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Department of Energy Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Draft Environmental Impact Statement

Volume 1

June 1994

U.S. Department of Energy
Office of Environmental Management
Idaho Operations Office

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ENVIRONMENTAL PROTECTION AGENCY

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COVER SHEET

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

TITLE: Department of Energy Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Draft Environmental Impact Statement.

CONTACT: For further information on this Environmental Impact Statement call or contact:

Public Comments on the SNF and INEL EIS
Attention: Tom Wichmann
DOE Idaho Operations Office
P.O. Box 3189
Idaho Falls, ID 83403-3189
1-800-682-5583

For general information on the U.S. Department of Energy NEPA process call 1-800-472-2756 to leave a message or contact:

Carol Borgstrom, Director
Office of NEPA Oversight (EH-25)
U.S. Department of Energy
1000 Independence Avenue, SW
Washington, D.C. 20585
202-586-4600

ABSTRACT: This document analyzes at a programmatic level the potential environmental consequences over the next 40 years of alternatives related to the transportation, receipt, processing, and storage of spent nuclear fuel under the responsibility of the U.S. Department of Energy. It also analyzes the site-specific consequences of the Idaho National Engineering Laboratory sitewide actions anticipated over the next 10 years for waste and spent nuclear fuel management and environmental restoration. For programmatic spent nuclear fuel management, this document analyzes alternatives of no action, decentralization, regionalization, centralization and the use of the plans that existed in 1992/1993 for the management of these materials. For the Idaho National Engineering Laboratory, this document analyzes alternatives of no action, ten-year plan, minimum and maximum treatment, storage, and disposal of U.S. Department of Energy wastes.

PUBLIC COMMENTS: Public meetings on the Draft Environmental Impact Statement will be announced in June 1994. Written and oral comments on the Draft Environmental Impact Statement will be accepted until September 30, 1994, at the Idaho address and telephone number provided above. The U.S. Department of Energy will consider these public comments in preparing the Final Environmental Impact Statement.

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Reader's Guide

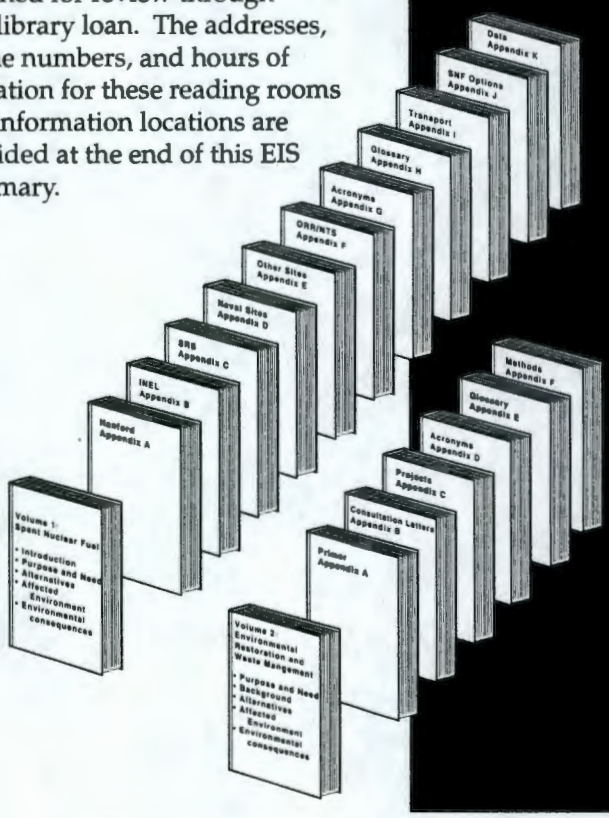
The U.S. Department of Energy's (DOE's) Environmental Impact Statement (EIS) for Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs [DOE/EIS-0203-D] is divided into two volumes:

- Volume 1, DOE Programmatic Spent Nuclear Fuel Management
- Volume 2, Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs (including site-specific spent nuclear fuel management).

Volume 1 comprises five primary sections and nine key appendices. The five primary sections provide (a) an introduction and overview to DOE's spent nuclear fuel management program throughout the nation, (b) the purpose and need for action to manage spent nuclear fuel, (c) management alternatives that are under consideration, (d) the affected environment, and (e) potential environmental consequences caused by the implementation of each alternative. The information contained in these sections relies, in part, upon more detailed information and analyses in the nine key appendices. These appendices describe and assess the site-specific spent nuclear fuel management programs at three primary DOE facilities and several alternative sites, the naval reactors spent nuclear fuel management program, offsite transportation of spent nuclear fuel, and environmental consequences data. Two additional appendices include a glossary and a list of acronyms and abbreviations.

Volume 2 is similarly constructed. Five primary sections are presented that provide (a) the purpose and need for an integrated 10-year environmental restoration, waste management, and spent nuclear fuel management program at the Idaho National Engineering Laboratory, (b) background, (c) management alternatives under consideration, (d) the affected environment, and (e) potential environmental consequences associated with the implementation of each alternative. The information presented in these sections relies, in part, upon four key appendices, which include a basic description of radioactivity and toxicology (chemical effects), agency consultation letters, detailed project summaries, and technical methodologies and key data. Two additional appendices include a glossary and a list of acronyms and abbreviations.

Each volume provides an index and a glossary, as well as a list of references to enable the reader to further review and research selected topics. DOE has established reading rooms and information locations across the United States where these references may either be reviewed or obtained for review through interlibrary loan. The addresses, phone numbers, and hours of operation for these reading rooms and information locations are provided at the end of this EIS Summary.



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Introduction

National Environmental Policy Act Process

The U.S. Department of Energy (DOE) is currently evaluating its options for two separate, but related, sets of decisions. The first involves programmatic (DOE-wide) approaches to DOE's management of spent nuclear fuel. The second involves site-specific approaches regarding the future direction of environmental restoration and waste management programs (including spent nuclear fuel) at the Idaho National Engineering Laboratory.

A key element of DOE's decisionmaking is a thorough understanding of the environmental impacts that may occur during the implementation of the proposed action. The National Environmental Policy Act of 1969, as amended, provides Federal agency decisionmakers with a process to consider potential environmental consequences (both positive and negative) of proposed actions before agencies make decisions. In following this process, DOE has prepared this draft Environmental Impact Statement (EIS) to assess various management alternatives and to provide the necessary background, data, and analyses to help decisionmakers and the public understand the potential environmental impacts of each alternative. Following consideration of public comments, DOE will prepare a final EIS. DOE's decisions will be discussed in a Record of Decision to be issued following completion of the final EIS.

National Environmental Policy Act

National Environmental Policy Act of 1969: A law that requires Federal agencies to consider in their decisionmaking processes the potential environmental effects of proposed actions and analyses of alternatives and measures to avoid or minimize the adverse effects of a proposed action.

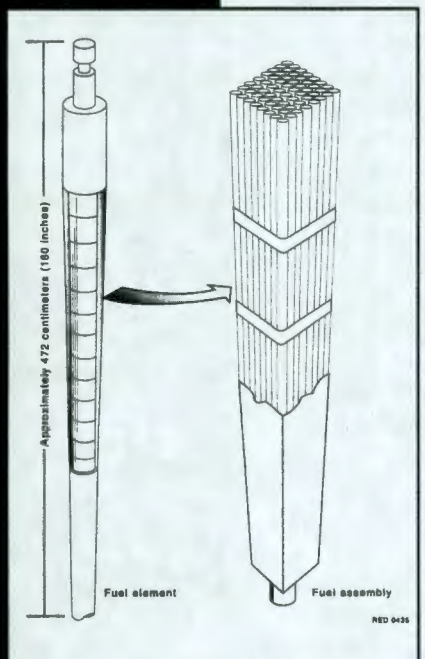
Alternatives: The range of reasonable options, including the No Action alternative, considered in selecting an approach to meeting the proposed objectives.

Environmental Impact Statement: A detailed environmental analysis for a proposed major Federal action that could significantly affect the quality of the human environment. A tool to assist in decisionmaking, it describes the positive and negative environmental effects of the proposed undertaking and alternatives.

Record of Decision: A concise public record of DOE's decision, which discusses the decision, identifies the alternatives (specifying which ones were considered environmentally preferable), and indicates whether all practicable means to avoid or minimize environmental harm from the selected alternative were adopted (and if not, why not).

General Scope of the Environmental Impact Statement

Volume 1 of this EIS considers programmatic (DOE-wide) alternative approaches to safely, efficiently, and responsibly manage existing and projected quantities of spent nuclear fuel until the year 2035. This amount of time may be required to make and implement a decision on the ultimate disposition of spent nuclear fuel. DOE's spent nuclear fuel responsibilities include fuel generated by DOE production, research, and development reactors; naval reactors; university and foreign research reactors; other miscellaneous generators; and special-case commercial reactors. Volume 1 focuses on the following:



Fuel assembly.

- Impacts to worker safety, public health, the environment, and socioeconomic factors related to transporting, receiving, stabilizing, and storing DOE and naval reactor spent nuclear fuel, as well as special-case commercial fuels under DOE responsibility.

- Siting locations for spent nuclear fuel management operations, which may include storing, stabilizing, and continuing research and development. (Stabilizing reduces fuel deterioration.)

- Fuel stabilization activities required for safe interim storage such as canning of degraded fuels or processing, research and development of spent nuclear fuel management technologies, and pilot programs.

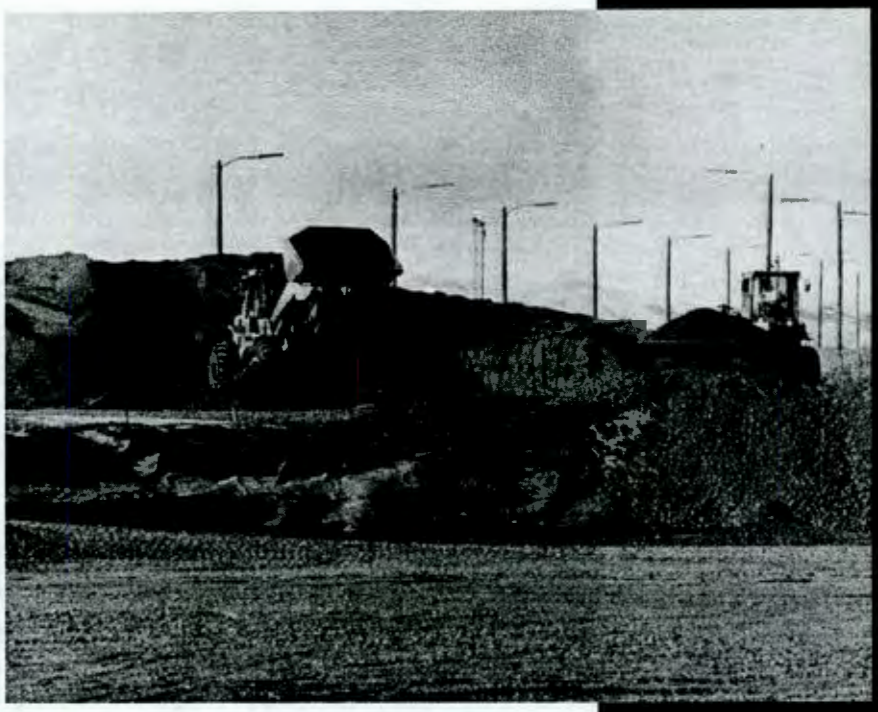
DOE will not address the ultimate disposition (final step in which material is either processed or disposed of) of spent nuclear fuel in this EIS. Nor will DOE select spent nuclear fuel stabilization technologies on the basis of this EIS. These technology-based decisions are more appropriately dealt with on a fuel-type basis. DOE will prepare additional National Environmental Policy Act documentation for research and development and characterization activities that help select technologies to place the fuel in a form suitable for ultimate disposition (this is commonly referred to as "tiering" within the National Environmental Policy Act process).

Except for special-case commercial fuel, management of spent nuclear fuel from commercial nuclear power plants is not the subject of this EIS.

Volume 2 of this EIS addresses alternative approaches for management of DOE's environmental restoration, waste management, and spent nuclear fuel activities over the next 10 years at the Idaho National Engineering Laboratory. This volume includes evaluations of potential environmental impacts associated with Idaho National Engineering Laboratory programs and site activities that contribute to waste streams requiring handling or disposal. Waste management activities are evaluated at both the site-wide and project-specific levels. Environmental restoration activities are addressed only at the site-wide level. Volume 2 considers site-specific

activities for spent nuclear fuel management, including fuel receipt, transportation, characterization, stabilization, storage, and technology development for ultimate disposition.

Volume 2 evaluates impacts of operations or programs associated with the spent nuclear fuel, environmental restoration, and waste management programs at the Idaho National Engineering Laboratory. Other activities are discussed when they are relevant to understanding the affected environment or are expected to occur during the next 10 years, and are included as part of the cumulative effects analysis.



Waste management activities at the Idaho National Engineering Laboratory.

This EIS does not evaluate the DOE-wide programmatic alternatives for environmental restoration and waste management, which are being evaluated in a separate programmatic EIS to be issued in draft form in the fall of 1994. However, the alternatives presented in Volume 2 have been developed to be consistent with the programmatic objectives of the Environmental Management Programmatic EIS, which DOE does not expect to be completed before the Record of Decision is signed for the EIS summarized here. Any conflicts between these Records of Decision will be evaluated and, as appropriate, additional National Environmental Policy Act documentation will be prepared in accordance with applicable regulations.

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Overview

The DOE Spent Nuclear Fuel Management Program is intended to (a) provide interim storage and management of fuel at specified locations until ultimate disposition, (b) stabilize the fuel as required for environmentally safe storage and protection of human health (for both workers and the public), (c) increase safe storage capacity by replacing facilities that cannot meet current standards and providing additional capacity for newly generated spent nuclear fuel, (d) conduct research and development initiatives to support safe storage or ultimate disposition, and (e) examine fuel generated by the Naval Nuclear Propulsion Program. DOE's spent nuclear fuel management responsibilities include fuel generated by DOE production and research and development reactors, naval reactors, university and foreign research reactors, other miscellaneous generators, and special-case commercial reactors. The primary goals of the management program are to reduce the risk of nuclear accidents during transportation and storage and to minimize the release of radionuclides to the environment where they can pose hazards to human health, plants, and animals.

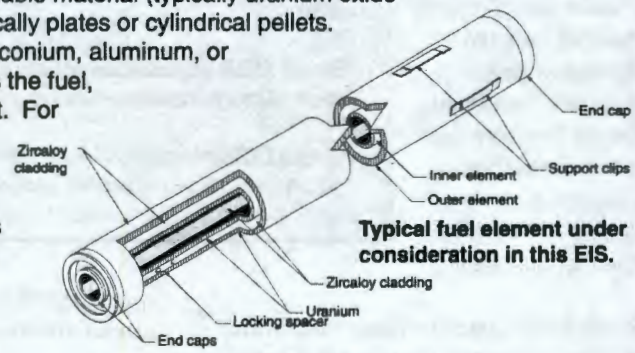
History of Spent Nuclear Fuel Management

Most DOE spent nuclear fuel is currently stored at three primary locations: the Hanford Site (State of Washington), the Idaho National Engineering Laboratory (State of Idaho), and the Savannah River Site

What Is Spent Nuclear Fuel?

Spent nuclear fuel is fuel that has been withdrawn from a nuclear reactor following irradiation, the constituent elements of which have not been separated. For purposes of this EIS, spent nuclear fuel inventory also includes uranium/neptunium target material, blanket subassemblies, pieces of fuel, and debris.

Fuel in a reactor consists of fuel assemblies that come in many configurations but generally consist of the fuel matrix, cladding, and structural hardware. The matrix, which contains the fissionable material (typically uranium oxide or uranium metal), is typically plates or cylindrical pellets. The cladding (typically zirconium, aluminum, or stainless steel) surrounds the fuel, confining and protecting it. For gas-cooled reactors, this may be a ceramic coating over fuel particles. Structural parts hold fuel rods or plates in the proper configuration and direct coolant flow (typically water) over the fuel. Structural hardware is generally nickel alloys, stainless steel, zirconium, or aluminum, or, for gas-cooled reactors, graphite.



Typical fuel element under consideration in this EIS.

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

(State of South Carolina) (Figure 1). Much smaller quantities of spent nuclear fuel remain at other locations throughout the nation (see Figure 1). Historically, DOE has reprocessed spent nuclear fuel at the three primary locations to recover and recycle uranium and plutonium.

Much of the spent nuclear fuel at the three primary locations resulted from production reactors at the Hanford and Savannah River Sites. These reactors are no longer operating, but they previously provided material for DOE's defense programs and research and development programs. Smaller quantities of spent nuclear fuel at other locations have resulted from experimental reactor operations and from research conducted by approximately 55 university- and Government-owned test reactors. DOE is proposing to renew the policy to return spent nuclear fuel containing enriched uranium that originated in the United States and was used in small foreign research reactors, consistent with the U.S. Nuclear Weapons Nonproliferation Policy. DOE also would accept spent nuclear fuel from development reactors, fuel used for destructive and nondestructive examination and testing, and other special-case fuel.

Since 1957, spent nuclear fuel from nuclear-powered naval vessels and naval reactor prototypes (operating reactors used for land-based training) has been transported from shipyards and prototype sites to the Naval Reactors Facility at the Idaho National Engineering Laboratory for testing and examination. However, a court order dated June 28, 1993 now limits the number of shipments of spent nuclear fuel to Idaho. Therefore, most naval spent nuclear fuel is being retained at shipyards.

Purpose and Need for Future Spent Nuclear Fuel Management

DOE is responsible for developing and maintaining a capability to safely manage its spent nuclear fuel. During the last four decades, DOE and its predecessor agencies have transported, received, stored, and reprocessed approximately 100,000 metric tons[a] of spent nuclear fuel. Currently, approximately 2,700 metric tons of heavy metal of spent nuclear fuel that are now stored at various locations in the United States and overseas have not been reprocessed. This spent nuclear fuel is in a wide range of enrichments (that is, percent uranium-235), types, and conditions. By the year 2035, this quantity may increase by approximately 100 metric tons of heavy metal.

The end of the Cold War led DOE to reevaluate the scale of its weapons production, nuclear propulsion, and research missions. In April 1992, DOE began to phase out reprocessing of

What Spent Nuclear Fuel Storage Decisions Will Be Made Based on this EIS?

Should DOE leave the spent nuclear fuel where it is today, with most at 3 sites and small quantities at almost 50 other sites?

Should DOE consolidate spent nuclear fuel storage at fewer sites to improve management efficiency?

Should DOE consolidate all spent nuclear fuel at a single site and stop spent nuclear fuel activities at other sites?

a. A metric ton of heavy metal is the unit used throughout this document to indicate the amount of spent nuclear fuel. It corresponds to 1,000 kilograms (2,200 pounds) of heavy metal (uranium, plutonium, thorium).

Existing Spent Nuclear Fuel Locations

1995 Inventory (Metric Tons Heavy Metal)[a]	
Hanford	2,133
Idaho National Engineering Laboratory	289
Savannah River Site	202
Oak Ridge Reservation	3
Other DOE Facilities	28
Universities	4
Other	16
Total	2,675

Legend

Source	No. of locations
U.S. Department of Energy Facilities	8
Naval Sites	7
Special-Case Commercial	4
Domestic Non-DOE	8
Urgent Relief Foreign Returns (potential port of entry)	5
Universities	33

Naval Sites[b]	State
Kesselring	New York
Newport News	Virginia
Norfolk	Virginia
Pearl Harbor	Hawaii
Portsmouth	Maine
Puget Sound	Washington
Windsor	Connecticut

DOE Facilities	State
Argonne National Laboratory-East	Illinois
Brookhaven National Laboratory	New York
Hanford	Washington
Idaho National Engineering Laboratory	Idaho
Los Alamos National Laboratory	New Mexico
Oak Ridge Reservation	Tennessee
Sandia National Laboratories	New Mexico
Savannah River Site	South Carolina

a. A metric ton of heavy metal is the unit used throughout this document to indicate the amount of spent nuclear fuel. It corresponds to 1,000 kilograms (2,200 pounds) of heavy metal (uranium, plutonium, thorium).

b. Name of shipyard or site.

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Figure 1. *Locations of current spent nuclear fuel generators and storage sites.*

spent nuclear fuel for recovery and recycling of plutonium and highly enriched uranium. In November 1993, DOE documented current and potential environmental, safety, and health vulnerabilities regarding DOE spent nuclear fuel storage facilities. DOE also identified storage locations with degraded fuel cladding (metal coverings to prevent fuel corrosion) and other problems that require action to ensure continued safe storage. This situation has also been identified by the independent Defense Nuclear Facilities Safety Board in Recommendation 94-1, issued May 26, 1994, wherein the Board concluded that imminent hazards could arise within several years unless certain problems are corrected, including spent fuel storage. Thus, DOE needs to establish an integrated complex-wide program that provides safe and effective management for present and reasonably foreseeable quantities of spent nuclear fuel, pending its permanent disposition. Relevant decisions that must be made include

- Selection of locations to conduct specific spent nuclear fuel management activities after evaluating existing and potential locations
- Appropriate capabilities, facilities, and technologies
- Type of research and development activities needed to support the DOE Spent Nuclear Fuel Management Program.

In other words, this EIS will provide the environmental information to support decisions that will facilitate a transition between DOE's current management practices and ultimate disposition of spent nuclear fuel.

Definition of Terms Related to Spent Nuclear Fuel

management (of spent nuclear fuel)—Emplacing, operating, and administering facilities, transportation systems, and procedures in order to ensure safe and environmentally responsible handling and storage of spent nuclear fuel pending (and in anticipation of) a decision on ultimate disposition.

stabilization (of spent nuclear fuel)—Actions taken to further confine or reduce the hazards associated with spent nuclear fuel, as necessary for safe management and environmentally responsible storage for extended periods of time. Activities which may be necessary to stabilize spent nuclear fuel include canning, processing, and passivation.

canning—The process of placing spent nuclear fuel in canisters to retard corrosion, contain radioactive releases, or control geometry.

processing (of spent nuclear fuel)—Applying a chemical or physical process designed to alter the characteristics of the spent nuclear fuel matrix.

passivation—The process of making metals inactive or less reactive. For example, to passivate the surface of steel by chemical treatment.

Alternatives

DOE proposes to manage spent nuclear fuel during the next 40 years, pending ultimate disposition. A range of reasonable alternatives that supports the decisions to be made was determined to include variations of several components: (a) multiple storage locations, (b) the amounts of spent nuclear fuel shipped, (c) fuel stabilization methods (ways to reduce deterioration) required, (d) the number and types of storage facilities to be constructed, and (e) the scope of technology research and development efforts for management technologies.

In addition to those three DOE sites that have conducted extensive spent nuclear fuel management activities, four naval shipyards (Norfolk, Portsmouth, Pearl Harbor, and Puget Sound) and one prototype reactor site (Kesselring Site) were selected as potential storage locations for naval spent nuclear fuel. In response to public comments raised during the scoping process, DOE undertook a process for identifying possible alternative sites. The end result of the selection process was the inclusion and evaluation of two additional sites, the Oak Ridge Reservation (State of Tennessee) and the Nevada Test Site (State of Nevada). (The Nevada Test Site is not considered to be a preferred site because of the State's current role as the host site for the Yucca Mountain Site Characterization Project.) Figure 2 depicts the various alternatives, options, and locations that DOE is evaluating for spent nuclear fuel management.

The programmatic approach that DOE selects may be a combination of parts of the alternatives analyzed. These programmatic (DOE-wide) decisions will not select all site-specific spent nuclear fuel management options. Such decisions will be made following additional site-specific National Environmental Policy Act evaluations.

DOE has not yet selected a preferred programmatic alternative but will identify one in the final EIS following receipt and consideration of public comments on the draft EIS. However, the Navy, as a cooperating agency, has identified its preferred alternative—to continue to conduct refueling and defueling of nuclear-powered vessels and prototypes, and to transport spent nuclear fuel to the Idaho National Engineering Laboratory for full examination and interim storage, using the same practices as in the past.

Alternatives for the Management of DOE Spent Nuclear Fuel

No Action

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

Decentralization

Store most spent nuclear fuel at or close to the generation site or current storage location with limited shipments to DOE facilities.

1992/1993 Planning Basis

Transport and store newly generated spent nuclear fuel at the Idaho National Engineering Laboratory or Savannah River Site.

Regionalization

Distribute existing and projected spent nuclear fuel among DOE sites based primarily on fuel type (Subalternative A) or geographic location (Subalternative B).

Centralization

Manage all existing and projected spent nuclear fuel inventories from DOE and the Navy at one site until ultimate disposition.

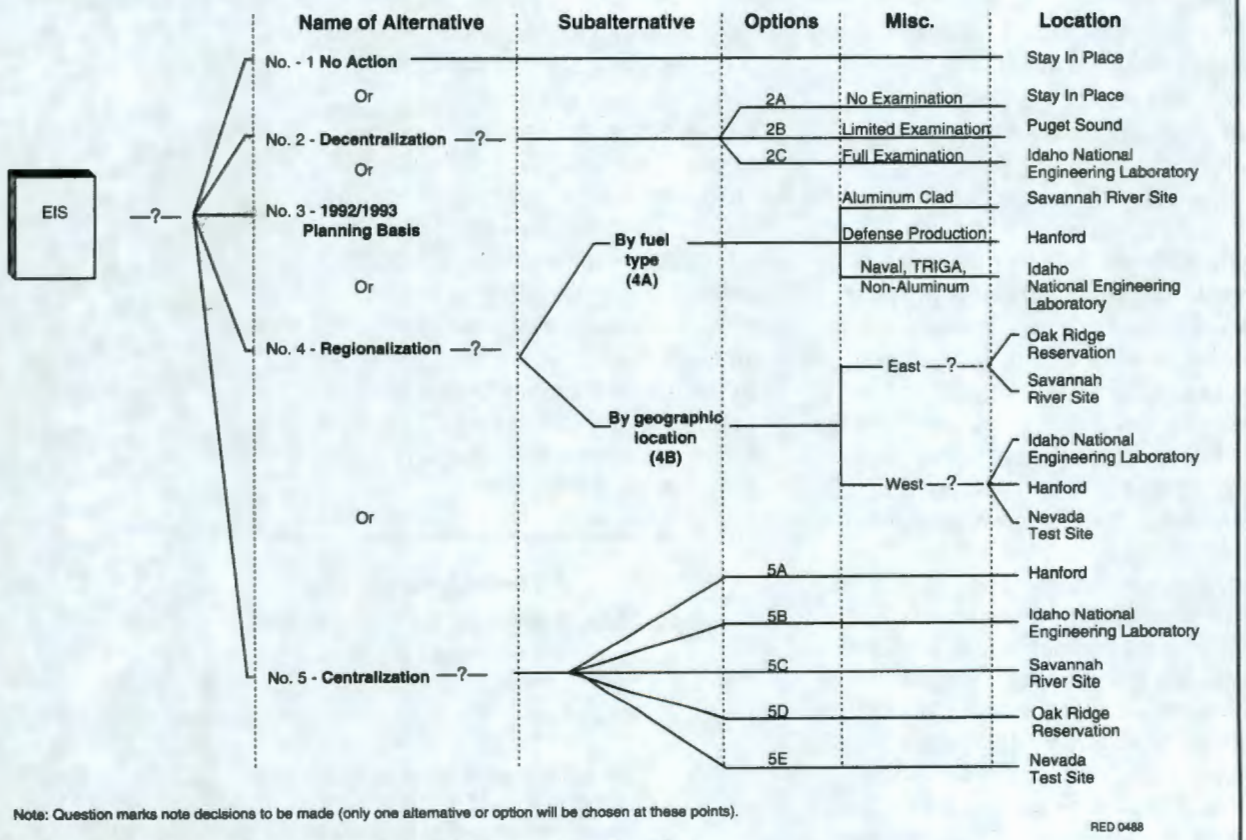


Figure 2. *Alternatives for management of DOE spent nuclear fuel.*

No Action Alternative

In the No Action alternative, which provides a baseline for comparison, DOE would limit actions to the minimum necessary for safe and secure management of spent nuclear fuel at or near the point where it is generated or currently located (Figure 3). Under this alternative, both small and large DOE sites, naval shipyards and prototypes, university and other non-DOE domestic reactors, and foreign research reactors would independently manage their fuel onsite. Naval spent nuclear fuel at the Newport News Shipyard would be transferred to Norfolk Naval Shipyard for retention.

