FINAL ENVIRONMENTAL IMPACT STATEMENT
ON THE
DISPOSAL OF DECOMMISSIONED, DEFUELED CRUISER,
OHIO CLASS,
AND
LOS ANGELES CLASS NAVAL REACTOR PLANTS

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United States
Department of the Navy

COVER SHEET

RESPONSIBLE AGENCIES:
Lead Federal Agency: U.S. Department of the Navy
Cooperating Agency: U.S. Department of Energy

By participating as a cooperating agency in this Environmental Impact Statement, the Department of Energy expects to be able to adopt this Environmental Impact Statement, if appropriate, to fulfill its environmental review obligations under the National Environmental Policy Act.

TITLE: Final Environmental Impact Statement on the Disposal of Decommissioned, Defueled cruiser, OHIO Class, and LOS ANGELES Class Naval reactor plants.

ABSTRACT: This statement describes in detail the preferred alternative - land burial of the entire reactor compartment at the Department of Energy Low Level Waste Burial Grounds at Hanford, Washington; the "no-action" alternative - protective waterborne storage for an indefinite period; disposal and reuse of subdivided portions of the reactor plant; and indefinite storage above ground at Hanford. Other alternatives examined in limited detail are sea disposal; land disposal at other sites; and permanent above ground disposal at Hanford.

Location of U.S. Department of Navy facilities considered for implementation of the preferred alternative: Puget Sound Naval Shipyard, Bremerton, Washington.

Location of U.S. Department of Energy facilities considered for implementation of the preferred alternative: Hanford Site, Benton County, Franklin County, and Grant County, Washington.

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SUMMARY

This Environmental Impact Statement analyzes the alternate ways for disposing of decommissioned, defueled reactor compartments from U.S. Navy nuclear-powered cruisers, (BAINBRIDGE, TRUXTUN, LONG BEACH, CALIFORNIA Class, and VIRGINIA Class) and LOS ANGELES Class, and OHIO Class submarines. A disposal method for the defueled reactor compartments is needed when the cost of continued operation is not justified by the ships' military capability or when the ships are no longer needed. After a nuclear-powered ship no longer has sufficient military value to justify continuing to maintain the ship or the ship is no longer needed, the ship can be: (1) placed in protective storage for an extended period followed by permanent disposal or recycling; or (2) prepared for permanent disposal or recycling. The alternatives examined in detail are the preferred alternative of land burial of the entire defueled reactor compartment at the Department of Energy Low Level Waste Burial Grounds at Hanford, Washington; the no-action alternative - protective waterborne storage for an indefinite period; disposal and reuse of subdivided portions of the reactor compartments; and indefinite storage above ground at Hanford. No new legislation is required to implement any of these alternatives. Several other alternatives are also examined in limited detail. These alternatives include sea disposal; land disposal at other sites; and permanent above ground disposal at Hanford.

In all of the alternatives considered in this Environmental Impact Statement there would be no spent nuclear fuel left in the reactor compartments. All the spent nuclear fuel would be removed before disposal. Management of the spent nuclear fuel is addressed in a separate Department of Energy National Environmental Policy Act (NEPA) document, U. S. Department of Energy Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Environmental Impact Statement, (DOE, 1995) for which the Navy is a cooperating agency. Nevertheless, there would be some other radioactive materials left within the reactor compartments. Therefore, this Final Environmental Impact Statement evaluates disposal of the reactor compartments after all the spent nuclear fuel has been removed. Recycling of the non-radioactive portion of nuclear-powered ships has been evaluated in an Environmental Assessment, and the Navy concluded that there was no significant environmental impact associated with the recycling process (USN, 1993a). Types of U.S. Navy nuclear-powered ships that are not expected to be decommissioned in the next 20 years (e.g., aircraft carriers, SEAWOLF Class submarines) are not included in this Final Environmental Impact Statement.

