as the input value.	Yu et al. 2007
Field capacity	0.3		RESRAD-OFFSITE default
b-parameter	5.3		RESRAD-OFFSITE default
Hydraulic conductivity (m/yr)	10		RESRAD-OFFSITE default
Cover layer			
Total porosity	0.4		RESRAD-OFFSITE default
Erosion rate (m/yr)	1.00E-05	Chose a small value so that the buried waste would remain covered within the time frame considered (i.e., would yield more conservative groundwater results because there would be no losses through surface runoff and erosion).	Yu et al. 2007
Dry bulk density (g/cm^3)	1.5		RESRAD-OFFSITE default
Soil erodibility factor	0.35	To obtain the erosion rate used as the input value.	Yu et al. 2007

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TABLE E-13 (Cont.)

Parameter	Value	Value Selection Rationale	Source
Unsaturated Zone 1		The perched aquifer located in the Dewey Lake Formation was selected as the groundwater of concern in the modeling. Among the subsurface and deep groundwater aquifers, it has the best water quality and was classified as a U.S. Environmental Protection Agency (EPA) Class II aquifer. The depth to the groundwater table (153 m) specified in Table 4.4-1 of Sandia 2007 (Task 3.4 report) also corresponds to this aquifer in Dewey Lake Formation.	
Thickness (m)	153	Comparable to the groundwater level measurement data.	DOE 2006b; Sandia 2007
Density (g/cm^3)	1.47	Average of sandy and silty soils. According to the description in DOE 2006b, the Dewey Lake Redbeds Formation consists of alternating thin beds of siltstone and fine-grained sandstone.	Yu et al. 2000
Total porosity	0.445	Average of silty and sandy soil.	Distribution information for silt and sand soils from Yu et al. 2000
Effective porosity	0.404	Average of silty and sandy soil.	Distribution information for silt and sand soils from Yu et al. 2000
Field capacity	0.1	Used a smaller value because the moisture content is expected to be low because of the small infiltration rate.	
Hydraulic conductivity (m/yr)	107.31	Geometric mean for sandy and silty soils. Geometric mean for sandy soil was calculated as 803.5 m/yr. Geometric mean for silty soil was calculated as 14.33 m/yr.	Distribution information for silt and sand soils from Yu et al. 2000
b-parameter	1.76	Geometric mean for sandy and silty soils. Geometric mean for sandy soil was calculated as 0.975. Geometric mean for silty soil was calculated as 3.1899.	Distribution information for sand and silt soils from Yu et al. 2000
Longitudinal dispersivity (m)	0	No dispersivity was assumed for the unsaturated zone.	Assumption used for all sites.

TABLE E-13 (Cont.)

Parameter	Value	Value Selection Rationale	Source
Saturated zone hydrology			
Thickness (m)	5.1	Saturated thickness for the natural water table identified in middle Dewey Lake.	DOE 2006b
Density of saturated zone (g/cm^3)	1.47	Average of sandy and silty soils.	Distribution information for silt and sand soils from Yu et al. 2000
Total porosity	0.445	Average of silt and sand soil.	Distribution information for silt and sand soils from Yu et al. 2000
Effective porosity	0.404	Average of silt and sand soil.	Distribution information for silt and sand soils from Yu et al. 2000
Hydraulic conductivity (m/yr)	107.31	Geometric mean for sandy and silty soils. Geometric mean for sandy soil was calculated as 803.5 m/yr. Geometric mean for silty soil was calculated as 14.33 m/yr.	Distribution information for silt and sand soils from Yu et al. 2000
Hydraulic gradient to well	0.017	The gradient in Dewey Lake is 20−40 ft/mi in the east. It is up to 150 ft/mi to the west. Average is 90 ft/mi.	Powers et al. 1978
Depth of aquifer contributing to well (m), below water table	5.1	Set to the depth of aquifer.	Yu et al. 2007
Longitudinal dispersivity (m)	10% of the distance traveled	Assumption used for all sites. Common practice for groundwater modeling.	
Horizontal lateral dispersivity (m)	10% of the longitudinal dispersivity	Assumption used for all sites. Common practice for groundwater modeling.	
Disperse vertically (yes/no)	Yes	To consider dispersion.	Yu et al. 2007
Vertical lateral dispersivity (m)	10% of the horizontal lateral dispersivity	Assumption used for all sites.	

TABLE E-14 Soil/Water Distribution Coefficients for Different Radionuclides for WIPP Vicinity[a]

	K_d Value (cm^3/g)			
Element	Unsaturated Zone	Saturated Zone	Value Selection Rationale[b]	Source
Ac	450	450	Value for sandy soil	Sheppard and Thibault 1990
Am	1,445	1,445	Value for generic soil	Yu et al. 2000
C	5	5	Value for sandy soil	Sheppard and Thibault 1990
Cm	4,000	4,000	Value for sandy soil	Sheppard and Thibault 1990
Co	60	60	Value for sandy soil	Sheppard and Thibault 1990
Cs	280	280	Value for sandy soil	Sheppard and Thibault 1990
Fe	209	209	Value for generic soil	Yu et al. 2000
Gd	825	825	Value for generic soil	Yu et al. 2000
H	0.06	0.06	Value for generic soil	Yu et al. 2000
I	1	1	Value for sandy soil	Sheppard and Thibault 1990
Mn	50	50	Value for sandy soil	Sheppard and Thibault 1990
Mo	10	10	Value for sandy soil	Sheppard and Thibault 1990
Nb	160	160	Value for sandy soil	Sheppard and Thibault 1990
Ni	400	400	Value for sandy soil	Sheppard and Thibault 1990
Np	5	5	Value for sandy soil	Sheppard and Thibault 1990
Pa	380	380	Value for generic soil	Yu et al. 2000
Pb	270	270	Value for sandy soil	Sheppard and Thibault 1990
Po	150	150	Value for sandy soil	Sheppard and Thibault 1990
Pu	550	550	Value for sandy soil	Sheppard and Thibault 1990
Ra	500	500	Value for sandy soil	Sheppard and Thibault 1990
Sr	15	15	Value for sandy soil	Sheppard and Thibault 1990
Sm	245	245	Value of sandy soil	Sheppard and Thibault 1990
Tc	0.1	0.1	Value for sandy soil	Sheppard and Thibault 1990
Th	3,200	3,200	Value for sandy soil	Sheppard and Thibault 1990
U	35	35	Value for sandy soil	Sheppard and Thibault 1990

[a] K_d values are listed for the unsaturated zones and the saturated zone. For the contaminated zone, the release fraction of radionuclides is correlated with the metal corrosion rate for the activated metal wastes, the site-specific soil K_d values for sealed sources, and site-specific soil K_d values and cementitious system K_d values for Other Waste.

[b] The K_d value selected was the smaller one of either the value for sandy soil given in Sheppard and Thibault (1990) or the value for generic soil recommended in NUREG/CR-6697 (Yu et al. 2000).

TABLE E-15 Water Infiltration Rates Used in the RESRAD-OFFSITE Analyses for the Six DOE Sites[a]

Parameter	Evaluated Sites					
	Hanford Site	INL Site	LANL	NNSS	SRS	WIPP Vicinity
Precipitation rate (m/yr)	0.17	0.22	0.36	0.13	1.2	0.3
Irrigation rate[b] (m/yr)	0	0	0	0	0	0
Infiltration rate used in the analyses (m/yr)	0.0035	0.05	0.005	0.00003	0.376	0.002

a Values were obtained from site reports.

b No agricultural activity over the disposal areas was assumed for this analysis

TABLE E-16 Unsaturated Zone Characteristics Used as Input Parameters in the RESRAD-OFFSITE Analyses for the Six DOE Sites[a]

	Disposal Site Considered					
Parameter	Hanford Site	INL Site	LANL	NNSS	SRS	WIPP Vicinity
Unsaturated Zone 1						
Thickness (m)	58	9.14	13	246	6.1	153
Density (g/cm^3)	1.65	1.64	1.4	1.65	1.65	1.47
Total porosity	0.37	0.5	0.41	0.36	0.39	0.445
Effective porosity	0.37	0.5	0.41	0.36	0.39	0.404
Field capacity	0.03	0.1	0.02	0.3	0.3	0.1
Hydraulic conductivity (m/yr)	710	29,200	61.81	0.00003	2.7	107.31
Soil b-parameter	4.05	4.34	0.175	5.3	6.62	1.76
Unsaturated Zone 2						
Thickness (m)	30	94.6	26	–[b]	16.9	–
Density (g/cm^3)	1.93	2.0	1.2	–	1.62	–
Total porosity	0.27	0.05	0.47	–	0.39	–
Effective porosity	0.27	0.05	0.47	–	0.39	–
Field capacity	0.024	0.001	0.02	–	0.3	–
Hydraulic conductivity (m/yr)	148	3650	46.36	–	29	–
Soil b-parameter	7.12	0.76	1.339	–	4.1	–
Unsaturated Zone 3						
Thickness (m)	–	7.47	16	–	–	–
Density (g/cm^3)	–	1.46	1.2	–	–	–
Total porosity	–	0.57	0.44	–	–	–
Effective porosity	–	0.57	0.44	–	–	–
Field capacity	–	0.3	0.04	–	–	–
Hydraulic conductivity (m/yr)	–	1.29	71.08	–	–	–
Soil b-parameter	–	3.6	2.152	–	–	–
Unsaturated Zone 4						
Thickness (m)	–	15.39	3	–	–	–
Density (g/cm^3)	–	1.64	0.8	–	–	–
Total porosity	–	0.5	0.67	–	–	–
Effective porosity	–	0.5	0.67	–	–	–
Field capacity	–	0.3	0.00001	–	–	–
Hydraulic conductivity (m/yr)	–	29,200	46.36	–	–	–
Soil b-parameter	–	10.4	1.891	–	–	–
Unsaturated Zone 5						
Thickness (m)	–	10.52	211	–	–	–
Density (g/cm^3)	–	2.0	2.7	–	–	–
Total porosity	–	0.05	0.001	–	–	–
Effective porosity	–	0.05	0.001	–	–	–
Field capacity	–	0.001	0.00001	–	–	–
Hydraulic conductivity (m/yr)	–	365,000	309.05	–	–	–
Soil b-parameter	–	1.67	2.71	–	–	–

[a] The values given here were used in the RESRAD-OFFSITE evaluations for post-closure performance of the vault method. A smaller value for thickness (of the effective unsaturated zone) was used as the input value for evaluating post-closure performance of the trench and borehole methods to simulate placement of the waste in the unsaturated zone for these two methods.

[b] A dash means not applicable.

TABLE E-17 Saturated Zone Characteristics Used as Input Parameters in the RESRAD-OFFSITE Analyses for the Six DOE Sites[a]

	Evaluated Site					
Parameter	Hanford Site	INL Site	LANL	NNSS	SRS	WIPP Vicinity
Thickness (m)	45	495	37.5	220	27.85	5.1
Density of saturated zone (g/cm^3)	1.98	2.0	2.7	1.6	1.39	1.47
Total porosity	0.25	0.05	0.05	0.36	0.38	0.445
Effective porosity	0.25	0.05	0.05	0.36	0.25	0.404
Hydraulic conductivity (m/yr)	12,775	1,979	309.1	439	1,265	107.31
Hydraulic gradient to well	0.00124	0.00075	0.013	0.000097	0.0079	0.017
Depth of aquifer contributing to well (m)	10	10	10	10	10	5.1

[a] Parameter values were obtained from site reports when available.

TABLE E-18 Soil/Water Distribution Coefficient (K_d) Values (cm^3/g) Used in RESRAD-OFFSITE Analyses for the Six DOE Sites[a]

		Evaluated Sites					
Element[b]	Soil Layer[c]	Hanford Site	INL Site	LANL[d]	NNSS	SRS	WIPP Vicinity
Ac	UZ	300, 30	225, 0, 225, 225, 0	130	7,000	8,500; 1,100	450
	SZ	300	9	130	7,000	1,100	450
Am	UZ	1,900; 190	225, 0, 225, 225, 0	2,400	7,000	8,500; 1,100	1,445
	SZ	1,900	9	2,400	7,000	1,100	1,445
C	UZ	4, 0.4	0.4, 0, 0.4, 0.4, 0	0	0	0, 0	5
	SZ	4	0.016	0	0	0	5
Cm	UZ	300, 30	4,000; 0; 4,000; 4,000; 0	50	4,000	8,500; 1,100	4,000
	SZ	300	160	50	4,000	1,100	4,000
Co	UZ	2,000; 200	10, 0, 10, 10, 0	0.45	60	30, 7	60
	SZ	2,000	0.4	0.45	60	7	60
Cs	UZ	80, 8	500, 0, 500, 500, 0	7.5	280	250, 50	280
	SZ	80	20	7.5	280	50	280
Fe	UZ	220, 22	220, 0, 220, 220, 0	209	209	400, 200	209
	SZ	220	8.8	209	209	200	209
Gd	UZ	825, 82.5	240, 0, 240, 240, 0	50	825	8,500; 1,100	825
	SZ	825	9.6	50	825	1,100	825

TABLE E-18 (Cont.)

		Evaluated Sites					
Element[b]	Soil Layer[c]	Hanford Site	INL Site	LANL[d]	NNSS	SRS	WIPP Vicinity
H	UZ	0, 0	0, 0, 0, 0, 0	0	0	0, 0	0.06
	SZ	0	0	0	0	0	0.06
I	UZ	0, 0	0, 0, 0, 0, 0	0	0	0.6, 0	1
	SZ	0	0	0	0	0	1
Mn	UZ	50, 5	50, 0, 50, 50, 0	158	50	200, 15	50
	SZ	50	2	158	50	15	50
Mo	UZ	10, 1	10, 0, 10, 10, 0	4	10	120, 6	10
	SZ	10	0.4	4	10	6	10
Nb	UZ	300, 30	500, 0, 500, 500, 0	100	7,000	0, 0	160
	SZ	300	20	100	7,000	0	160
Ni	UZ	400, 40	100, 0, 100, 100, 0	50	100	30, 7	400
	SZ	400	4	50	100	7	400
Np	UZ	2.5, 0.25	23, 0, 23, 23, 0	2.2	5	35, 0.60	5
	SZ	2.5	0.92	2.2	5	0.6	5
Pa	UZ	2.5, 0.25	8, 0, 8, 8, 0	5,500	5	35, 0.6	380
	SZ	2.5	0.32	5,500	5	0.6	380
Pb	UZ	80, 8	270, 0, 270, 270, 0	25	300	5,000; 2,000	270
	SZ	80	10.8	25	300	2,000	270
Po	UZ	150, 15	150, 0, 150, 150, 0	10	300	5,000; 2,000	150
	SZ	150	6	10	300	2,000	150

TABLE E-18 (Cont.)

		Evaluated Sites					
Element[b]	Soil Layer[c]	Hanford Site	INL Site	LANL[d]	NNSS	SRS	WIPP Vicinity
Pu	UZ	150, 15	2,500; 0; 2,500; 2,500; 0	4.1	7.5	5,900; 270	550
	SZ	150	100	4.1	7.5	270	550
Ra	UZ	10, 1	575, 0, 575, 575, 0	500	185	17, 5	500
	SZ	10	23	500	185	5	500
Sm	UZ	300, 30	2,500; 0; 2,500; 2,500; 0	50	245	8,500; 1,100	245
	SZ	300	100	50	245	1,100	245
Sr	UZ	10, 1	12, 0, 12, 12, 0	40	420	17, 5	15
	SZ	10	0.48	40	420	5	15
Tc	UZ	0, 0	0, 0, 0, 0, 0	0	0	0.2, 0.1	0.1
	SZ	0	0	0	0	0.1	0.1
Th	UZ	3,200; 320	500, 0, 500, 500, 0	5,000	7,000	2,000; 900	3,200
	SZ	3,200	20	5,000	7,000	900	3,200
U	UZ	0.6, 0.06	15.4, 0, 15.4, 15.4, 0	2.4	0.8	300, 200	35
	SZ	0.6	0.616	2.4	0.8	200	35

[a] K_d values were obtained from site reports and other site sources, as identified in Tables E-3, E-5, E-7, E-9, E-11, and E-13.

[b] The K_d values for different isotopes of the same element were assumed to be the same in the analysis.

[c] For purposes of this analysis, the transport of radionuclides leached from the disposal area was assumed to occur in vadose zones and the saturated zone at all potential disposal sites. The physical properties of these zones are site dependent. Abbreviations for vadose zones (which are unsaturated) and the saturated zone are UZ and SZ, respectively.

[d] For the LANL site, all the vadose zones were assumed to have the same K_d value.

TABLE E-19 RESRAD-OFFSITE Input Parameter Values for Groundwater Analysis for Generic Commercial Sites in the Four Regions

Parameter Name	Region I	Region II	Region III	Region IV
Site properties				
Precipitation (m/yr)[a]	0.074	0.18	0.05	0.001
Primary contamination area properties[b]				
Irrigation (m/yr)	0	0	0	0
Evapotranspiration coefficient	0	0	0	0
Runoff coefficient[c]	0	0	0	0
Rainfall and runoff[c]	160	160	160	160
Slope-length-steepness factor	0.4	0.4	0.4	0.4
Cover and management factor	0.03	0.03	0.03	0.03
Support practice factor	1	1	1	1
Contaminated zone[b]				
Total porosity	0.4	0.4	0.4	0.4
Erosion rate (m/yr)	1.00E-05	1.00E-05	1.00E-05	1.00E-05
Dry bulk density (g/cm^3)	1.8	1.8	1.8	1.8
Soil erodibility factor	0.42	0.42	0.42	0.42
Field capacity	0.3	0.3	0.3	0.3
b-parameter	5.3	5.3	5.3	5.3
Hydraulic conductivity (m/yr)	10	10	10	10
Cover layer[b]				
Total porosity	0.4	0.4	0.4	0.4
Erosion rate (m/yr)	1.00E-05	1.00E-05	1.00E-05	1.00E-05
Dry bulk density (g/cm^3)	1.5	1.5	1.5	1.5
Soil erodibility factor	0.35	0.35	0.35	0.35
Unsaturated zone 1[d]				
Thickness (m)	3.353	13.41	2.16	54.86
Density (g/cm^3)	1.6	1.5	1.5	1.6
Total porosity	0.38	0.42	0.44	0.41
Effective porosity	0.38	0.42	0.44	0.41
Field capacity	0.093	0.15	0.23	0.12
Hydraulic conductivity (m/yr)	1981	201	518	1798
b parameter[b]	5.3	5.3	5.3	5.3
Longitudinal dispersivity (m)[b]	0	0	0	0
Saturated zone hydrology[d]				
Thickness (m)	13.72	15.24	11.28	64
Density of saturated zone (g/cm^3)	1.6	1.8	1.6	1.7
Total porosity	0.38	0.4	0.38	0.3
Effective porosity	0.22	0.23	0.22	0.17
Hydraulic conductivity (m/yr)[e]	103.6	18.9	21.03	91
Hydraulic gradient to well[e]	1	1	1	1
Depth of aquifer contributing to well (m), below water table	10	10	10	10
Longitudinal dispersivity (m)	10% of distance traveled	10% of distance traveled	10% of distance traveled	10% of distance traveled

TABLE E-19 (Cont.)

Parameter Name	Region I	Region II	Region III	Region IV
Horizontal lateral dispersivity (m)	10% of longitudinal dispersivity	10% of longitudinal dispersivity	10% of longitudinal dispersivity	10% of longitudinal dispersivity
Disperse vertically (yes/no)	Yes	Yes	Yes	Yes
Vertical lateral dispersivity (m)	10% of horizontal lateral dispersivity	10% of horizontal lateral dispersivity	10% of horizontal lateral dispersivity	10% of horizontal lateral dispersivity

[a] The input value for the precipitation rate was set to match the infiltration rate used in NUREG-0782, Vol. 4 (NRC 1981). In order to obtain the same infiltration rate to the vadose zone as that used in NUREG-0782, the irrigation rate, evapotranspiration rate, and runoff coefficient were all set to 0.

[b] Input parameters for the primary contamination area, contaminated zone, and cover layers were kept the same as those used for the DOE alternate sites, unless specifically noted.

[c] The evapotranspiration rate and runoff coefficient were set to zero in order to obtain the desired water infiltration rate. See also note footnote a.

[d] Input parameters for the unsaturated and saturated zones were obtained from Toblin (1998, 1999), and Poe (1998), unless specifically noted.

[e] To obtain the same Darcy's velocity as used in Toblin (1999), the hydraulic conductivity was set to the Darcy velocity value, while the hydraulic gradient was set to 0.

TABLE E-20 Soil/Water Distribution Coefficients (cm^3/g) for Different Radionuclides[a] for Commercial Facilities in the Four Regions

	Region I		Region II		Region III		Region IV	
Element	Unsaturated Zone	Saturated Zone	Unsaturated Zone	Saturated Zone	Unsaturated Zone	Saturated Zone	Unsaturated Zone	Saturated Zone
Ac	228	228	538	228	538	228	228	228
Am	82	82	200	82	200	82	82	82
C	0	0	0	0	0	0	0	0
Cm	82	82	200	82	200	82	82	82
Co	2	2	9	2	9	2	2	2
Cs	51	51	249	51	249	51	51	51
Fe[b]	209	209	209	209	209	209	209	209
Gd[b]	50	50	50	50	50	50	50	50
H	0	0	0	0	0	0	0	0
I	0	0	0	0	0	0	0	0
Mn[b]	50	50	50	50	50	50	50	50
Mo[b]	4	4	4	4	4	4	4	4
Nb	50	50	100	50	100	50	50	50
Ni	12	12	59	12	59	12	12	12
Np	3	3	3	3	3	3	3	3
Pa	0	0	50	0	50	0	0	0
Pb	234	234	597	234	597	234	234	234
Po[c]	234	234	597	234	597	234	234	234
Pu	10	10	100	10	100	10	10	10
Ra	24	24	100	24	100	24	24	24
Sm	228	228	538	228	538	228	228	228
Sr	24	24	100	24	100	24	24	24
Tc	3	3	3	3	3	3	3	3
Th	100	100	100	100	100	100	100	100
U	0	0	50	0	50	0	0	0

a K_d values were obtained from Toblin (1999) unless specifically noted.

b Selected K_d values for Fe, Gd, Mn, Mo, respectively, were the smallest values among those used for the six federal sites.

c The value of the K_d for Po was set to be same as the value of the K_d for Pb.

TABLE E-21 Estimated Peak Annual Doses (in mrem/yr) from the Use of Contaminated Groundwater for the No Action Alternative[a,b]

		Peak Annual Dose (mrem/yr) within 10,000 and 100,000 Years							
		GTCC LLRW				GTCC-Like Waste			
NRC Region	Time Period of Analysis (yr)	Activated Metals	Sealed Sources	Other Waste - CH	Other Waste - RH	Activated Metals	Sealed Sources	Other Waste - CH	Other Waste - RH
I	10,000	130	73,000	3,800	26,000	–	–	97,000	270,000
	100,000	130	73,000	3,800	26,000	–	–	97,000	270,000
II	10,000	10	210	–	850	0.14	–	0.14	0
	100,000	170	16,000	–	3,200	0.14	–	180	14,000
III	10,000	6.2	120	–	–	–	–	–	–
	100,000	190	13,000	–	–	–	–	–	–
IV	10,000	0	0	0	0	0	0	0	0
	100,000	0	9.3	0	0.023	0	0	0.89	9.8

[a] CH = contact-handled, GTCC = greater-than-Class C, RH = remote-handled, Region I–IV = a generic storage site located within each of the four NRC regions.

[b] These annual doses are associated with the use of contaminated groundwater by a hypothetical resident farmer located 100 m (330 ft) from the edge of the storage facility. All values are given to two significant figures, and a dash means there is no inventory for that waste type. The values given in this table represent the peak annual doses from each waste type. Because of the different radionuclide mixes and activities contained in the different waste types, the peak annual doses that could result from each waste type individually generally occur at different times than the peak annual dose from the entire inventory. The peak annual doses from the entire GTCC LLRW and GTCC-like waste inventory are given in Chapter 3 of the EIS.

TABLE E-22 Estimated Peak Annual Doses (in mrem/yr) from the Use of Contaminated Groundwater at the Various Sites for the Stored Group 1 Inventory[a,b]

			Peak Annual Dose (mrem/yr) within 10,000 and 100,000 Years							
			GTCC LLRW				GTCC-Like Waste			
Site	Method	Time Period of Analysis (yr)	Activated Metals	Sealed Sources	Other Waste - CH	Other Waste - RH	Activated Metals	Sealed Sources	Other Waste - CH	Other Waste - RH
Hanford Site	Vault	10,000	0.26	–[b]		0.044	0	0	0.012	40
		100,000	0.26	–	< 0.001	0.36	0	< 0.001	20	40
		10,000	0.33	–		0.042	0	0	0.014	39
		100,000	0.33	–	< 0.001	0.35	0	< 0.001	24	39
		10,000	0.17	– 0		0.013	0	0	< 0.0042	0.11
		100,000	0.17	–	0	0.11	< 0.001	< 0.001	7.5	0.63
INL Site	Vault	10,000	7.7	0 –	0	2.3	0.86	0	5.5	2,200
		100,000	7.7	– 0		2.3	0.86	0	70	2,200
	Trench	10,000	8.9	–		2.0	0.99	0	6.4	1,900
		100,000	8.9	–		2.0	0.99	0	78	1,900
	Borehole	10,000	6.2	– 0.0029		0.79	0.68	0	48	750
		100,000	6.2	–		0.79	0.68	0	53	750
LANL	Vault	10,000	60	0 – 0	0	0.22	0.45	0	1.8	230
		100,000	60	– 0		0.22	0.45	0	1.8	230
	Trench	10,000	5.2	– 0		0.21	0.55	0	2.2	210
		100,000	5.2	–		0.21	0.55	0	2.2	210
	Borehole	10,000	3.0	–		0.065	0.33	0	0.74	67
		100,000	3.0	– 0		0.065	0.33	0	0.74	67
NNSS	Vault	10,000	0	0 – 0	0	0	0	0	0	0
		100,000	0	– 0	0	0	0	0	0	0
	Trench	10,000	0	– 0	0	0	0	0	0	0
		100,000	0	–	0	0	0	0	0	0
	Borehole	10,000	0	–	0	0	0	0	0	0
		100,000	0	–	0	0	0	0	0	0

Trench

Borehole

TABLE E-22 (Cont.)

			Peak Annual Dose (mrem/yr) within 10,000 and 100,000 Years							
			GTCC LLRW				GTCC-Like Waste			
Site	Method	Time Period of Analysis (yr)	Activated Metals	Sealed Sources	Other Waste - CH	Other Waste - RH	Activated Metals	Sealed Sources	Other Waste - CH	Other Waste - RH
SRS[c]	Vault	10,000	2.9	–	0.0051	1.3	0.21	< 0.001	40	1,000
		100,000	2.9	–		1.3	0.21	< 0.001	120	1,000
		10,000	4.0	–		1.4	0.27	< 0.001	62	1,100
		100,000	8.0	–		1.4	0.27	< 0.001	130	1,100
WIPP Vicinity	Vault	10,000	0	0.0051 –	0	0	0	0	0	0
		100,000	2.9	0.0059 –		0.16	0	0	0.039	36
		10,000	0	0.0059 –	0	0	0	0	0	0
		100,000	2.9	–		0.12	0	0	0.039	28
	Trench	10,000	0	–	0	0	0	0	0	0
		100,000	2.9	– 0		0.068	0	0	0.022	16
Region I[c]	Vault	10,000	14	– 0	0	24	0.027	0.0075	700	3,200
		100,000	14	–		24	0.027	0.0075	700	3,200
Trench				0						
Region II[c] Borehole	Vault	10,000	0.98	–	0.013	0.056	0.13	0	18	940
		100,000	16	–		5.4	0.13	0	130	940
		10,000	1.7	– 0		0.25	0.16	0	20	950
		100,000	62	–		18	0.16	0	590	2,100
Region III[c]	Vault	10,000	1.1	0.013 –	0	0.077	0.16	0	6.3	410
		100,000	32	– 0		3.7	0.16	0	90	410
Region IV Trench	Vault	10,000	0	0 –	0	0	0	0	0	0
		100,000	0.0041	–		0.11	0	0	5.8	5.7
		10,000	0	– 0		0	0	0	0	0
		100,000	0.0072	–		0.10	0	0	7.1	5.4
		10,000	0	–		0	0	0	0	0
		100,000	0.028	– 0		0.034	0.0039	0	2.3	1.7

Footnotes appear on next page.

0
0
Trench
0
0
Borehole

TABLE E-22 (Cont.)

[a] CH = contact-handled, GTCC = greater-than-Class C, INL = Idaho National Laboratory, LANL = Los Alamos National Laboratory, NNSS = Nevada National Security Site, RH = remote-handled, SRS = Savannah River Site, WIPP = Waste Isolation Pilot Plant, Region I–IV = a generic commercial site located within each of the four major regions of the country.

[b] These annual doses are associated with the use of contaminated groundwater by a hypothetical resident farmer located 100 m (330 ft) from the edge of the disposal facility. All values are given to two significant figures, and a dash means there is no inventory for that waste type. Annual doses of less than 0.001 mrem/yr are reported as <0.001. The values given in this table represent the peak annual doses from each waste type. Because of the different radionuclide mixes and activities contained in the different waste types, the peak annual doses that could result from each waste type individually generally occur at different times than the peak annual dose from the entire inventory. The peak annual doses from the entire GTCC LLRW and GTCC-like waste inventory are given in the site-specific chapters of the EIS.

[c] The above-grade vault is the only method evaluated for Region I and Region III because of the shallow groundwater depth. The borehole method is not considered suitable for SRS and Regions I, II, and III.

TABLE E-23 Estimated Peak Annual Doses (in mrem/yr) from the Use of Contaminated Groundwater at the Various Sites for the Projected Group 1 Inventory[a,b]

			Peak Annual Dose (in mrem/yr) within 10,000 and 100,000 Years							
			GTCC LLRW				GTCC-Like Waste			
Site	Method	Time Period of Analysis (yr)	Activated Metals	Sealed Sources	Other Waste - CH	Other Waste - RH	Activated Metals	Sealed Sources	Other Waste - CH	Other Waste - RH
Hanford Site	Vault	10,000	4.0	0	–[b]		0	0	0.0045	0.12
		100,000	4.0	21	–	0.011	0	0.0012	5.6	480
		10,000	5.0	0	–	0.0013	0	0	0.0055	0.12
		100,000	5.0	25	–	0.011	0	0.0015	6.9	460
		10,000	2.6	0	– 0.0013	< 0.001	0	0	0.0016	0.036
		100,000	2.6	11	–	0.0033	< 0.001	< 0.001	2.1	140
INL Site	Vault	10,000	120	0.028	–	0.069	2.1	0	1.6	6.4
Trench		100,000	120	150	–	0.069	2.1	0.0058	19	1,700
		10,000	140	0	–	0	2.5	0	1.8	5.7
Borehole		100,000	140	170	–	0	2.5	0	22	1,500
		10,000	93	32	–	0.024	1.7	0	8.4	580
		100,000	93	74	–	0.024	1.7	0	8.6	580
LANL	Vault	10,000	64	0	–	0	1.1	0	0.52	0.62
Trench		100,000	64	0	–	0	1.1		0.52	0.62
	Trench			0	–	0	1.4	0	0.63	0.58
Borehole		100,000	78	0	–	0	1.4		0.63	0.58
	Borehole	10,000	46	0	–	0	0.81	0	0.21	0.18
	10,000	100,000 78	46	0	–	0	0.81 0	0	0.21	0.18
NNSS	Vault	10,000	0	0	–	0	0 0	0	0	0
		100,000	0	0	–		0	0	0	0
		10,000	0	0	–		0	0	0	0
		100,000	0	0	–		0	0	0	0
		10,000	0	0	–		0	0	0	0
		100,000	0	0	–	0	0	0	0	0

0
0
Trench
0
0
Borehole

TABLE E-23 (Cont.)

			Peak Annual Dose (mrem/yr) within 10,000 and 100,000 Years							
			GTCC LLRW				GTCC-Like Waste			
Site	Method	Time Period of Analysis (yr)	Activated Metals	Sealed Sources	Other Waste - CH	Other Waste - RH	Activated Metals	Sealed Sources	Other Waste - CH	Other Waste - RH
SRS[c]	Vault	10,000	45	150	–	0.039	0.53	< 0.001	10	3.6
		100,000	45	150	–	0.039	0.53	< 0.001	33	400
	Trench			170	–	0.043	0.66	< 0.001	16	3.9
		100,000	120	330	–	0.043	0.66	0.073	38	430
WIPP Vicinity	Vault 10,000	10,000 60	0	0	–	0	0	0	0	0
		100,000	44	0	–	0.0047	0	0		0.44
		10,000	0	0	–	0	0	0	0	0
		100,000	44	0	–	0.0037	0	0	0.014	0.34
		10,000	0	0	–	0	0	0	0	0
		100,000	44	0	–	0.0021	0	0 0.014	< 0.001	0.19
Region I[c]	Vault	10,000	220	5,300	–	0.73	0.067	10	200	9,700
Trench		100,000	220	5,300	–	0.73	0.067	10	200	9,700
Region II[c] Borehole	Vault	10,000	15	220	–	0.0059	0.33	0	3.2	0.55
		100,000	250	1,400	–	0.16	0.33		37	330
	Trench			250	–	0	0.39	0	4.7	320
		100,000	940	5,400	–	0.54	0.39 0.049	4.6	170	430
Region III[c]	Vault 10,000	10,000 26	18	95	–	0	0.40		1.4	0.2
		100,000	490	940	–	0.11	0.40	0.19	26	170
Region IV	Vault	10,000	0	0	–	0	0 0	0	0	0
		100,000	0.062	5.7	–	0.0032	0	0	1.6	130
		10,000	0	0	–	0	0	0	0	0
		100,000	0.11	6.9	–	0.0031	0.0013	0	1.9	130
		10,000	0	0	–	0	0	0	0	0
		100,000	0.45	2.3	–	< 0.001	< 0.001	0	0.64	44

Footnotes appear on next page.

Trench

Borehole

TABLE E-23 (Cont.)

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[a] CH = contact-handled, GTCC = greater-than-Class C, INL = Idaho National Laboratory, LANL = Los Alamos National Laboratory, NNSS = Nevada National Security Site, RH = remote-handled, SRS = Savannah River Site, WIPP = Waste Isolation Pilot Plant, Region I–IV = a generic commercial site located within each of the four major regions of the country.

[b] These annual doses are associated with the use of contaminated groundwater by a hypothetical resident farmer located 100 m (330 ft) from the edge of the disposal facility. All values are given to two significant figures, and a dash means there is no inventory for that waste type. Annual doses of less than 0.001 mrem/yr are reported as <0.001. The values given in this table represent the peak annual doses from each waste type. Because of the different radionuclide mixes and activities contained in the different waste types, the peak annual doses that could result from each waste type individually generally occur at different times than the peak annual dose from the entire inventory. The peak annual doses from the entire GTCC LLRW and GTCC-like waste inventory are given in the site-specific chapters of the EIS.

[c] The above-grade vault is the only method evaluated for Region I and Region III because of the shallow groundwater depth. The borehole method is not considered suitable for SRS and Regions I, II, and III.

TABLE E-24 Estimated Peak Annual Doses (in mrem/yr) from the Use of Contaminated Groundwater at the Various Sites for the Total Group 1 Inventory[a,b]

			Peak Annual Dose (mrem/yr) within 10,000 and 100,000 Years							
			GTCC LLRW				GTCC-Like Waste			
Site	Method	Time Period of Analysis (yr)	Activated Metals	Sealed Sources	Other Waste - CH	Other Waste - RH	Activated Metals	Sealed Sources	Other Waste - CH	Other Waste - RH
Hanford Site	Vault	10,000	4.2	0	0	0.045	0	0	0.016	41
		100,000	4.2	21	< 0.001	0.38	0	0.0012	26	490
		10,000	5.3	0	0	0.043	0	0	0.02	39
		100,000	5.3	25	< 0.001	0.36	0	0.0015	31	480
		10,000	2.8	0	0	0.013	0	0	0.0058	0.14
		100,000	2.8	11	0	0.11	< 0.001	< 0.001	9.6	140
INL Site	Vault	10,000	130	0.028	0	2.3	3.0	0	7.1	2,200
	Trench	100,000	130	150	0.0029	2.3	3.0	0.0058	89	2,200
		10,000	150	0	0	2.0	3.4	0	8.2	1,900
	Borehole	100,000	150	170	0	2.0	3.4	0	100	1,900
		10,000	99	32	0	0.81	2.4	0	56	750
		100,000	99	74	0	0.81	2.4	0	61	750
LANL	Vault	10,000	120	0	0	0.22	1.6	0	2.3	230
	Trench	100,000	120	0	0	0.22	1.6	0	2.3	230
		10,000	84	0	0	0.21	1.9	0	2.8	210
	Borehole	100,000	84	0	0	0.21	1.9	0	2.8	210
		10,000	49	0	0	0.065	1.1	0	0.95	67
		100,000	49	0	0	0.065	1.1	0	0.95	67
NNSS	Vault	10,000	0	0	0	0	0	0	0	0
	Trench	100,000	0	0	0	0	0	0	0	0
		10,000	0	0	0	0	0	0	0	0
	Borehole	100,000	0	0	0	0	0	0	0	0
		10,000	0	0	0	0	0	0	0	0
		100,000	0	0	0	0	0	0	0	0

Trench

Borehole

TABLE E-24 (Cont.)

			Peak Annual Dose (mrem/yr) within 10,000 and 100,000 Years							
			GTCC LLRW				GTCC-Like Waste			
Site	Method	Time Period of Analysis (yr)	Activated Metals	Sealed Sources	Other Waste - CH	Other Waste - RH	Activated Metals	Sealed Sources	Other Waste - CH	Other Waste - RH
SRS[c]	Vault	10,000	48	150	0.0051	1.3		< 0.001	50	1,000
		100,000	48	150	0.0051	1.3	0.74	< 0.001	150	1,000
		10,000	64	170	0.0059	1.4	0.74 0.93	< 0.001	79	1,100
		100,000	130	330	0.0059	1.4	0.93	0.073	170	1,100
WIPP Vicinity	Vault	10,000	0	0	0	0	0	0	0	0
		100,000	47	0	0	0.16	0	0	0.054	36
		10,000	0	0	0	0	0	0	0	0
Trench		100,000	47	0	0	0.13	0	0	0.053	28
		10,000	0	0	0	0	0	0	0	0
		100,000	47	0	0	0.070	0	0	0.030	16
Region I[c]	Vault	10,000	230	5,300	0	25	0.093	10	900	10,000
Trench		100,000	230	5,300	0	25	0.093	10	900	10,000
Region II[c] Borehole	Vault	10,000	16	220	0.013	0.060	0.46	0	19	940
		100,000	260	1,400	0.013	5.5	0.46	0.049	170	940
		10,000	27	250	0	0.25	0.55	0	22	950
		100,000	1,000	5,400	0	18	0.55	4.6	760	2,600
Region III[c]	Vault	10,000	19	95	0	0.077	0.55	0	6.8	410
		100,000	520	940	0	3.8	0.55	0.19	120	580
Region IV Trench	Vault	10,000	0	0	0	0	0	0	0	0
		100,000	0.066	5.7	0	0.11	0	0	7.3	140
		10,000	0	0	0	0	0	0	0	0
		100,000	0.12		0	0.11	0.0013		9	130
		10,000	0	0	0	0	0	0	0	0
		100,000	0.48	2.3	0	0.035	0.013	0	3	45

6.9 0

Footnotes appear on next page.

Trench

Borehole

TABLE E-24 (Cont.)

[a] CH = contact-handled, GTCC = greater-than-Class C, INL = Idaho National Laboratory, LANL = Los Alamos National Laboratory, NNSS = Nevada National Security Site, RH = remote-handled, SRS = Savannah River Site, WIPP = Waste Isolation Pilot Plant, Region I– IV = a generic commercial site located within each of the four major regions of the country.

[b] These annual doses are associated with the use of contaminated groundwater by a hypothetical resident farmer located 100 m (330 ft) from the edge of the disposal facility. All values are given to two significant figures. Annual doses of less than 0.001 mrem/yr are reported as <0.001. The values given in this table represent the peak annual doses from each waste type. Because of the different radionuclide mixes and activities contained in the different waste types, the peak annual doses that could result from each waste type individually generally occur at different times than the peak annual dose from the entire inventory. The peak annual doses from the entire GTCC LLRW and GTCC-like waste inventory are given in the site-specific chapters of the EIS.

[c] The above-grade vault is the only method evaluated for Region I and Region III because of the shallow groundwater depth. The borehole method is not considered suitable for SRS and Regions I, II, and III.

TABLE E-25 Estimated Peak Annual Doses (in mrem/yr) from the Use of Contaminated Groundwater at the Various Sites for the Total Group 2 Inventory[a,b]

			Peak Annual Dose (rem/yr) within 10,000 and 100,000 Years							
			GTCC LLRW				GTCC-Like Waste			
Site	Method	Time Period of Analysis (yr)	Activated Metals	Sealed Sources	Other Waste - CH	Other Waste - RH	Activated Metals	Sealed Sources	Other Waste - CH	Other Waste - RH
Hanford Site	Vault	10,000	2.0	0	0.025	1.6	–[b]	–	0.0062	0.23
		100,000	2.0	0	3.7	9.4	–	–		22
		10,000	2.5	0	0.031	1.5	–	–		0.22
		100,000	2.5	0	4.5	8.9	–	–		21
		10,000	1.3	0	0.0091	0.47	–	–		0.066
		100,000	1.3	0	1.4	2.8	–	–11 0.0076		6.5
INL Site	Vault	10,000	57	0	2.4	100	–	–14 0.0023	3.1	12
Trench		100,000	57	0	13	100	–	–		76
		10,000	65	0	2.9	100	–	–4.2		11
Borehole		100,000	65	0	14	100	–	–		69
		10,000	45	0	5.6	50	–	–		26
		100,000	45	0	5.9	50	–	–38 3.6		30
LANL	Vault	10,000	30	0	0.87	40	–	–43	1.0	3.1
Trench		100,000	30	0	0.87	40	–	–17		3.1
		10,000	37	0	1.0	38	–	–18		2.9
Borehole		100,000	37	0	1.0	38	–	–		2.9
		10,000	22	0	0.35	13	–	–		0.96
		100,000	22	0	0.35	13	–	–1.0 1.2		0.96
NNSS	Vault	10,000	0	0	0	0	–	–1.2	0	0
Trench		100,000	0	0	0	0	–	–0.42		0
		10,000	0	0	0	0	–	–0.42		0
Borehole		100,000	0	0	0	0	–	–		0
		10,000	0	0	0	0	–	–		0
		100,000	0	0	0	0	–	–0		0
								0		
								0		
Trench								0		
								0		
Borehole										

TABLE E-25 (Cont.)

			Peak Annual Dose (mrem/yr) within 10,000 and 100,000 Years							
			GTCC LLRW				GTCC-Like Waste			
Site	Method	Time Period of Analysis (yr)	Activated Metals	Sealed Sources	Other Waste - CH	Other Waste - RH	Activated Metals	Sealed Sources	Other Waste - CH	Other Waste - RH
SRS[c]	Vault	10,000	21	0	10	390	–	–	20	50
		100,000	21	0	26	390	–	–		110
		10,000	28	0	13	460	–	–		59
		100,000	62	0	27	460	–	–		59
WIPP Vicinity	Vault	10,000	0	0	0	0	–	−66	0	0
		100,000	20	0	0.017	3.6	–	−32		0.67
		10,000	0	0	0	0	–	−76		0
Trench		100,000	20	0	0.016	2.8	–	–		0.52
		10,000	0	0	0	0	–	– 0.022		0
		100,000	19	0	0.0091	1.6	–	–		0.29
Region I[c]	Vault	10,000	110	0	71	490	–	– 0 0.022	410	820
Trench		100,000	110	0	71	490	–	– 0 0.012		820
Region II[c] Borehole	Vault	10,000	7.1	0	5.4	210	–	–	6.3	39
		100,000	120	0	10	210	–	–		150
		10,000	12	0	6.6	210	–	–410		35
		100,000	480	0	43	330	–	–		530
Region III[c]	Vault	10,000	7.8	0	2.1	83	–	−76	2.5	15
		100,000	240	0	7.1	74	–	−9.5 340		110
Region IV Trench	Vault	10,000	0	0	0	0	–	–	0	0
		100,000	0.11	0	1.0	8.4	–	–		6.2
		10,000	0	0	0	0	–	−56		0
		100,000	0.14	0	1.2	6.9	–	–		5.8
		10,000	0	0	0	0	–	–		0
		100,000	0.26	0	0.41	1.5	–	−3.1		2.0

0
3.9

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Trench

0
1.3

Borehole

TABLE E-25 (Cont.)

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[a] CH = contact-handled, GTCC = greater-than-Class C, INL = Idaho National Laboratory, LANL = Los Alamos National Laboratory, NNSS = Nevada National Security Site, RH = remote-handled, SRS = Savannah River Site, WIPP = Waste Isolation Pilot Plant, Region I–IV = a generic commercial site located within each of the four major regions of the country.

[b] These annual doses are associated with the use of contaminated groundwater by a hypothetical resident farmer located 100 m (330 ft) from the edge of the disposal facility. All values are given to two significant figures, and a dash means there is no inventory for that waste type. Annual doses of less than 0.001 mrem/yr are reported as <0.001. The values given in this table represent the peak annual doses from each waste type. Because of the different radionuclide mixes and activities contained in the different waste types, the peak annual doses that could result from each waste type individually generally occur at different times than the peak annual dose from the entire inventory. The peak annual doses from the entire GTCC LLRW and GTCC-like waste inventory are given in the site-specific chapters of the EIS.

[c] The above-grade vault is the only method evaluated for Region I and Region III because of the shallow groundwater depth. The borehole method is not considered suitable for SRS and Regions I, II, and III.

TABLE E-26 Sensitivity Analysis Cases Addressed in the EIS

Parameter	Base Case	Case I	Case II	Case III	Case IV	Case V	Case VI	Case VII	Case VIII	Case IX	Case X
Effective period of grout (yr)	500	500	500	2,000	2,000	2,000	5,000	5,000	5,000	500	500
Percentage of natural infiltration rate into the waste units after 500 years (%)	20	50	100	20	50	100	20	50	100	20	20
Distance to the hypothetical receptor (m)	100	100	100	100	100	100	100	100	100	300	500

TABLE E-27 Peak Annual Doses within 10,000 Years and the Occurrence Times at the WIPP Vicinity for the Different Sensitivity Analysis Cases[a]

Result	Base Case	Case I	Case II	Case III	Case IV	Case V	Case VI	Case VII	Case VIII	Case IX	Case X
Peak annual dose (mrem/yr)	0	0	0	0	0	0	0	0	0	0	0
Time (yr)	0	0	0	0	0	0	0	0	0	0	0

[a] The sensitivity analysis considered the disposal of stored Group 1 GTCC-like Other Waste - CH by using the trench method.

TABLE E-28 Peak Annual Doses within 10,000 Years and the Occurrence Times at SRS for the Different Sensitivity Analysis Cases[a]

Result	Base Case	Case I	Case II	Case III	Case IV	Case V	Case VI	Case VII	Case VIII	Case IX	Case X
Peak annual dose (mrem/yr)	62	140	250	41	85	130	37	72	100	23	13
Time (yr)	610	580	550	2,100	2,100	2,000	5,100	5,100	5,100	780	940

[a] The sensitivity analysis considered the disposal of stored Group 1 GTCC-like Other Waste - CH by using the trench method. All values are given to two significant figures. The times for the peak annual doses represent the time after failure of the cover and engineered barriers (which is assumed to begin 500 years after closure of the disposal facility).

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Young, M.H., and K.F. Pohlmann, 2003, *Analysis of Vadose Zone Monitoring System: Computer Simulation of Water Flux under Conditions of Variable Vegetative Cover: E Area Disposal Trenches*, Publication No. 41188, Division of Hydrologic Sciences, Desert Research Institute, Las Vegas, Nev., Aug.

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Yu, C., et al., 2001, *User's Manual for RESRAD Version 6*, ANL/EAD-4, Argonne National Laboratory, Argonne, Ill., July.

Yu, C., et al., 2007, *User's Manual for RESRAD-OFFSITE Version 2*, ANL/EVS/TM07-1, DOE/HS-0005, NUREG/CR-6937, prepared by Argonne National Laboratory, Argonne, Ill., for U.S. Department of Energy and U.S. Nuclear Regulatory Commission, June.

APPENDIX F:

CONSULTATION CORRESPONDENCE FOR THE DRAFT AND FINAL ENVIRONMENTAL IMPACT STATEMENT FOR THE DISPOSAL OF GREATER-THAN-CLASS C (GTCC) LOW-LEVEL RADIOACTIVE WASTE AND GTCC-LIKE WASTE

Table F-1 lists the consultation correspondence related to the GTCC reference locations evaluated in this EIS. (Note that in the letters, the Nevada National Security Site was still referred to as the Nevada Test Site or NTS, and this was not changed.) Copies of the correspondence follow this table. Background information on the project, which was included as an attachment to each letter from A.M. Edelman of the U.S. Department of Energy, Office of Disposal Operations, is provided at the end of this appendix, after the letters.

TABLE F-1 Consultation Correspondence

Page	Source	Recipient	Date of Letter
F-3	U.S. Department of Energy (A.M. Edelman)	U.S. Fish and Wildlife Service, Wenatchee, Wash. (J. Gonzales)	December 10, 2009
F-4	U.S. Fish and Wildlife Service, Wenatchee, Wash. (K.S. Berg)	U.S. Department of Energy (A.M. Edelman)	January 27, 2010
F-8	U.S. Department of Energy (A.M. Edelman)	U.S. Fish and Wildlife Service, Boise, Id. (J. Foss)	December 10, 2009
F-9	U.S. Fish and Wildlife Service, Chubbock, Id. (D. Miller)	U.S. Department of Energy (A.M. Edelman)	January 4, 2010
F-10	U.S. Department of Energy (A.M. Edelman)	U.S. Fish and Wildlife Service, Albuquerque, N.M. (W. Murphy)	December 10, 2009
F-11	U.S. Fish and Wildlife Service, Albuquerque, N.M. (W. Murphy)	U.S. Department of Energy (A.M. Edelman)	February 2, 2010
F-13	U.S. Department of Energy (A.M. Edelman)	U.S. Fish and Wildlife Service, Reno, Nev. (R. Williams)	December 10, 2009
F-14	U.S. Fish and Wildlife Service, Reno, Nev. (R.D. Williams)	U.S. Department of Energy (A.M. Edelman)	January 21, 2010
F-19	U.S. Department of Energy (A.M. Edelman)	U.S. Fish and Wildlife Service, Charleston, S.C. (M. Tobin)	December 10, 2009
F-20	U.S. Fish and Wildlife Service, Charleston, S.C. (D.L. Lynch)	U.S. Department of Energy (A.M. Edelman)	January 6, 2010

TABLE F-1 (Cont.)

Page	Source	Recipient	Date of Letter
F-23	U.S. Department of Energy (A.M. Edelman)	Washington State Department of Fish and Wildlife Service, Yakima, Wash. (J. Tayer)	January 19, 2010
F-25	U.S. Department of Energy (A.M. Edelman)	Idaho Department of Fish and Game, Idaho Falls, Id. (S. Schmidt)	January 19, 2010
F-27	U.S. Department of Energy (A.M. Edelman)	Ecological Services, Albuquerque, N.M. (W. Murphy)	January 19, 2010
F-29	U.S. Department of Energy (A.M. Edelman)	Nevada Natural Heritage Program, Carson City, Nev. (J.E. Newmark)	January 19, 2010
F-31	Nevada Natural Heritage Program, Carson City, Nev. (E.S. Miskow)	U.S. Department of Energy (A.M. Edelman)	February 10, 2010
F-35	U.S. Department of Energy (A.M. Edelman)	South Carolina Department of Natural Resources, Columbia, S.C. (J. Holling)	January 19, 2010
F-37	South Carolina Department of Natural Resources, Columbia, S.C. (J. Holling)	U.S. Department of Energy (A.M. Edelman)	January 27, 2010
F-40	U.S. Department of Energy (A.M. Edelman)	Los Alamos Site Office (J. Griego)	January 19, 2010
F-41	U.S. Department of Energy (A.M. Edelman)	Department of Archeology and Historic Preservation, Olympia, Wash. (A. Brooks)	January 19, 2010
F-43	U.S. Department of Energy (A.M. Edelman)	State Historic Preservation Office, Boise, Id. (K. Reid)	January 19, 2010
F-45	U.S. Department of Energy (A.M. Edelman)	State of New Mexico Department of Cultural Affairs, Santa Fe, N.M. (J. Biella)	January 19, 2010
F-47	U.S. Department of Energy (A.M. Edelman)	Nevada State Historic Preservation Office, Carson City, Nev. (R. James)	January 19, 2010
F-49	Nevada State Historic Preservation Office, Carson City, Nev. (A.M. Baldrica)	U.S. Department of Energy (A.M. Edelman)	February 26, 2010
F-50	U.S. Department of Energy (A.M. Edelman)	Department of Archives and History, Columbia, S.C. (E. Emerson)	January 19, 2010

Department of Energy
Washington, DC 20585

December 10, 2009

Ms. Jessica Gonzales
Assistant Project Leader
Wenatchee Field Office
U.S. Fish and Wildlife Service
215 Melody Lane, Suite 119
Wenatchee, Washington 98801

Dear Ms. Gonzalez:

The Department of Energy, Office of Environmental Management is preparing an Environmental Impact Statement (EIS) under the National Environmental Policy Act for the disposal of Greater-Than-Class-C Low-Level-Radioactive Waste (GTCC LLRW). In compliance with the Endangered Species Act, the EIS will contain an analysis of the proposed action and potential impacts to listed and proposed threatened and endangered species. We request that you provide us with any information regarding the occurrence of federally listed and proposed threatened and endangered species that may occur on or in the vicinity of the proposed GTCC LLRW disposal location immediately south of the Integrated Disposal Facility site in the 200 East Area in the central portion of the Hanford Site, Benton County that should be considered in preparing the EIS.

I have enclosed a brief background of the project, including information on the potential Hanford GTCC location, and a copy of the Notice of Intent. I wish to thank you in advance for the information that you will be providing to us. If you have any questions, please contact me at (301) 903-5145 or at arnold.edelman@em.doe.gov.

Sincerely,

Arnold M. Edelman
EIS Document Manager
Office of Disposal Operations

Enclosures

cc: Woody Russell, ORP

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United States Department of the Interior

FISH AND WILDLIFE SERVICE

Washington Fish and Wildlife Office
Central Washington Field Office
215 Melody Lane, Suite 119
Wenatchee, WA 98801

January 27, 2010

In Reply Refer To:
USFWS Reference: 13260-2010-SL-0019

Arnold M. Edelman
EIS Document Manager, Office of Disposal Operations
Department of Energy
1000 Independence Ave., SW
Washington, DC 20585

Dear Mr. Edelman:

We have received your request for information on endangered and threatened species and their critical habitats that may be present near your potential disposal location of Greater-Than-Class-C Low-Level Radioactive Waste (GTCC LLRW) in Benton County, Washington. For your convenience, updated countywide species and habitat listings are now available on our website at http://www.fws.gov/easternwashington. To view the listings in your area of concern, select "county species lists" within the ESA programs page, and then select the county of interest. The lists available on our website are compliant with Section 7(c) of the Endangered Species Act of 1973, as amended (Act), and are the most current available listings of endangered, threatened and proposed species and critical habitats in a given area. For optional consideration, the lists also contain updated species of concern and candidate species. Please be aware that the U.S. Fish and Wildlife Service is in the process of proposing bull trout critical habitat.

Species of anadromous fish that have been listed under the Act by the National Marine Fisheries Service (NMFS) may also occur in your project area. Please contact NMFS in Ellensburg, Washington, at (509) 962-8911 to request information on listed species within NMFS's jurisdiction.

If you would like information concerning state listed species or species of concern, you may contact the Washington Department of Fish and Wildlife, at (360) 902-2543, for fish and wildlife species; or the Washington Department of Natural Resources, at (360) 902-1667, for plant species.

When you submit a request for Section 7 consultation, we request that you include your downloaded species list and the date it was downloaded, as an attachment. If applicable,

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Arnold M. Edelman 2

please also include the USFWS reference number on your consultation request. This will document your compliance with 50 CFR 402.12 (c).

Should your project plans change significantly, or if the project is delayed more than 90 days, you should update your species lists through our website and through the above listed agencies.

Thank you for your efforts to protect our nation's species and their habitats. If you have any questions concerning the above information, please contact Jeff Krupka at (509) 665-3508, extension 18, or via e-mail at Jeff_Krupka@fws.gov.

Sincerely,

Jessica L. Gonzales

Ken S. Berg, Manager
Washington Fish and Wildlife Office

cc: Joe Bartoszek, Mid-Columbia River NWR Complex, USFWS, Burbank, WA

Enclosure A

LISTED AND PROPOSED ENDANGERED AND THREATENED SPECIES,
CRITICAL HABITAT, CANDIDATE SPECIES, AND SPECIES OF CONCERN
THAT MAY OCCUR IN THE COUNTIES OF EASTERN WASHINGTON
AS LISTED BY THE U.S. FISH AND WILDLIFE SERVICE

January 27, 2010

FWS Reference: 13260-2010-SL-0019

COMMENTS

Major concerns that should be addressed in your biological assessment of project impacts to listed threatened, endangered, or proposed animal species are:

1. Level of use of the project area by listed species.
2. Effect of the project on listed species' primary food stocks and foraging areas in all areas influenced by the project.
3. Impacts from project construction and implementation (e.g. increased noise levels, increased human activity and/or access, loss or degradation of habitat) which may result in disturbance to listed species and/or their avoidance of the project area.

Major concerns that should be addressed for listed or proposed plant species are:

1. Distribution of taxon in project vicinity.
2. Disturbance (trampling, uprooting, collecting, etc.) of individual plants and loss of habitat.
3. Changes in hydrology where taxon is found.

Candidate species are those species for which the U.S. Fish and Wildlife Service has sufficient information to propose for listing as threatened or endangered under the Act. Species of concern (some of which are former Category 1 and Category 2 candidates) are those species whose conservation standing is of concern to the Service, but for which status information is still needed. Conservation measures for species of concern and candidate species are voluntary but recommended. Protection provided to these species now may preclude possible listing in the future.

For information regarding species listed by NOAA Fisheries, please visit the following website http://www.nwr.noaa.gov/lsalmon/salmesa/index.hhn or call (509) 962-8911 in Ellensburg, Washington.

BENTON COUNTY

Updated 4/15/2008

Listed

Endangered

Pygmy rabbit (*Brachylagus idahoensis*) – Columbia Basin distinct population segment

Threatened

Bull trout *(Salvelinus confluentus)* – Columbia River distinct population segment
Spiranthes diluvialis (Ute ladies'-tresses), plant

Candidate

Yellow-billed cuckoo (*Coccyzus americanus*)
Eriogonum codium (Umtanum desert buckwheat), plant

Species of Concern

Animals

Bald eagle *(Haliaeetus leucocephalus)* (delisted, monitor status)
Burrowing owl *(Athene cunicularia)*
California floater *(Anodonta californiensis)*, mussel
Columbia clubtail *(Gomphus lynnae)*, dragonfly
Ferruginous hawk *(Buteo regalis)*
Giant Columbia spire snail *(Fluminicola columbiana)*
Loggerhead shrike *(Lanius ludovicianus)*
Long-eared myotis (*Myotis evotis*)
Margined sculpin *(Cottus marginatus)*
Pacific lamprey *(Lampetra tridentata)*
Pallid Townsend's big-eared bat *(Corynorhinus townsendii pallescens)*
Redband trout (*Oncorhynchus mykiss*)
River lamprey *(Lampetra ayresi)*
Sagebrush lizard *(Sceloporus graciosus)*
Townsend's ground squirrel (*Spermophilus townsendii)*
Western brook lamprey (*Lampetra richardsoni*)

Vascular Plants

Astragalus columbianus (Columbia milk-vetch)
Cryptantha leucophaea (Gray cryptantha)
Haplopappus liatriformis (Palouse goldenweed)
Lomatium tuberosum (Hoover's desert-parsley)
Mimulus jungermannioides (Liverwort monkey-flower)
Rorippa columbiae (Persistent sepal yellowcress)

Department of Energy
Washington, DC 20585

December 10, 2009

Mr. Jeffery Foss, Field Supervisor
U.S. Fish and Wildlife Service
Idaho Fish and Wildlife Office
1387 South Vinnell Way, Suite 368
Boise, Idaho 83709-1657

Dear Mr. Foss:

The Department of Energy, Office of Environmental Management is preparing an Environmental Impact Statement (EIS) under the National Environmental Policy Act for the disposal of Greater-Than-Class-C Low-Level-Radioactive Waste (GTCC LLRW). In compliance with the Endangered Species Act, the EIS will contain an analysis of the proposed action and potential impacts to listed and proposed threatened and endangered species. We request that you provide us with any information regarding the occurrence of federally listed and proposed threatened and endangered species that may occur on or in the vicinity of the proposed GTCC LLRW disposal location at the Idaho National Laboratory (INL), southwest of the Reactor Technology Complex in the south central portion of INL, Butte County that should be considered in preparing the EIS.

I have enclosed a brief background of the project, including information on the potential INL GTCC location, and a copy of the Notice of Intent. I wish to thank you in advance for the information that you will be providing to us. If you have any questions, please contact me at (301) 903-5145 or at arnold.edelman@em.doe.gov.