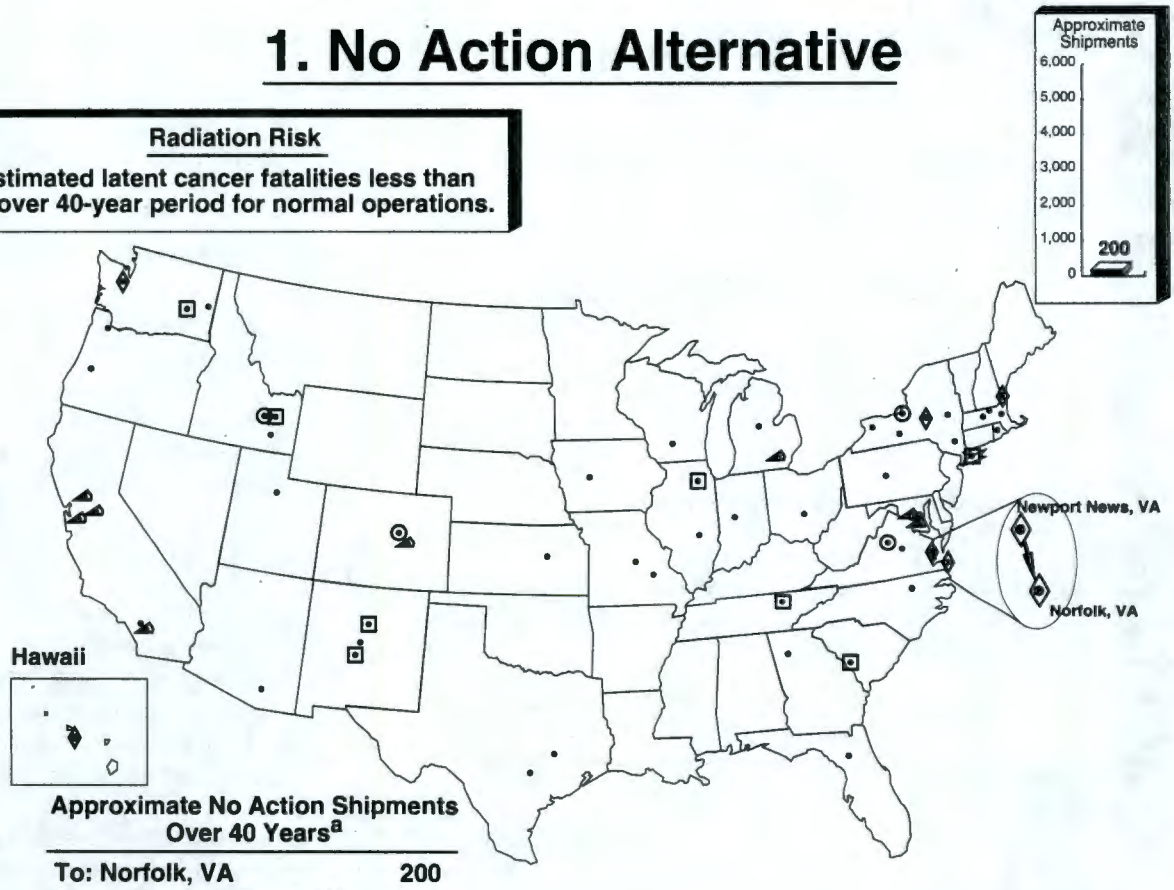
No spent nuclear fuel would be transported between DOE sites for management after about a three-year transition period, during which additional naval fuel shipments would be sent to the Idaho National Engineering Laboratory. Current technology development activities related to spent nuclear fuel management would continue within DOE.

Naval reactors would be refueled and defueled as planned. Naval spent nuclear fuel would be stored in shipping containers at the naval or DOE facility where refueling and defueling is conducted. This alternative would require about a three-year transition period to obtain additional approved containers for storage. During the transition period, fuel would be transported to the Idaho National Engineering Laboratory for examination at the Expended Core Facility. The approved containers would be unloaded and reused for additional refueling and defuelings. However, after the transition period, the fuel removed from naval reactors would remain in storage at the naval sites

1. No Action Alternative

Radiation Risk

Estimated latent cancer fatalities less than 1 over 40-year period for normal operations.



Approximate No Action Shipments Over 40 Years[a]

To: Norfolk, VA	200
From: Newport News, VA	

Approximate 2035 Inventory (Metric Tons Heavy Metal)

Hanford	2,133
Idaho National Engineering Laboratory	301
Savannah River Site	202
Naval Sites	55
Oak Ridge Reservation	4
Other	64
Total	2,759

Legend

Source	No. of locations
U.S. Department of Energy Facilities	8
Naval Sites	6
Special-Case Commercial	4
Domestic Non-DOE	8
Universities	33

Naval Sites[b]	State
Kesselring	New York
Norfolk	Virginia
Newport News	Virginia
Pearl Harbor	Hawaii
Portsmouth	Maine
Puget Sound	Washington

DOE Facilities	State
Argonne National Laboratory-East	Illinois
Brookhaven National Laboratory	New York
Hanford	Washington
Idaho National Engineering Laboratory	Idaho
Los Alamos National Laboratory	New Mexico
Oak Ridge Reservation	Tennessee
Sandia National Laboratories	New Mexico
Savannah River Site	South Carolina

a. Shipment numbers exclude shipments that would be made during transition period (see text).

b. Name of shipyard or site.

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Figure 3. *Spent nuclear fuel distribution for the No Action alternative.*

No Action Alternative

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

- After an approximate three-year transition period, no shipment of spent nuclear fuel to or from DOE facilities would occur.
- Stabilization activities would be limited to the minimum actions required to safely store spent nuclear fuel.
- Naval reactor spent nuclear fuel would be stored at naval sites.
- Facility upgrade/replacement and onsite fuel transfers would be limited to those necessary for safe interim storage.
- Existing research and development activities would continue.

Expended Core Facility at the Idaho National Engineering Laboratory would be shut down. Examinations of naval spent nuclear fuel would also cease.

Decentralization Alternative

Under this alternative, DOE would maintain existing spent nuclear fuel in storage at current locations and store new fuel at or near the site of generation (Figure 4). This alternative differs from the No Action alternative by increasing fuel shipments to DOE sites, which requires developing and upgrading facilities. Actions that would improve management capability, although not essential for safety, would be undertaken, and spent nuclear fuel research and development (including stabilization technology) would be performed.

The Decentralization alternative at the naval sites is similar to the No Action alternative because naval reactors would continue to be defueled and refueled as planned, and the fuel

Decentralization Alternative

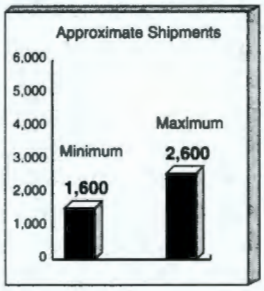
Store most spent nuclear fuel at or close to the generation site or current storage location with limited shipments to DOE facilities.

- Spent nuclear fuel shipments would be limited to the following:
  - Spent nuclear fuel stored or generated at universities and non-DOE facilities
  - Potential foreign research reactor fuel.
- Stabilization would be conducted to improve management capability.
- Some facilities would be upgraded/replaced and additional storage capacity required by the alternative would be constructed.
- Onsite fuel transfers would occur for improved safe storage.
- Research and development activities would be undertaken for spent nuclear fuel management, including stabilization technology.
- Three options for naval fuel
  - No inspection—fuel remains close to refueling/defueling site
  - Limited inspection at Puget Sound Naval Shipyard
  - Full inspection at the Idaho National Engineering Laboratory followed by storage close to refueling/defueling site.

2. Decentralization - Part 1

Radiation Risk

Estimated latent cancer fatalities less than 1 over 40-year period for normal operations.



Domestic Non-DOE

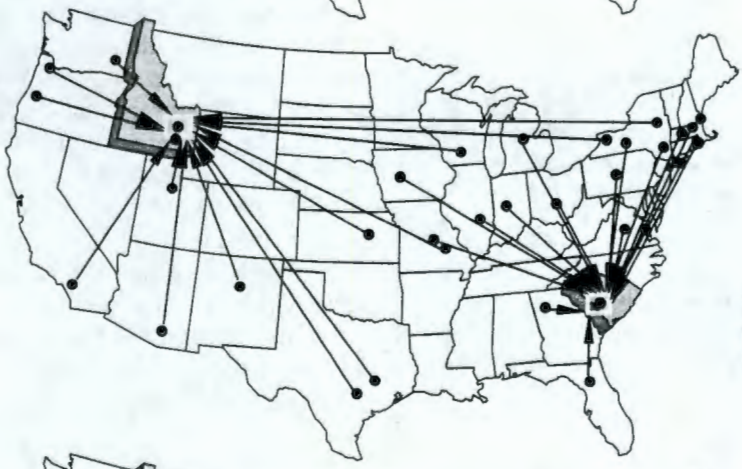
Approximate Shipments

To: Idaho National Engineering Laboratory	30
To: Savannah River Site	190

Fuel Source

Savannah River Site Destination:
- General Electric
- National Institute of Standards and Technology

Idaho National Engineering Laboratory Destination:
- Aerotest
- Armed Forces Radiobiology Research Institute
- Dow
- General Atomic
- U.S. Geological Survey
- U.S. Air Force



University

Approximate Shipments

To: Idaho National Engineering Laboratory	260
To: Savannah River Site	260

Foreign Fuel (potential ports of entry)

Approximate Shipments

To: Idaho National Engineering Laboratory	330
To: Savannah River Site	320

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Figure 4. *Spent nuclear fuel distribution for the Decentralization alternative.*

would be stored close to the refueling/defueling site (Figure 5). Three Decentralization options are included. The options differ only with regard to the examination of the fuel: no examination, limited examination, and full examination. Each option would require a transition period of about three years to develop storage facilities. During the transition period, spent nuclear fuel would be transported in shipping containers to the Idaho National Engineering Laboratory and the containers would be unloaded and reused.

The various small DOE, university, foreign research reactors, and miscellaneous generators would only ship spent nuclear fuel in limited amounts to permit continued operations. No additional storage facilities would be constructed at these locations.

1992/1993 Planning Basis

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

- Fuel would be transported
  - TRIGA fuel from the Hanford Site to the Idaho National Engineering Laboratory; Hanford Site receives limited fuel for research of storage and dispositioning technologies
  - Naval fuel to the Idaho National Engineering Laboratory for examination and storage
  - West Valley Demonstration Project and Fort St. Vrain fuel to Idaho National Engineering Laboratory
  - Oak Ridge Reservation fuel to the Savannah River Site
  - Domestic research fuel, and foreign research reactor fuel as may yet be determined, divided between the Savannah River Site and the Idaho National Engineering Laboratory.
- Facilities upgrades and replacements that were planned would proceed, including increased storage capacity.
- Research and development for spent nuclear fuel management would be undertaken, including stabilization technology.

1992/1993 Planning Basis Alternative

The 1992/1993 Planning Basis alternative represents DOE's plans (in 1992 and 1993) for management of its spent nuclear fuel. Under this alternative, DOE would transport and store newly generated spent nuclear fuel at the Idaho National Engineering Laboratory or the Savannah River Site.

DOE would transport and store newly generated fuel to the Idaho National Engineering Laboratory and the Savannah River Site (Figure 6). Some existing spent nuclear fuel at other sites would be consolidated at the Idaho National Engineering Laboratory. The Savannah River Site would also receive some test reactor fuel and some fuel from university and foreign research reactors. The Hanford Site would receive only limited quantities of fuel for research in support of storage and dispositioning technologies. DOE sites would generally upgrade facilities and construct new facilities to manage spent nuclear fuel. Activities related to spent nuclear fuel treatment would include research and development and pilot programs to support future decisions on the ultimate disposition of spent nuclear fuel.

Naval reactors would continue to be refueled and defueled as planned. Naval spent nuclear fuel would be transported from naval sites to the Expended Core Facility at the Idaho National Engineering Laboratory for examination. Following examination, fuel would remain in storage at the Idaho National Engineering Laboratory pending ultimate disposition.

Under this alternative, other generator and storage locations would continue to ship spent nuclear

2. Decentralization - Part 2

Naval Fuel Shipments[a]

Approximate Shipments	
To: Norfolk, VA	200
From: Newport News, VA	

Approximate Shipments	
To: Puget Sound, WA	50
To: Norfolk, VA	180

Approximate Shipments	
To: Idaho National Engineering Laboratory	580
From: Idaho National Engineering Laboratory	580

Note: All shipments to the Idaho National Engineering Laboratory for examination and then back to shipyards for storage.

a. Shipment numbers exclude shipments that would be made during transition period (see text).

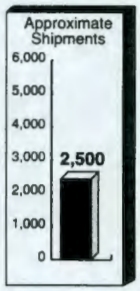
R94 0584

Figure 5. *Spent nuclear fuel distribution for the Decentralization alternative for naval fuel shipments.*

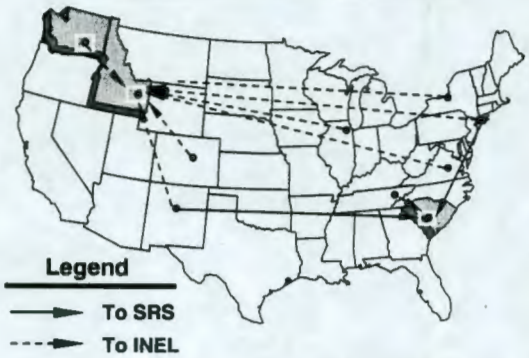
3. 1992 - 1993 Planning Basis

Radiation Risk

Estimated latent cancer fatalities less than 1 over 40-year period for normal operations.



DOE



Fuel Source

DOE Research
- Brookhaven National Laboratory, NY
- Hanford, WA
- Oak Ridge Reservation, TN
- Idaho National Engineering Laboratory, ID
- Savannah River Site, SC
- Sandia National Laboratories, NM

Argonne National Laboratory-East, IL
Special Case Commercial
- West Valley, NY
- Lynchburg, VA
- Fort St. Vrain, CO

Approximate Shipments

To: Idaho National Engineering Laboratory (INEL)	410
To: Savannah River Site (SRS)	120

Naval Fuel

Approximate Shipments

To: INEL for examination and storage	580

University

Approximate Shipments

To: INEL	260
To: SRS	260

Foreign Fuel (potential ports of entry)

Approximate Shipments

To: INEL	330
To: SRS	320

Domestic Non-DOE

Approximate Shipments

To: INEL	30
To: SRS	190

R94 0589

Figure 6. *Spent nuclear fuel distribution for the 1992/1993 Planning Basis alternative.*

fuel to the Idaho National Engineering Laboratory and the Savannah River Site. No additional storage facilities would be constructed at these originating locations.

Regionalization Alternative

This alternative would require a redistribution of spent nuclear fuel among DOE sites, either on the basis of fuel types (Subalternative A) (Figure 7) or on the basis of geography (Subalternative B) (Figure 8). Regionalization by fuel type (Subalternative A) would involve the use of either the Idaho National Engineering Laboratory or the Savannah River Site for storage of nondefense production spent nuclear fuel. Existing defense production spent nuclear fuel at the Hanford Site would remain there. Intersite transportation of fuel would depend on the site's existing capabilities to manage specific fuel types with respect to cladding material, physical and chemical composition, fuel condition, and adequate facilities to handle increased quantities of fuel. Naval fuel would be transported to

Regionalization

Regionalization Subalternative A: Distribute existing and projected spent nuclear fuel among DOE sites based primarily on fuel type.

- Naval fuel would be shipped to, examined, and stored at the Idaho National Engineering Laboratory.
- Aluminum-clad fuel shipped to the Savannah River Site; TRIGA and non-aluminum fuel to the Idaho National Engineering Laboratory; retain defense production fuel at the Hanford Site.
- Stabilization would be performed at the shipping site where required before transportation. Additional stabilization would be performed at the regional site.
- Facilities required to support spent nuclear fuel management would be upgraded or built as necessary.
- Research and development for spent nuclear fuel management would be undertaken, including stabilization technology.

Regionalization Subalternative B: Distribute existing and projected spent nuclear fuel between an Eastern Regional Site (either Oak Ridge Reservation or Savannah River Site) and a Western Regional Site (either Hanford Site, Idaho National Engineering Laboratory, or Nevada Test Site).

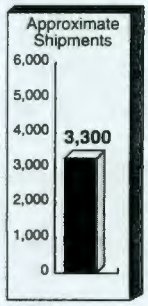
- The Eastern Regional Site would receive fuel from east of the Mississippi River and the Western Regional Site would receive fuel from west of the Mississippi River.
- Naval fuel would be shipped to, examined, and stored at either the Western Regional Site or the Eastern Regional Site.
- Stabilization would be performed at the shipping site where required for transportation. Additional stabilization would be performed at the regional site.
- Facilities required to support spent nuclear fuel management would be upgraded or built as necessary.
- Research and development would be undertaken for spent nuclear fuel management, including stabilization technology.

4. DOE - Regionalization (by Fuel Type)

Subalternative A

Radiation Risk

Estimated latent cancer fatalities less than 1 over 40-year period for normal operations.

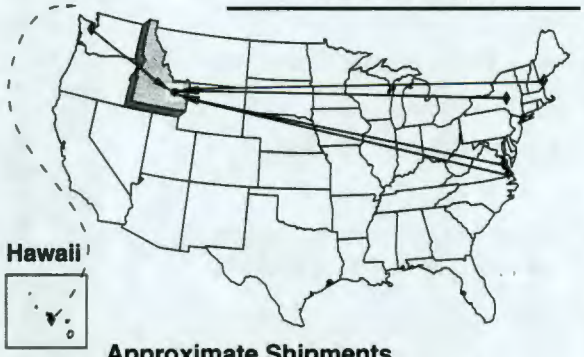


DOE

Approximate Shipments

To: Idaho National Engineering Laboratory (INEL)	1,000
To: Savannah River Site (SRS)	280

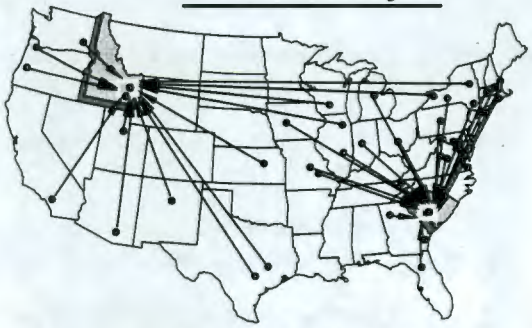
Naval Fuel



Approximate Shipments

To: INEL for examination and storage	580

University



Approximate Shipments

To: INEL	120
To: SRS	400

Foreign Fuel (potential ports of entry)

Approximate Shipments

To: INEL	70
To: SRS	580

Domestic Non-DOE

Approximate Shipments

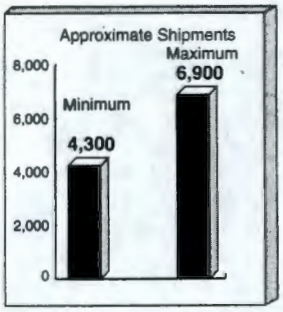
To: INEL	30
To: SRS	190

Figure 7. *Spent nuclear fuel distribution for Regionalization Subalternative A.*

R94 0590

4. DOE - Regionalization (by Geography) - Part 1

Subalternative B
East



Radiation Risk

Estimated latent cancer fatalities less than 1 over 40-year period for normal operations.

DOE - Regionalization

Subalternative B
(1 East - SRS)

Approximate Shipments[a]	
To: Savannah River Site (SRS)	1,200
Naval shipments if Expended Core Facility at SRS	580

DOE - Regionalization

Subalternative B
(2 East - ORR)

Approximate Shipments[a]	
To: Oak Ridge Reservation (ORR)	2,000
Naval shipments if Expended Core Facility at ORR	580

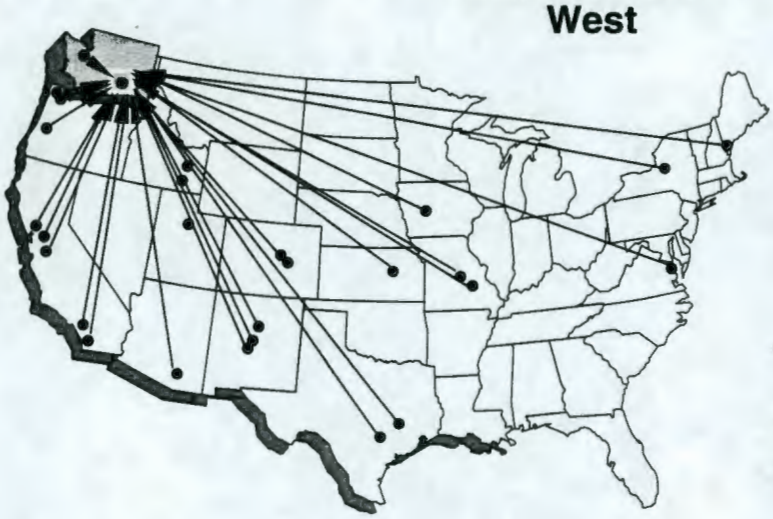
a. Shipment numbers exclude shipments that would be made during transition period (see text).

R94 0587

Figure 8. *Spent nuclear fuel distribution for Regionalization Subalternative B.*

4. DOE - Regionalization (by Geography) - Part 2

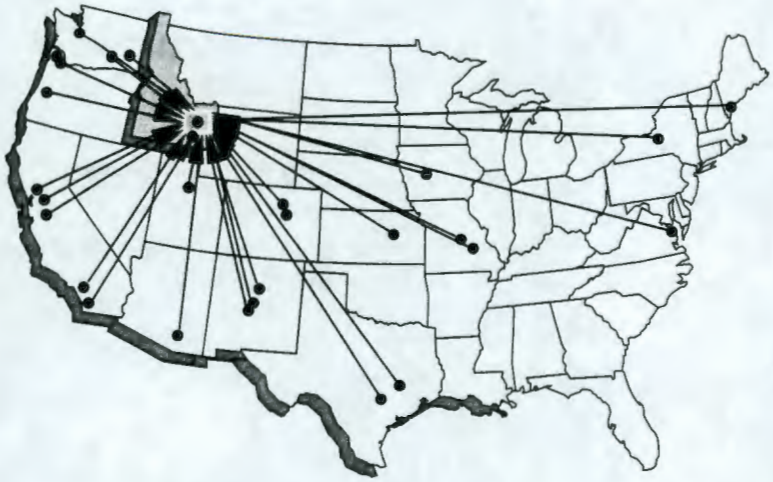
Subalternative B
West



DOE - Regionalization

Subalternative B
(1 West - Hanford)

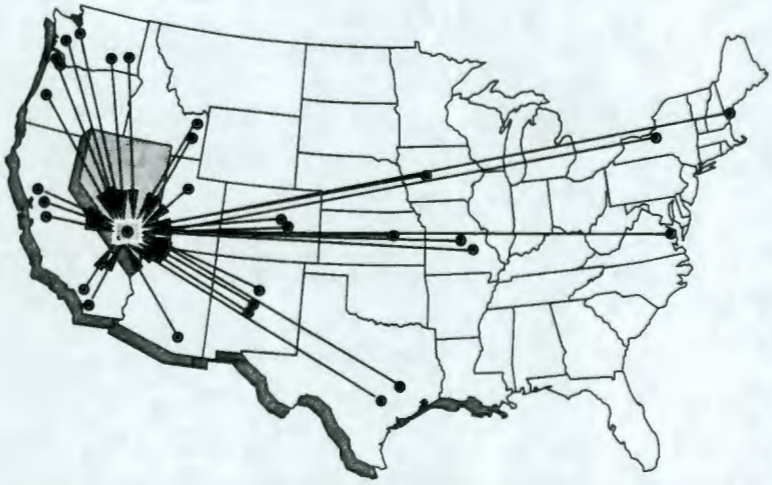
Approximate Shipments[a]	
To: Hanford	2,600
Naval shipments if Expended Core Facility at Hanford	580



DOE - Regionalization

Subalternative B
(2 West - INEL)

Approximate Shipments	
To: Idaho National Engineering Laboratory (INEL)	2,400
Naval shipments if Expended Core Facility at the INEL	580



DOE - Regionalization

Subalternative B
(3 West - NTS)

Approximate Shipments[a]	
To: Nevada Test Site (NTS)	4,400
Naval shipments if Expended Core Facility at NTS	580

a. Shipment numbers exclude shipments that would be made during transition period (see text).

R94 0586

Figure 8. *(continued).*

the Expended Core Facility at the Idaho National Engineering Laboratory for examination. Following examination, fuel would remain in storage at the Idaho National Engineering Laboratory. Facility upgrades, replacements, and additions would be undertaken to the extent required, including research and development activities.

Regionalization by geography (Subalternative B) would involve consolidation of spent nuclear fuel from the eastern United States at the Eastern Regional Site (Oak Ridge Reservation or Savannah River Site) and consolidation of fuel from the western United States at one of the Western Regional Sites (Hanford Site, Idaho National Engineering Laboratory, or Nevada Test Site[a]). Naval fuel would be shipped to, examined, and stored at either the Eastern or the Western Regional Site. Subalternative B has 10 options, based on the combination of sites selected as the Eastern and Western Regional Sites, and the placement of the Expended Core Facility at either of the sites. There are three potential Western and two potential Eastern Regional Sites that could be paired, with either supporting the Expended Core Facility. However, neither of the two possible combinations that include the Idaho National Engineering Laboratory as the Western Regional Site would consider moving the Expended Core Facility to the eastern site because of the estimated $1 billion cost of construction. Facility upgrades, replacements, and additions would be undertaken to the extent required, including research and development.

Under this alternative, other generator and storage locations would continue to ship spent nuclear fuel to the Idaho National Engineering Laboratory and the Savannah River Site. The exact destination of fuels would vary, depending on the fuel type under Regionalization Subalternative A and on the generator/storage location under Regionalization Subalternative B.

Centralization Alternative

Under the Centralization alternative, all spent nuclear fuel that DOE is obligated to manage would be transported to one DOE site (Figure 9). Candidate sites include the Hanford Site (Option A), Idaho National Engineering Laboratory (Option B), Savannah River Site (Option C), Oak Ridge Reservation (Option D), and Nevada Test Site[a] (Option E). New facilities would be built at the Centralization site to accommodate the increased inventories. Some spent nuclear fuel would require stabilization before shipment. All spent nuclear fuel facilities at the shipping sites would then be closed. Activities related to stabilization of fuel, including research and development and pilot programs, would also be centralized at this same site.

Shipment of naval spent nuclear fuel to the Idaho National Engineering Laboratory would continue only until storage and examination facilities are constructed at the central site. For consolidation at sites other than the Idaho National Engineering Laboratory, a new facility with capabilities comparable to the Expended Core Facility at the Idaho National Engineering Laboratory would be constructed.

All spent nuclear fuel from the other generator and storage sites would be shipped to the selected centralized DOE facility.