Navy submarine reactor plants constructed prior to the USS LOS ANGELES (SSN 688) (referred to as pre-LOS ANGELES Class submarines) share many common design characteristics with reactor plants from cruisers, OHIO Class submarines, and LOS ANGELES Class submarines. Pre-LOS ANGELES Class submarine reactor compartments are currently being disposed of at the Department of Energy Hanford Site in Eastern Washington, by Puget Sound Naval Shipyard in Bremerton, Washington consistent with the Record of Decision on disposal of decommissioned, defueled Naval submarine reactor plants (USN, 1984b). Because of the commonality of design with submarine reactor compartments from pre-LOS ANGELES Class submarines, it is feasible to use the same basic disposal method for disposal of reactor compartments from cruisers, LOS ANGELES Class submarines and OHIO Class submarines. The method currently being used for disposal of pre-LOS ANGELES Class reactor compartments, has been demonstrated to be cost effective, minimizes exposure to workers and the public, and has been used to safely package and ship over 40 reactor compartments from Puget Sound Naval Shipyard to the Hanford site for

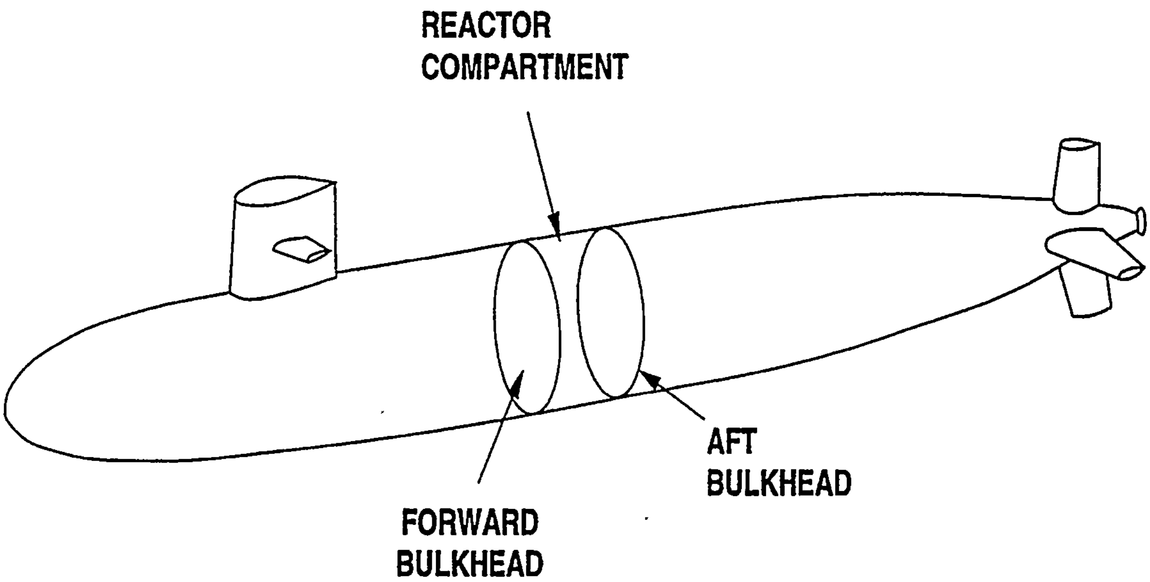

Figure S.1. Typical Submarine Reactor Compartment Location

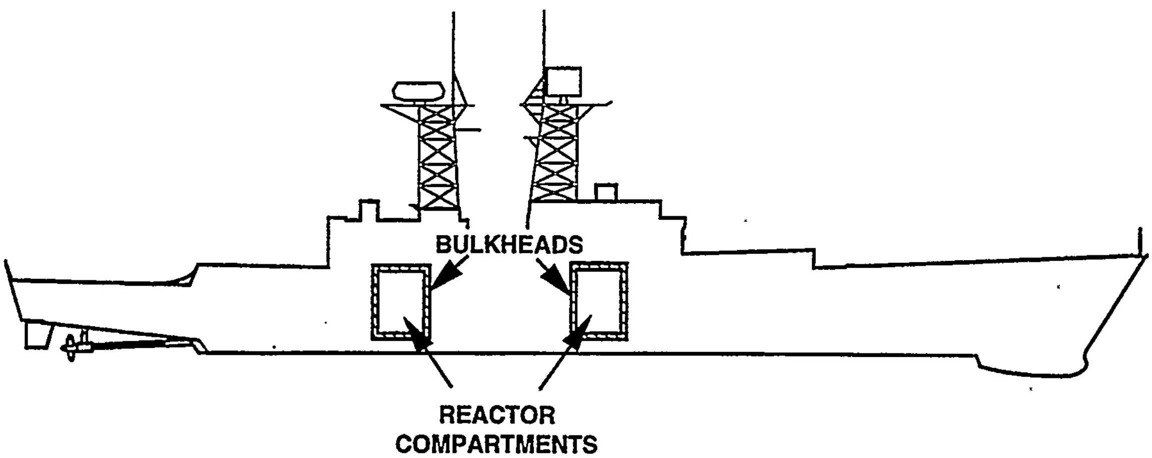

Figure S.2. Typical Cruiser Reactor Compartment Location

disposal. The Navy has determined that this same basic method is the preferred alternative for disposal of reactor compartments from cruisers, LOS ANGELES Class submarines and OHIO Class submarines when compared to the other alternatives evaluated in this EIS.

1. Background

As of the end of 1994, the U.S. Navy had 99 nuclear-powered submarines and 13 nuclear-powered surface ships in operation. Today, over 40% of the Navy's principal combatants are nuclear-powered.

A nuclear-powered ship is constructed with the nuclear power plant inside a section of the ship called the reactor compartment. Figure S.1 shows a typical submarine with the location of the reactor compartment identified. Figure S.2 shows a typical cruiser with the location of the reactor compartments identified. The components of the nuclear power plant include a high-strength steel reactor vessel, heat exchanger(s) (steam generator), and associated piping, pumps, and valves. Each reactor plant contains over 100 tons of lead shielding, part of which is made radioactive by contact with radioactive material or by neutron activation of impurities in the lead.