Sincerely,

Arnold M Edelman

Arnold M. Edelman
EIS Document Manager
Office of Disposal Operations

Enclosures

cc: Richard Kauffman, ID

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United States Department of the Interior
FISH AND WILDLIFE SERVICE
Eastern Idaho Field Office
4425 Burley Dr., Suite A
Chubbuck, Idaho 83202
Telephone (208) 237-6975
http://IdahoES.fws.gov

JAN 04 2010

Arnold M. Edelman
EIS Document Manager
Office of Disposal Operations
Department of Energy
Washington, DC 20585

Subject: Proposed Disposal of Greater-Than-Class-C Low-Level-Radioactive Waste at the INL in Southeast Idaho. SL #10-0116

Dear Mr. Edelman:

The U.S. Fish and Wildlife Service (Service) is writing in response to your request for information about the potential impacts to endangered, threatened, proposed, and/or candidate species from the proposed disposal of greater-than-C low-level-radioactive waste at the INL in Southeast Idaho. The Service has not identified any issues that indicate that consultation under section 7 of the Endangered Species Act of 1973, as amended, is needed for this project. This finding is based on our understanding of the nature of the project, local conditions, and/or current information indicating that no listed species are present. If you determine otherwise or require further assistance, please contact Sandi Arena of this office at (208)237-6975 ext 102.

Thank you for your interest in endangered species conservation.

Sincerely,

Damien Miller
Supervisor, Eastern Idaho Field Office

Department of Energy
Washington, DC 20585

December 10, 2009

Mr. Wally Murphy, Field Supervisor
U.S. Fish and Wildlife Service
New Mexico Ecological Services Field Office
2105 Osuna NE
Albuquerque, New Mexico 87113

Dear Mr. Murphy:

The Department of Energy, Office of Environmental Management is preparing an Environmental Impact Statement (EIS) under the National Environmental Policy Act for the disposal of Greater-Than-Class-C Low-Level-Radioactive Waste (GTCC LLRW). In compliance with the Endangered Species Act, the EIS will contain an analysis of the proposed action and potential impacts to listed and proposed threatened and endangered species. We request that you provide us with any information regarding the occurrence of federally listed and proposed threatened and endangered species that may occur on or in the vicinity of the three proposed GTCC LLRW disposal locations in your State: 1. Los Alamos National Laboratory within TA-54, on Mesita del Buey, Zone 6, North Site, and North Site Expanded, Los Alamos County; 2. the Waste Isolation Pilot Plant (WIPP) in Eddy County; and 3. Sections 27 and 35 in and around WIPP.

I have enclosed a brief background of the project, including information on the potential GTCC locations within the State, and a copy of the Notice of Intent. I wish to thank you in advance for the information that you will be providing to us. If you have any questions, please contact me at (301) 903-5145 or at arnold.edelman@em.doe.gov.

Sincerely,

Arnold M. Edelman
EIS Document Manager
Office of Disposal Operations

Enclosures

cc: George Rael, LASO
Nancy Werdel, DOE AL
Susan McCauslin, CBSO

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United States Department of the Interior

FISH AND WILDLIFE SERVICE
New Mexico Ecological Services Field Office
2105 Osuna NE
Albuquerque, New Mexico 87113
Phone: (505) 346-2525 Fax: (505) 346-2542

FEB -2 2010

Thank you for your recent request for information on threatened or endangered species or important wildlife habitats that may occur in your project area. The New Mexico Ecological Services Field Office has posted lists of the endangered, threatened, proposed, candidate and species of concern occurring in all New Mexico Counties on the Internet. Please refer to the following web page for species information in the county where your project occurs: http://www.fws.gov/southwest/es/NewMexico/SBC_intro.cfm. If you do not have access to the Internet or have difficulty obtaining a list, please contact our office and we will mail or fax you a list as soon as possible.

After opening the web page, find New Mexico Listed and Sensitive Species Lists on the main page and click on the county of interest. Your project area may not necessarily include all or any of these species. This information should assist you in determining which species may or may not occur within your project area.

Under the Endangered Species Act of 1973, as amended (Act), it is the responsibility of the Federal action agency or its designated representative to determine if a proposed action "may affect" endangered, threatened, or proposed species, or designated critical habitat, and if so, to consult with us further. Similarly, it is their responsibility to determine if a proposed action has no effect to endangered, threatened, or proposed species, or designated critical habitat. On December 16, 2008, we published a final rule concerning clarifications to section 7 consultations under the Act (73 FR 76272). One of the clarifications is that section 7 consultation is not required in those instances when the direct and indirect effects of an action pose no effect to listed species or critical habitat. As a result, we do not provide concurrence with project proponent's "no effect" determinations.

If your action area has suitable habitat for any of these species, we recommend that species-specific surveys be conducted during the flowering season for plants and at the appropriate time for wildlife to evaluate any possible project-related impacts. Please keep in mind that the scope of federally listed species compliance also includes any interrelated or interdependent project activities (e.g., equipment staging areas, offsite borrow material areas, or utility relocations) and any indirect or cumulative effects.

FEB-02-2010 09:27AM FROM-US FISH AND WILDLIFE +5053462542 T-237 P.002/004 F-406

2

Candidates and species of concern have no legal protection under the Act and are included on the web site for planning purposes only. We monitor the status of these species. If significant declines are detected, these species could potentially be listed as endangered or threatened. Therefore, actions that may contribute to their decline should be avoided. We recommend that candidates and species of concern be included in your surveys.

Also on the web site, we have included additional wildlife-related information that should be considered if your project is a specific type. These include communication towers, power line safety for raptors, road and highway improvements and/or construction, spring developments and livestock watering facilities, wastewater facilities, and trenching operations.

Under Executive Orders 11988 and 11990, Federal agencies are required to minimize the destruction, loss, or degradation of wetlands and floodplains, and preserve and enhance their natural and beneficial values. We recommend you contact the U.S. Army Corps of Engineers for permitting requirements under section 404 of the Clean Water Act if your proposed action could impact floodplains or wetlands. These habitats should be conserved through avoidance, or mitigated to ensure no net loss of wetlands function and value.

The Migratory Bird Treaty Act (MBTA) prohibits the taking of migratory birds, nests, and eggs, except as permitted by the U.S. Fish and Wildlife Service. To minimize the likelihood of adverse impacts to all birds protected under the MBTA, we recommend construction activities occur outside the general migratory bird nesting season of March through August, or that areas proposed for construction during the nesting season be surveyed, and when occupied, avoided until nesting is complete.

We suggest you contact the New Mexico Department of Game and Fish, and the New Mexico Energy, Minerals, and Natural Resources Department, Forestry Division for information regarding fish, wildlife, and plants of State concern.

Thank you for your concern for endangered and threatened species and New Mexico's wildlife habitats. We appreciate your efforts to identify and avoid impacts to listed and sensitive species in your project area.

Sincerely,

Wally Murphy
Field Supervisor

Department of Energy
Washington, DC 20585

December 10, 2009

Mr. Robert Williams, State Supervisor
U.S. Fish and Wildlife Service
Nevada Fish and Wildlife Office
1340 Financial Boulevard, Suite 234
Reno, Nevada 89502-7147

Dear Mr. Williams:

The Department of Energy, Office of Environmental Management is preparing an Environmental Impact Statement (EIS) under the National Environmental Policy Act for the disposal of Greater-Than-Class-C Low-Level-Radioactive Waste (GTCC LLRW). In compliance with the Endangered Species Act, the EIS will contain an analysis of the proposed action and potential impacts to listed and proposed threatened and endangered species. We request that you provide us with any information regarding the occurrence of federally listed and proposed threatened and endangered species that may occur on or in the vicinity of the proposed GTCC LLRW disposal location at the Nevada Test Site (NTS), in the vicinity north of Frenchman Flat, either southeast or west of the existing Radioactive Waste Management Facility, Nye County that should be considered in preparing the EIS.

I have enclosed a brief background of the project, including information on the potential NTS GTCC location, and a copy of the Notice of Intent. I wish to thank you in advance for the information that you will be providing to us. If you have any questions, please contact me at (301) 903-5145 or at arnold.edelman@em.doe.gov.

Sincerely,

Arnold M Edelman

Arnold M. Edelman
EIS Document Manager
Office of Disposal Operations

Enclosures

cc: Linda Cohn, NSO

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United States Department of the Interior

FISH AND WILDLIFE SERVICE
Nevada Fish and Wildlife Office
4701 North Torrey Pines Drive
Las Vegas, Nevada 89130
Ph: (702) 515-5230 ~ Fax: (702) 515-5231

January 21, 2010
File No. 84320-2010-SL-0133

Mr. Arnold Edelman
Office of Disposal Operations
U.S. Department of Energy
Cloverleaf Building (EM-43)
1000 Independence Avenue, SW
Washington, DC. 20585

Dear Mr. Edelman:

Subject: Request for Information on Federally Listed and Proposed Threatened or Endangered Species or Designated Critical Habitats that May Occur Near the Proposed Low-level Radioactive Waste Disposal Project Area on the Nevada Test Site in Nye County, Nevada

This responds to your letter dated December 10, 2009, requesting information on federally listed and proposed threatened or endangered species or designated critical habitat that may occur near the proposed project area on the Nevada Test Site in Nye County, Nevada. We have determined that there is no critical habitat in/near the action area, but that the following federally listed species may occur in/near the action area:

- Desert tortoise (*Gopherus agassizii*) (Mojave population), threatened

This response fulfills the requirement of the Fish and Wildlife Service (Service) to provide information on potential presence of federally listed species pursuant to section 7(c) of the Endangered Species Act of 1973 (Act), as amended (16 U.S.C. 1531 *et seq.*), for projects that are authorized, funded, or carried out by a Federal agency.

To minimize the potential effects to this species from the implementation of this proposed action, we recommend the Department of Energy (DOE) propose minimization measures in accordance with the terms of the *Incidental Take Statement* in our Final Programmatic Biological Opinion for Implementation of Actions Proposed on the Nevada Test Site, Nye County, Nevada dated February 12, 2009 (Service File No. 84320-2008-F-0416).

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Mr. Arnold M. Edelman File No. 84320-2010-SL-0133

As a reminder, pursuant to the Act if the action agency determines that the proposed action may affect listed species or designated critical habitat the action agency would request that the proposed action be appended under the programmatic consultation and provide project-specific information that: (1) describes each proposed action and the specific areas to be affected; (2) identifies the species and critical habitat that may be affected; (3) describes the manner in which the proposed action may affect listed species; (4) describes the anticipated effects; (5) specifies, if appropriate, that the *anticipated effects from the proposed project are consistent with those anticipated in the programmatic biological opinion*; (6) describes proposed measures to minimize potential effects of the action; (7) describes any additional effects, if any, not considered in the programmatic consultation. The project information and effects analysis should be accompanied by a cover letter that specifies that the action agency has determined the proposed project is consistent with the programmatic biological opinion.

The Nevada Fish and Wildlife Office no longer provides species-of-concern lists. Most of these species for which we have concern are on the at-risk or watch-list species lists for Nevada maintained by the State of Nevada's Natural Heritage Program (Heritage). Instead of maintaining our own list, we have adopted Heritage's lists and partnered with them to provide distribution data and information on the conservation needs for sensitive species to agencies or project proponents. The mission of Heritage is to continually evaluate the conservation priorities of native plants, animals, and their habitats, particularly those most vulnerable to extinction or those that are in serious decline. Consideration of these sensitive species and exploring management alternatives early in the planning process can provide long-term conservation benefits and avoid future conflicts.

For a comprehensive list of at-risk or watch-list species that may occur in the project area, you can obtain a data request form from http://heritage.nv.gov/forms.htm or by contacting the Administrator of Heritage at 901 South Stewart Street, Suite 5002, Carson City, Nevada, 89701, 775-684-2900. Please indicate on the form that your request is being obtained as part of your coordination with the Service under the Act. During your project analysis, if you obtain new information or data for any Nevada sensitive species, we request that you provide the information to Heritage at the above address.

We are concerned that the project may impact the Gila monster (*Heloderma suspectum cinctum*), a species listed as sensitive under the Heritage Program and as a protected species under Nevada State law. The banded Gila monster resides primarily in the Mojave desert scrub and salt desert scrub ecosystems in southern Nevada, southeastern California, southwestern Utah, and western Arizona. The Gila monster is one of only two venomous lizard species in the world. Gila monsters are difficult to locate as they spend the majority of the year in underground burrows; however, illegal collection, construction of roads, and loss of habitat continue to threaten this sensitive. Given that the Gila monster may occur within the project area, we encourage you to minimize project impacts to any existing populations and suitable habitat for this species.

2

Mr. Arnold M. Edelman File No. 84320-2010-SL-0133

Furthermore, certain species of fish and wildlife are protected by the State of Nevada (see http://www.leg.state.nv.us/NAC/NAC-503.html). You must first obtain the appropriate license, permit, or written authorization from the Nevada Department of Wildlife to take or possess any parts of protected wildlife species. Please visit http://www.ndow.org or contact Supervisory Biologist - Habitat, Nevada Department of Wildlife at 4747 Vegas Drive, Las Vegas, Nevada 89108, 702-486-5127.

The Service also has conservation responsibilities and management authority for migratory birds under the Migratory Bird Treaty Act (MBTA) of 1918, as amended (16 U.S.C. 703 *et seq*.). Under the MBTA, nests (nests with eggs or young) of migratory birds may not be harmed, nor may migratory birds be killed. Such destruction may be in violation of the MBTA. Therefore, we recommend land clearing, or other surface disturbance associated with the proposed project, be conducted outside the avian breeding season to avoid potential destruction of bird nests or young, or birds that breed in the area. If this is not feasible, we recommend a qualified biologist survey the area prior to land clearing. If nests are located, or if other evidence of nesting (*i.e.*, mated pairs, territorial defense, carrying nesting material, transporting food) is observed, a protective buffer (the size depending on the habitat requirements of the species) should be delineated and the entire area avoided to prevent destruction or disturbance to nests until they are no longer active.

In particular, we are concerned about the State-protected western burrowing owl (*Athene cunicularia hypugea*) and potential project impacts to this species from your project. The reduction of habitat in southern Nevada is a major threat to this species. Therefore, we recommend that the project avoid disturbing burrows that are used by burrowing owls. If this is not possible, we ask that the project incorporate the recommendations in our pamphlet, "Protecting Burrowing Owls at Construction Sites in Nevada's Mojave Desert Region" (Enclosure).

Please reference File No. 84320-2010-SL-0133 in future correspondence concerning this species list. If you have questions regarding this correspondence or require additional information, please contact Brian A. Novosak in the Nevada Fish and Wildlife Office in Las Vegas at 702-515-5230.

Sincerely,

for Robert D. Williams
State Supervisor

Enclosure

3

U. S. Fish and Wildlife Service

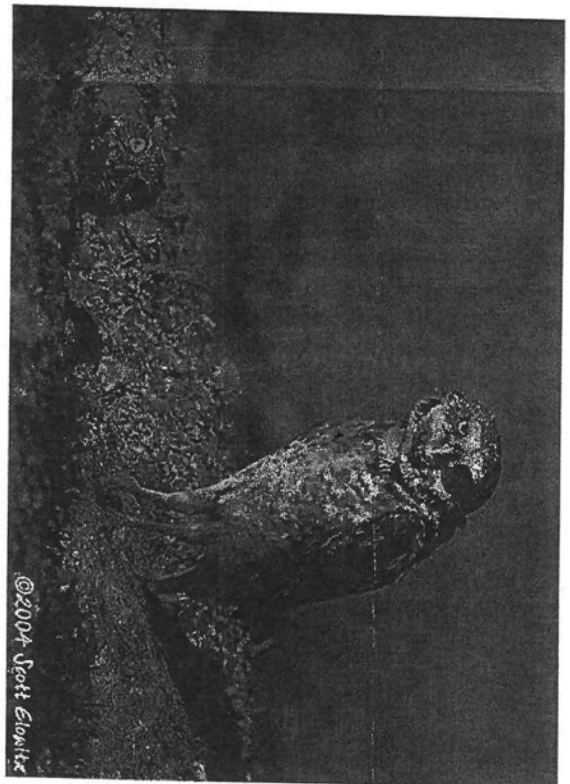
Nevada Fish and Wildlife Office
Conserving the Biological Diversity of Great Basin, Eastern Sierra & Mojave Desert

PROTECTING BURROWING OWLS AT CONSTRUCTION SITES IN NEVADA'S MOJAVE DESERT REGION

(June 2007)

Burrowing owl numbers are declining despite protection under the Migratory Bird Treaty Act. Killing or possessing these birds or destruction of their eggs or nest is prohibited.

Be part of the solution; help these owls!



U.S. Fish and Wildlife Service
Nevada Fish and Wildlife Office
4701 N. Torrey Pines Drive
Las Vegas, NV 89130
Phone: 702-515-5230
Fax: 702-515-5231

http://www.fws.gov/nevada

Though burrowing owls are capable of digging their own burrows, they often will use burrows of other animals for shelter and nesting. They will even adopt pipes or culverts 6" to 8" in diameter.

Tips for Protecting Burrowing Owls, Their Eggs and Young at Construction Sites:

Even though burrowing owls are often active during the day, always check burrows, cracks, and crevices for owls before beginning construction. Use of a fiber-optic scope or remote mini-camera to look into a burrow can help determine the presence of owls or nests. Ensure owls and eggs are not present in burrows when grading begins, to avoid burying them.

In southern Nevada, owls breed from about mid-March through August. If a burrow has an active nest, the site must be avoided until the chicks have fledged. To ensure that birds will not abandon the nest, a buffer of at least a 250-foot radius should be placed around the burrow, within which no construction should occur. It takes a minimum of 74 days from when eggs are laid until chicks are able to fly (fledge). After the young have fledged, check the nest burrow for any owlets before resuming construction.

The following owl behaviors may help determine breeding or the presence of an active nest:

- **A pair of owls is initially observed at a site, then only one owl is observed.** This may indicate that the pair has chosen a nest burrow, and the female has gone down into the burrow to lay and incubate eggs. Once incubation begins the female rarely leaves the burrow.
- **An owl is frequently observed carrying food to the burrow.** The male provides food for the female while she is incubating eggs. The best time of day to observe owls is dawn and dusk, but they may be active throughout the day. The male will most likely leave the food in front of the burrow and the female will come to the entrance to take the food. This is probably the best indication that the owls have an active nest.
- **Only one owl has been seen for a period of time; then, two owls are observed.** This may indicate that either the nest has failed, or the eggs have hatched, and the female has emerged from the burrow to assist the male in hunting for food to feed the chicks. The chicks will appear at the burrow entrance when they are about 10 days old.

If you are unsure of breeding status, seek the assistance of a professional biologist or other knowledgeable person. Should breeding behavior be observed, presence of an active nest should be assumed and the area avoided until the chicks have fledged or the nest is no longer occupied.

IMPORTANT! In the Mojave Desert portions of Clark, southern Lincoln and Nye counties, owls may use desert tortoise burrows for nesting and shelter. Desert tortoises are protected under the Endangered Species Act. Killing, harming, or harassing desert tortoises, including destruction of their nests with eggs, without prior authorization is prohibited by Federal law.*

*** IF YOUR PROJECT IS IN CLARK COUNTY, PLEASE READ ON:**

Clark County holds a permit from the U.S. Fish & Wildlife Service authorizing "take" of desert tortoises during the course of otherwise legal activities on non-federal lands. **In Clark County only,** discouraging burrowing owls from breeding in the construction site on private property is allowed by collapsing tortoise burrow's during the owl's non-breeding season (September through February). This may help avoid construction delays. Prior to collapsing a burrow, always check for owls or other protected wildlife occupying the burrow for the winter. Call the Nevada Department of Wildlife at 702-486-5127 if a Gila monster is found as this is a State protected species.

Thank you for your assistance in protecting migratory birds and Nevada's endangered and threatened species!

Department of Energy
Washington, DC 20585

December 10, 2009

Mr. Melvin Tobin, Field Supervisor
U.S. Fish and Wildlife Service
Charleston Ecological Services Field Office
176 Croghan Spur Road, Suite 200
Charleston, South Carolina 29407-7558

Dear Mr. Tobin:

The Department of Energy, Office of Environmental Management is preparing an Environmental Impact Statement (EIS) under the National Environmental Policy Act for the disposal of Greater-Than-Class-C Low-Level-Radioactive Waste (GTCC LLRW). In compliance with the Endangered Species Act, the EIS will contain an analysis of the proposed action and potential impacts to listed and proposed threatened and endangered species. We request that you provide us with any information regarding the occurrence of federally listed and proposed threatened and endangered species that may occur on or in the vicinity of the proposed GTCC LLRW disposal location at the Savannah River Site (SRS) at the upland ridge overlooking Tinker Creek, northeast of Area Z in the north-central portion of SRS, Aiken County, that should be considered in preparing the EIS.

I have enclosed a brief background of the project, including information on the potential SRS GTCC location, and a copy of the Notice of Intent. I wish to thank you in advance for the information that you will be providing to us. If you have any questions, please contact me at (301) 903-5145 or at arnold.edelman@em.doe.gov

Sincerely,

Arnold M Edelman

Arnold M. Edelman
EIS Document Manager
Office of Disposal Operations

Enclosure

cc: Drew Grainger, SR

Printed with soy ink on recycled paper

United States Department of the Interior

FISH AND WILDLIFE SERVICE
176 Croghan Spur Road, Suite 200
Charleston, South Carolina 29407

January 6, 2010

Mr. Arnold M. Edelman
EIS Document Manager
Office of Disposal Operations
Department of Energy
Washington, DC 20585

Re: Radioactive Waste Disposal, Savannah River Site, Aiken County, SC
FWS Log No. 42410-2010-SL-0118

Dear Mr. Edelman:

The U.S. Fish and Wildlife Service (Service) has received your request for information regarding threatened and endangered species in the vicinity of the proposed low level radioactive waste disposal site at the Savannah River Site in Aiken County, SC. The Department of Energy (DOE) is developing an Environmental Impact Statement (EIS) to consider alternative disposal sites for low level radioactive waste. The Savannah River Station is one of the sites under consideration. Information requested by the DOE is pursuant to the requirements of the National Environmental Policy Act (NEPA) of 1969, as amended.

Please find attached a list of T&E species that are known to or may occur in Aiken County. This list includes species of state and federal concern. Reconnaissance efforts for the project must include a search for the federally listed T&E species. We also recommend the DOE include all state listed species in its biological/ecological review. Please contact the S.C. Department of Natural Resources for further information on these species and their habitat requirements.

The Service appreciates the opportunity to provide comments and reserves the right to provide additional comments throughout the development of this project. If you have any questions concerning the submitted comments please contact the Service's project manager Mr. Mark Caldwell at (843) 727-4707 ext. 215.

Sincerely,

Diane L. Lynch
Acting Field Supervisor

DLL/MAC

TAKE PRIDE IN AMERICA

South Carolina Distribution Records of
Endangered, Threatened, Candidate and Species of Concern
March 2009

E	Federally endangered
T	Federally threatened
P	Proposed in the Federal Register
CH	Critical Habitat
BGEPA	Federally protected under the Bald and Golden Eagle Protection Act
C	The U.S. Fish and Wildlife Service or the National Marine Fisheries Service has on file sufficient information on biological vulnerability and threat(s) to support proposals to list these species
S/A	Federally protected due to similarity of appearance to a listed species
SC	Federal Species of concern. These species are rare or limited in distribution but are not currently legally protected under the Endangered Species Act.
*	Contact the National Marine Fisheries Service for more information on this species

These lists should be used only as a guideline, not as the final authority. The lists include known occurrences and areas where the species has a high possibility of occurring. Records are updated continually and may be different from the following.

AIKEN COUNTY

Bald eagle	Haliaeetus leucocephalus	BGEPA	Known
Wood stork	Mycteria americana	E	Known
Red-cockaded woodpecker	Picoides borealis	E	Known
Shortnose sturgeon	Acipenser brevirostrum*	E	Known
Relict trillium	Trillium reliquum	E	Known
Piedmont bishop-weed	Ptilimnium nodosum	E	Known
Smooth coneflower	Echinacea laevigata	E	Known
Southern Dusky Salamander	Desmognathus auriculatus	SC	Possible
Gopher frog	Rana capito	SC	Known
Small-flowered buckeye	Aesculus parviflora	SC	Known
Sandhills milk-vetch	Astragalus michauxii	SC	Known
Elliott's croton	Croton elliottii	SC	Known
Dwarf burhead	Echinodorus parvulus	SC	Known
Shoals spider-lily	Hymenocallis coronaria	SC	Known
White-wicky	Kalmia cuneata	SC	Known
Bog spicebush	Lindera subcoriacea	SC	Known
Boykin's lobelia	Lobelia boykinii	SC	Known
Carolina bogmint	Macbridea caroliniana	SC	Known
Awned-meadowbeauty	Rhexia aristosa	SC	Known
Pickering's morning-glory	Stylisma pickeringii var. pickeringii	SC	Known

AIKEN COUNTY (cont)

Reclined meadow-rue	Thalictrum subrotundum	SC	Known
Bachman's sparrow	Aimophila aestivalis	SC	Possible
Henslow's sparrow	Ammodramus henslowii	SC	Known
American kestrel	Falco sparverius	SC	Possible
Loggerhead shrike	Lanius ludovicianus	SC	Possible
Painted bunting	Passerina ciris ciris	SC	Possible
Redhorse, Robust	Moxostoma robustum	SC	Known
Arogos skipper	Atrytone arogos arogos	SC	Known
Rafinesque's big-eared bat	Corynorhinus rafinesquii	SC	Known
Gopher tortoise	Gopherus polyphemus	SC	Known
Southern hognose snake	Heterodon simus	SC	Known
Pine or Gopher snake	Pituophis melanoleucus melanoleucus	SC	Known

Department of Energy
Washington, DC 20585

JAN 19 2010

Mr. Jeff Tayer
Regional Program Director
Washington State Department of Fish and Wildlife
1701 South 24th Avenue
Yakima, Washington 98902

Dear Mr. Tayer:

The Department of Energy, Office (DOE) of Environmental Management is preparing an Environmental Impact Statement (EIS) under the National Environmental Policy Act for the disposal of Greater-Than-Class-C Low-Level-Radioactive Waste (GTCC LLRW). The development of this EIS is mandated under Section 631 of the Energy Policy Act (EPAct) of 2005 and Section 3(b)(1)(D) of the Low-Level Radioactive Waste Policy Amendments Act (LLRWPAA) of 1985. The LLRWPAA assigned the Federal Government responsibility for the disposal of GTCC LLRW that result from Nuclear Regulatory Commission (NRC) licensed activities. The LLRWPAA also directed that such waste be disposed of in a facility licensed by NRC. DOE is the Federal agency responsible for the disposal of GTCC LLRW. This Draft EIS will be issued for public comment in late spring 2010.

Pursuant to Section 631 of EPAct, before making a final decision on the disposal alternative(s) to be implemented, DOE is required to submit to Congress a report that describes all alternatives considered in the EIS and await Congressional action. DOE will issue a report to Congress once the Final EIS is published; anticipated in summer 2011.

The Department is in the process of analyzing the proposed action and potential impacts to listed and proposed threatened and endangered species both at the Federal and State level. We request that you provide us with any information regarding the occurrence of state listed and proposed threatened and endangered species and state sensitive species that may occur on or in the vicinity of the proposed GTCC LLRW disposal location immediately south of the Integrated Disposal Facility site in the 200 East Area in the central portion of the Hanford Site, Benton County that should be considered in preparing the EIS.

I have enclosed a brief background of the project, including information on the potential GTCC locations within the State, and a copy of the Notice of Intent. I wish to thank you in advance for the information that you will be providing to us. If you have any questions, please contact me at (301) 903-5145 or at arnold.edelman@em.doe.gov.

2

Please send the requested information to:

Arnold Edelman
Office of Disposal Operations
Department of Energy, Cloverleaf Building (EM-43)
1000 Independence Avenue, SW
Washington, DC 20585

Sincerely,

Arnold M Edelman

Arnold M. Edelman
EIS Document Manager
Office of Disposal Operations

Enclosures

cc: Woody Russell, ORP

Department of Energy
Washington, DC 20585

JAN 19 2010

Mr. Steve Schmidt
Idaho Department of Fish and Game
4279 Commerce Circle
Idaho Falls, Idaho 83401

Dear Mr. Schmidt:

The Department of Energy, Office (DOE) of Environmental Management is preparing an Environmental Impact Statement (EIS) under the National Environmental Policy Act for the disposal of Greater-Than-Class-C Low-Level-Radioactive Waste (GTCC LLRW). The development of this EIS is mandated under Section 631 of the Energy Policy Act (EPAct) of 2005 and Section 3(b)(1)(D) of the Low-Level Radioactive Waste Policy Amendments Act (LLRWPAA) of 1985. The LLRWPAA assigned the Federal Government responsibility for the disposal of GTCC LLRW that result from Nuclear Regulatory Commission (NRC) licensed activities. The LLRWPAA also directed that such waste be disposed of in a facility licensed by NRC. DOE is the Federal agency responsible for the disposal of GTCC LLRW. This Draft EIS will be issued for public comment in late spring 2010.

Pursuant to Section 631 of EPAct, before making a final decision on the disposal alternative(s) to be implemented, DOE is required to submit to Congress a report that describes all alternatives considered in the EIS and await Congressional action. DOE will issue a report to Congress once the Final EIS is published; anticipated in summer 2011.

The Department is in the process of analyzing the proposed action and potential impacts to listed and proposed threatened and endangered species both at the Federal and State level. We request that you provide us with any information regarding the occurrence of State listed and proposed threatened and endangered species and any state sensitive species that may occur on or in the vicinity of the proposed GTCC LLRW disposal location at the Idaho National Laboratory (INL), southwest of the Reactor Technology Complex in the south central portion of INL, Butte County that should be considered in preparing the EIS.

I have enclosed a brief background of the project, including information on the potential GTCC locations within the State, and a copy of the Notice of Intent. I wish to thank you in advance for the information that you will be providing to us. If you have any questions, please contact me at (301) 903-5145 or at arnold.edelman@em.doe.gov.

2

Please send the requested information to:

Arnold Edelman
Office of Disposal Operations
Department of Energy, Cloverleaf Building (EM-43)
1000 Independence Avenue, SW
Washington, DC 20585

Sincerely,

Arnold M. Edelman
EIS Document Manager
Office of Disposal Operations

Enclosures

cc: Jack Depperschmidt, IDSO

Department of Energy
Washington, DC 20585

JAN 19 2010

Mr. Wally Murphy, Field Office Supervisor
Ecological Services
2105 Osuna Road, NE
Albuquerque, New Mexico 87113

Dear Mr. Murphy:

The Department of Energy, Office (DOE) of Environmental Management is preparing an Environmental Impact Statement (EIS) under the National Environmental Policy Act for the disposal of Greater-Than-Class-C Low-Level-Radioactive Waste (GTCC LLRW). The development of this EIS is mandated under Section 631 of the Energy Policy Act (EPAct) of 2005 and Section 3(b)(1)(D) of the Low-Level Radioactive Waste Policy Amendments Act (LLRWPAA) of 1985. The LLRWPAA assigned the Federal Government responsibility for the disposal of GTCC LLRW that result from Nuclear Regulatory Commission (NRC) licensed activities. The LLRWPAA also directed that such waste be disposed of in a facility licensed by NRC. DOE is the Federal agency responsible for the disposal of GTCC LLRW. This Draft EIS will be issued for public comment in late spring 2010.

Pursuant to Section 631 of EPAct, before making a final decision on the disposal alternative(s) to be implemented, DOE is required to submit to Congress a report that describes all alternatives considered in the EIS and await Congressional action. DOE will issue a report to Congress once the Final EIS is published; anticipated in summer 2011.

The Department is in the process of analyzing the proposed action and potential impacts to listed and proposed threatened and endangered species both at the Federal and State level. We request that you provide us with any information regarding the occurrence of state listed and proposed threatened and endangered species and any State sensitive species that may occur on or in the vicinity of the three proposed GTCC LLRW disposal locations in your State: 1. Los Alamos National Laboratory within TA-54, on Mesita del Buey, Zone 6, North Site, and North Site Expanded, Los Alamos County; and 2. the Waste Isolation Pilot Plant (WIPP) in Eddy County; and 3. Sections 27 and 35 in and around WIPP.

I have enclosed a brief background of the project, including information on the potential GTCC locations within the State, and a copy of the Notice of Intent. I wish to thank you in advance for the information that you will be providing to us. If you have any questions, please contact me at (301) 903-5145 or at arnold.edelman@em.doe.gov.

2

Please send the requested information to:

Arnold Edelman
Office of Disposal Operations
Department of Energy, Cloverleaf Building (EM-43)
1000 Independence Avenue, SW
Washington, DC 20585

Sincerely,

Arnold M. Edelman
EIS Document Manager
Office of Disposal Operations

Enclosures

cc: George Rael, LASO
Nancy Werdel, DOE AL
Susan McCauslin, CBFO

Department of Energy
Washington, DC 20585

JAN 19 2010

Ms. Jennifer E. Newmark, Administrator
Nevada Natural Heritage Program
Richard H. Bryan Building
901 South Stewart Street, Suite 5002
Carson City, Nevada 89701-5245,

Dear Ms. Newmark:

The Department of Energy, Office (DOE) of Environmental Management is preparing an Environmental Impact Statement (EIS) under the National Environmental Policy Act for the disposal of Greater-Than-Class-C Low-Level-Radioactive Waste (GTCC LLRW). The development of this EIS is mandated under Section 631 of the Energy Policy Act (EPAct) of 2005 and Section 3(b)(1)(D) of the Low-Level Radioactive Waste Policy Amendments Act (LLRWPAA) of 1985. The LLRWPAA assigned the Federal Government responsibility for the disposal of GTCC LLRW that result from Nuclear Regulatory Commission (NRC) licensed activities. The LLRWPAA also directed that such waste be disposed of in a facility licensed by NRC. DOE is the Federal agency responsible for the disposal of GTCC LLRW. This Draft EIS will be issued for public comment in late spring 2010.

Pursuant to Section 631 of EPAct, before making a final decision on the disposal alternative(s) to be implemented, DOE is required to submit to Congress a report that describes all alternatives considered in the EIS and await Congressional action. DOE will issue a report to Congress once the Final EIS is published; anticipated in summer 2011.

The Department is in the process of analyzing the proposed action and potential impacts to listed and proposed threatened and endangered species both at the Federal and State level. We request that you provide us with any information regarding the occurrence of State listed and proposed threatened and endangered species and any state sensitive species that may occur on or in the vicinity of the proposed GTCC LLRW disposal location at the Nevada Test Site (NTS), in the vicinity north of Frenchman Flat, either southeast or west of the existing Radioactive Waste Management Facility, Nye County that should be considered in preparing the EIS.

I have enclosed a brief background of the project, including information on the potential GTCC locations within the State, and a copy of the Notice of Intent. I wish to thank you in advance for the information that you will be providing to us. If you have any questions, please contact me at (301) 903-5145 or at arnold.edelman@em.doe.gov.

Please send the requested information to:

Arnold Edelman
Office of Disposal Operations
Department of Energy, Cloverleaf Building (EM-43)
1000 Independence Avenue, SW
Washington, DC 20585

Sincerely,

Arnold M. Edelman
EIS Document Manager
Office of Disposal Operations

Enclosures

cc: Linda Cohn, NSO
Lori Plummer, NSO

ALLEN BIAGGI
Director

Department of Conservation
and Natural Resources

JENNIFER E. NEWMARK
Administrator

JIM GIBBONS
Governor

Nevada Natural Heritage Program
Richard H. Bryan Building
901 S. Stewart Street, Suite 5002
Carson City, Nevada 89701-5245
U.S.A.

tel: (775) 684-2900
fax: (775) 684-2909

STATE OF NEVADA
DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES

Nevada Natural Heritage Program

http://heritage.nv.gov

10 February 2010

Arnold Edelman
Office of Disposal Operations
Department of Energy, Cloverleaf Building (EM-43)
1000 Independence Ave., SW
Washington, DC 20585

RE: Data request received 25 January 2010

Dear Mr. Edelman:

We are pleased to provide the information you requested on endangered, threatened, candidate, and/or at risk plant and animal taxa recorded within or near the Proposed Greater-Than-Class-C Low Level Radioactive Waste disposal project area on the Nevada Test Site. We searched our database and maps for the following, a three kilometer radius around the location provided in your request including:

Township	12S	Range	54E	Sections	All
Township	12S	Range	55E	Sections	All
Township	13S	Range	53E	Sections	All
Township	13S	Range	54E	Sections	All
Township	13S	Range	55E	Sections	All

The enclosed printout lists the taxa recorded within the given area. Please be aware that habitat may also be available for: the Clokey pincushion, *Coryphantha vivipara* var. *rosea*, a Taxon determined to be Vulnerable by the Nevada Natural Heritage Program as well as a protected cactus under NRS 527.060-120); the Clarke phacelia, *Phacelia filiae*, a Nevada Bureau of Land Management (BLM) Sensitive Species; the western small-footed myotis, *Myotis ciliolabrum*, a Nevada BLM Sensitive Species; and the pallid bat, *Antrozous pallidus*, a Nevada BLM Sensitive Species. We do not have complete data on various raptors that may also occur in the area; for more information contact Chet VanDellen, Nevada Division of Wildlife at (775) 688-1565. Note that all cacti, yuccas, and Christmas trees are protected by Nevada state law (NRS 527.060-.120), including taxa not tracked by this office.

Please note that our data are dependent on the research and observations of many individuals and organizations, and in most cases are not the result of comprehensive or site-specific field surveys. Natural Heritage reports should never be regarded as

(NSPO 8-08)

final statements on the taxa or areas being considered, nor should they be substituted for on-site surveys required for environmental assessments.

Thank you for checking with our program. Please contact us for additional information or further assistance.

Sincerely,

Eric S. Miskow
Biologist/Data Manager

At Risk Taxa Recorded Near the GTCC Reference Location on the NTS Project Area
Compiled by the Nevada Natural Heritage Program for the U.S. Department of Energy
10 February 2010

Scientific name	Common name	Usfws	Blm	Usfs	State	Srank	Grank	UTM E	UTM N	Prec	Last observed
Plants											
Arctomecon merriamii	white bearpoppy		N	S		S3	G3	597410.49	4064718.51	G	1971-06-04
Astragalus funereus	black woollypod		N;C	S		S2	G2	596692.17	4086468.33	S	1979-05-10
Astragalus funereus	black woollypod		N;C	S		S2	G2	593788.82	4084956.51	S	1992-05-04
Astragalus funereus	black woollypod		N;C	S		S2	G2	593421.31	4084613.41	S	1992-05-05
Camissonia megalantha	Cane Spring suncup		N			S3	G3Q	594939.94	4081610.01	M	1978-09-26
Camissonia megalantha	Cane Spring suncup		N			S3	G3Q	593595.51	4086772.70	M	1992-08-17
Camissonia megalantha	Cane Spring suncup		N			S3	G3Q	594251.35	4083420.67	S	1992-08-04
Camissonia megalantha	Cane Spring suncup		N			S3	G3Q	593834.18	4085326.80	S	1992-08-04
Cymopterus ripleyi var. *saniculoides*	sanicle biscuitroot		N;C			S3	G3G4T3Q	590467.43	4073764.28	G	1965-05-19
Cymopterus ripleyi var. *saniculoides*	sanicle biscuitroot		N;C			S3	G3G4T3Q	589218.92	4088821.27	G	1965-05-20
Cymopterus ripleyi var. *saniculoides*	sanicle biscuitroot		N;C			S3	G3G4T3Q	595068.38	4070085.31	G	1941-05-13
Phacelia beatleyae	Beatley scorpionflower		N			S3	G3	595818.80	4087105.60	M	1976-06-21
Phacelia beatleyae	Beatley scorpionflower		N			S3	G3	594839.83	4083920.27	S	1992-06-11
Phacelia beatleyae	Beatley scorpionflower		N			S3	G3	597347.06	4083301.44	M	1979-05-10
Phacelia beatleyae	Beatley scorpionflower		N			S3	G3	596294.14	4086648.76	S	1977-PRE
Phacelia beatleyae	Beatley scorpionflower		N			S3	G3	597773.31	4089285.29	M	1979-05-10
Reptiles											
Gopherus agassizii	desert tortoise (Mojave Desert pop.)	LT	S	T	YES	S2S3	G4	599229.05	4079008.49	M	1994-PRE
Gopherus agassizii	desert tortoise (Mojave Desert pop.)	LT	S	T	YES	S2S3	G4	599850.80	4076673.52	M	1994-PRE
Gopherus agassizii	desert tortoise (Mojave Desert pop.)	LT	S	T	YES	S2S3	G4	587377.81	4072961.68	M	1994-PRE
Gopherus agassizii	desert tortoise (Mojave Desert pop.)	LT	S	T	YES	S2S3	G4	593997.43	4081753.65	S	1993-05-05
Gopherus agassizii	desert tortoise (Mojave Desert pop.)	LT	S	T	YES	S2S3	G4	587532.46	4079619.89	M	1994-PRE
Mammals											
Notiosorex crawfordi	Crawford's desert shrew					S3	G5	595367.85	4067684.80	G	1961-10-11

U. S. Fish and Wildlife Service (Usfws) Categories for Listing under the Endangered Species Act:

- LT — Listed Threatened - likely to be classified as Endangered in the foreseeable future if present trends continue

Bureau of Land Management (Blm) Species Classification:

- S — Nevada Special Status Species - USFWS listed, proposed or candidate for listing, or protected by Nevada state law
- N — Nevada Special Status Species - designated Sensitive by State Office
- C — California Special Status Species (see definition S and N)

United States Forest Service (Usfs) Species Classification:

- S — Region 4 (Humboldt-Toiyabe NF) sensitive species
- T — Region 4 and/or Region 5 Threatened species

Nevada State Protected (State) Species Classification:

Fauna:
- YES — Species protected under NRS 501.

Precision (Prec) of Mapped Occurrence:

Precision, or radius of uncertainty around latitude/longitude coordinates:

- S — Seconds: within a three-second radius
- M — Minutes: within a one-minute radius, approximately 2 km or 1.5 miles
- G — General: within about 8 km or 5 miles, or to map quadrangle or place name

Nevada Natural Heritage Program Global (**Grank**) and State (**Srank**) Ranks for Threats and/or Vulnerability:

- G — Global rank indicator, based on worldwide distribution at the species level
- T — Global trinomial rank indicator, based on worldwide distribution at the infraspecific level
- S — State rank indicator, based on distribution within Nevada at the lowest taxonomic level
  - 1 — Critically imperiled and especially vulnerable to extinction or extirpation due to extreme rarity, imminent threats, or other factors
  - 2 — Imperiled due to rarity or other demonstrable factors
  - 3 — Vulnerable to decline because rare and local throughout its range, or with very restricted range
  - 4 — Long-term concern, though now apparently secure; usually rare in parts of its range, especially at its periphery
  - 5 — Demonstrably secure, widespread, and abundant
    - A — Accidental within Nevada
    - B — Breeding status within Nevada (excludes resident taxa)
    - H — Historical; could be rediscovered
    - N — Non-breeding status within Nevada (excludes resident taxa)
    - Q — Taxonomic status uncertain
    - U — Unrankable
    - Z — Enduring occurrences cannot be defined (usually given to migrant or accidental birds)
    - ? — Assigned rank uncertain

Department of Energy
Washington, DC 20585

JAN 19 2010

Ms. Julie Holling
Department of Natural Resources
Wildlife and Freshwater Fisheries Division
P.O. Box 167
Columbia, South Carolina 29202-0167

Dear Ms. Holling:

The Department of Energy, Office (DOE) of Environmental Management is preparing an Environmental Impact Statement (EIS) under the National Environmental Policy Act for the disposal of Greater-Than-Class-C Low-Level-Radioactive Waste (GTCC LLRW). The development of this EIS is mandated under Section 631 of the Energy Policy Act (EPAct) of 2005 and Section 3(b)(1)(D) of the Low-Level Radioactive Waste Policy Amendments Act (LLRWPAA) of 1985. The LLRWPAA assigned the Federal Government responsibility for the disposal of GTCC LLRW that result from Nuclear Regulatory Commission (NRC) licensed activities. The LLRWPAA also directed that such waste be disposed of in a facility licensed by NRC. DOE is the Federal agency responsible for the disposal of GTCC LLRW. This Draft EIS will be issued for public comment in late spring 2010.

Pursuant to Section 631 of EPAct, before making a final decision on the disposal alternative(s) to be implemented, DOE is required to submit to Congress a report that describes all alternatives considered in the EIS and await Congressional action. DOE will issue a report to Congress once the Final EIS is published; anticipated in summer 2011.

The Department is in the process of analyzing the proposed action and potential impacts to listed and proposed threatened and endangered species both at the Federal and State level. We request that you provide us with any information regarding the occurrence of State listed and proposed threatened and endangered species and any state sensitive species that may occur on or in the vicinity of the proposed GTCC LLRW disposal location at the Savannah River Site (SRS) at the upland ridge overlooking Tinker Creek, northeast of Area Z in the north-central portion of SRS, Aiken County, that should be considered in preparing the EIS.

I have enclosed a brief background of the project, including information on the potential GTCC locations within the State, and a copy of the Notice of Intent. I wish to thank you in advance for the information that you will be providing to us. If you have any questions, please contact me at (301) 903-5145 or at arnold.edelman@em.doe.gov.

Please send the requested information to:

Arnold Edelman
Office of Disposal Operations
Department of Energy, Cloverleaf Building (EM-43)
1000 Independence Avenue, SW
Washington, DC 20585

Sincerely,

Arnold M. Edelman
EIS Document Manager
Office of Disposal Operations

Enclosures

cc: Drew Grainger, SR

South Carolina Department of
Natural Resources

DNR

John E. Frampton
Director

Ken Rentiers
Deputy Director for
Land, Water and Conservation Division

January 27, 2010

Mr. Arnold M. Edelman, EIS Document Manager
Office of Disposal Operations
Department of Energy, Cloverleaf Building (EM-43)
1000 Independence Avenue, SW
Washington, DC 20585

RE: Threatened and Endangered Species and GTCC LLRW waste disposal at Savannah River Site, South Carolina

Dear Mr. Johnson,

Because our database does not represent a comprehensive biological inventory of the state, I can only verify the known occurrences in the vicinity of your project. There may be occurrences of species in the vicinity of your project area that have not been reported to us. Fieldwork remains the responsibility of the investigator.

Since this is a preliminary report and only a rough idea given for the location, I have reviewed our database a little more broadly than usual. There are no known occurrences or any federally or state listed threatened or endangered within the expected drainage of the project area. However, there are a number of rare plant records for the drainage area, including: *Carex folliculata* (Long Sedge, G4G5, S1), *Ilex amelanchier* (Sarvis Holly, G4, S3), *Lindera subcoriacea* (Bog Spicebush, G2G3, S3), *Nestronia umbellula* (Nestronia, G4, S3), *Nolina georgiana* (Georgia Bear-grass, G3G5, S3), *Platanthera lacera* (Green-fringe Orchis, G5, S2), and *Rhododendron flammeum* (Piedmont azalea, G3, S3). Although these species do not have any legal protection, we ask that you consider protecting them during your work. As further indication of other species that may occur in the project area, I have also enclosed the list of rare, threatened, and endangered species and communities that occur within roughly 5 miles of the project site.

Rembert C. Dennis Building • 1000 Assembly Street • PO Box 167 • Columbia, SC 29202 • Telephone: 803-734-9100 • Fax: 803-734-9200
EQUAL OPPORTUNITY AGENCY www.dnr.sc.gov PRINTED ON RECYCLED PAPER

As a professional courtesy, we ask that you acknowledge S.C. Heritage Trust as a source of information whenever you use this data in reports.

If you need additional assistance, please contact me by phone at 803-734-3917 or by e-mail at HollingJ@dnr.sc.gov.

Sincerely,

Julie Holling

Julie Holling, Data Manager
SC Department of Natural Resources
Heritage Trust Program

Encl.

Rare, Threatened, and Endangered Species and Communities Known to Occur within 5 miles of SRS GTCC LLRW Disposal Site
January 26, 2010

Scientific Name	Common Name	USESA Designation	State Protection	Global Rank	State Rank
Vertebrate Animals					
Condylura cristata	Star-nosed Mole			G5	S3?
Corynorhinus rafinesquii	Rafinesque's Big-eared Bat		SE-Endangered	G3G4	S2?
Egretta caerulea	Little Blue Heron			G5	SNRB,SNRN
Heterodon simus	Southern Hognose Snake			G2	SNR
Neotoma floridana	Eastern Woodrat			G5	S3S4
Pituophis melanoleucus	Pine or Gopher Snake			G4	S3S4
Rana capito	Gopher Frog		SE-Endangered	G3	S1
Vascular Plants					
Allium cuthbertii	Striped Garlic			G4	S2
Baptisia lanceolata	Lance-leaf Wild-indigo			G4	S3
Carex folliculata	Long Sedge			G4G5	S1
Coreopsis rosea	Rose Coreopsis			G3	S2
Croton elliottii	Elliott's Croton			G2G3	S2S3
Echinacea laevigata	Smooth Coneflower	LE: Listed endangered		G2G3	S3
Echinodorus tenellus	Dwarf Burhead			G5?	S2
Eleocharis robbinsii	Robbins Spikerush			G4G5	S2
Ilex amelanchier	Sarvis Holly			G4	S3
Lindera subcoriacea	Bog Spicebush			G2G3	S3
Ludwigia spathulata	Spatulate Seedbox			G2G3	S3
Nestronia umbellula	Nestronia			G4	S3
Nolina georgiana	Georgia Beargrass			G3G5	S3
Paronychia americana	American Nailwort			G3G4	SNR
Platanthera lacera	Green-fringe Orchis			G5	S2
Rhododendron flammeum	Piedmont Azalea			G3	S3
Sagittaria isoetiformis	Slender Arrow-head			G4?	S3
Utricularia floridana	Florida Bladderwort			G3G5	S2
Utricularia olivacea	Piedmont Bladderwort			G4	S2
Communities					
Fagus grandifolia - (*Liquidambar styraciflua*) / *Oxydendrum arboreum* / *Kalmia latifolia* forest	Piedmont/coastal Plain Beech - Mountain Laurel Slope Forest			G3?	SNR

Page 1 of 2

Department of Energy
Washington, DC 20585

JAN 19 2010

MEMORANDUM FOR JUAN GRIEGO
ASSISTANT MANAGER FOR
NATIONAL SECURITY MISSION
LOS ALAMOS SITE OFFICE

FROM: CHRISTINE GELLES
DIRECTOR
OFFICE OF DISPOSAL OPERATIONS

SUBJECT: Cultural and Paleontological Resources Consultation for the *Disposal of Greater-Than-Class C (GTCC) Low Level Radioactive Waste and GTCC-Like Waste Environmental Impact Statement (DOE/EIS-0375D)*

The Department of Energy, Office of Environmental Management is preparing an Environmental Impact Statement (EIS) under the National Environmental Policy Act for the disposal of Greater-Than-Class-C Low-Level-Radioactive Waste (GTCC LLRW). In compliance with the National Historic Preservation Act of 1966 (PL-89-665), the EIS will contain an analysis of the proposed action and potential impacts to cultural resources. We request that you provide us with any information regarding cultural resources that may be affected by the location of the proposed GTCC LLRW disposal locations within TA-54, on Mesita del Buey, Zone 6, North Site, and North Site Expanded, Los Alamos County.

I have attached a brief background of the project, including information on the potential GTCC location, and a copy of the Notice of Intent. I wish to thank you in advance for the information that you will be providing to us. If you have any questions, please contact Arnie Edelman at (301) 903-5145 or at arnold.edelman@em.doe.gov.

Please send the requested information to:

Arnold Edelman
Office of Disposal Operations
Department of Energy, Cloverleaf Building (EM-43)
1000 Independence Avenue, SW
Washington, DC 20585

Attachment

cc: Vicki Loucks, LASO

Printed with soy ink on recycled paper

Department of Energy
Washington, DC 20585

JAN 19 2010

Dr. Allyson Brooks
State Historic Preservation Officer
Department of Archeology and Historic Preservation
Washington Department of Community, Trade and Economic Development
P.O. Box 48343
Olympia, Washington 98504-8343

Dear Dr. Brooks:

The Department of Energy, Office (DOE) of Environmental Management is preparing an Environmental Impact Statement (EIS) under the National Environmental Policy Act for the disposal of Greater-Than-Class-C Low-Level-Radioactive Waste (GTCC LLRW). The development of this EIS is mandated under Section 631 of the Energy Policy Act (EPAct) of 2005 and Section 3(b)(1)(D) of the Low-Level Radioactive Waste Policy Amendments Act (LLRWPAA) of 1985. The LLRWPAA assigned the Federal Government responsibility for the disposal of GTCC LLRW that result from Nuclear Regulatory Commission (NRC) licensed activities. The LLRWPAA also directed that such waste be disposed of in a facility licensed by NRC. DOE is the Federal agency responsible for the disposal of GTCC LLRW. This Draft EIS will be issued for public comment in late spring 2010.

Pursuant to Section 631 of EPAct, before making a final decision on the disposal alternative(s) to be implemented, DOE is required to submit to Congress a report that describes all alternatives considered in the EIS and await Congressional action. DOE will issue a report to Congress once the Final EIS is published; anticipated in summer 2011.

In compliance with the National Historic Preservation Act of 1966 (PL-89-665), the EIS will contain an analysis of the proposed action, and potential impacts to cultural and paleontological resources. The Department is in the process of analyzing information regarding cultural and paleontological resources in the 200-West Area. This information will be presented in the Draft EIS chapter on Hanford.

Should the EIS Record of Decision, expected to be issued in 2011, select a site near the Hanford Site Central Waste Complex for disposal of GTCC waste, a formal Cultural Resources Review would be conducted in accordance with Section 106 of the National Historic Preservation Act, and Advisory Council on Historic Preservation regulations for Protection of Historic Properties (36 CFR Part 800).

In support of the preparation of this EIS, DOE is soliciting any specific concerns you may have regarding cultural resources that may be affected by the proposed project.

2

I have enclosed a brief background of the project, including information on the location of the potential GTCC location within the State, and a copy of the Notice of Intent. I wish to thank you in advance for the information that you will be providing to us. If you have any questions, please contact me at (301) 903-5145 or at arnold.edelman@em.doe.gov.

Please send the requested information to:

Arnold Edelman
Office of Disposal Operations
Department of Energy, Cloverleaf Building (EM-43)
1000 Independence Avenue, SW
Washington, DC 20585

Sincerely,

Arnold M Edelman

Arnold M. Edelman
NEPA Document Manager
Office of Disposal Operations

Enclosure

cc: Woody Russell, ORP
A. Rodriguez, DOE-RL
R. Corey, DOE-RL

Department of Energy
Washington, DC 20585

JAN 19 2010

Mr. Ken Reid, Deputy SHPO
State Historic Preservation Office
210 Main Street (The Assay Office)
Boise, Idaho 83702

Dear Mr. Reid:

The Department of Energy, Office (DOE) of Environmental Management is preparing an Environmental Impact Statement (EIS) under the National Environmental Policy Act for the disposal of Greater-Than-Class-C Low-Level-Radioactive Waste (GTCC LLRW). The development of this EIS is mandated under Section 631 of the Energy Policy Act (EPAct) of 2005 and Section 3(b)(1)(D) of the Low-Level Radioactive Waste Policy Amendments Act (LLRWPAA) of 1985. The LLRWPAA assigned the Federal Government responsibility for the disposal of GTCC LLRW that result from Nuclear Regulatory Commission (NRC) licensed activities. The LLRWPAA also directed that such waste be disposed of in a facility licensed by NRC. DOE is the Federal agency responsible for the disposal of GTCC LLRW. This Draft EIS will be issued for public comment in late spring 2010.

Pursuant to Section 631 of EPAct, before making a final decision on the disposal alternative(s) to be implemented, DOE is required to submit to Congress a report that describes all alternatives considered in the EIS and await Congressional action. DOE will issue a report to Congress once the Final EIS is published; anticipated in summer 2011.

In compliance with the National Historic Preservation Act of 1966 (PL-89-665), the EIS will contain an analysis of the proposed action, and potential impacts to cultural and paleontological resources. The Department is in the process of analyzing the proposed action and their potential impacts. We request that you provide us with any information regarding cultural and paleontological resources that may be affected by the proposed GTCC LLRW disposal location at the Idaho National Laboratory (INL), southwest of the Reactor Technology Complex in the south central portion of INL, Butte County that should be considered in preparing the EIS.

I have enclosed a brief background of the project, including information on the location of the potential GTCC location within the State, and a copy of the Notice of Intent. I wish to thank you in advance for the information that you will be providing to us. If you have any questions, please contact me at (301) 903-5145 or at arnold.edelman@em.doe.gov.

2

Please send the requested information to:

Arnold Edelman
Office of Disposal Operations
Department of Energy, Cloverleaf Building (EM-43)
1000 Independence Avenue, SW
Washington, DC 20585

Sincerely,

Arnold M. Edelman
NEPA Document Manager
Office of Disposal Operations

Enclosure

cc: Jack Depperschmidt, IDSO

Department of Energy
Washington, DC 20585

JAN 19 2010

Ms. Jan Biella
State of New Mexico Department of Cultural Affairs
Bataan Memorial Building
407 Galisteo Street
Suite 236
Santa Fe, New Mexico 87501

Dear Ms. Biella:

The Department of Energy, Office (DOE) of Environmental Management is preparing an Environmental Impact Statement (EIS) under the National Environmental Policy Act for the disposal of Greater-Than-Class-C Low-Level-Radioactive Waste (GTCC LLRW). The development of this EIS is mandated under Section 631 of the Energy Policy Act (EPAct) of 2005 and Section 3(b)(1)(D) of the Low-Level Radioactive Waste Policy Amendments Act (LLRWPAA) of 1985. The LLRWPAA assigned the Federal Government responsibility for the disposal of GTCC LLRW that result from Nuclear Regulatory Commission (NRC) licensed activities. The LLRWPAA also directed that such waste be disposed of in a facility licensed by NRC. DOE is the Federal agency responsible for the disposal of GTCC LLRW. This Draft EIS will be issued for public comment in late spring 2010.

Pursuant to Section 631 of EPAct, before making a final decision on the disposal alternative(s) to be implemented, DOE is required to submit to Congress a report that describes all alternatives considered in the EIS and await Congressional action. DOE will issue a report to Congress once the Final EIS is published; anticipated in summer 2011.

In compliance with the National Historic Preservation Act of 1966 (PL-89-665), the EIS will contain an analysis of the proposed action and potential impacts to cultural and paleontological resources The Department is in the process of analyzing the proposed action and their potential impacts. We therefore request that you provide us with any information regarding cultural and paleontological resources that may be affected by the location of the proposed GTCC LLRW disposal locations in your State, the Waste Isolation Pilot Plant (WIPP) in Eddy County; and Sections 27 and 35 in and around WIPP. Please note that we are working with our DOE offices on development of the EIS and that Consultation with the State, if needed for LANL, will occur through the Los Alamos Site Office.

I have enclosed a brief background of the project, including information on the potential New Mexico GTCC locations, and a copy of the Notice of Intent. I wish to thank you in advance for the information that you will be providing to us. If you have any questions, please contact me at (301) 903-5145 or at arnold.edelman@em.doe.gov.

Please send the requested information to:

Arnold Edelman
Office of Disposal Operations
Department of Energy, Cloverleaf Building (EM-43)
1000 Independence Avenue, SW
Washington, DC 20585

Sincerely,

Arnold M. Edelman
NEPA Document Manager
Office of Disposal Operations

Enclosure

cc: Susan McCauslin, CBFO
Vicki Loucks, LASO
Elizabeth Withers, DOE-AL

Department of Energy
Washington, DC 20585

JAN 19 2010

Mr. Ronald James
Historic Preservation Office
100 North Stewart Street
Capitol Complex
Carson City, Nevada 89701-4285

Dear Mr. James:

The Department of Energy, Office (DOE) of Environmental Management is preparing an Environmental Impact Statement (EIS) under the National Environmental Policy Act for the disposal of Greater-Than-Class-C Low-Level-Radioactive Waste (GTCC LLRW). The development of this EIS is mandated under Section 631 of the Energy Policy Act (EPAct) of 2005 and Section 3(b)(1)(D) of the Low-Level Radioactive Waste Policy Amendments Act (LLRWPAA) of 1985. The LLRWPAA assigned the Federal Government responsibility for the disposal of GTCC LLRW that result from Nuclear Regulatory Commission (NRC) licensed activities. The LLRWPAA also directed that such waste be disposed of in a facility licensed by NRC. DOE is the Federal agency responsible for the disposal of GTCC LLRW. This Draft EIS will be issued for public comment in late spring 2010.

Pursuant to Section 631 of EPAct, before making a final decision on the disposal alternative(s) to be implemented, DOE is required to submit to Congress a report that describes all alternatives considered in the EIS and await Congressional action. DOE will issue a report to Congress once the Final EIS is published; anticipated in summer 2011.

In compliance with the National Historic Preservation Act of 1966 (PL-89-665), the EIS will contain an analysis of the proposed action, and potential impacts to cultural and paleontological resources. The Department is in the process of analyzing the proposed action and their potential impacts. We request that you provide us with any information regarding cultural and paleontological resources that may be affected by the proposed GTCC LLRW disposal location at the Nevada Test Site (NTS), in the vicinity north of Frenchman Flat, either southeast or west of the existing Radioactive Waste Management Facility, Nye County that should be considered in preparing the EIS.