Centralization

Manage all existing and projected spent nuclear fuel inventories at one site until ultimate disposition.

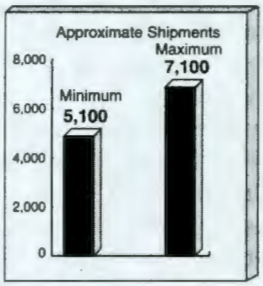
- **Existing spent nuclear fuel would be shipped to the centralized site.**
- **Naval fuel would be shipped to, examined, and stored at the centralized site.**
- **Projected spent nuclear fuel receipts would be shipped to the centralized site.**
- **Fuels at existing DOE sites would be stabilized as needed before shipment. Other spent nuclear fuel would be stabilized as required for storage at the centralized site.**
- **Facility upgrade/ replacement and new storage capacity would be provided at the centralized site; stabilization facilities would be provided at the shipping sites.**
- **Research and development would be undertaken for spent nuclear fuel management, including stabilization technology.**

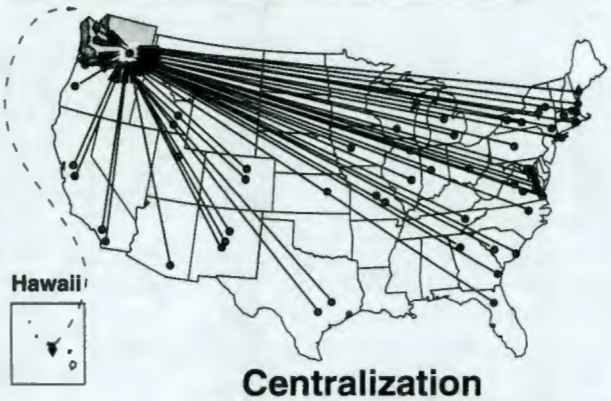
a. DOE does not consider the Nevada Test Site to be a preferred site for the management of spent nuclear fuel because of the State's current role as the host site for the Yucca Mountain Site Characterization Project and the Nevada Test Site's lack of current spent nuclear fuel handling experience.

5. Centralization

Radiation Risk

Estimated latent cancer fatalities less than 1 over 40-year period for normal operations.



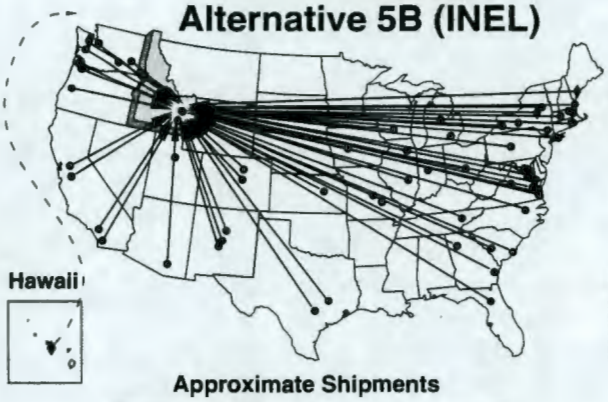


Centralization Alternative 5A (Hanford)

Approximate Shipments[a]

To: Hanford	4,700
Naval Shipments	580

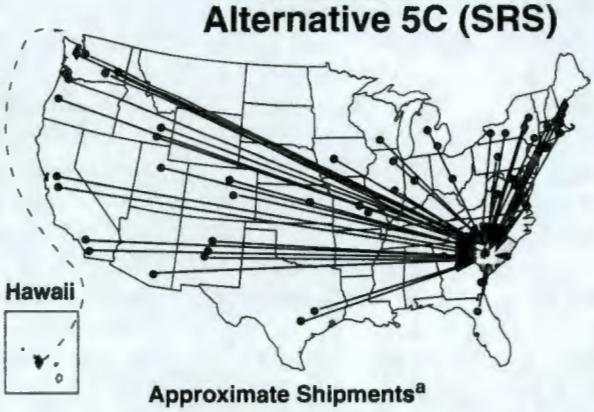
Centralization Alternative 5B (INEL)



Approximate Shipments

To: Idaho National Engineering Laboratory (INEL)	4,500
Naval Shipments	580

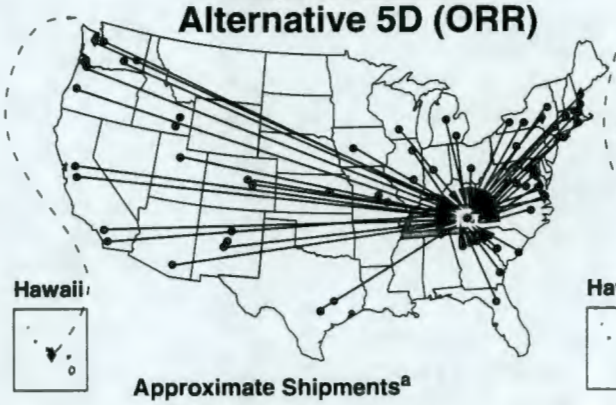
Centralization Alternative 5C (SRS)



Approximate Shipments[a]

To: Savannah River Site (SRS)	5,600
Naval Shipments	580

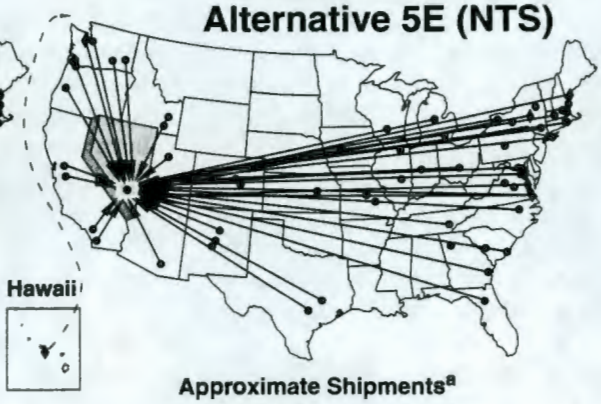
Centralization Alternative 5D (ORR)



Approximate Shipments[a]

To: Oak Ridge Reservation (ORR)	6,300
Naval Shipments	580

Centralization Alternative 5E (NTS)



Approximate Shipments[a]

To: Nevada Test Site (NTS)	6,500
Naval Shipments	580

a. Shipment numbers exclude shipments that would be made during transition period (see text).

R94 0588

Figure 9. *Spent nuclear fuel distribution for the Centralization alternative.*

Environmental Consequences

Estimates in the EIS of potential environmental consequences resulting from programmatic (DOE-wide) alternatives are based on conservative assumptions (that is, with a tendency to overestimate). Analytical approaches are designed to provide estimates of the maximum reasonably foreseeable consequences. As indicated in the EIS, the environmental consequences of the five spent nuclear fuel management alternatives would be small or negligible. For example, analyses of air quality, water quality, and land use for each alternative showed little or no impact. The details of these examinations are discussed in Chapter 5 of Volume 1. The comparison of alternatives in this Summary, therefore, concentrates on (a) the areas in which the public has expressed considerable interest and (b) programmatic factors important to DOE decisionmaking. The following factors were selected for comparison:

- Number of shipments among sites
- Public and worker health effects
- Spent nuclear fuel-related employment
- Generation of radioactive waste
- Impact on DOE or Navy missions
- Cost of implementation.

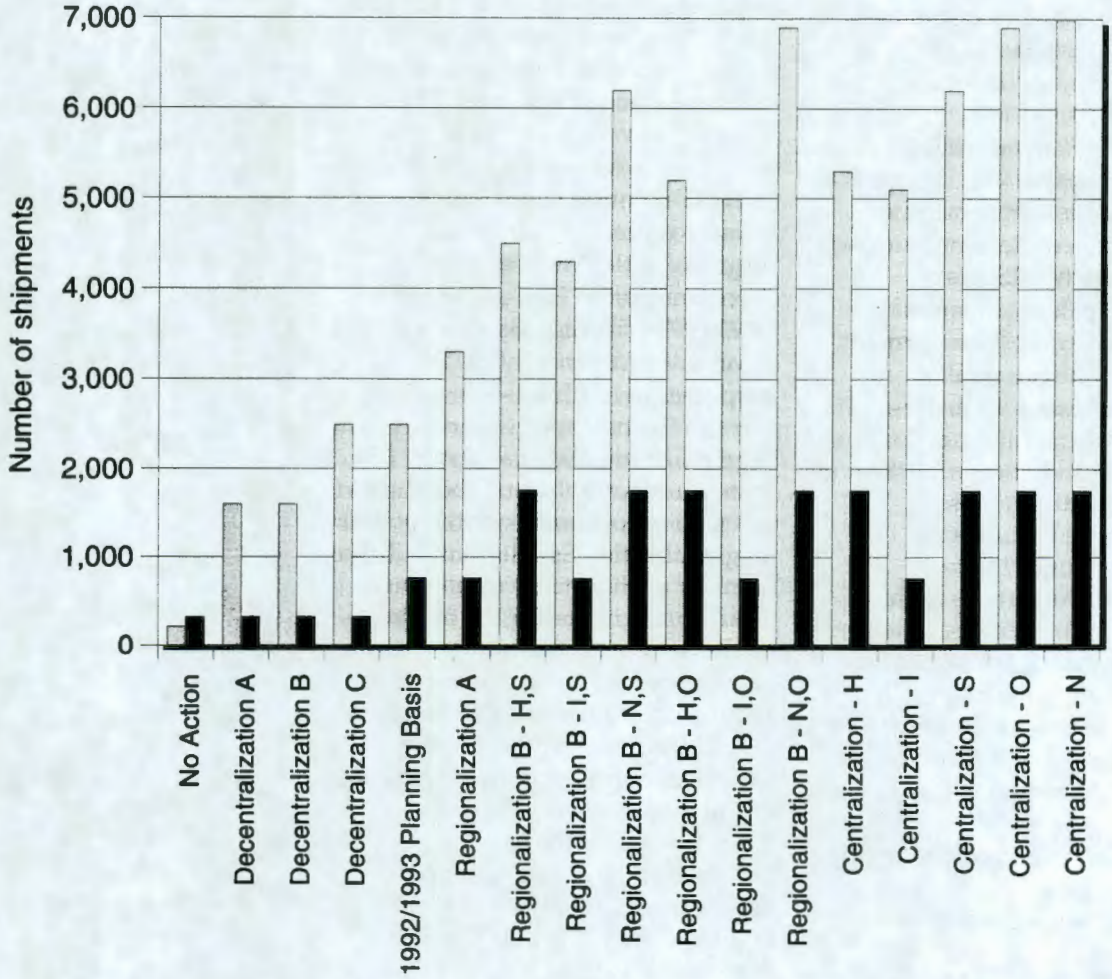
Number of Shipments

Figure 10 and Table 1 show the number of offsite shipments that would occur under each alternative. Figure 10 quantifies shipments of test specimens, as well as fuel elements. Shipments of naval test specimens are included because of their contribution to cumulative impacts of naval spent nuclear fuel transportation. The No Action alternative would involve only a limited number of naval spent nuclear fuel shipments (about 200). The Decentralization alternative, 1992/1993 Planning Basis alternative, and Regionalization Subalternative A mostly involve shipments from the smaller reactor and storage sites and the naval sites to DOE sites. These shipments would range in number from approximately 1,600 shipments under Decentralization Options A or B to approximately 3,300 under Regionalization Subalternative A. Decentralization Option C and the 1992/1993 Planning Basis each would involve approximately 2,500 shipments over the 40-year period. For the Centralization alternative and Regionalization Subalternative B, spent nuclear fuel would be shipped to one or two sites, respectively. For Regionalization Subalternative B, the number of shipments would range from approximately 4,300 for the Idaho National Engineering Laboratory/Savannah River Site to about 6,900 for the Nevada Test Site/Oak Ridge Reservation. For the Centralization alternative, the number of shipments would range from approximately 5,100 for Option B at the Idaho National Engineering Laboratory to 7,000 for Option E at the Nevada Test Site.

Public and Worker Health Effects

Spent nuclear fuel management activities would result in radiation exposures to the workers and the public from facility operations, transportation activities, and accidents. Radiation exposures also occur from natural sources such as cosmic radiation and from artificial sources such as chest X-rays.

The effects of radiation exposure on humans (and the environment) depend on (a) the kind of radiation received, (b) the total amount of radiation received (the rate of exposure times the length of exposure), and (c) the part(s) of the body exposed. Radiation can cause a variety of health effects in people. The



Key:

Decentralization A: No examination of Naval fuels
Decentralization B: Limited examination of Naval fuels at Puget Sound Naval Shipyard
Decentralization C: Full examination of Naval fuels at Idaho National Engineering Laboratory with SNF stored at Naval sites
Regionalization A: Regionalization by fuel type
Regionalization B: Regionalization by location

Site initials:
H: Hanford Site
I: Idaho National Engineering Laboratory
S: Savannah River Site
O: Oak Ridge Reservation
N: Nevada Test Site

Spent fuel
Test specimens[a]

a. Test specimens are small quantity fuel samples shipped for laboratory analysis

Figure 10. *Number of spent nuclear fuel and test specimen shipments between the years 1995 and 2035.*

Table 1. *Number of spent nuclear fuel shipments by alternative.*

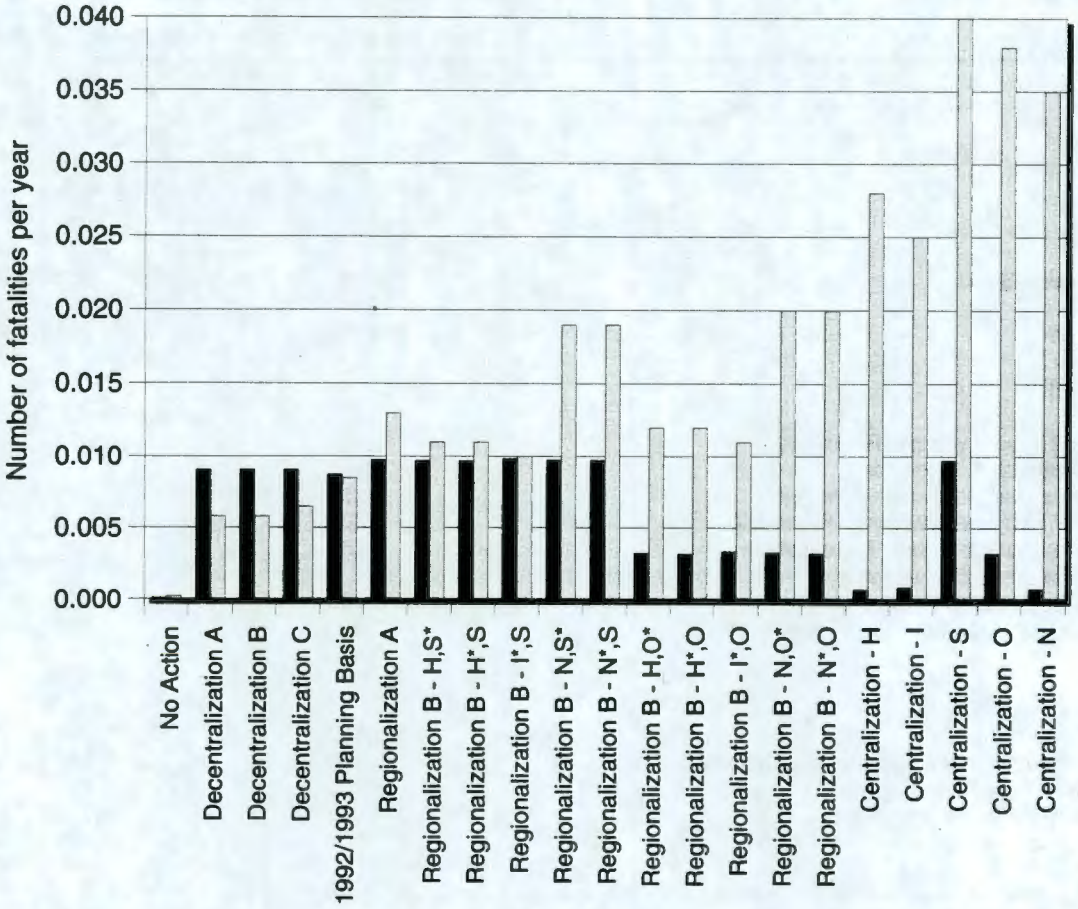
Alternative	Number of shipments: Spent fuel shipments[a]	Number of shipments: Test specimen shipments[b]
No Action	200	320
Decentralization		
A	1,600	320
B	1,600	320
C	2,500	320
1992/1993 Planning Basis	2,500	760
Regionalization A	3,300	760
Regionalization B		
Hanford Site/Savannah River Site	4,500	1,750
Idaho National Engineering Laboratory/Savannah River Site	4,300	760
Nevada Test Site/Savannah River Site	6,200	1,750
Hanford Site/Oak Ridge Reservation	5,200	1,750
Idaho National Engineering Laboratory/Oak Ridge Reservation	5,000	760
Nevada Test Site/Oak Ridge Reservation	6,900	1,750
Centralization		
A Hanford Site	5,300	1,750
B Idaho National Engineering Laboratory	5,100	760
C Savannah River Site	6,200	1,750
D Oak Ridge Reservation	6,900	1,750
E Nevada Test Site	7,000	1,750

a. Naval spent nuclear fuel shipments would be by rail, and DOE spent nuclear fuel shipments would be by truck.
b. Test specimens would be shipped by truck.

most significant health effect to describe the consequences of public and worker radiation exposures is "latent cancer fatality." It is referred to as "latent" because the cancer may take many years to develop and for death to occur.

Under all alternatives (over a 40-year period), the estimated number of latent cancer fatalities from the normal operation of DOE spent nuclear fuel management facilities would range from approximately zero to about two latent cancer fatalities, or about 0.04 latent cancer fatalities per year (Figure 11). In general, the greatest radiation exposure from normal spent nuclear fuel site activities and incident-free transportation results when large quantities of spent nuclear fuel are transported among sites, such as under Regionalization Subalternative B or the Centralization alternative. Under incident-free transportation, the estimated total latent cancer fatalities are less than two for all alternatives, with the highest estimates being those associated with the Centralization options. This reflects the higher number of shipments associated with these options.

The risk of latent cancer facilities associated with facility accidents is small across all the alternatives, as shown in Figure 12. The evaluated facility accident scenario with the highest risk (breach of a fuel assembly for the Centralization alternative at the Savannah River Site) would result in an estimated 0.0072 latent cancer fatality per year (one latent fatal cancer in 140 years).



Key:

Decentralization A: No examination of Naval fuels
Decentralization B: Limited examination of Naval fuels at Puget Sound Naval Shipyard
Decentralization C: Full examination of Naval fuels at Idaho National Engineering Laboratory with SNF stored at Naval sites
Regionalization A: Regionalization by fuel type
Regionalization B: Regionalization by location

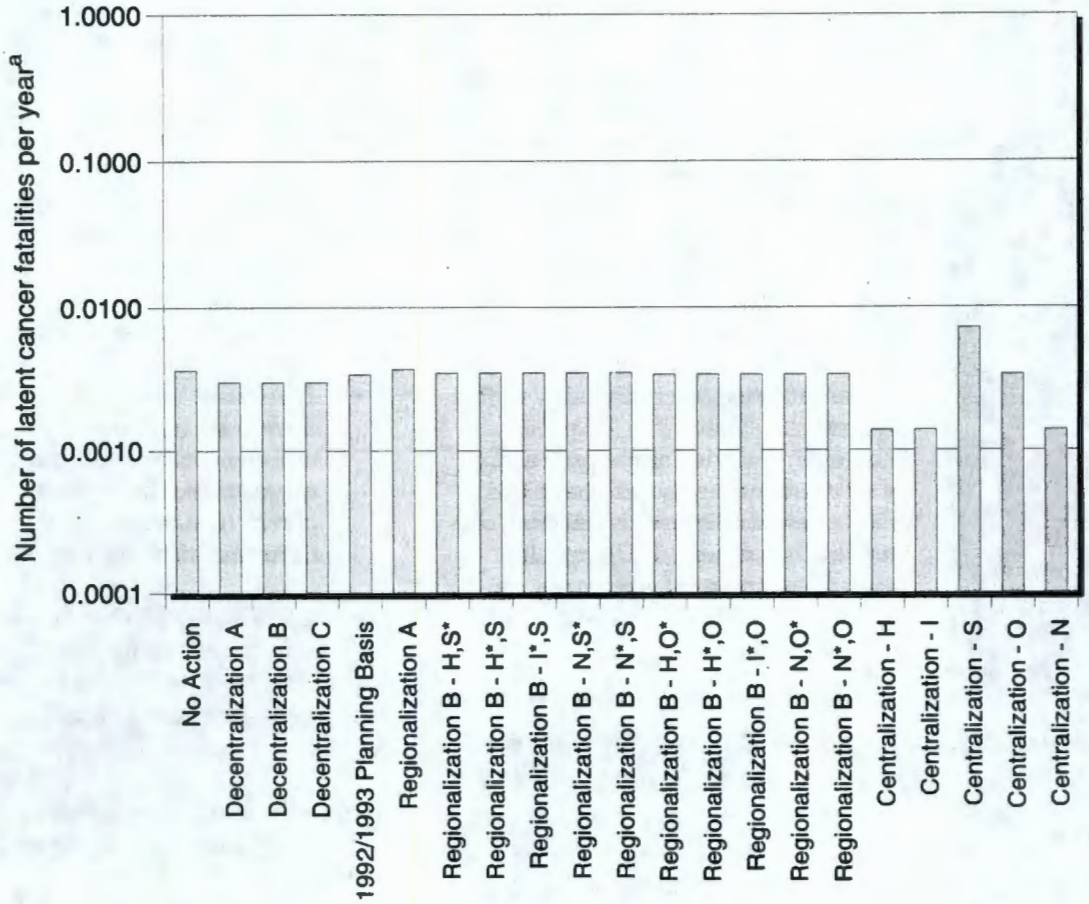
Site initials:
H: Hanford Site
I: Idaho National Engineering Laboratory
S: Savannah River Site
O: Oak Ridge Reservation
N: Nevada Test Site

■ Operations
▒ Transportation[a]

* Location of Expended Core Facility

a. Total fatalities are the sum of the estimated number of radiation-related latent cancer fatalities for workers and the general population plus the estimated number of nonradiological fatalities from vehicular emissions.

Figure 11. *Maximum estimated latent cancer fatalities per year in the general population from normal spent nuclear fuel site operations and total fatalities from incident-free transportation.*



Key:

Decentralization A: No examination of Naval fuels
Decentralization B: Limited examination of Naval fuels at Puget Sound Naval Shipyard
Decentralization C: Full examination of Naval fuels at Idaho National Engineering Laboratory with SNF stored at Naval sites
Regionalization A: Regionalization by fuel type
Regionalization B: Regionalization by location

Site initials:
- H: Hanford Site
- I: Idaho National Engineering Laboratory
- S: Savannah River Site
- O: Oak Ridge Reservation
- N: Nevada Test Site

* Location of Expended Core Facility
a. Facility risks are based on the product of the probability and consequences of the respective maximum foreseeable facility accident for each alternative and expressed in latent cancer fatalities per year.

Figure 12. *Estimate of risk of latent cancer fatalities in general population from facility accidents for spent nuclear fuel management activities.*

The risk associated with radiation from transportation accidents poses a lower risk than facility accidents (Figure 13). The risks associated with traffic fatalities (nonradiological) are greater than the risks associated with cancer caused by radiation exposure, although both are very small (Figure 13). The evaluated transportation accident scenario with the largest consequences (spent nuclear fuel transportation accident in an urban area) would lead to 55 latent cancer fatalities; the probability of this occurrence is about 1 in 10 million. However, considering the probability of all accidents analyzed, the risk is nearly zero that is, much less than one over a 40-year period. The results provide estimates of maximum foreseeable consequences of very low probability accidents.

Latent Cancer Fatalities Caused Per Rem for an Individual Member of the General Public

Dose:

Radioactivity from all sources combined, including natural and medical sources, produces about a 0.3 rem dose to the average individual per year.

Probability:

The probability of this happening is essentially one.

Average life span:

72 years is considered to be the average lifetime.

Latent cancer fatalities caused per rem for an individual member of the general public:

0.0005 cancers are estimated to be caused by exposure to 1 rem.

Calculation:

Dose rate x life span x cancers caused per rem = 0.3 rem/year x 72 years x 0.0005 cancers per rem = 0.01 fatal cancers per individual lifetime.

Risk:

Probability x fatal latent cancers = 1 x 0.01 = 0.01 fatal cancer, which is about 1 chance in 100 of death from exposure to natural background radiation over a lifetime.

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

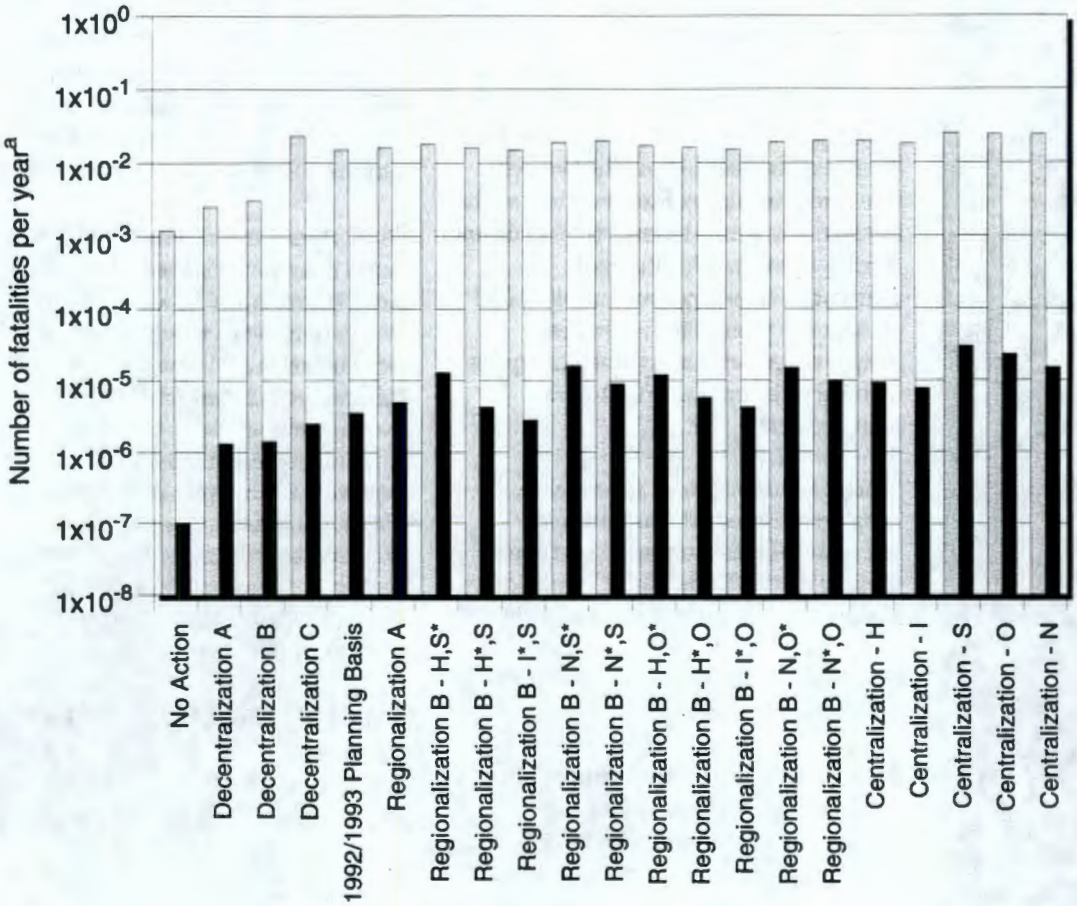
- Zero latent cancer fatalities from normal facility operations and facility accidents
- Zero latent cancer fatalities from transportation accidents
- Zero latent cancer fatalities from most incident-free transportation under most alternatives; up to two latent cancer fatalities under the Centralization alternative.