Before a ship is taken out of service, the spent fuel is removed from the reactor pressure vessel of the ship in a process called defueling. This defueling removes all of the fuel and most of the radioactivity from the reactor plant of the ships. The fuel removed from the decommissioned ships would be handled in the same manner as that removed from ships which are being refueled and returned to service. Unlike the low-level radioactive material in defueled reactor plants, the Nuclear Waste Policy Act of 1982, as amended, requires disposal of spent fuel in a deep geological repository. Storage and disposal of spent fuel from refuelings and defuelings of nuclear-powered ships does not affect the decision of how to dispose of the defueled reactor compartments. Further, handling of spent fuel from these ships was addressed in the Programmatic Spent Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Environmental Impact Statement, (DOE, 1995) in which the Navy is a cooperating agency. Therefore, handling and disposal of spent fuel is not the subject of this Environmental Impact Statement.

Prior to disposal, the reactor pressure vessel, radioactive piping systems, and the reactor compartment disposal package would be sealed. Thus, they act as a containment structure for the radioactive atoms and delay the time when any of the radioactive atoms inside would be available for release to the environment as the metal corrodes. This is important because radioactivity "decays" away with time; that is, as time goes on radioactive atoms change into nonradioactive atoms. Since radioactivity decays away with time, the effect of a delay is that fewer radioactive atoms would be released to the environment. Over 99.9% of these atoms are an integral part of the metal and they are chemically just like ordinary iron, nickel, or other metal atoms. These radioactive atoms are only released from the metal as a result of the slow process of corrosion. The remaining 0.1% which is corrosion and wear products, will decay away prior to penetration of the containment structures by corrosion.