I have enclosed a brief background of the project, including information on the location of the potential GTCC location within the State, and a copy of the Notice of Intent. I wish to thank you in advance for the information that you will be providing to us. If you have any questions, please contact me at (301) 903-5145 or at arnold.edelman@em.doe.gov.

Please send the requested information to:

Arnold Edelman
Office of Disposal Operations
Department of Energy, Cloverleaf Building (EM-43)
1000 Independence Avenue, SW
Washington, DC 20585

If you have any questions, please contact me at (301) 903-5145.

Sincerely,

Arnold M. Edelman
NEPA Document Manager
Office of Disposal Operations

Enclosure

cc: Linda Cohn, NSO

From: Alice Baldrica [mailto:ABaldrica@nevadaculture.org]
Sent: Wednesday, March 24, 2010 5:39 PM
To: Edelman, Arnold
Subject: RE: your request for information

Dear Mr. Edelman:

I checked the Nevada Cultural Resources Information System (NVCRIS), the State's electronic database for archaeological resources. A handful of very small lithic scatters are located within the alternative project area but none of them are eligible for inclusion in the National Register of Historic Places.

Historic properties resulting from nuclear testing activities have been recorded at Frenchman Flat that are associated with the Cold War. At the present time, the effect of a project on such historic properties is unknown.

If you have any questions let me know.

Alice M. Baldrica
State Historic Preservation Office
100 N. Stewart St.
Carson City, NV 89701
Telephone: 775-684-3444
FAX: 775-684-3442
abaldrica@nevadaculture.org

Department of Energy
Washington, DC 20585

JAN 19 2010

Mr. Eric Emerson
Department of Archives and History
8301 Parklane Road
Columbia, South Carolina 29223-4905

Dear Mr. Emerson:

The Department of Energy, Office (DOE) of Environmental Management is preparing an Environmental Impact Statement (EIS) under the National Environmental Policy Act for the disposal of Greater-Than-Class-C Low-Level-Radioactive Waste (GTCC LLRW). The development of this EIS is mandated under Section 631 of the Energy Policy Act (EPAct) of 2005 and Section 3(b)(1)(D) of the Low-Level Radioactive Waste Policy Amendments Act (LLRWPAA) of 1985. The LLRWPAA assigned the Federal Government responsibility for the disposal of GTCC LLRW that result from Nuclear Regulatory Commission (NRC) licensed activities. The LLRWPAA also directed that such waste be disposed of in a facility licensed by NRC. DOE is the Federal agency responsible for the disposal of GTCC LLRW. This Draft EIS will be issued for public comment in late spring 2010.

Pursuant to Section 631 of EPAct, before making a final decision on the disposal alternative(s) to be implemented, DOE is required to submit to Congress a report that describes all alternatives considered in the EIS and await Congressional action. DOE will issue a report to Congress once the Final EIS is published; anticipated in summer 2011.

In compliance with the National Historic Preservation Act of 1966 (PL-89-665), the EIS will contain an analysis of the proposed action, and potential impacts to cultural and paleontological resources. The Department is currently in the process of analyzing the proposed action and their potential impacts. We request that you provide us with any information regarding cultural and paleontological resources that may be affected by the proposed GTCC LLRW disposal location at the Savannah River Site (SRS) at the upland ridge overlooking Tinker Creek, northeast of Area Z in the north-central portion of SRS, Aiken County, which should be considered in preparing the EIS.

I have enclosed a brief background of the project, including information on the location of the potential GTCC location within the State, and a copy of the Notice of Intent. I wish to thank you in advance for the information that you will be providing to us. If you have any questions, please contact me at (301) 903-5145 or at arnold.edelman@em.doe.gov.

Please send the requested information to:

Arnold Edelman
Office of Disposal Operations
Department of Energy, Cloverleaf Building (EM-43)
1000 Independence Avenue, SW
Washington, DC 20585

Sincerely,

Arnold M. Edelman
NEPA Document Manager
Office of Disposal Operations

Enclosure

cc: Drew Grainger, SRSO

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PROJECT BACKGROUND INFORMATION

This is a copy of the information attached as an enclosure to the letter sent out by A.M. Edelman of DOE.

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Enclosure

Project Background Information

The following provides a brief background of the project and an overview of the alternative disposal sites.

The Department of Energy (DOE) published its Notice of Intent (NOI) to prepare an Environmental Impact Statement (EIS) for disposal of Greater-Than-Class-C Low-Level-Radioactive Waste (GTCC LLRW) in the Federal Register (Vol. 72, No.140) on July 23, 2007. (A copy of the NOI is attached).[1] DOE proposes to construct and operate a new facility or facilities, or use an existing facility or facilities, for the disposal of GTCC LLRW and GTCC-like waste. DOE would then close the facility or facilities at the end of each facility's operational life. Institutional controls, including monitoring, would be employed for a period of time determined during the implementation phase. A combination of disposal methods and locations may be appropriate, depending on the characteristics of the waste and other factors.

The Waste Isolation Pilot Plant (WIPP) in Eddy County, New Mexico is evaluated for deep geologic disposal. Land disposal methods (i.e., boreholes, trench and above-grade vault methods) are evaluated at seven federally owned sites: (1) Hanford Site in Benton County, Washington; (2) Idaho National Laboratory (INL) in Butte County, Idaho; (3) Los Alamos National Laboratory (LANL) in Los Alamos County, New Mexico; (4) Nevada Test Site (NTS) in Nye County, Nevada; (5) Oak Ridge Reservation (ORR) in Roane and Anderson Counties, Tennessee; (6) Savannah River Site (SRS) in Aiken County, South Carolina; and (7) WIPP Vicinity in Eddy County, New Mexico. The WIPP Vicinity location is situated just outside the boundary of the WIPP facility. A map of these sites being considered for waste disposal is provided in Figure 1.

The DOE sites evaluated for the land disposal methods were chosen on the basis of mission compatibility (i.e., only DOE sites that currently have radioactive waste disposal as part of their ongoing mission were considered). Since these sites are currently being used for disposal of LLRW, it is expected that they may contain areas within them that are suitable for disposal of similar but generally higher-activity LLRW (i.e., the GTCC LLRW and GTCC-like waste inventory that will be discussed in the EIS). These DOE sites would also have supporting infrastructure already in place that might be useful for future potential GTCC waste disposal activities. The WIPP Vicinity was chosen because of its proximity to ongoing waste disposal operations at WIPP and the potential to use its supporting infrastructure.

Aside from mission compatibility, site factors that were considered in identifying an acceptable area for developing a GTCC LLRW disposal facility were as follows: have sufficient depth to avoid groundwater; not to be located within the 100-year floodplain or in or near wetlands; be consistent with current land use plans; have low probability for erosion, mass wasting, faulting, folding, and seismic activity; and have site data available for modeling or evaluation purposes.

[1] The proposed Yucca Mountain repository mentioned in the NOI is no longer being considered for a disposal site for GTCC LLRW.

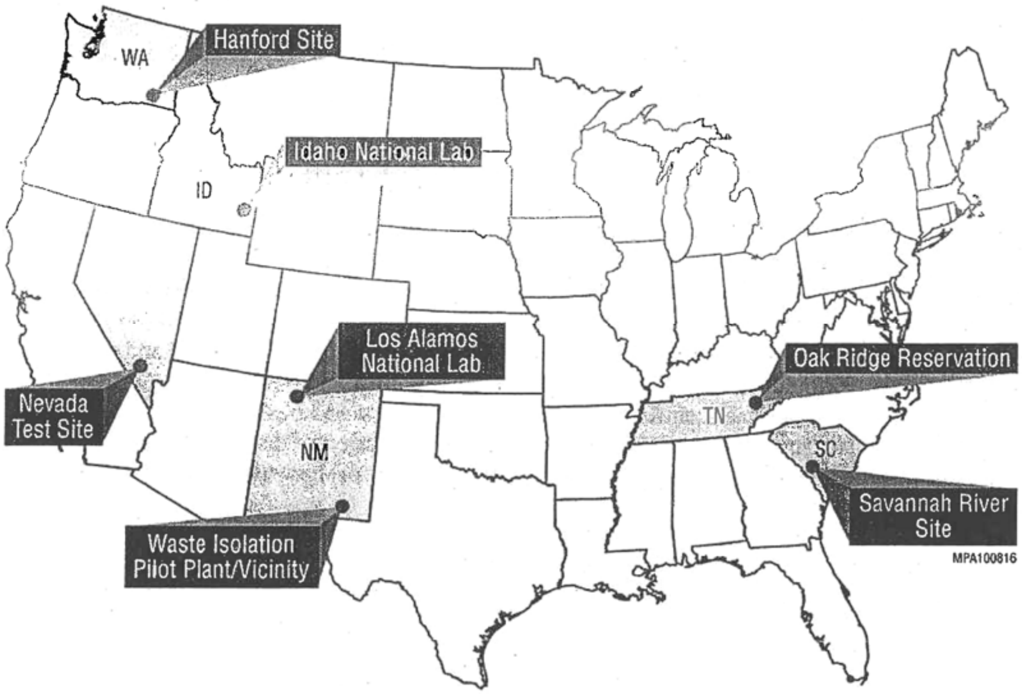

FIGURE 1 Map of Sites Being Considered for Disposal of GTCC LLRW and GTCC-Like Waste

WIPP

WIPP is a DOE facility that is the world's first underground repository permitted by the U.S. Environmental Protection Agency (EPA) and the state of New Mexico to safely and permanently dispose of defense-related TRU radioactive waste associated with the research and production of nuclear weapons. WIPP is located 26 mi east of Carlsbad, New Mexico, in the Chihuahuan Desert in the southeast corner of the state (Figure 2). Project facilities include disposal rooms that are mined 2,150 ft under the ground in a salt formation (the Salado Formation) that is 2,000-ft thick and has been stable for more than 200 million years. The WIPP facility sits in the approximate center of a 16-mi^2 area that was withdrawn from public domain and transferred to DOE (Figure 3). The facility footprint itself encompasses 35 fenced acres of surface space and about 7.5 mi of underground excavations in the Salado Formation.

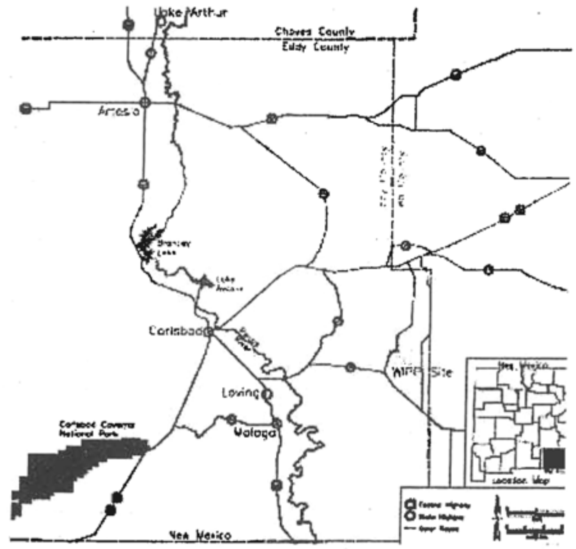

FIGURE 2 General Location of WIPP in Eddy County, New Mexico

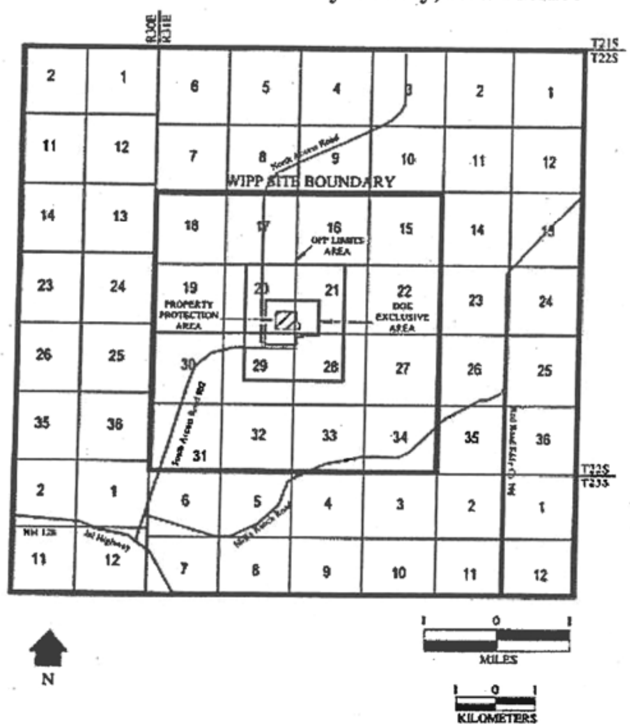

FIGURE 3 Land Withdrawal Area Boundary at WIPP

3

Hanford Site

The Hanford Site is located in south-central Washington State on 586 mi^2 of land between the Cascade Range and the Rocky Mountains (Figure 4). The Columbia River flows through the northern portion of the site and forms part of its eastern boundary. Hanford has been operated by DOE and its predecessors (the Manhattan Engineer District, U.S. Atomic Energy Commission [AEC], and U.S. Energy Research and Development Administration) since it was created in 1943. Its primary mission was to produce nuclear materials in support of national defense, research, and biomedical programs. Operations associated with those programs used facilities for the fabrication of nuclear reactor fuel, reactors for nuclear materials production, chemical separation plants, nuclear material processing facilities, research laboratories, and waste management facilities. Current activities include research, environmental restoration, and waste management. The U.S. Fish and Wildlife Service (Service) and DOE co-manage the 195,000-acre Hanford Reach National Monument, which was established by Presidential proclamation in 2000.

The GTCC reference location is immediately south of the Integrated Disposal Facility (IDF) site in the 200 East Area in the central portion of the Hanford Site (Figure 4). The 200 East and West Areas are located on a plateau about 7 and 5 miles, respectively, south of the Columbia River. Historically, these areas have been dedicated to fuel reprocessing and to waste management and disposal activities.

Current waste management activities at the Hanford Site include the treatment and disposal of LLRW on site, the processing and certification of TRU waste pending its disposal at WIPP, and the storage of high-level radioactive waste on site pending its disposal in a geologic repository. The main areas where waste management activities occur are the 200 West Area and the 200 East Area, which are south of the Columbia River. These 200 Areas cover about 6 mi^2. Activities at the 200 Areas include the operation of lined trenches for the disposal of LLRW and mixed LLRW and the operation of the Environmental Restoration Disposal Facility for the disposal of LLRW generated by environmental restoration activities that are being conducted at Hanford Site to comply with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). U.S. Ecology, Inc., operates a commercial LLRW disposal facility on a 40-ha (100-ac) site leased by the State of Washington near the 200 East Area. The facility is licensed by the NRC and the State of Washington.

INL

INL is located in southeastern Idaho on 890 mi^2 of relatively undisturbed DOE land in the upper Snake River Plain (Figure 5). Basalt flows cover most of the plain, producing a rolling topography. INL is bordered by mountain ranges on the north and by volcanic buttes and open plain on the south. Lands immediately adjacent to the INL site consist of open rangeland, foothills, and agricultural fields. About 60 percent of the site is open to livestock grazing. Key facilities at INL consist of clusters of buildings and structures that are typically less than a few square miles each, separated from each other by miles of gently rolling sagebrush-covered semi-arid desert. The GTCC reference location is southwest of the Reactor Technology Complex

(RTC) in the south central portion of INL (Figure 5). The RTC is dedicated to research supporting DOE missions, including nuclear technology research.

Current waste management activities at INL include the treatment and storage of mixed LLRW (waste containing hazardous constituents in addition to radionuclides) on site, the treatment and disposal of LLRW on site, the storage of TRU waste on site, and the storage of high-level radioactive waste and Spent Nuclear Fuel (SNF) on site pending the disposal of these last two materials in a geologic repository. These wastes originate from DOE activities and from the on-site Naval Reactors Program. LLRW from INL site operations is disposed of at the Subsurface Disposal Area at the Radioactive Waste Management Complex (RWMC). TRU waste is also stored and treated at the RWMC to prepare it for disposal at WIPP.

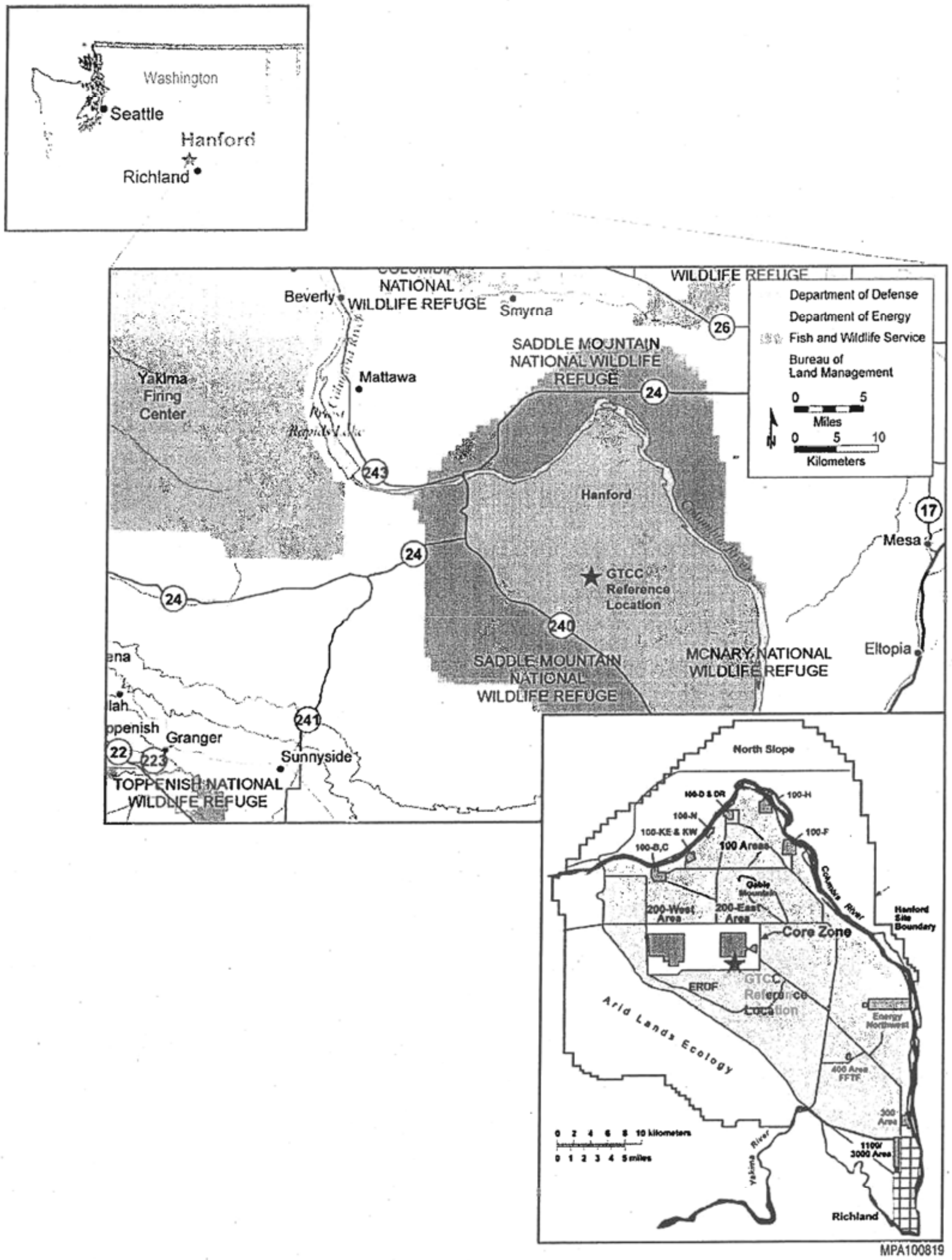

FIGURE 4 GTCC Reference Location at the Hanford Site

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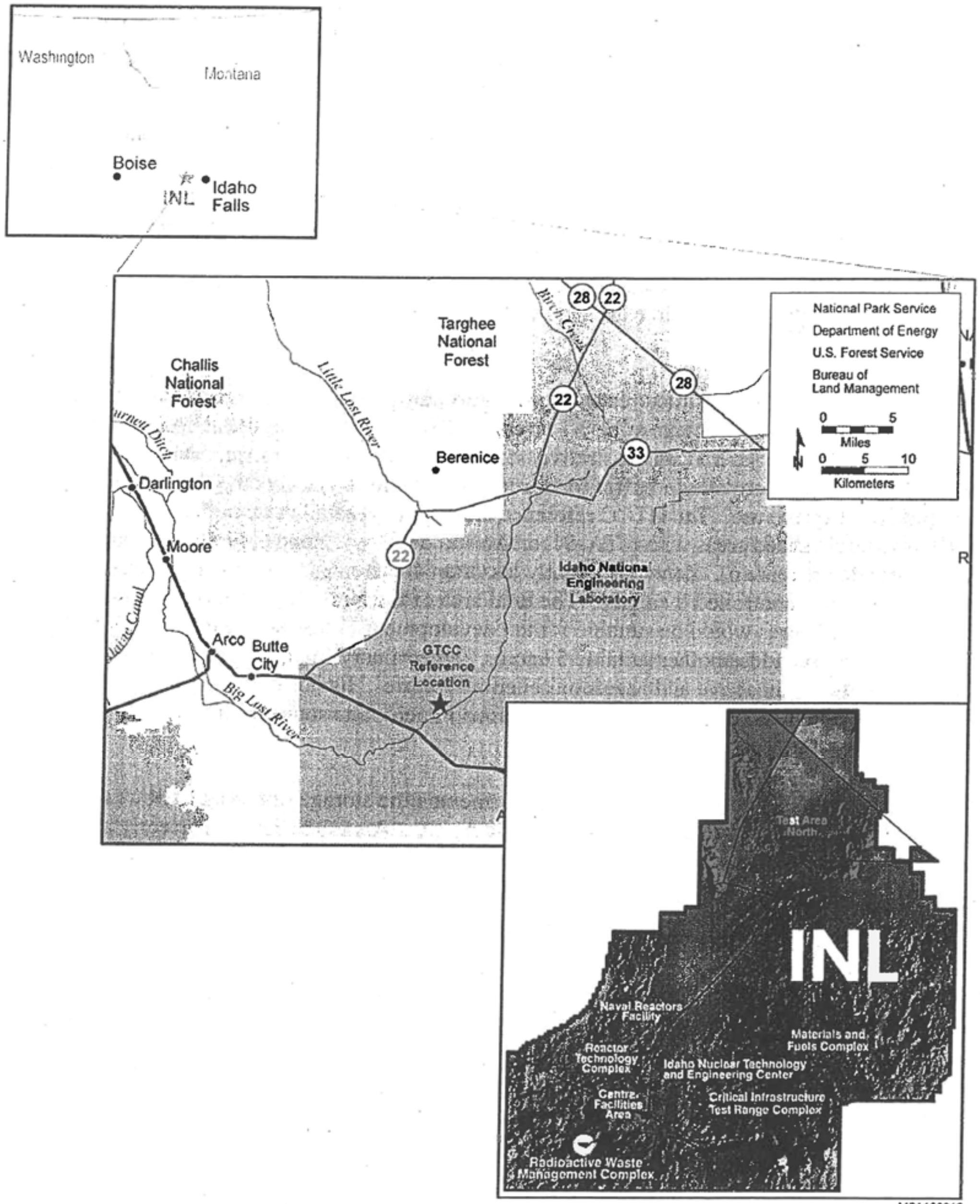

FIGURE 5 GTCC Reference Location at INL

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LANL

LANL is located in northern New Mexico, within Los Alamos County, on 40 mi^2 or 25,600 acres of land owned by the U.S. Government. The laboratory is administered by DOE and the National Nuclear Security Administration (NNSA) (Figure 6). The site is situated on the eastern flank of the Jemez Mountains along an area known as the Pajarito Plateau. The terrain in the LANL area consists of mesa tops and canyon bottoms that trend in a west-to-east direction, with the canyons intersecting the Rio Grande River to the east of LANL. Laboratory operations are conducted in numerous facilities located in 48 designated technical areas (TAs) and at other leased properties located nearby. The laboratory's core mission has been to maintain the effectiveness of the nation's nuclear deterrent. As one of the world's leading research institutions, it is also involved in hydrogen fuel cell development, supercomputing, and applied environmental research.

There are more than 2,000 structures on the site, providing about 8.6 million ft^2 of covered space. About half of the square footage at LANL is considered laboratory or production space; the remaining area is considered administrative, storage, service, or other space. Most of the site is undeveloped, which provides a buffer for security and safety and offers the possibility of expansion for future use. The GTCC reference location is situated in two undeveloped and relatively undisturbed areas within TA-54, on Mesita del Buey: Zone 6, North Site, and North Site Expanded (Figure 6). Zone 6 is slightly less than 40 acres in area. It is not fenced, but access by road is controlled by a gate. The total area of the North Site is about 63 acres, of which about 50 acres would be suitable for the development of disposal cells. The North Site Expanded section adds another suitable 57 acres. The primary function of TA-54 is the management of radioactive and hazardous chemical wastes. Its northern border coincides with the boundary between LANL and the San Ildefonso Pueblo; its southeastern boundary borders the town of White Rock.

Current waste management activities at LANL include the storage of mixed LLRW, the disposal of LLRW on site, and the storage of TRU waste on site. Area G at TA-54 currently accepts on-site LLRW for disposal, and in special cases, off-site waste has also been accepted from other DOE sites for disposal. Engineered shafts are actively used to dispose of remote handled LLRW.

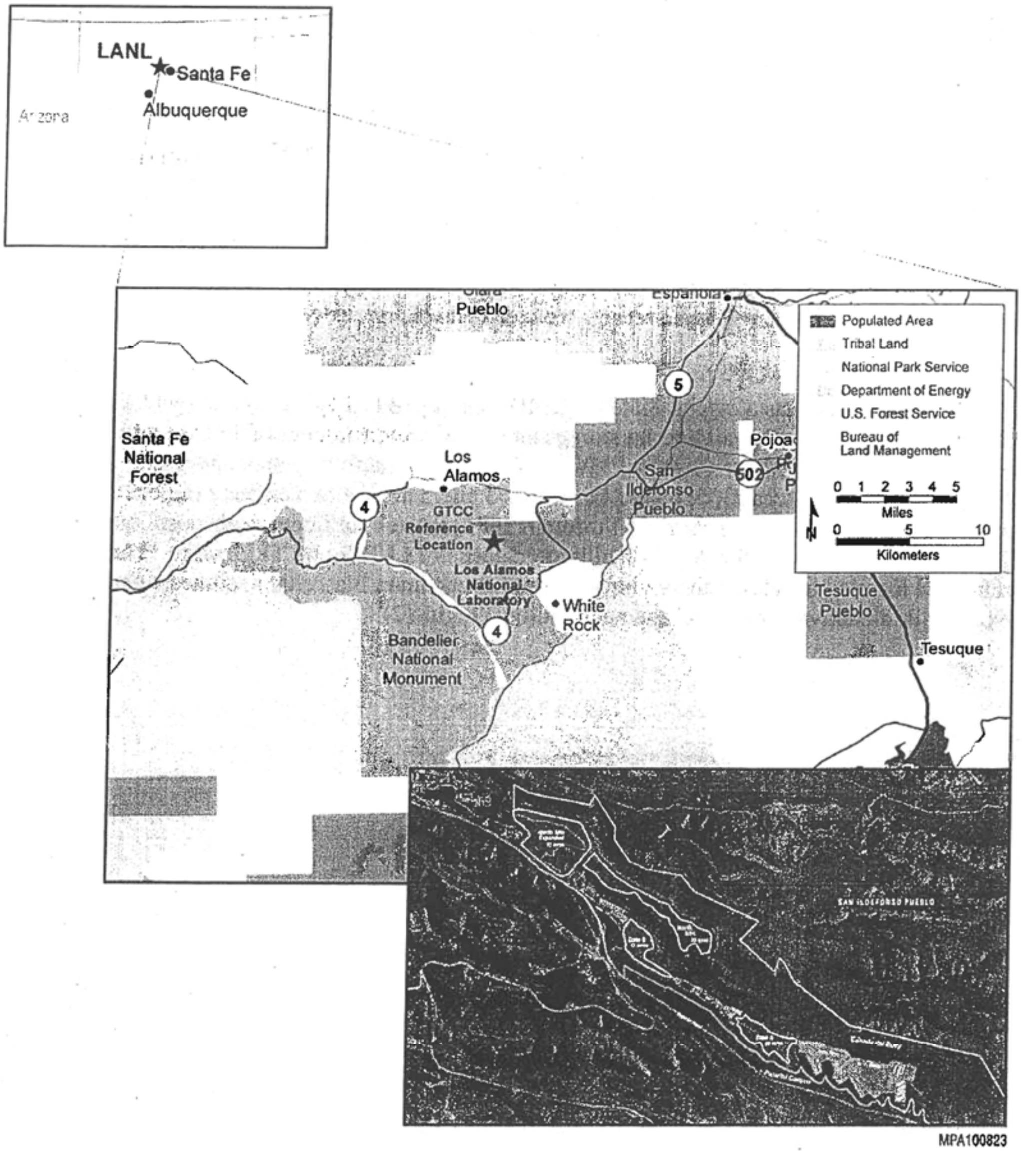

FIGURE 6 GTCC Reference Location at LANL

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NTS

NTS is located about 65 miles northwest of Las Vegas in southern Nevada on 1,350 mi^2 of land managed by DOE (Figure 7). Its terrain is characterized by high relief, with elevations ranging from about 3,000 ft at Frenchman Flat in the southeastern portion of the site to about 7,400 ft on Rainier Mesa. Historically, the primary mission of NTS was to conduct nuclear weapons tests. The tests have altered the natural topography of NTS, creating craters in Yucca Flat and Frenchman Flat basins and on the Pahute and Rainier Mesas. Since the moratorium on nuclear testing that began in October 1992, the mission of NTS has changed to one of maintaining readiness to conduct nuclear tests in the future. The site also supports DOE's waste management program, as well as other national-security related research and development and testing programs.

NTS presently serves as a disposal site for LLRW and mixed LLRW generated by DOE defense-related facilities. It is also an interim storage site for a limited amount of TRU mixed wastes pending transfer to WIPP for disposal. Waste management activities are conducted in four primary NTS areas: Areas 3, 5, 6, and 11. Areas 3 and 5 are the two existing radioactive waste management sites at NTS. From 1984 through 1989, greater confinement disposal (at depths of 70 to 120 ft) was used at the Area 5 facility to dispose of LLRW and TRU waste. The GTCC reference location at NTS in the vicinity north of Frenchman Flat, either southeast or west of the existing Radioactive Waste Management Facility (Figure 7).

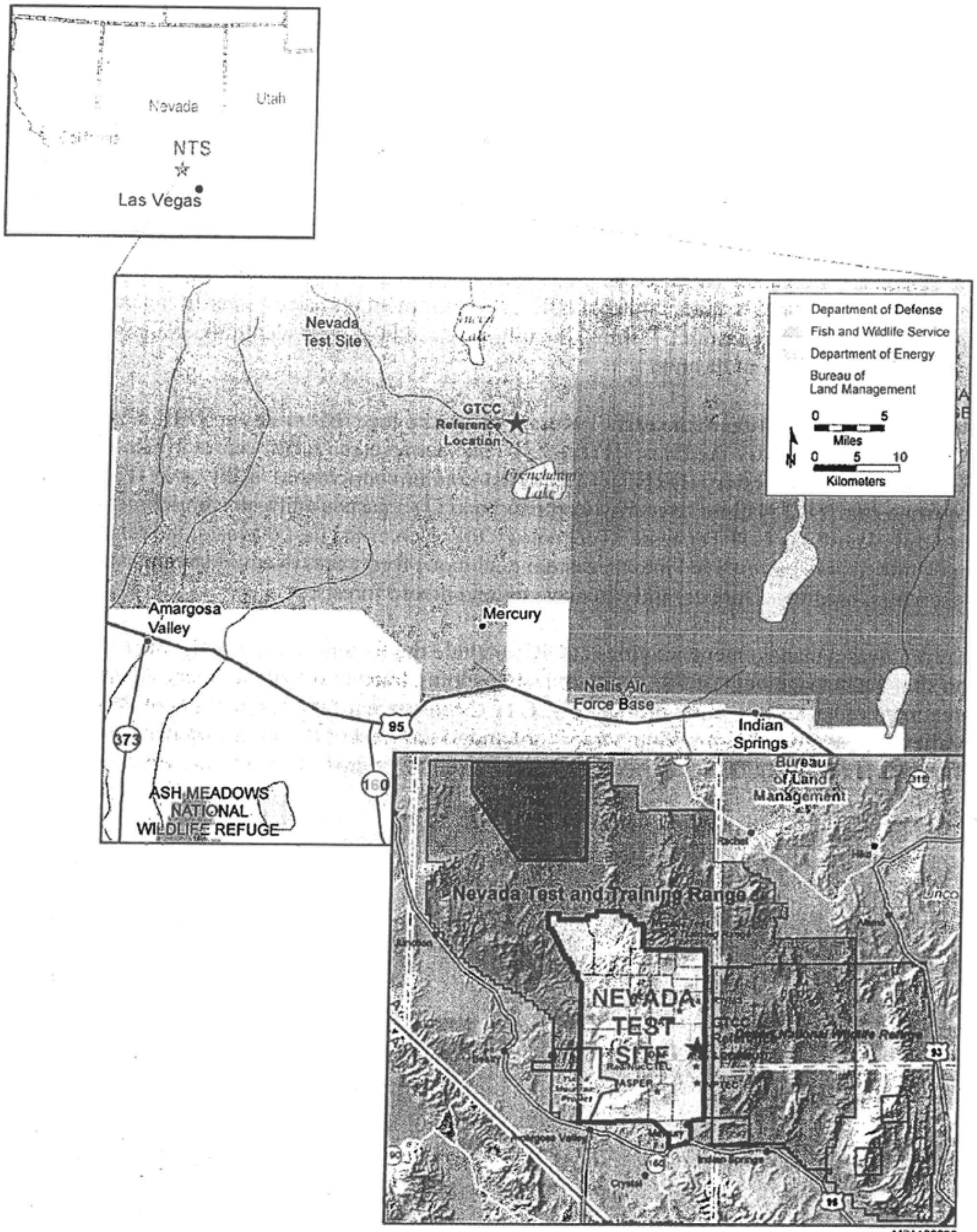

FIGURE 7 GTCC Reference Location at NTS

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ORR

ORR is located in eastern Tennessee, in Roane and Anderson Counties, on 34,241 acres of mostly contiguous land owned by DOE (Figure 8). The terrain is characterized by a series of parallel valleys and ridges with a northeast-southwest trend caused by the differential weathering of interstratified formations exposed at the surface. The topographic relief between valley floors and ridge crests is generally about 300 to 350 ft. The majority of ORR lies within the corporate limits of the city of Oak Ridge. The residential section of Oak Ridge forms ORR's northern and eastern boundaries; the Tennessee Valley Authority's Melton Hill and Watts Bar Reservoirs on the Clinch and Tennessee Rivers form the southern and western boundaries. Except for the city of Oak Ridge, the land within 5 miles of ORR is semirural and is used primarily for residences, small farms, and cattle pasture. Fishing, boating, water skiing, and swimming are popular recreational activities in the area.

Following its acquisition in the early 1940s, much of the land that makes up ORR served as a buffer for three primary facilities: (1) the X-10 nuclear research facility currently known as Oak Ridge National Laboratory (ORNL); (2) the first uranium enrichment facility or Y-12, currently known as the Y-12 National Security Complex; and (3) a gaseous diffusion enrichment facility currently known as East Tennessee Technology Park. Over the past 60 years, the relatively undisturbed area has evolved into an eastern deciduous forest ecosystem of streams and reservoirs, hardwood forests, and extensive upland mixed forests.

Current waste management activities at ORR include the treatment and storage of mixed LLRW on site, the management of TRU waste on site pending transfer off site for disposal, and the treatment of hazardous waste on site. The GTCC reference location is in Western Bear Creek Valley, just south of White Wing Scrap Yard and to the west of the Y-12 Complex (Figure 8). The area is relatively flat and bisected by a creek running perpendicular to the valley's trend.

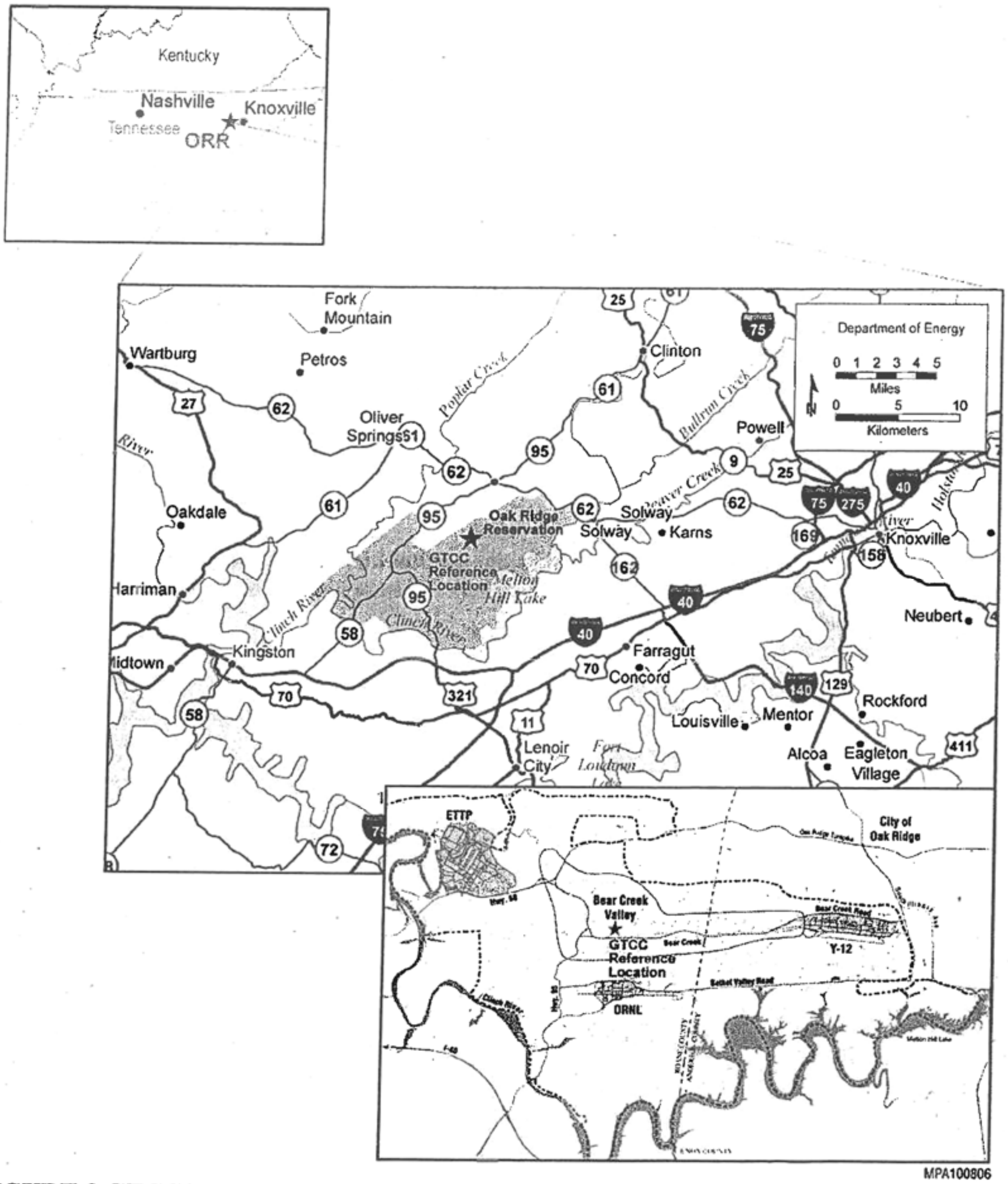

FIGURE 8 GTCC Reference Location at ORR

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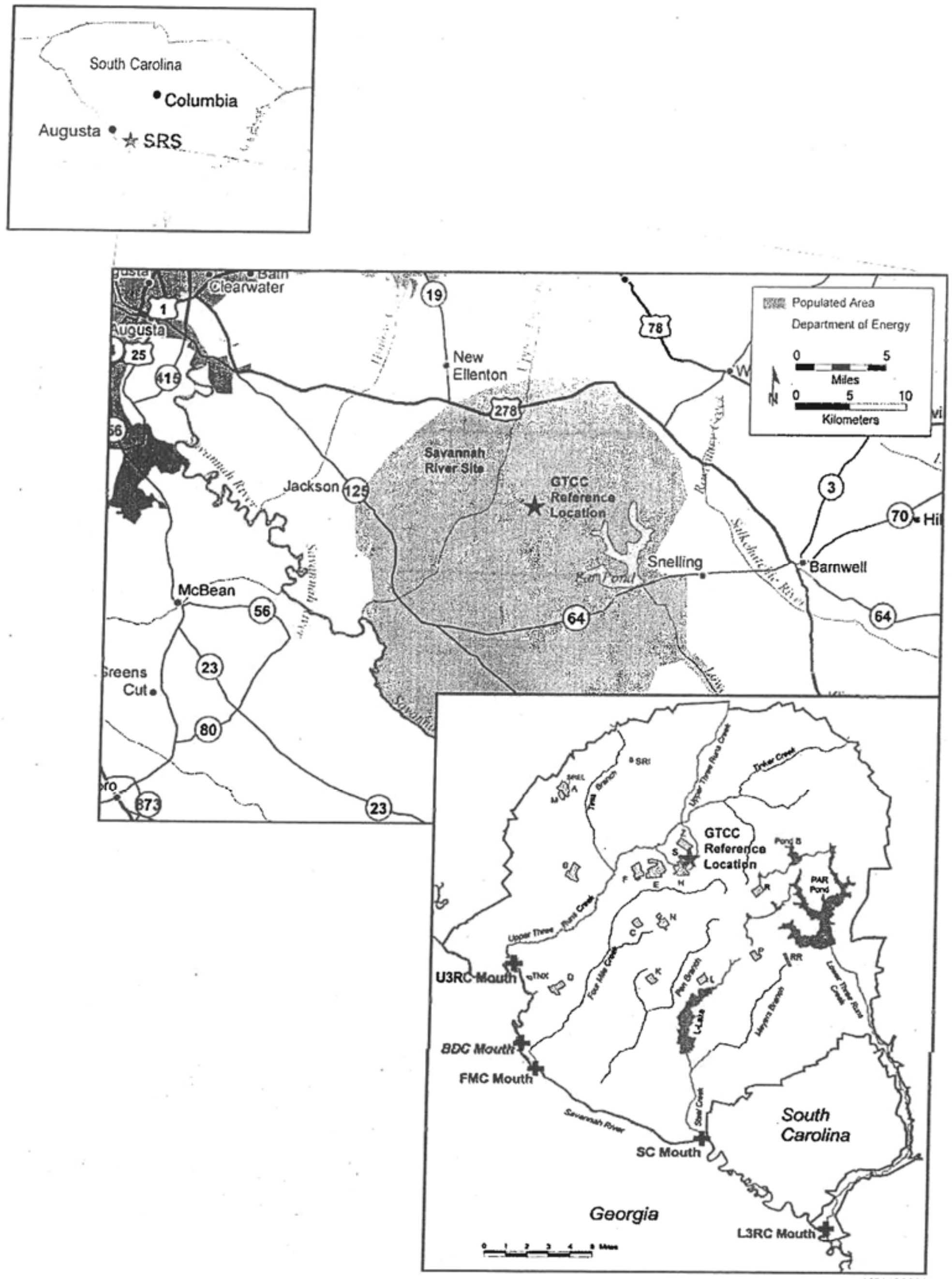
SRS

SRS is located on 310 mi^2 of DOE land along the Savannah River, about 12 miles south of Aiken, South Carolina, and 15 miles southeast of Augusta, Georgia, in southwestern South Carolina (Figure 9). Until the early 1990s, SRS primary mission was the production of special radioactive isotopes to support national defense programs. Currently, the site's mission emphasizes waste management, environmental restoration, and decontamination and decommissioning of facilities that are no longer needed for its traditional defense activities.

Current waste management activities at SRS include shipping hazardous waste, mixed LLRW, and TRU waste off site for treatment and disposal. High-level radioactive waste is stored on site pending disposal in a geologic repository. LLRW is treated and disposed of on site as well as at other DOE or commercial facilities. In addition, mixed LLRW may be treated and stored on site before being shipped off site. Other on-site activities include the treatment of LLRW prior to disposal and the preparation of TRU waste for shipment to WIPP for disposal. On-site disposal facilities at SRS include engineered trenches and vaults for the permanent disposal of solid LLRW.

The GTCC reference location is on an upland ridge overlooking Tinker Creek, to the northeast of Area Z in the north-central portion of SRS (Figure 9). The area is not currently being used for waste management.



GTCC Reference Location at SRS

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WIPP Vicinity

The WIPP Vicinity reference locations are within Section 27, within the WIPP Land Withdrawal Boundary (LWB) and Section 35, outside of and immediately adjacent to the south eastern boundary of the WIPP LWB. WIPP is located in Eddy County in southeastern New Mexico, about 30 miles east of the city of Carlsbad (Figure 10). The land is a relatively flat area. It is primarily used for grazing, potash mining, and oil and gas exploration. There are currently no waste management activities being conducted within either of these locations.

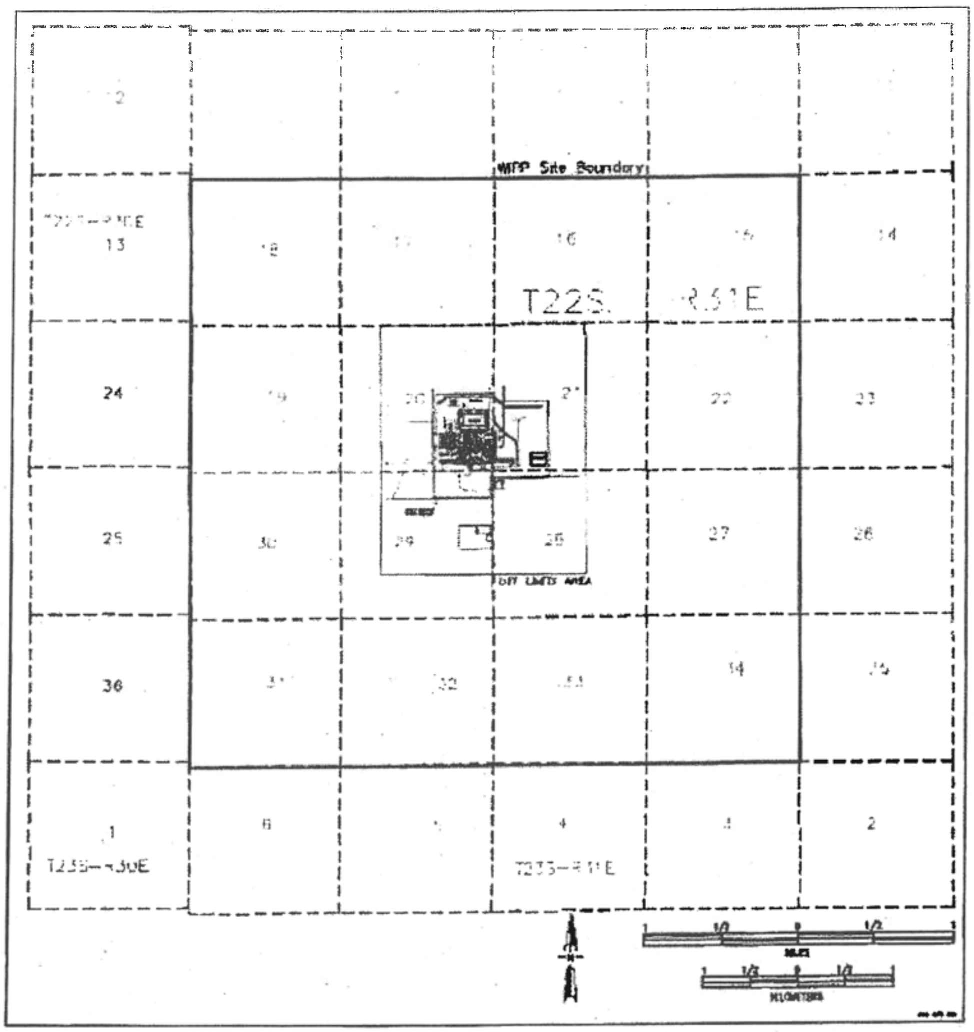

FIGURE 10 GTCC Reference Locations (Section 27 and 35) at the WIPP Vicinity

Attachment

Federal Register /Vol. 72, No. 140 /Monday,

DEPARTMENT OF ENERGY

Notice of Intent To Prepare an Environmental Impact Statement for the Disposal of Greater-Than-Class-C Low-Level Radioactive Waste

AGENCY: Department of Energy.

ACTION: Notice of Intent To Prepare an Environmental Impact Statement.

SUMMARY: The Department of Energy (DOE) announces its intent to prepare an environmental impact statement (EIS) under the National Environmental Policy Act (NEPA) for the disposal of Greater-Than-Class-C low-level radioactive waste (GTCC LLW). GTCC LLW is defined by the Nuclear Regulatory Commission (NRC) in 10 CFR 72.3 as "low-level radioactive waste that exceeds the concentration limits of radionuclides established for Class C waste in [10 CFR 61.55]." GTCC LLW is generated by NRC or Agreement State-licensed activities (hereafter referred to as NRC-licensed activities). DOE proposes to evaluate alternatives for GTCC LLW disposal: in a geologic repository; in intermediate depth boreholes; and in enhanced near surface facilities. Candidate locations for these disposal facilities would be: the Idaho National Laboratory (INL) in Idaho; the Los Alamos National Laboratory (LANL) and Waste Isolation Pilot Plant (WIPP) in New Mexico; the Nevada Test Site (NTS) and the proposed Yucca Mountain repository in Nevada; the Savannah River Site (SRS) in South Carolina; the Oak Ridge Reservation (ORR) in Tennessee; and the Hanford Site (Hanford) in Washington. DOE will also evaluate disposal at generic commercial facilities in arid and humid locations.

In addition, DOE proposes to include DOE LLW and transuranic waste having characteristics similar to GTCC LLW and which may not have an identified path to disposal (hereafter referred to as GTCC-like waste) in the scope of this EIS. DOE's GTCC-like waste is owned or generated by DOE. The use of the term "GTCC-like" does not have the intent or effect of creating a new classification of radioactive waste.

DOE invites public comment on the scope of this EIS during a 60-day public scoping period. During this period, DOE will hold public scoping meetings to provide the public with an opportunity to comment on the scope of the EIS and to learn more about the proposed action from DOE officials.

DOE issued an Advance Notice of Intent (ANOI), 70 FR 24775 (May 11, 2005), inviting the public to provide preliminary comments on the potential scope of the EIS. This Notice of Intent (NOI) includes a summary of the public comments received on the ANOI.

DATES: The public scoping period starts with the date of publication of this NOI in the **Federal Register** and will continue until September 21, 2007. DOE will consider all comments received or postmarked by September 21, 2007 in defining the scope of this EIS. Comments received or postmarked after that date will be considered to the extent practicable.

Public scoping meetings will be held to provide the public with an opportunity to present comments on the scope of the EIS and to learn more about the proposed action from DOE officials. The locations, dates, and times for the public scoping meetings are listed in the "Public Scoping" section under **SUPPLEMENTARY INFORMATION.**

ADDRESSES: Written comments on the scope of the GTCC LLW EIS or requests to speak at one of the public scoping meetings should be sent to: James L. Joyce, Document Manager, Office of Regulatory Compliance (EM–10), U.S. Department of Energy, 1000 Independence Avenue, SW., Washington, DC 20585–0119. Telephone: (301) 903–2151. Fax: 301–903–4303. E-mail: *gtcceis@anl.gov*. Written comments on the scope of the GTCC LLW EIS and requests to speak at one of the public scoping meetings can also be submitted through the Web site at *http://www.gtcceis.anl.gov*.

FOR FURTHER INFORMATION CONTACT: To request further information about the EIS, the public scoping meetings, or to be placed on the EIS distribution list, use any of the methods (fax, telephone, e-mail, or Web site) listed under **ADDRESSES** above. For general information concerning the DOE NEPA process, contact: Carol Borgstrom, Director, Office of NEPA Policy and Compliance (GC–20), U.S. Department of Energy, 1000 Independence Avenue, SW., Washington, DC 20585–0119.

Telephone: 202–586–4600, or leave a message at 1–800–472–2756.
Fax: 202–586–7031.

This NOI will be available on the internet at *http://www.eh.doe.gov/nepa.* Additional information on the GTCC LLW EIS can be found at *http://www.gtcceis.anl.gov.*

SUPPLEMENTARY INFORMATION:

Background

GTCC LLW is defined by NRC in 10 CFR 72.3 as ''low-level radioactive waste that exceeds the concentration limits of radionuclides established for Class C waste in 10 CFR 61.55.'' In 10 CFR 61.55, the NRC defines classes of LLW as A, B and C by the concentration of specific short- and long-lived radionuclides, with Class C LLW having the highest radionuclide concentration limits. Consistent with NRC's and DOE's authorities under the Atomic Energy Act of 1954 (as amended), the NRC LLW radioactive waste classification system does not apply to radioactive wastes generated or owned by DOE and disposed of at DOE facilities. However, DOE owns and generates LLW and transuranic radioactive waste with characteristics similar to GTCC LLW and that may not have a path to disposal. For the purposes of this EIS, DOE is referring to this DOE waste as GTCC-like waste (the use of the term ''GTCC-like'' does not have the intent or effect of creating a new classification of radioactive waste). DOE proposes to evaluate alternatives for the disposal of both GTCC LLW and DOE GTCC-like waste in this EIS.

Section 3(b)(1)(D) of the Low-Level Radioactive Waste Policy Amendments Act of 1985 (LLRWPAA) assigns the responsibility for the disposal of GTCC LLW to the Federal Government. The LLRWPAA specifies that the GTCC LLW covered under Section 3(b)(1)(D) is to be disposed of in a facility licensed and determined to be adequate by the NRC. DOE is the federal agency responsible for the disposal of GTCC LLW. This responsibility was described in a 1987 report to Congress, *Recommendations for Management of Greater-Than-Class-C Low-Level Waste* (DOE/NE–0077), U.S. Department of Energy, February 1987. The report can be obtained by contacting the Document Manager listed under ADDRESSES above or from the Web site at *http://www.gtcceis.anl.gov.*

The September 11, 2001, attacks and subsequent threats have heightened concerns that terrorists could gain possession of radiological sealed sources, including GTCC LLW sealed sources, and use them for malevolent purposes. Since 2003, the Government Accountability Office (GAO) has issued three reports on matters related to the security of uncontrolled sealed sources, including the Department's progress in developing a GTCC LLW disposal facility.1 In addition, the Energy Policy Act of 2005 contains several provisions (e.g., sections 631, 651, and 957) directed at improving the control of sealed sources, including disposal availability.

Because of its technical expertise in radiation protection, the U.S. Environmental Protection Agency (EPA) will participate as a cooperating agency in the preparation of this EIS. NRC will be a commenting agency.

Energy Policy Act of 2005 Reporting Requirements

Section 631 of the Energy Policy Act of 2005 requires the Secretary of Energy to: provide Congress with notification of the DOE office with responsibility for completing activities needed to provide for safe disposal of GTCC LLW; submit a report to Congress containing an estimate of the cost and schedule to complete an EIS and record of decision (ROD) for a permanent disposal facility for GTCC LLW; and prior to making a final decision on the disposal alternative or alternatives to be implemented, submit to Congress a report that describes all alternatives considered in the EIS. In meeting these requirements thus far, DOE has named the Office of Environmental Management as the lead organization having responsibility to develop GTCC LLW disposal capability and has submitted a report to Congress dated July 2006 on the estimated cost and proposed schedule to complete the EIS.

Types and Estimated Quantities of GTCC LLW and DOE GTCC-like Waste

GTCC LLW may generally be categorized into the following three types: sealed sources, activated metals, and other miscellaneous waste (e.g., contaminated equipment). Sealed sources are typically small, high-activity radioactive materials encapsulated in closed metal containers. They are used for a variety of purposes including irradiating food and medical products for sterilization, detecting flaws and failures in pipelines and metal welds,

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calculating moisture content in soil and other materials, and assisting in the diagnosis and treatment of illnesses. Activated metal wastes are primarily generated in nuclear reactors during facility modifications and decommissioning. There are 104 operating commercial reactors in the United States and an additional 18 that have been closed or decommissioned. The activated metals consist of internal nuclear components that have become radioactive from neutron absorption. These components include portions of the reactor vessel and other stainless steel components near the fuel assemblies.

Other miscellaneous waste includes all GTCC LLW that is not activated metals or sealed sources. This waste includes contaminated equipment, debris, trash, scrap metal and decontamination and decommissioning waste from miscellaneous industrial activities, such as the manufacture of sealed sources and laboratory research.

DOE GTCC-like waste includes some sealed sources owned or generated by DOE activities; activated metals including reflector materials from research reactors as well as other miscellaneous waste owned by DOE or generated by DOE activities that has characteristics similar to GTCC LLW and may not have a path to disposal. Most of the DOE GTCC-like waste consists of transuranic waste[2] (a DOE waste category) that may have originated from non-defense activities and therefore may not be authorized for disposal at WIPP under the Waste Isolation Pilot Plant Land Withdrawal Act of 1992 and has no other currently identified path to disposal.

DOE estimates a total inventory (existing and projected to be generated) of approximately 2,600 cubic meters of GTCC LLW and approximately 3,000 cubic meters of GTCC-like waste. A small percentage of this waste is mixed waste (i.e., radioactive waste that contains a hazardous component subject to the Resource Conservation and Recovery Act). Table 1 shows estimated quantities of GTCC LLW and GTCC-like waste that DOE proposes to analyze and is based on the report entitled *Greater-Than-Class C Low-Level Radioactive Waste Inventory Estimates*, (DOE, July 2007). This report updates the 1993 inventory estimates contained in the report entitled *Greater-Than-Class C Low-Level Radioactive Waste Characterization: Estimated Volumes, Radionuclides, Activities, and Other Characteristics,* DOE/LLW–114, Revision 1 (Sept. 1994), which served as the basis for inventories in the ANOI. Copies of both reports are available by contacting the Document Manager listed under **ADDRESSES** above or at *http://www.gtcceis.anl.gov*.

2 [2] Transuranic waste is radioactive waste containing more than 100 nanocuries of alphaemitting transuranic isotopes per gram of waste, with half-lives greater than 20 years, except for: (1) High-level waste; (2) waste that the Secretary of Energy has determined, with the concurrence of the Administrator of EPA, does not need the degree of isolation required by the 40 CFR Part 191 disposal regulations; or (3) waste that the NRC has approved for disposal on a case-by-case basis in accordance with 10 CFR Part 61.

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TABLE 1.—INVENTORY SUMMARY OF ESTIMATED QUANTITIES OF GTCC LLW AND DOE GTCC-LIKE WASTE[a]

Waste type	In storage	Projected	Total stored and projected			
			Volume in cubic meters (m³)	Activity[b] MCi	Volume m³	Activity[b] MCi
GTCC LLW:						
Activated metal	58	3.5	810	110	870	110
Sealed sources	([c])	([c])	1,700	2.4	1,700	2.4
Other[d]	76	0.0076	1.0	0.00023	77	0.0078
Total GTCC LLW	130	3.5	2,500	110	2,600	110
DOE GTCC-like waste:						
Activated metal	5.0	0.11	29	0.82	34	0.93
Sealed sources	8.7	0.013	25	0.030	34	0.043
Other[d]	860	11	2,000	19	2,900	30
Total DOE GTCC-like waste	870	11	2,100	20	3,000	31
Total GTCC and GTCC-like waste	1,000	15	4,600	130	5,600	140

[a] Values have been rounded to two significant figures.
[b] Radioactivity values are in millions of curies (MCi).
[c] There are sealed sources currently possessed by NRC licensees that may become GTCC LLW when no longer needed by the licensee. The estimated volume and activity of those sources are included in the projected inventory, notwithstanding the lack of information on the current status of the sources (e.g., in use, waste, etc.).
[d] Other GTCC LLW and DOE GTCC-like waste includes contaminated equipment, debris, trash, scrap metal and decontamination and decommissioning waste.

Purpose and Need for Action

As shown in Table 1, NRC and Agreement State licensees have generated and continue to generate GTCC LLW for which there is no permitted disposal facility. DOE is responsible for the safe and secure disposal of GTCC LLW covered under Section 3(b)(1)(D) of the LLRWPAA, including determining how and where to dispose of these wastes. In addition, DOE owns or generates certain LLW and transuranic wastes with characteristics similar to GTCC LLW that also may not have an identified path to disposal.

Proposed Action

DOE proposes to construct and operate a new facility or facilities, or use an existing facility, for the disposal of GTCC LLW and GTCC-like waste. DOE would then close the facility or facilities at the end of each facility's operational life. Based on the EIS analysis, DOE expects to make a decision on the method(s) and location(s) for disposing of GTCC LLW and DOE GTCC-like waste. A combination of disposal methods and locations may be appropriate based on the characteristics of the waste and other factors.