Up to one fatality could result over the 40-year period from nonradiological traffic accidents. By comparison about 40,000 people are killed annually in U.S. traffic accidents.

Although the anticipated potential for radiation exposures would be small, DOE would use the "as low as reasonably achievable" principle for controlling exposures to workers and the public. For example, practices would be implemented to avoid or reduce production of potentially harmful substances and waste minimization would be practiced to reduce the toxicity and volume of secondary wastes to be managed. Furthermore, all sites would update their current worker training, emergency planning, emergency preparedness, and emergency response programs to address new spent nuclear fuel management activities.

Spent Nuclear Fuel-Related Employment

Under various alternatives, the total labor force involved in spent nuclear fuel management could decrease by 85 to 130 jobs or increase by more than 2,100 jobs, averaged over the period



Key:

Decentralization A: No examination of Naval fuels
Decentralization B: Limited examination of Naval fuels at Puget Sound Naval Shipyard
Decentralization C: Full examination of Naval fuels at Idaho National Engineering Laboratory with SNF stored at Naval sites
Regionalization A: Regionalization by fuel type
Regionalization B: Regionalization by location

Site initials:
H: Hanford Site
I: Idaho National Engineering Laboratory
S: Savannah River Site
O: Oak Ridge Reservation
N: Nevada Test Site

Traffic fatality risk
Radiological risk

* Location of Expended Core Facility
a. Radiological risk is in terms of latent cancer fatalities per year from spent nuclear fuel shipments; traffic fatalitiy risk is in terms of estimated nonradiological traffic accident fatalities per year from spent nuclear fuel shipments

Figure 13. *Estimate of average annual risk from transportation accidents for spent nuclear fuel management activities.*

1995 to 2005, as compared to the 1995 baseline (Figure 14). The peak employment is difficult to estimate because it depends on implementation timing and funding profiles; however, the Regionalization alternative with the Nevada Test Site as the western site and Oak Ridge Reservation as the eastern site would result in the highest employment peak. The peak, estimated to be approximately 4,600 jobs in the year 2000, includes employment at sites preparing spent nuclear fuel for shipment to the selected sites.

Under the No Action alternative, employment would not increase substantially for any site, and the closure of the Expended Core Facility at the Idaho National Engineering Laboratory would result in a net loss of just over 500 spent nuclear fuel management-related jobs.

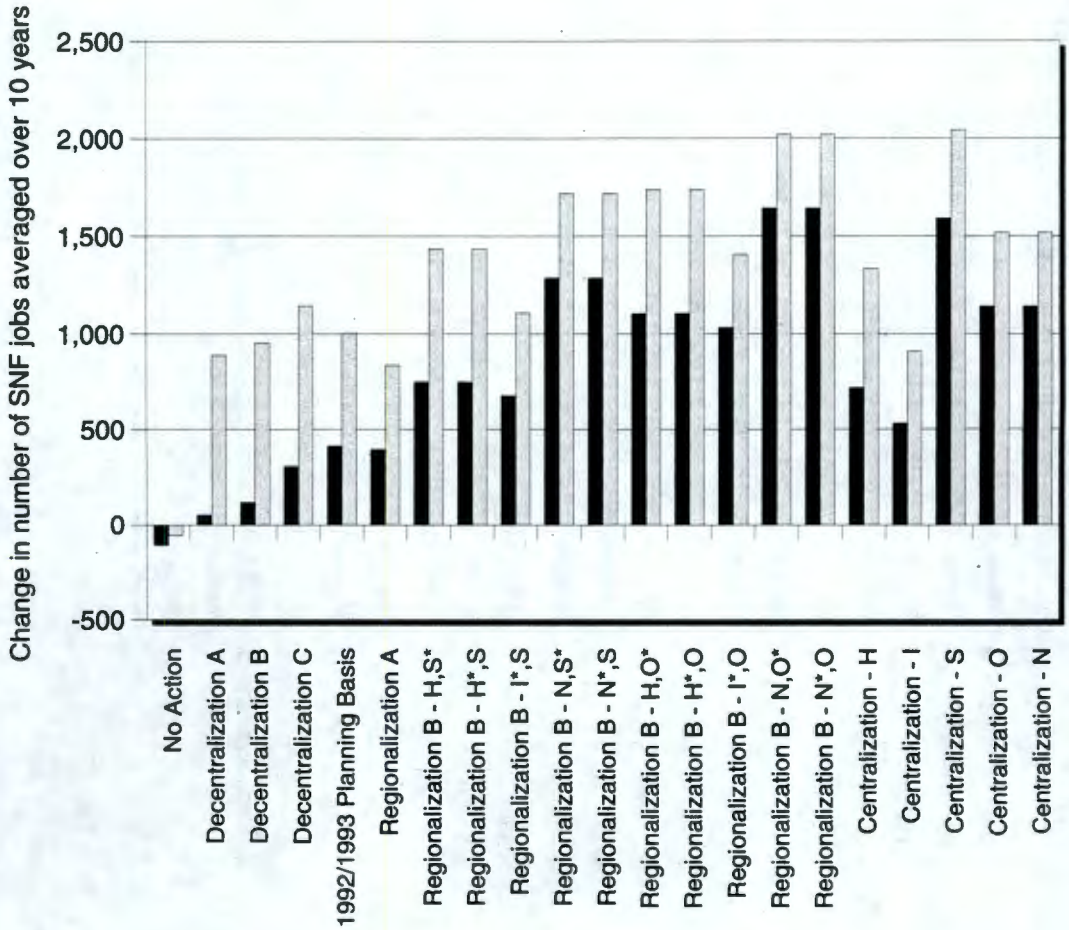
Relocation of large amounts of spent nuclear fuel, such as under Regionalization Subalternative B and the Centralization alternative, would eventually result in closure of spent nuclear fuel management facilities at major DOE sites and, thus, long-term job loss at the closed facilities. However, some of the job losses at closed facilities would be accompanied by job gains at the sites receiving the shipped fuels.

For all three Decentralization options, the 1992/1993 Planning Basis alternative, and Regionalization Subalternative A, no more than an average additional 2,100 jobs would be required over the period 1995 to 2005 for implementation. Some of the more significant spent nuclear fuel employment requirements (particularly those involving the Hanford Site) would result from the development and operation of processing facilities needed to stabilize stored spent nuclear fuel. In addition, the relocation of the Expended Core Facility to sites other than the Idaho National Engineering Laboratory would result in an increase of about 500 jobs per year in the support of naval spent nuclear fuel examinations at those sites, and would result in a corresponding loss of approximately 500 jobs at the Idaho National Engineering Laboratory.

Thus, minor employment-related impacts are anticipated. To mitigate these impacts, DOE would coordinate its planning efforts with local communities and county planning agencies to address changes in community services, housing, infrastructure, utilities, and transportation. Such coordination with local planning agencies is intended to avoid placing undue burdens on local agency resources. DOE may provide support to local agencies if necessary.

Generation of Radioactive Wastes

When spent nuclear fuel is stored onsite, very little high-level, transuranic, or mixed waste is generated (see Figure 15). These small quantities of radioactive wastes would usually be generated during stabilization activities. As a result, under the No Action alternative fewer than 20 cubic meters (25 cubic yards) per year of transuranic wastes would be generated from spent nuclear fuel management nationwide because spent nuclear fuel would not be stabilized. Under all other alternatives, where stabilization activities would occur, between 20 and 50 cubic meters (25 and 65 cubic yards) of high-level waste and between 20 and 100 cubic meters (25 and 130 cubic yards) of transuranic waste would be generated each year. The lower generation rates would occur in the Decentralization alternative, where small amounts of spent nuclear fuel would be shipped among major DOE sites (and stabilization for shipment would not be necessary).



Key:

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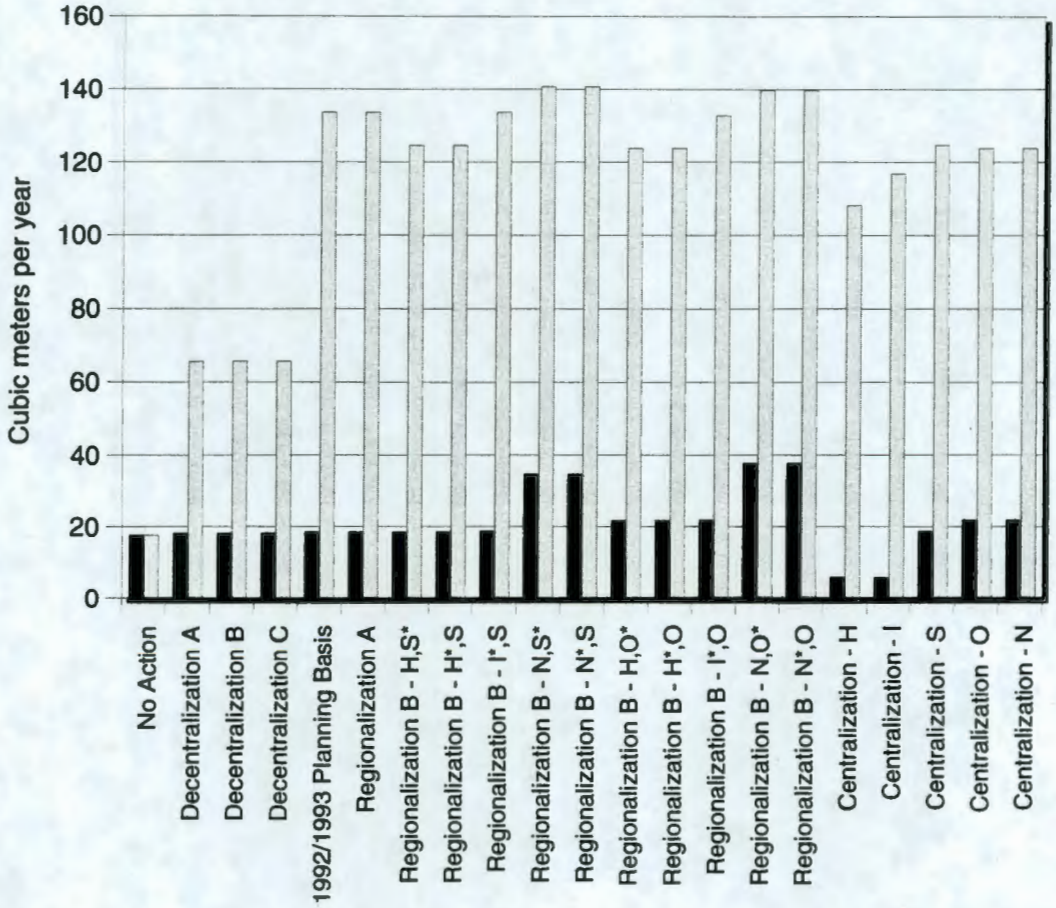
■ Min[a]
□ Max[a]

* Location of Expended Core Facility
a. The maximum values occur with processing; the minimum values occur without processing.

Figure 14. *Change in the number of jobs averaged over the years 1995 to 2005 for spent nuclear fuel management activities.*



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■ Min[a]
▒ Max[a]

* Location of Expended Core Facility

a. The maximum values occur with processing; the minimum values occur without processing

Figure 15. *Average volume of high-level, transuranic, and mixed waste generated per year over the years 1995 to 2005 for spent nuclear fuel management activities.*

For all other alternatives, greater amounts of spent nuclear fuel would be shipped among sites; therefore, more spent nuclear fuel would require stabilization before shipment and more waste would be generated.

Low-level waste also is generated as a result of spent nuclear fuel management. Figure 16 indicates an estimated range of annual volumes for each of the alternatives. The higher values are principally the result of processing for stabilization.

To control the volume of waste generated and reduce impacts on the environment, pollution prevention practices would be implemented. DOE is responding to Executive Order 12856, "Federal Compliance with Right to Know Laws and Pollution Prevention Requirements," and associated DOE orders and guidelines by reducing the use of toxic chemicals; improving emergency planning, response, and accident notification; and encouraging the development and use of clean technologies and the testing of innovative pollution prevention technologies. Pollution prevention programs have already been implemented at DOE sites. Program components include waste minimization, source reduction and recycling, and procurement practices that preferentially procure products made from recycled materials.

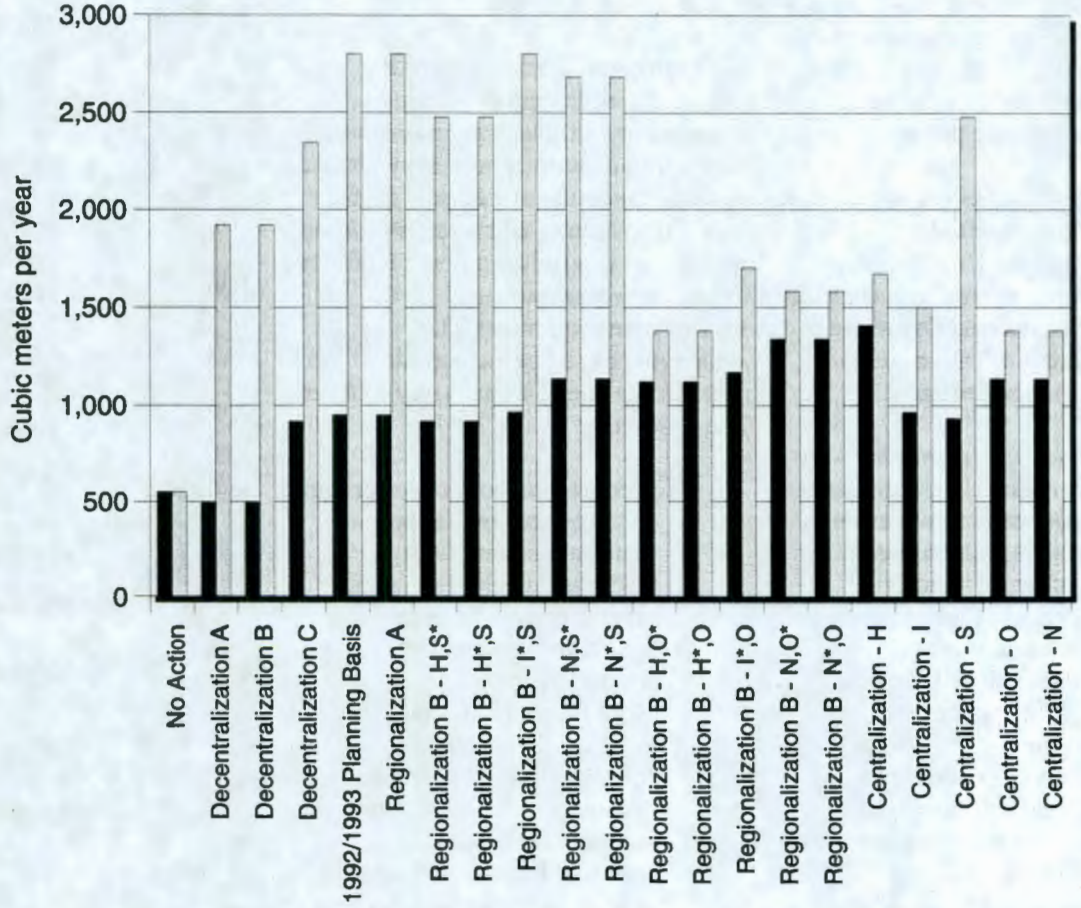
Impact on DOE and Navy Missions

The mission concerns of DOE and the Navy relate to storing spent nuclear fuel safely, meeting obligations, preparing spent nuclear fuel for ultimate disposition, and examining naval fuel. Under the 1992/1993 Planning Basis, Regionalization, and Centralization alternatives, the missions of DOE and the Navy would be met. Under the No Action and Decentralization alternatives, however, some parts of their missions would not be achieved.

DOE's mission is most severely impacted under the No Action alternative. In this alternative, only the minimal actions necessary would be undertaken to store spent nuclear fuel. This means that there would be no facility upgrades, no new facilities, and no new research and development activities. The consequences of pursuing this alternative could include any or all of the following:

- Progressive loss or reduction of safety margin as spent nuclear fuel and storage facilities deteriorate, posing greater threats to human health and the natural environment
- More frequent and possibly more costly repairs to equipment and facilities as the frequency of breakdowns increases
- Eventual loss of the use of storage facilities because equipment or facilities are beyond repair or because there is no flexibility in storage capacity to permit repair work
- No development of improved storage technologies and facilities, reducing DOE's ability to meet future needs and implement future decisions regarding ultimate disposition of spent nuclear fuel.

The Navy's mission would be hindered if the full examination of fuels at an Expended Core Facility were not possible. No or limited examination would occur under the No Action alternative and Decentralization alternative (Options A and B). The examinations are an important aspect of the Navy's ongoing advanced fuel research and



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■ Min [a]
□ Max [a]

* Location of Expended Core Facility

a. The maximum values occur with processing; the minimum values occur without processing

Figure 16. *Average volume of low-level wastes generated per year over the years 1995 to 2005 for spent nuclear fuel management activities.*

development program. The information derived from the examinations provides engineering data to support the design of new reactors, continued safety of existing reactors, and improvements in nuclear fuel performance and reactor operation by providing confirmation of their proper design and allowing maximum use of their fuel.

The No Action alternative would also impact ongoing nuclear research and training activities at universities that have little or no storage capacity for spent nuclear fuel. Such activities would cease once storage capacity is exhausted.

Cost of Implementation

To determine whether there are significant cost differences between EIS alternatives, DOE is developing a cost evaluation that it expects to complete and make available to the public before the Record of Decision is issued. This evaluation will allow near-term spent nuclear fuel decisions to be made with consideration of long-term (life cycle) cost implications. For each alternative, the cost evaluation will consider capital cost for upgrades to existing facilities and new facilities, operation and maintenance costs for existing and new facilities, decontamination and decommissioning costs for new facilities, and spent nuclear fuel transportation costs. While this evaluation will focus on spent nuclear fuel management costs, it will also address total system life cycle costs, including ultimate disposition alternatives such as repository disposal. The results of the evaluation will be considered by DOE in preparing the Record of Decision.

Cumulative Impacts

A cumulative impact results from the incremental impact associated with implementing an alternative plus the impacts of other past, present, and reasonably foreseeable future actions. "Other" actions include DOE projects at the potentially affected sites not related to spent nuclear fuel management, as well as projects of other Government agencies, private businesses, or individuals.

On a nationwide basis, the implementation of any of the spent nuclear fuel management alternatives would not significantly contribute to cumulative impacts. Although impacts to the natural environment (for example, water, air, ecology, and land use) were analyzed, the cumulative impacts are very small, especially if mitigation measures are taken.

In general, the contribution to cumulative impacts from activities required for spent nuclear fuel management would be very small at sites where fuel is stored, in comparison to other ongoing and reasonably expected nonfuel-related projects. Even for those alternatives (Regionalization or Centralization) where the use of nonrenewable resources would be relatively large, increases in the impacts at the selected site(s) would be accompanied by changes at nonselected sites—resulting in a very small net change.

On a site-specific basis, the implementation of any of the alternatives would not significantly contribute to cumulative impacts. Generally, the contribution to cumulative impacts from spent nuclear fuel management activities at a specific site is minor, relative to other DOE and non-DOE projects. Radiological emissions from normal operations and from transportation of spent nuclear fuel would be well within regulatory requirements. The volumes of waste produced from fuel management activities would be a small addition to waste volumes generated by other ongoing and

expected projects. For some alternatives, increased employment averaged over 10 years would be relatively high (1992/1993 Planning Basis, Regionalization Subalternative A, and Decentralization). Even for these alternatives, the net contribution to cumulative impacts (such as demand on housing or school systems) would be low because of anticipated overall declines in site employment over the next few years.

Consultations and Environmental Requirements

DOE is committed to operating its spent nuclear fuel management program in compliance with all applicable environmental laws, regulations, executive orders, DOE orders, and permits and compliance agreements with regulatory agencies. The DOE regulations that implement the National Environmental Policy Act require consultation with other agencies, when appropriate, to incorporate any relevant requirements as early as possible in the process. These consultation and coordination requirements will commence and be completed as site-specific spent nuclear fuel management projects and decisions are proposed. To the extent that this EIS supports existing site-specific proposals, those consultations and coordination efforts are contained within Volume 2 of the EIS.

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Attachment—Reading Rooms and Information Locations

Department of Energy Reading Rooms

Public Reading Room for U.S. Department of Energy Headquarters
Room 1E-190, Forrestal Building
Freedom of Information Reading Room
1000 Independence Avenue, SW
Washington, DC 10585
(202) 586-6020
Monday-Friday 9:00 a.m. to 4:00 p.m.

Public Reading Room for U.S. Department of Energy
Oakland Operations Office
Environmental Information Center
1301 Clay Street, Room 700 N
Oakland, CA 94612
(510) 637-1762
Monday-Friday 8:30 a.m. to 5:00 p.m.

Public Reading Room for U.S. Department of Energy
Rocky Flats Operations Office
Front Range Community College Library
3645 W. 112th Ave.
Level B, Center or the Building
Westminister, CO 80030
(303) 469-4435
Monday and Tuesday 10:30 a.m. to 6:30 p.m., Wednesday 10:00 a.m. to 4:00 p.m., Thursday 8:00 a.m. to 4:00 p.m.

Public Reading Room for U.S. Department of Energy
Idaho Operations Office
Public Reading Room
1776 Science Center Drive
Idaho Falls, ID 83402
(208) 526-9162
Monday-Friday 8:00 a.m. to 5:00 p.m.

Public Reading Room for U.S. Department of Energy
University of Illinois at Chicago Library
Government Documents Section
801 South Morgan Street
Chicago, IL 60607
(312) 996-2738
Monday-Friday 8:00 a.m. to 10:00 p.m., Saturday 10:00 a.m. to 5:00 p.m.

Public Reading Room for U.S. Department of Energy
National Atomic Museum
20358 Wyoming Boulevard, SE
Albuquerque, NM 87185
(505) 845-4378
Monday-Friday 9:00 a.m. to 5:00 p.m.

Public Reading Room for U.S. Department of Energy
Nevada Operations Office
Coordination and Information Center
3084 South Highland Drive
P.O. Box 98521
Las Vegas, NV 89106
(702) 295-0731
Monday-Friday 7:00 a.m. to 4:00 p.m.

Public Information Room for U.S. Department of Energy
Fernald Operations Office
Public Environmental Center
JANTER Building 10845
Hamilton-Cleves Highway
Harrison, OH 445030
(513) 738-0164
Monday and Thursday 9:00 a.m. to 8:00 p.m., Tuesday, Wednesday, Friday 9:00 a.m. to 4:30 p.m., Saturday 9 a.m. to 1 p.m.

Public Reading Room for U.S. Department of Energy
Savannah River Operations Office
Public Reading Room
Road 1A, Building 703A, D232
Aiken, SC 29802
(803) 725-1408
Monday-Thursday 8:00 a.m. to 11:00 p.m., Friday 8:00 a.m. to 5:00 p.m., Saturday 10:00 a.m. to 5:00 p.m., Sunday 2:00 p.m. to 11:00 p.m.

Public Reading Room for U.S. Department of Energy
Oak Ridge Operations Office
Public Reading Room
55 Jefferson Avenue
Oak Ridge, TN 37831
(615) 576-1216
Monday-Friday 8:00 a.m. to 11:30 a.m. and 12:30 p.m. to 5:00 p.m.

Public Reading Room for U.S. Department of Energy
Richland Operations Office
Washington State University Tri-Cities
100 Sprout Road, Room 130 West
Richland, WA 99352
(509) 376-8583
Monday-Friday 8:00 a.m. to 12:00 p.m. and 1:00 p.m. to 4:00 p.m.

Navy Information Locations

Norfolk Naval Shipyard

Chesapeake Central Library
298 Cedar Rd.
Chesapeake, VA 23320-5512
(804) 436-8300
Monday-Thursday 9:00 a.m to 9:00 p.m., Friday and Saturday 9:00 a.m to 5:00 p.m., Sunday 1:00 p.m to 5:00 p.m.

Newport News Public Library
Grissom Branch
366 Deshazor Dr.
Newport News, VA 23602
(804) 886-7896
Monday-Thursday 9:00 a.m. to 9:00 p.m., Friday and Saturday 9:00 a.m. to 6:00 p.m.

Kiln Library
301 East City Hall Ave.
Norfolk, VA 23510
(804) 441-2429
Monday-Thursday 9:00 a.m. to 9:00 p.m., Friday 9:00 a.m. to 5:00 p.m., Saturday 9:00 a.m. to 5:00 p.m.

Hampton Public Library
4207 Victoria Boulevard
Hampton, VA 23669
(804) 727-1154
Monday-Thursday 9:00 a.m. to 9:00 p.m., Friday and Saturday 9:00 a.m. to 5:00 p.m.

Portsmouth Public Library
Main Branch
601 Court St.
Portsmouth, VA 23704
(804) 393-8501
Monday-Thursday 9:00 a.m to 9:00 p.m, Friday and Saturday 9:00 a.m to 5:00 p.m.

Virginia Beach Central Library
4100 Virginia Beach Blvd.
Virginia Beach, VA 23452
(804) 431-3001
Monday-Thursday 10:00 a.m. to 9:00 p.m., Friday and Saturday 10:00 a.m. to 5:00 p.m., Sunday 1:00 p.m. to 5:00 p.m.

Puget Sound Naval Shipyard

Kitsap Regional Library
1301 Sylvan Way
Bremerton, WA 98310
(206) 377-7601
Monday-Thursday 9:30 a.m. to 9:00 p.m., Friday and Saturday 9:30 a.m. to 5:30 p.m., Sunday 12:30 p.m. to 5:30 p.m.

Kitsap Regional Library
Downtown Branch
612 5th Ave.
Bremerton, WA 98310
(206) 377-3955
Monday-Friday 10:00 a.m. to 6:00 p.m.

Suzallo Library SM25
University of Washington Libraries
University of Washington
Seattle, WA 98185
(206) 543-9158
Monday-Thursday 7:30 a.m. to 12:00 midnight, Friday 7:30 a.m. to 6:00 p.m., Saturday 9:00 a.m. to 5:00 p.m., Sunday 12:00 p.m. to 12:00 midnight

Portsmouth Naval Shipyard

Rice Public Library
8 Wentworth Street
Kittery, ME 03904
(207) 439-1553
Monday-Wednesday, Friday 10:00 a.m. to 5:00 p.m., Thursday 10:00 a.m. to 8:00 p.m., Saturday 10:00 a.m. to 4:00 p.m.

Portsmouth Public Library
8 Islington Street
Portsmouth, NH 03801
(804) 393-8501
Monday-Thursday 9:00 a.m. to 9:00 p.m., Friday and Saturday 9:00 a.m. to 5:00 p.m.

Pearl Harbor Naval Shipyard

Aiea Public Library
99-143 Monalua Rd.
Aiea, HI 96701
(808) 488-2654
Monday and Thursday 10:00 a.m. to 8:00 p.m., Tuesday, Wednesday, Friday, Saturday 10:00 a.m. to 5:00 p.m.

Hawaii State Library
478 South King Street
Honolulu, HI 96813
(808) 586-3535
Monday, Wednesday, Friday, Saturday 9:00 a.m. to 5:00 p.m., Tuesday, Thursday 9:00 a.m. to 8:00 p.m.

Pearl City Public Library
1138 Waimano Home Rd.
Pearl City, HI 96782
(808) 455-4134
Monday-Wednesday 10:00 a.m. to 8:00 p.m., Thursday-Saturday 10:00 a.m. to 5:00 p.m., Sunday 1:00 p.m. to 5:00 p.m.