The decay of radioactive atoms produces radiation, which can cause damage to tissue if there is insufficient distance or shielding between the source and the tissue. The effects on people of radiation that is emitted during decay of a radioactive substance depends on the kind of radiation (alpha and beta particles, and gamma and x-rays) and the total amount of radiation energy absorbed by the body. Within kinds of radiation, the energy of the radiation varies depending on the source isotope. The more energetic radiation of a given kind, the more energy that will be absorbed, in general. The total energy absorbed per unit quantity of tissue is referred to as absorbed dose. The absorbed dose, when multiplied by certain quality factors and factors that take into account different sensitivities of various tissues, is referred to as effective dose equivalent, or where the context is clear, simply dose. The common unit of effective dose equivalent is the rem or mrem (0.001 or 10^{-3} rem).

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

Doses are often classified into two categories: acute, which is a large dose received over a few hours or less; and chronic, which involves repeated small doses over a long time (months or years). Chronic doses are usually less harmful than acute doses because the time between exposures at low dose rates allows the body to repair damaged cells. Only chronic effects are considered here as the exposures discussed are much less than the threshold for acute effects. The most significant chronic effect from environmental and occupational radiation exposures is induction of latent cancer fatalities. This effect is referred to as latent because the cancer may take many years to develop.

Hypothetical health effects can be expressed in terms of estimated latent cancer fatalities. The health risk conversion factors used in this evaluation are taken from the International Commission on Radiological Protection which specifies 0.0005 latent cancer fatalities per person-rem of exposure to the public and 0.0004 latent cancer fatalities per person-rem for workers (ICRP, 1991).

To place exposure into perspective with normal everyday activities of the general public, a typical person in the United States receives 300 mrem of radiation exposure each year from natural background radiation, (NCRP, 1987). Natural background radiation is radiation that all people receive every day from the sun or from cosmic radiation, and from the natural radioactive materials that are present in our surroundings, including the rocks or soil we walk on.

2. Summary of Alternatives

a. Preferred Alternative - Land Burial of the Entire Reactor Compartment at the Department of Energy Low Level Waste Burial Grounds at Hanford, WA

In this alternative, the reactor compartments would be prepared for shipment at Puget Sound Naval Shipyard, shipped to and buried at the Department of Energy (DOE) Hanford Site in the state of Washington. The Hanford Site is used for disposal of radioactive waste from DOE operations. The pre-LOS ANGELES Class submarine reactor compartments are placed at the Hanford Site Low Level Burial Grounds for disposal, at the 218-E-12B burial ground in the 200 East area.

The Hanford Site is a large federal government site, occupying 1450 square kilometers (560 square miles) (365,000 acres) in southeastern Washington state. In the middle of the site on the Central Plateau, approximately 210 hectares (518 acres) have been designated as the Low Level Burial Grounds. The Low Level Burial Grounds are about seven miles from the Columbia River. The Hanford Site, and in particular the 218-E-12B low level burial ground, is well suited to the permanent disposal of these reactor compartments due to (1) accessibility by barge via the Columbia River and proximity to barge off-loading facilities, (2) an arid climate, (3) excellent soil characteristics which inhibit the corrosion of metal and the migration of metals and radionuclides down through the soil, (4) the current designation of the area for disposal of low level radioactive waste and current placement of pre-LOS ANGELES class submarine reactor compartments at the 218-E-12B burial ground for disposal, (5) isolation of the 218-E-12B burial ground and all Hanford low level burial grounds from the general public, and (6) institutional controls for the management of radioactive and dangerous waste.

The disposal of the reactor compartments from the cruisers, LOS ANGELES, and OHIO Class submarines would be consistent with the pre-LOS ANGELES Class submarine reactor compartment disposal program. The land required for the burial of approximately 100 reactor compartments from the cruisers, LOS ANGELES, and OHIO Class submarines would be approximately 4 hectares (10 acres) which is similar to the land area needs for the pre-LOS ANGELES Class submarine reactor compartments. Besides the reactor compartments, the volume of mixed waste generated by this alternative is estimated to be about 1625 cubic meters (57,400 cubic feet). This mixed waste would be managed in accordance with the approved Shipyard Site Treatment Plan and associated implementing order pursuant to the Federal Facility Compliance Act.