Alternatives Proposed for Evaluation

The GTCC EIS will evaluate the range of reasonable alternatives for the disposal of GTCC LLW and GTCC-like waste, together with a no action alternative. The NRC regulations at 10 CFR 61.55(a)(2)(iv) define GTCC LLW as that waste which would require disposal in a geologic repository as defined in 10 CFR Part 60 or 63, unless proposals for an alternative method of disposal are approved by NRC under 10 CFR 61.55(a)(2)(iv). Although NRC regulations state that GTCC LLW is generally not acceptable for near surface-disposal, the NRC recognizes in 10 CFR 61.7(b)(5) that "there may be some instances where waste with concentrations greater than permitted for Class C waste would be acceptable for near-surface disposal with special processing or design." Therefore, the disposal methods DOE proposes to evaluate in the EIS include deep geologic repository disposal, intermediate depth borehole disposal, and enhanced near-surface disposal. For deep geologic disposal, DOE intends to analyze disposal at Yucca Mountain in Nevada, a proposed geologic repository to be licensed under 10 CFR Part 63. DOE will also evaluate deep geologic repository disposal at WIPP in New Mexico. Identification of the proposed Yucca Mountain repository for analysis in the EIS is based on the 10 CFR 61.55 regulations, which identify disposal in a geologic repository licensed under 10 CFR Part 60 or 63 as an acceptable method for the disposal of GTCC LLW. Identification of WIPP is based on its characteristics as

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a geologic repository, although not subject to NRC licensing as a geologic repository under 10 CFR Parts 60 or 63. DOE does not plan to evaluate an additional deep geologic repository facility because siting of another deep geologic repository facility for GTCC LLW and GTCC-like waste is impractical due to the cost, time, and the relatively small volume of GTCC LLW and GTCC-like waste.

DOE also intends to evaluate disposal of GTCC LLW and GTCC-like waste in a new intermediate depth borehole facility and enhanced-near surface facility at existing DOE sites and generic commercial locations. The DOE sites considered for analysis include INL in Idaho, LANL in New Mexico, WIPP vicinity (either within the WIPP Land Withdrawal perimeter that is under the jurisdiction of DOE, or on government property in the vicinity of WIPP), NTS in Nevada, SRS in South Carolina, ORR in Tennessee, and Hanford in Washington. Identification of these sites for potential analysis is based on mission compatibility (these DOE sites currently have waste disposal operations as part of their mission) and physical characteristics of the sites such as hydrogeology and topography.

In addition, DOE intends to evaluate a generic enhanced near surface and intermediate depth borehole commercial disposal facility under both arid and humid conditions in the EIS.

In a Request for Information in the *FedBizOpps* on July 1, 2005, DOE solicited technical capability statements from commercial vendors that may be interested in constructing and operating a GTCC waste disposal facility. Although several commercial vendors expressed an interest, no vendors have provided specific information on disposal locations and methods for analysis in the EIS. Including a generic commercial facility in the EIS would allow DOE to make a programmatic determination regarding disposal of GTCC LLW and GTCC-like waste in such a facility. Should one or more commercial facilities be identified at a later time, DOE would conduct further NEPA review, as appropriate.

DOE intends to evaluate each of the GTCC waste types (*i.e.*, sealed sources, activated metals, and other waste) individually and in combination for each of the disposal alternatives, taking into account the characteristics of the waste types and other considerations (e.g., waste volumes, physical and radiological characteristics, and generation rates). For example, GTCC LLW containing transuranic radionuclides with longer half-lives may require greater isolation or other special measures to protect against potential inadvertent human intrusion, whereas GTCC LLW containing radionuclides with shorter half-lives may require less extensive measures. DOE will also consider volumes and time periods when wastes would be generated and require disposal.

In the GTCC LLW EIS, DOE will describe the statutory and regulatory requirements for each disposal alternative and whether legislation or regulatory modifications may be needed to implement the alternative under consideration. In summary, DOE proposes to evaluate the alternatives listed below:

Alternative 1: No Action—under this alternative, current and future GTCC LLW and GTCC-like waste would be stored at designated locations consistent with ongoing practices, such as storage of GTCC LLW activated metals at nuclear utilities;

Alternative 2: Disposal in a Geologic Repository at WIPP—under this alternative, DOE would dispose of GTCC LLW and GTCC-like waste at WIPP;

Alternative 3: Disposal in a Geologic Repository at Yucca Mountain—under this alternative, DOE would dispose of GTCC LLW and GTCC-like waste at the proposed Yucca Mountain Repository;

Alternative 4: Disposal at a New Enhanced Near-Surface Facility—under this alternative, DOE would dispose of GTCC LLW or GTCC-like waste at a new enhanced near-surface facility at INL, LANL, WIPP vicinity, NTS, SRS, ORR, and Hanford, or a commercial facility should such a facility be identified in the future;

Alternative 5: Disposal at a New Intermediate Depth Borehole Facility—under this alternative, DOE would dispose of GTCC LLW or GTCC-like waste at a new intermediate depth borehole facility at INL, LANL, WIPP vicinity, NTS, SRS, ORR and Hanford, or a commercial facility should such a facility be identified in the future.

Identification of Environmental Issues

DOE proposes to evaluate disposal

technologies at various DOE and generic commercial locations for the construction, operation, and closure of a facility or facilities for the disposal of GTCC LLW and GTCC-like waste. DOE proposes to address the issues listed below in the process of considering the potential impacts of the proposed disposal alternatives.

□ Potential impacts on air, noise, surface water and groundwater.

□ Potential impacts from the shipment of GTCC LLW and GTCC-like waste to the disposal site(s).

□ Potential impacts from postulated accidents.

□ Potential impacts on human health, including impacts to involved and noninvolved site workers and members of the public.

□ Potential impacts to historical and cultural artifacts or sites of historical and cultural significance.

□ Potential disproportionately high and adverse effects on low income and minority populations (environmental justice).

□ Potential Native American concerns.

□ Short-term and long-term land use impacts.

□ Long-term site suitability, including erosion and seismicity.

□ Potential impacts to endangered species.

□ Intentional destructive acts.

□ Compliance with applicable federal, state, and local requirements.

□ Irretrievable and irreversible commitment of resources.

□ Cumulative impacts from past, present and reasonably foreseeable actions.

This list is not intended to be inclusive, and we invite interested parties to suggest other issues to be considered, including aspects of the waste inventories presented in Table 1.

Summary of Public Comments on the Advance Notice of Intent

In 2005, DOE issued an ANOI, 70 Fed. Reg. 24775 (May 11, 2005), inviting the public to provide preliminary comments on the potential scope of the EIS. DOE received comments on the ANOI from: the states of Nevada, Oregon and Washington; the Sacramento Municipal Utility District; the New England Coalition; the Sierra Club; the Nuclear Energy Institute; and the Savannah River Site Citizens Advisory Board. The major scoping issues identified in the comments are summarized below, along with DOE's response.

□ *EIS General Scope:* Commenters questioned the need for the EIS, assuming that GTCC LLW would be disposed of in the proposed Yucca Mountain repository for spent nuclear fuel and high-level waste. Some commenters favored the inclusion of DOE's GTCC-like waste along with GTCC LLW generated from NRClicensed activities in the EIS, while other commenters recommended restricting the scope of the EIS to GTCC LLW analyzed in the Yucca Mountain EIS (DOE/EIS–0250, February 2002) or to waste generated from NRC-licensed activities. Still other commenters questioned the basis for projecting the GTCC LLW volume to 2035 and 2055.

Response: GTCC waste is LLW, not high-level waste or spent nuclear fuel; nevertheless, DOE has identified the proposed Yucca Mountain repository as one of the sites to be analyzed in the EIS for GTCC LLW as a disposal alternative, as well as other appropriate sites, in accordance with 10 CFR Part 61. Under the LLRWPAA, DOE is responsible for disposing of this waste, and because such disposal would be a major federal action, DOE is required by the Council on Environmental Quality regulations that implement NEPA to complete an EIS analyzing the range of reasonable alternatives for this action. The Energy Policy Act of 2005 also requires DOE to take actions related to the preparation of an EIS for GTCC LLW. DOE plans to include its GTCC-like waste that may have no path to disposal, as well as waste generated from NRC or Agreement State licensed activities, and to identify where economies of scale may be achieved in using the same disposal methods and locations.

DOE has identified the estimated GTCC LLW and GTCC-like waste volumes based on the best available data. DOE has changed the projections to 2035 and 2062 to include the 20-year license renewal that commercial reactors may receive plus an additional 6-year "cooling period" before commencing reactor decommissioning activities. Thus GTCC LLW and GTCClike waste estimates are projected through 2035, except for GTCC LLW activated metals estimates, which are projected through 2062, based on anticipated nuclear reactor

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decommissioning schedules.

□ *Waste Disposal Alternatives:* Commenters stated that DOE should identify its criteria for including sites considered in the EIS as potential disposal locations and criteria for selecting the technologies and disposal methods to be evaluated.

Response: DOE has identified its basis for the disposal locations and disposal methods proposed for analysis in the EIS under ''Alternatives Proposed for Evaluation'' in this Notice.

□ *Waste Inventories:* Commenters stated that the inventory data provided in the ANOI should be updated.

Response: DOE has updated the inventory data as shown in Table 1. DOE will incorporate other appropriate inventory data that may become available during preparation of the EIS.

□ *Resource Areas Proposed for Analysis:* Commenters suggested a number of subjects that DOE should include in the EIS impact analyses.

Response: DOE's list of subjects proposed for evaluation in the EIS under ''Identification of Environmental Issues'' in this NOI responds to those comments.

□ *Concentration Averaging:* Commenters raised questions about DOE's potential use of ''concentration averaging'' in which, for example, the activity of one component is averaged over the volume or mass of waste to identify applicable waste classification standards.

Response: For the purposes of analysis in the EIS, DOE would use guidance in the *Branch Technical Position on Concentration Averaging and Encapsulation,* U.S. Nuclear Regulatory Commission, Washington DC, January 1995, to determine when LLW is greater than Class C as defined at according to 10 CFR Part 61.

□ *Regulatory Requirements:* A number of commenters discussed the need to address compliance with regulatory and other legal requirements in the EIS.

Response: The EIS would describe applicable regulatory and other legal requirements and consider the extent to which the alternatives analyzed meet those requirements.

Public Scoping

Interested parties are invited to participate in the public scoping process to provide their comments on the proposed disposal alternatives for analysis in the EIS and the environmental issues to be analyzed. The scoping process is intended to involve all interested agencies (federal, state, county, and local), public interest groups, Native American tribes, businesses, and members of the public. Public scoping meetings will be held at the following locations and times:

□ *Carlsbad, New Mexico:* Pecos River Village Conference Center, Carousel House, 711 Muscatel Avenue, Carlsbad, New Mexico, Monday, August 13, 2007, 6 p.m.–9 p.m.

□ *Los Alamos, New Mexico:* Hilltop House Best Western, La Vista Room, 400 Trinity Drive, Los Alamos, New Mexico, Tuesday, August 14, 2007, 6 p.m.–9 p.m.

□ *Oak Ridge, Tennessee:* DOE Oak Ridge Information Center, 475 Oak Ridge Turnpike, Oak Ridge, Tennessee, Wednesday, August 22, 6 p.m.—9 p.m.

□ *North Augusta, South Carolina:* North Augusta Community Center, 495 Brookside Avenue, North Augusta, South Carolina, Thursday, August 23, 6 p.m.–9 p.m.

□ *Troutdale, Oregon:* Comfort Inn & Suites-Columbia Gorge West, 477 NW Phoenix Drive, Troutdale, Oregon, Monday, August 27, 2007, 6 p.m.–9 p.m.

□ *Pasco, Washington:* Red Lion Hotel, Gold Room, 2525 N 20th Avenue, Pasco, Washington, Tuesday, August 28, 2007, 6 p.m.–9 p.m.

□ *Idaho Falls, Idaho:* Red Lion Hotel On The Falls, Yellowstone/Teton Rooms, 475 River Parkway, Idaho Falls, Idaho, Thursday, August 30, 2007, 6 p.m.–9 p.m.

□ *Las Vegas, Nevada:* Atomic Testing Museum, 755 E. Flamingo Road (Just East of Paradise Road), Las Vegas, Nevada, Tuesday, September 4, 2007, 6 p.m.–9 p.m.

□ *Washington DC:* Hotel Washington, Washington Room, 15th and Pennsylvania Avenue, NW., Washington, DC, Monday, September 10, 1 p.m.–5 p.m.

During the first hour of each scoping meeting, DOE officials will be available for informal discussions with attendees. During the formal part of the meeting, the public will have the opportunity to provide comments orally or in writing. The presiding officer will establish procedures to ensure that everyone who wishes to speak has a chance to do so. Both oral and written comments will be considered and given equal weight.

Issued in Washington, DC on July 17, 2007.
James A. Rispoli,
Assistant Secretary for Environmental Management.
[FR Doc. E7–14139 Filed 7–20–07; 8:45 am]
BILLING CODE 6450–01–P

DEPARTMENT OF ENERGY

Office of Civilian Radioactive Waste Management; Safe Routine Transportation and Emergency Response Training; Technical Assistance and Funding

AGENCY: Department of Energy.

ACTION: Notice of revised proposed policy and request for comments.

SUMMARY: The Department of Energy (DOE) is publishing this notice of revised proposed policy to set forth its revised plans for implementing Section 180(c) of the Nuclear Waste Policy Act of 1982 (the NWPA). Under Section 180(c) of the NWPA, DOE shall provide technical and financial assistance for training of local public safety officials to States and Indian Tribes through whose jurisdictions the DOE plans to transport spent nuclear fuel or high-level

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APPENDIX G:

TRIBAL NARRATIVES

[a] In the tribal narratives, the Nevada National Security Site was still referred to as the Nevada Test Site or NTS, and this was not changed.

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American Indian Writers Committee
of the
Consolidated Group of Tribes and Organizations

Tribal Narrative for the Nevada Test Site

May 11-15, 2009

American Indian Writers Committee
Richard Arnold
Jerry Charles
Betty Cornelius
Maurice Frank-Churchill
Danelle Gutierrez
Gerald Kane
Lalovi Miller

Facilitated By
Richard W. Stoffle, University of Arizona

Document Approved by
Consolidated Group of Tribes and Organizations
Meeting August 31 – September 2, 2009
Mercury, Nevada

Date Submitted to DOE/EM Division

September 2009

Tribal Views on Nevada Test Site: Affected Environment and Consequences

1.0 Affected Environment

1.1 Climate

CGTO knows that the climate of the region has changed over the thousands of years that the Indian people have lived in this region (See Indian Appendix for more). The NTS has only occupied this area since the early 1940s. It is important to recognize that major climatic changes have taken place since the end of the Pleistocene and shorter term climate changes such as the wet period in the 1980s and 1990s contrast with the current 10-year drought. It is important for the GTCC EIS to assess the impacts of short term and long term climatic changes because the DOE expects to safely manage these GTCC wastes for up to 10K years during which similar climate changes can be expected.

The current climate description in the GTCC EIS is specific to the present decade-long period of extended drought (a similar one occurred between 1896 and 1906) so this type of drought and the wet period between 1980s and 1990s may be a factor in siting the GTCC facility. An analysis of long term impacts based on current conditions will neither be representative of climate conditions viewed over much longer periods nor applicable to a short climate shift to much wetter conditions.

1.2 Groundwater

The CGTO knows that most dry lakes are not known to be completely dry. An example is Soda Lake near Barstow, California. The Mohave River flows into this dry lake and most of the year it looks dry but it actually flows underground. Building berms on dry lake beds to offset water and runoff doesn't sound like a good idea to the Indian way of thinking. As one CGTO member added, to Indian people "water is life. Our water has healing powers" (NRC 2009a). So why build a GTCC site on and use this playa when the odds of radiation seem feasible? The Indian people who visited this site recommend not to bother Frenchmen Playa. It is only one of two in the immediate region and has special meanings. There should be a more descriptive study to fully understand the impacts. More time is needed, also for Indians to revisit this site. Although some people continue to view Frenchman playa as a wasteland, the CGTO knows it is not. Further ethnographic studies are needed.

1.3 Ecology

The CGTO knows that this site (in Area 5) is an ancient playa, surrounded by mountain ranges (See Indian Appendix for more). The runoff from these ranges serves to maintain the healthy desert floor. Animals frequent this area, there are numerous animals' trails, and these play a significant part in the history of the locality and of the Indian lifestyles. Our ancestors knew that the Creator always provided for them and this site is one of their favorite places to hunt and trap rabbits. We have special leaders that organized large rabbit hunts. Many people participated so this place would be occupied at times by all kinds of our people. Rabbits provided good eating, bones for tool-making, warm blankets, and even games. Indian people refrained from eating coyote, wolves, and birds but these contribute to our stories which tell us how to behave and why we are here. We have many stories and songs that include animals and birds who have human-like antics. From these antics Indian people learn the life lessons to build character to become better persons. So animals and the places where they live contribute to our history and culture.

This culturally central place was used by and important to Indian people from our agricultural and horticultural communities located to the north – near Reese River Valley and Duckwater, to the south – near Ash Meadows, to the southeast – near Indian Springs and Corn Creek, to the east – near the Pahranagat-Muddy River, and west – near the Oasis Valley. It was also used by people from our agricultural and horticultural communities to the far west in Owens Valley, to the far south near Cottonwood Island and Palo Verde Valley on the Colorado River, to the far southwest at Twenty Nine Palms, to the far east along the Virgin River, Santa Clara River, and Kanab Creeks, to the far north along the Humbolt River and Ruby Valley.

Plants

The CGTO knows based on previous DOE-sponsored ethnobotany studies that there are at least 364 Indian use plants on the NTS (see Appendix G). Indian people visiting the proposed location of the GTCC facility identified the following traditional use plants: (1) Indian Tea, (2) White Sage or Winter Fat, (3) Indian Rice Grass, (4) Creosote, (5) Wolfberries, (6) Four O'clock, (7) Spiny Hop Sage, (8) Joshua Tree, (9) Daises, (10) Desert Trumpet, (11) Cholla, (12) Globe Mallow, (13) Fuzzy Sage, (14) Tortoise Food plant, (15) Sacred Datura, (16) Wheat Grass, and (17) Lichen. Other plants were present but not identified due to the late season and the dry condition of the plants.

Plants are still used for medicine, food, basketry, tools, homes, clothing, fire, and ceremony – both social and healing. The characteristics of the plants at the proposed GTCC area are smaller and thinner than in other desert areas where it is wetter. Indian people from elsewhere traveled to this area to gather specific plants because they have stronger characteristics when they grow in dry places. The sage is used for spiritual ceremonies, smudging, and medicine. The Indian rice grass and wheat grass are used for breads and puddings. Joshua trees and Yucca plants are important for hair dye, basketry, foot ware, and rope. Datura is used for hallucinogenic effects during which alternative places can be visited by medicine men. Datura also goes itself to disturbed areas and heals them. The globe mallow had traditional medicine uses, but in recent times is also used for curing European contagious diseases.

Animals/Insects

The CGTO knows based on previous DOE-sponsored ethnofauna studies that there are at least 170 Indian use animals on the NTS (see Appendix G). Indian people visiting the proposed location of the GTCC facility identified the following traditional use animals: (1) Jack Rabbits, (2) Whiptail Lizards, (3) Antelope, (4) Tortoise, (5) Kangaroo Rats, (6) Horned Toad, (7) Rock Wrens, (8) Ravens, (9) Grasshoppers, and (10) Stink Bugs. Other animals (such as snakes, bats, and owls) were perceived to be present but not observed because they primarily emerge at night.

All animals and insects were and are culturally important and the relationships between them, the Earth, and Indian people are represented by the respectful roles they play in the stories of our life then and now. The GRCC valley is where a spiritual journey occurred. It involved Wolf (*Tavats* in Southern Paiute, *Bia esha* in Western Shoshone, *Wi gi no ki* in Owens Valley Paiute) and Coyote (*Sinav* in Southern Paiute, *Duhvo esha* in Western Shoshone, *Esha* in Owens Valley Paiute) and is considered a Creation Story. Only parts of this can be presented here. When Wolf and Coyote had a battle over who was more powerful, Coyote killed Wolf and felt glorious. Everyone asked Coyote what happened to his brother Wolf. Coyote felt extremely guilty and tried to run and hide but to no avail. Meanwhile, the Creator took Wolf and made him into a beautiful Rainbow (*Paro wa tsu wu nutuvi* in Southern Paiute, *Oh ah podo* in Western Shoshone, *Paduguna* in Owens Valley Paiute). When Coyote saw this special privilege he cried to the Creator in remorse and he too wanted to be a Rainbow. Because Coyote was bad, the Creator put Coyote as a fine white mist at the bottom of the Rainbow's arch. This story and the spiritual trails discussed in the full version are connected to the Spring Mountains and the large sacred cave in the Pintwater Mountains as well as to lands now called the Nevada Test Site. This area is the home place of Wolf who is still present and watches over the area and us.

Minerals

The CGTO knows based on previous DOE-sponsored cultural studies that there are many minerals on the NTS (no complete list available). Indian people visiting the proposed GTCC site identified the following traditional use minerals: (1) Obsidian, (2) chalcedony, (3) Yellow Chert or Jasper, (4) Black Chert, (5) Pumice, (6) Quartz Crystal, and (7) Rhyolite Tuff. Other minerals were perceived to be present but not observed because of the limited time and search area.

All minerals are culturally important and have significant roles in many aspects of Indian life. For example, the Chalcedony on the proposed GTCC site would have made an attractive offering which would be acquired here by a ceremonial traveler and then left at the vision quest or medicine site located to the north on top of a volcano like Scrugham Peak. Returning ceremonial travelers would also bring offerings back to where they had acquired offerings, thus the Yellow Chert or Jasper (observed on the GTCC site) which outcrops about 70 miles to the north would be gathered there and returned to the Chalcedony site as an offering.

Playas

The CGTO knows, based on cultural studies funded by the DOE on the NTS and playa-specific studies funded by Nellis Air Force Test and Training Range (Henderson 2008), that playas occupy a special place in Indian culture. Playas are often viewed as empty and meaningless places by western scientists, but to Indian people playas have a role and often contain special resources that occur no where else. The following text was prepared by the Indian people who visited the proposed GTCC site.

Is a playa a wasteland? According to Indian elders playas were used in traveling or moving to places where work, hunting, pine cutting or gathering of other important foods and medicine could be done. One elder remembers crossing over dry lake beds and traveling around but near the edges and they discussed how provisions were left there and at nearby springs by previous travelers at camping spots. Indian people left caches in playa areas for people who crossed valleys when water and food was scarce. Frenchmen Playa is such a place. Indian people took advantage of traveling through this playa as mountains completely surround this area. The CGTO knows that most dry lakes are not known to be completely dry. An example is Soda Lake near Barstow, California. The Mohave River flows into this dry lake and most of the year it looks dry but it actually flows underground. Building berms on dry lake beds to offset water and runoff doesn't sound like a good idea to the Indian way of thinking. As one CGTO member added, to Indian people "water is life. Our water has healing powers" (NRC 2009a). So why build a GTCC site on and use this playa when the odds of radiation seem feasible? The Indian people who visited this site recommend not to bother Frenchmen Playa. It is only one of two in the immediate region and has special meanings. There should be a more descriptive study to fully understand the impacts. More time is needed, also for Indians to revisit this site. Although some people continue to view Frenchman playa as a wasteland, the CGTO knows it is not. Further ethnographic studies are needed.

1.4 Environmental Justice

DOE has recognized the need to address environmental justice concerns of the CGTO based on disproportionately high and adverse impacts to their member tribes from DOE NTS activities. In 1996, the CGTO expressed concerns relating to environmental justice that included (1) damage to Holy Lands, (2) negative health impacts, and (3) lack of access to traditional places that contributes to breakdowns in cultural transmission. In the 2002 NTS SA, NNSA/NSO concluded that with the selection of the Preferred Alternative, the CGTO would be impacted at a disproportionately high and adverse level consequently creating an environmental justice issue. Since 2002, NNSA/NSO has supported a few ethnographic studies involving the CGTO and culturally important places including in 2004, when NNSA/NSO arranged for tribal representatives to conduct evening ceremonies at Water Bottle Canyon. While the opportunity for the evening ceremony was a significant accommodation, disproportionately high and adverse impacts from DOE NTS activities continue to affect American Indians. The three environmental justice issues noted by the CGTO need to be addressed.

1.5 Radiation

The CGTO knows that radiation can be and is viewed from both a western science and a Native American perspective (See Indian Appendix for more). These alternative and competing perspectives are key for understanding the cultural foundations of American Indian responses to the mining, processing, use, transportation, and disposal of radioactive materials. At some level of analysis from and Indian perspective, all radioactive waste is basically the same problem to Indian people. Subtle differences in classification from a western science perspective of radioactive waste only mask and do not significantly modify the basic cultural problems of radioactive waste for Indian people and their traditional lands.

The Angry Rock is a concept used by Indian people, involved in DOE funded radioactive waste transportation and disposal studies, to quickly summarize the complex cultural problems associated with what happened to this known mineral when it was improperly taken and used by non-Indians. The notion of an Angry Rock is premised on the belief that all of the earth is alive, sentient, speaks Indian, and has agency. When the elements of the earth are approached with respect and asked for the permission before being used they share their power with humans. The reverse occurs when they are taken without permission – they become angry withhold their power and often using it against humans. Thus uranium is an Angry Rock. Uranium has been known and carefully used by spiritual specialists and medicine persons for thousands of years (Lindsay et al. 1968). The following American Indian elder quote from a DOE funded report (Austin 1998) begins to explain this perspective:

We are the only ones who can talk to these things. If we do not make sure that we talk to those things, then they are going to give us more bad harm, because it is already happening throughout the country. Those are the reasons why the Indian people say ... like uranium, for one, uranium was here since the beginning of this Earth, when it was here we knew uranium at one time. And still it is used, but then they got a hold of it and made something else out of it. Now it is a man made thing, and today it accumulates waste from nuclear power plants, it accumulates more, it has its own life. Radiation has said to us at one time "If you use me make sure you tell me before you use me why you are going to use me and what for. " And we never said anything to that uranium at all, and we put something else in there with it, which shouldn't belong with it. It gives it more power to eliminate the life, of all living things on this planet of ours. Those are the reasons, why the Indian people always say, and I know because I have been there. The rocks have a voice...

Although from a Western science perspective radiation can be isolated and contained by conventional techniques, the Angry Rock has the power to move and cannot be contained by barriers. Indian people who have dealt with the Angry Rock for thousands of years note that there are traditional ways to deal with uranium, the natural rock, if used by trained Indian specialists, but these may or may not work with the Angry Rock of modern radiation waste.

Songs ... we are the ones who should be talking to those things. Radiation is going to take all of our lives; it is continuously moving over the land. The land don't want it, nobody wants it. And today, we are doing a bad thing by using radiation on each other. Radiation is something that should not be used to kill animal life...

Another elder noted:

And can it be contained? As it's transformed it can be, I think it can be contained physically but not spiritually, and again I think spiritually as it's been altered because it's in that energy field because it's been altered. The spirit, that's where it can do its harm in an altered form. It doesn't do any good to anybody. And there you're just in the wrong place in the wrong time, it does influence plants and animals, minerals and air, the spirit of any area it passes through. The reason somebody is sick. I don't think it's necessary to talk about how each one of these is influenced, it just is.

Another elder noted:

As far as the transportation of waste there's a lot of unknowns and we don't know what the consequences are. We know there are many sicknesses that come out from people that have been contaminated by nuclear waste and as far as Indian people go, we show respect to the land, show respect to other people, for the animals, the plants, the rocks. The power of the rock – Just looking at Chemehuevi Mountain, it's a very spiritual mountain from this perspective right here. When I look out towards the mountains and I don't just see a mountain, I see a place *of power, I see a place where I can go and meditate and speak with the Creator directly and ask for prayers and blessings for people directly. Just like anything else, you have to give prayers all the time because the creator is here to watch and protect over us. I feel that we wouldn't have come this far if he wasn't here to watch over us and we are here to pray and we are here to protect the other resources.*

Another elder said:
I can envision the animals standing back once it goes through for the first time and they recognize that there's a danger that they would move away because of fear. That they would no longer be there and that there's something bad coming down the road and they disperse and move away into different corridors. Kind of like a dust storm, they disperse and move further and further away. I see it from the animals' standpoint, they're a lot smarter than us and they've been doing this for longer than us and their senses are more keen and I think the animals would get back and it would create dead zones throughout the country. Through these corridors or transportation routes of course at the site there will be those that are curious who want to go see.

Another elder said:
I don't know what you would do with this rock if it's angry and this is its way of rebelling, getting back. I think as a Native American I would backstep and ask for forgiveness. Sometimes forgiving is not very easy because there's sacrifices we have to make and there's consequences ... I don't think it can be done as a group, it's an individual thing and each one of us has to go back and ... ask for forgiveness for what has taken place. It's not just only that I think it's going to be more complicated than going out into the mountains and saying, "hey, I'm sorry, I won't do this, I won't do that and I won't bother you anymore. There's a lot of other things that need to be forgiven. The rock is the most precious and it's the largest and it's the one that needs to be forgiven the most. There's a lot of small forgiveness that have to be given before the large rock. I think it's a stepping stone… the rocks are angry, yes, they're striking out saying "don't do this to me, don't touch me, don't let this happen. " In a sense you look at it from a spirituality standpoint, it's the spirits of Mother Earth telling us don't mess with Mother Earth. It remains a matter of debate as to whether traditional means of placating powerful rock-based forces can be used to control or placate radioactive waste. Western scientists have created a problem for Indian people that, despite being very critical to their future, is not easily resolved.

1.6 Cultural Resources

The CGTO knows that American Indian cultural resources include all physical, artifactual, and spiritual aspects of the NTS. The CGTO has established that formal studies of these aspects of the land should be conducted to identify, assess, mitigate, and manage these resources. These resources should be studied with members of the CGTO recommended for the study. Such studies are termed: (1) Ethnoarchaeology, (2) Ethnobotany, (3) Ethnozoology, (4) Storied Rocks, (5) Traditional Cultural Properties, (6) Ethnogeography, and (7) Cultural Landscapes (see Appendix G).

The CGTO knows that many of these cultural resources are directly present on the GTCC proposed site, in the Indian Defined Area of Potential Effect, and immediate region surrounding the GTCC site. The Indian people who visited the GTCC site note that their time on site was insufficient to fully identify, analyze, and evaluate resource that may be present. They recommend one or more of the kinds of resource studies identified above be conducted. Based on their site visit they do know that the area contains important cultural resources including plants, animals, minerals, trails, and portions of cultural landscapes (see Indian Appendix of this EIS).

Cultural Artifacts and Features

The CGTO knows based on previous DOE-sponsored cultural studies that there are many cultural artifacts and features on the NTS (American Indian Transportation Committee, Stoffle, and Toupal 1998; American Indian Transportation Committee, et al. 1999; American Indian Writers Subgroup, CGTO 1996; Arnold et al. 1997; Arnold et al.1998; Arnold et al. 1999; Austin 1998; Stoffle et al. 2001a; Stoffle et al. 2001b; Stoffle, Evans, Harshbarger 1989; Stoffle, Evans, Halmo 1988; Stoffle et al. 1989; Stofle, Halmo, and Dufort 1994; Stoffle, Olmsted, and Evans 1988; Stoffle, Zedeño, and Carroll 2000; United States Department of Energy (USDOE) 1996; USDOE, National Nuclear Security Administration 2002; USDOE, National Nuclear Security Administration 2008; Henderson 2008). Indian people visiting the proposed GTCC site identified the following traditional cultural artifacts and features: (1) Chert Flakes, (2) Rock Alignments, (3) Boulder Grinding Indentation or metate (*Mata* in Owens Valley, *Doso* in Western Shoshone, *Mada* in Southern Paiute), (4) Hand Grinding Stone or mano (*Paha* or *Tusu* in Owens Valley, *Botoh* in Western Shoshone, *Mohum* in Southern Paiute), (5) Volcanoes, (6) Trails, and (7) Chalcedony, and (8) Yellow Jasper.

Artifacts are the evident signs of our ancestors on this land. They are proof that we were here for thousands of years. We were told by our elders never to move artifacts or take them from their place. This is their home because they were left there for us to see and understand the past. We never remove them because they still belong to the ancestors who put them there for us and still watch over them today. Artifacts come from parts of the living earth and are still alive with a right to remain where they were placed. Whether or not there is evidence of being modified, the volcanoes, stones, rocks and trails that we incorporated into our lives are artifacts. These were visited for ceremony, chosen and moved as offerings, and traveled on our journeys and thus were a part of our life, are artifacts of our ancestors that we respect, and are there for future generations.

1.7 Visual Resources

Views are important cultural resources that contribute to the location and performance of American Indian ceremonialism. Views combine with other cultural resources to produce special places where power is sought for medicine and other types of ceremonies. Views can be of any landscape, but more central viewscapes are experienced from high places, which are often the tops of mountains and the edges of mesas. Indian viewscapes tend to be panoramic and are special when they contain highly diverse topography. The viewscape panorama is further enhanced by the presence of volcanic cones and lava flows. Viewscapes are tied with songscapes and storyscapes, especially when the vantage point has a panorama composed of multiple locations from either song or story. Key to the Indian experience of viewscapes is isolation. Successful performance of ceremonies (whether by individuals or groups) is often commemorated by the building of rock cairns and by storied rocks and paintings. The CGTO tribes recognize the cultural significance of viewscapes and have identified a number of these on the NTS. The Timber Mountain Caldera contains a number of significant points with different panoramas, including Scrugham Peak-Buckboard Mesa and the Shoshone Mountain massif.

1.8 Waste Management

The CGTO requests an analysis of the hydrological and ecological impacts of the existing water diversion dike of the current Radioactive Waste Management Complex in Area 5. The DOE recognizes that this is a very flood prone area, with major flooding episodes occurring about every 23 years. Indian people visiting this site observed that even though the current dike has been built recently and thus not experienced a 23-year flood, it has diverted and consolidated sufficient runoff that a small arroyo has been established. The Indian people visiting this site believe that the existing dike has unnaturally stressed down-slope plants and animals who now do not receive normal sheet runoff. The Indian people visiting the site believe that by concentrating the runoff, the dike has reduced the amount of water absorbed during normal sheet runoff because the consolidated runoff moves more quickly and only flows in the new and developing eroded arroyo. It is believed by the Indian people visiting the site that were a GTCC facility to be established east of the current RWMC then the dike would necessarily have to be extended causing an even greater runoff shadow and an even greater developing arroyo. The desert tortoise in the area will have to move out of this larger runoff shadow and may be concentrated in the area of Frenchmen Playa. Moving their living areas towards the playa will expose them to higher levels of radioactivity. The Indian people visiting the site believe that these current and potential impacts should be analyzed, monitored by Indian people, and reported back to the CGTO at the next annual meeting.

1.9 Site Description

The CGTO knows that the southern bajada (alluvial fan) of French Peak and associated hills to the east combine to periodically cause massive runoffs which flow rapidly towards Frenchman Playa making it a seasonal shallow lake. Frenchman Playa has a 140 square-mile watershed that could impact the GTCC site as it potentially does the current RWMS (Raytheon Services 1993). Especially considered in these Indian comments are runoffs from the north of the proposed GTCC storage area. This watershed involves 13.6 square miles and directly impacts the current RWMS. This runoff from this area is normally sheetflow, but every 23 years or so a major flood occurs. This threat has resulted in the RWMS building a large diversion dike and trench to protect the current Radioactive Waste Management Complex. The Raytheon study indicates that the southwest corner of the RWMS is located in the 100-year flood hazard zone, but the entire northern alluvial fan brings runoff directly into the immediate area.

1.10 Climate and Air Quality

One performance objective in selecting a preferred site is to protect individuals and communities who might occupy the disposal site after active and passive controls are no longer present. These individuals are to be protected from exposure to GTCC radiation while they engage in normal activities such as agriculture, dwelling construction, food acquisition, and ceremony. The CGTO believes that a wetter climate will raise the water table up to or over the GTCC waste site. Nearby wetland plants and animals would absorb radiation and then expose local people. Drinking water from these wetlands will also result in exposure. Indian people visiting the site believe their descendants will live near and use these wetlands as their ancestors did thousands of years ago.

The climatic effects of both wet and dry periods should be analyzed and incorporated in the GTCC site assessment.

2.0 Environmental Consequences

2.1 Radiation

Indian people have raised in past radioactive waste disposal and transportation studies a range of questions regarding how to protect themselves and their natural resources from exposure to what they call the Angry Rock (See Indian Appendix for more). The analysis of GTCC waste should address directly these potential impacts and suggest ways to either avoid or mitigate them. The potential impacts to Indian people and their life are significant including potentially blocking the path to the afterlife (Stoffle and Arnold 2003).

2.2 Cultural Resources

The CGTO knows that there are physical, spiritual, and archaeological elements associated with the entire Frenchman Flat valley. Impacts to any of these elements are considered important and need to be considered during GTCC siting considerations. There are direct impacts to Indian cultural resources that have been observed by the Indian people who visited the current RWMS. Especially obvious is the construction of a water diversion dike and subsequent arroyo cutting and dewatering of areas down slope of the dike. Surface disturbance will remove medicine and food plants, impact animal habitat and concentrate certain species of animals. The Chalcedony deposits and chert offerings will be totally removed thus causing a disconnect between the Indian ancestors who used these and contemporary and future generations of Indian people. This is an act of disrespect.

2.3 Waste Management

The CGTO requests an analysis of the hydrological and ecological impacts of the existing water diversion dike of the current Radioactive Waste Management Complex in Area 5. The DOE recognizes that this is a very flood prone area, with major flooding episodes occurring about every 23 years. Indian people visiting this site observed that even though the current dike has been built recently and thus not experienced a 23-year flood, it has diverted and consolidated sufficient runoff that a small arroyo has been established. The Indian people visiting this site believe that the existing dike has unnaturally stressed down-slope plants and animals who now do not receive normal sheet runoff. The Indian people visiting the site believe that by concentrating the runoff, the dike has reduced the amount of water absorbed during normal sheet runoff because the consolidated runoff moves more quickly and only flows in the new and developing eroded arroyo. It is believed by the Indian people visiting the site that were a GTCC facility to be established east of the current RWMS then the dike would necessarily have to be extended causing an even greater runoff shadow and an even greater developing arroyo. The desert tortoise in the area will have to move out of this larger runoff shadow and may be concentrated in the area of Frenchmen Playa. Moving their living areas towards the playa will expose them to higher levels of radioactivity. The Indian people visiting the site believe that these current and potential impacts should be analyzed, monitored by Indian people, and reported back to the CGTO at the next annual meeting.

2.4 Cumulative Impacts from the GTCC Action at NTS

According to the CGTO tribes, increased land disturbances associated with all forms of activities and development on the NTS could result in a decrease in access to these areas for American Indians. Limiting access could reduce the traditional use of the NTS and other areas and affect their sacred nature. Increased development at the NTS could increase the potential for greater disturbance and vandalism of American Indian cultural resources. The CGTO tribes believe (See Final Environmental Impact Statement for the NevadaTest Site and Off-Site Locations in the State of Nevada 1996: Appendix G) that cumulative impacts in the following areas may occur:

- *Holy land violations*. Further destruction of traditional cultural sites, making the water disappear, general treatment of the land without proper respect.

- *Cultural survival*. Decreased ability and access to perform ceremonies.

- *Environmental restoration*. Revegetation of restored lands with native species.

- *Empowerment process*. Over the past 17 years of regular consultation between the NNSA/NV and the CGTO tribes, there has been a growing co-management role for the tribes. Their recommendations have been heard and, for the most part, responded to by the NNSA/NV. Indian access to places on the NTS has increased, after an early period of access loss. Unfortunately, each new program that is added to the NTS decreases the amount of space that is available for the practice of Indian religions, ceremonies, and cultural persistence. However, having no programs also can have an impact. For example, even though the mesas are now accessible to Indians for ceremonies, the roads are not maintained because there are no projects on the mesas. This makes access to the ceremonially important areas difficult.

- *Radiation risks*. These risks began with nuclear testing. Today, the CGTO tribes perceive that the radioactive risks continue in known and unknown ways underground.

There are still ongoing risks to Indian people from storage and disposal of waste and these will continue. Finally, transportation of radioactive materials is continuing and increasing. It is not clear to the CGTO tribes that, after two American Indian studies of radioactive waste transportation, there has been a meaningful consideration of their concerns. It is not clear to what extent further radioactive waste disposal at the proposed GTCC facility will do to increase radiation risks to the physical and spiritual dimensions of Frenchman Playa area but some assessment is possible by Indian religious leaders.

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Appendix A: Native American Responses to The GTCC Proposal on the NTS

This Greater Than Class C EIS study was funded by the Waste Management Office of the DOE and NNSA/NSO. Text was provided by the American Indian Subgroup who represents the seventeen tribes and Indian organizations that are in consultation with the NNSA/NSO regarding the Nevada Test Site (NTS) and related locations. The consulting Indian tribes and organizations are known as the Consolidated Group of Tribes and Organizations (CGTO), within which there are numerous subgroups who act in different roles such as the American Indian Writers Subgroup (AIWS). The recognized role of the AIWS and other CGTO subcommittees is to follow closely specific issues and report to the CGTO. The CGTO members then report back to their respective tribal governments or Indian organization governing boards. It is important to note that official responses to issues only come from tribal governments and governing boards.

The role of the AIWS is to review all manuscripts that involve Indian people on the NTS and to review fieldwork proposals. The AIWS is composed of a coordinator, three officially appointed members, and three alternates who were selected by the subgroup members. The members of this subcommittee are (1) Southern Paiutes – Betty Cornelius and Lalovi Miller, (2) Western Shoshones – Maurice Frank-Churchill and Jerry Charles, and (3) Owens Valley Paiutes – Gerald Kane and Danelle Gutierrez. Richard Arnold is the appointed AIWS coordinator.

AIWS Responses

The AIWS believes that the Native American responses for the current GTCC EIS should be presented together with some responses also repeated in relevant sections of the main body of the EIS. Their responses, however, are directed at different sections of this EIS and vary in terms of structure and purpose. The current American Indian text builds upon already established ideas presented in Appendix G (American Indian Writers Subgroup, CGTO 1996), the *2002 Nevada Test Site Supplement Analysis* (United States Department of Energy, National Nuclear Security Administration 2002) and the *2008 Draft Nevada Test Site Supplement Analysis* (United States Department of Energy, National Nuclear Security Administration 2008). This writing procedure reflects the ongoing interest of the CGTO in the activities and potential environmental impacts of NNSA/NSO, and emphasizes the continuity of issues established in the previous documents and again in this SA.

The following text is provided as an appendix of this GTCC EIS. This integrated essay represents the responses of the consulting tribes who have participated for almost 23 years in the NNSA/NSO American Indian Program and who refer to themselves in this consultation as the CGTO. Some portions of the following text are repeated in other sections of this report. The full analysis and text are held together in this section so that the consulting tribes and organizations who will review this document will have a holistic view of the American Indian responses. This report reflects the assessments of the AIWS, but it was technically finalized by the Bureau of Applied Research in Anthropology (BARA) team at the University of Arizona.

LAND USE (DaMiDovia "Our Land", Ia-vooTuvipum "Our Land")

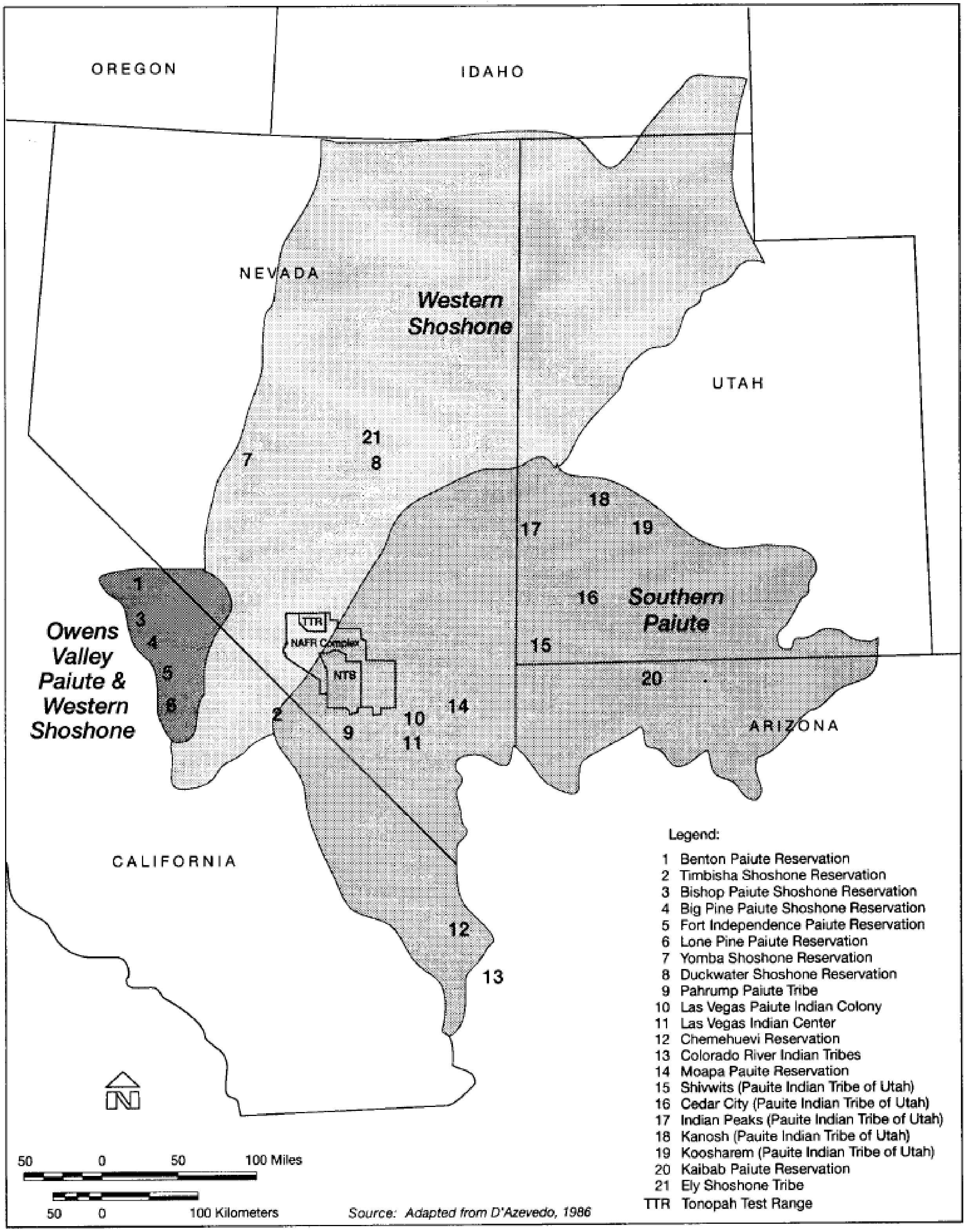

Figure A-1 American Indian Region of Influence for NTS GTCC EIS

The CGTO maintains that members of the consulting tribes have Creation based rights to protect, use, and access lands (Divia, 1 Tuvip, 2) of the NTS and immediate area. These rights were established at Creation and persist forever. During the past decade representatives of the consulting tribes have visited portions of the NTS and have identified places, Puha Paths, and cultural landscapes of traditional and contemporary cultural significance. The managers of the NTS have responded to CGTO requests that portions of these identified areas be set aside for traditional and contemporary ceremonial use. Because this is a public document the exact locations of these areas will not be revealed, however they do include a burial cave, a Native American Graves Protection and Repatriation Act (NAGPRA) reburial area, and a local Puha Path and ceremonial landscape near a large water tank (Stoffle, Evans, and Harshbarger1989; Stoffle et al. 2001a; Stoffle et al. 2001b; Stoffle, Zedeño, and Halmo 2001; Stoffle et al. 2006). These actions by the agency are in keeping with the persistent recommendations of the CGTO that portions of their holy lands be placed under co-stewardship arrangements. In order to fulfill the holy land use expectations, the members of the consulting tribes of the CGTO recommend continuing to identify special places, Puha Paths, and landscapes and setting aside these places for unique co-stewardship and ceremonial access. For example, currently studies have begun and portions are completed regarding the identification of places, Puha Paths and cultural landscapes in the Timber Mountain Caldera (Stoffle et al. 1994a; Stoffle, Halmo, and Dufort 1994; Stoffle et al. 2001a; Stoffle et al. 2001b; Stoffle, Zedeño, and Halmo 2001; Stoffle et al. 2006). These studies are planned to continue and when completed will add a Native American cultural sensitivity component which will contribute to the currently recognized importance of this National Natural Landmark and Area of Critical Environmental concern.

Climate

CGTO knows that the climate of the region has changed over the thousands of years that the Indian people have lived in this region. The NTS has only occupied this area since the early 1940s. It is important to recognize that major climatic changes have taken place since the end of the Pleistocene and shorter term climate changes such as the wet period in the 1980s and 1990s contrast with the current 10-year meteorological drought. It is important for the GTCC EIS to assess the impacts of short term and long term climatic changes because the DOE expects to safely manage these GTCC wastes for up to 10K years during which similar climate changes can be expected.

The current climate description in the GTCC EIS is specific to the present decade-long period of extended drought (a similar one occurred between 1896 and 1906), so this type of drought and the wet period between 1980s and 1990s may be factors in siting the GTCC facility. An analysis of long term impacts based on current conditions will neither be representative of climate conditions viewed over much longer periods nor applicable to short climate shift to much wetter conditions.

The CGTO maintains that during the last decade the NTS and surrounding region has experienced a meteorological drought. Current meteorological analysis suggests that this is a 10-year duration type drought and even could be the beginning of a longer drought episode. The region has not experienced a drought with these characteristics since a decade spanning the beginning of the 20th century. Therefore, this meteorological episode can be termed a 100-year drought. The early 20th century drought becomes an analog against which to discuss the environmental implications of the current episode (see Figure A–4).

The 100-Year Drought (Uh-na-hp dumime sogobe basa-type "A long time our Mother Earth has been dry", Minga- na-vas-so-quip "very dry land")

Nevada is "much below normal" to date in 2007. As of June 2007, the Palmer Z Index, which measures short term drought on a monthly scale, indicated that central Nevada, including the NTS, was in a "severe drought" condition. Data from the National Climatic Data Center shows that Nevada was ranked the driest state in the U.S. for the period of August 2006 to June 2007. This period reflects the drought trend in Nevada that has characterized the past decade (Figures A–1, A–2) (http://www.ncdc.noaa.gov/oa/climate/research/2007/jun/st026dv00pcp200706.html).

On a broad scale, the two previous decades (1980s and 1990s) were unusually wet with short periods of extensive droughts. The 1930s and 1950s showed the opposite trend with prolonged periods of extensive droughts and few wet periods http://www.ncdc.noaa.gov/oa/climate/research/2007/jun/us-drought.html).

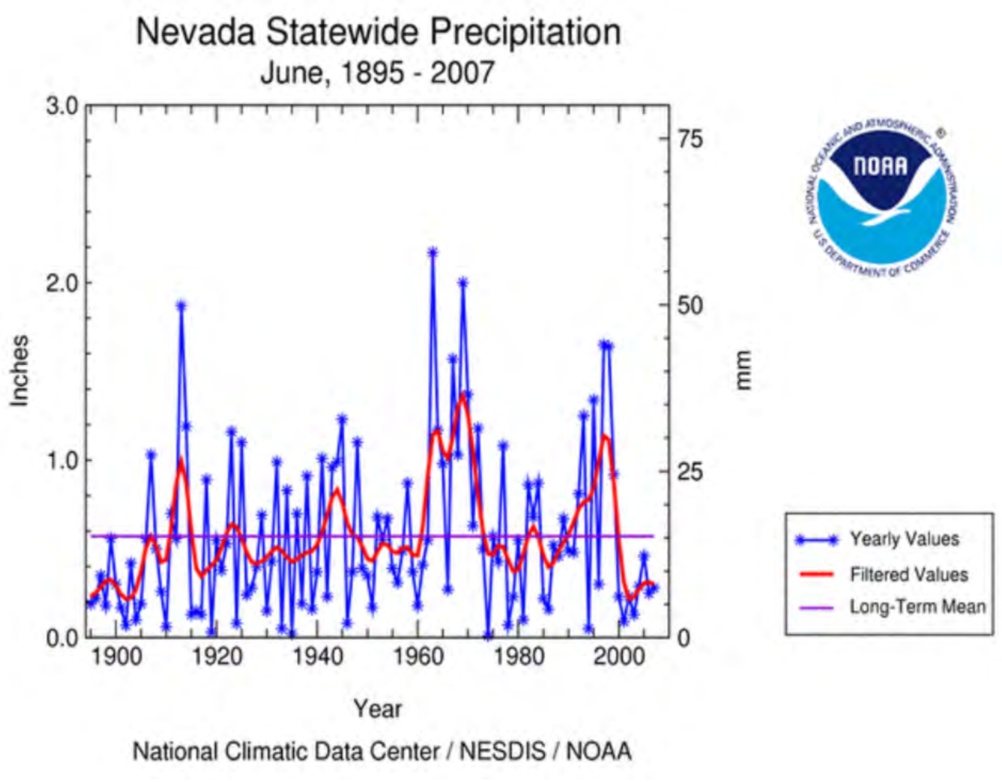

Figure A–2 One hundred and twelve years of Nevada precipitation averages

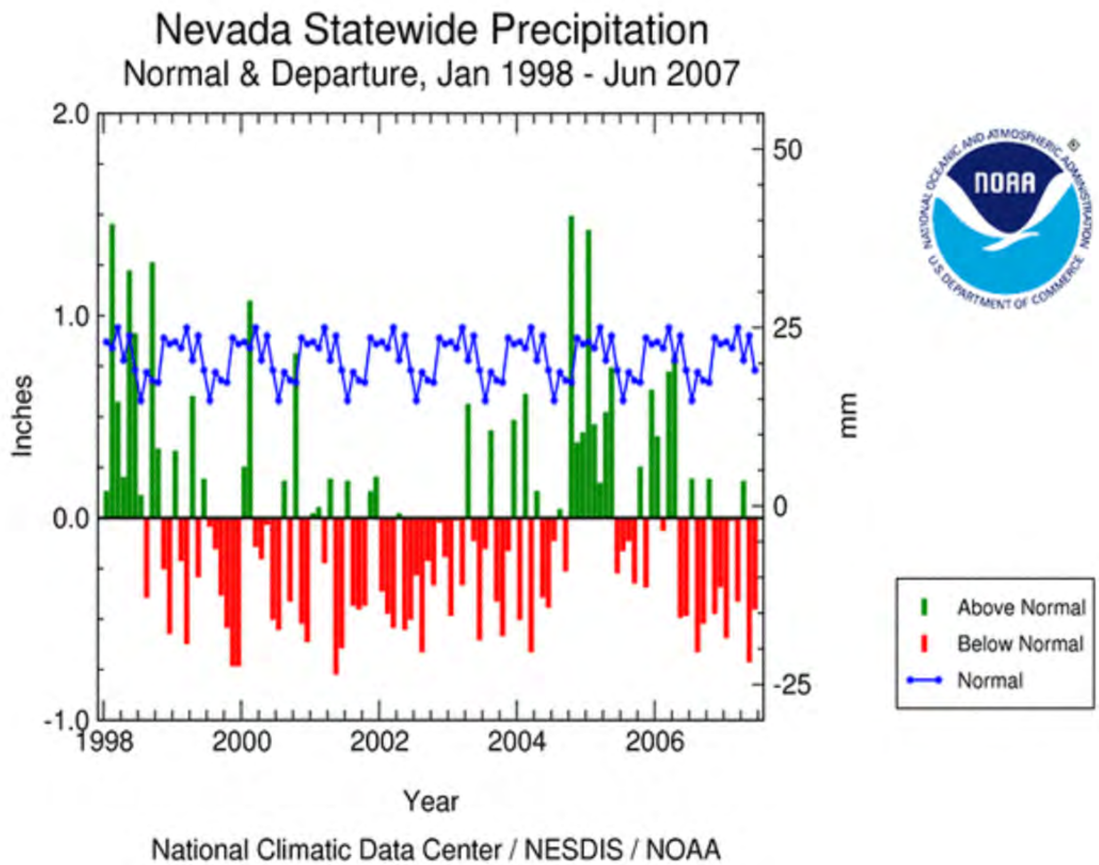

Figure A–3 Fluxuations in Nevada statewide precipitation since 1998

Hughes and Graumlich (1996) reconstructed 7979 years of annual precipitation from bristlecone pine in the White Mountains of eastern California to document the occurrence of eight multi-decadal droughts, with the two most recent centered on 924 AD and 1299 AD (Figure A–3).

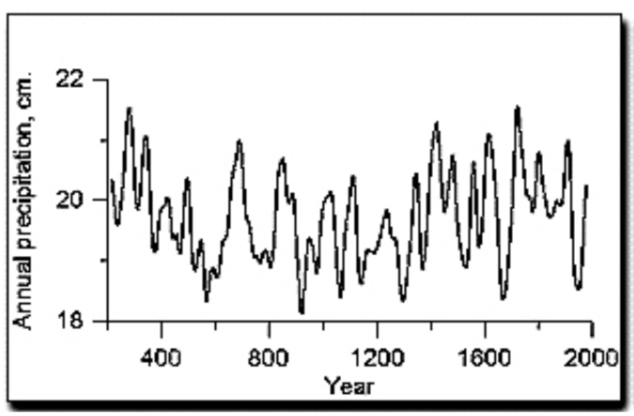

Figure A–4 7979 Years of annual precipitation reconstructed from bristlecone pine

Areas specific to the NTS and southern Nevada are in a 100-year drought cycle; Figure A–4 shows that major drought conditions have occurred in multiyear waves since 1895. The current drought that is affecting the NTS and its neighboring lands has persisted since 1996 (Goodrich 2007). Researchers think that the rise in greenhouse gases in the atmosphere may lead to a return of multi-decadal megadrought conditions that existed prior to 1600 AD. The most severe megadrought occurred between 900 AD and 1300 AD (Cook et al. 2004, Goodrich 2007).

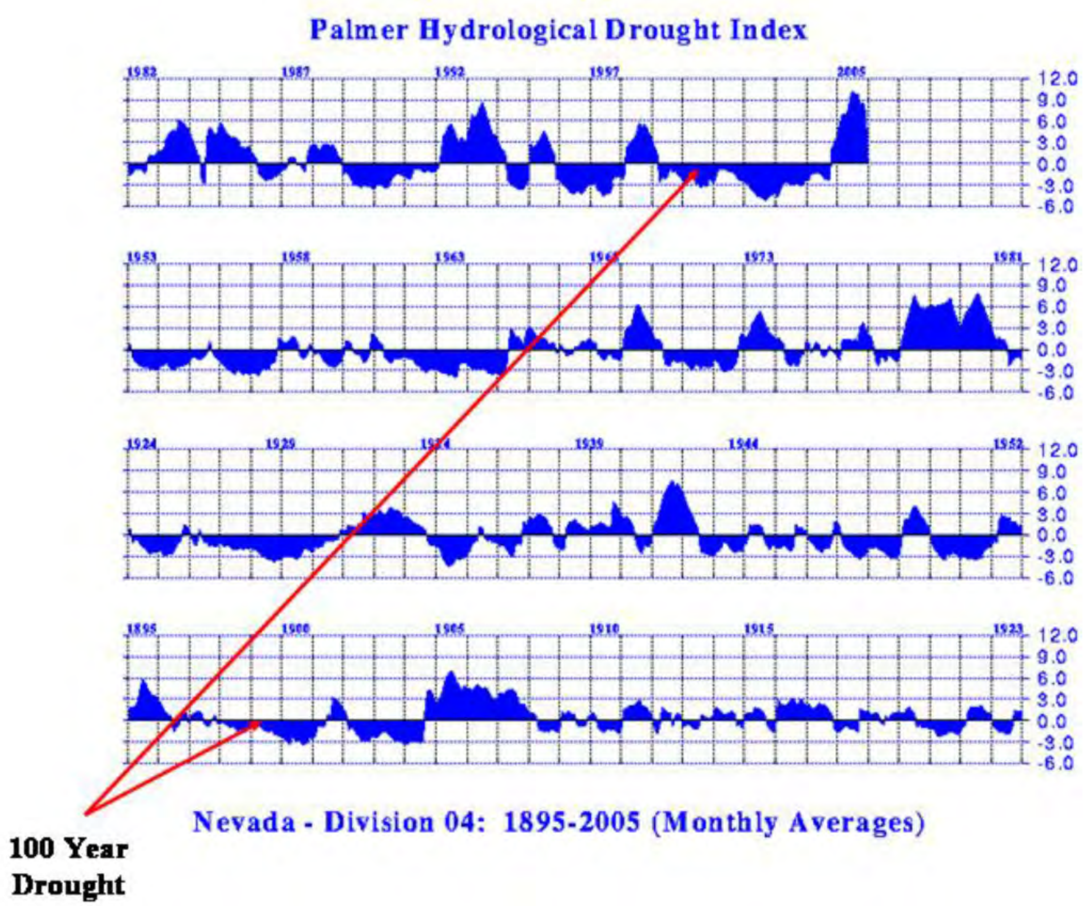

Figure A–5 Palmer hydrological drought index from 1895-2005 in Nevada – Division 04

The CGTO recommends that action be taken to lessen the impacts of this drought cycle through meaningful research and management applications because there is the potential for irreversible environmental degradation and biodiversity loss. This type of action is a concept found in social impact assessment and environmental studies known as the precautionary principle. This principle implies that there must be a willingness to take action in the advance of scientific proof or evidence of the need for proposed action. If there is a delay in action, it will be devastating to both society and nature (Cooney and Dickson 2005). The precautionary principle stresses that there must be ethical responsibilities towards maintaining the integrity of natural systems, and the fallibility of human understanding. The CGTO requests that traditional environmental management practices occur in order to help restore and maintain the ecology of the NTS.