Pearl Harbor Naval Base Library
Code 90L
1614 Makalapa Dr.
Pearl Harbor, HI 96860-5350
(808) 471-8238
Tuesday-Thursday 10:00 a.m. to 7:00 p.m., Friday and Saturday 9:00 a.m. to 5:00 p.m.

Kesselring Site

Albany Public Library
Reference and Adult Services
161 Washington Ave.
Albany, NY 12210
(518) 449-3380
Monday-Thursday 9:00 a.m. to 9:00 p.m., Friday 9:00 a.m to 6:00 p.m., Saturday 9:00 a.m. to 5:00 p.m.

Saratoga Springs Public Library
320 Broadway
Saratoga Springs, NY 12866
(518) 584-7860
Monday-Thursday 9:00 a.m. to 9:00 p.m., Friday 9:00 a.m. to 6:00 p.m., Saturday 9:00 a.m. to 5:00 p.m., Sunday 1:00 p.m. to 5:00 p.m.

Schenectady County Library
99 Clinton Street
Schenectady, NY 12305
(518) 388-4511
Monday-Thursday, 9:00 a.m. to 9:00 p.m., Friday-Saturday, 9:00 a.m. to 5:00 p.m., Sunday 1:00 p.m. to 5:00 p.m.

Other Locations

Main Library
University of Arizona
Tucson, AZ 85721
(602) 621-6433
Sunday-Thursday 8:00 a.m. to 1:00 a.m., Friday-Saturday 9:00 a.m. to 5:00 p.m.

Main Library
University of California at Irvine
Government Publications Receiving Dock
Irvine, CA 92717
(714) 856-7290
School Hours: Monday-Thursday 8:00 a.m. to 7:00 p.m., Friday 8:00 a.m. to 5:00 p.m., Saturday and Sunday 1:00 p.m. to 11:00 p.m. Summer Hours: Monday-Friday 8:00 a.m. to 5:00 p.m., Saturday and Sunday 1:00 p.m. to 5:00 p.m.

Pleasanton Public Library - Reference Desk
400 Old Bernal Avenue
Pleasanton, CA 94566
(510) 462-3535
Monday and Tuesday 1:00 p.m. to 8:00 p.m., Wednesday and Thursday 10:00 a.m. to 6:00 p.m., Saturday 2:00 p.m. to 6:00 p.m., Sunday 1:00 p.m. to 5:00 p.m.

San Diego Public Library
820 "E" Street
San Diego, CA 92101
(619) 236-5867
Monday-Thursday 10:00 a.m. to 9:00 p.m., Friday and Saturday 9:30 a.m. to 5:30 p.m., Sunday 1:00 p.m. to 5:00 p.m.

Denver Public Library
1357 Broadway
Denver, CO 80203
(303) 640-8845
Monday-Wednesday 10:00 a.m. to 9:00 p.m., Thursday-Saturday 10:00 a.m. to 5:30 p.m., Sunday 1:00 p.m. to 5:00 p.m.

George A. Smathers Libraries, Library West
University of Florida Library, Room 241
P.O. Box 117001
Gainesville, FL 32611-7001
(904) 392-0367
Monday-Thursday 8:00 a.m. to 9:30 p.m., Friday 8:00 a.m. to 5:00 p.m., Sunday 2:30 p.m. to 9:30 p.m.

Atlanta Public Library
1 Margaret Mitchell Square
Atlanta, GA 30303
(404) 730-1700
Monday 9:00 a.m. to 6:00 p.m., Tuesday-Thursday 9:00 a.m. to 8:00 p.m., Friday 9:00 a.m. to 5:00 p.m., Saturday 10:00 a.m. to 5:00 p.m.

Reese Library
Augusta College
2500 Walton Way
Augusta, GA 30904-2200
(706) 737-1744
School Hours: Monday-Thursday 7:45 a.m. to 10:30 p.m., Friday 7:45 a.m. to 5:00 p.m., Saturday 9:00 a.m. to 5:00 p.m., Sunday 1:30 p.m. to 9:30 p.m. Summer Hours: Monday-Friday 8:00 a.m. to 5:00 p.m.

Chatham-Effingham-Liberty Regional Library
2002 Bull Street
Savannah, GA 31401
(912) 234-5127
Monday-Thursday 9:00 a.m. to 9:00 p.m., Friday 9:00 a.m. to 6:00 p.m., Saturday 10:00 a.m. to 6:00 p.m.

Parks Library
Iowa State University
Government Publications Department
Ames, IA 50011-2140
(515) 294-3642
School Hours: Monday-Thursday 7:30 a.m. to 12:00 midnight, Friday 7:30 a.m. to 10:00 p.m., Saturday 10:00 a.m. to 10:00 p.m., Sunday 12:30 p.m. to 12:00 midnight, Summer Hours: Monday-Thursday 7:30 a.m. to 10:00 p.m., Friday 7:30 a.m. to 5:00 p.m., Saturday 12:30 p.m. to 5:00 p.m., Sunday 12:30 p.m. to 10:00 p.m.

Boise Public Library
715 South Capitol Boulevard
Boise, ID 83702
(208) 384-4023
Monday-Friday 10:00 a.m. to 6:00 p.m., Tuesday-Thursday 10:00 a.m. to 9:00 p.m., Saturday 1:00 p.m. to 5:00 p.m.

Idaho Department of Health and Welfare Idaho National Engineering Laboratory Oversight Program Library
1410 North Hilton
Boise, ID 83706
(208) 334-0498
Monday-Friday 8:00 a.m. to 5:00 p.m.

Idaho State Library
325 West State Street
Boise, ID 83702
(208) 334-2152
Monday-Friday 9:00 a.m. to 5:00 p.m.

Shoshone-Bannock Library
Bannock and Pima Streets, HRDC Building
Fort Hall, ID 83203
(208) 238-3882
Monday-Friday 8:00 a.m. to 4:30 p.m.

Idaho Falls Public Library
457 Broadway
Idaho Falls, ID 83402
(208) 529-1462
Monday-Thursday 8:00 a.m. to 7:00 p.m, Friday 8:00 a.m. to 5:00 p.m., Saturday 9:00 a.m. to 1:00 p.m.

University of Idaho Library
Rayburn Street
Moscow, ID 83844-2353
(208) 885-6344
Monday-Friday 8:00 a.m. to 12:00 midnight, Saturday 9:00 a.m. to 12:00 midnight, Sunday 10:00 a.m. to 12:00 midnight

Pocatello Public Library
812 East Clark Street
Pocatello, ID 83201
(208) 232-1263
Monday-Thursday 10:00 a.m. to 9:00 p.m, Friday and Saturday 10:00 a.m. to 6:00 p.m.

Twin Falls Public Library
434 Second Street East
Twin Falls, ID 83301
(208) 733-2964
Monday-Thursday 10:00 a.m. to 6:00 p.m, Friday 10:00 a.m. to 5:00 p.m., Saturday 12:00 p.m.to 5:00 p.m.

Main Library, Third Floor
University of Illinois
801 South Morgan, Mail Code 234
Chicago, IL 60607
(312) 413-2594
Monday-Thursday 7:30 a.m. to 10:00 p.m., Friday 7:30 a.m. to 5:00 p.m., Saturday 10:00 a.m. to 5:00 p.m., Sunday 1:00 p.m. to 9:00 p.m.

Documents Library, 200-D
University of Illinois
1408 W. Gregory Drive
Urbana, IL 61801
(217) 244-2060
School Hours: Monday-Thursday 8:00 a.m. to 12:00 midnight, Friday 8:00 a.m. to 6:00 p.m., Saturday 9:00 a.m. to 6:00 p.m., Sunday 1:00 p.m. to 12:00 midnight, Summer Hours: Monday-Thursday 8:00 a.m. to 9:00 p.m., Friday 8:00 a.m. to 6:00 p.m., Saturday 9:00 a.m. to 5:00 p.m., Sunday 1:00 p.m. to 5:00 p.m.

Engineering Library
Purdue University
West Lafayette, IN 47907
(317) 494-2871
School Hours: Monday-Friday 8:00 a.m. to 12:00 midnight, Saturday 9:00 a.m. to 5:00 p.m., Sunday 12:00 p.m. to 12:00 midnight, Summer Hours: Monday-Friday 8:00 a.m. to 8:00 p.m.

Manhattan Public Library
Julliette and Poyntz
Manhattan, KS 66502
(913) 776-4741
Monday-Friday 9:00 a.m. to 9:00 p.m., Saturday 9:00 a.m. to 6:00 p.m., Sunday 2:00 p.m. to 6:00 p.m.

Massachusetts Institute of Technology Science Library
160 Memorial Drive Building 14
Cambridge, MA 02139
(617) 253-5685
Monday-Thursday 8:00 a.m. to 12:00 midnight, Friday and Saturday 8:00 a.m. to 8:00 p.m., Sunday 12:00 p.m. to 12:00 midnight

O'Leary Library
University of Massachusetts
1 University Ave
Lowell, MA 01854
(508) 934-3205
School Hours: Monday-Thursday 7:30 a.m. to 11:00 p.m., Friday 7:30 a.m. to 5:00 p.m., Saturday 10:00 a.m. to 6:00 p.m., Summer Hours: Monday-Friday 8:30 a.m. to 9:00 p.m., Sunday 2:00 p.m. to 7:00 p.m.

Worcester Public Library
3 Salem Square
Worchester, MA 01608
(508) 799-1655
Monday and Wednesday 12:00 p.m. to 9:00 p.m., Tuesday 10:00 a.m. to 9:00 p.m., Thursday-Saturday 10:00 a.m. to 5:30 p.m.

Bethesda Public Library
7400 Arlington Road
Bethesda, MD 20814
(301) 986-4300
Monday-Thursday 10:00 a.m. to 8:30 p.m., Friday 10:00 a.m. to 5:00 p.m., Saturday 9:00 a.m. to 5:00 p.m., Sunday 1:00 p.m. to 5:00 p.m.

Gaithersburg Regional Library
18330 Montgomery Village Avenue
Gaithersburg, MD 20879
(301) 840-2515
Monday-Thursday 10:00 a.m. to 8:30 p.m., Friday 10:00 a.m. to 5:00 p.m., Saturday 9:00 a.m. to 5:00 p.m., Sunday 1:00 p.m. to 5:00 p.m.

Hyattsville Public Library
6530 Adelphi Road
Hyattsville, MD 20782
(301) 779-9330
Monday-Thursday 10:00 a.m. to 9:00 p.m., Friday 10:00 a.m. to 6:00 p.m., Saturday 10:00 a.m. to 5:00 p.m., Sunday 1:00 p.m. to 5:00 p.m.

Ann Arbor Public Library
343 South 5th Avenue
Ann Arbor, MI 48104
(313) 994-2333
Monday 10:00 a.m. to 9:00 p.m., Tuesday-Friday 9:00 a.m. to 9:00 p.m., Saturday 9:00 a.m. to 6:00 p.m., Sunday 1:00 p.m. to 5:00 p.m.

Zanhow Library
Saginaw Valley State University
7400 Bay Road
University Center, MI 48710
(517) 790-4240
School Hours: Monday-Thursday 8:00 a.m. to 11:00 p.m., Friday 8:00 a.m. to 4:30 p.m., Saturday 9:00 a.m. to 5:00 p.m., Sunday 1:00 p.m. to 9:00 p.m. Summer Hours: Monday-Thursday 8:00 a.m. to 10:30 p.m., Friday 8:00 a.m. to 4:30 p.m., Saturday 10:00 a.m. to 2:00 p.m., Sunday 1:00 p.m. to 5:00 p.m.

Ellis Library
University of Missouri
Columbia, MO 65201
(314) 882-0748
School Hours: Monday-Thursday 7:30 a.m. to 12:00 midnight, Friday 7:30 a.m. to 11:00 p.m.,Saturday 9:00 a.m. to 9:00 p.m., Sunday 12:00 p.m. to 1:00 a.m. Summer Hours: Monday and Thursday 8:00 a.m. to 8:00 p.m., Tuesday, Wednesday, and Friday 8:00 a.m. to 5:00 p.m., Saturday 12:00 p.m. to 5:00 p.m.

Curtis Laws Wilson Library
University of Missouri Library
Rolla, MO 65401-0249
(314) 341-4227
School Hours: Monday-Thursday 8:00 a.m. to 12:00 midnight, Friday 8:00 a.m. to 10:30 p.m., Saturday 8:00 a.m. to 5:00 p.m., Sunday 2:00 p.m. to 12:00 midnight, Summer Hours: Monday-Friday 8:00 a.m. to 10:00 p.m., Saturday 8:00 a.m. to 5:00 p.m., Sunday 2:00 p.m. to 10:00 p.m.

D.H. Hill Library
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P.O. Box 7111
Raleigh, NC 27695-7111
(919) 515-3364
School Hours: Monday-Thursday 7:00 a.m. to 1:00 a.m., Friday 7:00 a.m. to 6:00 p.m., Saturday 9:30 a.m. to 5:30 p.m., Sunday 1:00 p.m. to 1:00 a.m. Summer Hours: Monday-Thursday 7:00 a.m. to 11:00 p.m., Friday 7:00 a.m. to 6:00 p.m., Saturday 9:30 a.m. to 5:30 p.m., Sunday 1:00 p.m. to 11:00 p.m.

Omaha Public Library
215 S. 15th Street
Omaha, NE 68102
(402) 444-4800
Monday-Thursday 9:00 a.m. to 9:00 p.m., Friday and Saturday 9:00 a.m. to 5:30 p.m., Sunday 1:00 p.m. to 5:00 p.m.

General Library
University of New Mexico
Albuquerque, NM 87131-1466
(505) 277-5441
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U.S. DOE Community Reading Room
1450 Central Avenue, Suite 101
MS C314
Los Alamos, NM 87544
(505) 665-2127
Monday-Friday 8:00 a.m. to 5:00 p.m.

Lockwood Library
State University of New York-Buffalo
Buffalo, NY 14260-2200
(716) 645-2816
School Hours: Monday-Thursday 8:00 a.m. to 10:45 p.m., Friday 8:00 a.m. to 9:00 p.m., Saturday 9:00 a.m. to 5:00 p.m., Sunday 1:00 p.m. to 10:45 p.m., Summer Hours: Monday, Wednesday, Thursday, and Friday 9:00 a.m. to 6:00 p.m., Tuesday 9:00 a.m. to 10:00 p.m. Sunday 1:00 p.m. to 9:00 p.m.

Engineering Library
Cornell University
Carpenter Hall, Main Floor
Ithaca, NY 14853
(607) 255-5762
School Hours: Monday-Thursday 8:00 a.m. to 11:00 p.m., Friday 8:00 a.m. to 6:00 p.m., Saturday 10:00 a.m. to 6:00 p.m., Sunday 12:00 p.m. to 11:00 p.m., Summer Hours: Monday-Friday 8:00 a.m. to 6:00 p.m., Saturday 12:00 p.m. to 6:00 p.m.

Cardinal Hayes Library
Manhattan College
4531 Manhattan College Parkway
Riverdale, NY 10471
(718) 920-0100
School Hours: Monday-Thursday 8:00 a.m. to 11:00 p.m., Friday 8:00 a.m. to 6:30 p.m., Saturday 10:00 a.m. to 5:00 p.m., Sunday 1:00 p.m. to 11:00 p.m., Summer Hours: Monday-Friday 8:30 a.m. to 6:30 p.m.

Brookhaven National Laboratory
25 Brookhaven Avenue, Building 477 A
P.O. Box 5000
Upton, NY 11973-5000
(516) 282-3489
Monday-Friday 8:30 a.m. to 9:00 p.m., Saturday and Sunday 10:00 a.m. to 6:00 p.m.

Columbus Metropolitan Library
96 South Grant Avenue
Columbus, OH 43215
(614) 645-2710
Monday-Thursday 9:00 a.m. to 9:00 p.m., Friday and Saturday 9:00 a.m. to 6:00 p.m., Sunday 1:00 p.m. to 5:00 p.m.

Kerr Library
Oregon State University
Corvallis, OR 97331-4905
(503) 737-0123
Monday-Friday 7:45 a.m. to 2:00 a.m., Saturday and Sunday 10:00 a.m. to 2:00 a.m.

Brantford Price Millar Library
Portland State University
934 S.W. Harrison
Portland, OR 97201
(503) 725-4617
Monday-Friday 8:00 a.m. to 10:00 p.m., Saturday 10:00 a.m. to 10:00 p.m., Sunday 11:00 a.m. to 10:00 p.m.

Pattee Library
Pennsylvania State University
University Park, PA 16801
(814) 865-2112
School Hours Monday-Thursday 8:00 a.m. to 12:00 midnight, Friday 8:00 a.m. to 10:00 p.m., Saturday 8:00 a.m. to 9:00 p.m., Sunday 1:00 p.m. to 12:00 midnight, Summer Hours: Monday-Thursday 7:45 a.m. to 10:00 p.m., Friday 7:45 a.m. to 9:00 p.m., Saturday 8:00 a.m. to 9:00 p.m., Sunday 1:00 p.m. to 10:00 p.m.

Narragansett Public Library
35 Kingston Road
Narragansett, RI 02882
(401) 789-9507
Monday 10:00 a.m. to 9:00 p.m., Tuesday-Friday 10:00 a.m. to 6:00 p.m., Saturday 10:00 a.m. to 5:00 p.m. (Saturday hours September to May only)

Charleston County Main Library
404 King Street
Charleston, SC 29403
(803) 723-1645
Monday-Thursday 9:30 a.m. to 9:00 p.m., Friday-Saturday 9:30 a.m. to 6:00 p.m., Sunday 2:00 p.m. to 6:00 p.m.

South Carolina State Library
1500 Senate Street
Columbia, SC 29201
(803) 734-8666
Monday-Friday 8:15 a.m. to 5:30 p.m., Saturday 9:00 to 1:00 p.m.

Clinton Public Library
118 South Hicks Street
Clinton, TN 37716
(615) 457-0519
Monday and Thursday 10:00 a.m. to 8:00 p.m., Tuesday, Wednesday, Friday, Saturday 10:00 a.m. to 5:00 p.m.

Harriman Public Library
601 Walden Street
Harriman, TN 37748
(615) 882-3195
Monday-Thursday 9:00 a.m. to 5:00 p.m., Friday-Saturday 9:00 a.m. to 1:00 p.m.

Kingston Public Library
1000 Bradford Way Building #3
Kingston, TN 37763
(615) 376-9905
Monday and Thursday 10:00 a.m. to 7:30 p.m., Tuesday, Wednesday, Friday 10:00 a.m. to 5:30 p.m., Saturday 10:00 a.m. to 2:00 p.m.

Lawson McGhee Public Library
500 West Church Avenue
Knoxville, TN 37902
(615) 544-5750
Monday-Thursday 9:00 a.m. to 8:30 p.m., Friday 9:00 a.m. to 5:30 p.m., Saturday and Sunday 1:00 p.m. to 5:00 p.m.

Oak Ridge Public Library
Civic Center
Oak Ridge, TN 37830
(615) 482-8455
Monday-Thursday 10:00 a.m. to 9:00 p.m., Friday 10:00 a.m. to 6:00 p.m., Saturday 9:00 a.m. to 6:00 p.m., Sunday 2:00 p.m. to 6:00 p.m.

Oliver Springs Public Library
607 Easterbrook Avenue
Oliver Springs, TN 37840
(615) 435-2509
Tuesday-Thursday 2:00 p.m. to 4:00 p.m., Saturday 9:00 a.m. to 12:00 midnight

Rockwood Public Library
117 North Front Avenue
Rockwood, TN 37854
(615) 354-1281
Monday, Wednesday, Friday and Saturday 10:00 a.m. to 5:00 p.m., Tuesday and Thursday 10:00 a.m. to 8:00 p.m.

General Library
University of Texas
PCL 2.402X
Austin, TX 78713
(512) 495-4262
School Hours: Monday-Friday 8:00 a.m. to 2:00 a.m., Saturday 9:00 a.m. to 2:00 a.m., Sunday 12:00 p.m. to 2:00 a.m., Summer Hours: Monday-Friday 8:00 a.m. to 10:00 p.m., Saturday 9:00 a.m. to 10:00 p.m., Sunday 12:00 p.m. to 10:00 p.m.

Evans Library
Texas A&M University, MS 5000
College Station, TX 77843-5000
(409) 845-8850
School Hours: Monday-Thursday 7:00 a.m. to 12:00 midnight., Friday 7:00 a.m. to 7:00 p.m., Saturday 9:00 a.m. to 5:00 p.m., Sunday 1:00 p.m. to 11:00 p.m., Summer Hours: Monday-Thursday 7:00 a.m. to 11:00 p.m., Friday 7:00 a.m. to 7:00 p.m., Saturday 9:00 a.m. to 5:00 p.m., Sunday 1:00 p.m. to 11:00 p.m.

Marriott Library
University of Utah
Salt Lake City, UT 84112
(801) 581-8394
School Hours: Monday-Thursday 7:00 a.m. to 11:00 p.m., Friday 7:00 a.m. to 5:00 p.m., Saturday 9:00 a.m. to 5:00 p.m., Sunday 11:00 a.m. to 9:00 p.m. Summers Hours: Monday-Thursday 7:00 a.m. to 10:00 p.m., Friday 7:00 a.m. to 5:00 p.m., Saturday 9:00 a.m. to 5:00 p.m., Sunday 1:00 p.m. to 5:00 p.m.

Alderman Library
University of Virginia
Charlottesville, VA 22903-2498
(804) 924-3133
School Hours: Monday-Thursday 8:00 a.m. to 12:00 midnight, Friday 8:00 a.m. to 6:00 p.m., Saturday 9:00 a.m. to 6:00 p.m., Sunday 12:00 p.m. to 12:00 midnight, Summer Hours: Monday-Thursday 8:00 a.m. to 10:00 p.m., Friday 8:00 a.m. to 6:00 p.m., Saturday 9:00 a.m. to 6:00 p.m., Sunday 2:00 p.m. to 10:00 p.m.

Owen Science & Engineering Library
Washington State University
Pullman, WA 99164-3200
(509) 335-4181
School Hours: Monday-Thursday 8:00 a.m. to 11:00 p.m., Friday 8:00 a.m. to 9:00 p.m., Saturday 12:00 p.m. to 9:00 p.m., Sunday 12:00 p.m. to 11:00 p.m., Summer Hours: Monday and Thursday 7:30 a.m. to 11:00 p.m., Tuesday, Wednesday, and Friday 7:30 a.m. to 6:00 p.m., Saturday and Sunday 12:00 p.m. to 6:00 p.m.

Foley Center
Gonzaga University
East 502 Boone Avenue
Spokane, WA 99258
(509) 328-4220, extension 3125
School Hours: Monday-Thursday 8:00 a.m. to 12:00 midnight, Friday and Saturday 8:00 a.m. to 9:00 p.m., Sunday 11:00 a.m. to 12:00 midnight, Summer Hours: Monday-Friday 8:00 a.m. to 9:00 p.m., Saturday 10:00 a.m. to 6:00 p.m., Sunday 1:00 p.m. to 7:00 p.m.

Madison Public Library
201 W. Mifflin Street
Madison, WI 53703
(608) 266-6350
Monday-Wednesday 8:30 a.m. to 9:00 p.m., Thursday and Friday 8:30 a.m. to 5:30 p.m., Saturday 9:00 a.m. to 5:30 p.m.

Teton County Public Library
320 South King Street
Jackson, WY 83001
(307) 733-2164
Monday, Wednesday and Friday 10:00 a.m. to 5:30 p.m., Tuesday and Thursday 10:00 a.m. to 9:00 p.m., Saturday 10:00 a.m. to 5:00 p.m., Sunday 1:00 p.m. to 5:00 p.m.

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1. INTRODUCTION

The U.S. Department of Energy (DOE) is evaluating its options for two separate but related sets of decisions pertinent to the management of spent nuclear fuel (SNF). The first involves programmatic (DOE-wide) approaches to the management of DOE's SNF. The second involves site-specific approaches for environmental restoration and waste management activities at the Idaho National Engineering Laboratory, including SNF management. This Environmental Impact Statement (EIS) covers both issues, the first in Volume 1, the second in Volume 2. Prepared in accordance with the National Environmental Policy Act and its applicable implementing regulations (40 CFR Parts 1500-1508 and 10 CFR Part 1021), the EIS provides background information on management alternatives, describes the affected environment, and analyzes the potential environmental consequences of management alternatives.

Volume 1 has been developed to support DOE's initial decisionmaking on the most appropriate national strategies for managing SNF until its ultimate disposition is determined and implemented. For planning purposes, it has been assumed that if placement in a repository is selected, space may not be available for up to 40 years. The general environmental consequences of managing SNF in a range of configurations at various sites are summarized in this volume.

Volume 1 is supported by site-specific appendices (under separate cover) that provide detailed information on the consequences of management activities under each alternative at the Hanford Site (Appendix A); the Idaho National Engineering Laboratory (Appendix B); the Savannah River Site (Appendix C); Naval SNF management facilities, including management of Naval SNF at DOE facilities (Appendix D); other generator/storage sites (Appendix E); and the Oak Ridge Reservation and the Nevada Test Site (Appendix F).

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

SNF is DOE fuel that has been permanently withdrawn from a nuclear reactor following irradiation, the constituent elements of which have not been separated by reprocessing. The SNF considered in this EIS consists of the SNF removed from DOE defense production reactors at the Savannah River and Hanford Sites, United States Naval Nuclear Propulsion Program reactors, DOE test and experimental reactors, United States university research reactors, special-case power reactors, and special-case foreign research reactors. This DOE SNF management

responsibility is separated into two categories: DOE-managed fuel and commercial SNF.[a] The overall management of DOE-managed SNF is the responsibility of the DOE Office of Environmental Management. The management of commercial SNF is beyond the scope of this EIS. DOE's responsibilities with respect to commercial SNF are conducted by DOE's Office of Civilian Radioactive Waste Management. Commercial SNF is outside the scope of this EIS. DOE's Environmental Management Programmatic Environmental Impact Statement (PEIS) is evaluating clean-up and management of DOE's waste in general.

The approximately 2,800 metric tons of heavy metal (MTHM[b]) of DOE-managed SNF under consideration in Volume 1 of this EIS is what remains of the more than 100,000 MTHM of SNF produced by DOE since 1943. Under past practices, most of the remaining SNF would have been chemically processed to recover plutonium or uranium for the nuclear weapons program. Given recent changes in East-West political relations, in addition to a number of economic, safety, and regulatory considerations, the chemical processing plants at the Hanford Site (PUREX), Idaho National Engineering Laboratory (the Idaho Chemical Processing Plant), and the Savannah River Site (F-Canyon and H-Canyon) that historically reprocessed this SNF have ceased or are phasing out reprocessing operations. As a result, the remaining SNF must be managed until its ultimate disposition rather than for the few years originally intended.

These fuels are currently stored at many locations. Most of the fuel is stored in 20- to 40-year-old water pools (designed for temporary storage until fuel could be reprocessed) at several locations on the Hanford Site, Idaho National Engineering Laboratory, and Savannah River Site. Smaller quantities are stored at approximately 60 locations nationwide, including 55 non-DOE United States research reactor facilities. The prolonged storage of some of these fuels has a potential to create several types of problems, including corrosion-induced fuel failures and water leakage from the pools. The problems associated with the storage of SNF are identified in a recent DOE report to the Secretary of Energy entitled, *Spent Fuel Working Group Report on Inventory and Storage of the Department's Spent Nuclear Fuel and Other Reactor Irradiated Nuclear Materials and Their Environmental, Safety, and Health Vulnerabilities* (DOE 1993). Two action plans to address these problems have been issued (DOE 1994a, 1994b); a third action plan is being prepared.