Briefly, this alternative would involve draining the piping systems, tanks, vessels, and other components to the maximum extent practical, sealing the radioactive systems, removing the reactor compartment and enclosing it in a high integrity all-welded steel package. The reactor compartment packages would meet the Type B requirements of the Department of Transportation, the Nuclear Regulatory Commission, and the Department of Energy. Non radioactive metal, such as submarine hulls, could be recycled. The reactor compartment package would be transported by barge out of Puget Sound through the Strait of Juan de Fuca, down the Washington coast, and up the Columbia River to the Port of Benton where it would be loaded onto an overland transporter and hauled the short distance to the Department of Energy's Low Level Radioactive Waste Burial Grounds at the Department of Energy's Hanford Site near Richland, Washington.

Disposal of the reactor compartments would be in accordance with Department of Energy requirements for low level radioactive waste disposal. Disposal of the reactor compartments would be regulated by the State of Washington due to the lead shielding contained within the reactor compartments, and by the United States Environmental Protection Agency due to the small quantity of solid polychlorinated biphenyls within the reactor compartments in the form of industrial materials such as insulation, electrical cables, and rubber parts. The total volume of the reactor compartments is about 120,000 cubic meters (4,240,000 cubic feet).

An estimated cost for land burial of the reactor compartments is $10.2 million for each LOS ANGELES Class submarine reactor compartment, $12.8 million for each OHIO Class submarine reactor compartment, and $40 million for each cruiser reactor compartment. The estimated total Shipyard occupational exposure to prepare the reactor compartment disposal packages is 13 rem (approximately 0.005 additional latent cancer fatalities) for each LOS ANGELES Class submarine package, 14 rem (approximately 0.006 additional latent cancer fatalities) for each OHIO Class submarine package and 25 rem (approximately 0.01 additional latent cancer fatalities) for each cruiser package. The total estimated cost of this alternative is approximately $1,500 million and the total estimated Shipyard occupational exposure is 1508 rem (approximately 0.6 additional latent cancer fatalities). Occupational and public exposures, costs, and land commitments are further compared in Table S.1.

b. No Action Alternative - Protective Waterborne Storage for an Indefinite Period

A ship can be placed in floating protective storage for an indefinite period. Nuclear-powered ships can also be placed into storage for a long time without risk to the environment. The ship would be maintained in floating storage. About every 15 years each ship would have to be taken out of the water for an inspection and repainting of the hull to assure continued safe waterborne storage. However, this protective storage does not provide a permanent solution for disposal of the reactor compartments from these nuclear-powered ships. Thus, this alternative does not provide permanent disposal.

The two Naval Shipyards considered for this alternative are: Puget Sound Naval Shipyard located in Bremerton, Washington and Norfolk Naval Shipyard located in Portsmouth, Virginia. These are the two Naval Shipyards with inactive nuclear ship maintenance facilities.

An estimated cost to prepare a cruiser, LOS ANGELES, or an OHIO Class submarine for protected waterborne storage and to keep it in storage for 15 years is approximately $1.6 million each. To keep a cruiser, or a LOS ANGELES, or a OHIO Class submarine in waterborne storage for an additional 15 years is estimated to cost $1.75 million each. Occupational and public exposures, costs, and land commitments are further compared in Table S.1.

c. Disposal and Reuse of Subdivided Portions of the Reactor Plant

In general, disposal and reuse of subdivided portions of the reactor compartments would expand and build upon operations and processes in use at Naval Shipyards to overhaul ships and recycle non-radioactive portions of decommissioned ships. It would require large scale changes in terms of the numbers and size of components to be processed. Very large components, such as reactor vessels, steam generators and pressurizers, which are not removed from reactor compartments under current programs, would have to be removed, packaged and disposed of individually. In addition, the quantity of smaller components such as valves, pumps and gages to be processed would be orders of magnitude greater than under current Shipyard workloads. Compatible dismantlement processes, packaging methods, modes of transportation and disposition sites would be selected for each individual radioactive component. A massive shielded container would be needed for transport of the reactor vessel and its internal structure to the appropriate disposal site. Non-radioactive metal, such as submarine hulls, would be recycled.