HYDROLOGY

One inevitable implication of the current 100-year drought is that the surface water on the NTS and immediate areas has diminished and become more sporadic. Surface water is here defined as water available for shallow rooted plants during rainfall, water available during post-rain ponding, runoff, and absorption, and water recharged into near-surface aquifers. The modification and availability of surface water has the ability to affect all plants, animals, and associated trophic levels on the NTS.

Calling the Rain (Pahwwanipagee "calling the rain", Oo-wap-pi "calling the rain")

One type of interaction was in the form of calling the rain. Rain calling is a basic aspect of American Indian life and culture. Traditionally there were rain callers (rain shamans, rain doctors), rain ceremonies, and helpers from the spiritual world which would help facilitate rain production. Most traditional communities had a rain maker. When the special rain shaman called upon the rain, he sang songs and was aided by his spirit helper, which was usually in the form of a mountain sheep, to call upon the rain. The mountains had important roles in this activity. They interacted with the clouds and the sky to call down the rain.

Winter Ceremonies-Snow Making Ceremonies: Western Shoshone

The Winter Ceremony was performed in the fall to ensure that a good winter with heavy snow fall will happen. The spiritual leader (weather doctor) would call the people together and meet at a special place in the mountains, sometimes near a Pine Nut gathering area. Prayers and songs were done by the spiritual leader. Usually this ceremony lasted a day. If too much rain was falling certain precautions would be taken, for example, the children were not allowed to shake willows that would be used for weaving or to kill frogs as this would bring more rain. Hummingbirds
were not killed for many reasons, but if they were killed, there would be flooding and lighting storms, with lightning killing the person who killed the hummingbird.

Stinkbug (Bee-voos, Wu-who-koo-wechuts)

Even today, individual traditional native people can bring rain. This is done by turning a stinkbug on his back. The rain will come provided the stinkbug allows a person to tickle his belly with a small stick. As the person prays for rain, he tells the stinkbug why he is asking for rain.

Snow Fleas

Snow Fleas represent a special category of Native American environmental knowledge because they are almost invisible and live at the highest elevations on mountains. According to Indian beliefs during the late fall when it is cold there is a snow ceremony. A part of this ceremony involves calling on the snow fleas. The snow fleas are the ones that make the snow wet and absorb into the mountain. Without the snow fleas, the snow is dry and evaporates quickly. Without ceremonies and the water making fleas, there is less water for the mountains and the valleys below. The snow ceremony is conducted in relationship with ceremony of the seeds where young girls dance with seeds in winnowing trays and a spiritual person sings songs to bring whirlwinds which envelope the dancers and scatter the seeds as a gesture of fertilizing the earth. Thus, water is brought to the fertile and dispersed seeds.

Ecology Indian Comments

The CGTO knows that this site is an ancient playa, surrounded by mountain ranges. The runoff from these ranges serves to maintain the healthy desert floor. Animals frequent this area, there are numerous animals' trails, and these play a significant part in the history of the locality and of the Indian lifestyles. Our ancestors knew that the Creator always provided for them and this site is one of their favorite places to hunt and trap rabbits. We have special leaders that organized large rabbit hunts. Many people participated so this place would be occupied at times by all kinds of our people. Rabbits provided good eating, bones for tool-making, warm blankets, and even games. Indian people refrained from eating coyote, wolves, and birds but these contribute to our stories which tell us how to behave and why we are here. We have many stories and songs that include animals and birds who have human-like antics. From these antics Indian people learn the life lessons to build character to become better persons. So animals and the places where they live contribute to our history and culture.

This culturally central place was used by and important to Indian people from our agricultural and horticultural communities located to the north – near Reese River Valley and Duckwater, to the south – near Ash Meadows, to the southeast – near Indian Springs and Corn Creek, to the east – near the Pahranagat-Muddy River, and west – near the Oasis Valley. It was also used by people from our agricultural and horticultural communities to the far west in Owens Valley, to the far south near Cottonwood Island and Palo Verde Valley on the Colorado River, to the far southwest at Twenty Nine Palms, to the far east along the Virgin River, Santa Clara River, and Kanab Creeks, to the far north along the Humbolt River and Ruby Valley.

Plants

The CGTO knows based on previous DOE-sponsored ethnobotany studies that there are at least 364 Indian use plants on the NTS (see Appendix G). Indian people visiting the proposed location of the GTCC facility identified the following traditional use plants: (1) Indian Tea, (2) White Sage or Winter Fat, (3) Indian Rice Grass, (4) Creosote, (5) Wolfberries, (6) Four O'clock, (7) Spiny Hop Sage, (8) Joshua Tree, (9) Daises, (10) Desert Trumpet, (11) Cholla, (12) Globe Mallow, (13) Fuzzy Sage, (14) Tortoise Food Plant, (15) Sacred Datura, (16) Wheat Grass, and (17) Lichen. Other plants were present but not identified due to the late season and the dry condition of the plants.

Plants are still used for medicine, food, basketry, tools, homes, clothing, fire, and ceremony – both social and healing. The characteristics of the plants at the proposed GTCC area are smaller and thinner than in other desert areas where it is wetter. Indian people from elsewhere traveled to this area to gather specific plants because they have stronger characteristics when they grow in dry places. The sage is used for spiritual ceremonies, smudging, and medicine. The Indian rice grass and wheat grass are used for breads and puddings. Joshua tree is important for hair dye, basketry, foot ware, and rope. Datura is used for hallucinogenic effects during which alternative places can be visited by medicine men. Datura also goes itself to disturbed areas and heals them. The globe mallow had traditional medicine uses, but in recent times is also used for curing European contagious diseases.

Animals/Insects

The CGTO knows based on previous DOE-sponsored ethnofauna studies that there are at least 170 Indian use animal on the NTS (see Appendix G). Indian people visiting the proposed location of the GTCC facility identified the following traditional use animals: (1) Jack Rabbits, (2) Whiptail Lizards, (3) Antelope, (4) Tortoise, (5) Kangaroo Rats, (6) Horned Toad, (7) Rock Wrens, (8) Ravens, (9) Grasshoppers, and (10) Stink Bugs. Other animals (such as snakes, bats, and owls) were perceived to be present but not observed because they primarily emerge at night.

All animals and insects were and are culturally important and the relationships between them, the Earth, and Indian people are represented by the respectful roles they play in the stories of our life then and now. The GRCC valley is where a spiritual journey occurred. It involved Wolf (*Tavats* in Southern Paiute, *Bia esha* in Western Shoshone, *Wi gi no ki* in Owens Valley Paiute) and Coyote (*Sinav* in Southern Paiute, *Duhvo esha* in Western Shoshone, *Esha* in Owens Valley Paiute) and is considered a Creation Story. Only parts of this can be presented here. When Wolf and Coyote had a battle over who was more powerful, Coyote killed Wolf and felt glorious. Everyone asked Coyote what happened to his brother Wolf. Coyote felt extremely guilty and tried to run and hide but to no avail. Meanwhile, the Creator took Wolf and made him into a beautiful Rainbow (*Paro wa tsu wu nutuvi* in Southern Paiute, *Oh ah podo* in Western Shoshone, *Paduguna* in Owens Valley Paiute). When Coyote saw this special privilege he cried to the Creator in remorse and he too wanted to be a Rainbow. Because Coyote was bad, the Creator put Coyote as a fine white mist at the bottom of the Rainbow's arch. This story and the spiritual trails discussed in the full version are connected to the Spring Mountains and the large sacred cave in the Pintwater Mountains as well as to lands now called the Nevada Test Site. This area is the home place of Wolf who is still present and watches over the area and us.

Minerals

The CGTO knows based on previous DOE-sponsored cultural studies that there are many minerals on the NTS (no complete list available). Indian people visiting the proposed GTCC site identified the following traditional use minerals: (1) Obsidian, (2) Chalcedony, (3) Yellow Chert or Jasper, (4) Black Chert, (5) Pumice, (6) Quartz Crystal, and (7) Rhyolite Tuff. Other minerals were perceived to be present but not observed because of the limited time and search area.

All minerals are culturally important and have significant roles in many aspects of Indian life. For example, the Chalcedony on the proposed GTCC site would have made an attractive offering which would be acquired here by a ceremonial traveler and then left at the vision quest or medicine site located to the north on top of a volcano like Scrugham Peak. Returning ceremonial travelers would also bring offerings back to where they had acquired offering, thus the Yellow Chert or Jasper (observed on the GTCC site) which outcrops about 70 miles to the north would be gathered there and returned to the Chalcedony site as an offering.

Playas

The CGTO knows, based on cultural studies funded by the DOE on the NTS and playa-specific studies funded by Nellis Air Force Test and Training Range (Henderson 2008), that playas occupy a special place in Indian culture. Playas are often viewed as empty and meaningless places by Western scientists, but to Indian people playas have a role and often contain special resources that occur nowhere else. The following text was prepared by the Indian people who visited the proposed GTCC site.

Is a playa a wasteland? According to Indian elders playas were used in traveling or moving to places where work, hunting, pine cutting or gathering of other important foods and medicine could be done. One elder remembers crossing over dry lake beds and traveling around but near the edges and they discussed how provisions were left there and at nearby springs (See NRC 2009b for additional information about the cultural importance of springs) by previous travelers at camping spots. Indian people left caches in playa areas for people who crossed valleys when water and food was scarce. Frenchmen playa is such a place. Indian people took advantage of traveling through this playa as mountains completely surround this area. The CGTO knows that most dry lakes are not known to be completely dry. An example is Soda Lake near Barstow, California. The Mohave River flows into this dry lake and most of the year it looks dry but it actually flows underground. Building berms on dry lakes beds to offset water and runoff doesn't sound like a good idea to the Indian way of thinking. So why build a GTCC site on and use this playa when the odds of radiation seem feasible? The Indian people who visited this site recommend not to bother Frenchmen Playa. It is only one of two in the immediate region and has special meanings. There should be a more descriptive study to fully understand the impacts. More time is needed, also for Indians to revisit this site. Although some people continue to view Frenchman playa as a wasteland, the CGTO knows it is not. Further ethnographic studies are needed.

BIOLOGICAL RESOURCES (Dá Me Na-Nu-Wu-Tsi "Our Relations All of Mother Earth")

It is nearly impossible to observe and monitor the changes on cultural resources on the NTS study lands. Some changes occur quickly and certain changes happen slowly. For an example, an earthquake could cause serve damage instantly and the onslaught of impending drought and famine can become a great heavy burden on mankind and his environment.

The current 100-year drought has increasingly stressed all of the plants and animals on the NTS. Because this is a unique, albeit, perhaps a cyclical event, its environmental impacts are unprecedented in the history of the operation and management of the lands of the NTS. It is expected that the 100-year drought has modified the abundance and distribution of all animals and plants. The quality, quantity, and distribution of indigenous plants necessary to sustain a healthy environment to maintain a productive animal habitat is clearly affected.

Because Native Americans view the NTS lands as holy lands there is deep concern for it. Certain springs have dried up, which makes animals travel into other districts, makes food foraging difficult, and dries up the land (See NRC 2009b for additional information about the cultural importance of springs). The remaining stressed animals and plants have lower fecundity and nutritional value in the food chain. The CGTO recognizes the nation-wide need to identify and protect threatened and endangered plants and animals.

The members of the consulting tribes who have lived on these lands since Creation value all plants and animals, yet some of these occupy a more culturally central position in their lives. The main characteristic of a healthy landscape is healthy plants, animals, and visual beauty. The role of land managers is to help care for the land and its ecosystems. Therefore, the CGTO applauds the efforts being designed to minimize the severe impacts of the ongoing drought. Conservation and preservation should become high priority. In order to convey the Native American meaning of these plants, a series of studies were conducted and the findings were negotiated into a set of criteria for assessing the cultural importance of each plant and of places where plant communities exist. The CGTO provided these cultural guidelines so that NEPA analysis and other agency decisions could be assessed from a Native American perspective.

Because of these stresses, the animals and plants of the NTS require management interventions unforeseen during the 1996 *NTS EIS*. American Indian people have faced such drought episodes in the past and have the capacity to suggest and carry out adaptive responses. Adaptive responses to extreme climatic fluctuations involve both physical and spiritual interventions designed to restore balance and well-being to the area. All tribes involved in the CGTO recognize a range of these interventions, which have been successful in the past. The following are a series of cases that demonstrate how Native American people have interacted with the land and natural elements to help all aspects of life.

What is Out There?

The CGTO has identified as fundamental in their cultural concern a list of 364 plants and 170 animals which were traditionally used and are currently culturally central. Concerns exist that this larger list has been reduced to an official list of 107 plants and 26 animals (see American Indian Writers Subgroup, CGTO 1996: Table G-1, G-2, pp G-14 – G-17, G-18). The CGTO argues that the full list should be used to assess impacts because both plants and animals appear and disappear on the NTS at various seasons and during various climatic episodes. Thus the working list of potentially impacted plants and animals needs to be expanded to the full list of Indian plants and animals. These species have been identified as indicators of the health of NTS ecosystems.

Native Americans have always been concerned that the native species of vegetation on the NTS may be in danger of being lost. To native people, plants provided most of the food resources as well as the raw materials for medicines, tools, shelter, and even ceremonial objects. Take the tobacco, considered highly sacred, the tobacco plant was carefully cultivated to ensure its posterity. Religious leaders and traditionalists would guard the location for their own use. The plant used properly would bloom and blossom for the user, because it was being utilized appropriately. Other sacred plants were the sage, sweet-grass and cedar. These are considered as gifts from the earth and are to be applied in traditional ceremonies and not for so-called “recreational” purposes. There is much evidence that regaining and reclaiming Indian plant knowledge could benefit humans in many ways. The CGTO would like the land managers of the NTS to implement measures with the goal of restoring lands with native species. Ecosystem health includes the people with whom the natural environment developed, specifically, the member tribes of the CGTO. By involving the CGTO in the design, implementation, and analysis of the biological surveys, NNSA/NSO can obtain more comprehensive reports of ecosystem health and potential impacts, as well as further facilitate government-to-government consultation with the CGTO.

Environmental Justice

The CGTO would like to have their DOE approved definition of Environmental Justice added to the current Environmental Justice description.

DOE has recognized the need to address environmental justice concerns of the CGTO based on disproportionately high and adverse impacts to their member tribes from DOE NTS activities. In 1996, the CGTO expressed concerns relating to environmental justice that included 1) damage to Holy Lands, 2) negative health impacts, and 3) lack of access to traditional places that contributes to breakdowns in cultural transmission. In the 2002 NTS SA, NNSA/NSO concluded that with the selection of the Preferred Alternative, the CGTO would be impacted at a disproportionately high and adverse level consequently creating an environmental justice issue. Since 2002, NNSA/NSO has supported a few ethnographic studies involving the CGTO and culturally important places including in 2004, when NNSA/NSO arranged for tribal representatives to conduct evening ceremonies at Water Bottle Canyon. While the opportunity for the evening ceremony was a significant accommodation, disproportionately high and adverse impacts from DOE NTS activities continue to affect American Indians. The three environmental justice issues noted by the CGTO need to be addressed.

The CGTO is the voice for acclaiming the responsibility of maintaining stewardship with the land for all Native American Indian Tribes. The bonding is a privilege to be faceted above all else and must be carried and held by enabling principles. The CGTO believes this right was given to them at Creation and must be followed. Otherwise, the networking of the other spirit world will be severed. The CGTO knows there are places on the NTS landscape that needs traditional ceremonies and blessings to offset the tensions of severe land disturbances done to it. An example is Shoshone Mountain. Shoshone Mountain is large and long. Roads are limited to its crest making it inaccessible for religious and traditional people to go there to conduct ceremonies. The CGTO recommends that special privileges be allowed for ceremonial journeys to take place and to provide funding for transporting traditional leaders to inaccessible places such as Shoshone Mountain by helicopter to perform ceremonies.

Environmental Justice and the Ruby Valley Treaty of 1863

The CGTO supports the efforts of the Western Shoshone to have the Ruby Valley Treaty of 1863 be fully recognized as originally intended. Previously, DOE/ NNSA has relied on the Supreme Court Decision of U.S. v. Dann as a means of abrogating their trust responsibilities. The focus of this case dealt with trespass violations associated with grazing cattle on government land. In the opinion of the Western Shoshone people, this treaty of peace and friendship is still in full force and affect. Subsequent, to this court decision, the Western Shoshone Nation brought the matter before the United Nations and the Organization of Human Rights in Geneva, Switzerland. On January 9, 2003, the Inter-American Commission on Human Rights rendered its final decision in the case of Western Shoshone land rights in favor of Mary and Carrie Dann. This international body found the actions of the U.S. Government to be in violation of Western Shoshone rights with regard to property, due process, and equality under the law.

In 2004, the United States attempted to bring closure to the Western Shoshone claims by offering compensation. This highly controversial action has not affected nor diminished the aboriginal claims of the Western Shoshone to the land. It is maintained in previous EIS documents that the United States has failed to uphold its trust responsibility and negotiate further with the Western Shoshone Nation. No nation to nation discussions as promulgated under federal law have occurred. In this regard, the Western Shoshone Nation should receive equal treatment as afforded to other countries.

In March 2005, the Western Shoshone Nation filed a lawsuit against the DOE for the siting of a High-Level Nuclear Waste and Spent Nuclear Fuel Underground Geologic Repository at Yucca Mountain. It is the position of the Western Shoshone that such action being proposed by the DOE violates the terms and conditions of the Ruby Valley Treaty of 1863. At this current time, all activities at Yucca Mountain have been suspended as ordered by President Obama. Despite this freeze, the CGTO recommends that the DOE abide by the treaty as originally intended.

Transportation

The transportation of low level radioactive waste (LLRW) was a major issue originally addressed in Appendix G of the 1996 EIS. The AIWS addressed serious flaws in the then draft transportation study by noting that neither the CGTO nor the tribes were consulted formally. The tribes were only informed of the matter through a series of public meetings, which the AIWS viewed as a violation of federal legislation requiring government to government consultation. The AIWS also detected limited and faulty assessments of new railroads and other activities on cultural and Native American resources. The study documents revealed missing or misnamed Indian tribes and reservations therefore, the AIWS recommended a systematic comprehensive study of American Indian transportation issues to complete the general study that incorporated concerns of "stakeholders."

Native Americans Respond to the Transportation of Low Level Radioactive Waste to the Nevada Test Site (Austin 1998)

On July 25, 1996, the DOE/NV sent a letter announcing a comprehensive Native American LLRW study and requested tribal participation. The five members of the AIWS who recommended the study participated in a planning team and formed the core of the American Indian Transportation Committee (AITC). The planning team began by meeting with DOE/NV officials to determine which proposed transportation routes were under consideration. A study proposal was developed and three criteria were determined that needed to be met by each tribe invited to participate in the study. The criteria were aboriginal and/or historic cultural affiliation to the lands along any of the three proposed routes, location near any of the three proposed routes in the vicinity of Nevada, and frequent use of the proposed routes by tribal members.

In addition to the regular CGTO members, the AITC planning team identified six additional Western Shoshone tribes, bands, communities, and organizations, as well as Mohave, Hopi, Navajo, and Goshute peoples all of whom met the criteria for participation in the study. A total of 29 tribes, subgroups, bands, communities, and organizations were potentially affected by the transportation of LLRW.

This study addressed perceived risks by American Indians that derive from the transportation of LLRW. It focused on three truck haul routes as these pass through in a four-state area that generally reflects the administrative responsibility of the DOE/NV. The study involved a series of unique methods including both quantitative and qualitative data collection. The study documented that radiation is perceived as an Angry Rock by many Indian people. It exists and acts according to epistemological guidelines that do not reflect those perceived as existing in Western science. This is an extremely important finding because American Indian responses to radioactivity reflect its spiritual as well as its physical dimensions (Austin 1998).

U.S. DOE Nevada Operations Office, Intermodal Transportation of LLRW to the Nevada Test Site, Summary of Meeting with Native Americans, November 18 to 20, 1998, Tonopah, NV (American Indian Transportation Committee 1998)

While the initial Native American LLRW study was being completed, the DOE decided to conduct an Environmental Assessment of the Intermodal Transportation of Low Level Radioactive Waste (IM EA). Intermodal refers to the use of both railroad and trucks to haul LLRW from its producers to the NTS. The intermodal study introduced the concept of an entrepot (a trans-shipment facility) where LLRW would be taken from railroads, perhaps stored for a period of time, and then reshipped via truck to the NTS. The DOE asked the members of the AITC to take the findings from the Austin report and any pertinent previous studies and apply them directly to the IM EA. This task was accomplished at a meeting held in Tonopah, Nevada and resulted in a report entitled *U.S. DOE Nevada Operations Office, Intermodal Transportation of LLRW to the Nevada Test Site, Summary of Meeting with Native Americans, November 18 to 20, 1998, Tonopah NV (American Indian Transportation Committee 1998).*

American Indian Transportation Committee Field Assessment of Cultural Sites Regarding the U.S. Department of Energy Pre-approval Draft Environmental Assessment of Intermodal Transportation of Low-Level Radioactive Waste to the Nevada Test Site (American Indian Transportation Committee 1999)

The AITC concluded that the Austin study (1) was not designed to assess specific locations along its study-area highways, (2) the IM EA was considering some highway routes that had not been considered in the Austin study, and (3) the IM EA raised the issue of potential LLRW impacts along railroad routes. The AITC thus recommended to the DOE/NV that they support the AITC to conduct on-site studies along the new highway routes. This request was resulted in a formal research proposal submitted to the DOE on December 22, 1998. The proposal was funded on January 4, 1999. The AITC went into the field on January 11, 1999 and worked continuously until January 21, 1999. The direct field observations of the AITC during this period of study were the foundation for their summary of findings.

The study was guided by a series of agreed to methods for collecting data. Given the great distances and the time needed to assess each place visited along the proposed routes, it was agreed by the AITC that two kinds of site evaluations would be conducted. The first is a complete site evaluation and the second was called a mini-site evaluation. Each had his/her own forms and each AITC member filled out one or the other form at each site that was identified along the proposed routes. At the end of three days of site visits, the AITC spent one day writing the results of their evaluations. These site descriptions and evaluations were fully discussed by the AITC; therefore, the text provided in this summary of findings has been agreed to by the entire AITC.

A total of 25 sites were evaluated by the AITC. The sites were dispersed across an extensive area within the previously established region of influence, from Moapa and Caliente, Nevada in the east, to Barstow, California in the west. This vast stretch of land contained a large variety of culturally significant Indian places. Cultural resources and cultural landscape features were identified and evaluated; these included mountains, valleys, springs, trails, a variety of plants and animals, archaeological remains, storied rocks, rivers, and urban communities considered important to Numic and Yuman speaking peoples.

Comments and concerns made for the places visited and the associated resources, as well as Indian socioeconomics and environmental justice were edited and integrated into the existing pre-approval draft IM EA text sections. Also recommendations pertaining to further Native American input and assessments as part of the EA process were made to the DOE (Arnold et al. 1999).

Confronting the Angry Rock: American Indians' Situated Risks from Radioactivity (Stoffle and Arnold 2003)

This article synthesized the key findings from the previous transportation studies by discussing Numic-speaking peoples' epistemological views towards radioactive materials and how it could impact places and resources on traditional lands. The article framed the discussion in terms of perceived risks from the transportation of radioactive waste. As mentioned earlier, Numic-speaking people view radioactive material as an angry rock and they have possessed this knowledge and have used this rock for thousands of years. The angry rock is a powerful spiritual being that is a threat that cannot be controlled nor contained through conventional means. It has the power to pollute places, food, and medicines thus they cannot be used afterwards by Indian people. The angry rock also has the ability to cause serious spiritual impacts. The transportation of the angry rock along the highways poses threats to areas like Animal Creation places (the Red Tail Hawk Origin Site), access to spiritual beings (Potato Woman), human souls that have not been sung to the afterlife (Hiko Massacre Site), and ceremonial areas (Black Canyon, Pahranagat Valley).

The findings presented in this article demonstrate that American Indian risk perceptions are real and need to be understood as calculated risks. Also the shared cognitions of risk among people who share a common culture raise questions of alternative epistemologies which are not normally addressed in risk assessments. The article concluded with thoughts on the "logical step" towards addressing risk. There is a need to afford special protection for Indian people and their connected environment and allow the reestablishment of this relationship (Stoffle and Arnold 2003). The AIWS addresses this issue directly in the Biological Resources and Environmental Justice sections of this essay.

The Angry Rock

The CGTO knows that radiation can be and is viewed from both a western science and a Native American perspective. These alternative and competing perspectives are key for understanding the cultural foundations of American Indian responses to the mining, processing, use, transportation, and disposal of radioactive materials. At some level of analysis from an Indian perspective, all radioactive waste is basically the same problem to Indian people. Subtle differences in classification from a Western science perspective of radioactive waste only mask and do not significantly modify the basic cultural problems of radioactive waste for Indian people and their traditional lands.

The Angry Rock is a concept used by Indian people, involved in DOE funded radioactive waste transportation and disposal studies, to quickly summarize the complex cultural problems associated with what happened to this known mineral when it was improperly taken and used by non-Indians. The notion of an Angry Rock is premised on the belief that all of the earth is alive, sentient, speaks Indian, and has agency. When the elements of the earth are approached with respect and asked for the permission before being used they share their power with humans. The reverse occurs when they are taken without permission – they become angry withhold their power and often using it against humans. Thus, uranium is an Angry Rock. Uranium has been known and carefully used by spiritual specialists and medicine persons for thousands of years (Lindsay et al. 1968). The following American Indian elder quote from a DOE funded report (Austin 1998) begins to explain this perspective:

We are the only ones who can talk to these things. If we do not make sure that we talk to those things, then they are going to give us more bad harm, because it is already happening throughout the country. Those are the reasons why the Indian people say ... like uranium for one, uranium was here since the beginning of this Earth, when it was here we knew uranium at one time. And still it is used, but then they got a hold of it and made something else out of it. Now it is a man made thing, and today it accumulates waste from nuclear power plants, it accumulates more, it has its own life. Radiation has said to us at one time "If you use me make sure you tell me before you use me why you are going to use me and what for. " And we never said anything to that uranium at all, and we put something else in there with it, which shouldn't belong with it. It gives it more power to eliminate the life, of all living things on this planet of ours. Those are the reasons, why the Indian people always say, and I know because I have been there. The rocks have a voice...

Although from a Western science perspective radiation can be isolated and contained by conventional techniques, the Angry Rock has the power to move and cannot be contained by barriers. Indian people who have dealt with the Angry Rock for thousands of years note that there are traditional ways to deal with the uranium the natural rock if used by trained Indian specialists, but these may or may not work with the Angry Rock of modern radiation waste.

Another elder noted:

Songs ... we are the ones who should be talking to those things. Radiation is going to take all of our lives, it is continuously moving over the land. The land don't want it, nobody wants it. And today, we are doing a bad thing by using radiation on each other. Radiation is something that should not be used to kill animal life...

Another elder noted:

And can it be contained? As it's transformed it can be, I think it can be contained physically but not spiritually, and again I think spiritually as it's been altered because it's in that energy field because it's been altered. The spirit, that's where it can do its harm in an altered form. It doesn't do any good to anybody. And there you're just in the wrong place in the wrong time, it does influence plants and animals, minerals and air, the spirit of any area it passes through. The reason somebody is sick. I don't think it's necessary to talk about how each one of these is influenced, it just is.

Another elder noted:

As far as the transportation of waste there's a lot of unknowns and we don't know what the consequences are. We know there are many sicknesses that come out from people that have been contaminated by nuclear waste and as far as Indian people go, we show respect to the land, show respect to other people, for the animals, the plants, the rocks. The power of the rock – Just looking at Chemehuevi Mountain, it's a very spiritual mountain from this perspective right here. When I look out towards the mountains and I don't just see a mountain, I see a place of power, I see a place where I can go and meditate and speak with the Creator directly and ask for prayers and blessings for people directly. Just like anything else, you have to give prayers all the time because the creator is here to watch and protect over us. I feel that we wouldn't have come this far if he wasn't here to watch over us and we are here to pray and we are here to protect the other resources.

Another elder said:

I can envision the animals standing back once it goes through for the first time and they recognize that there's a danger that they would move away because of fear. That they would no longer be there and that there's something bad coming down the road and they disperse and move away into different corridors. Kind of like a dust storm, they disperse and move further and further away. I see it from the animals' standpoint, they're a lot smarter than us and they've been doing this for longer than us and their senses are more keen and I think the animals would get back and it would create dead zones throughout the country. Through these corridors or transportation routes of course at the site there will be those that are curious who want to go see.

Another elder said:

I don't know what you would do with this rock if it's angry and this is its way of rebelling, getting *back. I think as a Native American I would backstep and ask for forgiveness. Sometimes forgiving is not very easy because there's sacrifices we have to make and there's consequences ... I don't think it can be done as a. group, it's an individual thing and each one of us has to go back and ... ask for forgiveness for what has taken place. It's not just only that I think it's going to be more complicated than going out into the mountains and saying, "hey, I'm sorry, I won't do this, I won't do that and I won't bother you anymore. There's a lot of other things that need to be forgiven. The rock is the most precious and it's the largest and it's the one that needs to be forgiven the most. There's a lot of small forgiveness that have to be given before the large rock. I think it's a stepping stone...*

... the rocks are angry, yes, they're striking out saying "don't do this to me, don't touch me, don't let this happen. " In a sense you look at it from a spirituality standpoint, it's the spirits of Mother Earth telling us don't mess with Mother Earth.

It remains a mater of debate as to whether traditional means of placating powerful rock-based forces can be used to control or placate radioactive waste. Western scientists have created a problem for Indian people that, despite being very critical to their future, is not easily resolved.

Cultural Resources

The CGTO affirms a commitment to assisting the archaeology program by providing CGTO appointed tribal monitors. These monitors are provided approved guidance and training by the CGTO as well as extensive project orientation by the professional archaeologists. Monitors are trained so they know certain appropriate cultural responses to materials identified during archaeological survey, but they recognize that certain kinds of cultural resources require spiritual specialists who are then called in to evaluate and respond to newly identified cultural resources. In cases where NAGPRA relevant resources are identified then the CGTO is contacted and will set into motion NAGPRA inadvertent discovery protocols (NAGPRA 1990; Stoffle, Halmo, and Dufort 1994; Stoffle, Zedeño, and Carroll 2000). At the end of the monitoring experience, each monitor provides his or her own personal notes and experiences for a summary report that is prepared and submitted to the CGTO.

The CGTO knows the distribution and density of known archaeology sites has not significantly changed since the 1996 NTS EIS. They know the largest number of recorded cultural resources is in the northwest part of the NTS, on and around Jackass Flats, Yucca Mountain and Shoshone Mountain. The reason for this is because numerous activities were conducted on those portions of the NTS within the last 10 years, less attention has been directed to these regions and adverse impacts has been minimized. While this lapse is occurring, NTS decision-makers may consider conducting new projects and investigations. The CGTO recommends that prior to land disturbances of projects a timely American Indian Assessment be completed.

Types of American Indian Resources

The CGTO knows, based upon its collective knowledge of Indian culture and past American Indian studies, that American Indian people view cultural resources as being integrated. Thus certain systematic studies of a variety of American Indian cultural resources must be conducted before the cultural significance of a place, area, or region can be fully assessed. Although some of these studies have been conducted, in other areas studies have not begun. A number of studies are currently planned. Indian people can fully assess the cultural significance of a place and its associated natural and cultural resources when all studies have been completed and our governments and tribal organizations have reviewed the recorded thoughts of our elders and have officially supported these conclusions. American Indian studies focus on one topic at a time so that tribes and organizations can send experts in the subject being assessed. The following is a list of studies for a complete American Indian assessment:

- Ethnoarchaeology – the interpretation of the physical artifacts produced by our Indian ancestors.

- Ethnobotany – the identification and interpretation of the plants used by Indian people.

- Ethnozoology – the identification and interpretation of the animals used by Indian people.

- Storied Rocks – the identification and interpretation of traditional Indian paintings and rock peckings.

- Traditional Cultural Properties – the identification and interpretation of places of central cultural importance to a people, called Traditional Cultural Properties; often Indian people refer to these as "power places." Native American Indian properties and interpretations shall be determined by Native American spiritual person when:
    - Cleansing (removing negatives)
    - Purifications/preparations (repatriations and related issues).

- Ethnogeography – the identification and interpretation of soils, rocks, water, and air.

- Cultural Landscapes – the identification and interpretation of special units that are culturally and geographically unique areas for American Indian people.

When all of these subjects have been studied, then it will be possible for American Indian people to assess three critical issues: (1) What is the natural condition of this portion of our traditional lands? (2) What has changed due to DOE activities? And (3) What impacts will proposed alternatives have on either furthering existing changes in the natural environment or restoring our traditional lands to their natural condition? Indian people believe that the natural state of their traditional lands was what existed before 1492, when Indian people were fully responsible for the continued use and management of these lands. The NTS and nearby lands were central to the Western Shoshone, Owens Valley Paiute, and Southern Paiute people. The lands were central in the lives of these people and so were mutually shared for religious ceremony, resource use, and social events (Stoffle et al. 1990a and b). When Europeans encroached on these lands, the numbers of Indian people, their relations with one another, and the condition of their traditional lands began to change. European diseases killed many Indian people; European animals replaced Indian animals and disrupted fields of natural plants; Europeans were guided to and then assumed control over Indian minerals; and Europeans took Indian agricultural areas. Despite the pollution and destruction of some cultural resources and the physical separation from the NTS and neighboring lands, Indian people continue to value and recognize the central role of these lands in their continued survival.

Recognizing this continuity in traditional ties between the NTS and Indian people, the DOE in 1985 began long-term research involving the inventory and evaluation of American Indian cultural resources in the area. This research was designed to comply with the American Indian Religious Freedom Act (AIRFA), which specifically reaffirms the First Amendment of the U.S. Constitution rights of American Indian people to have access to lands and resources essential in the conduct of their traditional religion. These rights are exercised not only in tribal lands, but also beyond the boundaries of a reservation (AIRFA 1978; Stoffle et al. 1994; Stoffle, Halmo, and Dufort1994). To reinforce their cultural affiliation rights to prevent the loss of ancestral ties to the NTS, 17 tribes and organizations have aligned themselves to form the CGTO. This group is formed by officially appointed representatives who are responsible for representing their respective tribal concerns and perspectives. The CGTO has established a long standing relationship with the DOE. The primary focus of the group has been the protection of cultural resources.

The DOE and the CGTO have participated in cultural resource management, including the Yucca Mountain Project (Stoffle 1987; Stoffle, Evans, and Halmo 1988; Stoffle, Olmsted, and Evans 1988; Stoffle, Evans, and Harsbarger 1989; Stoffle et al. 1989; Stoffle, Halmo, and Olmsted 1990; Stoffle et al. 1990a; Stoffle et al. 1990b; Stoffle and Evans 1988; Stoffle and Evans 1990; Stoffle and Evans 1992), the Underground Weapons Testing Project (Stoffle et al. 1994), the Rock Art Study (Zedeño et al. 1999), the Water Bottle Canyon Interpretation and Traditional Cultural Property Study (Arnold et al. 1998; Stoffle, Van Vlack, and Arnold 2005) and the Timber Mountain Caldera Study (Stoffle et al. 2006). These studies are used in this GTCC EIS, along with the collective knowledge of the CGTO, as the basis of the comments in the 1996 NTS EIS, 2002 NTS SA, and the current SA. The cultural resource management projects sponsored by the DOE have been extremely useful for expanding the inventory of American Indian cultural resources beyond the identification of archaeological remains and historic properties.

Visual Resources

Views are important cultural resources that contribute to the location and performance of American Indian ceremonialism. Views combine with other cultural resources to produce special places where power is sought for medicine and other types of ceremonies. Views can be of any landscape, but more central viewscapes are experienced from high places, which are often the tops of mountains and the edges of mesas. Indian viewscapes tend to be panoramic and are special when they contain highly diverse topography. The viewscape panorama is further enhanced by the presence of volcanic cones and lava flows. Viewscapes are tied with songscapes and storyscapes, especially when the vantage point has a panorama composed of multiple locations from either song or story. Key to the Indian experience of viewscapes is isolation. Successful performance of ceremonies (whether by individuals or groups) is often commemorated by the building of rock cairns and by storied rocks and paintings. The CGTO tribes recognize the cultural significance of viewscapes and have identified a number of these on the NTS. The Timber Mountain Caldera contains a number of significant points with different panoramas, including Scrugham Peak-Buckboard Mesa and the Shoshone Mountain massif.

Waste Management

The CGTO requests an analysis of the hydrological and ecological impacts of the existing water diversion dike of the current Radioactive Waste Management Complex in Area 5. The DOE recognizes that this is a very flood prone area, with major flooding episodes occurring about every 23 years. Indian people visiting this site observed that even though the current dike has been built recently and thus not experienced a 23-year flood, it has diverted and consolidated sufficient runoff that a small arroyo has been established. The Indian people visiting this site believe that the existing dike has unnaturally stressed down-slope plants and animals who now do not receive normal sheet runoff. The Indian people visiting the site believe that by concentrating the runoff, the dike has reduced the amount of water absorbed during normal sheet runoff because the consolidated runoff moves more quickly and only flows in the new and developing eroded arroyo. It is believed by the Indian people visiting the site that were a GTCC facility to be established east of the current RWMC then the dike would necessarily have to be extended causing an even greater runoff shadow and an even greater developing arroyo. The desert tortoise in the area will have to move out of this larger runoff shadow and may be concentrated in the area of Frenchmen Playa. Moving their living areas towards the playa will expose them to higher levels of radioactivity. The Indian people visiting the site believe that these current and potential impacts should be analyzed, monitored by Indian people, and reported back to the CGTO at the next annual meeting.

NTS Waste Management in Perspective

After 11 years of formal transportation studies the CGTO continues to have reservations in regards to the storage of low-level and other hazardous wastes at the NTS and the transportation of low-level waste to the NTS for storage. The CGTO still maintains that what was suggested 11 years ago still exists and affects cultural resources. Disposal diminishes the potential for visitation by members of the CGTO representatives and other Indian people.

The CGTO still believes that the waste should be disposed of in a culturally appropriate manner and that the transportation of low-level radioactive waste poses risks to the people and the environment. Previous reports on this issue document the extent and depth of our concerns for these issues (American Indian Transportation Committee 1998; Arnold et al.1997; Austin 1998; Stoffle and Arnold 2003). Waste disposal activity on the NTS is still ongoing in regards to non-Nevada low-level radioactive waste. The NTS presently uses the Disposal Crater Complex, which is expected to close by 2010. Although the NTS has future low-level radioactive waste disposal pits on standby, there is a possibility that additional craters would need to be developed. Disposal of the following materials is performed at the NTS: Nevada-generated low-level radioactive waste, mixed low-level radioactive waste, greater confinement disposal waste, asbestiform low level radioactive waste, Nevada-generated mixed waste and transuranic waste, mixed transuranic waste. These materials are stored on-site until shipped elsewhere. The CGTO remains on record as opposed to this type of practice as it potentially will limit cultural activities involving the Indian tribes.

Cumulative Impacts

Cumulative Impacts are key to the various Indian peoples connected to the NTS and specifically the proposed GTCC waste facility in Frenchman Flats. These issues have been discussed for more than 13 years with the DOE (See American Indian Writers Subgroup, CGTO 1996) but it remains unclear the extent that the process of negative impacts to Indian people and culture has been mitigated by DOE actions. Still some progress has occurred through appropriate consultation with the CGTO and their subsequent involvement in the identification and management of cultural resources (see earlier discussion of what Indian people define as cultural resources).

According to the CGTO tribes, increased land disturbances associated with all forms of activities and development on the NTS could result in a decrease in access to these areas for American Indians. Limiting access could reduce the traditional use of the NTS and other areas and affect their sacred nature. Increased development at the NTS could increase the potential for greater disturbance and vandalism of American Indian cultural resources. The CGTO tribes believe (See Appendix G – AIWS 1996) that cumulative impacts in the following areas may occur:

- *Holy land violations*. Further destruction of traditional cultural sites, making the water disappear, general treatment of the land without proper respect.

- *Cultural survival*. Decreased ability and access to perform ceremonies.

- *Environmental restoration*. Revegetation of restored lands with native species.

- *Empowerment process*.

- *Radiation risks*. These risks began with nuclear testing. Today, the CGTO tribes perceive that the radioactive risks continue in known and unknown ways underground.

Over the past 17 years of regular consultation between the NNSA/NV and the CGTO tribes, there has been a growing co-management role for the tribes. Their recommendations have been heard and, for the most part, responded to by the NNSA/NV. Indian access to places on the NTS has increased, after an early period of access loss. Unfortunately, each new program that is added to the NTS decreases the amount of space that is available for the practice of Indian religions, ceremonies, and cultural persistence. However, having no programs also can have an impact. For example, even though the mesas are now accessible to Indians for ceremonies, the roads are not maintained because there are no projects on the mesas. This makes access to the ceremonially important areas difficult.

There are still ongoing risks to Indian people from storage and disposal of waste and these will continue. Finally, transportation of radioactive materials is continuing and increasing. It is not clear to the CGTO tribes that, after two American Indian studies of radioactive waste transportation, there has been a meaningful consideration of their concerns. It is not clear to what extent further radioactive waste disposal at the proposed GTCC facility will do to increase radiation risks to the physical and spiritual dimensions of Frenchman Playa area but some assessment is possible by Indian religious leaders.

GTCC Waste Repository

Nez Perce Tribe Narrative for EIS

Department of Energy, Hanford Site

2009

INTRODUCTION

Nez Perce History and Perspective

Preparing for the Nez Perce

Tribal memory can still recall the origins of the Nimiipuu or Nez Perce. The oral traditions bind the Nez Perce to the landscape. They also explain how to perceive and value the landscape and its many resources. The oral traditions described hereafter are formative in the Nez Perce relationship with the land and its resources. The first story describes how the animal people stepped forth in council to offer assistance and guidance to the new people to help them survive. It is one of the earliest oral traditions explaining the arrival of the Nimiipuu. The synopsis of this oral tradition is as follows:

At one time only the animal people lived on the land and all of them spoke the same language. Each animal could communicate with the others. A council was called and the animal people began to gather around. It was announced that the land would change with the arrival of a new creature that walked on two legs and this new creature will need help to survive. It would need to learn what to eat and how to keep warm. The animal people were asked to make an offering to help this creature survive. A great commotion arose as the animal people engaged in discussion about what was going to be offered. First among them was Nacox the Salmon. It said that it would give its entire body as food to help the new people survive. It said that it would travel to far away places and give gifts to the people upon its return. Nacox said that its sacrifice must be remembered by allowing it to die in the place in which it was born.

All were impressed by the generosity of the Salmon and followed its example by making an offering of food. One group of animals was discussing how they were going to look. They were trying to settle their size, color of fur and horns as well as which direction their horns or antlers were going to face. At last they stepped forth and declared that they give their bodies to be foods for the new people just as salmon had proclaimed, adding that their skins could be made into clothing for the new people to keep warm. They also announced that their bones, horns and antlers could be made into tools to process hides into clothing and shelter. The were recognized with names and they are Bison, Moose, Elk, Mountain Sheep, Mountain Goat, Antelope and various kinds of deer. The birds were next and they went through the same process and were recognized as the various birds. Some of them are Prairie Chicken, Raven, Crow, Meadowlark, Owl, Hawk, Eagle, Condor and the many other types of birds found in Nez Perce Country. In a similar manner, the rest of the animal people stepped forth and proclaimed their gifts in front of the council; stating how they would assist the new people in their efforts to survive.

There was one animal that was late to the council and when it asked what was going on, everything had to be retold. It was announced that there would be a new creature to walk the land and that each animal was making an offering to help the creature to live. Each gift was described again and upon hearing the news, the late one wanted to be like Grizzly Bear. It was asked to display how it would be a convincing Grizzly. It promptly showed its small teeth, slightly growled and passed its little claws through the air. All the *animal people laughed because, although this late one was furry, it was nowhere near as fierce as Grizzly Bear. So then the late one said it wanted to be like Eagle and it backed up and ran toward the center of the council and jumped into the air landing only a short distance away. All the people laughed again because it failed to capture the grace of an eagle in the air. Then it wanted to be a salmon so it was sent to the river to demonstrate its agility in the water. It promptly dived in the water and slowly paddled around in the fashion of a dog and all the animal people laughed as it crawled from the river and shook the water from its fur. All the positions were taken so a special task was given to this creature. It would be the one to create the new two-legged creatures and its name would be 'Iceyeeye or Coyote. 'Iceyeeye was cautioned that all the qualities he possessed would be carried on by the creatures he went on to create: 'Iceyeeye was known to be good, helpful, very intelligent, curious to a fault and, at times, fool hardy. He was also very forgetful. Some of the animal people chose to remain in the area in which the council occurred; pulling their robes up over their shoulders and heads. They became stone in order to serve as a reminder of the great council that occurred wherein the animal people gave tremendous gifts for the survival of the coming new people.*

The place of the council can still be seen in the Nez Perce homeland along the valley of the Clearwater River in North Central Idaho (Landeen and Pinkham 1999 p.4-8).

> *'Iceyeeye went on to numerous adventures; frequently proclaiming his preparations for the new people. 'Iceyeeye turned many animal people to stone to serve as a reminder of both proper and improper conduct. He carved rivers into the ground, turned giants into mountains and turned some animal people into constellations in the night sky so the new people could travel to far away places.*

Seasonal Round

The seasonal round is best described as a *return to a specific area* for the purpose of gathering resources: food, medicinal or otherwise. The seasonal round advanced in area and elevation simultaneously. It is not the act of following resources wherever they occur but rather a return to an area to gather resources based on prior knowledge or experience. It is also marked by the availability as warming seasonal temperatures foster development of the resource. Examples are the return to root digging areas as spring or summer temperatures have warmed plants to the point of opening the opportunity to harvest, or a return to a hunting area in the fall before temperatures drop to low. The map below shows how the Hanford area fits into the area used by the Nez Perce over time.

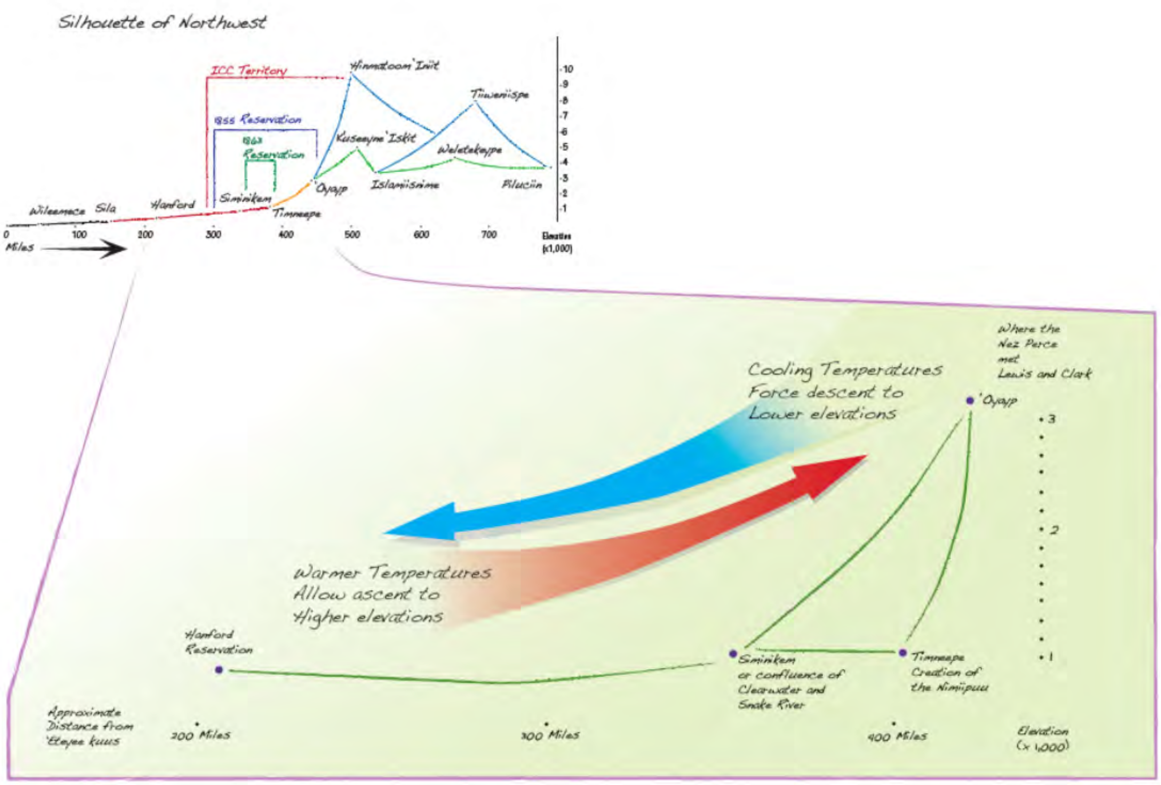

Diagram 1

The time for gathering resources is marked by lunar changes. Since there were more foods than there were moons during the year some resource gathering times were simultaneous. The diagram below shows how the seasons for gathering various foods correspond to the commonly used twelve-month calendar and four seasons. The Nez Perce changed elevations depending on the warming weather and this is shown through another diagram showing the names of the gathering seasons and the elevations.

It also covered an elevation from sea level up to ten thousand feet. The map titled “Silhouette of the Northwest” shows the elevation difference in the usual and accustomed areas used by the Nez Perce. The beginning of the seasonal round is marked with a Ke’uyit or first foods ceremony in the spring. Ke’uyit translates to “first bite” and is an annual ritual of prayer immersed in song for the first foods of the year. Traditional foods are laid out on the floor in the order in which they are gathered throughout the year beginning with Salmon. This annual ritual is an expression of gratitude to the foods for their return and for those gathered during the seasonal round. Other tribes have more than one feast such as a root feast and a huckleberry feast but the Nez Perce only have one and it is held toward the latter part of the spring.

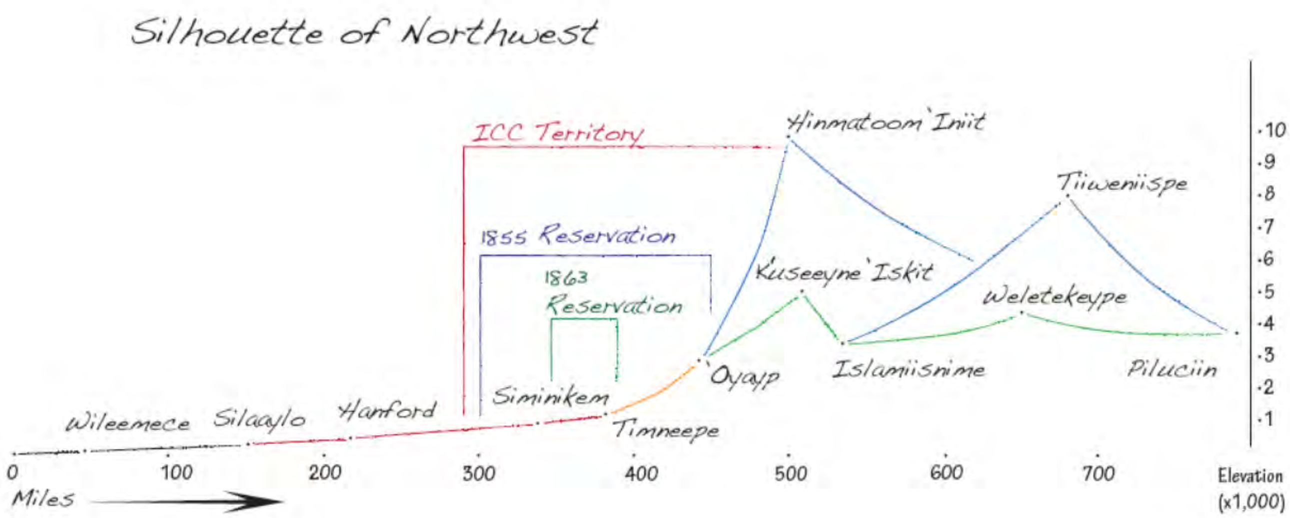

Diagram 2

Gathering Times

Examples of resource gathering times is shown in diagram 3:

Wiluupup: Time when cold air travels. Often corresponds to the month of January.

‘Alatam’aal: Time between winter and spring or the time for fires (often corresponds to the month of February) ‘Ala=fire

Miseemi latiit’al: Time of false blossoms roughly corresponding to early March. Miseemi=to lie or speak falsely, Latii=to bloom or blossom.

Latiit’al or Latiit’aal: Time when flowers bloom. Roughly corresponds to the month of March. Latii=to bloom or blossom.

Qeqiit’aal or qaqiit’aal: Time of gathering qeqiit roots. Roughly corresponds to April.

‘Apa’aal: Time for digging roots and making them into small cakes called ‘Apa. Roughly corresponds to the month of May or June.

Tustimasaatal: Ascend to higher mountain areas. Roughly corresponds to the month of June. Tusti=higher/above

’Il’aal: The time of the first run of Salmon. Roughly corresponds to the month of June.

Haso’al’: The time to gather eels or Pacific Lamprey. Roughly corresponds to the month of June. Heesu=eel.

Qama’aal: Time for digging and roasting qem’es bulbs. Often corresponds to the month of July. Qem’es=camas bulbs.

Q’oyx̲c’aal: Time of gathering Blueback Salmon. Often around the month of July. Q’oyxc=Blueback Salmon

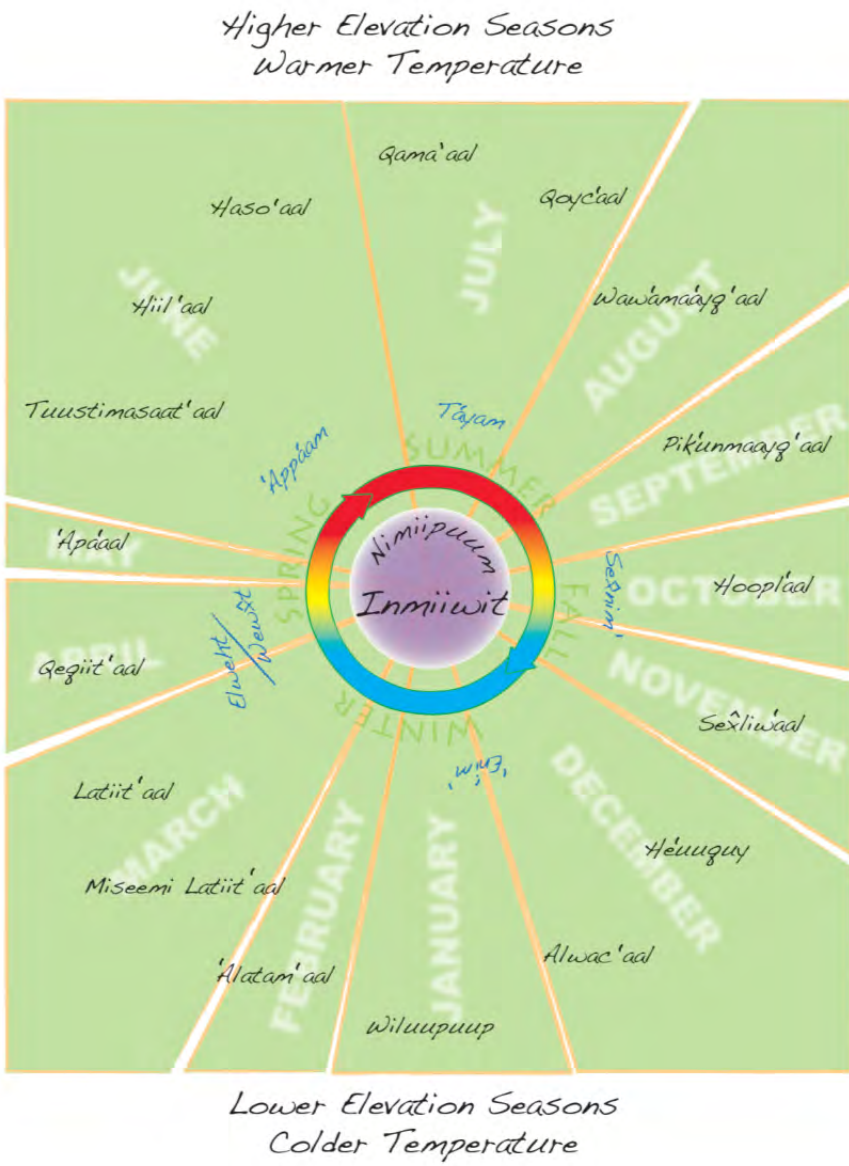

Diagram 3

Waw'ama'aq'aal: Season when salmon swim to the headwaters of streams (often corresponds to August) Waaw'am=headwaters

Pik'unma'ayq'al or pik'onma'ayq'aal: Time when Chinook Salmon return to the main river and steelhead begin their ascent. Roughly corresponds to September. Piik'un=river

Hoopl'al: Time when Tamarack needles begin to fall. Huup=to fall (as Pine needles do). Roughly corresponds to October.

Sexliw’aal: Autumn or the time roughly corresponding to November.

He’uquy: Time of calf elk or foaling roughly corresponding to December.

‘Alwac’aal: Time of Bison Yearling roughly corresponding to December. ‘Alawa=bison yearling.

Oral History

Oral histories impart basic beliefs, taught moral values, and explained the creation of the world, the origin of rituals and customs, the location of food, and the meaning of natural phenomena. The oral tradition provides accounts and descriptions of the region’s flora, fauna, and geology. Fish and other animals are characters in many of these stories. Coyote, is the main character in many of the stories because he exhibits all the good and bad of traits of human beings. Although some of the characters and themes may differ slightly, many of these same stories are held in common by Columbia Basin tribes.

Tribal Values

Tribal values lie imbedded within the rich cultural context of oral tradition and are conveyed to the next generation by the depth of the Nez Perce language. The numerous landmarks that season the precious landscape are reminders to the events, stories, and cultural practices of our people. How to properly perceive life and land are among the core tenets of which the stories speak. The values are what must endure and they can only be properly conveyed by the oral traditions and language. Overall the values are intent on protection, preservation and perpetuation of resources for the sake of survival. The Nez Perce still maintain those same values for our children just as they were for those that carry them today. The most appropriate way to convey the values of the Nez Perce is to discuss some of the cultural practices still conducted on our landscape. They reflect a complex tradition of high regard for the land by utilizing the resources, but not using so much that the resource cannot propagate to preserve their continued existence.

Land was managed by cultural practices so that resources would not be jeopardized by the actions of one generation. The Nez Perce Tribe utilized resource areas with several other tribes that carried similar resource values. The Nez Perce value the landscape for the rich resources it offers our children for their survival. The landscape is full of powerful reminders that were placed in their respective areas in the form of rock features associated with oral traditions relating the exploits of the animal people. The Nez Perce elders recall hunting and fishing areas taught to them when they were young. These are the same places they learned about in the same way from their elder kinsmen. The women dig roots and harvest berries in the same places that they learned about from their grandmothers. Each place utilized for the resources was maintained with balance to sustain children and future generations.

Each plant had a window of harvest in which it could be gathered. The window of harvest was always honored because gathering at another time would either affect its strength or viability. When women were gathering *qem'es* bulbs, they would evaluate the field to ensure that others had not already gathered past the threshold of the resource's stability. If the field looked as though others had already been there and the resource needed to be left so it could continue on, then they would simply go to another place. When a place was found which could be used for harvest, the digging would begin with prayer songs and it was common for many of the women to sing as they continued to dig. When the work was finished for the day it was closed with a prayer song just as it had began. They were cautious about the way in which they gathered the roots as well. Arguing and fighting didn't occur while gathering foods, even among the young, because they were strictly forbidden. Root diggers were reminded by the elderly to be prayerful and concentrate on good thoughts as they conducted their work avoiding negative feelings that might be carried by the foods to those that would consume them. Peelings from the roots always were to be returned to the original grounds from which they came or buried in the earth. They are never to be simply thrown in the garbage. There are traditional stories that communicate values that regardless of where the oral tradition originated, it applies during times that native tribes are on site and practicing usual and accustomed rights. These are teachings tied to the landscape and the land ethic that is our culture.

Fishing and hunting were conducted in the same way. Young boys were raised with the guidance of elder kinsmen. A group of hunters or fishermen would depart for areas that were, on occasion, previously scouted for the presence of fish and/or game. Young hunters and fishermen would observe the actions of those that were responsible for imparting knowledge of how to conduct oneself appropriately as game was stalked or fish were caught. Expectations were similar to those of the young women; concentrate on good thoughts and feelings, prohibited acts included fighting and arguing. Excessive pride and boasting were frowned upon by elder kinfolk since the hunt was to be conducted with the utmost humility. Hunters and fisherman learned to avoid catching the largest fish or killing the largest animal they could find because it preserved the gene pool that replaced that size animal. Upon return, the hunters were not questioned as to the number each hunter killed and it was never announced because it was deemed as a group activity. One exception was when a young hunter killed an animal for the first time or caught his first fish. At this time the family recognized the young hunter or fisherman as a provider with a ceremonial feast. The elder fisherman and hunters sat around the meat which was to be boiled, baked or prepared in some traditional fashion as stories were told conveying more teachings and proper conduct. As the elder hunters and fishermen consumed the meat the newly recognized hunter or fisherman was not allowed to partake of even a morsel of the meal. Everyone else was to eat before the hunter or fisherman could consume a meal. This reinforced their role as a provider rather than someone that merely killed game or caught fish for recreational purposes.