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

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

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

For a number of reasons, including the lack of characterization data on the interim storage behavior of certain SNF types and the fact that the acceptance criteria for ultimate disposition have not yet been defined, DOE cannot yet make all of these decisions for the full 40-year period. Therefore, this EIS focuses on issues relating to deciding the locations of future SNF management activities and largely will defer major decisionmaking on remaining issues until National Environmental Policy Act reviews tiered from this EIS have been completed.

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

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

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

3. What research and development activities should support the SNF Management Program?

1.1 Overview of Spent Nuclear Fuel Management in the DOE Complex

1.1.1 What is Spent Nuclear Fuel

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

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

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

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

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

The radioactivity produces heat so that cooling of the assemblies to prevent excessive fuel temperatures from being reached is required for a period of months to years following removal from the reactor. Typically, the SNF removed from reactors has been stored in water pools for a

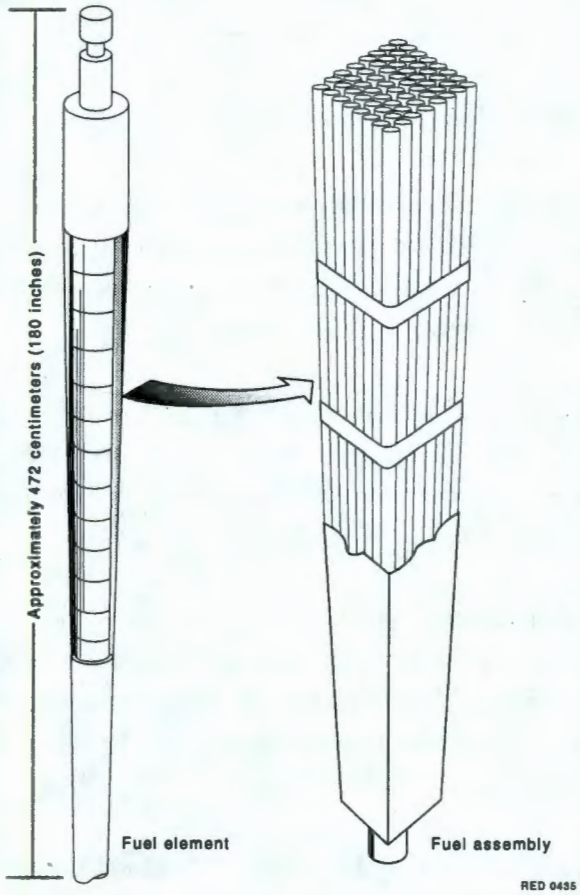

Figure 1-1. Representative reactor fuel assembly and element.

period of 3 to 18 months for cooling before transfer to other facilities for storage or processing. Storage systems are designed to prevent nuclear criticality.

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

1.1.2 Generation and Storage Sites for Spent Nuclear Fuel

This section provides information on the historic and current generation and storage of SNF as the program structure exists in June 1994.

1.1.2.1 Existing and Projected Spent Nuclear Fuel, Storage Locations, and Inventories. During the last 4 decades, DOE and its predecessor agencies have generated, transported, received, reprocessed, and stored SNF at various facilities in the nationwide DOE complex. This SNF was generated from various sources, including the following:

- DOE production reactors constructed and operated at the Hanford Site and Savannah River Site to provide special nuclear material for the Nation's defense programs. These reactors, which are no longer operating, have generated 86 percent by weight of the existing DOE SNF.

- DOE experimental, test, and research reactors that have operated at many DOE sites nationwide. Of these reactors, five are still operating, but SNF is being stored at shut-down reactors as well. These reactors have generated 8 percent of the existing DOE SNF.

- Naval nuclear propulsion reactors. Since 1957, the SNF removed from nuclear-powered Naval vessels and prototypes has been transported from shipyards and prototype sites to the Naval Reactors Facility at the Idaho National Engineering Laboratory. These reactors have generated less than 1 percent of the existing DOE SNF.

- Approximately 55 non-DOE domestic, licensed facilities, including training, research, and test reactors from university, commercial establishments, and Government-owned installations for which DOE has contractual obligations to accept SNF. These reactors have generated less than 1 percent of the existing DOE SNF.

- Special-case commercial power reactors. Under certain conditions, DOE has agreed to accept small quantities of SNF from commercial nuclear power plants. This includes SNF from development reactors (Shippingport, Peach Bottom Unit 1, and Fort St. Vrain); SNF used for destructive and nondestructive examination and testing; SNF remaining at the West Valley Demonstration Project; and special-case SNF remnants (Three-Mile Island Unit 2). This inventory is less than 1 percent of the existing DOE SNF.

- Special-case foreign research reactors. In accordance with national nuclear nonproliferation goals, DOE has accepted and is also considering renewal of the policy to accept SNF that contains enriched uranium that originated in the United States and was used in foreign research reactors. Such reactors have generated less than 1 percent of the existing DOE SNF.

Table 1-1 summarizes the current inventories of SNF at DOE and other facilities and those projected to be generated through the year 2035. These estimates are based on assumptions regarding reasonably foreseeable future reactor operations and the generation rates of SNF for which DOE is responsible.

Locations of the principal SNF generators and storage sites for SNF and representative ports of entry for foreign fuels under consideration in the EIS are illustrated in Figure 1-2 and described in Appendices A through F.

The largest quantities of SNF are stored at DOE locations where the SNF was generated or where special nuclear material was recovered by reprocessing. DOE SNF from the sources discussed in this section is currently stored at the Hanford Site, Idaho National Engineering Laboratory, and Savannah River Site and in much smaller quantities at other locations, including

Legend

Source	No. of locations
U.S. Department of Energy Facilities	8
Naval Sites	7
Special-Case Commercial	4
Domestic Non-DOE	8
Urgent Relief Foreign Returns (potential port of entry)	5
Universities	33

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

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

Generator or storage site[b]	Existing (1995) MTHM[c]	Existing (1995) Percent	Future increases (through 2035) MTHM[c]	Future increases (through 2035) Percent	Total (2035) MTHM[c]	Total (2035) Percent
Hanford Site	2132.84	79.8	0.00	0.0	2132.84	77.3
Idaho National Engineering Laboratory[d]	288.68	10.8	12.36	14.6	301.04	10.9
Savannah River Site	201.50	7.5	0.00	0.0	201.50	7.3
Naval Nuclear Propulsion Reactors	0.00[e]	0.0	55.00	65.0	55.0	2.0
Oak Ridge Reservation	3.02	0.1	1.13	1.3	4.15	0.2
Other DOE Sites	27.80	1.0	1.56	1.8	29.36	1.1
Non-DOE Domestic Research Reactors[f]	3.87	0.1	2.72	3.2	6.59	0.2
Special-Case Commercial Reactors[g]	16.22	0.6	0.27	0.3	16.49	0.6
Foreign Research Reactors	0.00	0.0	11.63	13.7	11.63	0.4
Total[h]	2673.93		84.68		2758.60	
Percent of 2035 total	96.9		3.1		100.0	

a. Source: DOE (1994c)

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

c. One MTHM equals approximately 2,200 pounds.

d. Sum of fuel located at the Idaho National Engineering Laboratory.

e. Existing inventory of Naval SNF is included in the Idaho National Engineering Laboratory totals (9.95 MTHM).

f. Includes research reactors at commercial, university, and Government facilities.

g. This total is just that stored at non-DOE facilities (Babcock & Wilcox Research Center and Fort St. Vrain). The total inventory of SNF from special-case commercial reactors is 186.41 MTHM. This fuel is also stored at the Idaho National Engineering Laboratory, Oak Ridge National Laboratory, Hanford Site, Savannah River Site, and West Valley Demonstration Project.

h. Numbers may not sum due to rounding.

Brookhaven National Laboratory, Oak Ridge Reservation, and Los Alamos National Laboratory. In addition, the West Valley Demonstration Project in New York is storing SNF, primarily from special-case commercial nuclear reactors. Naval SNF is being stored at the Idaho National Engineering Laboratory.

1.1.2.2 Spent Nuclear Fuel Vulnerability Assessment. Prolonged storage of some types of SNF has resulted in deterioration of the cladding, degradation of the fuel matrix, or other storage problems leading to significant environmental, safety, and health concerns. DOE reported its evaluation of these concerns in a Spent Fuel Working Group report in December 1993 (DOE 1993). This evaluation was followed by a *Plan of Action to Resolve Spent Nuclear Fuel Vulnerabilities* in February 1994, which identified three phases to resolve those vulnerabilities (DOE 1994a). This Phase I Action Plan, which addresses the most urgent activities, was issued immediately. The Phase II Action Plan was released April 1994 for public comment (DOE 1994b). The Phase III plan is intended to be issued in September 1994. Phases I, II, and III corrective actions include activities at the main DOE SNF storage sites. Examples of corrective action projects include installing equipment to improve storage pool water quality at the Savannah River Site; transferring fuel from an old, inadequate water pool to a newer pool at the Idaho National Engineering Laboratory; and canning fuel with cladding breaches at the Hanford Site.

Some of the SNF Action Plan activities could potentially result in emission and effluents. These effects are not individually analyzed, but they are enveloped by the SNF management activities reported and analyzed for each site in Volume 1 and the respective site appendices. Successful completion of the corrective actions would significantly reduce the potential for health and safety problems to the workers and public and minimize degradation to the environment.

1.1.2.3 DOE Spent Nuclear Fuel Management.

Hanford Site—As shown in Table 1-1, the Hanford Site currently stores nearly 80 percent (by MTHM) of the complex-wide SNF. This percentage includes a wide variety of fuel types, but the primary source is N Reactor fuel. The SNF at facilities associated with the Hanford Site include N Reactor SNF, single-pass reactor SNF, Shippingport Core II SNF, Fast Flux Test Facility SNF, and miscellaneous special-case commercial and experimental SNF.

The ongoing actions at the existing Hanford Site facilities are focused on improving worker health and safety and severing pathways to the environment. Activities include reducing water contamination levels at the 105-KE Basin, performing physical upgrades necessary to assure facility safety for the appropriate lifetimes, characterizing SNF condition, and repackaging some SNF for near-term storage.

Idaho National Engineering Laboratory—The Idaho National Engineering Laboratory currently stores approximately 290 MTHM of SNF from a variety of DOE programs and a limited number of commercial and foreign sources. The ongoing activities include continued safe storage of SNF, the continued receipt of some additional Naval SNF, and onsite fuel transfers to reduce identified vulnerabilities. Characterization and technology research and development activities, the establishment of a new dry SNF storage facility, and the construction and operation of a Technology Development Facility have also been proposed.

Savannah River Site—DOE is storing approximately 200 MTHM of SNF at the Savannah River Site. Most of the SNF from Savannah River Site reactor operations is stored under water in concrete storage basins at the K- and L-Reactor disassembly basins and the Receiving Basin for Offsite Fuels at the site. These reactor disassembly basins were originally intended for only short-term storage of production reactor SNF. About 30 percent of the SNF in the Receiving Basin for Offsite Fuels consists of uranium clad in stainless steel or zirconium alloy, which Savannah River Site facilities cannot process without facility modifications.

Ongoing activities to improve the use of existing storage facilities provide for continued safe storage of the more corrosion-prone aluminum-clad SNF currently stored at the Savannah River Site. These existing facilities consist of the Receiving Basin for Offsite Fuels and reactor basins.

Oak Ridge Reservation—Approximately 2 MTHM of SNF is either in storage or being generated at several facilities at the Oak Ridge Reservation, including the High Flux Isotope Reactor, which is in operation and has 46 elements in onsite wet storage; the Tower Shielding Reactor No. II, which is shut down but has 1 element in the core; and the Bulk Shielding Reactor, which is shut down but has 73 elements in onsite wet storage.

Other DOE Sites—SNF, principally from experimental and test reactors, is also being stored at a number of other DOE sites, including the following:

- Brookhaven National Laboratory, which is generating and storing SNF at two facilities. The Brookhaven High Flux Beam Reactor currently has 28 elements in the operating reactor core and about 800 SNF elements in onsite wet storage. The Brookhaven Medical Research Reactor, which is operating at the present time, has 31 elements in the reactor and 4 elements in onsite wet storage.

- Los Alamos National Laboratory, which has SNF at the Omega West Reactor. This reactor has been shut down since December 1992. There are no elements in the reactor, 40 elements in onsite wet storage, and 46 elements in onsite dry storage.

- Sandia National Laboratories, which have reactors that operate as needed. These reactors will generate small quantities of SNF when shut down and defueled.

1.1.2.4 Naval Spent Nuclear Fuel Management. Naval SNF is removed from vessels at approved shipyards and prototype sites and placed in shielded shipping containers. A limited amount is being shipped by rail to the Idaho National Engineering Laboratory. The SNF is then removed from the shielded shipping containers and placed into a water pool at the Expended Core Facility. In the water pool, each Naval fuel assembly receives, as a minimum, an internal and external visual examination to confirm that it performed as designed and to identify anomalies that would warrant more detailed examination. After examination, the SNF is loaded into shielded containers and transferred to the Idaho Chemical Processing Plant for storage.

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

1.1.2.5 Spent Nuclear Fuel Management at Other Generator/Storage Locations.

Domestic Research and Test Reactors—DOE owns and/or has obligations to accept the return of SNF from various university and other non-DOE research reactors. Fifty-five non-DOE facilities, which have been licensed by the U.S. Nuclear Regulatory Commission, are domestic, licensed, small generators of SNF. Listed in Table 1-2, these facilities include training, research, and test reactors at universities, commercial establishments, and several government installations. The table summarizes the types and quantities (by number of fuel elements and MTHM) of SNF in storage and forecasts SNF generation at each of the facilities that currently have or are expected to generate SNF by the year 2035. Facilities that do not currently have and are not expected to generate SNF by the year 2035 are not included. As indicated on the table, Category 1 reactors have limited storage capacity compared to generation rates, and Category 2 reactors do not routinely generate additional SNF or have sufficient storage space when compared to SNF generation rates. Appendix E provides more detailed descriptions of these facilities.

Table 1-2. Domestic non-DOE research reactors.[a]

Licensee location	Reactor type	Category[b]	Current total elements	MTHM[c,d]	Additional SNF generation through 2035 (elements)	MTHM
General Electric Company, Pleasanton, CA	NTR	1	16	0.004	16	0.004
Kansas State University, Manhattan, KS	TRIGA	1	107	0.025	140	0.038
Massachusetts Institute of Technology, Cambridge, MA	Res.HW	1	63	0.026	483	0.243
National Institute of Standards and Technology, Gaithersburg, MD	Test	1	186	0.04	1,232	0.264
Rhode Island Atomic Energy Commission, Narragansett, RI	Pool	1	53	0.03	200	0.218
State University of New York—Buffalo, Buffalo, NY	Pulstar	1	40	0.493	4	0.1
Texas A&M University, College Station, TX	TRIGA	1	186	0.027	378	0.189
U.S. Geological Survey, Denver, CO	TRIGA	1	161	0.02	39	0.005
University of Illinois, Urbana, IL	LOPRA	1	193	0.038	269	0.059
University of Michigan, Ann Arbor, MI	Pool	1	72	0.093	504	0.401
University of Missouri-Columbia, Columbia, MO	Tank	1	64	0.047	1,092	0.772
University of Virginia, Charlottesville, VA	Pool	1	32	0.025	85	0.027
Aerotest, San Ramon, CA	TRIGA (Indus)	2	91	0.015	0	0
Arkansas Technical University, Russellville, AR	TRIGA	2	0	0	0	0
Armed Forces Radiobiology Research Institute, Bethesda, MD	TRIGA	2	110	0.019	0	0
Cornell University (TRIGA), Ithaca, NY	TRIGA	2	6	0.021	39	0.144
Cornell University (ZPR), Ithaca, NY	ZPR	2	814	1.7	0	0
Dow North America, Midland, MI	TRIGA	2	78	0.014	0	0

Table 1-2. (continued).

Licensee location	Reactor type	Category[b]	Current total elements	MTHM[c,d]	Additional SNF generation through 2035 (elements)	MTHM
General Atomics, San Diego, CA	TRIGA Mark I	2	263	0.045	20	0.003
Georgia Institute of Technology, Atlanta, GA	Research HW	2	25	0.029	1.25	0.126
Idaho State University, Pocatello, ID	AGN-201	2	9	0.011	0	0
Iowa State University, Ames, IA	UTR-10 Pool	2	28	0.02	0	0
McClellan Air Force Base, McClellan, CA	SNRS	2	90	0.015	0	0
Manhattan College, Riverdale, NY	Tank-ZPR	2	17	0.019	0	0
North Carolina State University, Raleigh, NC	Pulstar	2	34	0.445	25	0.331
Ohio State University, Columbus, OH	Pool	2	24	0.02	0	0
Oregon State University, Corvallis, OR	TRIGA	2	96	0.017	96	0.055
Pennsylvania State University, University Park, PA	TRIGA	2	175	0.036	42	0.008
Purdue University, West Lafayette, IN	Lockheed	2	13	0.014	13	0.014
Reed College, Portland, OR	TRIGA	2	63	0.013	0	0
Rensselaer Polytechnic Institute, Troy, NY	Critical assembly	2	597	0.388	0	0
Texas A&M University, College Station, TX	AGN-201	2	9	0.011	0	0
University of Arizona, Tucson, AZ	TRIGA	2	97	0.018	8	0.002
University of California at Irvine, Irvine, CA	TRIGA	2	113	0.021	0	0
University of Florida, Gainesville, FL	Argonaut	2	28	0.024	22	0.018
University of Maryland, College Park, MD	TRIGA	2	93	0.017	0	0.017

Table 1-2. (continued).

Licensee location	Reactor type	Category[b]	Current total elements	MTHM[c,d]	Additional SNF generation through 2035 (elements)	MTHM
University of Massachusetts at Lowell, Lowell, MA	GE Pool	2	32	0.023	0	0
University of Missouri—Rolla, Rolla, MO	Pool	2	56	0.018	0	0
University of New Mexico, Albuquerque, NM	AGN-201	2	9	0.004	0	0
University of Texas, Austin, TX	TRIGA-Mark II	2	151	0.029	0	0
University of Utah, Salt Lake City, UT	TRIGA	2	84	0.026	0	0
University of Wisconsin, Madison, WI	TRIGA	2	228	0.039	101	0.03
Veterans Administration Medical Center, Omaha, NE	TRIGA	2	56[e]	0	0	0
Washington State University, Pullman, WA	TRIGA	2	215	0.037	78	0.039
Worcester Polytechnic Institute, Worcester, MA	Pool	2	27	0.018	0	0

a. Source: Jentz (1993) and DOE (1994c).

b. Category 1: Facility generates SNF and has limited storage capacity when compared to SNF generation rate.
Category 2: Facilities that do not routinely generate additional SNF or have sufficient storage space when compared to SNF generation rate.

c. One MTHM equals approximately 2,200 pounds.

d. Numbers may not sum due to rounding.

e. Is not classified as SNF.

NOTE: The total of SNF currently in storage at these facilities is approximately 4.0 MTHM and the additional SNF estimated to be generated by 2035 is approximately 3.1 MTHM.

Special-Case Nuclear Power Plant Spent Nuclear Fuel—DOE has also taken possession of SNF assemblies and complete or sectioned SNF rods from various commercial nuclear power plants that were to be used to support DOE-sponsored research and development programs. Table 1-3 summarizes the types and quantities of special-case nuclear power plant SNF in storage. This SNF currently is in storage at either the West Valley Demonstration Project in West Valley, New York, or the Babcock & Wilcox Lynchburg Research Center in Campbell County, Virginia. Additionally, special-case commercial SNF (such as from Three-Mile Island, Peach Bottom, and Shippingport) is also stored at the Hanford Site, Idaho National Engineering Laboratory, Savannah River Site, Naval Reactors Facility at the Idaho National Engineering Laboratory, and Oak Ridge Reservation. Appendix E provides additional detail on these sites.

In addition, by way of a three-party agreement among the Public Services Company of Colorado, General Atomics, and the Atomic Energy Commission, the DOE has an agreement to provide dry storage at the Idaho National Engineering Laboratory for eight segments of Fort St. Vrain spent fuel (approximately 1,920 SNF elements). Three segments of this SNF have been transported to the Idaho National Engineering Laboratory; the other five are currently being stored at the Fort St. Vrain site.

Table 1-3. Special-case nuclear power plant spent nuclear fuel.

Category	Storage location	SNF in storage[a]	MTHM[b]
Light-water reactor fuel	West Valley, NY	125 elements	27
Light-water reactor partial fuel elements	Lynchburg, VA	3 full-length rods and 17 sectioned rods	0.044
High-temperature gas-cooled reactor fuel	Fort St. Vrain, CO	1,482 elements; the DOE has committed to take possession of 1,242 of these elements at some time in the future.	16

a. No additions projected through 2035.

b. One MTHM equals approximately 2,200 pounds.

NOTE: DOE also has possession of other special-case commercial SNF from the Arkansas, Calvert Cliffs, Connecticut Yankee, Consolidated Edison, Cooper, Dresden, H.B. Robinson, Monticello, Oconee, Peach Bottom, Point Beach, Quad Cities, Saxton, Shippingport, Surry, and Three Mile Island reactors. These represent very small quantities of SNF and are currently stored at the Hanford Site, Idaho National Engineering Laboratory, Savannah River Site, Naval Reactors Facility at the Idaho National Engineering Laboratory, or the Oak Ridge Reservation. This special-case commercial fuel is discussed in the corresponding appendix for each of these sites.

NOTE: The approximate total of SNF currently at these locations is 43 MTHM.

Foreign Research Reactor Spent Nuclear Fuel—In April 1994, DOE decided to accept up to 409 additional SNF elements from eight foreign research reactors in seven European countries for storage at the Savannah River Site.

1.1.3 Technologies for Management of Spent Nuclear Fuel

DOE must safely manage SNF until its ultimate disposition. Some SNF, such as Naval reactor fuel, was designed for long-term operation and to survive combat conditions; therefore, it is rugged enough to retain its integrity during prolonged storage. Commercial reactor fuel is also inherently stable and suitable for prolonged storage.

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

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

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

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

Further analysis of additional storage and stabilization technologies for specific sites and fuel types would be accomplished through subsequent National Environmental Policy Act reviews.

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

The casks serve two functions: (1) providing gamma radiation shielding from the SNF so that the radiation level outside the casks meets regulatory requirements and (2) providing protection to and containment of the SNF even in case of accidents. The casks are designed to withstand a wide range of very severe accidents. Because the SNF is generally metallic in form, most of the radionuclides stay within the metal fuel even in maximum foreseeable transportation accidents. The risks to both workers and the public have been evaluated many times, most recently in Appendix I of this EIS, and have shown to be low.

1.1.3.4 Ultimate Disposition. Congress has determined that the ultimate disposition of commercial SNF and high-level waste be disposal in a geologic repository. Others believe that the residual values in DOE SNF (for example, uranium and plutonium that may be used to fuel nuclear reactors) should be recovered before the remainder of the SNF (such as radioactive fission products) is disposed of as waste. Regardless of the disposition method that is chosen, some manner of technologies may have to be applied to DOE SNF to meet the final repository acceptance requirements, which are currently unknown and are several years from finalization. Nevertheless, except perhaps for a need to develop them further, the technologies described above for stabilization and safe storage are available for the management of SNF and appear adequate to meet the needs of ultimate disposition. Disposal in a repository, for example, may require canning, encapsulation, or processing the fuel to create a vitrified waste form. Resource recovery requires dissolving the fuel to separate the fissile material from the waste and producing a stable waste form. These required technologies already have been applied and are under continued development in several countries. Once the acceptance criteria are established, the appropriate technologies can be identified and finalized to ensure the SNF can be put in an acceptable form for ultimate disposal.

1.2 Relationship to Other National Environmental Policy Act Documents

Several National Environmental Policy Act reviews are related to aspects of the SNF Management Program. Table 1-4 lists these documents, which are managed from various offices within DOE.

1.2.1 Environmental Restoration and Waste Management Programmatic Environmental Impact Statement

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

- Cost-effective management of processes and facilities for treatment, storage, and disposal of radioactive, hazardous, and mixed waste
- Approaches (new or existing technologies) used to remediate contaminated sites
- The types of treatment needed for waste management
- The need for developing new treatment technologies
- The need to use existing facilities or construct new facilities
- Locations for new facilities if needed.

The analyses also support decisions on land use planning. The Draft Environmental Management PEIS is scheduled to be available for public and agency review and comment by the fall of 1994.

Although the DOE Environmental Management PEIS was originally intended to provide the programmatic analyses of alternatives for SNF management, these analyses are now presented in this volume. The PEIS is expected to summarize and consider, as part of its analysis of cumulative environmental consequences, the impacts of the SNF alternatives identified in this EIS on the SNF Management Program.

Table 1-4. Major National Environmental Policy Act reviews related to Volume 1 of this EIS as of June 1994.

Site	Subject	Type of NEPA document	Status
West Valley Demonstration Project	Management of SNF in Storage at the West Valley Demonstration Project	EA[a]	In preparation
Savannah River Site	Urgent-relief acceptance of foreign research reactor SNF	EA/FONSI	Issued
	Interim Management of Nuclear Materials at Savannah River Site	EIS	In preparation
Oak Ridge Reservation	High Flux Isotope Reactor SNF storage reracking	EA	In preparation
	High Flux Isotope Reactor dry storage pod	EA	Future
Idaho National Engineering Laboratory	Fort St. Vrain Fuel shipments to the Idaho Chemical Processing Plant	EA/FONSI	Issued[b]
	Test Area North Pool Stabilization Project (also known as Dry Cask Storage Project)	EA	In preparation
Hanford Site	105-KE and 105-KW Basins fuel encapsulation and repackaging, 100-K Area	EA/FONSI	Issued
	Transfer of Plutonium Uranium Extraction Plant and N Reactor Irradiated Fuel for encapsulation and storage at the K-Basins.	EA	In preparation
	Shut down of the Fast Flux Test Facility	EA	In preparation
	Relocating TRIGA[c] reactor fuel from 308 Building (covers SNF, lightly irradiated fuel, and unirradiated fuel)	EA	In preparation
	Hanford SNF Management EIS	EIS	Future
	Construction and operation of a special-case waste storage unit	EA	In preparation
DOE (Headquarters)	Environmental Management Programmatic EIS	EIS	In preparation
	Reconfiguration of Weapons Complex Programmatic EIS	EIS	In preparation
	Federal geologic repository for spent nuclear fuel and high-level waste	EIS	Future
	Proposed policy for the acceptance of United States origin foreign research reactor spent nuclear fuel	EIS	In preparation
	Programmatic EIS for the Management and Disposition of Excess Nuclear Material	EIS	Future
U.S. Navy	Short-term storage of Naval SNF	EA/FONSI	Issued

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

b. The Environmental Assessment and Finding of No Significant Impact were determined by the District Court to be inadequate. Volumes 1 and 2 of this EIS address shipments of Fort St. Vrain fuel.

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

1.2.2 Reconfiguration of Weapons Complex Programmatic Environmental Impact Statement

The Nuclear Weapons Complex Reconfiguration Program has evolved considerably since its original Notice of Intent to prepare a PEIS was issued in February 1991. DOE was proposing to reconfigure the Nation's nuclear weapons complex to be smaller, less diverse, and less expensive to operate. This proposal offered the added advantage of enabling the closure and remediation of the Mound and Rocky Flats Plants. At that time, no new plutonium or highly enriched uranium storage facilities were envisioned, and a new tritium production facility was being planned as part of the New Production Reactors Program. DOE's needs have evolved since then for many reasons, but primary among them is the end of the Cold War. The tangible effects of this include the significant reduction in the size of the Nation's stockpile of nuclear weapons and no foreseeable requirements for new weapons production programs.