The amount of waste estimated for the subdivision alternative ranged from a high of 120,000 cubic meters (4,240,000 cubic feet) to a low of 10,000 cubic meters (353,000 cubic feet) with an intermediate estimate of 24,000 cubic meters (847,000 cubic feet). The amount of mixed waste was estimated to be from 2,255 to 6,255 cubic meters (79,600 to 221,000 cubic feet).

The cost of this alternative is estimated to be between $82.2 million and $93.6 million, per reactor compartment depending upon the estimating method used (see Appendix C). The radiological dose to workers is estimated to be between 230 and 1,115 rem per reactor compartment if accomplished immediately (0.09 to 0.45 additional latent cancer fatalities) or between 60 and 338 rem per reactor compartment (0.02 to 0.14 additional latent cancer fatalities) if deferred 10 years. Deferral of subdivision operations would not result in any significant reduction in radioactive waste volume. Deferral would require placement of inactivated ships in protected waterborne storage as described in the no action alternative. Occupational and public exposures, costs, and land commitments are further compared in Table S.1.

d. Indefinite Storage Above Ground at Hanford

In this alternative, reactor compartments would be stored indefinitely at the Department of Energy Hanford Site. At the Hanford Site, Trench 94 in the 218-E-12B low Level Burial Ground of the 200 East area is currently used for disposal of pre-LOS ANGELES Class submarine reactor compartments. The area to the north of this trench is available for Navy use and could accommodate the storage of 100 reactor compartments.

Compartment packaging and transport methods would be identical to those for the preferred alternative. Estimated costs for packaging and transporting compartments to the storage site are identical to those for the preferred alternative. Corresponding radiation exposures are also identical. See Table S.1 for further comparison.

This alternative is similar to the preferred alternative through shipment of the reactor compartments to the 218-E-12B burial ground. However, as in the no-action alternative, storage is not a disposal alternative. Such storage would only defer the need to permanently disposition the radioactive, hazardous and PCB waste contained by the reactor compartments.

e. Other Alternatives

The following alternatives were eliminated from detailed evaluation as discussed below.

(1) Sea Disposal

Sea disposal would involve sinking the entire ship in the deep ocean. Ocean dumping of low level radioactive material is prohibited by the London Convention for 25 years (IMO, 1993). This alternative would require new legislation to implement.

(2) Land Disposal of Entire Reactor Compartments at Other Sites

The Low Level Radioactive Waste Policy Act Amendments of 1985 state the Federal Government shall be responsible for disposal of low-level radioactive waste owned or generated by the U.S. Navy as a result of the decommissioning of U.S. Navy vessels. In addition, the need to maintain control of the classified design information inherent in the reactor compartments and many of their components requires a site under Federal control. Federal nuclear waste disposal sites are located at Department of Energy Sites.

Department of Energy radioactive waste disposal sites, other than the preferred alternate site at Hanford, pose physical limitations. Disposal of the entire reactor compartment disposal package at any site is dependent on the ability to transport the package to the site. In general, the only feasible means of transportation over long distances for packages over 1000 tons and over 30 feet tall is by barge. Physical restrictions to overland transport of the packages include bridges, overhead obstructions, embankments, road load bearing capacity, and steep or narrow roads. Because of the lack of availability of a nearby barge transportation route and land transportation required over long distances, all other Department of Energy land disposal sites would be inaccessible.

(3) Permanent Above Ground Disposal at Hanford

In this alternative, cruiser, LOS ANGELES, and OHIO class reactor compartments would be placed above ground at the Hanford Site, and covered with soil, entombing the reactor compartments in a soil mound. A Resource Conservation and Recovery Act compliant closure cover would be placed over the compartments. The gentle slope of this cover would occupy more land space than if the compartments were placed below ground in a trench. The gentle slope would result in a minor recontouring of the original land surface into a natural looking gradual rise. For sites with groundwater aquifers that are non-existent or deep underground like Hanford, the resulting environmental impacts of this alternative are very similar to the preferred alternative.