Young hunters were taught proper shot placement, as it was crucial to the hunting experience. Young hunters were taught to shoot an animal so that it would be killed as quickly and limit the animal's suffering as much as possible. Shooting an animal or catching a fish was only part of the overall commitment to the animal's sacrifice. It had to be cleaned and taken care of with the same regard as the roots and berries. The utmost gratitude and respect was offered to the animal's spirit for imparting a tremendous gift of life to the people.

Spiritual or religious aspects of natural resources are the heart of Indian culture. There is a connection to the daily activities of a traditional lifestyle communicated through the oral traditions that tell how to take care of the land. Even landmarks have oral traditions associated with them. These landmarks are tangible cultural reminders.

Value of uncontaminated resources- For natural resources to be uncontaminated as part of Niimiipuu physical and spiritual well-being, then land and waters and air from which they come should be uncontaminated otherwise the risk to human health increases the potential for illness and other ailments.

For tribal use of natural resources to be fully utilized, the example of manufacturing and using a *wistiitam'o* or sweat lodge is presented. One purpose of a sweat lodge is for purification. It is for cleansing and a time for meditation, spiritual reflection, healing, sharing oral history and teaching. The *wistiitam'o* is often a place where the Nez Perce return to have spiritual well-being restored after family losses. It is a place of contemplation and an opportunity to relieve stress and anxiety built up from the day's activities. It is a place for centering your soul through prayer and meditation. It is also a place where many socialize with family and friends and learn what is happening in the community.

For these reasons, it is imperative that the materials used in making a sweat lodge come from the natural environment. The structure is to be made of willows gathered from the immediate vicinity of where the sweat lodge will stand. The covering is to be of animal hides, or other natural materials. The water for the bathing after sweating is to be from a natural spring or stream. Herbs are collected in their proper season with prayers and gratitude offered for their service.

Sitting in a sweat bath is a rigorous activity. While outwardly relaxed, your inner organs are as active as though you were exercising. The skin is the largest organ of the body and through the pores it plays a major role in the detoxifying process along with the lungs, kidneys, bowels, liver and the lymphatic and immune systems. Capillaries dilate permitting increased flow of blood to the skin in an attempt to draw heat from the surface and disperse it inside the body. The heart is accelerated to keep up with the additional demands for circulation. Impurities in the liver, stomach, muscles, brain, and most other organs are flushed from the body. It is in this way that purification occurs.

Affected Environment

NEPA approaches the environment with a certain defined boundary. This fragmentation of the natural and human environment does not adequately describe different resource values that a particular part of society may have, like a formally recognized tribe and its federally protected rights. A tribal environmental ethic, which maintains a cultural and spiritual connection to the natural environment and a holistic approach, is difficult to communicate in a NEPA document. There needs to be a placeholder in this document to accept these important yet different values that tribes bring to evaluating environmental and human impacts.

The Nez Perce Tribe recommends that the draft EIS include the following analysis or issues for the GTCC Programmatic EIS evaluation. We have summarized the issues/concerns by EIS sections for ease of DOE's organization and inclusion. This *Tribal Narrative* is for DOE to consider for inclusion into the EIS.

Climate, Air Quality, and Noise

Climate

Climate is one of the dominate issues of our time. Indian people have experience with volcanic periods when it seemed our world was on fire and times when our world was much colder. Distinct climatic periods have occurred during which Tribal life adapted to environmental changes and our oral history reflects these climate changes and adaptations. Scientific and historic knowledge validates tribal oral history for many thousands of years.

Columbia Plateau Tribes have stories about the world being transformed from a time considered prehistoric to what is known today. The Nez Perce remember volcanoes, great floods, and animals now extinct. Mammoth and bison harvest sites are found throughout the Columbia Plateau. They have memories of their world being destroyed by fire and water and believe it will happen again.

The Nez Perce know and remember about the weather and its changes because it was so important to forming their lives. Oral histories indicate that the climate was much wetter and supported vast forests in the region. Oral histories also recall a time when Gable Mountain or *Nookshia* (Relander1986: 305), a major landscape feature on the Hanford Reservation, rose out of the Missoula floods. There is a story about Indian people who fought severe winds that were common a long time ago. One story tells of how a family trained their son by having him fight with the ice in the river until he became strong enough to fight the wind. He then beat the very strong winds of the past and now we do not have such winds.

Holocene (Roberts 1998) is the term used to describe the climate since the last glaciers (11,700 years ago), covering much of the northwestern North America. This archaeological record confirms the prehistory that includes arctic foxes found with Marmes Rock Shelter (Browman and Munsell 1969; Hicks 2004). The Palynological data would be a good source for recreating climates that supported ecosystems of the past 10,000 years.

Air Quality

The Nez Perce believe that radioactivity is brought into the air by high winds – commonly blowing 40-45 miles per hour and intermittently much stronger (http://www.bces.wa.gov/windstorms.pdf). High winds over 150 mile per hour were recorded in 1972 on Rattlesnake Mountain and in 1990 winds on the mountain were recorded at 90 miles per hour. Dust devils can be massive in size, spin up to 60 miles per hour, and frequently occur at the site. Tornadoes have been observed in Benton County which is regionally famous for receiving strong winds.

It gets so windy that the site managers at Environmental Restoration Disposal Facility (ERDF) occasionally sends all workers home and close down the facility due to the degree of blowing dust making it unsafe to work. Air quality monitoring results, including radioactive dust, should be presented for ERDF, various plant operations, emission stacks, venting systems, and power generation sites. Also, fugitive dust can affect Viewshed and contribute to health affects during inversions.

Noise

Native people understand that non-natural noise can be offensive while traditional ceremonies are being held. Traditional ceremonies have been held at the Hanford site in recent years. Some of the cultural use of the Hanford site by Tribes is being lost. Not all ceremonial sites are known to non-Indians. The noise generated by the Hanford facility may presently create noise interference for ceremonies held at sites like Gable Mountain and Rattlesnake Mountain. Noise generating projects, such as the GTCC proposed site, can interrupt the thoughts and focus and thus the spiritual balance and harmony of the community participants of a ceremony (Greider 1993). The Nez Perce Tribe recommends that quiet zones and time periods should be identified for known Native American ceremonial locations on and near the Hanford Reservation. The general values or attributes provide solitude, quietness, darkness and wilderness-like or undegraded environments. These attributes provide unquantifiable value and are fragile. These types of values are also discussed in the Viewshed section.

Light pollution

Artificial light can be a "pollutant" when it creates measurable harm to the environment. Light can affect nocturnal and diurnal animals. It can affect reproduction, migration, feeding and other aspects of survival. Artificial light can also reduce the quality of experience during tribal cultural and ceremonial activities.

Geology and Soils

Geology

Physiography- The Yakima Fold Belt and the Palouse Slope play potentially very significant roles at Hanford both culturally and geologically. Rattlesnake and Gable Mountains are examples of folded basalt structures within the Yakima Fold Belt. These geological features have direct bearing on the ground water and groundwater flow direction. There are oral history accounts of these basalt features above the floodwaters of Lake Missoula. Many other topography features have oral history explanations such as the Mooli Mooli (flood ripples along the river terrace) and the sand dunes.

Site Geology and Stratigraphy - The GTCC referenced vadose zone location is similar to that of the 200 West area. A primary similarity between the GTCC location and the 200 West is that the underlying sediments are the Hanford Formation and possibly the Cold Creek formation. Like the 200 west area there is uncertainly about the geology and hydraulic conductivity in this area.

The vadose zone needs to be discussed as part of the Stratigraphy Section of the GTCC EIS and is probably one of the most important elements to discuss for a potential Hanford GTCC repository. It should be noted that within those sediments, a major subsurface trough feature exists (an eroded channel at the surface of the Ringold Formation) that can be traced in the stratigraphy from Gable Gap across the eastern part of 200 East and on to the southeast. This trough contains the Cold Creek sedimentary unit. Geologists are still trying to determine the effects this subsurface feature in the vadose zone has on contaminant transport.

Clastic dikes are networks of features in the near surface wherein cracks were developed in the vadose zone from sediments either upwelling from a deeper layer, or by filling in from a feature open at the surface, or a combination of both. These features are thought to be related to seismic activity. What affect these have directly on contaminant transport needs to be understood, and thus far they have not. There is a question as to whether or not the DOE has looked for them at the site. They were noted to be present in the 200 Areas during the tank farm construction.

Regional Seismicity –The Pacific Northwest has been historically geologically active and this needs to be discussed if there is to be analysis of putting more contaminants in the ground at Hanford. The 1936 earthquake and the 1973 earthquakes at Hanford need to be discussed in terms of the GTCC.

Geologic structure of the Pacific Northwest includes a feature called the Olympic-Wallowa Lineament (the OWL). Surface and depth data have identified a structural “line” within the earth's crust that can be traced roughly from southeast of the Wallowa Mountains, under Hanford, through the Cascades and under Seattle and the Sound. Such lineaments are signals of crustal structure that are not yet well identified. Emerging research being reported through the USGS is highlighting the importance of Seattle area faults connecting under the Cascades into the Yakima Fold Belt and on along the OWL. The geologic stress on the surface of the earth in the local region have a north-south compressional force direction that has caused the surface to wrinkle in folds that trend approximately east-west, thus creating the Yakima Fold Belt. Fault movement along these folds occurs all the time, and studies have shown these to be considered active fault zones (Repasky, TR, et.al., 1998; Campbell, N.P., et.al., 1995).

Soils

Native Peoples understand the importance of soils and minerals. Oral history has suggested that soils have a medicinal purpose for healing wounds as well as used for building structures, creating mud baths, and filtering water. Material from the White bluffs was used for cleaning hides, making paints, and whitewashing villages.

Soil characteristics: soil chemistry (ph, ion activity, micronutrients, microorganisms, lack of this knowledge is a data gap such as the influence of past tank leaks on soil chemistry and characteristics/properties. Sandy soils have high transmissivity. Soil integrity is important to tribes since the soils support plant life, which supports many other life forms, which are all important to tribes.

Minerals and Energy Resources

Tribal Comments: Barrow material site and waste material site: Alternatives selection will have varying degrees of impact and footprint. For example, a vault alternative will need significant capping material from barrow area C that has its own set of ramifications.

Questions to be answered: What will the energy use be for a fully functioning GTCC waste site? What is the size and location of the footprint?

Water Resources

Groundwater

Purity of water is very important to the Nez Perce, and thus DOE should be managing for an optimum condition considering Tribal cultural connection and direct use of water, rather than managing for a minimum water quality threshold.

From the perspective of the Nez Perce Tribe, the greatest long-term threat at the Hanford site lies in the contaminated groundwater. There is insufficient characterization of the vadose zone and groundwater. There is a tremendous volume of radioactive and chemical contamination in the groundwater. The mechanisms of flow and transport of contaminants through the soil to the groundwater are still largely unknown. The volumes of contamination within the groundwater and direction of flow are still only speculative. Due to lack of knowledge and limited technical ability to remediate the vadose zone and groundwater puts the Columbia River at continual risk.

Water Use

The Columbia River is the lifeblood of the Nez Perce people. It supports the salmon and every food or material that they rely on for subsistence. It is an essential human right to have clean water.

If water is contaminated it then contaminates all living things. Tribal members that exercise a traditional lifestyle would also become contaminated. A perfect example is making a sweat lodge and sweating. It is a process of cleansing and purification. If water is contaminated then the sweat lodge materials and process of cleansing would actually contaminate the individual.

Tribal people are well known for adopting technology if it were instituted wisely and did not sacrifice or threaten the survival of the group as a whole. This approach applies to tribal use of groundwater. Even though groundwater was not used except at springs, tribes would have potentially used technology for developing wells and would have used groundwater if seen to be an appropriate action. The existing contamination is considered an impact to tribal rights to utilize this valuable resource.

The hyporheic zone in the Columbia River needs to be more fully characterized to understand the location and potential of groundwater contaminants discharging to the Columbia River.

Contaminated groundwater plumes at Hanford are moving towards the Columbia River and some contaminants are already recharging to the river. It is the philosophy of the Columbia River Tribes that groundwater restoration and protection be paramount to DOE's management of Hanford. Institutional controls, such as preventing use of groundwater, should only be a temporary measure for the safety of people and animals. It will be questioned when DOE views institutional controls as a viable long-term management option to allow natural attenuation. The timeline of natural attenuation may not best represent a Tribal preference of a proactive corrective cleanup measure(s). for contamination plumes. Cleanup should be a priority before considering placement of additional waste like GTCC in the 200 area.

Human Health

Nez Perce health involves access to traditional foods and places. Both of these are located on the Hanford facility and can be impacted by placement of the GTCC waste in the 200 area.

Definition of Tribal health- Native American ties to the environment are much more complex and intense than is generally understood by risk assessors (Harris 1998, Oren Lyons[1]). All of the foods and implements gathered and manufactured by the traditional American Indian are

[1] http://www.ratical.org/many_worlds/6Nations/OLatUNin92.html; http://www.youtube.com/watch?v=hDF7ia23hVg.

interconnected in at least one way, but more often in many ways. Therefore, if the link between a person and his/her environment is severed through the introduction of contamination or physical or administrative disruption, the person's health suffers, and the well being of the entire community is affected.

To many American Indians, individual and collective well being is derived from membership in a healthy community that has access to, and utilization of, ancestral lands and traditional resources. This wellness stems from and is enhanced by having the opportunity and ability to live within traditional community activities and values. If the links between a tribal person and his or her environment were severed through contamination or DOE administrative controls, the well being of the entire community is affected.

Risk Assessments

Risk assessments should take a public health approach to defining community and individual health. Public health naturally integrates human, ecological, and cultural health into an overall definition of community health and well-being. This broader approach used with risk assessments is adaptable to indigenous communities that, unlike westernized communities, turn to the local ecology for food, medicine, education, religion, occupation, income, and all aspects of a good life (Harris, 1998, 2000; Harper and Harris, 2000).

"Subsistence" in the narrow sense refers to the hunting, fishing, and gathering activities that are fundamental to the way of life and health of many indigenous peoples.

The more concrete aspects of a subsistence lifestyle are important to understanding the degree of environmental contact and how subsistence is performed in contemporary times. Also, traditional knowledge can be learned directly from nature. Through observation this knowledge is recognized and a spiritual connection is often attained as a result. Subsistence utilizes traditional and modern technologies for harvesting and preserving foods as well as for distributing the produce through communal networks of sharing and bartering. The following is a useful explanation of "subsistence," slightly modified from the National Park Service:

> *"While non-native people tend to define subsistence in terms of poverty or the minimum amount of food necessary to support life, native people equate subsistence with their culture. It defines who they are as a people. Among many tribes, maintaining a subsistence lifestyle has become the symbol of their survival in the face of mounting political and economic pressures. To Native Americans who continue to depend on natural resources, subsistence is more than eking out a living. The subsistence lifestyle is a communal activity that is the basis of cultural existence and survival. It unifies communities as cohesive functioning units through collective production and distribution of the harvest. Some groups have formalized patterns of sharing, while others do so in more informal ways. Entire families participate, including elders, who assist with less physically*

> *demanding tasks. Parents teach the young to hunt, fish, and farm. Food and goods are also distributed through native cultural institutions. Nez Perce young hunters and fisherman are required to distribute their first catch throughout the community at a first feast (first bite) ceremony. It is a ceremony that illustrates the young hunter is now a man and a provider for his community. Subsistence embodies cultural values that recognize both the social obligation to share as well as the special spiritual relationship to the land and resources."*[2]

The following four categories of an undisturbed environment contribute to individual and community health. Impacts to any of these functions can adversely affect health. Metrics associated with impacts within each of these categories are presented in Harper and Harris (1999).

***Human Health-Related Goods and Services*:** This category includes the provision of water, air, food, and native medicines. In a tribal subsistence situation, the land provided all the food and medicine that was necessary to enjoy long and healthy lives. From a risk perspective, those goods and services can also be exposure pathways.

***Environmental Functions and Services*:** This category includes environmental functions such as soil stabilization and the human services that this provides, such as erosion control or dust reduction. Dust control in turn would provide a human health service related to asthma reduction.

Environmental functions such as nutrient production and plant cover would provide wildlife services such as shelter, nesting areas, and food, which in turn might contribute to the health of a species important to ecotourism. Ecological risk assessment includes narrow examination of exposure pathways to biota as well as examination of impacts to the quality of ecosystems and the services provided by individual biota, ecosystems, and ecology.

***Social and Cultural Goods, Functions, Services, and Uses*:** This category includes many things valued by suburban and tribal communities about Introduction particular places or resources associated with intact ecosystems and landscapes. Some values are common to all communities, such as the aesthetics of undeveloped area s, intrinsic existence value, environmental education, and so on.

***Economic Goods and Services*:** This category includes conventional dollar-based items such as jobs, education, health care, housing, and so on. There is also a parallel non-dollar indigenous economy that provides the same types of services, including employment (i.e., the functional role of individuals in maintaining the functional community and ensuring its survival), shelter (house sites, construction materials), education (intergenerational knowledge required to ensure sustainable survival throughout time and maintain personal and community identity), commerce (barter items and stability of extended trade networks), hospitality, energy (fuel), transportation

[2] National Park Service: http://www.cr.nps.gov/aad/cg/fa_1999/Subsist.htm

(land and water travel, waystops, navigational guides), recreation (scenic visitation areas), and economic support for specialized roles such as religious leaders and teachers.

Ecology

The Nez Perce people have lived in these lands for a very long time and thus have learned about the resources and their ecological interrelationships. They knew about environmental indicators that foretold seasons and conditions that guided them. When Cliff Swallows first appear in the spring, their arrival is an indicator that the fish are coming up the river. Doves are the fish counters, telling how many fish are coming. Many natural phenomena foretell when the earth is coming alive again in the spring, even if things are dormant underground. The Nez Perce has traditional ecological knowledge of this environment and tribal people have ceremonies that acknowledge the arrival of Spring. The winds bring information about what will happen. It provides guidance about how to bring balance back to the land.

Biodiversity on the National Monument

The Monument encompasses a biologically diverse landscape containing an irreplaceable natural and historic legacy. Limited development over approximately 70 years has allowed for the Monument to become a haven for important and increasingly scarce plants and animals of scientific, historic and cultural interest. It supports a broad array of newly discovered or increasingly uncommon native plants and animals. Migrating salmon, birds and hundreds of other native plant and animal species, some found nowhere else in the world, rely on its natural ecosystems. The Monument also includes 46.5 miles of the last free-flowing, non-tidal stretch of the Columbia River, known as the “Hanford Reach.”

Salmon

Columbia River salmon runs, once the largest in the world, have declined over 90% during the last century. The 7.4 – 12.5 million average annual number of fish above Bonneville Dam have dropped to 600,000. Of these, approximately 350,000 are produced in hatcheries. Many salmon stocks have been removed from major portions of their historic range (Columbia Basin Fish and Wildlife Authority, 2009).

Multiple salmon runs reach the Hanford Nuclear Reservation. These runs include Spring Chinook, Fall Chinook, Sockeye, Silver and Steelhead. The runs tend to begin in April and end in November.

Salmon runs have been decimated as a result of loss and change to habitat. The changes include non-tribal commercial fisheries, agriculture interests, and especially construction of hydro-projects on the Columbia River. Protection and preservation of anadromous fisheries were not a priority when the 227 Columbia River dams were constructed. Some dams were constructed without fish ladders and ultimately eliminated approximately half of the spawning habit available in the Columbia System.

The Hanford Reach is approximately 51 miles long and is the only place on the upper main stem of the Columbia River where Chinook salmon still spawn naturally. This reach is the last free flowing section of the Columbia River above Bonneville Dam. It produces about eighty to ninety percent of the fall Chinook salmon run on the Columbia River.

Tribal elders say that the last runs of big salmon (Chinook) that came through the Hanford Reach occurred in 1905. Non-Tribal Commercial fisheries on the lower Columbia are largely responsible for the loss of the large Chinook salmon.

The Columbia River Tribes, out of a deep commitment to the fisheries and in spite of the odds, plan to restore stocks of Chinook, Coho, Sockeye, Steelhead, Chum, Sturgeon and Pacific Lamprey. This effort was united in 1995 under a recovery plan called the Wy-Kan-Ush-Mi Wa-Kish-Wit (Spirit of the Salmon). Member tribes are the Nez Perce Umatilla, Warm Springs and Yakama.

The Columbia River tribes see themselves as the keepers of ancient truths and laws of nature. Respect and reverence for the perfection of Creation are the foundation of their culture. Salmon are part of our spiritual and cultural identity. Tribal values are transferred from generation to generation with the salmon returns. Without salmon, tribes would loose the foundation of their spiritual and cultural identity.

All tribes affected by the Hanford site are co-managers of Columbia River fisheries including assisting in tagging fry and counting redds along the Hanford Reach for the purposes of estimating fish returns. This information is essential in the negotiation of fish harvest between the USA and Canada as well as between Indian and non-Indian fishermen.

In many ways, the loss of salmon mirrors the plight of native people. Elders remind us that the fate of humans and salmon are linked. The circle of life has been broken with the loss of traditional fishing sites and salmon runs on the Columbia River.

Socioeconomics

Modern tribal economy

A subsistence economy is one in which currency is limited because many goods and services are produced and consumed within families or bands, and currency is based as much on obligation and respect as on tangible symbols of wealth and immediate barter. It is well-recognized in anthropology that indigenous cultures include networks of materials interlinked with networks of obligation. Together these networks determine how materials and information flow within the community and between the environment and the community. Today, there is an integrated interdependence between formal (cash-based) and informal (barter and subsistence-based) economic sectors that exists and must be considered when thinking of economics and employment of tribal people.[3]

Indian people engage in a complex web of exchanges that often involves traditional plants, minerals, and other natural resources. These exchanges are a foundation of community and intertribal relationships. Thus there are natural resource issues, some of which are located on Hanford, that involve direct production that permeate Indian life. Indian people, catch salmon that become gifts to others living near and far. Sharing self-gathered food or self-made items is a part of establishing and maintaining reciprocal relationships. People have similar relationships between places and elements of nature, which are based on mutual respect for the rights of animals, plants, places and people.

Use of the Hanford site and surrounding areas by tribes was tied primarily to the robust Columbia River fishery. Past social activities of native people include gatherings for such activities like marriages, trading, feasts, harvesting, fishing, and mineral collection. Tribal families and bands lived along the Columbia either year round or seasonally for catching, drying and smoking salmon. The reduction of salmon runs, loss of fishing sites due to dam impoundments and Hanford land use restrictions have contributed to the degradation of the supplies necessary for this gifting and barter system of our tribal culture.

The future of salmon and treaty-reserved fisheries will likely be determined during the life of the GTCC waste. With the tremendous efforts to recover salmon (and other fish species) by tribes, government agencies, and conservation organizations, Tribal expectations are that these species will be recovered to healthy populations.

If aquatic species were to recover, the regional economy and tribal barter economy would likely greatly increase in the Hanford area. These fish returns and the associated social and economic potential should be considered within the lifecycle of a GTCC waste repository.

Direct Production

Direct production by tribes is part of the economy that needs to be represented, especially considering the Tribe's emphasis on salmon recovery. This type of individual commerce in modern economics is termed and calculated as "direct production". The increase in direct production would be relational to the region's salmon recovery, yet there is no economic measure (within the NEPA process) to account for this robust element of a traditional economy.

In a traditional sense, direct production is a term of self and community reliance on the environment for existence as opposed to employment or modern economies. Direct production is use of salmon and raw plant materials for foods, ceremonial, and medicinal needs and the associated trading or gifting of these foods and materials. Direct production needs to be

[3] http://arcticcircle.uconn.edu/NatResources/subsistglobal.html

understood, and should include elements like: use of plant foods, ceremonial plants, medicinal plants, beadwork, hide work, tule mats and dried salmon.

An example of this economy would be the documented number of Native Americans that fished at Celilo Falls; as many as 1500 fisherman assembled at the site not far from Hanford during the peak fishing seasons. Trading between and among tribes include but are not limited to items like dentalia shells, mountain sheep horns, bows, horses, baskets, tule mats, art, bead work, leather and raw hide, and buffalo robes.

Environmental Justice

President Clinton signed Executive Order 12898 to address Environmental Justice issues and to commit each federal department and agency to “make achieving Environmental Justice part of its mission.” (Environmental Biosciences Program 2001). According to the Executive Order, no single community should host disproportionate health and social burdens of society’s polluting facilities. Many American Indians are concerned about the interpretation of “Environmental Justice” by the U.S. Federal Government in relation to tribes. By this definition, tribes are included as a minority group. However, the definition as a minority group fails to recognize tribes’ sovereign nation-state status, the federal trust responsibility, or protection of treaty and statutory rights of American Indians. Because of a lack of the these details, tribal governments and federal agencies have not been able to develop a clear definition of Environmental Justice in Indian Country, and thus it is difficult to determine appropriate actions.

American Indian and Alaskan Natives use and manage the environment holistically; everything is viewed as living and having a spirit. Thus, many federal and state environmental laws and regulations designed to protect the environment do not fully address the needs and concerns of American Indian and Alaskan Natives. Land based resources are the most important assets to tribes spiritually, culturally and economically.

Land Use

The Nez Perce Tribe recommends that DOE continue efforts to identify special places and landscapes with spiritual significance. Newly identified sites would be added to those already requiring American Indian ceremonial access and needing long-term stewardship.

Native people maintain that aboriginal and treaty rights allow for the protection, access to, and use of resources. These rights were established at the origin of the Native People and persist forever. There are sites or locations within the existing Hanford reservation boundary with tribal significance that are presently restricted through DOE’s institutional controls and should be considered for special protections or set aside for traditional and contemporary ceremonial uses. Sites like the White Bluffs, Gable Mountain, Rattlesnake Mountain, Gable Butte, and the islands on the river are known to have special meaning to Tribes and should be part of the discussion for special access and protection. These locations should be placed in co-management with DOE, FWS and the Tribes for long-term management and protection.

Tribal Access

In the Regulatory Section there are several federal regulations, policies, and executive orders that define tribal access that override institutional controls of the CLUP or the CCP when risk levels are acceptable for access. The following is a brief summary of those legal references:

According to the *American Indian Religious Freedom Act*, tribal members have a protected right to conduct religious ceremonies at locations on public lands where they are known to have occurred before. There has been an incomplete effort to research the full extent of tribal ceremonial use of the Hanford site.

Executive Order 13007 supports the American Religions Freedom Act by stating that Tribal members have the right to access ceremonial sites. This includes agencies to maintain existing trails or roads that provide access to the sites.

DOE managers that are considering the placement of GTCC waste at Hanford must evaluate any potential impact to ceremonial access as part of their trust responsibility to Tribes.

There are locations that have specific protections due to culturally significant findings, burial sites, artifact clusters, etc. These types of areas are further described under the Cultural Resources Sections. As decommissioning and reclamation occurs across the Hanford site, any culturally significant findings will continue to expand the list of sites and their locations with special protections that override existing land use designation as outlined in the CLUP or other documents.

Comprehensive Land Use Plan (CLUP):

The present DOE land use document for Hanford, called the Comprehensive Land Use Plan (CLUP), has institutional controls that limit present and future use by Native Americans. DOE plans to remove some institutional controls over time as the contamination footprint is reduced as a result of instituting the 2015 vision along the river and also the proposed cleanup of the 200 area. With removal of institutional controls, the affected tribes assume they can resume access to usual and accustomed areas.

Future decisions about land transfer must consider the implications for Usual and Accustomed uses (aboriginal and treaty reserved rights) in the long-term management of resource areas.

The 50-year management time horizon of the CLUP does create permanent land use designations. On the contrary, land use designations or their boundaries can be changed in the interim at the discretion of DOE and/or Hanford stakeholders. The CLUP is often misused by assuming designations are permanent. Also, it is important to not that the interim land use designations in the CLUP cannot abrogate treaty rights. That requires an act of Congress.

Hanford National Monument

A Presidential Proclamation established the Hanford Reach National Monument (Monument) (Presidential Proclamation 7319) and it directed the DOE and the U.S. Fish and Wildlife Service

(FWS) jointly manage the monument. The Monument covers an area of 196,000 acres on the Department of Energy's (DOE) Hanford Reservation. DOE permits and agreements delegates authorities to FWS for 165,000 acres. The DOE directly manages approximately 29,000 acres, and the Washington Department of Fish and Wildlife currently manages the remainder (approximately 800 acres) through a separate DOE permit.

The Monument is co-managed by the FWS and the DOE; each agency has several missions they fulfill at the Hanford Site. The FWS is responsible for the protection and management of Monument resources and people's access to Monument lands under FWS control. The FWS also has the responsibility to protect and recover threatened and endangered species; administer the Migratory Bird Treaty Act; and protect fish, wildlife and Native American and other trust resources within and beyond the boundaries of the Monument.

The FWS developed a comprehensive conservation plan (CCP) for management of the Monument as part of the National Wildlife Refuge System as required under the National Wildlife Refuge System Improvement Act. The CCP is a guide to managing the Monument lands (165,000 acres). It should be understood that FWS management of the Monument is through permits or agreements with the DOE.

Tribes participated in the development of the CCP with regard to protection of natural and cultural resources and tribal access. Based on the Presidential Proclamation that established the Hanford Reach National Monument, Affected tribes assume that all of Hanford will be restored and protected:[4]

Operable Units (OUs)

Hanford has delineated contamination areas called operable units (OUs) both subsurface contamination OUs and surface contamination OUs. When describing the affected environment for land use it is essential to reference this information that should be presented in the soils and groundwater sections. By understanding the types and extent of surface and subsurface contamination will give better understanding of the CLUP landuse designations. For example, the proposed GTCC site at Hanford lies somewhere in or near the 200 ZP-1 groundwater OU. This OU has contamination from uranium, technetium, iodine 129 and other radioactive and chemical constituents.

[4] FR Volume 36--Number 23: 1271-1329; Monday, June 12, 2000

Transportation

Traditional transportation:

Indian people have been traveling this homeland to usual and accustomed areas for a very long time. Early modes of transportation began with foot travel. Domesticated dogs were utilized to carry burdens. Dugout canoes were manufactured and used to traverse the waterways when the waters were amiable. Otherwise, trails along the waterways were used. The arrival of the horse changed how people traveled. Numerous historians note its arrival to the Columbia Plateau in the late 1700's but they are mistaken. The arrival of the horse was actually a full century earlier in the late 1600's. Its acquisition merely quickened movement on an already extant and heavily used travel network. This travel network was utilized by many tribal groups on the Columbia Plateau and was paved by thousands of years of foot travel. Early explorers and surveyors utilized and referenced this extensive trail network. Some of the trails have become major highways and the Columbia and Snake Rivers are still a crucial part of the modern transportation network.

The Middle Columbia Plateau of the Hanford area is the crossroads of the Columbia Plateau located half way between the Great Plains and the Pacific Northwest Coast. In this area major Columbia River tributaries the Walla Walla, Snake, and Yakima Rivers flow into this section of the main stem Columbia River. These rivers formed a critical part of a complex transportation network north, south, east, and west through the region including the Columbia River through the Hanford site. The slow water at the Wallula Gap was one of the few places where horses could traverse the river year round. The river crossing at Wallula provided access to a vast web of trails that crossed the region. Portions of these trails are known to cross the Hanford site.

Present Transportation:

There are two interstate highways that near the site [Interstate 90 (I-90) and Interstate 84 (I-84)]. There are estimates of as many as 12,000 shipments of GTCC waste that would need to be delivered to Hanford by rail, barge or highway. The Nez Perce Tribe believes that decision-making criteria need to be presented in the EIS to clarify how rail, barge or highway routing will be determined. Treaty resources and environmental protections are important criteria in determining a preferred repository location. The public needs to be assured that the public health and high valued resources like salmon and watersheds are going to be protected.

Northwest river systems have received significant federal and state resources over recent decades in an attempt to recover salmon and rehabilitate damaged watersheds. DOE needs to describe how public safety, salmon and watersheds "fit" into the criteria selection process for determining a GTCC waste site and multiple shipping options. The protection and enhancement of existing river systems are critical to sustaining tribal cultures along the Columbia River.

The interstate highway system is a primary transportation corridor for shipping nuclear waste through the states of Oregon, Washington, and Idaho. Waste moving across these states will cross many major salmon bearing rivers that are important to the Tribes. Major rail lines also cross multiple treaty resource areas.

Cultural Resources

From a tribal perspective, all things of the natural environment are recognized as a cultural resource. This is a different perspective from those who think of cultural resources as artifacts or historic structures. The natural environment provides resources for a subsistence lifestyle for tribal people. This daily connection to the land is crucial to Nez Perce culture and has been throughout time. All elements of nature therefore are the connection to tribal religious beliefs. Oral histories confirm this cultural and religious connection.

> "According to our religion, everything is based on nature. Anything that grows or lives, like plants and animals, is part of our religion..." *Horace Axtell (Nez Perce Tribal Elder).*

Landscape and Ethno-Habitat

For thousands of years American Indians have utilized the lands in and around the Hanford Site. Historically, groups such as the Yakama, the Walla Walla, the Wanapum, the Palouse, the Nez Perce, the Columbia, and others had ties to the Hanford area. "The Hanford Reach and the greater Hanford Site, a geographic center for regional American Indian religious activities, is central to the practice of the Indian religion of the region and many believe the Creator made the first people here (DOI 1994). Indian religious leaders such as Smoholla, a prophet of Priest Rapids who brought the Washani religion to the Wanapum and others during the late 19th century, began their teachings here (Relander 1986). Prominent landforms such as Rattlesnake Mountain, Gable Mountain, and Gable Butte, as well as various sites along and including the Columbia River, remain sacred. American Indian traditional cultural places within the Hanford Site include, but are not limited to, a wide variety of places and landscapes: archaeological sites, cemeteries, trails and pathways, campsites and villages, fisheries, hunting grounds, plant gathering areas, holy lands, landmarks, important places in Indian history and culture, places of persistence and resistance, and landscapes of the heart (Bard 1997). Because affected tribal members consider these places sacred, many traditional cultural sites remain unidentified." NEPA 18 4.6.1.2 (p. 4.120).

Viewshed

The Nez Perce Tribe utilizes vantage points to maintain a spiritual connection to the land. Viewsheds must remain in their natural state, they tend to be panoramic and are made special when they contain prominent uncontaminated topography. The viewshed panorama is further enhanced by abrupt changes in topography and or habitats.

Nighttime viewsheds are also significant to indigenous people who still use the Hanford Reach. Each tribe has stories about the night sky and why stars lie in their respective places. The patterns convey spiritual lessons via oral traditions. Often, light pollution from neighboring developments diminishes the view of the constellations. It is getting difficult to find places to simultaneously relate the oral traditions and view the corresponding constellations.

There are several culturally significant viewsheds located on the Hanford site. The continued use of these sites brings spiritual renewal. Special considerations should be given to tribal elders and youth to accommodate traditional ceremonies.

Salmon

Salmon remain a core part of the oral traditions of the tribes of the Columbia Plateau and still maintains a presence in native peoples' diet just as it has for generations. Salmon are recognized as the first food at tribal ceremonies and feasts. One example is the *ke'uyit*, which translates to "first bite." It is a ceremonial feast that is held in spring to recognize the foods that return to take care of the people. It is a long-standing tradition among the people and it is immersed in prayer songs and dancing. Salmon is the first food that is eaten by the attendants. Extending gratitude to the foods for sustaining the life of the people is among the tenets of plateau lifestyle. Nez Perce life is perceived as being intertwined with the life of the Salmon. A parallel can be seen between the dwindling numbers of the Salmon runs and the struggle of native people (Landeen and Pinkham 1999).

Waste Management

The Nez Perce Tribe will continue to work with DOE via its cooperative agreement on cleanup issues to ensure that treaty rights and cultural and natural resources are being protected and that interim cleanup decisions are protective of human health and the environment.

Cumulative Impacts

Within this EIS process, a cumulative risk assessment needs to be developed for the Hanford option. This risk assessment needs to utilize the existing Hanford Tribal risk scenarios (CTUIR, Yakama Indian Nation, DOE default), and include existing Hanford risk values to determine cumulative impacts.

Institutional control boundaries need to be clearly displayed in a map, showing the GTCC proposed repository and the extent it will add to the size, scope, and timeframe of limiting access. For tribal people, a 10,000-year repository extends institutional controls without reasonable compensation or mitigation.

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Appendix A

Legal Framework

TREATY RIGHTS AND OBLIGATIONS

The Nez Perce Tribe is a sovereign government whose territory comprises over 13 million acres of what are today northeast Oregon, southeast Washington, and north-central Idaho. In 1855 the Nez Perce Tribe entered into a treaty with the United States, securing, among other guarantees a permanent homeland, as well as fishing, hunting, gathering, and pasturing rights. (Treaty with the Nez Perces, June 11, 1855; 12 Stat. 957).

Since 1855, many federal and state actions have recognized and reaffirmed the Tribe's treaty-reserved rights. The Tribe's treaty-reserved interests in the Hanford Reach area inform its legal relationship with the United States. Aboriginal rights provided in the 1855 Treaty extend to areas of land in Idaho and surrounding states, including the Columbia, Snake, and Salmon River regions, which may be impacted by DOE activities. Because these rights are of enormous importance to the Tribe 's subsistence and cultural fabric, the ecosystems that support fish and wildlife (including both flora and fauna) must remain undamaged and productive. DOE recognizes the existence of reserved treaty rights and is committed to identifying and assessing impacts of all DOE activities to both on and off-reservation lands.

The Nez Perce Tribe has the responsibility to protect the health, welfare, and safety of its members, and the environment and cultural resources of the Tribe. Therefore, activities (such as any release of hazardous/radioactive substances to the air, water, or soil column) related to the Hanford operations and cleanup should avoid endangering the Tribe 's environment and culture, or impairing their ability to protect the health and welfare of Tribal members.

The Nez Perce Tribe Treaty of 1855

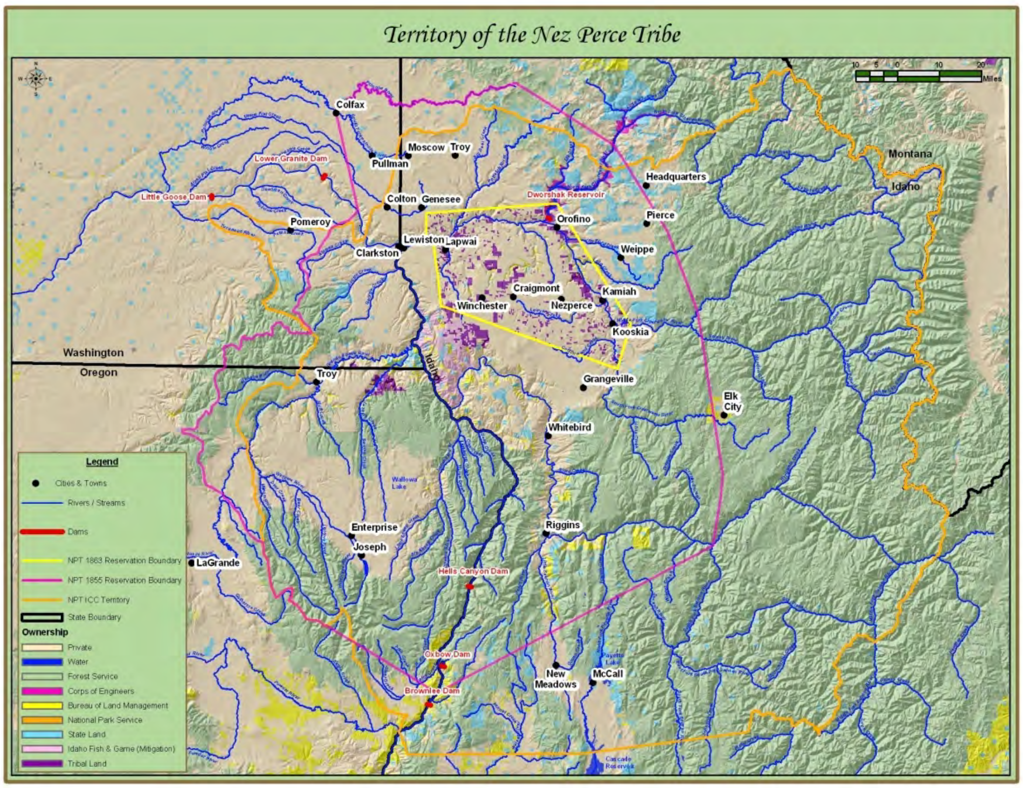
The Nez Perce Tribe Treaty of 1855 promulgated articles of agreement between the United States and the Tribe. The Treaty is superior to any conflicting state laws or state constitutional provisions under the Supremacy Clause of the U.S. Constitution (Art. VI. cl. 2).

Under the Treaty of 1855, the Tribe ceded certain areas of its aboriginal lands to the United States and reserved for its exclusive use and occupation certain lands, rights, and privileges; and the United States assumed fiduciary responsibilities to the Tribe.

> Rights reserved under the Treaty of 1855 include those found in Article 3 of the Treaty, "*The exclusive right of taking fish in all the streams where running through or bordering said reservation is further secured to said 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, together*

> *with the privilege of hunting, gathering roots and berries, and pasturing their horses and cattle upon open and unclaimed land*."

The reserved rights to the aforementioned areas are a fundamental concern to the Nez Perce Tribe. The fish, roots, wild game, religious sites, and ancestral burial and living sites remain integral to the Nez Perce culture. The Tribe expects, accordingly, to be the primary consulting party in all federal actions related to Hanford that stand to affect or implicate the Tribe's treaty-reserved or cultural interests.



Treaty Reserved Resources

Treaty reserved resources situated on and off the Reservation (hereinafter referred to as "Tribal Resources") include but are not limited to:

Tribal water resources located within the Columbia, Snake, and Clearwater River Basins including those water resources associated with the Tribe's usual and accustomed fishing areas and Tribal springs and fountains described in Article 8 of the Nez Perce Tribe Treaty of 1863;

Fishery resources situated within the Reservation, as well as those resources associated with the Tribe's usual and accustomed fishing areas in the Columbia, Snake, and Clearwater River Basins;

Areas used for the gathering of roots and berries, hunting, and other cultural activities within open and unclaimed lands including lands along the Columbia, Clearwater, and Snake River Basins;

Open and unclaimed lands which are or may be suitable for domestic livestock grazing;

Forest resources situated on the Reservation and within the ceded areas of the Tribe;

Land holdings held in trust or otherwise located on and off the Nez Perce Reservation in the States of Idaho, Oregon; and Washington;

Culturally sensitive areas, including, but not limited to, areas of archaeological, religious, and historic significance, located both on and off the Reservation.

FEDERAL RECOGNITION OF TRIBAL SOVEREIGNTY

A unique political relationship exists between the United States and Indian Tribes, as defined by treaties, the United States Constitution, statutes, federal policies, executive orders, court decisions, , which recognize Tribes as separate sovereign governments.
As a fiduciary, the United States and all its agencies owe a trust duty to the Nez Perce Tribe and other federally-recognized tribes. *See United States v. Cherokee Nation of Oklahoma,* 480 U.S. 700, 707 (1987); *United States v. Mitchell,* 463 U.S. 206, 225 (1983); *Seminole Nation v. United States,* 316 U.S. 286, 296-97 (1942). This trust relationship has been described as “one of the primary cornerstones of Indian law,” Felix Cohen, Handbook of Federal Indian Law 221 (1982), and has been compared to one existing under the common law of trusts, with the United States as trustee, the tribes as beneficiaries, and the property and natural resources managed by the United States as the trust corpus. *See, e.g. Mitchell,* 463 U.S. at 225.

The United States’ trust obligation includes a substantive duty to consult with a tribe in decision-making to avoid adverse impacts on treaty resources and a duty to protect tribal treaty-reserved rights “and the resources on which those rights depend.” *Klamath Tribes v. U.S.,* 24 Ind. Law Rep. 3017, 3020 (D.Or. 1996). The duty ensures that the United States conduct meaningful consultation “in advance with the decision maker or with intermediaries with clear authority to present tribal views to the … decision maker.” *Lower Brule Sioux Tribe v. Deer,* 911 F. Supp 395, 401 (D. S.D. 1995).

Consistent with the United States’ trust obligation to Tribes, Congress has enacted numerous laws to protect Tribal resources and cultural interests, including, but not limited to the National Historic Preservation Act (NHPA) of 1966; the Archaeological Resources Protection Act of 1979; the Native American Graves Protection and Repatriation Act (NAPRA) of 1990; and the American Indian Religious Freedom Act (AIRFA) of 1978.

Executive Orders

Executive order, 13007, May 24, 1996. Updated April 30, 2002.

Section 1. Accommodation of Sacred Sites. (a) In managing Federal lands, each executive branch agency with statutory or administrative responsibility for the management of Federal lands shall, to the extent practicable, permitted by law, and not clearly inconsistent with essential agency functions, (1) accommodate access to and ceremonial use of Indian sacred sites by Indian religious practitioners and (2) avoid adversely affecting the physical integrity of such sacred sites. Where appropriate, agencies shall maintain the confidentiality of sacred sites.

This Executive Order directs Federal land-managing agencies to accommodate Native Americans' use of sacred sites for religious purposes and to avoid adversely affecting the physical integrity of sacred sites. {267} Some sacred sites may be considered traditional cultural properties and, if older than 50 years, may be eligible for the National Register of Historic Places. Thus, compliance with the Executive Order may overlap with Section 106 and Section 110 of NHPA. Under the Executive Order, Federal agencies managing lands must implement procedures to carry out the directive's intent. Procedures must provide for reasonable notice where an agency's action may restrict ceremonial use of a sacred site or adversely affect its physical integrity. {268} Federal agencies with land-managing responsibilities must provide the President with a report on implementation of Executive Order No. 13007 one year from its issuance.

Executive Order No. 13007 builds upon a 1994 Presidential Memorandum concerning government-to-government relations with Native American tribal governments. The Memorandum outlined principles Federal agencies must follow in interacting with federally recognized Native American tribes in deference to Native Americans' rights to self-governance. {269} Specifically, Federal agencies are directed to consult with tribal governments prior to taking actions that affect federally recognized tribes and to ensure that Native American concerns receive consideration during the development of Federal projects and programs. The 1994 Memorandum amplified provisions in the 1992 amendments to NHPA enhancing the rights of Native Americans with regard to historic properties.

Executive Order 11593

Section 1. Policy. The Federal Government shall provide leadership in preserving, restoring and maintaining the historic and cultural environment of the Nation. Agencies of the executive branch of the Government (hereinafter referred to as "Federal agencies") shall (1) administer the cultural properties under their control in a spirit of stewardship and trusteeship for future generations, (2) initiate measures necessary to direct their policies, plans and programs in such a way that federally owned sites, structures, and objects of historical, architectural or archaeological significance are preserved, restored and maintained for the inspiration and benefit of the people, and (3), in consultation with the Advisory Council on Historic Preservation (16 U.S.C. 4701), institute procedures to assure that Federal plans and programs contribute to the preservation and enhancement of non-federally owned sites, structures and objects of historical, architectural or archaeological significance.

The Executive Order requires Federal agencies to administer cultural properties under their control and direct their policies, plans, and programs in such a way that federally owned sites, structures, and objects of historical, architectural, or archeological significance were preserved, restored, and maintained. {250} To achieve this goal, Federal agencies are required to locate, inventory, and nominate to the National Register of Historic Places all properties under their jurisdiction or control that appear to qualify for listing in the National Register. {251} The courts have held that Executive Order No. 11593 obligates agencies to conduct adequate surveys to locate "any" and "all" sites of historic value, {252} although this requirement applies only to federally owned or federally controlled properties. {253} Moreover, the Executive Order directs agencies to reconsider any plans to transfer, sell, demolish, or substantially alter any property determined to be eligible for the National Register and to afford the Council an opportunity to comment on any such proposal. {254} Again, the requirement applies only to properties within Federal control or ownership. {255} Finally, the Executive Order requires agencies to record any listed property that may be substantially altered or demolished as a result of Federal action or assistance and to take necessary measures to provide for maintenance of and future planning for historic properties. {256}

Executive Order 13175, November 6, 2000

Executive Order 13175 establishes regular and meaningful consultation and collaboration with tribal officials in the development of Federal policies that have tribal implications, to strengthen the United States government-to-government relationships with Indian tribes, and to reduce the imposition of unfunded mandates upon Indian tribes. The executive Order applies to all federal programs, projects, regulations and policies that have Tribal Implications.

E.O. further provides that each “agency shall have an accountable process to ensure meaningful and timely input by tribal officials in the development of regulatory policies that have tribal implications.” According to the President’ April 29, 1994 memorandum regarding Government-to-Government Relations with Native American Tribal Governments, federal agencies “shall assess the impacts of Federal Government plans, projects, programs, and activities on tribal trust resources and assure that Tribal government rights and concerns are considered during the development of such plans, projects, programs, and activities.” As a result, Federal agencies must proactively protect tribal interest, including those associated with tribal culture, religion, subsistence, and commerce. Meaningful consultation with the Nez Perce Tribe is a vital component of this process.

On November 5, 2009 President Obama issued a Presidential Memorandum for the Heads of Executive Departments and Agencies. That Memorandum affirms the United States’ government-to-government relationship with Tribes, and directs each agency to submit to the Office of Management and Budget (OMB), within 90 days and following consultation with tribal governments, "a detailed plan of actions the agency will take to implement the policies and directives of Executive Order 13175."

U.S. Department of Energy American Indian Policy

On November 29, 1991, DOE announced a seven-point American Indian Policy, which formalizes the government-to-government relationship between DOE and federally recognized Indian Tribes. A key policy element pledges prior consultation with Tribes where their interests or reserved treaty rights might be affected by DOE activities. The DOE American Indian Policy provides another basis for the Cooperative Agreement. The Cooperative Agreement will also serve as an Office of Environmental Management Implementation Plan for the DOE American Indian Policy regarding interactions with the Nez Perce Tribe.

THE ROLES OF THE NEZ PERCE TRIBE AT HANFORD

The Tribe has a duty to protect its reserved treaty rights and privileges, environment, culture, and welfare as well as to educate its members and neighboring public to its activities. The Tribe assumes many different roles. It is a governmental entity with powers and authorities derived from its inherent sovereignty, from its status as the owner of land, and from legislative delegations from the Federal government. The Tribe exercises its powers and authority to serve its members and to regulate activities occurring within the reservation. The Tribe is also a cultural entity and is accordingly charged with the responsibility of protecting and transmitting that culture which is uniquely Nez Perce. The Tribe is also a beneficiary within the context of federal trust relationship with, and obligations to Indian Tribes. The Tribe is a trustee responsible for the protection and betterment of its members and the protection of its and their rights and privileges. The Tribe is also party to treaties between itself and the United States government.

Nez Perce and DOE Relationship

The relationship between the Tribe and DOE is defined by the trust relationship that exists between the Federal government and the Tribe, by treaty, federal statute, executive orders, administrative rules, caselaw, DOE's American Indian Policy, and by the mutual and generally convergent interests of the parties in the efficient and expeditious cleanup of the DOE weapons complex, and by the Cooperative Agreement. The structured relationship embodied by the Cooperative Agreement can best be described as a partnership grounded in the site-specific cleanup of Hanford, and extends to all trust-related activities of the Department.

The Tribe sees itself not only as an advisor to DOE, but also as an technical resource available to assist DOE. The Tribe sees its members and employees as a source of technically trained and certified labor for environmental restoration and decontamination and decommissioning work.

The continuation of the Cooperative Agreement contemplates an approach that will integrate these and other roles into a comprehensive Nez Perce-DOE program.

The Tribe is asked to review and comment on documents and activities by DOE implicates our Treaty reserved rights and DOE's acknowledgement of other federal statutes, laws, regulations, executive orders and memoranda governing the United States' relationship with Native Americans and the Nez Perce people. Several tribal departments lend their respective technical expertise to DOE Hanford issues and present recommendations to the Nez Perce Tribal Executive Committee (NPTEC), for consideration and guidance. The NPTEC also may requests formal consultation with the federal agency to discus a proposal or issue further.

Consultation with Native Americans

DOE's consultation responsibilities to the Tribe are enumerated generally in the document entitled, Consultation with Native Americans. This policy defines consultation in relevant part:

> "Consultation includes, but is not limited to: prior to taking any action with potential impacts upon American Indian ands Alaska Native nations, providing for mutually agreed protocols for timely communication, coordination, cooperation, and collaboration to determine the impact on traditional and cultural lifeways, natural resources, treaty and other federally reserved rights involving appropriate tribal officials and representatives through the decision making process."

In regard to security clearance, none of the various provisions of the continuation of the Cooperative Agreement shall be construed as providing for the release of reports or other classified information designated as "classified" or "Unclassified Controlled Nuclear Information" to the Nez Perce Tribe, or as waiving any other security requirements. Classified information includes National Security Information (10 CFR Part 1045) and Restricted Data (10 CFR Part 1016). Unclassified Controlled Nuclear Information is described in 10 CFR Ch. X, Part 1017.

In the event that reports or information requested under the provisions of the continuation of the Cooperative Agreement, while not "classified" or "Unclassified Controlled Nuclear Information," are determined by DOE-RL to be subject to the provisions of the Privacy Act, or the exemptions provided under the Freedom of Information Act, DOE-RL may, to the extent authorized by law, provide such reports or information to the Tribes upon receipt of the Tribe's written assurance that the Nez Perce Tribe will maintain the confidentiality of such data.

Greater Than Class C Radioactive Waste Environmental Impact Statement

Pueblo Views on Environmental Resource Areas

Los Alamos Meeting of Pueblo EIS Writers

June 7 – 12, 2009

Pueblo Writers Representatives

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Facilitated By

Richard W. Arnold, Pahrump Paiute Tribe
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1.1 Climate

The Pueblo people, having lived since the beginning of time in the region of the proposed GTCC waste disposal site, are concerned about meteorological climate shifts occurring over hundreds of years and longer term climate changes occurring over thousands of years. Such shifts impact vegetation. During dryer periods vegetation burns increase and post-burn erosion is accelerated. The Cerro Grande fire (Grieggs, Ramos, and Percy 2001) increased post-fire storms' runoff flows in some drainages more than 1,000 times the pre-fire levels (United States Department of Energy [DOE] 2008: 4-59). These higher runoff flows increased erosion and moved radioactive and hazardous materials downstream towards the Pueblo people.

During warmer periods, more intense rainfall episodes occur and less snow falls in winter, thus increasing erosion. Tree ring data document shifts in annual rainfall between 1523 and today, with a rainfall high in 1597 of 40 inches to a low in 1685 of 2.4 inches (Sean Rev 4.0: 2008 2-12).

During the Holocene, major shifts occurred in this region, and the GTCC disposal is to be evaluated for a duration of 10,000 years. These climate shifts are both culturally important to the Pueblo people who conduct ceremonies to balance climate and pertinent to the consideration of GTCC proposal.

1.2 Existing Air Emissions

Contaminated air emissions either from fugitive dust, violent storms, dust devils, emission stacks, bomb testing, burn pits, or from the Cerro Grande fire have spread to surrounding Pueblo lands and communities. A Santa Clara Pueblo wind monitor meteorological station recorded a wind of 70 miles per hour. Dust devils have been recorded by LANL at 73 miles per hour. Santa Clara, Pueblo de San Ildefonso, Pueblo de Cochiti, and Jemez perceive that they have received contaminated ash and air from the Cerro Grande fire, from more than 110 historic and active LANL emission stacks, and bomb testing detonations. Nambe, Pojoaque, and the surrounding Pueblos perceive that they too received contaminated ash from the Cerro Grande fire. The contaminations from these events exposed natural resource users ranging from hunters of animals to gatherers of clay for pots. Even normal Pueblo residents were exposed in many ways from farming to outdoor activities to everyday life.

The Pueblo de Cochiti is situated within Sandoval County, and emissions rates here were not compared in the GTCC to emission rates of LANL. The Pueblo de Cochiti is located south of LANL and adjacent to the PSD [Prevention of Significant Deterioration] Class I Bandelier National Monument. The Pueblo de Cochiti could thus be considered a PSD Class I area as well and all emissions pose a threat to this classification.

All the Accord Pueblos (Pueblo de San Ildefonso, Pueblo de Cochiti, Santa Clara, and Jemez Pueblo) are currently conducting independent studies of air emissions from LANL.

These studies have been ongoing for about ten years. Some Pueblos have their findings evaluated by independent laboratories. These studies are monitoring tritium, plutonium, uranium, americium, and other radionuclides and metals. Some of the studies have documented contaminated air emissions on Pueblo lands.

1.3 Existing Noise Environment

The Sacred Area is currently monitored for noise by Pueblo de San Ildefonso. Noise, which from a Pueblo perspective is an unnatural sound, does disturb ceremony and the place itself. Currently non-Indian voices, machinery, and processing equipment have been recorded by Pueblo de San Ildefonso monitors as coming from Area G to the Sacred Area.

1.4 Geology

The Pueblo people are aware of the occurrence of major earthquakes in the GTCC study area (up to 2000 have been recorded in recent times). These cause vertical displacements, large fissures, and small fractures. Water seeps into these fissures and plant roots follow them to great depths (up to 66 feet). Pueblo people believe that plant roots will eventually penetrate the GTCC facility.

1.5 Minerals and Energy Resources

The Pueblo people who visited the proposed GTCC disposal site note the likelihood of traditionally used minerals occurring there. They assess that this is a medium to high probability. There is a need for a cultural mineral assessment and study to identify the existence of minerals of cultural significance and use.

Although there is no current Pueblo ethnogeology studies for the LANL, one was recently developed for Bandelier National Monument (Stoffle et al. 2007). That study, which was approved by the participating pueblos, documented that 96 geological resources were found to have specific uses by Pueblo people, which is estimated to be the bulk of the occurring minerals in Bandelier NM. The following are the ten most frequently cited mineral resources, presented in order of frequency of reference. Included also is the number of pueblos that were documented to have used the named resource (1) Clay 17 times mentioned for 7 pueblos; (2) Turquoise 15 times mentioned for 7 pueblos; (3) Basalt 15 times mentioned for 5 pueblos; (4) Obsidian 9 times mentioned for 4 pueblos; (5) Gypsum 8 times mentioned for 5 pueblos; (6) Rock Crystal 8 times mentioned for 5 pueblos; (7) Salt 7 times mentioned for 4 pueblos; (8) Mica 6 times mentioned for 5 pueblos; (9) Sandstone 6 times mentioned for 5 pueblos; and (10) Hematite 6 times mentioned for 4 pueblos. Just as there are certain minerals that are more frequently documented, certain pueblos were more often the subject of observations and ethnographies (Stoffle et al. 2007: 33).

1.6 Surface Water

Pueblo people know that drainages in LANL flow during major runoff and storm events. These flows, though at times low in volume, have a potential to reach the Rio Grande and lower water bodies. In 1996, the Pueblo of Cochiti conducted a cooperative sediment study with LANL and the USGS in which Pre-1960s Legacy Waste was identified using the Thermal Ionization Mass Spectroscopy (TIMS) method. This Pre-1960s Legacy Waste has been recorded on the up-river portion of the Cochiti Reservoir, which is on the Rio Grande as it passes through the Cochiti Reservation.

There exists high potential for continuing pollution flows as indicated in the GTCC text above, and now the Cerro Grande fire has increased the potential for constituent movement as indicated in the Site-Wide EIS (DOE 2008: 4-59, 4-60). Evidence of radioactivity and hazardous waste (PCBs) movement from LANL has led to fish consumption warnings on eating fish from the Rio Grande.

1.7 Groundwater

Pueblo people know that extensive work has been completed to map and determine flow rates, direction, and quality of groundwater systems. There are independent studies published which challenge these findings. These other studies maintain that monitoring at sites is inadequate and that the drilling practices influence the results (see Bob Gilkeson Reports).

Santa Clara Pueblo is concerned that their groundwater is being contaminated by LANL – especially from TA 54 waste deposits. Even though Santa Clara Pueblo is upstream when only surface water is considered, known faults between LANL and SCP are suspected to connect reservation groundwater and TA 54 wastes in LANL groundwater. Current investigations by Santa Clara Pueblo science teams and funded by the Pueblo are on-going to determine if Santa Clara Pueblo groundwater is connected through water bearing faults.

1.8 Human Health

Standard calculations of human heath exposure as used for the General Public are not applicable to Pueblo populations. The concept General Public is an EPA term that is a generalization that derives from studies of average adult males. Residency time for the General Public tends to be a short period of an individual’s lifetime and exposure is voluntary. Pueblo people live here in their Sacred Home Lands for their entire lives and will continue to reside here forever.

Pueblo people use their resources differently than average US citizens so standard dosing rates do not apply. For ceremonial purposes, for example, water is consumed directly from surface water sources and natural springs. Potters, for example, have direct and intimate contact with stream and surface clay deposits. Natural pigment paints, for example, are placed on people's bodies and kept there through long periods of time during which strenuous physical activities opens the pores.

1.9 Ecology

Pueblo People know that they have many traditional plants and animals located on and near to the GTCC proposal area. During a brief visit to the proposed GTCC site, Pueblo EIS writers identified traditional use plants, which include medicinal, ceremonial, and domestic use plants. These plants were identified in a brief period and it was noted that many plants could be identified were a full ethnobotany of the site to be conducted. During this site visit the Pueblo EIS writers identified the presence of traditional animals, but noted that more could easily be identified during a full ethnozoological study.