Accordingly, the Reconfiguration PEIS now addresses only alternatives associated with new tritium production and the recycling of tritium recovered from weapons being retired from the stockpile. Alternative technologies for producing tritium are planned to be analyzed at five candidate sites (Savannah River Site, Oak Ridge National Laboratory, the Pantex Plant, the Idaho National Engineering Laboratory, and the Nevada Test Site).

1.2.3 Programmatic Environmental Impact Statement for the Management and Disposition of Excess Nuclear Materials

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

1.2.4 Proposed Policy for the Acceptance of United States Origin Foreign Research Reactor Spent Nuclear Fuel

DOE proposes to adopt and implement a policy to accept SNF containing enriched uranium that originated in the United States and was used by foreign research reactors. Under the proposed policy, the United States would accept approximately 15,000 elements (12 MTHM) of high enriched uranium or low enriched uranium SNF during a maximum 15-year period from foreign research reactors in approximately 30 nations. Alternative methods of implementing the proposed action and the No Action alternative are being analyzed in an EIS. DOE will not make a final decision on the acceptance of SNF from these foreign research reactors until after the EIS

for the Proposed Policy for the Acceptance of United States Origin Foreign Research Reactor SNF and this programmatic SNF EIS are both completed. These EISs are scheduled to be completed in 1995.

The proposed action would support the nuclear nonproliferation policy of the United States by removing the SNF from these reactors from international commerce. The implementation of this policy would result in the receipt of foreign research reactor SNF at one or more United States marine ports of entry and overland transport to one or more DOE sites.

1.3 Scope of this Volume

1.3.1 Scoping Process

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

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

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

(issued October 29, 1993, and amended on May 9, 1994) for this EIS summarizes these comments and DOE's responses.

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

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

1.3.2 Scope

1.3.2.1 Programmatic Spent Nuclear Fuel Disposition. The focus of this volume of the EIS is the management of SNF in a safe and environmentally sound manner until decisions regarding its ultimate disposition are made and implemented. The question of ultimate disposition will require separate National Environmental Policy Act documentation after ongoing studies are completed. Congress has mandated that the Federal Government pursue the development of mined geologic repositories for the permanent disposal of SNF and high-level waste, and has directed DOE to study the Yucca Mountain, Nevada, site to determine whether it is a suitable site. Ultimate disposition of DOE SNF, however, is outside the scope of this programmatic SNF EIS.

1.3.2.2 Programmatic Spent Nuclear Fuel Stabilization. DOE is phasing out reprocessing activities because of decreased demand for the recovery and reuse of certain nuclear materials. For this reason, reprocessing technologies and impacts are not relevant for this EIS. Fuel stabilization activities potentially required for safe interim storage/management of SNF, such as canning of some degraded fuels or processing as necessary, are relevant to the safe storage of SNF and within the scope of this EIS. Worker safety, public health, and potential environmental impacts associated with SNF stabilization, research and development of technologies, and pilot

programs are topics of importance in analyzing the appropriate alternatives for interim storage of SNF and are included in this EIS.

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

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

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

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

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

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

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2. PURPOSE AND NEED FOR AGENCY ACTION

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

The end of the Cold War led DOE to reevaluate the scale of its weapons production, nuclear propulsion, and research missions. In April 1992, the Secretary of Energy directed DOE to phase out reprocessing of SNF for recovery and recycling of plutonium and highly enriched uranium to support the nuclear weapons stockpile. In 1993, a DOE report[a] documented current and potential environmental, safety, and health vulnerabilities regarding existing DOE SNF storage facilities. The report identified locations with degraded fuel cladding integrity and other problems that require action to ensure continued safe storage. As a result of the Secretary's directive and the information in the DOE report, it is clear that DOE needs to establish an integrated complex-wide program that provides safe and effective management for present and reasonably foreseeable quantities of additional SNF pending its permanent disposition.

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

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

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

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3. ALTERNATIVES

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

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

Summary of Alternatives for the Management of DOE Spent Nuclear Fuel

No Action
Take minimum actions required for safe and secure management of SNF at or close to the generation site or current storage location.

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

1992/1993 Planning Basis
Transport and store newly generated SNF at the Idaho National Engineering Laboratory or Savannah River Site. Consolidate some existing fuels at the Idaho National Engineering Laboratory.

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

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

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

In developing the alternatives, the need to comply with applicable regulations, permits, and DOE orders was assumed. In addition, under these alternatives, DOE would honor existing

commitments to accept SNF from utilities (for example, Fort St. Vrain), domestic research reactor SNF, and potential agreements to accept foreign research reactor SNF and would consider ways to reduce costs for the management of SNF.

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

The planning period for this EIS is 40 years, beginning with the issuance of the Record of Decision (that is, baseline conditions in June 1995) and extending through the year 2035. This time period may be required to make and implement a decision on the ultimate disposition of SNF.

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

DOE has not yet identified a preferred alternative for the interim management of SNF, but DOE will identify a preferred alternative in the final EIS after comments on the draft EIS are considered. DOE has identified components of the alternatives considered in the EIS that may be included when selecting the preferred alternative in the Final EIS:

- DOE mission requirements
- Naval Nuclear Propulsion Program requirements
- Public and Agency concerns expressed as comments on the EIS
- Potential environmental impacts
- Estimated cost of interim and prolonged management
- Technical feasibility.

While the Nevada Test Site is analyzed in this EIS as an alternative site for SNF management activities, DOE does not consider it to be a preferred site for the management of SNF because of the State of Nevada's current role as the host site for the Yucca Mountain Site Characterization Project and the Nevada Test Site's lack of current SNF handling experience. However, the Navy, as a cooperating agency, has stated a preferred alternative, which is to continue to conduct refueling and defueling of nuclear-powered vessels and prototypes and to transport SNF to the Idaho National Engineering Laboratory for fuel examination and interim storage using the same practices as in the past. Details and analyses supporting the Navy's preferred alternative can be found in Appendix D.

3.1 Overview of Alternatives Considered

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

Table 3-1. Summary of the No Action alternative.

NO ACTION Take only the actions required for the safe storage and management of SNF at the site.							
Actions	Hanford Site	Idaho National Engineering Laboratory	Savannah River Site	Oak Ridge Reservation	Nevada Test Site	Naval sites	Other locations
Transportation— No shipment to or from site. Onsite movement limited to actions required for safe storage.	No shipment to or from the site. Fuel stored in 105-KE Basin may be transferred to 105-KW Basin. Fuel in PUREX, 308 Building Annex, 324 Building, 325 Building, and 327 Building to be relocated onsite.	No shipment to or from the site. Some naval SNF would be received during a 3-year transition period. After Expended Core Facility closure, onsite movement limited to needs for safe storage.	No shipments to or from the site. Limit onsite transfers to those required for safe storage.	No shipment to or from the site.	No shipment to or from the site.	Shipments to Idaho National Engineering Laboratory during 3-year transition period. Thereafter retained at refueling sites. SNF removed at Newport News, Virginia, shipped to Norfolk Naval Shipyard.	No shipments onsite or offsite. Shut down reactors as storage capacity met.
Stabilization— Stabilization activities limited to those *minimum* actions required to store SNF safely.	Fuel and sludge in 105-KE to be canned.	Additional canning and characterization capabilities as needed.	Place aluminum-clad fuels that are badly corroded and in danger of cladding failure in containers and return them to wet storage.	Only as required for safe storage.	Not applicable.	None.	Only as required for safe storage at facilities not licensed by the Nuclear Regulatory Commission. As stipulated by license for facilities licensed by Nuclear Regulatory Commission.
Storage— Minimum facility modifications to support safe storage.	Fuel stored in 105-KE and 105-KW Basins Fast Flux Test Facility, T Plant, and 200 Area Low-Level Waste Burial Grounds. Fuel also stored near-term in 308 Building Annex, 324 Building, 325 Building, and 327 Building. No new facilities.	Replace Test Area North storage pool with dry storage facility.	Store fuels in Receiving Basin for Offsite Fuels and in an upgraded reactor basin. Requires no new facilities.	Continued use of existing onsite storage facilities.	Not applicable.	SNF stored in shipping containers at Naval sites.	Continued use of existing onsite storage facilities for sites not licensed by Nuclear Regulatory Commission. As stipulated by license for sites licensed by the Nuclear Regulatory Commission.
Research and Development— Research and development underway for DOE SNF management will continue.	Characterization of defense production fuel to support canning.	Ongoing research and development for SNF management continues.	Continue existing SNF-related research and development.	Onsite continues as planned.	Not applicable.	None.	Not applicable.
Naval Fuel Examination— Examination will cease.	Not applicable.	Close Expended Core Facility after a transition period.	Not applicable.	Not applicable.	Not applicable.	No examination at storage locations.	Not applicable.

Table 3-2. Summary of the Decentralization alternative.

DECENTRALIZATION Store most SNF close to existing locations with limited SNF shipments to DOE facilities.							
Actions	Hanford Site	Idaho National Engineering Laboratory	Savannah River Site	Oak Ridge Reservation	Nevada Test Site	Naval sites	Other locations
Transportation—Limited SNF shipments.	No shipments to or from the site. All fuel to be relocated onsite.	Some receipt of non-DOE domestic research SNF. Receipt of naval SNF for examination and return. (Option C for Navy). Some onsite transfer for consolidation.	Receive small quantities of aluminum-clad and stainless-steel clad fuels. Limit onsite transfers to those required for safe storage, consolidation, and research and development. Later relocate fuels to new wet or dry storage facility or move aluminum-clad fuels to F- and H-Canyons for processing.	No SNF shipment to or from the site except for research and development activities.	Not applicable.	Option A: Limited offsite shipment. Option B: Limited shipments to Puget Sound. Option C: All SNF shipped to Idaho National Engineering Laboratory and returned.	Shipments as required for continued operation for both non-Nuclear Regulatory Commission and Nuclear Regulatory Commission-licensed facilities.
Stabilization—Stabilization activities.	Fuel and sludge in 105-KE to be canned. Defense fuels possibly stabilized by one of three methods.	Canning and characterization facility (Phase I of Dry Fuel Storage Facility).	Can aluminum-clad fuels and place them in wet or dry storage or process existing fuel through F- and H-Canyons. Place stainless steel and zircaloy fuels in wet or dry storage.	As required for safe storage.	Not applicable.	None.	As required for safe storage, by Nuclear Regulatory Commission license, or as planned.
Storage—Facility upgrade/replacement and onsite fuel transfers to support safe storage and to allow onsite consolidation.	Defense production fuel stored in new wet or dry facilities. Shippingport, Fast Flux Test Facility, and miscellaneous fuel stored in new dry facilities.	Upgrade/increase storage capacity. Replacement storage facility for SNF from Test Area North.	Store in Receiving Basin for Offsite Fuels and in an upgraded reactor basin until new wet or dry storage facility is built. Requires new receiving and characterization facility, new wet or dry canning facility, and new wet or dry storage facility.	Continued use of existing onsite storage facilities. New construction as planned.	Not applicable.	Storage at Naval sites. New transport containers, dry storage, or water pools.	Continued use of existing onsite storage facilities. New construction as planned.
Research and Development—Treatment technology and research and development activities for DOE SNF management, including stabilization technology.	Evaluation of dry storage for Shippingport, Fast Flux Test Facility, and miscellaneous fuels; research and development on defense production fuel stabilization; characterization of N Reactor and single pass reactor fuels to determine the feasibility of dry storage.	Actinide recycling using limited quantities of commercial SNF. New technology development facility.	Develop technology (canning and storage design) to store Savannah River Site aluminum-clad fuels in dry storage vault.	Onsite continues as planned.	Not applicable.	None.	Not applicable.
Naval Fuel Examination	Not applicable.	Expended Core Facility phase out under Navy Options A and B.	Not applicable.	Not applicable.	Not applicable.	A: None. B: Limited examinations at Puget Sound Naval Shipyard under Navy Option B. C: Full.	Not applicable.

Table 3-3. Summary of the 1992/1993 Planning Basis alternative.

1992/1993 PLANNING BASIS Transport and store newly generated SNF at the Idaho National Engineering Laboratory or Savannah River Site. Consolidate some existing fuels at the Idaho National Engineering Laboratory.							
Actions	Hanford Site	Idaho National Engineering Laboratory	Savannah River Site	Oak Ridge Reservation	Nevada Test Site	Naval sites	Other locations
Transportation—1992/1993 planning basis implemented	Ship 0.04 MTHM of TRIGA fuel to the Idaho National Engineering Laboratory in four shipments. All other fuel to be relocated onsite.	Receipt of some foreign SNF. Receipt of Fort St. Vrain and West Valley SNF. Naval SNF to Idaho National Engineering Laboratory for examination and then storage at Idaho Chemical Processing Plant. Receipt of non-DOE SNF/domestic research SNF. Some onsite SNF movement.	Receive small quantities of aluminum-clad and stainless steel-clad fuels. Limit onsite transfers to those required for safe storage, consolidation, and research and development. Later relocate fuels to new wet or dry storage facility, or move aluminum-clad fuels to F- and H-Canyon for processing.	No SNF shipments to the site except for research and development activities. SNF shipments to other DOE facilities as planned.	Not applicable.	Ship all SNF to Idaho National Engineering Laboratory.	SNF shipments to DOE facilities as planned.
Stabilization—Stabilization activities as planned.	Fuel and sludge in 105-KE to be canned. Defense fuels possibly stabilized by one of three methods.	Canning and characterization facility.	Can aluminum-clad fuels and place them in wet or dry storage or process existing fuel through F- and H-Canyons. Place stainless steel and zircaloy fuels in wet or dry storage.	As required for safe storage or as planned.	Not applicable.	None.	As required for safe storage by Nuclear Regulatory Commission license or as planned.
Storage—Facility upgrade/replacement and increased storage capacity as planned.	Defense production fuel stored in new wet or dry facilities. Shippingport, Fast Flux Test Facility, and miscellaneous fuel stored in new dry facilities.	Upgrade/increase storage capacity. Replacement storage facility for SNF from Test Area North. Increased rack capacity in storage pools.	Store fuels in Receiving Basin for Offsite Fuels and in an upgraded reactor basin until new wet or dry storage facility is built. Requires new receiving and characterization facility, new wet or dry canning facility and new wet or dry storage facility.	Continued use of existing onsite storage facilities. New construction as planned.	Not applicable.	None.	Continued use of existing onsite storage facilities. New construction as planned.
Research and Development—Treatment technology and research and development activities for DOE SNF management and disposal as planned.	Evaluation of dry storage for Shippingport, Fast Flux Test Facility, and miscellaneous fuels; research and development on defense production fuel stabilization; characterization of N Reactor and single pass reactor fuels to determine the feasibility of dry storage.	Actinide recycling using limited quantities of commercial SNF. New technology development facility.	Develop technology (canning and storage design) to store Savannah River Site aluminum-clad fuels in dry storage vault. Research and pilot-scale operations to determine best technology for ultimate disposition of aluminum-clad fuels.	Onsite continues as planned.	Not applicable.	None.	Not applicable.
Naval Fuel Examination	Not applicable.	Full examination at Idaho National Engineering Laboratory.	Not applicable.	Not applicable.	Not applicable.	Not applicable.	Not applicable.

Table 3-4. Summary of the Regionalization alternative.

REGIONALIZATION Distribute existing and projected SNF among DOE sites based on fuel type (Subalternative A) or geographic location (Subalternative B).							
Actions	Hanford Site	Idaho National Engineering Laboratory	Savannah River Site	Oak Ridge Reservation	Nevada Test Site	Naval sites	Other locations
Transportation— Distribute existing and projected SNF to three DOE sites (Subalternative A) or two DOE sites (Subalternative B).	Subalternative A: Defense production fuel and fuel in 324 Building, 325 Building, 327 Building, and 308 Building Annex to be relocated onsite. All fuel except defense production fuel shipped offsite. Subalternative B: All fuel to be relocated onsite. Receive in a new facility all fuels from generators west of the Mississippi River (if Western Regional Site); ship all fuels to Western Regional Site (if not Western Regional Site).	Subalternative A: Receive naval, TRIGA, and nonaluminum fuels. Subalternative B: Receive all fuels from generators west of the Mississippi River (If Western Regional Site); ship all fuels to Western Regional Site (if not Western Regional Site); Receive Naval SNF if selected for Expended Core Facility site.	Subalternative A: Receive aluminum-clad fuel from DOE and non-DOE sites. Ship stainless steel and zircaloy fuel to Idaho National Engineering Laboratory. Utilize new wet or dry storage facilities, or move aluminum-clad fuels to F- and H-Canyon for processing. Subalternative B: Receive all fuels from generators east of the Mississippi River (if Eastern Regional Site); ship all fuels to Oak Ridge Reservation (if not Eastern Regional Site); Receive Naval SNF if selected for Expended Core Facility site.	Subalternative A: Ship all SNF to Savannah River Site (as feasible). Subalternative B: Receive all fuel from generators east of the Mississippi River (if Eastern Regional Site) and naval SNF (if selected). Ship all SNF to designated site if not selected.	Subalternative A: Not applicable. Subalternative B: Receive all fuel from generators west of the Mississippi River (if Western Regional Site) and naval SNF (if selected).	Subalternative A: Ship all SNF to Idaho National Engineering Laboratory. Subalternative B: Ship all SNF to either Eastern or Western Regional Site depending on location for Expended Core Facility.	Subalternative A or B: Ship fuel to Eastern or Western Regional Site as appropriate.
Stabilization— Fuels to be retained at existing DOE sites would be stabilized as planned. For fuel to be shipped to regional site, any stabilization beyond that required for transportation would be performed at the regional site.	Fuel and sludge in 105-KE to be canned. Defense fuels possibly stabilized by one of three methods or stabilized for shipping offsite.	Canning and characterization facility needed for stabilization. Subalternative A: Requires receipt facility. Subalternative B: Requires shipping facility (if not Western Regional Site).	Subalternative A: Can aluminum-clad fuels and place them in wet or dry storage; or process existing fuel through F- and H-Canyons. Subalternative B: Can aluminum-clad fuels and place them in wet or dry storage or process them through F- and H-Canyons. Place nonaluminum-clad fuels in wet or dry storage.	Subalternative A: As required for shipment. Subalternative B: As required for receipt and storage. Same as subalternative A if not selected as Eastern Regional Site.	Subalternative A: Not applicable. Subalternative B: As required for receipt and storage. Same as subalternative A if not selected as Eastern Regional Site.	None.	Subalternative A or B: As required for shipment.
Storage— Facility upgrade/ replacement and onsite fuel transfers to support safe storage and to allow onsite consolidation.	Subalternative A: Defense production fuel stored in new wet or dry facilities. Subalternative B: All fuel stored in new wet or dry facilities if Western Regional Site.	Upgrade/increase capacity, as required, as applicable for subalternative. Replacement storage facility for Test Area North SNF.	Subalternative A: Store fuel in Receiving Basin for Offsite Fuels and in an upgraded reactor basin. Requires new receiving and characterization facilities, and new canning facilities. Subalternative B: Store fuels in Receiving Basin for Offsite Fuel in a reactor basin until new storage facility is built.	Subalternative A: continued use of existing onsite storage facilities. Subalternative B: Construction of new facilities necessary for inventories. Same as Subalternative A if not selected as Eastern Regional Site.	Subalternative A: Not applicable. Subalternative B: Construction of new facilities necessary for inventories if selected as Western Regional Site.	None.	Subalternative A or B: Continued use of existing onsite storage facilities

Table 3-4. (continued).

REGIONALIZATION Distribute existing and projected SNF among DOE sites based on fuel type (Subalternative A) or geographic location (Subalternative B).							
Actions	Hanford Site	Idaho National Engineering Laboratory	Savannah River Site	Oak Ridge Reservation	Nevada Test Site	Naval sites	Other locations
Research and Development— Treatment technology and research and development activities for DOE SNF management, including stabilization technology.	Subalternative A: Research and development on defense production fuel stabilization; characterization of N Reactor and single pass reactor fuels to determine the feasibility of dry storage. Subalternative B: Activities listed above for Subalternative A, plus, if selected for the Western Regional Site: new technology development facility; additional research and development as needed for DOE SNF management and ultimate disposition of SNF.	Subalternative A and as applicable under Subalternative B: Actinide recycling using limited quantities of commercial SNF. New technology development facility; additional research and development as needed for DOE SNF management and ultimate disposition of SNF. Subalternative B: If not, Western Regional Site, research and development activities phased-out.	Subalternative A: Develop technology (canning and storage design) to store aluminum-clad fuels in dry storage vault. Research to determine best technology for ultimate disposition of aluminum-clad fuels. Subalternative B: Develop technology (canning and storage design) to store aluminum-clad fuels in dry storage vault. Develop technology for storage of nonaluminum-clad fuels. Research to determine best technology for ultimate disposition of fuels.	Subalternative A: Onsite continues as planned. Subalternative B: Build research and development facility. Same as Subalternative A if not selected as Eastern Regional Site.	Subalternative A: Not applicable. Subalternative B: Build research and development facility. Same as Subalternative A if not selected as Western Regional Site.	None.	Not applicable.
Naval Fuel Examination	Subalternative A: Not applicable. Subalternative B: Full examination if selected as site for Expended Core Facility.	Subalternative A: Full examination. Subalternative B: Full examination if selected as site for Expended Core Facility.	Subalternative A: Not applicable. Subalternative B: Full examination if selected as site for Expended Core Facility.	Subalternative A: Not applicable. Subalternative B: Full examination if selected as site for Expended Core Facility.	Subalternative A: Not applicable. Subalternative B: Full examination if selected as site for Expended Core Facility.	Subalternative A or B: Not applicable.	Subalternative A or B: Not applicable.

Table 3-5. Summary of the Centralization alternative.

CENTRALIZATION A.Hanford Site B.Idaho National Engineering Laboratory C.Savannah River Site D.Oak Ridge Reservation E.Nevada Test Site Manage all existing and projected SNF inventories from DOE and the Navy at one site until ultimate disposition.							
Actions	Hanford Site	Idaho National Engineering Laboratory	Savannah River Site	Oak Ridge Reservation	Nevada Test Site	Naval sites	Other locations
Transportation— Existing SNF shipped to the centralized site.	Option A: Receive all SNF. Requires facility for receipt and handling of fuel. All Hanford Site fuel to be relocated onsite Options B, C, D, and E: Ship all Hanford Site SNF to the central site.	Option B: Receive all SNF. Options A, C, D, and E: Ship all Idaho National Engineering Laboratory SNF to the central site.	Option C: Receive all SNF. Options A, B, D, and E: Ship all Savannah River Site SNF to the central site.	Option D: Receive all SNF. Options A, B, C, E, F: Ship Oak Ridge Reservation SNF to the central site.	Option E: Receive all SNF. Options A, B, C, D: Not applicable	Ship all SNF to: Option A: Hanford Site Option B: Idaho National Engineering Laboratory Option C: Savannah River Site Option D: Oak Ridge Reservation Option E: Nevada Test Site	Options A through E: Ship all fuel to central site as appropriate.
Stabilization— Fuels at existing DOE sites would be stabilized before shipment. Other SNF would be stabilized as required at the centralization site.	Option A: Requires facility for handling and receipt of fuel. Fuel and sludge in 105-KE to be canned. Defense fuels possibly stabilized by one of three methods. Options B, C, D, and E: Requires facility for stabilizing and shipping fuel.	All Options: Canning and characterization facility needed for stabilization. Option B: Require facility for receipt and storage. Options A, C, D, and E: Require shipping facility.	Options A, B, D, and E: Can all SNF before shipment. Option C: Can aluminum-clad fuels and place them in wet or dry storage; or process existing fuel through F- and H-Canyons. Characterize fuel received from offsite.	Options A through C and E: As required for shipment. Option D: As required for receipt and storage.	Options A through D: As required for shipment. Option E: As required for receipt and storage.	None.	Options A through E: As required for shipment.
Storage— New facilities for SNF management.	Option A: Requires new storage facilities. Options B, C, D, and E: Phase out of storage facilities.	Option B: Requires new storage facilities. Options A, C, D, and E: Phase out storage facilities.	Options A, B, D, and E: Store existing aluminum-clad fuel in renovated Receiving Basin for Offsite Fuel and stainless-steel and zircaloy-fuel in an upgraded reactor basin until characterization and shipment offsite. Requires new fuel characterization facility. Option C: Store aluminum-clad fuel in Receiving Basin for Offsite Fuels and store zircaloy-clad and stainless steel-clad fuels in reactor basin until new storage facilities are available. Store fuel shipments in new storage facility. Requires new receiving, and characterization and canning facilities.	Option D: Construction of new facilities necessary for inventories. Options A through C and E: Use of existing onsite storage facilities.	Option E: Construction of new facilities necessary for inventories. Options A through D: Not applicable.	None.	Options A through E: Continued use of existing onsite storage facilities.

Table 3-5. (continued).

CENTRALIZATION A.Hanford Site B.Idaho National Engineering Laboratory C.Savannah River Site D.Oak Ridge Reservation E.Nevada Test Site Manage all existing and projected SNF inventories from DOE and the Navy at one site until ultimate disposition.							
Actions	Hanford Site	Idaho National Engineering Laboratory	Savannah River Site	Oak Ridge Reservation	Nevada Test Site	Naval sites	Other locations
Research and Development—Treatment technology and research and development activities for DOE SNF management and disposal occurs at the centralization site.	Option A: Research and development needed for DOE SNF management and ultimate disposition of SNF. New technology facility. Options B, C, D, and E: Research and development on defense production fuel stabilization and feasibility for canning and dry storage.	Option B: Actinide recycling using limited quantities of commercial SNF. New technology facility. Research and development needed for DOE SNF management and disposal of SNF. Options A, C, D, and E: Research and development ceases.	Option C: Develop technology (canning and storage design) to store Savannah River Site aluminum-clad fuels in dry storage vault. Research and development and pilot-scale operations to determine best technology for ultimate disposition of SNF. Options A, B, D, and E: Develop technology to stabilize and ship corroded aluminum-clad fuel.	Option D: Build research and development facility. Options A through C and E: Onsite continues as planned.	Option E: Build research and development facility. Options A through D: Not applicable.	None.	Not applicable.
Naval Fuel Examination	Option A: Expended Core Facility developed. Full examination. Options B, C, D, and E: Not applicable.	Option B: Expended Core Facility continues operation. Options A, C, D, and E: Expended Core Facility phased-out.	Option C: Expended Core Facility developed. Full examination. Options A, B, D, and E: Not applicable.	Option D: Build Expended Core Facility. Full examination. Options A through C and E: Not applicable.	Option E: Build Expended Core Facility. Full examination. Options A through D: Not applicable.	Not applicable.	Options A through E: Not applicable.

3.1.1 No Action

The No Action alternative is an alternative required under the Council on Environmental Quality regulations for implementing the National Environmental Policy Act of 1969. Under the No Action alternative, DOE would limit actions to the minimum necessary for safe and secure management of SNF at the generation site or current storage location. Under this alternative, small and large DOE sites, Naval sites, university and other non-DOE domestic reactors, and foreign research reactors would all independently manage their SNF onsite. Generally, no SNF would be transported between sites for management. Figure 3-1 indicates SNF inventories. The technology development activities related to SNF management, limited to activities already approved, would continue within DOE. Figure 3-1 also shows the distribution of fuel from 1995 through 2035.