3. Summary of Environmental Consequences

The preferred alternative of land burial of the entire reactor compartment at the DOE's Hanford site would result in a much lower potential for latent cancer fatalities among workers in addition to a much lower cost as compared to the subdivision alternative. The environmental consequences of the preferred alternative, the no action alternative and the alternative of indefinite storage above ground at Hanford would all be low, but the preferred alternative has the advantage of being a permanent solution whereas the other two alternatives are interim solutions that only defer the need for permanent disposition.

a. Preferred Alternative - Land Burial of the Entire Reactor Compartment at the Department of Energy Low Level Waste Burial Grounds at Hanford, WA

(1) Shipyard Operations

Radiation exposure to Shipyard workers associated with reactor compartment disposal packaging operations to accomplish the preferred alternative has been estimated to be 1508 rem (approximately 0.6 additional latent cancer fatalities).

In all of the alternatives, the Navy would generate radioactive waste, PCB waste, and hazardous waste for disposal. However, the Navy would minimize the amount generated and any waste generated would be disposed of in accordance with applicable state and federal regulations using licensed transportation contractors and disposal sites.

(2) Transport Route

The impacts along the transport route that would be used to move reactor compartments from Puget Sound Naval Shipyard to the Hanford Site for disposal are evaluated in Appendix E. It is estimated that the preferred alternative would involve 100 reactor compartment shipments and would result in exposure to the general population of 5.8 person-rem (0.003 latent cancer fatalities). For the transportation crew it is estimated that exposure would be 5.8 person-rem (0.002 latent cancer fatalities).

In order to use the existing land transport route, six overhead power lines may need to be modified to accommodate the larger reactor compartment disposal packages under consideration in this EIS. If necessary, these modifications would only affect the sections of the power line within the immediate vicinity of the land transport route.

(3) Land Disposal Site

Approximately 4 hectares (10 acres) of land from the 218-E-12B low level burial ground in the 200 East area of the Hanford Site would be required for land disposal of the approximately 100 reactor compartment disposal packages from the cruisers, LOS ANGELES, and OHIO Class submarines. As is the case with other areas of the Hanford Site used for radioactive waste disposal, the land area used for disposal of the reactor compartment disposal packages and the surrounding buffer zone would constitute commitment of that land area and the natural resources contained therein.

The cruiser, LOS ANGELES, and OHIO Class reactor compartment disposal packages would be regulated for their radioactivity, lead, and PCB content. The release rates for these constituents are expected to be extremely small such that applicable environmental standards are not expected to be exceeded. The volume of mixed waste generated by this alternative would be less than 120,000 cubic meters (4,240,000 cubic feet). The migration of these constituents from the reactor compartments to the groundwater aquifer and to the Columbia River is also expected to be slow. For radioactivity, no short lived radionuclides are expected to be released.

b. No-Action Alternative

Shipyard Operations

Radiation exposure to the Shipyard workers associated with preparing the ships for indefinite waterborne storage following inactivation and decommissioning to accomplish the No Action alternative is estimated to be approximately 50 rem (0.02 latent cancer fatalities). This would include the first 15 years of waterborne storage maintenance operations and inspections. Because radiation exposure to the workers is primarily due to Cobalt-60 which has a half life of 5.3 years, during each 15 years storage period nearly three half lives of radioactive decay occur. As a result, exposure during the second 15 years waterborne storage period would be only 5.3 rem (0.002 latent cancer fatalities). Existing moorage capacity is adequate until after the year 2000.

c. Disposal and Reuse of Subdivided Portions of the reactor compartment

(1) Shipyard Operations

Based on results from dismantling of the Shippingport nuclear power plant and NRC projections for decommissioning of a commercial nuclear power plant, this alternative would result in from 22,500 to 109,000 rem (9.1 to 43.7 additional latent cancer fatalities) of worker radiation dose if performed immediately after decommissioning of the ships. Worker radiation dose would be reduced by about one–half for every 5 years that operations are deferred such that after a ten year deferral, worker radiation dose would be reduced to between 6,090 and 33,100 rem. (2.4 to 13.2 additional latent cancer fatalities).