While a full list of the traditional use plants was not available at the time of this analysis, a recent study conducted on the adjacent Bandelier National Monument identified 205 Pueblo use plants there (Stoffle et al. 2007). These use plants represent 59% of the known plants on the official plant inventory of Bandelier.

A Pueblo Writers' GTCC site visit and a draft LANL LLRW study for Area G documented the presence of the following plants:

Plants From LLRW Areas	Listed in Area G LLRW Study	Observed by Pueblo Writer's Group
Blue Grama (*Bouteloua gracilis*)	X	P
Indian Rice Grass (*Achnatherum hymenoides*)		P
Cutleaf Evening Primrose (*Oenothera caespitosa*	X	
Mullein Amaranth (*Verbascum thapsus*)	X	P
Indian Paintbrush (*Castilleja* sp.)		P
4-O'Clock (*Mirabilis jalapa*)		P
Narrowleaf Yucca (*Yucca angustissima*)	X	P
Penstemon spp.		P
Prickly Pear (*Opuntia polyacantha*)	X	P
Small Barrel (*Sclerocactus*)		P
Sunflower (*Helianthus petiolaris*)	X	P
Apache Plume (*Fallugia paradoxa*)	X	P
Big Sage (*Artemisia tridentada*)	X	P
Chamisa (*Ericamerica nauseosa* ssp. *nauseosa* var. *nauseosa*)	X	P

Four-Wing Saltbush (*Atriplex canescens*)	X	P
Mountain Mahogany (*Cercocarpus montanus*)	X	
New Mexico Locust (*Robinia neomexicana*)	X	
Oak (*Quercus* spp.)	X	
Snakeweed (*Guiterrezia sarothrae*)	X	
Squawberry (*Rhus trilobata*)	X	
Wax Currant (*Ribes cereum*)	X	
Wolfberry (*Lycium barbarum*)		P
One-Seed Juniper(*Juniperus monosperma*)	X	P
Pinon Pine (*Pinus edulis*)	X	P
Ponderosa Pine (*Pinus ponderosa*)	X	P

While a full list of the traditional use animals was not available at the time of this analysis, a recent study conducted on the adjacent Bandelier National Monument identified 76 Pueblo use animals there (Stoffle et al. 2007). The use animals represent 76% of the animals on the official animal inventory.

A Pueblo GTCC site visit and a LANL LLRW study for Area G documented the presence of the following animals:

Deer
Elk
Lizards
Harvester Ants
Rattlesnake
Cicadas
Mocking Bird
Pocket Mice and Kangaroo Rats
Pocket Gophers
Chipmunks and Ground Squirrels

Pueblo people note that LANL intends to use cover plants such as grasses on disposal pits at closure. These reseeding efforts have caused the intrusion of non-Native plants as well as the intended stabilization grasses. This is a cultural violation because the artificial intrusion of plant seed not normally found in an area is inappropriate. In addition, while grasses are the initial reseeding plants, other plants, trees and woody plants will soon establish in the soft pit closure soils putting deep roots into the disturbed subsoil.

1.10 Environnemental Justice

As Indian peoples culturally affiliated with land currently occupied by LANL, the Pueblo people would like to expand the definition of Environmental Justice so that it reflects the unique burdens borne by them. This definition is defined more fully below.

Pueblo people and their lands have been encroached upon by Europeans since the 1500s. During this time they have experienced loss of control over many aspects of their lives including (1) loss of traditional lands, (2) damage to Sacred Home Lands, (3) negative health effects due to European diseases and shifting diet, and (4) lack of access to traditional places. Negative encroachments that occurred during the Spanish period were continued after 1849 under the United States of America's federal government. The removal of lands for the creation of LANL in 1942 were a major event causing great damage to Pueblo peoples. Resulting pollution to the natural environment and ground disturbances from LANL activities constitute a base-line of negative Environmental Justice impacts. The GTCC proposal needs to be assessed in terms how it would continue these Environmental Justice impacts and thus further increase the differential emotional, health, and cultural burdens borne by the Pueblo peoples.

The Congress of the United States recognized this violation of their human, cultural, and national rights when the American Indian Religious Freedom Act (AIRFA) was passed in 1978. In the AIRFA legislation Congress told all Federal agencies to submit plans which would assure they would no longer violate the religious freedom of American Indian peoples (Stoffle et al. 1990). Subsequent legislation like the Native American Graves Protection and Repatriation Act (NAGPRA) (1990) and Executive Order 13007 – Sacred Sites Access (1996) have further defined their rights to Sacred Home Lands and traditional resources. The Federal Government also has a Trust Responsibility to American Indian peoples which is recognized in the DOE American and Alaska Native policy (http://www.em.doe.gov/pages/emhome.aspx). Environmental Justice is one point of analysis where these concerns can be expressed by Pueblo peoples and the obligations addressed by Federal Agencies during the NEPA EIS process.

Pueblo people believe that their health has been adversely affected by LANL operations including different types of cancers. These concerns were publicly recorded in videos produced with Closing the Circle grants provided by the National Park Service and the DOE (Pueblo de San Ildefonso 2000; Santa Clara 2001). Documentation of these adverse health affects is difficult because post-mortem analysis is not normal due to cultural rules regarding the treatment of the deceased and burial practices.

1.11 Land Use

There are two major power transmission lines, the Norton and Reeves Power lines, which exist on both mesas that are considered by the proposed GTCC (see DOE 2008: 4-136, 4-137). One line goes through GTCC Zone 6 and the other through GTCC North Side and North Side Expanded. These major district power lines occupy the centers of both mesas and greatly reduce the potential areas of the GTCC. Along both lines are a series of

Pueblo archaeology sites, which are currently signed as restricted access areas protected under the National Historic Protection Act.

1.12 Transportation

Pueblo people note that all waste shipments move by highway. There are no local railroads. Pueblo people believe that GTCC waste shipments will adversely impact natural resources, reservation communities, tribal administration activities, public schools, day schools, and businesses located along Highway 502 and Highway 84/285.

The Pueblo of Nambe is located on Highway 84/285 between the Pueblos of Pojoaque and Tesuque. The Pueblo of Nambe is located on the Rio Nambe, which joins the Rio Grande a few miles downstream. The Rio Nambe is the major water source for the Pueblo. Nambe Falls is on the reservation is an eco-tourism destination. Also on the reservation is Nambe Lake, which is used for irrigation of fields (crops) and recreation. Nambe has established several businesses on Highway 84/285, such as the Nambe Pueblo Development Corporation, Nambe Falls Travel Center, Hi-Tech, and many more businesses are planned for this location. New businesses include a water bottling factory, a housing complex, and solar and wind energy projects.

The Pueblo of Nambe raises the issue of security. The Pueblo government wants to know when radioactive waste is being transported past the reservation lands. We have a “need to know” and this information should be provided to appropriate tribal authorities such as First Responders and Emergency Managers. The tribes with Indian Land on transportation routes should be funded by the DOE to train their own radiation monitor teams, to maintain capability for their own safety and to protect sovereign immunity of Native American Tribes as independent Nations within the United States. This would enable tribes to be effective participants in handling hazards and threats as mandated by US. Department of Homeland Security in the “Metrics for Tribes” to be compliant with NIMS. Tribes should be able to participate in the preparations of waste materials for transportation at DOE sites. This participation/observation would give Tribes confidence that proper packing techniques and guidelines are adhered to. Currently Tribes are expected to “trust” that State and Federal authorities are doing this phase properly. The Indian people will feel more comfortable if we have some role in observing the process/procedures particularly if our observers are properly trained to understand the scientific reasons associated with packaging methodology.

The Pueblo of Nambe wants to monitor the transportation of GTCC materials in the same way that transuranic waste is monitored on its route from LANL to WIPP site at Carlsbad.

The Pueblo of Santa Clara is traversed by NM 30. Near this road are tribal residential areas, tribal businesses, schools, and economic developments. This highway is not an alternate route for radioactive waste hauling. A violation of this rule occurred in 2006 when three semi-trailer trucks loaded with radioactive soils from LANL were seen using NM30 as a short-cut route (they should have remained on NM 502) Drivers had disregarded tribal regulations. A tribal representative caught up with them nearby and recorded the violation.

Other Pueblo people have business and tribal resources along potential transportation routes. The Pueblo de San Ildefonso, for example, is concerned about radioactive waste transportation along Highway 502. The Totavi Business Plaza, is an area that was traditionally occupied, and is now a restaurant and gas station and may be a location for new tribal housing. The Pueblo de San Ildefonso youth attend a Day School, a District High School, Middle School, and Elementary Schools along 502. Pojoaque has a business park and two gas stations along 502 and 84/285 as well as their youth attend these schools.

1.13 Cultural Resources

Pueblo oral histories document that they have lived in and used the entire area of LANL including the GTCC proposed site since the beginning of time. Because of this Pueblo people are the descendants of the people who have lived here throughout time and included time periods referred by LANL archaeologists by the terms (1) Paleo-Indian, (2) Archaic, (3) Ancestral Pueblo, (4) American Indian, and (5) Federal Scientific Laboratory (See DOE 2008). Pueblo people lived in the area before the Ancestral Pueblo period, which is dated at 1600AD. Pueblo people continue to know about and value lands, natural resources, and archaeological materials located on LANL. Pueblo people continue to desire and have a culturally important role and responsibilities in the management of all of these traditional lands.

Recent cultural resource surveys have been conducted on LANL, which have identified some sites that were not identified when LANL was established after 1943. Pueblo people believe that these sites are connected with other much larger sites that were destroyed when the LANL facility was built and operated. The Pueblo people express concern that many early LANL developments destroyed culturally significant sites and that no effort has been made to conduct ceremonies that may alleviate the violations association with site destruction.

A known Sacred Area, primarily identified with Pueblo de San Ildefonso, is located on the next mesa to the north of the proposed GTCC waste site. It is spiritually connected to the surrounding area and is not bounded any federal boundaries. It is recognized as a Sacred Area on old USGS quads. The Sacred Area is continually monitored by Pueblo de San Ildefonso to constantly check on its cultural integrity. It has visual, auditory, and spiritual dimensions. Pueblo de San Ildefonso air quality program consistently monitors for tritium releases, which derive from nearby area G on TA 54 on LANL. Winds blow across this area from the Southwest from LANL on to the Sacred Area. The Cerro Grande fire brought ash debris which contained radionuclides to the Sacred Area. The Sacred Area is thus believed to have been contaminated by the ash from Cerro Grande fire. Dust contaminated from ongoing operations from area G has blown into the Sacred Area.

Although four American Indian pueblos, called by LANL the Accord Tribes: Santa Clara Pueblo, Pueblo de San Ildefonso, Jemez Pueblo, and Pueblo de Cochiti have been singled out during the GTCC consultation process as being both nearby and culturally connected with LANL, there is a widely recognized undestanding that other American Indian tribes are also culturally connected with LANL. These include but are not limited to (1) all 8 northern pueblos including San Juan O'Hkayowingee, Nambe O-weenge, Pojoaque, Picuris; (2) Jicarilla Apache; (3) southern Pueblos like Santo Domingo; and (4) western pueblos like Zuni and Hopi. Important LANL actions like the GTCC EIS undergoing a major analysis should include all the culturally connected (affiliated) American Indian tribes.

The LANL NAGPRA consultation report includes the following statement "It is noted that since around 1994, LANL has consistently consulted with five tribes on issues relating to cultural resources management, or at least have informed them of proposed construction projects and other issues surrounding cultural resources management at LANL." These include the "Accord Pueblos" of San Ildefonso, Santa Clara, Cochiti, and Jemez, each of which has signed agreements with LANL, along with the Mescalero Apache Tribe. In addition, the Pueblo of Acoma and the Jicarilla Apache Nation have been recognized as having an active interest in cultural resources management at LANL. A draft version of that NAGPRA report was subsequently also sent in January 2002 to all New Mexico Pueblos and to the Pueblos of Hopi in Arizona and Ysleta del Sur in Texas, as well as to the Jicarilla Apache Nation, the Mescalero Apache Tribe, the Navajo Nation, and the Ute Mountain and Southern Ute Tribes. The pueblo writers find the patterns of consultation by LANL to be confusing and not clearly grounded in a formal policy based on an agreed to Cultural Affiliation study.

Meaning of Artifacts, Places, and Resources – There is a general pueblo concern for pre-agricultural period Indian artifacts and the places where they were left. These include the role of ceremony itself as an act of sanctifying places, such as has been conducted and occurred near Sacred Area over the past thousands of years. Pueblo people believe they have been in the area since the beginning of time. This connection back in time thus connects them to all places, artifacts, and resources in the area.

1.14 Waste Management

The Pueblo people would like to point out a direct conflict in current LANL policy and the GTCC proposal. Today LANL is officially remediating contaminated areas. These actions result in the waste being moved to new sites such as WIPP. Some of this may be transported past Pueblo communities and economic business along transportation routes. LANL has already agreed to remove radioactive waste from Area G to WIPP. Currently LANL is shipping most kinds of radioactive and TRU waste off-site (DOE 2008: 4-160). This current LANL policy is in conflict with the GTCC proposal, which would place radioactive waste and TRU waste on LANL and near Area G. In addition, the Pueblos along the transportation routes will now be exposed twice – once to current LANL waste leaving for elsewhere like the WIPP site, and secondly to new GTCC waste shipments that are arriving from elsewhere.

The Pueblo people note that one of the potential GTCC sites, indicated as Zone 4, that is being considered in the EIS appears to have been withdrawn (June 2009) from consideration for GTCC waste because LANL is continuing to dispose of LLRW waste there (DOE 2008: 4-151). This is LLRW that has been or will be produced by LANL. These additional LANL wastes add to perceived contamination risks by the Pueblo people.

The Pueblo people note that the potential site for the GTCC waste disposal is already leaking radioactive contaminants around the perimeter of Area G and DARHT (DOE 2008: 4-32). GTCC waste could only increase the contamination of this area and add to the off-site flow of contaminants.

There is a known Sacred Area on the next ridge next to the existing LANL Area G radioactive waste isolation facility and also across from the proposed GTCC site. This Sacred Area is spiritually connected to the surrounding area and is not bounded any federal boundaries (it is even recognized as a sacred area on old USGS quads). Area is constantly monitored by Pueblo de San Ildefonso to check on its integrity. The Sacred Area has visual, auditory dimension, which are consistently monitoring for tritium from nearby areas. Winds blow across this area. The Cerro Grande fire brought ash debris, which contained radionuclides to the Sacred Area, thus the area is believed to have been contaminated by the ash from Cerro Grande fire. Radioactive Dust has blown away from Area G and has been recorded near Sacred Area. The Pueblo de San Ildefonso and other pueblo people believe that locating a GTCC facility in this area will further diminish the spiritual integrity of the Sacred Area.

Radioactivity studies using the TIMS (Thermo Ionization Mass Spectrometry) method have been fingerprinted and thus identified the source (1996) of radioactivity found in the sediments of Cochiti Reservoir as coming from LANL. This is a major concern for the Cochiti people. Storm and snow run off bring LANL radioactivity downstream to places where clay is deposited. There has even been a 100-year runoff event since the Cerro Grande fire. Automated recorders have documented radioactivity being recently brought down as far as the Pueblo de San Ildefonso. Jemez Pueblo potters also express concerns they these radioactive movement will impact them when they dig through these deposits while collecting clay for pottery and minerals for other uses.

1.15 Cumulative Impacts from the GTCC Proposed Action at LANL

Pueblo people express a concern that negative *stigmas* have been attached and will continue to be attached to their Sacred Home Lands, the natural resources from these lands, their businesses, and even themselves. The concept of having something, some place, or some people stigmatized is well documented in the NEPA-based literature (Grieggs, Ramos, and Pearcy 2001; Gregory, Flynn, and Slovic 1995; Messer et al. 2006; Metz 1994; Slovic, Flynn, and Gregory 1994). Projects having a significant potential for causing harm are recognizing as having the potential of attaching negative evaluations to the places, people, and resources near where they are located. This has been especially true of hazardous and radioactivity related projects.

The Pueblo people believe that the presence and activities of LANL has caused a variety of negative stigmas, which Pueblo people constantly attempt to address. All of the Accord Pueblos received Federal Closing the Circle grants to both document and address tribal concerns about what LANL has caused. Both NPS and DOE funds were provided to the Accord Pueblos to videotape oral histories regarding what impacts Indian people perceive that the establishment and operation of LANL have had on traditional environmental uses, cultural activities, and spiritual life (http://www.nps.gov/history/hps/HPG/Tribal/index.htm). One set of these impacts can be termed *stigmas*.

Since 1943, when LANL was established, these former pristine Pueblo lands have been disturbed and polluted. This process began immediately during the development of the atomic bomb when sub-critical explosions and radioactive materials processing released radioactivity and mixed wastes. During this period waste disposal was weakly regulated with many disposal sites being poorly documented and contained. The Center for Disease Control is currently reconstructing waste releases during this early period of LANL operations in order to determine whether or not a Dose Reconstruction Study should be formally conducted for LANL (http://www.lahdra.org). Public perceptions of the LANL area as being polluted have grown through time. Recently studies have added to rather than reduced this perception.

Pueblo people document existing and potential kinds of stigmas. Some Pueblos sponsor elk hunting for fundraisers. Recent newspaper discussions of radioactivity being present in area plants, water, and animals have caused, according to Pueblo accounts, reduced participation in such hunts. One tribal fishing lake was identified in a newspaper account as having radioactive fish, which greatly reduced fishing at that lake. Food pollution fears are widely documented. Tribal members also express concerns about using animals. Many Pueblos are moving towards commercial sales of garden products, which are marketed as local Indian-produced organic products. Concerns were expressed that were contaminated clay to be used by a Pueblo potter and the pot subsequently found to be contaminated that this event could greatly reduce all area pottery sales. Other Pueblo people with commercial businesses along highways are concerned that radioactive waste transportation accidents could reduce customer's willingness to stop at tribal businesses. Even Pueblo people themselves believe that there are polluted areas which they currently not do not visit because of their concern for contamination.

Pueblo people believe that the existing background of awareness of contamination would be increased were the public to become aware that GTCC wastes were being transported to and deposited at LANL.

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Umatilla Input from NEPA Analysis for CTUIR at Hanford

<u>Note to EIS preparers.</u> The following information is intended to supplement the Hanford NEPA boilerplate[1] by adding tribal perspectives. This material evolved significantly from the materials submitted by the GTCC Tribal Writers group, but has not been reviewed by them. For questions, please call Stuart Harris (541-966-2400) or Barbara Harper (541-966-2804).

A. CTUIR Introduction to Affected Resources

A.1 History and Standing

For at least 12,000 years, the Columbia River Plateau has supported the survival and thriving for many indigenous peoples. The Columbia River flows through what was a cultural and economic center for the Plateau communities. The indigenous communities were part of the land and its cycles, and it was part of them. The land and its many entities and attributes provided for all their needs: hunting and fishing, food gathering, and endless acres of grass on which to graze their horses, commerce and economy, art, education, health care, and social systems. All of these services flowed among the natural resources, including humans, in continuous interlocking cycles. These relationships form the basis for the unwritten laws or *Tamanwit* that were taught by those who came before, and are passed on through generations by oral tradition in order to protect those yet to arrive. The ancient responsibility to respect and uphold these teachings is directly connected to the culture, the religion, and the landscape along the Columbia Plateau. The cultural identity, survival, and sovereignty of the native nations along the Columbia River and its tributaries are maintained by adhering to, respecting, and obeying these ancient unwritten laws here in this place along the N'Chi Wana, or Big River.

In contemporary times, Indian life along the Columbia River and its tributaries continues to be based on the responsibility to manage modern daily affairs and environmental management practices in a manner consistent with the ancient teachings. This responsibility is to protect, preserve, and enhance this earth including the air, water, and ground, and all that grows and lives here. In order to fulfill this responsibility, the native sovereign nations need cold, clean, uncontaminated water; clean, clear uncontaminated air; uncontaminated soil; clean, vibrant, and uncontaminated biological resources; clean, uncontaminated, and wholesome foods; and clean, uncontaminated, and healthful medicines.

[1] Duncan, J.P. (ed.)(2007) Hanford Site National Environmental Policy Act (NEPA) Characterization. PNNL-6415 Rev. 18.

A.1.1 Treaties of 1855

In 1855, representatives of the U.S. Government signed treaties with representatives from many of the different Indian groups in the southern Plateau. The Indian groups ceded ownership of huge tracts of land to the federal government in return for promises food, education, health care, and other services, and retained the perpetual right to fish, hunt, erect fish-curing structures, gather food, and graze stock throughout the region, including the area in and around Hanford. Through the Treaties, the native nations sought to protect their homeland and food gathering rights within the traditional use areas necessary to sustain their citizens, preserve their cultural, subsistence, and ceremonial practices, and ensure the survival of future generations. The Treaties are legal contracts binding the native sovereign nations and the United States of America, and bring forth Federal fiduciary and trusteeship responsibilities to protect these interests.

A.1.2 Nuclear Waste Policy Act of 1982 and Tri-Party Agreement of 1989

The Nuclear Waste Policy Act of 1982 recognized the three native nations (the Confederated Tribes of the Umatilla Indian Reservation, the Yakama Nation, and the Nez Perce Tribe) as "affected Indian Tribes" at Hanford because they have "federally defined possessory or usage rights to other lands outside of the reservation's boundaries arising out of congressionally ratified treaties" and could be "substantially and adversely affected by the locating of such a facility." (Title 42, Chapter 108).

In 1989, the cleanup of the Site began with the Hanford Federal Facility and Consent Order, also known as the Tri-Party Agreement, which is the legal framework for cleanup of the Site. Through the original NWPA designation, these three native sovereign nations were recognized as having vital interests in the cleanup process. In 1992, cooperative agreements between the U.S. DOE-Headquarters and the three affected tribes were agreed upon to enable tribal participation in Hanford cleanup issues and decisions, protection of cultural resources, and (more recently) to engage in natural resource injury assessment and restoration activities as Natural Resource Trustees.

A.1.3 Policy on American Indian and Alaskan Native Tribal Government (2000) and DOE Order 1230.2 (1992).

In this policy DOE formalized its commitment to meeting its government-to-government relationships. The most important doctrine derived from this relationship is the trust responsibility of the United States to protect tribal sovereignty and self-determination, tribal lands, assets, resources, and treaty and other federally recognized and reserved rights. These aspects carry through the evaluation of affected resources.

A.1.4 Framework to Provide Guidance for Implementation of US DOE's Policy (2007) and DOE Oder 144.1

This framework enhances DOE's government-to-government working relationship with Indian Nations. DOE offices of EM, NE, SC, and NNSA will work to foster the government-to-government relationship with Indian Nations impacted by its activities and to maintain DOE'S trust responsibilities including: (a) protecting tribal people and tribal resources from EM, NE, SC, or NNSA actions that could harm their health, safety, or sustainability; and (b) protecting cultural and religious artifacts and sites on lands managed by DOE. DOE will endeavor to protect natural resources which include plants, animals, minerals, and natural features that have religious significance to Indian tribes and/or are held in trust by the Federal Government. The aspects of health and resource protection carry through the evaluation of affected resources.

A,2 The Fiduciary Trust Relationship

"The Federal Government has enacted numerous statutes and promulgated numerous regulations that establish and define a trust relationship with Indian tribes. The United States continues to work with Indian tribes on a government-to-government basis to address issues concerning Indian tribal self-government, tribal trust resources, and Indian tribal treaty and other rights" (Executive Order 13175, 65 Fed. Reg. 67249 (November 9, 2000)).

The Ninth Circuit has underscored the importance of trust responsibility for all agencies:

> "We have noted, with great frequency, that the federal government is the trustee of the Indian tribes' rights, including fishing rights. *See*, e.g., Joint Bd. of Control v. United States, 862 F.2d 195, 198 (9th Cir. 1988). This trust responsibility extends not just to the Interior Department, but attaches to the federal government as a whole."

Tribal trust law is most well developed in the arena of trust property and money[2]. Indian Trust assets include, but are not limited to money, lands, rights, and water. The federal Indian trust doctrine is considered the "cornerstone" of federal Indian law.

> *See* Dep't of the Interior v. Klamath Water Users Protective Ass'n, 532 U.S. 1, 11 (2001) ("The fiduciary relationship has been described as 'one of the primary cornerstones of Indian law,' and has been compared to one existing under a common law trust, with the United States as trustee, the Indian tribes or individuals as beneficiaries, and the property and natural resources managed by the United States as the trust corpus.").

The courts have made it clear that certain kinds of Indian property and monies are held by the United States in trust. In such cases, the government must assume the obligations of a fiduciary or trustee. The courts have imposed trust duties with respect to tribal funds. Additionally, as the Indian Claims Commission noted, "the fiduciary obligations of the United States toward restricted Indian reservation land, including minerals and timber, are established by law and require no proof." *Blackfeet and Gros Ventre Tribes of*

[2] **http://www.msaj.com/papers/43099.htm**

Indians, 32 Ind. Cl. Comm. 65, 77 (1973). As a general matter, the United States must properly manage and, protect such resources as: tribal land, *United States v. Shoshone Tribe of Indians*, 304 U.S. 111 (1938); *Lane v. Pueblo of Santa Rosa*, 249 U.S. 110 (1919); tribal minerals, *Navajo Tribe of Indians v. United States*, 9 Cl. Ct. 227 (1985); oil and gas, *Navajo Tribe of Indians v. United States*, 610 F.2d 766 (Ct. Cl. 1979); grazing lands, *White Mountain Apache Tribe v. United States*, 8 Cl. Ct. 677 (1985); water, I*d.*, and timber, *United States v. Mitchell,* (*Mitchell II*), *supra*.

> "An Indian Trust Asset (ITA) is defined by the Bureau of Reclamation (Reclamation) as a legal interest in an asset that is held in trust by the U.S. Government for Indian Tribes or individual Tribal members. Examples of ITA's include water rights, lands, minerals, hunting and fishing rights, money, and claims."[3]

Fiduciary trustee must always act in the interests of the beneficiaries (*Covelo Indian Community v. FERC,* 895 F.2d 581 (9th Cir. 1990 at 586). A trustee is obligated to not waste the trust asset. The Trust responsibility means that the federal government needs to be on the side of the Tribes. The federal government must act on behalf of the tribe, and is not supposed to treat tribes as stakeholders to be considered.

The Supreme Court, in defining the trust responsibility, has held that:

> [The federal government] has charged itself with moral obligations of the highest responsibility and trust. Its conduct, as disclosed in the acts of those who represent it in dealing with the Indians, should therefore be judged by the most exacting fiduciary standards. *Seminole Nation v. United States*, 316 U.S. 286, 296-97 (1941).

United States v. White Mountain Apache Tribe, 537 U.S. 465, 475 (2003) recognizes that the fundamental common law duty of a trustee is to maintain trust assets. Fort Mojave Indian Tribe v. United States, 23 Cl. Ct. 417, 426 (Cl. Ct. 1991) found the federal trust duty to protect Indian water rights because "the title to plaintiffs' water rights constitutes the trust property which the government, as trustee, has a duty to preserve."

The same trust principles that govern private fiduciaries also define the scope of the federal government's obligations to the Tribe. *See Covelo Indian Community v. F.E.R.C.*, 895 F.2d 581, 586 (9th cir. 1990). These include: 1) preserving and protecting the trust property; 2) informing the beneficiary about the condition of the trust resource; and 3) acting fairly, justly and honestly in the utmost good faith and with sound judgment and prudence. *See Assiniboine and Sioux Tribes v. Board of Oil and Gas Conservation*, 792 F.2d 782, 794 (9th Cir. 1986); *Trust*, 89 C.J.S. §§ 246-62. Additionally, a long line of cases imposes a trust duty of protection on agencies when their off-reservation actions threaten the use and enjoyment of Indian land. *See, e.g., Northern Cheyenne Tribe v. Hodel*, 851 F.2d 1152 (9th Cir. 1988); *Joint Tribal Council of Passomoquaddy Tribe v. Morton*, 528 F.2d 370, 379 (1st Cir. 1975).

[3] http://www.ose.state.nm.us/water-info/AamodtSettlement/Appendix21.pdf

In addition to the fiduciary trust obligations of the federal government to the Hanford tribes, the Confederated Tribes of the Umatilla Indian Reservation, Yakama Nation, and the Nez Perce Tribe are recognized by the federal government as trustees of the natural resources at Hanford.[4]

> "The concept of natural resource trustees is derived from the public trust doctrine. This ancient principal of law provides that governments hold certain property and natural resources in trust for the benefit of the public. Furthermore, the governments have the duty and authority to protect and preserve such property and resources for public uses."

Both CERCLA and OPA define "natural resources" broadly to include "land, fish, wildlife, biota, air, water, ground water, drinking water supplies, and other such resources..." Both statutes limit "natural resources" to those resources held in trust for the public, termed Trust Resources. While there are slight variations in their definitions, both CERCLA and OPA state that a "natural resource" is a resource "belonging to, managed by, held in trust by, appertaining to, or otherwise controlled by" the United States, any State, an Indian Tribe, a local government, or a foreign government [CERCLA §101(16); OPA §1001(20)].[5]

In summary, it is the opinion of the CTUIR and the Indian Writer's Group that the "reference location" for the GTCC disposal at Hanford involves a Trust Resource under natural resource trusteeship rules, and has associated obligations of the federal fiduciary trustee (the federal government) to the Tribes, and of the natural resource trustees (Tribes, states, and federal government) to each other and their constituencies.

A.3 Regional and Sitewide Tribal Context

The natural law, or Tamanwit, teaches that American Indian people are not separate from the environment. A tremendous amount of tribal knowledge is contained and taught through oral traditions. Some stories and oral histories contain factual information, while others contain social principles and cultural values. Traditional environmental knowledge reflects tribal science and keen observation, sometimes expressed as accurate explanations of environmental processes, and sometimes expressed in symbolic terms. These teachings have been built over thousands of years, and teach each generation how to live and behave to sustain themselves and the community. This lifestyle is resilient, having persisted through floods, droughts, cataclysms, upheavals, and warfare.

[4] http://www.hanford.gov/?page=292&parent=291
[5] http://www.epa.gov/superfund/programs/nrd/primer.htm

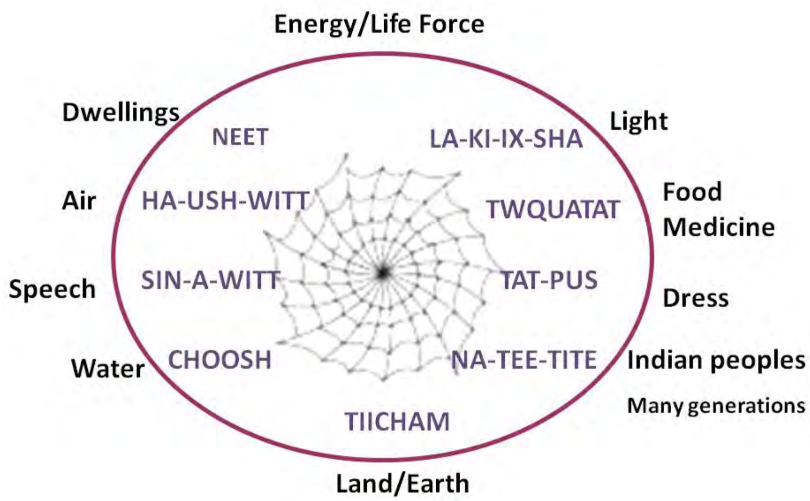

Figure. Depiction of CTUIR Tamanwit, the Natural Law.

Native American ties to the environment are much more complex and intense than is generally understood by risk assessors (Harris 1998). All of the foods and implements gathered and manufactured by the traditional American Indian are interconnected in at least one way, but more often in many ways. Everything is woven together in a web that extends across space-time. To many American Indians, individual and collective well-being is derived from membership in a healthy community that has access to, and utilization of, ancestral lands and traditional resources, so that they may fulfill their part of the natural cycles and their responsibility to uphold the natural law. Adverse impacts to one resource ripple through the entire web and through interconnected biological and human communities. Therefore, if the link between a person and his/her environment is severed through the introduction of contamination or physical or administrative disruption, natural resource service flows may be interrupted, the person's health suffers, and the well being of the entire community is affected.

B. CTUIR Affected Resources – Features, Attributes, Goods, and Services

B.1 Climate and Ethnohistory

People have inhabited the Columbia Basin throughout the entire Younger Dryas era (from 10,000 years ago to the present). Several even earlier archaeological sites are known. Mammoth and bison harvest sites are found throughout the Columbia Plateau. As the temperatures rose throughout this period, the Pleistocene lakes began to shrink and wither away into alkali basins. The post-glacial grasslands of the Great Basin and Columbia Basin were replaced by desert grasses, juniper, and sage, and megafauna likewise decreased through ecological and hunting pressure. The glaciers in the Cascades, Wallowa and Steens mountains rapidly disappeared.[6]

After about 5400 B.P. increasing precipitation and rising water tables were apparent again on both sides of the Cascades. Pollen history indicates continual short, sharp climatic shifts that, directly (e.g., soil moisture) or indirectly (e.g., fire and disease), produced rapid changes in the Northwest's vegetation. The plants and animals were now modern in form. Hunters switched to deer, elk, antelope and small game such as rabbits and birds. Fishing also became important along the coastal streams and in the Columbia River system, with an increasing emphasis on the annual runs of the salmon even though salmon runs date considerably farther back. [6]

The human ethnohistory in the Columbia Basin is divided into cultural periods that parallel the climatic periods and represent cultural adaptations to changing environmental conditions. Throughout this entire period the oral history continually added information needed for survival and resiliency as the climate fluctuated. The oral history of local native people is consistent with contemporary scientific and historic knowledge of the region and validates the extreme climate changes that have occurred in the region over thousands of years. Cameron (2008)[7] examined archaeological, ethnographic, paleo-environmental, and oral historical studies from the Interior Plateau of British Columbia, Canada, from the Late Holocene period, and found correlations among all four sources of information.

Tribal stories tell of eruptions, volcanoes, great floods, and animals now extinct. Indian people on the Columbia Plateau have stories about the world being destroyed by fire and water. Some of these were directly experienced, for example, the Mazama eruption

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[6] http://www.oregon-archaeology.com/archaeology/oregon/;
http://www.wac6.org/livesite/precirculated/1803_precirculated.pdf;
Mehringer, P.J. (1996) "Columbia River Basin EcosystemsL Late Quaternary.
http://www.icbemp.gov/science/mehringe.pdf.

[7] Camerion, I (2008) "Late Holocene environmental change on the Interior Plateau of Western Canada as seen through the archaeological and oral historical records." World Archaeological Congress 6, Dublin, Ireland.

6,800 years ago, and the last of the Missoula floods 13,000 years ago. A major landscape feature at Hanford, Gable Mountain or Nookshia (Relander1986: 305), is remembered when it rose out of the flood waters. Older events were accurately inferred from geologic features and then taught, either as literal explanations of the physiography or in symbolic terms as stories or fables (i.e., taking the opportunity to teach a beneficial eco-behavioral lesson).

Large scale manipulation of plants and animals through fire as a tool to reduce plants tied up in climax vegetation and to increase valued plant (and animals that depended on them) started perhaps 3500-3000 years ago, particularly in moister areas where burning out climax vegetation reduced the biomass tied up in cellulose (trees), and increased the diversity of the natural habitat. Important species such as elk, camas (a root food), tarweed (a seed food) and oak were enhanced with periodic burning. Other plants used for food, medicine, and fiber also increase in relative abundance with the use of fire.

Climate change that will occur over the next 10,000 years will inevitably draw on knowledge from the past, whether the climate becomes wetter or drier. Evaluation of future climate scenarios will need to include as much variation as occurred in the last 10,000 years.

B.2 Air Quality

The importance of clean fresh air is often overlooked in NEPA analysis. For example, while wind and fire are part of the natural regime, and an intact soil surface with a cryptogam crust in the desert reduces dust resuspension during wind events.

While chemical and radioactive air emissions are relatively low at Hanford presently, the extensive cleanup and construction activities on Hanford contribute to blowing dust, increased traffic, diesel emissions, deposition or re-deposition of radionuclides, and generation of ozone, particulate matter, and other air pollutants with unknown human and environmental health effects. Viewshed and haze are also affected.

B.3 Physical Resources

It is well known that environmental attributes or qualities such as wilderness, solitude, peace, calm, quiet, and darkness are important to individual species that need large undisturbed habitat as well as to humans who value those experiential qualities[8]. These qualities are very fragile, and once lost are hard to recover. A single light at night breaks the quality of darkness, just as the first drop of contamination changes the quality of water from pure to impure. CTUIR recommends that more attention be paid to the value of unfragmented and undisturbed shrub steppe habitat and natural resources.

[8] http://findarticles.com/p/articles/mi_m1145/is_n8_v29/ai_15769900/; http://findarticles.com/p/articles/mi_m1145/is_n8_v29/ai_15769900/

B.3 .1 Quiet

Noise can affect living organisms in the ecosystem through interruption of reproductive cycles and migration patterns, and driving away species that are sensitive to human presence. Non-natural noise can be offensive while traditional ceremonies are being held. The noise generated by the Hanford facility may presently create noise interference for ceremonies held at sites like Gable Mountain and Rattlesnake Mountain by interrupting the thoughts and focus and thus the spiritual balance and harmony of the community participants of a ceremony (Greider 1993)[9].

B.3.2 Darkness

Light at night affects nocturnal animals such as bats, owls, night crawlers and other species. Night light also has known affects on diurnal creatures and plants by interrupting their natural patterns. Light can affect reproduction, migration, feeding and other aspects of a living organism's survival. Light at night also disrupts the quality of human experience, including star gazing and cultural activities. Extensive light pollution is already being produced from by the Hanford site.

B.4 Geological Resources

Geological resources include soils, sediments, minerals, geological landscapes and associated features, borrow materials, gas, and petroleum.

B.4.1 Soils, Minerals

Native Peoples understand the importance of soils and minerals. Many uses of soils are included in the attached material on exposure pathways. At Hanford, material from the White Bluffs was used for cleaning hides, making paints, and whitewashing villages. Borrow material for caps, barriers, and clean fill is a particular concern, and needs to be part of each NEPA analysis.

B.4.2 Landscapes

The human aspects of Hanford landscapes are discussed briefly here. The CTUIR recommend that DOE pay more attention to landscape features and visual and aesthetic services that flow from the geologic formations at Hanford. Cultural and sacred landscapes may be invisible unless they are disclosed by the peoples to whom they are important. Tribal values lie embedded within the rich cultural landscape and are conveyed to the next generation through oral tradition by the depth of the Indian languages. Numerous landmarks are mnemonics to the events, stories, and cultural practices of native peoples. Oral histories impart basic beliefs, taught moral values and the land ethic, and helped explained the creation of the world, the origin of rituals and customs, the location of food, and the meaning of natural phenomena. The oral tradition

[9] Greider, T (1993) Aircraft Noise and the Practice of Indian Medicine: The Symbolic Transformation of the Environment. Human Organization 52(1): 76-82.

provides accounts and descriptions of the region's flora, fauna, and geology. Within this landscape are songs associated with specific places; when access is denied a song may be lost.

"At Hanford there are three overlapping cultural landscapes that overlie the natural landscape. These are not displacements of a previous landscape by a new landscape, but a coexistence of all three simultaneously even if one landscape is more visible in a particular area. The first represents the American Indians, who have created a rich archeological and ethnographic record spanning more than 10,000 years. This is the only stretch of the Columbia River that is still free-flowing, and one of the few areas in the Mid-Columbia Valley without modern agricultural development. As a result, this is one of the few places where native villages and campsites can still be found. Still today, local American Indian tribes revere the area for its spiritual and cultural importance, as they continue the traditions practiced by their ancestors." The second landscape was created by early settlers, and the third by the Manhattan Project. Today, DOE is removing much of the visible portion of the Manhattan landscape, returning the surface of the site to a more natural state (restoration and conservation) and thus revealing the cultural landscape that remains underneath.[10]

The Hanford Reach and the greater Hanford Site, a geographic center for regional American Indian religious activities, is central to the practice of the Indian religion of the region and many believe the Creator made the first people here. Indian religious leaders such as Smoholla, a prophet of Priest Rapids who brought the Washani religion to the Wanapum and others during the late 19th century, began their teachings here. Prominent landforms such as Rattlesnake Mountain, Gable Mountain, and Gable Butte, as well as various sites along and including the Columbia River, remain sacred. American Indian traditional cultural places within the Hanford Site include, but are not limited to, a wide variety of places and landscapes: archaeological sites, cemeteries, trails and pathways, campsites and villages, fisheries, hunting grounds, plant gathering areas, holy lands, landmarks, important places in Indian history and culture, places of persistence and resistance, and landscapes of the heart. Because affected tribal members consider these places sacred, many traditional cultural sites remain unidentified.

More generally, cultural landscapes have been defined by the World Heritage Committee as distinct geographical areas or properties uniquely representing the combined work of nature and of man. They identified and adopted three categories of landscape: the purely natural landscape, the human-created landscape, and an associative cultural landscape which may be valued because of the religious, artistic or cultural associations of the natural and/or human elements.

Sacred natural sites are natural places recognized by indigenous and traditional peoples as having spiritual or religious significance. They can be mountains, rivers, lakes, caves, forest groves, coastal waters, and entire islands. The reasons for their sacredness are diverse. They may be perceived as abodes of deities and ancestral spirits; as sources of healing water and plants; places of contact with the spiritual, or communication with the

[10] http://www.hanford.gov/doe/history/?history=archaeology.

'beyond-human' reality; and sites of revelation and transformation. As a result of access restrictions, many sacred places are now important reservoirs of biological diversity. Sacred natural sites such as forest groves, mountains and rivers, are often visible in the landscape as vegetation-rich ecosystems, contrasting dramatically from adjoining, non-sacred, degraded environments.[11]

B.4.3 Viewsheds

Viewscapes tend to be panoramic and are made special when they contain prominent topography. Viewscapes are tied with songscapes and storyscapes, especially when the vantage point has a panorama composed of multiple locations from either song or story. Viewscapes are critical to the performance of some Indian ceremonies. As told by a Wanapum elder, within the Hanford viewshed (at an undisclosed location) is at least one calendar wheel that guided native residents in their movements and activities. The wheel had spokes which were duplicated at villages. At each village a white stone was placed in the ground and atop this stood a high post. The post would cast a shadow which was read. When it reached a certain angle, like the spoke in the wheel, the people would respond with the proper action. The wheel was a reference point that held time schedules. Gable Mountain is a central area which is also a point of reference for many ceremonies. Many of the reference points that were set on the ground are organized like the stars – they are related in important ways that are described in detailed songs and stories. Interruption of the vista by large facilities or bright lights impairs the cultural services associated with the viewshed.

A viewshed map is included in the Hanford NEPA boilerplate document (Duncan 2007).

B.5 Water

Water sustains all life. As with all resources, there is both a practical and a spiritual aspect to water. Water is sacred to the Indian people, and without it nothing would live. When having a feast, a sip of water is taken either first or after a bite of salmon, then a bit of salmon, then small bites of the four legged animals, then bites of roots and berries, and then all the other foods.

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[11] Oviedo, G. (2002). member of the Task Force of Non-Material Values of Protected Areas of the World Commission on Protected Areas (WCPA), at the Panel on Religion, Spirituality and the Environment of the World Civil Society Forum, Geneva, 17 July 2002.
Stoffle, R.W., Halmo, D.B., Austin, D.E. (1998). Cultural Landscapes and Traditional Cultural Properties: a Southern Paiute View of the Grand Canyon and Colorado River. American Indian Quarterly, Vol. 21: 229-250.
Walker, D.E., 1991. "Protection of American Indian Sacred Geography," in: *Handbook of American Indian Religious Freedom*, Vecsey, C., Ed., Crossroad, New York, NY, pp. 100-115.

The quality of purity is very important for ceremonial use of water. For example, making a sweat lodge and sweating is a process of cleansing and purification. The sweat lodge should be made with clean natural materials and the water used for sweat-bathing should also be uncontaminated. The concept of sacred water or holy water is global, and often connects people, places, and religion; religions that are not land-connected may lose this concept.[12] Additionally, concepts related to the flow of services from groundwater and the valuation of groundwater are receiving increased attention.[13]

Although DOE's threshold for groundwater injury may be regulatory standards based on human or biological health, perhaps the most important criterion for contamination from a tribal perspective is the first drop of contamination, which moves the water from a condition of purity to a condition of degraded. This concept sets a threshold of injury at background or the detection limit.

From the CTUIR's perspective, contamination in the groundwater at the Hanford site is the greatest long-term threat to the Columbia River. There is a tremendous volume of radioactive and chemical contamination in the vadose zone and the groundwater. The mechanics of transport of contaminants through the soil to the ground water is still largely unknown. The actual volumes of contamination within the ground water and the direction of ground water flow are not fully characterized. The uncertainly due to this lack of knowledge and the limited technical ability to remediate the vadose zone and ground water puts the Columbia River and its biota at continual risk. The tremendous importance of groundwater means that the uncertainty about present and future contamination must play a key role in the risk assessment – the severity of the consequences if groundwater and the river become more contaminated is high (risk = probability x severity).

[12] Altman, N. (2002) Sacred Water: the Spiritual Source of Life. Mahwah, NJ: Hidden Spring Publ.;
Marks, W.E. (2001) The Holy Order of Water. Vancouver BC: Steiner Books Inc.;
Burmil, S., Daniel, T.C., and Hetherington, J.D. (1999). Human values and perceptions of water in arid landscapes. *Landscape and Urban Planning*, 44: 99-109;
Mazumdar, S. and Mazumdar, S. (2004). Religion and place attachment: A study of sacred places. Journal of Environmental Psychology, 24: 385-397.

[13] National Research Council (1997) Valuing Ground Water: Economic Concepts and Approaches. Washington D.C.: National Academy Press.

B.6 Biological Resources

B.6.1 Ethno-Habitat

Natural resources are integral to many traditional practices and celebrations throughout the year, many of which honor the traditional foods or First Foods. Based on the importance and many uses of the natural resources, an exposure scenario reflecting the underlying **ethnohabitat or eco-cultural system** was developed for use in dose and risk assessments at Hanford (Harper and Harris 1997; Harris and Harper 2000; CTUIR 2004)[14]. Ethno-habitats can be defined as the set of cultural, religious, nutritional, educational, psychological, and other services provided by intact, functioning ecosystems and landscapes. Although the concept of ethnohabitat or ethnoecology has been used various forms in anthropological disciplines for many years, it had never been used in risk assessment.

A healthy ethno-habitat or eco-cultural system is one that supports its natural plant and animal communities and also sustains the biophysical and spiritual health of its native peoples. Ethno-habitats are places clearly defined and well understood by groups of people within the context of their culture. These are living systems that serve to help sustain modern Native American peoples' way of life, cultural integrity, social cohesion, and socio-economic well-being. The lands, which embody these systems, encompass traditional Native American homelands, places, ecological habitats, resources, ancestral remains, cultural landmarks, and cultural heritage. Larger ethno-habitats can include multiple interconnected watersheds, discrete geographies, seasonal use areas, and access corridors.[15] A depiction of the eco-cultural system for the CTUIR is shown as a seasonal round that includes both terrestrial and aquatic resources.

Figure. Umatilla Seasonal Round

[14] Harris, S.G. and Harper, B.L. "A Native American Exposure Scenario." Risk Analysis, 17(6): 789-795, 1997; S Harris and B Harper. "Using Eco-Cultural Dependency Webs in Risk Assessment and Characterization." Environmental Science and Pollution Research, 7(Special 2): 91-100, 2000; http://www.hhs.oregonstate.edu/ph/tribal-grant-main-page.

[15] Modified from the East-Side EIS of the Interior Columbia Environmental Management Plan (ICBEMP).

B.6.2 Terrestrial Resources of the Plateau Culture Area

An ethnoecological approach to describing terrestrial resources begins with a description of the potential natural vegetation within the Columbia Basin ecozones, and then describes the natural resource usage patterns of the Plateau Culture Area.[16]

All natural resources are significant to tribal culture as part of functioning ecosystems, and many are individually important as useful for food, medicines, materials, or other uses. A comprehensive list of potentially injured biota was compiled for the tribal natural resource trustees, including 13 algae species, 56 fish species, 269 bird species, 52 mammal species, 21 amphibian and reptile species, over 800 aquatic and terrestrial plant species, and dozens of orders, families, and genera of aquatic and terrestrial insects.

The Hanford shrub steppe is a Washington State priority habitat[17] due to its large and largely unfragmented nature, which is now rare. In the 1970s, the National Environmental Research Park (NERP) program created seven NERPs to set aside land for ecosystem preservation and study. The Hanford NERP, managed by the Department of Energy, includes the Fitzner/Eberhardt Arid Lands Ecology Reserve, which is the only remaining sizable remnant (312 square kilometers, 120 square miles) of the Washington shrub-steppe landscape that is still in a relatively pristine condition, the industrial zone of the Hanford Site, which contains nuclear production facilities in various stages of cleanup and closure, and buffer zones on the opposite shore of the Columbia River: the US Department of the Interior's Saddle Mountain Wildlife Reserve and the Washington State wildlife management area.[18] Ecological functions that require this degree of intactness is make Hanford very valuable, and make contiguity, biodiversity, and attributes of a similar scale very important to preserve and enhance.

Based on the Presidential Proclamation that established the Hanford Reach National Monument, the CTUIR policy seeks to ensure that all of Hanford will be restored and protected:[19]

> "The area being designated as the **Hanford Reach** National Monument forms an arc surrounding much of what is known as the central **Hanford** area. While a portion of the central area is needed for Department of Energy missions, much of the area contains the same shrub-steppe habitat and other objects of scientific and historic interest that I am today permanently protecting in the monument. Therefore, I am directing you to manage the central area to protect these important values where practical. I further direct you to consult with the Secretary of the Interior on how best to permanently protect these objects, including the possibility of adding lands to the monument as they are remediated."

[16] http://www.fs.fed.us/land/pubs/ecoregions/ch48.html#342I
[17] http://www.fws.gov/hanfordreach/natural-resources.html
[18] http://www.pnl.gov/nerp/
[19] FR Volume 36--Number 23: 1271-1329; Monday, June 12, 2000

In addition to biological resources and natural resource goods, ecological functions and services that flow to people may be injured by contamination or physical disturbance. For tribal members, human use services that natural resources provide include both direct use of resources (e.g., hunting, fishing, and gathering of edible plants) and nonuse services (e.g., spiritual identity). Because Tribal identity is so strongly defined by their relationship to their natural environment, natural resources provide more services (on average) to Tribal members than to other members of the general public.

An overview of the resources that can serve as conduits of exposure to native peoples is presented in the CTUIR and Yakama Nation exposure scenarios. The CTUIR exposure factors based on natural resources is presented in the "Reference Indian" section.

B.6.3 Aquatic Resources of the Plateau Culture Area

The Columbia River, which cuts through the Hanford site, is the life blood of the region, with rich diverse fisheries delicately balanced on thriving aquatic ecosystems. The Hanford Reach is the last free-flowing segment of the Columbia River and is home of the last remaining naturally spawning fall Chinook. Ancestral CTUIR fisheries sites are located throughout the Hanford Reach. The health of the Hanford Reach is the keystone essential to the survival of Columbia Basin fisheries and CTUIR Treaty rights and resources.

Use of the Hanford site and surrounding areas by tribes was tied primarily to the robust Columbia River fishery. Past social activities of native people include gatherings for such activities like marriages, trading, feasts, harvesting, fishing, and mineral collection. Tribal families and bands lived along the Columbia either year round or seasonally for catching, drying and smoking salmon. The reduction of salmon runs, loss of fishing sites due to dam impoundments and 70 years of DOE institutional controls at Hanford have contributed to the degradation of the supplies necessary for this gifting and barter system of CTUIRculture.

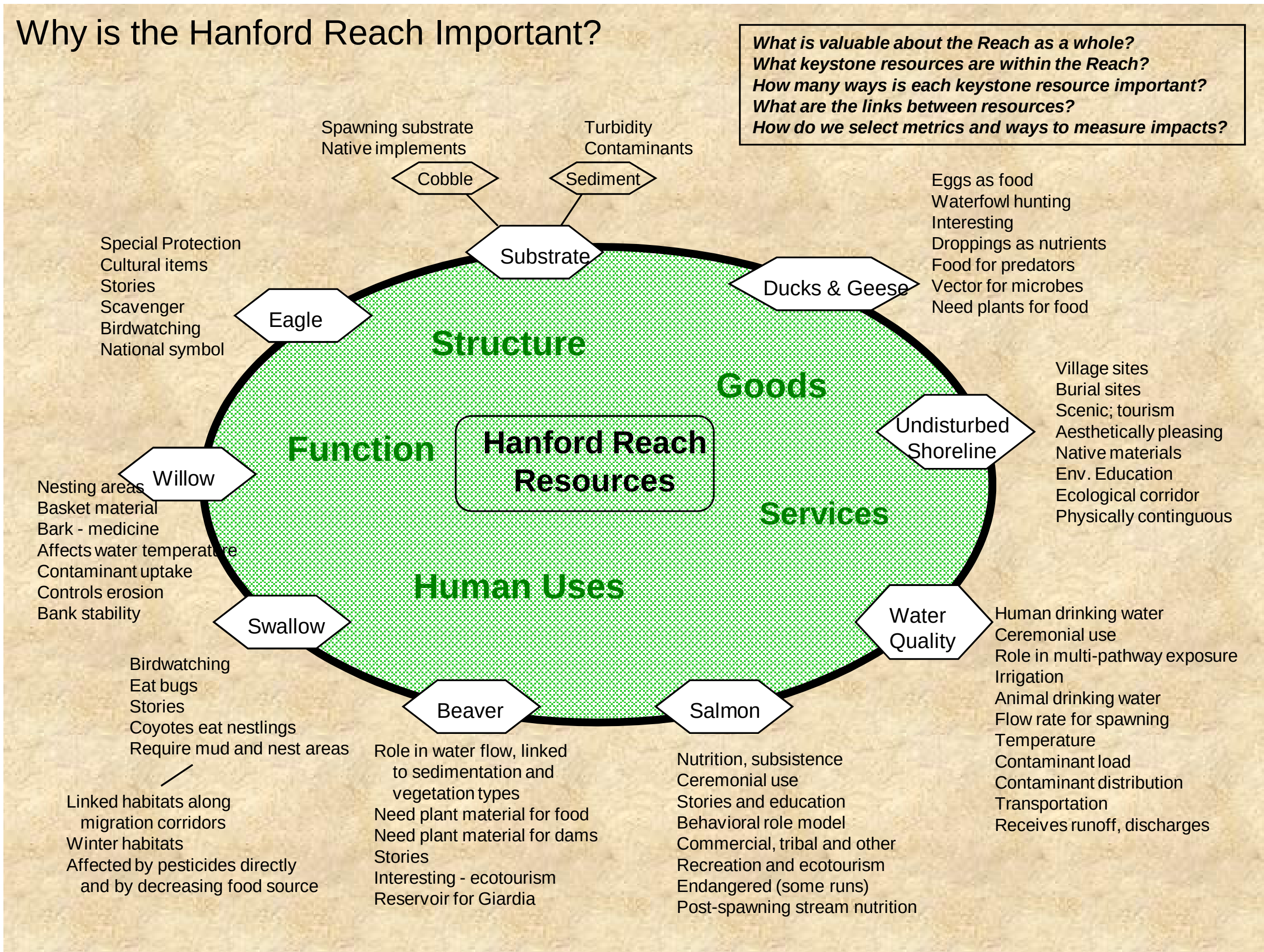
Salmon remains a core part of the oral traditions of the tribes of the Columbia Plateau and it still maintains a presence in native peoples' diet just as it has for thousands of generations. Salmon is among those foods regularly recognized ceremonially. One example is the *ke'uyit* which translates to "first bite." It is a ceremonial feast that is held in spring to recognize the foods that return to take care of the people. It is a long standing tradition among the people and it is immersed in prayer songs and dancing. Salmon is the first food that is eaten by the attendants. Extending gratitude to the foods for sustaining the life of the people is among the tenets of plateau lifestyle. Life is perceived as intertwined with the life of the Salmon. A parallel can be seen between the dwindling numbers of the Salmon runs and the struggle of native people. *from Salmon and His People*[20]

[20] Landeen, D. (1999) Salmon and His People: Fish and Fishing in Nez Perce Culture. Lewiston, ID: Lewis and Clark State College Press.

The people of the Columbia River tribes have always shared a common understanding -- that their very existence depends on the respectful enjoyment of the Columbia River Basin's vast land and water resources. Indeed, their very souls and spirits were and are inextricably tied to the natural world and its myriad inhabitants. Among those inhabitants, none were more important than the teeming millions of anadromous fish enriching the basin's rivers and streams. Despite some differences in language and cultural practices, the people of these tribes shared the foundation of a regional economy based on salmon. The Treaties of 1855 between the Tribes and the federal government explicitly reserved the right to continue fishing forever. Over the next century, settlers encroached on most tribal fishing grounds, blocked access, stole nets, destroyed boats, arrested Indians, over-fished, destroyed habitat, and built dams. In 1974 Judge George Boldt decided in *United States v. Washington* (384 F. Supp. 312) that the "fair and equitable share" of fish for tribes was, in fact, 50 percent of all the harvestable fish destined for the tribes' traditional fishing places. The following year, Judge Belloni applied the 50/50 standard to *U.S. v. Oregon* and the Columbia River. Judge Boldt's decision also affirmed tribal rights to self-regulation when in compliance with specific standards. In 1988, Public Law 10- 581, Title IV Columbia River Treaty Fishing Access Sites, was enacted. The primary purpose of the legislation is to provide an equitable satisfaction of the United States' commitment to provide lands for Indian treaty fishing activities in lieu of those inundated by construction of Bonneville Dam (www.critfc.org).

Salmon will always be important and necessary for physical health and for spiritual well-being. Tribal people continue to fish for ceremonial, subsistence and commercial purposes employing, as they always have, a variety of technologies. Tribal people fish from wooden scaffolds and boats, and use set nets, spears, dip nets and poles and lines. Tribal people still maintain a dietary preference for salmon, and its role in ceremonial life remains preeminent.

Aquatic resources in the Hanford Reach (the area of the river flowing through the Hanford site) include many species, including people. An illustration of resource interconnections and services is shown in figure X.


Why is the Hanford Reach Important?
What is valuable about the Reach as a whole?
What keystone resources are within the Reach?
How many ways is each keystone resource important?
What are the links between resources?
How do we select metrics and ways to measure impacts?
Spawning substrate
Native implements
Cobble
Turbidity
Contaminants
Sediment
Substrate
Eggs as food
Waterfowl hunting
Interesting
Droppings as nutrients
Food for predators
Vector for microbes
Need plants for food
Ducks & Geese
Special Protection
Cultural items
Stories
Scavenger
Birdwatching
National symbol
Eagle
Structure
Goods
Function
Hanford Reach Resources
Services
Human Uses
Village sites
Burial sites
Scenic; tourism
Aesthetically pleasing
Native materials
Env. Education
Ecological corridor
Physically contiguous
Undisturbed Shoreline
Willow
Nesting areas
Basket material
Bark - medicine
Affects water temperature
Contaminant uptake
Controls erosion
Bank stability
Swallow
Birdwatching
Eat bugs
Stories
Coyotes eat nestlings
Require mud and nest areas
Linked habitats along migration corridors
Winter habitats
Affected by pesticides directly and by decreasing food source
Beaver
Role in water flow, linked to sedimentation and vegetation types
Need plant material for food
Need plant material for dams
Stories
Interesting - ecotourism
Reservoir for Giardia
Salmon
Nutrition, subsistence
Ceremonial use
Stories and education
Behavioral role model
Commercial, tribal and other
Recreation and ecotourism
Endangered (some runs)
Post-spawning stream nutrition
Water Quality
Human drinking water
Ceremonial use
Role in multi-pathway exposure
Irrigation
Animal drinking water
Flow rate for spawning
Temperature
Contaminant load
Contaminant distribution
Transportation
Receives runoff, discharges

TRANSPORTATION

The Middle Columbia Plateau of the Hanford area is the crossroads of the Columbia Plateau, being located half way between the Great Plains and the Pacific Northwest Coast. In the Hanford area major Columbia River tributaries (the Walla Walla, Snake, and Yakima Rivers) flow into this section of the main stem Columbia River. The slow water at the Wallula Gap was one of the few places where the river could be traversed by horses year round including during the spring melt. The river crossing at Wallula provided access to a vast web of trails that crossed the region.

This travel network was utilized by many tribal groups on the Columbia Plateau for thousands of years of foot travel. Early explorers and surveyors utilized and referenced this extensive trail network. Some of the trails have become major highways and rail lines. Part of the ancient trail system, at one time called the Oregon Trail, now Interstate 84 (I-84) is a primary transportation corridor for nuclear waste enters the State of Oregon at Ontario, Oregon. I-84 and a Union Pacific rail line also cross the Umatilla Indian Reservation, including some steep and hazardous grades that are notorious nationally for fog and freezing fog, freezing rain and snow.

Any waste traveling to Hanford will cross many major rivers that are important salmon bearing watersheds including the Snake River, the Burnt River, the Grande Ronde River (Tributaries of the Snake River), the Umatilla River and Columbia River main stem. All of these river systems have threatened and endangered species issues.

Consequence Evaluation

Recommendations for features and measures are presented in a format similar to the Features-Events-Processes (FEPs) method, but reflecting the tribally-important or eco-cultural attributes of each resource. More detail is contained in the text of various other sections.