(2) Transport Routes

The impacts along transportation routes that would be used to move subdivided portions of reactor compartments to disposal sites are evaluated in Appendix E. Four origin-destination cases are evaluated (Puget Sound to Hanford, Puget Sound to Savannah River, Norfolk to Hanford and Norfolk to Savannah River). Since two of the cases are for origins and destinations on the same coast and two are for origins and destinations on opposite coasts, the evaluation is considered to bound shipment of subdivided components from either of the two origins (Puget Sound and Norfolk) to any disposal site within the 48 contiguous states. It is estimated that the subdivision alternative would involve 1571 shipments and would result in exposure to the general population of 11 to 119 person-rem (0.006 to 0.060 latent cancer fatalities). For the transportation crew it is estimated that exposure would be from 12 to 96 person-rem (0.005 to 0.039 latent cancer fatalities).

(3) Disposal Sites

The amount of waste estimated for the subdivision alternative ranged from a high of 120,000 cubic meters (4,240,000 cubic feet), assuming no volume reduction, to a low of 10,000 cubic meters (353,000 cubic feet) assuming extensive volume reduction. An assumption of moderate volume reduction resulted in an intermediate estimate of 24,000 cubic meters (847,000 cubic feet). In all three cases the amount of mixed waste was estimated to be from 2,255 to 6,255 cubic meters (79,600 to 221,000 cubic feet).

d. Indefinite Storage Above Ground at Hanford

The impacts of this alternative would be the same as for the preferred alternative as, except for actual burial at Hanford, identical actions are performed. As in the No Action alternative, storage is not a disposal alternative. Such storage would only defer the need to permanently disposition the radioactive and hazardous material contained by the reactor compartment package.

4. Comparison of Alternatives

A comparison of the preferred alternative, the no action alternative, the subdivision alternative, and the indefinite storage above ground alternative is provided in Table S.1.

Table S.1 Comparison of Alternatives

	Preferred Alternative	No Action Alternative	Subdivision[4] Alternative		Indefinite Storage Above Ground Alternative
			Immediate	10 Year Deferral	
Number of Shipments	100	0	1571	1571	100
Additional fatalities Occupational[1] Public[2] (Radiological) Public[3] (Non-radiological)	 0.602 0.003 0.001	 0.02 0 0	 9.1 to 43.7 0.006 0.03	 2.4 to 13.2 0.002 0.03	 0.602 0.003 0.001
Land Commitment	Approximately 10 Acres	N/A	Approximately 10 Acres		Approximately 10 Acres
Estimated Cost	$1,500,000,000 (5)	$140,000,000 for first 15 years of storage plus cost of final disposition.	$9,400,000,000 (6)		$1,500,000,000 plus caretaker cost plus cost of final disposition.

[1] Occupational fatalities consist of on-site worker and transportation worker latent cancer fatalities. Occupational latent cancer fatalities are calculated by multiplying occupational exposure in rem by 0.0004 additional latent cancer fatalities per rem.

[2] Public (Radiological) fatalities consist of radiation related latent cancer fatalities for the general population, which are calculated by multiplying estimated general population exposure in rem by 0.0005 additional latent cancer fatalities per rem. The estimated number of radiological fatalities include those associated with accidents, which account for less than 15% of the total for all of the alternatives.

[3] Public (Non-radiological) fatalities consist of fatalities from non-radiological causes related to transportation accidents (which accounts for about 90% of the risk) and transportation vehicle exhaust emissions.

[4] Values shown for the subdivision alternative are based on shipment from Puget Sound Naval Shipyard to the Hanford Site.

[5] The discounted amount would be 0.7 billion dollars based on a discount rate of 4.9% over a 32 year period beginning in 1997.

[6] The discounted amount would be 4.3 billion dollars based on a discount rate of 4.9% over a 32 year period beginning in 1997.

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