Resource or Topic	Features, Attributes, Functions, Goods, Services	Measures of loss or benefit (positive or negative movement; degree of movement)
Sitewide Whole	Support services for traditional lifeways; Intact webs of resources, goods, service flows.	Degree of impact (or enhancement) of traditional lifeways by cultural QALY measure (under development); Loss or recovery of individual traditional activities (hunting, gathering, fishing); Loss or recovery of access to areas or media such as groundwater; Security of protection from development or other loss of acreage, resources, or rights.
Landscape	Intact scape for places, names, songs, calendar, other services. Undisturbed physiographic profile.	Loss or preservation of future land use options. Loss or enhancement of conservation potential; Impact on physiographic profile; Loss or recovery of native scapes.
Light, Noise, other aesthetic attributes.	Quiet needed for ceremonies, experiential quality; Darkness needed for same; Buffer of solitude, isolation, safety from intrusion	Degradation or improvement in quiet during transportation and storage; Degradation or improvement in darkness at night during transport and storage; Duration of impacts (lifecycle of operation); Quality of recovery plan after operation is over.
Viewshed	Uninterrupted viewshed	Degrees in visual field without impact x volume of space with natural features; Significance of direction or features of interruption (line of sight).
Air quality, dust	Clean fresh air for life support and quality of life, without toxics, haze, or dust.	More or fewer emissions during construction, transport, operations, closure. Potential for dust resuspension during each phase. Indirect impacts from energy production, ozone emissions, diesel use. Contribution or benefit to PSD area or attainment status. Greenhouse gas emissions.
Soil,	Clean shallow and deep soil; special materials (White Bluffs);	Mass of contaminated soil x degree of exceedance of human health standards x duration of contamination; Undisturbed soil profile; Intactness of cryptogam crust. Access to special materials.
Minerals, gravel, fill, barrier material		Volume and area of clean fill; Quality of resource mitigation actions;

		Minimization of linked resource impacts.
Sediments	Clean sediment	Present or future exceedance of a standard, including tribal health standard; Function in aquatic ecosystems.
Water	Clean, clear, cold water for drinking, ceremonies	Comparison to tribal standards; Gallon-years above detection limit or background.
Terrestrial Ecosystems	Large-scale ecoregion preservation; Support for tribal lifeways components;	Evaluation of NRDA impacts; Preservation of biodiversity; Reduction in ecological stressors; Loss or benefit in contiguity (fragmentation); Formal process for stressor identification; Identification of valued ecological components.
Terrestrial habitats and species	Provision of goods for food, clothing, shelter, ceremonies, mental health, peace of mind, and so on.	Selection of habitat suitability index; Number of impacted ecological acre-years; Consideration of tribally-important species; Number of impacted cultural acre-years; Time to full recovery.
Aquatic Ecosystems	Large-scale ecoregion preservation; Support for tribal lifeways components;	Proximity of action to river; Evaluation of NRDA impacts; Formal process for stressor identification; Identification of valued ecological components.
Aquatic habitats and species, shorelines	Provision of goods for food, clothing, shelter, ceremonies, mental health, peace of mind, and so on.	Impacted number of river-miles Consideration of tribally-important species; Number of impacted cultural acre-years Time to full recovery
Transportation	Features and events related to safety and vulnerability of adjacent areas.	General transportation risks; Routes through tribal lands; Routes near critical habitats, rivers.
Hazardous substances; safety aspects	Baseline (target) is lack of contamination but current condition is tremendous contamination.	Amount of hazardous material imported, generated, stored, or disposed. Amount of hazardous material already on site, both permitted and contaminated.
Human Health	Target is both lack of excessive exposure and active multi-dimensional health promotion.	Individual and community doses and risks using Tribal scenarios, Multigenerational exposures and risk, Consideration of broader health context.
Env Justice	Tribally-appropriate EJ analysis needed to understand disproportionate impacts.	Compliance with Treaty and Trust; Presence of disadvantaged or disproportionally affected groups-Tribes; Eco-spatial basis for tribal EJ analysis.
Economic	Recognition of subsistence economy methods.	Convention analysis for general pop; Impacts to subsistence for tribes.
Cultural Resources	Need evaluation of likelihood of adverse or beneficial impacts to sites, zones, districts.	Amount of activity in TCP, archaeological zone, sacred sites, and NHPA sites.
Energy and Infrastructure	Need lifecycle energy and infrastructure evaluation, including adequacy of closure plans.	Energy requirement Infrastructure footprint Replacement-mitigation of resources Road needs, water and sewer needs. Intensity of security needs
Climate-Energy Values	Targets of energy efficiency, net zero, sustainability, planning for	Net-zero operations Carbon footprint

	climate change.	
Cumulative	Lifeways support	Impacts to health, ecology, cultural, socio-economic, other analyses. Space-time mapping of impacts. Lifecycle impacts and costs. Sitewide totals of hazardous materials, footprints; Impact on the ability to reach a fully restored endstate.

PLATEAU SUBSISTENCE ECONOMY

The eco-cultural system described in other sections includes human, biological, and physical components, and supports the flow of nutritional, religious, spiritual, educational, sociological, and economic services. No component or service is separable from any other. It is well-recognized in anthropology that indigenous cultures include networks of materials interlinked with networks of obligation and trust. Indian people engage in a complex web of exchanges that are the foundation of community and intertribal relationships. Together these networks determine how materials, services, and information flow within the community and between the environment and the community.

In economic terms, this system is called a subsistence economy. An explanation of "subsistence" developed by the EPA Tribal Science Council is as follows.[21]

> "Subsistence is about relationships between people and their surrounding environment, a way of living. Subsistence involves an intrinsic spiritual connection to the earth, and includes an understanding that the earth's resources will provide everything necessary for human survival. People who subsist from the earth's basic resources remain connected to those resources, living within the circle of life. Subsistence is about living in a way that will ensure the integrity of the earth's resources for the beneficial uses of generations to come.

As the National Park Service explains,

> "While non-native people tend to define subsistence in terms of poverty or the minimum amount of food necessary to support life, native people equate subsistence with their culture. It defines who they are as a people. Among many tribes, maintaining a subsistence lifestyle has become the symbol of their survival in the face of mounting political and economic pressures. To Native Americans who continue to depend on natural resources, subsistence is more than eking out a living. The subsistence lifestyle is a communal activity that is the basis of cultural existence and survival. It unifies communities as cohesive functioning units through collective production and distribution of the harvest. Some groups have formalized patterns of sharing, while others do so in more informal ways. Entire families participate, including elders, who assist with less physically demanding tasks. Parents teach the young to hunt, fish, and farm. Food and goods are also distributed through native cultural institutions. Young hunters, gatherers, and fisherman are required to distribute their first catch or harvest throughout the community at a first feast ceremony. It is a ceremony that illustrates the young person is now a provider for his community. Subsistence embodies cultural values that recognize both the social obligation to share as well as the special spiritual

[21] Tribal Science Council (2002). "Subsistence: A Scientific Collaboration between Tribal Governments and the USEPA." Provided by John Persell (jpersell@lldrm.org).

relationship to the land and resources. This relationship is portrayed in native art and in many ceremonies held throughout the year."[22]

The terms "fish, hunt or gather" are shorthand labels that identify some of the most visible activities within this personally self-sufficient or subsistence economy, but they also include a wide range of associated activities such as preparation, processing, using or consuming, and various traditional and cultural activities. A subsistence economy includes people with a wide range of 'jobs' such as food procurement, processing, and distribution; transportation (pasturing and veterinary); botany/apothecary services; administration and coordination (chiefs); education (elders, linguists); governance (citizenship activities, conclaves); finance (trade, accumulation and discharge of obligations); spiritual health care; social gathering organization; and so on. The categories of 'fish, hunt, and gather' each include a full cross section of these activities. This is why 'hunting' is not just the act of shooting and eating an animal, but includes a full cross-section of all the activities that a hunter-specialist does within their community.

The natural resources that are located on Hanford are essential to this system of relationships. When access and resources needed for personal enterprise associated with salmon or any other resource are blocked, there are psychological, nutritional, monetary, social, welfare, self-esteem, and many other impacts that ripple through the entire community. This includes collection and preparation of animals, plants or other raw materials for foods, ceremonial, medicinal, beadwork, hide work, tule mats and many other items along with the associated trading or gifting. The number of individuals that participate in these personal enterprises would greatly increase if access to Hanford is regained and resources restored.

The more concrete aspects of a subsistence lifestyle are important to understanding the degree of environmental contact and how subsistence is performed in contemporary times. Today, there is an integrated interdependence between formal (cash-based) and informal (barter and subsistence-based) economic sectors that exists and must be considered when thinking of economics and employment of tribal people.[23] Today's subsistence family generates may include members engaged in both monetary and subsistent activities as wage-laborers, part-time workers, professional business people, traditional craft makers, seasonal workers, hunters, fishers, artisans, and so on. Today's subsistence utilizes traditional and modern technologies for harvesting and preserving foods as well as for distributing the produce through communal networks of sharing and bartering. This information is used when describing the lifestyle and developing the dietary and direct exposure factors in the "reference Indian" scenario.

[22] National Park Service: http://www.cr.nps.gov/aad/cg/fa_1999/Subsist.htm
[23] http://arcticcircle.uconn.edu/NatResources/subsistglobal.html

Environmental Justice Analysis

DOE analysis of Environmental Justice is uniformly inadequate to address Native American rights, resources, and concerns. At Hanford, Tribal rights, health, and resources are always more impacted than those of the general population due to the traditional lifeways, close connections to the natural and cultural resources, and natural resource trusteeship. Thus, Hanford EJ analyses generally find that beneficial impacts of new missions, such as new jobs or more taxes, accrue to the local non-native community, yet fail to recognize that the majority of negative impacts accrue to Native Americans, such as higher health risk, continuation of restricted access, lack of natural resource improvement, and so on.

President Clinton signed Executive Order 12898 to address Environmental Justice issues and to commit each federal department and agency to "make achieving Environmental Justice part of its mission." According to the Executive Order, no single community should host disproportionate health and social burdens of society's polluting facilities. Many American Indians and Alaskan Natives are concerned about the interpretation of "environmental justice communities" by the U.S. Federal Government in relation to tribes. By this definition, tribes are included as a minority group. However, the definition as a minority group fails to recognize tribes' sovereign nation-state status, identify the federal trust responsibility to tribes, promote economic and social development, or protect the treaty and statutory rights of American Indians and Alaskan Natives.

The identification of rural EJ populations, particularly Native Americans, is not always obvious if an impacted area is not directly on a reservation. If natural resources appertaining to tribes are present, or if cultural resources or traditional sites within a ceded or usual and accustomed are affected, then an "EJ Community" is present. Further, Native American communities face environmental exposures that are greater than those faced by other EJ communities because of their greater contact with the environment that occurs during traditional practices and resource uses.

Thus, the EJ analysis begins with an identification of resources and who uses them, not with county demographics. The first step in evaluating EJ for Native Americans at Hanford is to answer the following questions:

- Do tribal members live in (now or in the past), visit, or use resources from the impacted zone?
- Is the affected area within a tribal historic area, a traditional cultural property, or a tribally important landscape?
- Is the affected area linked ecologically, culturally, visually, or hydrologically to tribal or other EJ population resources or uses?
- Is a tribe a Natural Resource Trustee of the affected resource or lands?

If the answer to any of these questions is positive (the answers are all 'yes' at Hanford), the EJ analysis may proceed with more detailed evaluation.

- *Resource identification and quantification.* Likelihood that cultural resources are present within an impact zone or that the site or resource has tribal or community significance, including sacred sites, historical/ archaeological sites, burial sites, and sites containing important traditional foods, medicines, or cultural materials or with associated cultural uses or history, or general community importance (values recreational areas, physical features by which the community identifies itself, etc.). The quantity of goods and services, or acreage, is quantified in this step.

- *Damage Potential.* The probability and severity of the damage in terms of physical disturbance, existing stressors, contamination, desecration, or degradation. Predicted peak concentrations, time to impact, and resiliency of the affected system are also estimated. This is a vulnerability index that includes aspects of imminence, severity, and resiliency or reversibility. Are tribal exposure factors higher than for a rural residential population?

- *Consequence Potential.* The consequences of the damage on cultural activities, resources or values. This parameter represents the combination of the first two parameters (the probability of a resource being present and the probability of damage). Consequence might be restricted access or loss of future use options, and associated impacts such as loss of place names or a cultural skill associated with loss of access, or interruption of other goods and services. It may also include how much the Trust is fulfilled or not, and the potential for multiple generations to be inequitably affected. [24]

<u>Economic Analysis.</u> Conventional EJ evaluates impacts to local economy and jobs. When Native American resources are impacted, the economic analysis of the subsistence economy is appropriate (see section on Subsistence Economy).

<u>Equity analysis.</u> Evaluating disproportionate impacts to Native Americans involves the following:

- Are the exposures different when the tribal subsistence scenario is used as compared to the rural residential or other non-native scenario? Whose risks are highest?
- Are the natural resources of tribal interest more impacted than those identified by the general population? How important are those resources or places? How many ways are those resources or places important? How large is the impacted area from a tribal perspective?
- Do disparities in impact accumulate over many generations, and do they accumulate at a higher rate in the EJ communities? Have the next seven or more generations been taken into consideration?

[24] Harper, B. and Harris, S. (2001) An Integrated Framework for Characterizing Cumulative Tribal Risks. Posted at www.iiirm.org.; Harper, B.L. and Harris, S.G., "Measuring Risks to Tribal Community Health and Culture," *Environmental Toxicology and Risk Assessment: Recent Achievements in Environmental Fate and Transport, Ninth Volume, ASTM STP 1381,* F. T. Price, K. V. Brix, and N. K. Lane, Eds., American Society for Testing and Materials, West Conshohocken, PA, 1999.

- Is the tribe already vulnerable (at risk) due to existing health disparities, economic disadvantages, higher exposure to other toxics, or existence of several dozen co-risk factors (e.g., poor housing, high unemployment, etc – contact authors for more details)?
- What proportion of tribal members is affected (rather than absolute numbers of people)?
- Is the federal fiduciary Trust obligation being met?
- Is cultural awareness and respect shown equitably to the affected tribes as to the local civic entities?[25]

[25] From: AMERIC&AN INDIAN ALASKAN NATIVE ENVIRONMENTAL JUSTICE ROUNDTABLE Albuquerque, New Mexico August 3-4, 2000; Final Report, January 31, 2001. Edited by the Environmental Biosciences Program, Medical University of South Carolina Press.

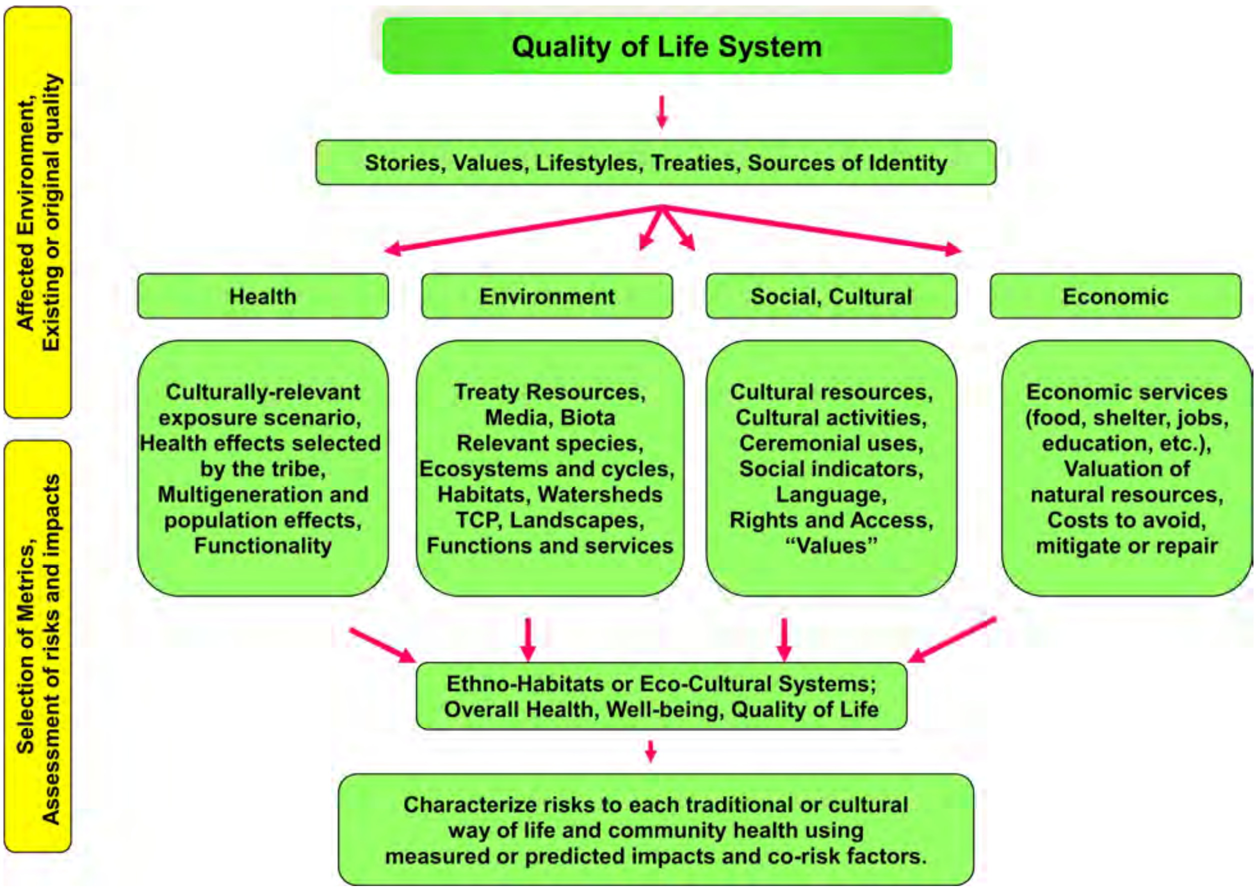
Cumulative Tribal Impacts

There is a growing recognition that conventional risk assessment methods do not address all of the things that are “at risk” in communities facing the prospect of contaminated waste sites, permitted chemical or radioactive releases, or other environmentally harmful situations. Conventional risk assessments do not provide enough information to "tell the story" or answer the questions that people ask about risks to their community, health, resource base, and way of life. As a result, cumulative risks, as defined by the community, are often not described, and therefore the remedial decisions may not be accepted. The full span of risks and impacts needs to be evaluated within the risk assessment framework in order for cumulative risks to be adequately characterized. This is in contrast to a more typical process of evaluating risks to human health and ecological resources within the risk assessment phase and deferring the evaluation of risks to socio-cultural and socioeconomic resources until the risk management phase (National Research Council, 1994, 1996; President's Commission, 1997).

Because many communities need more information than simply risk and dose results, the Environmental Protection Agency developed a Comparative Risk method over a decade ago for adding a community welfare or quality of life component (EPA, 1993). The Comparative Risk field has been developing methods for community Quality of Life (QOL) that combine cultural, social, and economic measures along with aesthetics and any other factor the community identifies as important. The original Manual (EPA 1993) and many Comparative Risk Projects across the country were developed for situations where environmental planning and prioritization was needed. Several of the Comparative Risk Projects have been done by or for tribes such as the Coeur d'Alene Tribe. The QOL metrics identified in that report included the categories of Localized Effects, Economy/ Subsistence, Aesthetics, Fairness and Equity, Trends (annual and multi-year), Degree of Uncertainty, Personal Well-Being, and Spiritual/Moral factors.

We have modified this concept to reflect traditional tribal cultural values as well as secular or social community aspects that apply to suburban as well as to tribal communities (Harper et al., 1995; Harper and Harris, 2000). We envisioned three or four components to the risk assessment process: human health (using appropriate exposure scenarios), ecological health, and socio-cultural/socio-economic health, all of which are elements of the overall eco-cultural system (Figure).

One of the premises of cumulative impact analysis is that risks to the entire tribal community, not just to a maximally exposed individual, must be evaluated. It is not necessarily true that protecting a MEI protects the entire community, or that protecting threatened and endangered species protects an entire ecosystem. Thus, we need to define tribal community health. John M. Last defines individual human health as “a state characterized by anatomic integrity, ability to perform personal, family, work, and community roles; ability to deal with physical, biological, and social stress; a feeling of well-being; and freedom from the risk of disease and untimely death” (Last 1998). This definition is broader than the regulatory approach which tends to equate good health with lack of excessive exposure. Definitions of health and functionality from the public health literature include a variety of medical and functional measures, but may not specifically call out the fact that the survival and well-being of every individual and culture depends on a healthy environment.



When risk assessments take a public health approach to defining community and individual health, they integrate human, ecological, and cultural health into an overall definition of community health and well-being. This broader approach used with risk assessments is adaptable to indigenous communities that, unlike westernized communities, turn to the local ecology for food, medicine, education, religion, occupation, income, and all aspects of a good life (Harris, 1998, 2000; Harper and Harris, 2000). The attributes of the eco-cultural system that support these services are described in affected resources as clean fresh air, clean cold water, unimpacted landscapes, clean wholesome foods, clean healthful medicines, and robust thriving habitats and ecosystems.

Human Health-Related Goods and Services: This category includes the provision of water, air, food, and native medicines. In a tribal subsistence situation, the land provided all the food and medicine that was necessary to enjoy long and healthy lives. From a risk perspective, those goods and services can also be exposure pathways.

Environmental Functions and Services: Ecological risk assessment includes narrow examination of exposure pathways to biota as well as examination of impacts to the quality of ecosystems and the services provided by individual biota, ecosystems, and ecology. Broader than this, intact ecosystems provide many functions such as soil stabilization and the human services that result from them. For example, the function of erosion control or dust reduction would provide a human health service related to asthma reduction. Other environmental functions such as nutrient production and plant cover would provide wildlife services such as shelter, nesting areas, and food for people and animals, which in turn might contribute to the health of a species important to ecotourism.

Social and Cultural Goods, Functions, Services, and Uses: This category includes many things valued by suburban and tribal communities about Introduction particular places or resources associated with intact ecosystems and landscapes. Some values are common to all communities, such as the aesthetics of undeveloped area s, intrinsic existence value, environmental education, and so on. Because social impact assessment and other aspects of community health are unfamiliar to risk assessors, several measure are suggested as follows:

- Impact on societal structure and cohesion (hours per year unavailable for social interaction through loss or reduced value of the resource or area)
- Educational opportunity (lost study areas associated with traditional stories or place names or family history or traditional practices; lost R&D opportunity)
- Integrity of cultural resources: number of sites with any disturbance or contamination, weighted by type and years of history associated with the site.
- Access to traditional lands: degree of restricted access (full restriction to any area or resource evidenced by institutional controls or barriers or reduced visits), fraction of ceremonial resources available relative to original quantity and quality
- Cultural landscape quality: proxy scale (1-10?) with elicited judgment based on original condition; total remaining landscape size without encroachments
- Degree of compliance with Treaty rights (proxy scale based on access, safety, natural and cultural resource integrity and quality, freedom from encroachments, hassle-free exercise of rights)
- Degree of Compliance with Trusteeship obligations (basis for NRDA injury, restoration costs, human use of natural resources
- Preservation of future land use and remedial options (acres of permanent losses including plumes, number of uses no longer viable, number of curies x half-life in irretrievable waste forms)
- Degree of sustainability of the resource, its degree of permanent administrative protection, and associated exercise of Treaty rights of access and use.

Economic Goods and Services: This category includes conventional dollar-based items such as jobs, education, health care, housing, and so on. There is also a parallel non-dollar indigenous economy that provides the same types of services, including employment (i.e., the functional role of individuals in maintaining the functional community and ensuring its survival), shelter (house sites, construction materials), education (intergenerational knowledge required to ensure sustainable survival throughout time and maintain personal and community identity), commerce (barter items and stability of extended trade networks), hospitality, energy (fuel), transportation (land and water travel, waystops, navigational guides), recreation (scenic visitation areas), and economic support for specialized roles such as religious leaders and teachers.

Cumulative Space-Time evaluation often leads to impacts expressed as service-acre-years. This is the most common unit of quantification for habitat-scale natural resource injury. In our experience, it is most logical to use cultural service-acre-years as the ecological dimension of tribal impacts. The environmental perspective held by indigenous communities mean that eco-spatial characteristics should be identified and evaluated for the extent, magnitude and duration of eco-cultural impairment of each service. In a cultural evaluation, specific cultural services associated with a site or resource can be identified by tribal elders or other community leaders according to general importance (thus avoiding trespass on intellectual property and proprietary information). As a simple surrogate for many of these services, the areal extent and duration of contamination (i.e., outer boundary at the detection limit) can be measured and graded accorded to the size of the area degraded or the percent of degradation, and the duration for which each gradation of impact persists can be estimated.

The functions and services provided by an intact and functioning habitat have been receiving increased attention recently (Costanza and Folke 1997, Scott et al. 1998, Daly 1996, Daily 1997). Many of the metrics used in natural resource valuation require spatial and temporal descriptors in addition to concentrations at individual points of compliance because they deal with ecosystems. Many of the concerns raised as cultural risk issues are parallel and also related to areas, ecosystems, or landscapes as well as to the duration of the contamination or the effect. Many of the concepts used in natural resource valuation are applicable to the evaluation of cultural risk and the culturally-related goods and cultural services provided by a healthy environment.

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Human Health Risk Assessment -- Reference Indian

Title: A "Reference Indian" for use in radiological and chemical risk assessment.

Authors: B. Harper and S. Harris (CTUIR)

Two tribal exposure scenarios have been developed for use at Hanford by the Confederated Tribes of the Umatilla Indian Reservation (CTUIR 2004) and the Yakama Nation (Ridolfi 2007) in Hanford risk assessments.[26] Both of these scenarios reflect traditional tribal uses of the lands and resources on the Hanford Site, including hunting, fishing, gathering, and use of the sweat lodge. They are multimedia (air, dust, surface soil, vadose soil, surface water, groundwater, plants, and animals) and are full-time residential scenarios. These scenarios should be used to evaluate risks to tribal members at the location of the proposed federal and any impacted areas, i.e., 'Reference Indian' scenarios. These scenarios can also be considered baseline and inadvertent intruder scenarios, as required by DOE Order 435.1.

EPA is required to identify populations who are more highly exposed; for example, subsistence populations and subsistence consumption of natural resources (Executive Order 12898[27]). EPA is also required to protect sensitive populations.[28] Some of the factors known to increase sensitivity include developmental stage, age (very young and very old), gender, genetics, and health status[29], and this is part of EPA's human health research strategy.[30]

> "The Superfund law requires cleanup of the site to levels which are protective of human health and the environment, which will serve to minimize any disproportionately high and adverse environmental burdens impacting the EJ community"[31].

This scenario reflects an active, outdoor lifestyle with a subsistence economic base. Subsistence food sources include gathering, gardening, hunting, pasturing livestock, and fishing. The forager relies all or in part on native foods and medicines, while the residential farmer relies on domesticated but self-produced foods. Thus, the CTUIR scenario is at the foraging end of the subsistence spectrum, while the residential farmer is at the domesticated end of the subsistence spectrum. Both are active, outdoor lifestyles,

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[26] CTUIR (2004) Exposure Scenario for CTUIR Traditional Subsistence Lifeways. Report prepared by the CTUIR Department of Science & Engineering, October. http://www.hhs.oregonstate.edu/ph/tribal-grant/index.html.
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[27] White House, 1994. Federal Actions To Address Environmental Justice In Minority Populations And Low income Populations: Feb. 11, 1994; 59 FR 7629, Feb. 16, 1994.
[28] *Superfund Exposure Assessment Manual*. EPA/540/1-88/001 OSWER directive 9285.5-1. U.S. Environmental Protection Agency Office of Remedial Response, U.S. Environmental Protection Agency, Washington, D.C. 1988.
[29] http://www.epa.gov/nheerl/research/childrens_health.html
[30] EPA/600/R-02/050, September 2003 (posted at http://www.epa.gov/nheerl/publications/).
[31] http://www.epa.gov/region02/community/ej/superfund.htm

and are consistent with the reasonable maximum exposure (RME) approach to baseline risk assessment. Traditional or subsistence scenarios are similar in format to existing residential recreational, or occupational exposure scenarios, but reflect and are inclusive of tribal cultural and lifestyle activities. They are comprised of:

1. standard exposure pathways and exposure factors (such as inhalation or soil ingestion but with increased environmental contact rates),
2. traditional diets composed of native plants and animals possibly supplemented with a home garden, and
3. unique pathways such as the sweatlodge.

Tribal exposure scenarios pose a unique problem in that much of the specific cultural information about the uses of plants and animals for food, medicine, ceremonial, and religious purposes is proprietary. However, major activities in the generally-recognized activity categories can be described in enough detail to understand the basic frequency, duration, and intensity of environmental contact within each category and habitat.

Table 1. Major Activity Categories

Activity Type	***General Description***
Hunting	Hunting includes a variety of preparation activities of low to moderate intensity. Hunting occurs in terrain ranging from flat and open to very steep and rugged. It may also include setting traplines, waiting in blinds, digging, climbing, etc. After the capture or kill, field dressing, packing or hauling, and other very strenuous activities occur, depending on the species. Subsequent activities include cutting, storing (e.g., smoking or drying), etc.
Fishing	Fishing includes building weirs and platforms, hauling in lines and nets, gaffing or gigging, wading (for shellfish), followed by cleaning the fish and carrying them to the place of use. Activities associated with smoking and constructing drying racks may be involved.
Gathering	A variety of activities is involved in gathering, such as hiking, bending, stooping, wading (marsh and water plants), digging, and carrying.
Sweatlodge Use	Sweatlodge building and repairing is intermittent, but collecting firewood is a constant activity.
Materials and Food Use	Many activities of varying intensity are involved in preparing materials for use or food storage. Some are quite vigorous such as pounding or grinding seeds and nuts into flour, preparing meat, and tanning hides, Many others are semi-active, such as basket making, flintknapping, construction of storage containers, cleaning village sites, sanitation activities, home repairs, and so on.

Once the activities comprising a particular subsistence lifestyle are known, they are translated into a format that is used for risk assessment. This translation captures the degree of environmental contact that occurs through activities and diet, expressed as numerical “exposure factors.” Direct exposure pathways include exposure to abiotic media (air, water, and soil), which can result in inhalation, soil ingestion, water ingestion, and dermal exposure. Indirect pathways refer to contaminants that are incorporated into biota and subsequently expose people who ingest or use them. There are also unique exposure pathways that are not accounted for in scenarios for the general public, but may be significant to people with certain traditional specialties such as pottery or basket making, flint knapping, or using natural medicines, smoke, smudges, paints and dyes.

These activities may result in increased dust inhalation, soil ingestion, soil loading onto the skin for dermal exposure, or exposure via wounds, to give a few examples. While the portals of entry into the body are the same (primarily via the lungs, skin, mouth), the amount of contaminants may be increased, and the relative importance of some activities (e.g., basketmaking, wetlands gathering), pathways (e.g., steam immersion or medicinal infusions) or portals of entry (e.g., dermal wounding) may be different than for the general population.

Together, this information is then used to calculate the direct and indirect exposure factors. This process follows the general sequence:

1. Environmental setting – identify what resources are available;
2. Lifestyle description – activities and their frequency, duration and intensity, and uses of natural resources;
3. Diet (indirect exposure factors);
4. Pathways and media;
5. Exposure factors - Crosswalk between pathways and direct exposure factors; cumulative soil, water and air exposures.

The basic components of the exposure scenario are given below. A great deal of peer-reviewed documentation has been provided to DOE, and the CTUIR and YN scenarios are being used at Hanford.

- Soil ingestion = 400 mg/d for all age groups
- Inhalation rate = 25 m^3/d for adults, with children scaled from the adult value
- Drinking water = 3L/d for adults, with children scaled from the adult value; an additional 1L is ingested during each use of the sweat lodge.
- Based on the ecological resources and on the anthropological literature, the CTUIR developed two relevant diets, one for the Columbia River regions where salmon forms a large percentage of the protein source, and one for upland and mountain areas with resident fish and spawning areas for anadromous species.

CTUIR Columbia River Diet					CTUIR Blue Mountain Diet				
Food Category	***gpd***	**kcal/ 100g**	**kcal/d**	**Percent of calories**	***Food Category***	***gpd***	**kcal/1 00g**	**kcal/d**	**Percent of calories**
Fish	620	175	1085	49%	Fish	142	175	249	11%
Game, large and small	125	175	219	10%	Game, large and small	600	175	1050	48%
Fowl & Eggs	62	200	124	6%	Fowl & Eggs	62	200	124	6%
Bulbs (onions, other)	40	30	12	1%	Bulbs (onions, other)	40	30	12	1%
Berries, Fruits	125	100	125	6%	Berries, Fruits	125	100	125	6%
Other vegetation (lichen, pith, cambium)	40	100	40	2%	Other vegetation (lichen, pith, cambium)	40	100	40	2%
Greens, Tea, Medicines, Spices	133	30	40	2%	Greens, Tea, Medicines, Spices	133	30	40	2%
Honey, Sweete	15	275	41	2%	Honey, Sweete	15	275	41	2%
Seeds, Nuts, Grain	24	500	120	5%	Seeds, Nuts, Grain	24	500	120	5%
Roots, Tubers	400	100	400	18%	Roots, Tubers	400	100	400	18%
TOTALS	***1584***		***2206***		***TOTALS***	***1584***		***2201***	

Human Health Reference Indian ADDENDUM – SOIL INGESTION

Ingestion of soil, sediment, or dust is the result of hand-to-mouth contact, swallowing inhaled dust, mouthing of objects, and ingestion of dirt or dust on food. The recommended subsistence soil ingestion rate of 400 mg/d is based on a review of EPA guidance, soil ingestion studies in suburban and indigenous populations, military, construction and utility worker studies, and local climatic, habitat, and geologic conditions. Components of the traditional lifestyle that contribute to soil ingestion include hunting, gathering, digging roots, processing and eating wild foods, preparing and using natural materials such as basket materials, tending livestock, building and repairing sweat lodges, tending cemeteries, and social gatherings. It also considers occupational activities such as wildlife field work, construction or road work, sample collection, and cultural resource field work.

1.0 EPA Guidance

EPA reviewed studies relevant to suburban populations and published summaries in its Exposure Factors Handbook (1989, 1991, and 1997). In the current iteration of the Exposure Factors Handbook[32], EPA recommends100 mg/d as a mean value for children in suburban settings, 200 mg/day as a conservative estimate of the mean, and a value of 400 mg/day as an "upper bound" value (exact percentile not specified). Most state and federal guidance uses 200 mg/d for children and 100 mg/d for adults in residential or agricultural settings.

A value for an ingestion rate for adult outdoor activities is no longer given in the 1997 Exposure Factors Handbook for adults as "too speculative." However, EPA's soil screening guidance recommends 330 mg/d for a construction or other outdoor worker. Risk assessments for construction workers typically use a rate of 480 mg/d. Some states recommend the use of 1 gram per acute soil ingestion event[33] to approximate a non-average day for children, such as an outdoor day.

2.0 Military Guidance

The US military assumes 480 mg per exposure event[34] or per field day (Technical Guide 230).[35] Department Of Defense (2002)[36] recommendations for certain activities such as construction, landscaping, or other field activities is 480 mg/day. During deployment, DOD assumes that half

[32] Environmental Protection Agency. 1997. Exposure Factors Handbook. Volumes I, II, III. U.S. Environmental Protection Agency, Office of Research and Development. EPA/600/P-95/002Fa.

[33] MADEP (1992). Background Documentation For The Development Of An "Available Cyanide" Benchmark Concentration. http://www.mass.gov/dep/ors/files/cn_soil.htm

[34] http://www.gulflink.osd.mil/pesto/pest_s22.htm, citing US Environmental Protection Agency, Office of Research and Development, Exposure Factors Handbook, Volume I, EPA/600/P-95/002a, August 1997 as the basis for the 480 mg/d.

[35] USACPPM TG 230A (1999). Short-Term Chemical Exposure Guidelines for Deployed Military Personnel. U.S. Army Center for Health Promotion and Preventive Medicine. Website: http://www.grid.unep.ch/btf/missions/september/dufinal.pdf

[36] Reference Document (RD) 230, "Exposure Guidelines for Deployed Military" A Companion Document to USACHPPM Technical Guide (TG) 230, "Chemical Exposure Guidelines for Deployed Military Personnel", January 2002. Website: http://chppm-www.apgea.army.mil/desp/; and http://books.nap.edu/books/0309092213/html/83.html#pagetop.

of a soldier's time is spent in thes higher-contact activities. The UN Balkans Task Force assumes that 1 gram of soil can be ingested per military field day[37].

3.0 Studies in suburban or urban populations

Written knowledge that humans often ingest soil dates back to the classical Greek era. Soil ingestion has been widely studied from a perspective of exposure to soil parasite eggs and other infections. More recently, soil ingestion was recognized to be a potentially significant pathway of exposure to contaminants. Several early studies estimated intakes by children. Estimates based on observation of 'sticky sweets' (Day et al., 1975), outdoor activities (Hawley, 1985), or camping (Van Wijnen et al., 1990). Other studies used tracer elements (Binder, et al., 1986; Clausing et al., 1987; Thompson and Burmaster, 1991; Calabrese et al., 1989; Stanek and Calabrese (1995a, 1997). These studies estimated a wide range of soil ingestion rates.

Pica (ingestion of more than 5000 mg/d) is generally thought of as a pediatric condition. ATSDR estimates that between 10 and 50% of children may exhibit pica behavior at some point. Regulatory guidance recommends using a soil ingestion rate of 5 or 10g/d for pica children. Some examples are:

(1) EPA (1997) recommends a value of 10g/d for a pica child.
(2) Florida recommends 10g per event for acute toxicity evaluation[38].
(3) ATSDR uses 5 g/day for a pica child[39].

4.0 Studies in Indigenous Populations

Studies of soil ingestion in indigenous populations have largely centered on estimates of past exposure (or dose reconstruction) of populations affected by atomic bomb tests. Haywood and Smith (1992) estimated potential doses to aboriginal inhabitants of the Maralinga and Emu areas of South Australia by considering the number of hours per week spent in sleeping, sitting, hunting or driving, cooking or butchering, and other activities. They noted that virtually all food, whether of local origin or purchased, has some dust content by the time of consumption due to methods of preparation and the nature of the environment. They recommend a soil intake of 1 to 10 gpd. Other authors have used estimates of 0.5 or 1 gpd in other indigenous populations such as the Marshall Islanders (Sun and Meinhold, 1997; LaGoy, 1987). Simon (1998) recommended using a soil ingestion rate for indigenous people in hunters/food gathering/nomadic societies of 1g/d in wet climates and 2 g/d in dry climates, and 3 g/d for all indigenous children, and 5 g/d if geophagia is common.

These estimates are supported by studies of human coprolites from archaeological sites. For instance, Nelson (1999) noted that human coprolites from a desert spring-fed aquatic system included obsidian chips (possibly from sharpening points with the teeth), grit (pumice and quartzite grains from grinding seeds and roots), and sand (from mussel and roots consumption). Her conclusions are based on finding grit in the same coprolites as seeds, and sand in the same

[37] UNEP/UNCHS Balkans Task Force (BTF) (1999). The potential effects on human health and the environment arising from possible use of depleted uranium during the 1999 Kosovo conflict. www.grid.unep.ch/btf/missions/september/dufinal.pdf

[38] Proposed Modifications To Identified Acute Toxicity-Based Soil Cleanup Target Level, December 1999, www.dep.state.fl.us/waste/quick_topics/ publications/wc/csf/focus/csf.pdf .

[39] For Example: El Paso Metals Survey, Appendix B, www.atsdr.cdc.gov/HAC/PHA/elpaso/epc_toc.html.

coprolites as mussels and roots. She concludes that “the presence of sand in coprolites containing aquatic root fibers suggests that the roots were not well-cleaned prior to consumption.

5.0 Geophagia

Despite the limited awareness of geophagia in western countries, the deliberate consumption of dirt, usually clay, has been recorded in every region of the world both as idiosyncratic behavior of isolated individuals and as culturally prescribed behavior (Abrahams, 1997; Callahan, 2003; Johns and Duquette, 1991; Reid, 1992). It also routinely occurs in primates (Krishnamani and Mahaney (2000). Indigenous peoples have routinely used montmorillonite clays in food preparation to remove toxins (e.g., in acorn breads), as condiments or spices, or to aid digestion (e.g., kaolin clay in Kaopectate) (Reid, 1992; Krishnamani and Mahaney, 2000). Callahan (2003) also suggests that certain soils may reduce parasite loads (demonstrated in monkeys) through immune enhancement, and clays with aluminum salts may have an adjuvant effect as they do in commercial vaccines.

Pregnancy is the most common occasion for eating dirt in many societies, especially kaolin and montmorillonite clays in amounts of 30g to 50g a day. In some cultures, well-established trade routes and clay traders make rural clays available for geophagy even in urban settings. Clays from termite mounds are especially popular among traded clays, perhaps because they are rich in calcium (Callahan, 2003; Johns and Duquette, 1991). In countries such as Uganda where modern pharmaceuticals are either unobtainable or prohibitively expensive, ingested soils may be very important as a mineral supplement, particularly iron and calcium (Abrahams, 1997; Krishnamani and Mahaney, 2000; Johns and Duquette, 1991).

7.0 Data from dermal adherence

Dermal adherence of soil is generally studied in relation to dermal absorption of contaminants, but soil on the hands and face can be ingested, as well. Kissel, et al. (1996) included reed gatherers in tide flats. “Kids in mud” at a lakeshore had by far the highest skin loadings. Reed gatherers were next highest, followed by farmers and rugby players and irrigation installers. Holmes et al. (1999) studied a variety of occupations. Farmers, reed gatherers and kids in mud had the highest overall skin loadings, followed by equipment operators, gardeners, construction, and utility workers. Archaeologists and several other occupations had somewhat lower skin loadings.

Grain size affects adherence and tactile responses to ingested soil. Particles below the sand-silt size division (0.075 mm) adhering more than smaller sizes (see EPA, 1992[40] for more details). Sieving is recommended, and data for particle size <0.044 cm (RAGSe, App. C, Table C-4).

8.0 Data from washed or unwashed vegetables.

Direct soil ingestion also occurs via food, for example from dust blowing onto food (Hinton, 1992), residual soil on garden produce or gathered native plants, particles on cooking utensils, and so on. Beresford and Howard (1991) found that soil adhesion to vegetation was highly

[40] EPA (1992). Interim Report: Dermal Exposure Assessment: Principles And Applications. Office of Health and Environmental Assessment, Exposure Assessment Group. /600/8-91/011B

seasonal, being highest in autumn and winter, and is important source of deposited radionuclides to grazing animals.

9.0 Subsistence lifestyles and rationale for soil ingestion rate

The derivation of the soil ingestion rate is based on the following points:

- The foraging-subsistence lifestyle is lived in close contact with the environment.
- Plateau winds and dust storms are fairly frequent. Incorporated into overall rate, rather than trying to segregate ingestion rates according to number of high-wind days per year because low-wind days are also spent in foraging activities.
- The original Plateau lifestyle – pit houses, caches, gathering tules and roots - includes processing and using foods, medicines, and materials. This is considered but not as today's living conditions.
- The house is assumed to have little landscaping other than the natural conditions or xeriscaping, some naturally bare soil, a gravel driveway, no air conditioning (more open windows), and a wood burning stove in the winter for heat.
- All persons participate in day-long outdoor group cultural activities at least once a month, such as pow-wows, horse races, and seasonal ceremonial as well as private family cultural activities. These activities tend to be large gatherings with a greater rate of dust resuspension and particulate inhalation. These are considered to be 1-gram events or greater.
- 400 mg/d is based on the following:
    1. 400 mg/d is the upper bound for suburban children (EPA); traditional or subsistence activities are not suburban in environs or activities
    2. This rate is within the range of outdoor activity rates for adults (between 330 and 480); subsistence activities are more like the construction, utility worker or military soil contact levels. However, it is lower than 480 to allow for some low-contact days.
    3. The low soil-contact days are balanced with many 1-gram days and events (as suggested by Boyd et al., 1999) such as root gathering days, tule and wapato gathering days, pow wows, rodeos, horse training and riding days, sweat lodge building or repair days, grave digging, and similar activities. There are also likely to be many high or intermediate-contact days, depending on the occupation (e.g., wildlife field work, construction or road work, cultural resource field work).
    4. This rate does not account for pica or geophagy
    5. Primary data is supported by dermal adherence data in gatherers and 'kids in mud'. Tule and wapato gathering are kid-in-mud activities
    6. This rate includes a consideration of residual soil on roots (a major food category) through observation and anecdote, but there is no quantitative data.

Human Health Reference Indian ADDENDUM - INHALATION RATE

Many risk assessments use the EPA default value of $20m^3/d$ (EPA 1997), which reflects contemporary lifestyles of the general population. However, EPA recognizes that inhalation rates may be higher in certain populations, such as athletes or outdoor workers, because levels of activity outdoors may be higher over long time periods. "If site-specific data are available to show that subsistence farmers and fishers have higher respiration rates due to rigorous physical activities than other receptors, that data may be appropriate."[41] Such subpopulation groups are considered 'high risk' subgroups.[42]

In order to develop inhalation rates more appropriate to traditional lifestyles, we evaluated the approach that uses specific activity levels to estimate short-term and long-term inhalation rates. Several examples of this approach are:

- EPA's National Air Toxics Assessment (homepage: http://www.epa.gov/ttn/atw/nata/natsa3.html) uses the CHAD database to estimate national average air toxics exposures by selecting a series of single day's patterns to represent an individual's annual activity pattern.
- The California Air Resources Board (CARB, 2000) reviewed ventilation rates for many activities in the CHAD database and concluded that 20 m^3/d represents an 85th percentile of typical adult activity lifestyles reflecting 8 hours sleeping and 16 hours of light activity with little moderate or heavy activity.
- In their technical guidance document, "Long-term Chemical Exposure Guidelines for Deployed Military Personnel," the US Army Center for Health Promotion and Preventive Medicine (USACHPPM) recommended an inhalation rate of 29.2 m^3/d for US Armed Service members that includes 8 hours of moderate duties.[43]
- EPA used 30 m^3/day for a year-long exposure estimate for the general public at the Hanford Superfund site in Washington state, based on a person doing 4 hours of heavy work, 8 hours of light activity, and 12 hours resting.[44]
- The DOE's Lawrence Berkeley Laboratory also used 30 m^3/d: "the working breathing rate is for 8 hours of work and, when combined with 8 hours of breathing at the active rate and 8 hours at the resting rate, gives a daily equivalent intake of 30 m^3 for an adult."[45]
- The Rocky Flats Oversight Panel recommended using 30 m^3/d.[46]

Using EPA guidance on hourly inhalation rates for different activity levels, a reasonable inhalation rate for an average tribal member's active lifestyle is an average rate of 26.2 m^3/d, based on 8 hours sleeping at 0.4 m^3/hr, 2 hours sedentary at 0.5 m^3/hr, 6 hours light activity at 1 m^3/hr, 6 hours moderate activity at 1.6 m^3/hr, and 2 hours heavy activity at 3.2 m^3/hr. Unlike most other exposure factors, which are upper bounds, the inhalation rate is an average rate, so to be consistent with national methodology, we have rounded the rate down to 25 m^3/day.

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[41] EPA (OSWER) "Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities, Support Materials Volume 1: Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities" page 6-4, at (http://www.epa.gov/earth1r6/6pd/rcra_c/protocol/volume_1/chpt6-hh.pdf)

[42] Exposure Factors Handbook, 1997, Volume 1. page 5-24

[43] http://www.gulflink.osd.mil/particulate_final/ particulate_final_s06.htm and http://www.gulflink.osd.mil/pm/pm_en.htm.

[44] "Report of Radiochemical Analyses for Air Filters from Hanford Area" Memorandum from Edwin L. Sensintaffar, Director of the National Air and Radiation Environmental Laboratory to Jerrold Leitch, Region 10 Radiation Profram Manager (http://yosemite.epa.gov/R10/AIRPAGE.NSF/webpage/Hanford+Environmental+Perspective)

[45] (www.lbl.gov/ehs/epg/tritium/TritAppB.html)

[46] RAC (Risk Assessment Corporation). 1999. *Task 1: Cleanup Levels at Other Sites. Rocky Flats Citizens Advisory Board, Rocky Flats Soil Action Level Oversight Panel.* RAC Report No. 3-RFCAB-RFSAL-1999' http://www.itrcweb.org/Documents/RAD-2.pdf

The estimate of the activity levels associated with traditional lifestyles is based on anthropological studies, ethnographic literature on foraging theory and hunting-gathering lifestyles, and confirmatory interviews with Tribal members. The inhalation rate reflects a wide range of traditional indoor and outdoor activities, including (a) youth who are learning traditional subsistence skills, (b) adults who hunt, gather, fish, and work in environmental management occupations, and (c) elders who gather plants and medicines, prepare and use them, and teach traditional activities. At present, it is not possible to extrapolate directly from the CHAD database from window washing, for example, to hide scraping; research is underway to fill this data gap using heart rate monitors keyed to respiration rate during specific traditional activities.

Finally, there may be some ethnic specificity in the link between metabolic and inhalation rates such as thrifty genotype(s) and oxidation adiposity patterns (Goran, 2000; Fox et al., 1998; Muzzin et al., 1999; Rush et al., 1997; Saad et al., 1991; Kue Young et al., 2002), as well as ethnic differences in spirometry (Crapo et al., 1988; Lanese et al., 1978; Mapel et al., 1997; Aidaraliyev et al., 1993; Berman et al., 1994). There are several stress response genes that enable indigenous populations to respond to environmental stresses and to the rapid transition between extremes, including feast and famine, heat and cold, disruption in circadian rhythms, dehydration, seasonality, and explosive energy output or rapid transitions between minimum and maximum exercise and $VO2_{max}$ (Kimm et al., 2002; Snitker et al., 1998). This may affect inhalation rate, but at present this remains a testable hypothesis.

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Wanapum Overview and Perspectives

Developed During Tribal Narrative Workshop (June 15-19, 2009)

Hanford, WA

January 2010

Wanapum Introduction

Before the Columbia, there was Chiwana. Wanapum, which means the River People, are part of the river and the land through which it flows. They are a part of the people who lived there and those who continue to live along the river's shores. Coyote created the river in his efforts to care for the Wanapum. The Columbia is the river of life and myth. The Wanapum people have been supported by the river's bounty for thousands of years – honor the spirit of the river. Teachings of the Wanapum tell all who will listen to be responsible to the land, to the creatures that live within the water and on the land, to the ancestors that are buried in the land, and to those who have not yet been born. The Wanapum are the caretakers responsible for the land and passing on the teachings of the natural world to the next generation.

The Wanapum live on the Columbia River; it has been their home from time immemorial. As Indian people, they were put there to protect and preserve the land and river for themselves, their children, and those not yet born. As spiritual people the Wanapum continue to practice their religion. Friendly, understanding, and respectful of all people and things, the Wanapum only wish to live in peace. Through strenuous and prudent efforts the Wanapum have successfully built relationships with federal, state, and local agencies. The respect, trust, and mutual understanding that results from these relationships allow the Wanapum to actively participate in decision-making processes that affect their responsibilities to care for all things put here by the Creator.

Wanapum Background

The Wanapum made their homes along the Columbia River in an area known as the Columbia Plateau. They traditionally lived in small villages. The villages included mat lodges made from tules for housing and a longhouse for spiritual ceremonies.

Priest Rapids became a central location for the Wanapum because the location offered optimal fishing conditions. The Wanapum traveled regularly up and down the coast of the Columbia River for food and other resources. Their proximity to the river allowed the Wanapum to catch plentiful salmon. The Wanapum learned the ways of the land and discovered hundreds of ways to create medicines and other remedies from plants.

In 1870, an outbreak of smallpox left the Wanapum with just 300 living members. Within 30 years many of the Wanapum people became members of nearby reservations because of health, family connections, or employment opportunities. In 1930, the Wanapum population reached an all-time low with just 30 to 50 members. The Wanapum managed to preserve their traditions throughout the 1940s.

In the decades that followed, the Wanapum experienced various impositions on their land. The construction of the Hanford Plutonium Plant and the U.S. Army Training Center took nearly 1,000 square miles of Wanapum land. The Priest Rapid Dam and the Wanapum Dam forever changed their fishing and living routines.

The self-sufficient Wanapum chose to remain an unrecognized tribe, meaning they do not have obligations to nor receive support from the U.S. government. The Wanapum frequently join forces with other recognized tribes to further common causes. They work within their own group to preserve their own culture and traditions. The survival of the Wanapum culture is evidence of the determination and strength of the people.

Tribal Values

In essence, tribal values are intent on protecting, preserving and perpetuating resources for the sake of traditional and cultural existence. Each resource had a time or a season on when to gather, store, and properly use. This harmony and connection to the land is our culture and is captured and passed down in our oral history. It is imperative that materials available for use in from Hanford for a substance lifestyle be uncontaminated. Once resources become contaminated or lost then part of our connection to the land and part of our culture is lost.

General Comments

- We assume that all of Hanford will be eventually restored and protected[1].

- Any new proposals at Hanford should at a minimum utilize the "Hanford Site NEPA Guidance Document" as a primary reference for creating any NEPA document, especially the Affected Environment section.

- We expect to be proactively engaged by DOE during the scoping and alternatives development for Hanford proposals. Tribes are part trustees of Hanford and should be informed and have opportunity to be engaged beyond the NEPA public involvement process.

- NEPA documents at Hanford need to include sections describing Viewscapes and Soundscapes that are important to our tribal culture.

- Socioeconomic Section of a NEPA EIS should be separated into sections *Social* and *Economics*.

- A GTCC repository at Hanford is a conflicting mission with present DOE cleanup efforts.

[1] FR Volume 36--Number 23: 1271-1329; Monday, June 12, 2000

- Salmon and water are important cultural resource that are intertwined with the subsistence lifestyle of affected tribes.

- Affected Tribes and the trust responsibilities of DOE and other federal agencies (NEPA 18, section 6) need to be clearly described in the GTCC EIS. It needs to include tribal aboriginal rights, treaty rights and Executive Orders 12898, 13007, and 13175.

- Climate is simply not a snapshot in time. Archeological evidence supports tribal oral history that speaks of a time when the region had extreme climate and weather changes. We have stories of volcanic activity, glacial periods, times of great floods, and what we know today. A GTCC repository should consider climate change and extreme weather changes expected over 10,000 year period.

- We recommend that quiet zones and time periods should be identified for known Native American ceremonial locations on and near the Hanford Reservation.

- Not all ceremonial sites at Hanford have been shared with DOE beyond Gable Mountain and Rattlesnake Mountain.

- Hanford in general is composed of sandy soils that do not retain water very well and consideration must be made for the potential long-term moisture percolation affecting any underground structure.

- Some soils have medicinal purposes for healing like the White Bluffs area. Care should be taken to recognize those with such properties.

- Proposal of any new risk of further contamination of the Columbia River system will receive high priority review.

- The affected environment needs to fully describe and graphically illustrate known groundwater plumes surrounding the Area of Potential Effect (APE). Contamination in the ground water is the greatest long-term threat at the Hanford site. The groundwater section needs to also identify where groundwater and its contaminant are not fully characterized. This uncertainly and limited technical ability to remediate the vadose zone and ground water puts the Columbia River at increased risk.

- Indian health is sustained through a balanced traditional lifestyle. Any contamination or restriction is a negative affect on tribal health. We are against adding any waste to the Hanford site that adds risk to tribal health.

- "Reference Indian" scenarios should be considered in any risk assessment development. These scenarios can also be considered inadvertent intruder scenarios, as required by DOE Order 435.1.

- Biodiversity within National Monument include rare plant and wildlife species.

- We expect DOE to comply with Comprehensive Conservation Plan (CCP).

- Columbia River Tribes have created a salmon recovery plan called the Wy-Kan-Ush-Mi Wa-Kish-Wit (Spirit of the Salmon). We expect that DOE's potential placement of a repository to not conflict with elements of this Plan.

- A tribal subsistence economy needs to be described in terms of long-term "personal" enterprise. ("Personal enterprise" is the term for self and community reliance on the environment for existence as opposed to employment or modern economies.)

- The potential for large returning salmon runs should be considered part of potential changes to the economy. A goal of tribes, federal and state governments, is to dramatically improve salmon returns in the Columbia River.

- Tribal employment at Hanford and surrounding area should be part of the employment description.

- Environmental justice (EJ) in Indian country needs to be better defined to clarify sovereign nation-state status, federal trust responsibility to tribes, and include treaty and aboriginal rights.

- We maintain that aboriginal rights allow for the protection, access to, and use of open and unclaimed lands of the Hanford Reservation when human health and safety are not in jeopardy.

- There are sites or locations within the existing Hanford reservation boundary that should be considered for special protections or set aside for tribal ceremonial uses.

- We propose that ceremonial sites be placed in co-stewardship with DOE, USFWS and affected tribes for long-term management and protection.

- The Comprehensive Land Use Plan (CLUP) has institutional controls (ICs) that limit present and future use by Native Americans. These ICs should be described as part of the affected environment. Any new proposals that extend, expand, or create new IC should be considered cumulative impacts to native people.

- The 50-year management time horizon of the CLUP and its land use designations are often incorrectly assumed to be permanent designations. CLUP landuse designations and their boundaries can be changed at the discretion of DOE with recommendations by Hanford stakeholders, including affected tribes.

- According to the *American Indian Religious Freedom Act*, tribal members have a protected right to conduct religious ceremonies at locations on public lands where they are known to have occurred.

- *Executive Order 13007* states that Tribal members have the right to access ceremonial sites.

- DOE and USFWS must maintain trails or roads that are presently providing access to known ceremonial sites.

- New culturally significant findings are required to be added to the list of sites and locations with special cultural protections that override any land use designation of the CLUP or other documents.

- Shipment routes need to be described for proposed Hanford site. Travel routes will cross many major rivers and salmon-bearing watersheds that are important to Tribes.

- All things of the natural environment we recognize as cultural resources. Nature provides for a subsistence live style, and thus, the daily interaction with the land is our culture, and our foundation of our religious beliefs.

- *Cultural Landscapes* have been defined by the World Heritage Committee as distinct geographical areas or properties uniquely representing the combined work of nature and of man.

- There are three overlapping cultural landscapes that overlie the natural landscape at Hanford. The first is the tribal archeological and ethnographic record spanning more than 10,000 years. The second was created by early settlers, and the third by the Manhattan Project. DOE is presently removing much of the Manhattan landscape to a more *natural* state (restoration and conservation).

- We recognize culturally significant viewscapes as described in the Hanford Cultural Resources Management Plan. Special protections and visit considerations should be given to tribal elders and youth to maintain and accommodate educational opportunities of tribal cultural and ceremonial activities.

- A proposed Repository must consider local DOE strategies of Hanford recovery, including the 200 Area 7th ROD and the 2015 Vision for the River Corridor. These long-term recovery strategies must be part of the NEPA evaluation for a repository.

- The APE for the cultural landscape should include areas across the lower Columbia Plateau from the Wallula Gap to the Sentinel Gap.

- There are many cemeteries, ceremonial sites, and areas of spiritual significance within the Hanford Boundary. Not all sites are known to DOE.

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APPENDIX H:

PUBLIC DISTRIBUTION FOR THE DRAFT AND FINAL ENVIRONMENTAL IMPACT STATEMENT FOR THE DISPOSAL OF GREATER-THAN-CLASS C (GTCC) LOW-LEVEL RADIOACTIVE WASTE AND GTCC-LIKE WASTE

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David Haught	B.S., Electrical Engineering, M.S. Information Technology; 20 years of experience in nuclear waste management and disposal	DOE Senior Technical Advisor
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Argonne National Laboratory		
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Bruce Biwer	Ph.D., Chemistry; 22 years of experience in environmental assessment and transportation risk analysis	Transportation, accidents, facility design, inventory database
Brian Cantwell	B.S., Forestry, 29 years of experience in cartography and GIS	Environmental justice maps and tables
Young-Soo Chang	Ph.D., Chemical Engineering; 24 years of experience in air quality and noise impact analysis	Climate, air quality, noise
Shih-Yew Chen	Ph.D., Nuclear Engineering; 24 years of experience in environmental assessment, waste and risk analysis	Senior technical advisor
Jing-Jy Cheng	Ph.D., Polymer Science and Engineering; 22 years of experience in computer model development and applications for human health and ecological risk assessments	RESRAD model, human health impacts
Deborah Elcock	B.A., Mathematics; M.B.A.; 21 years of experience in regulatory analysis	Applicable laws, regulations, and other requirements
Stephen Folga	Ph.D., Gas Engineering; 16 years of experience in technology assessment and waste management	Technology assessment, accident assessment, resource materials
Elizabeth Hocking	J.D.; 21 years of experience in environmental and energy policy analysis	Applicable laws, regulations, and other requirements
Timothy Klett	M.S., Computer Science; 12 years of experience in software development and data management	Inventory database

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John Peterson	M.S., Nuclear Engineering; Certified Health Physicist (CHP); 31 years of experience in nuclear engineering and health physics	Technical coordinator, waste inventory, human health impacts
Mary Picel	M.S., Environmental Health Sciences; 26 years of experience in environmental assessment, risk assessment, and waste management	Project manager, document manager, human health impacts, waste management, cumulative impacts
Albert Smith	Ph.D., Physics; 34 years of experience in environmental assessment	Climate, air quality, noise
David Tomasko	Ph.D., Civil Engineering; 28 years of experience in hydrogeology and fluid mechanics	Water resources
William Vinikour	M.S. and B.S., Biology with environmental emphasis; 37 years of experience in ecological research and environmental assessment	Ecology, land use

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