No Action Alternative

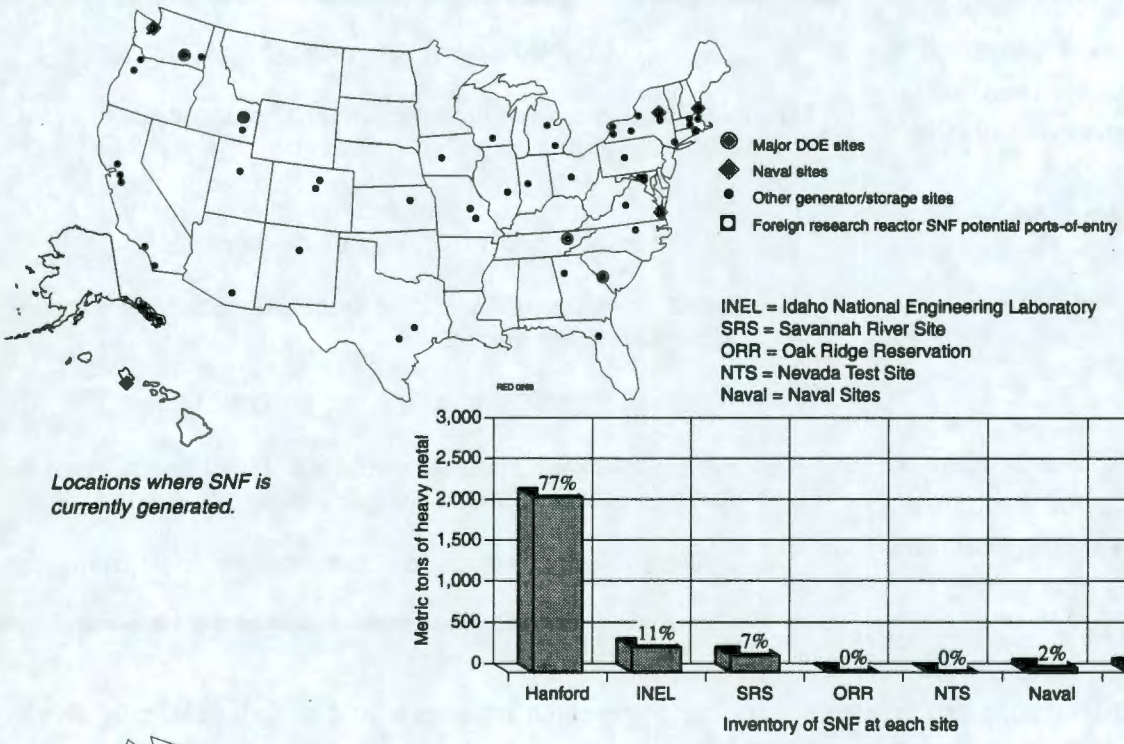
Take minimum actions required for safe and secure management of SNF at or close to the generation site or current storage location.

- After an approximate 3-year transition period, no shipment of SNF to or from DOE facilities would occur.
- Stabilization activities would be limited to the minimum actions required to safely store SNF.
- Naval reactor SNF would be stored at Naval sites.
- Facility upgrade/replacement and onsite fuel transfers would be limited to those necessary for safe interim storage.
- Existing research and development activities would continue.

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

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

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



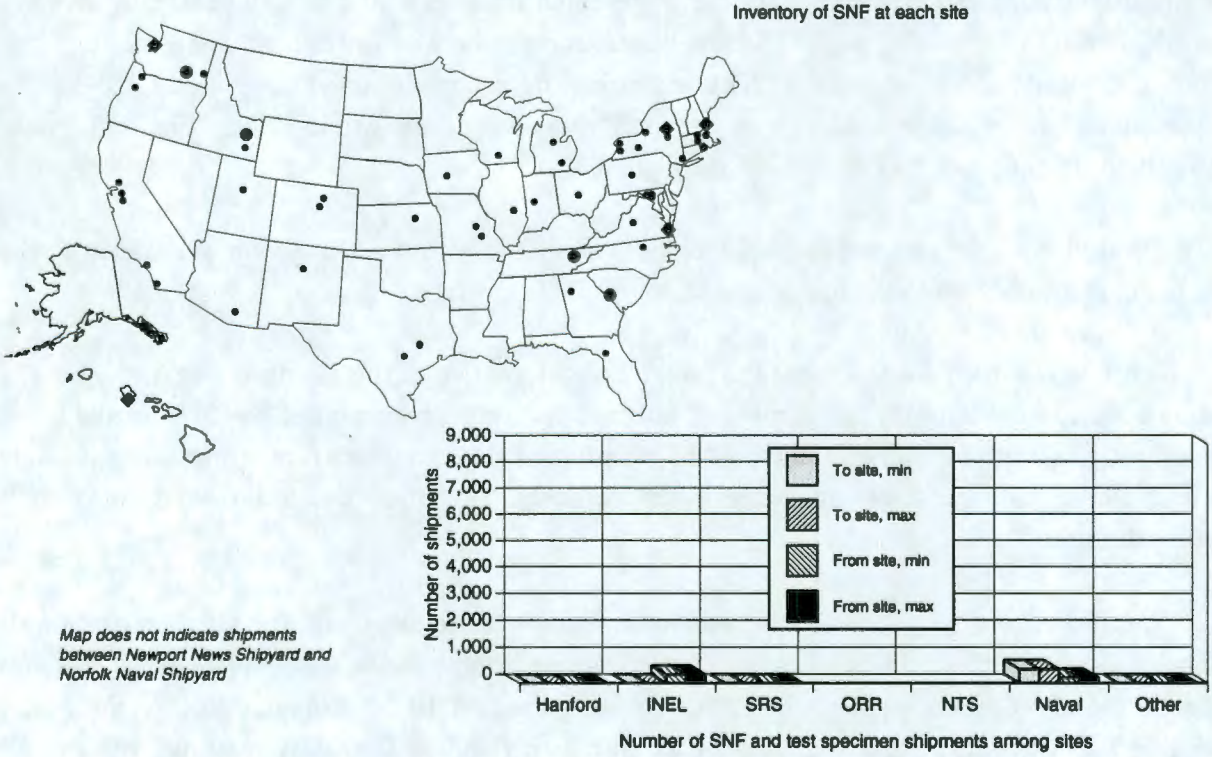


Figure 3-1. Spent nuclear fuel distribution, location, and inventory for the No Action alternative.

No new facilities are planned under the No Action alternative.

3.1.1.2 Idaho National Engineering Laboratory. For the No Action alternative, DOE would maintain SNF close to defueling or current storage locations with minimal facility upgrades or replacements. The Idaho National Engineering Laboratory would neither receive nor ship SNF except for Naval SNF during a transition period of about 3 years (see Section 3.1.1.6). After the transition period, Naval SNF would not be transferred to the Idaho National Engineering Laboratory, and the Expended Core Facility at the Idaho National Engineering Laboratory would be shut down. DOE would continue to transfer onsite SNF to the Idaho Chemical Processing Plant until the existing storage capacity is used.

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

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

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

Eight Savannah River Site facilities are used for the storage of SNF; most of the fuel is in the Receiving Basin for Offsite Fuels, the K-Reactor disassembly basin, and the L-Reactor disassembly basin. DOE would accomplish onsite transfers as required to ensure the safety of aluminum-clad fuel. The Receiving Basin for Offsite Fuels and an upgraded reactor basin would be utilized for continued storage of this fuel. Additionally, DOE would place the aluminum-clad fuel, which is degrading because of corrosion, in containers to minimize the spread of radioactive

material in the pools in case the cladding is breached. DOE would continue existing SNF-related research and development.

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

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

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

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

3.1.1.7 Other Generator/Storage Locations. Under the No Action alternative, the SNF generated and/or stored at DOE research and non-DOE research reactors and other locations

would not be shipped offsite. For the purposes of this analysis, it is assumed that SNF from foreign research reactors would not be shipped to the United States under this alternative. DOE research reactors with adequate storage capacity could continue operating as planned. If the onsite storage capacity is inadequate or cannot be expanded, new plans would have to be considered, including potential cessation of reactor operations after storage capacity limits are reached.

The No Action alternative would also affect the management of SNF from nuclear power plants that DOE is obligated to store. For this alternative, the SNF would remain at these sites. Stabilization would be performed, as necessary, to ensure safe storage.

3.1.2 Decentralization

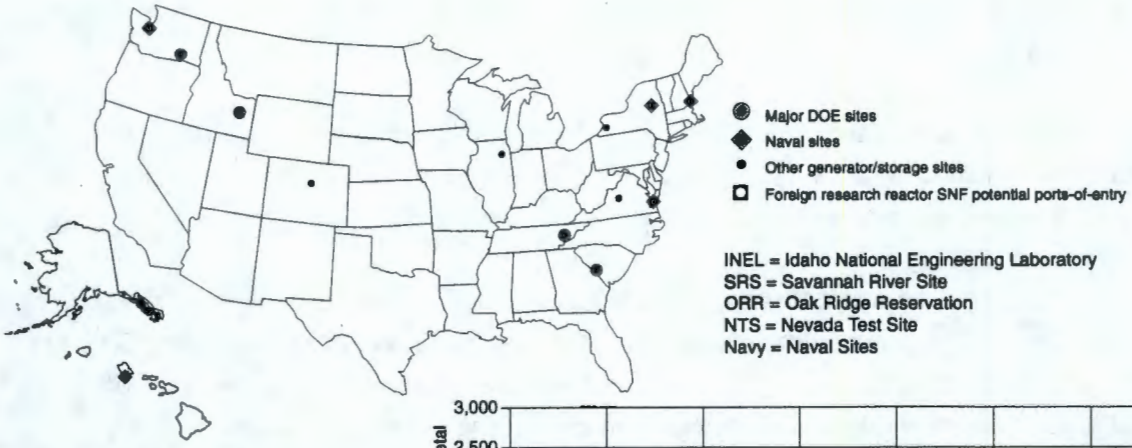
Decentralization Alternative

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

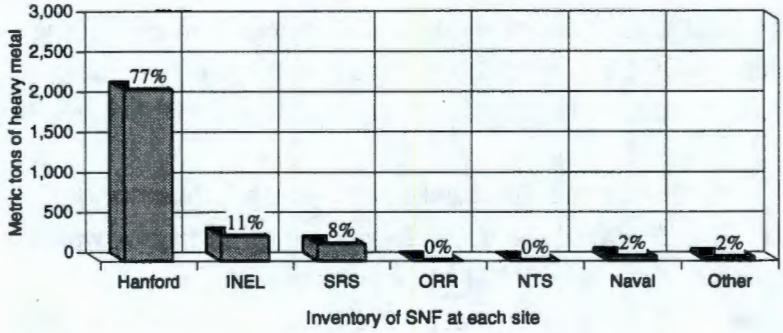
- SNF shipments would be limited to the following:
  - SNF stored or generated at universities and non-DOE facilities
  - Potential foreign research reactor fuel.
- Stabilization would be conducted to improve management capability.
- Some facilities would be upgraded/replaced and additional storage capacity required by the alternative would be constructed.
- Onsite fuel transfers would occur for improved safe storage.
- Research and development activities would be undertaken for SNF management, including stabilization technology.
- Three options for Naval fuel
  - No inspection—fuel remains close to refueling/defueling site
  - Limited inspection at Puget Sound Naval Shipyard
  - Full inspection at the Idaho National Engineering Laboratory followed by storage close to refueling/defueling site.

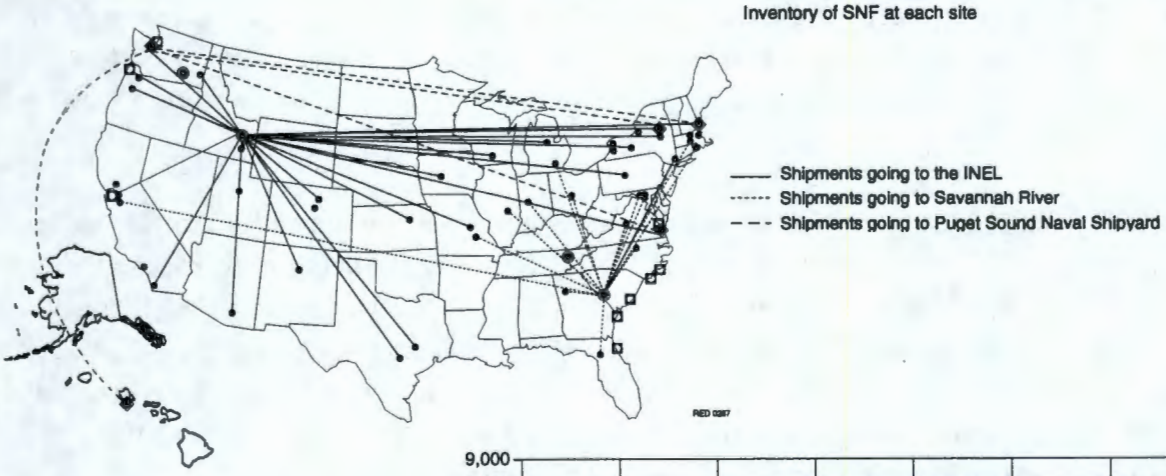
Under the Decentralization alternative, DOE would (a) maintain existing SNF in storage at current locations and (b) store new SNF at or near the site of generation, thereby reducing the amount of fuel transported before a decision on ultimate disposition. This alternative differs from the No Action alternative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

3.1.2.1 Hanford Site. Under the Decentralization alternative, the near-term activities at the Hanford Site include those activities identified under the No Action alternative, as well as substantial facility development and upgrades,, and SNF processing research and development. In addition to the three principal activities identified for the No Action alternative (that is, fuel characterization, fuel and sludge canning, and cask procurement for Fast Flux Test Facility fuel), the following general activities would also occur: evaluating wet and dry storage methods for defense production N Reactor and Single Pass Reactor fuel; evaluating dry storage methods for



Locations where SNF would be stored.





Map does not indicate shipments between Newport News Shipyard and Norfolk Naval Shipyard

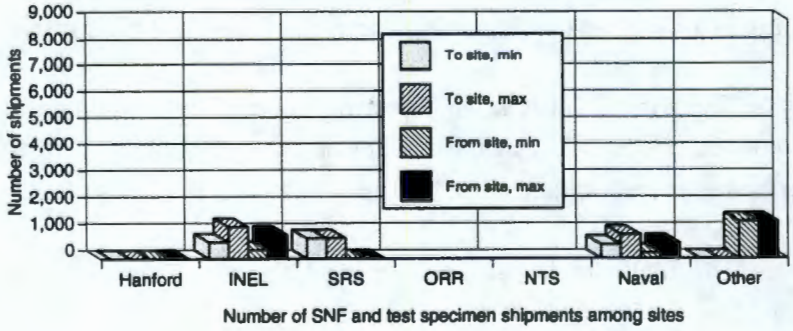


Figure 3-2. Spent nuclear fuel distribution, location, and inventory for the Decentralization alternative.

other fuels (Shippingport Core II, Fast Flux Test Facility, miscellaneous); conducting extensive research and development on defense production SNF stabilization techniques; and constructing and using wet and/or dry storage facilities and possibly a stabilization facility.

The Hanford Site would not ship SNF to or receive SNF from offsite locations, but local transport of fuel would occur to support safety requirements, improved SNF management, and research and development activities.

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

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

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

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

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

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

Fuel would continue to be stored in the Receiving Basin for Offsite Fuels and in an upgraded reactor basin until it is either canned, placed in wet or dry storage, or is processed. The processing option represented for evaluation in the EIS consists of processing existing Savannah River Site aluminum-clad fuel using existing chemical separations facilities (that is, F- and H-Canyons) and storing the current inventory of stainless-steel-clad and zirconium-clad fuel as well as future receipts of aluminum-clad SNF. This option is analyzed because DOE has data from past processing that can be used for analyses. The impacts from this technology are representative of other processing technology options that may be considered in the future. Other processing options, such as processing all SNF or processing coupled with vitrification, are also feasible and would be analyzed as part of the site-specific National Environmental Policy Act documentation needed to implement any option for this alternative.

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

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

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

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

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

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

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

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

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

3.1.2.7 Other Generator/Storage Locations. The Decentralization alternative for other generators and storage locations is similar to the No Action alternative because offsite shipment

of SNF would be allowed in limited amounts for continued operation. Thus, both DOE and non-DOE research reactors would be allowed to ship SNF offsite, as necessary. Additional SNF interim storage facilities at domestic research reactors would not be required. For this alternative, SNF currently stored at the West Valley Demonstration Project, Babcock & Wilcox Research Center, and the Fort St. Vrain power plant would remain at these sites.

3.1.3 1992/1993 Planning Basis

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

1992/1993 Planning Basis Alternative

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

- Fuel would be transported
  - TRIGA fuel from the Hanford Site to the Idaho National Engineering Laboratory; Hanford Site receives limited fuel for research of storage and dispositioning technologies
  - Naval fuel to the Idaho National Engineering Laboratory for examination and storage
  - West Valley Demonstration Project and Fort St. Vrain fuel to the Idaho National Engineering Laboratory
  - Oak Ridge Reservation fuel to the Savannah River Site
  - Domestic research fuel, and foreign research reactor fuel as may yet be determined, divided between the Savannah River Site and the Idaho National Engineering Laboratory.
- Facilities upgrades and replacements that were planned would proceed, including increased storage capacity.
- Research and development for SNF management would be undertaken, including stabilization technology.

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

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

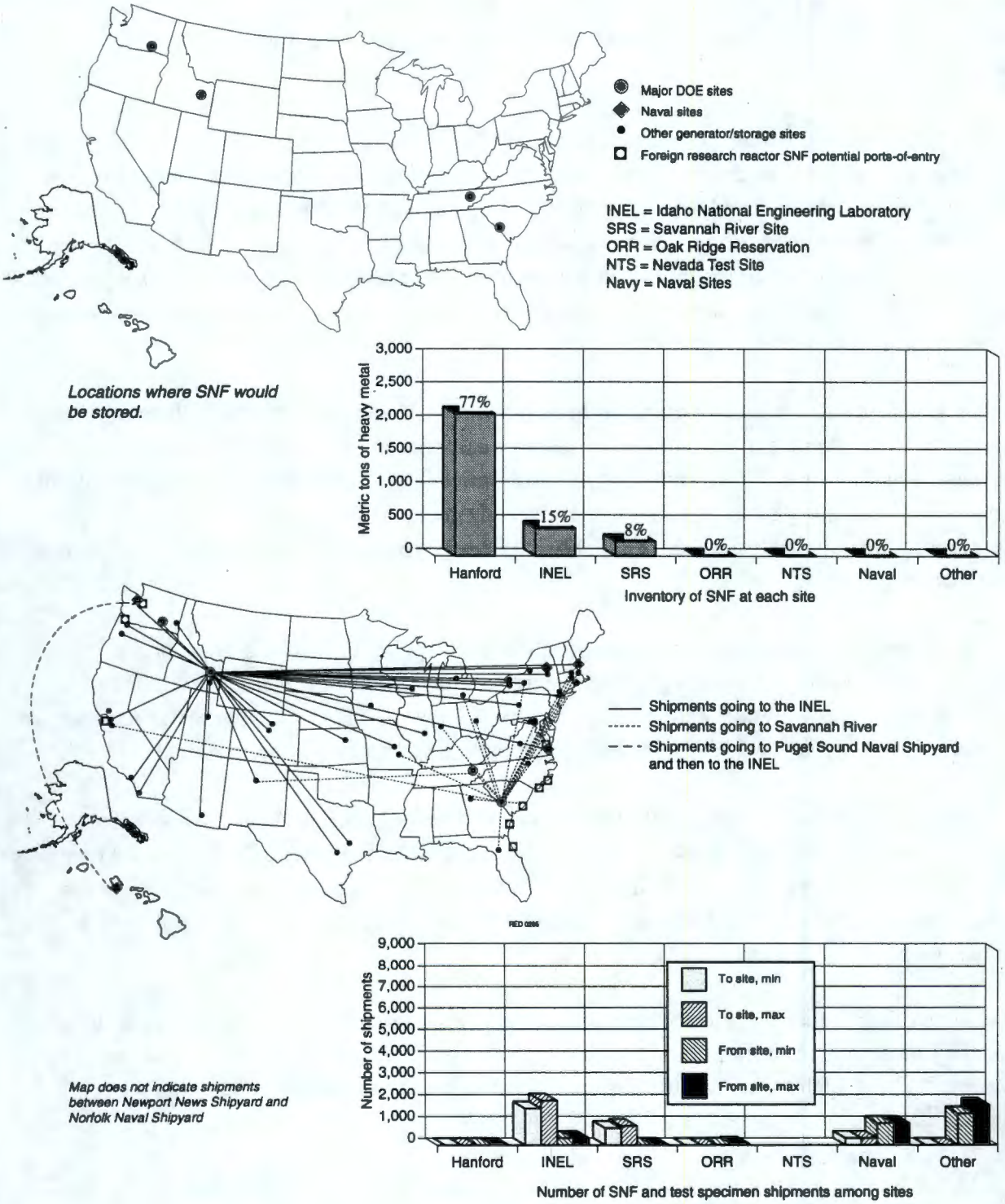


Figure 3-3. Spent nuclear fuel distribution, location, and inventory for the 1992/1993 Planning Basis alternative.

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

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

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

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

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

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

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

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

3.1.3.4 Oak Ridge Reservation. Under the 1992/1993 Planning Basis alternative, the Oak Ridge Reservation would ship excess SNF to other DOE locations as necessary to permit continued operations of Oak Ridge reactors. The amount of SNF stored at the Oak Ridge Reservation would not increase. Research and development activities would continue, and SNF interim storage capacity would not increase.

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

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

3.1.3.7 Other Generator/Storage Locations. Under this alternative, SNF would continue to be shipped to designated DOE sites, and DOE assumes that no additional SNF interim storage facilities would be constructed at the generator/storage site. For this alternative, SNF currently stored at the West Valley Demonstration Project, Babcock & Wilcox Research Center, and the Fort St. Vrain power plant would be shipped to the Idaho National Engineering Laboratory.

3.1.4 Regionalization

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

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

Regionalization A Subalternative

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

- Naval fuel would be shipped to, examined, and stored at the Idaho National Engineering Laboratory.
- Aluminum-clad fuel shipped to the Savannah River Site; TRIGA and nonaluminum fuel to the Idaho National Engineering Laboratory; retain defense production fuel at the Hanford Site.
- Stabilization would be performed at the shipping site where required before transportation. Additional stabilization would be performed at the regional sites.
- Facilities required to support SNF management would be upgraded or built as necessary.
- Research and development for SNF management would be undertaken, including stabilization technology.

The Regionalization A subalternative is the management of SNF based on the specific fuel type. One of two existing major sites (Idaho National Engineering Laboratory and Savannah River Site) would be selected for storage of nondefense production SNF. This subalternative is similar to the 1992/1993 Planning Basis alternative but involves more inter-site transportation of SNF to the sites, depending on the existing capabilities of the sites to manage the specific fuel types with respect to cladding material, physical and chemical composition, fuel condition, and adequate facilities to handle the increased quantity. Actions for this alternative would assign all but defense production SNF to either the Idaho National Engineering Laboratory or the Savannah River Site, depending on the fuel type.

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

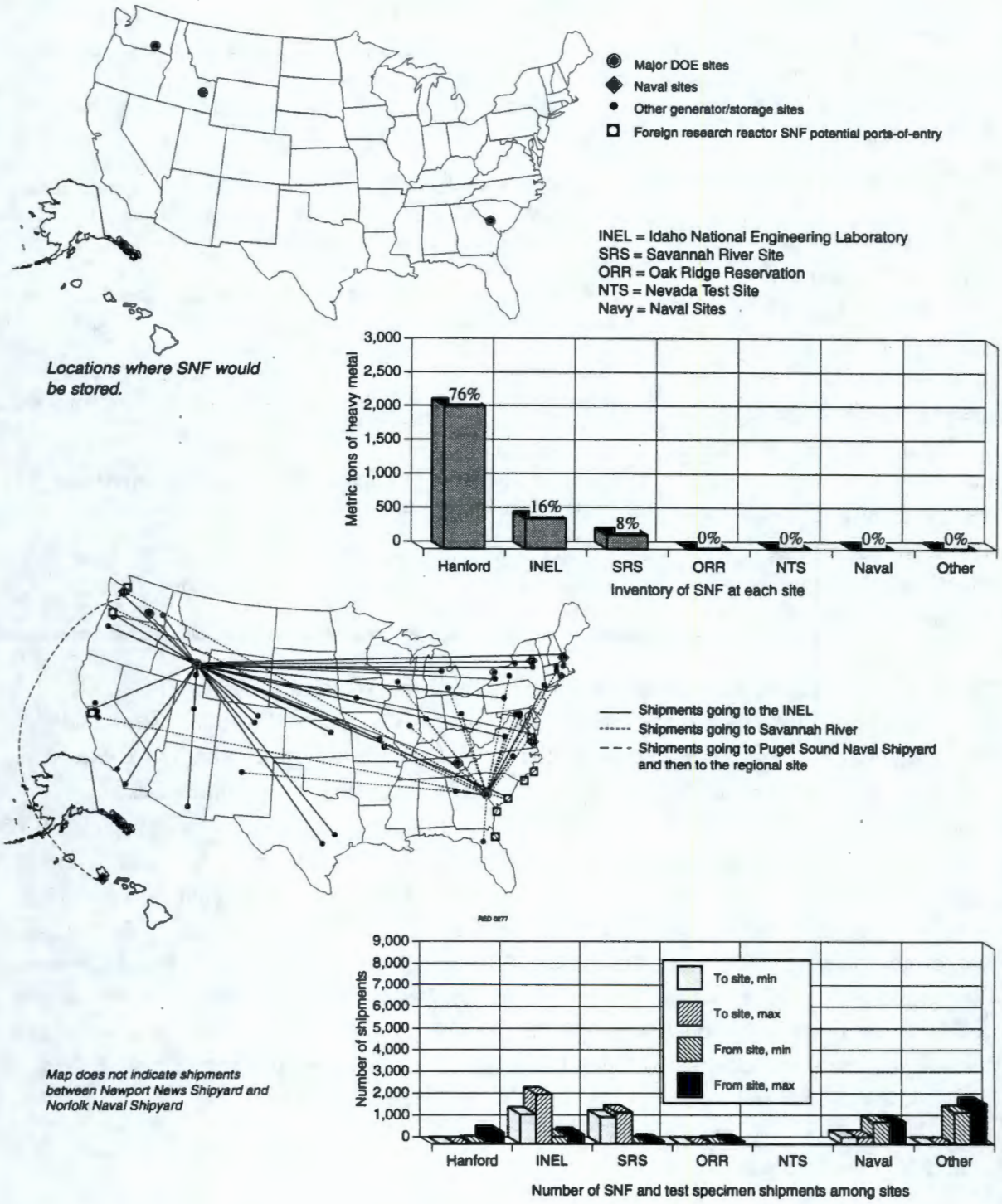


Figure 3-4. Spent nuclear fuel distribution, location, and inventory for the Regionalization A subalternative.

Regionalization B Subalternative

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

- The Eastern Regional Site would receive fuel from east of the Mississippi River and the Western Regional Site would receive fuel from west of the Mississippi River.
- Naval fuel would be shipped to, examined, and stored at either the Western Regional Site or the Eastern Regional Site.
- Stabilization would be performed at the shipping site where required for transportation. Additional stabilization would be performed at the regional site.
- Facilities required to support SNF management would be upgraded or built as necessary.
- Research and development would be undertaken for SNF management, including stabilization technology.

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

3.1.4.1 Hanford Site.

Regionalization A Subalternative—Under the Regionalization A subalternative, activities at the Hanford Site would be intermediate to those of the Decentralization and the

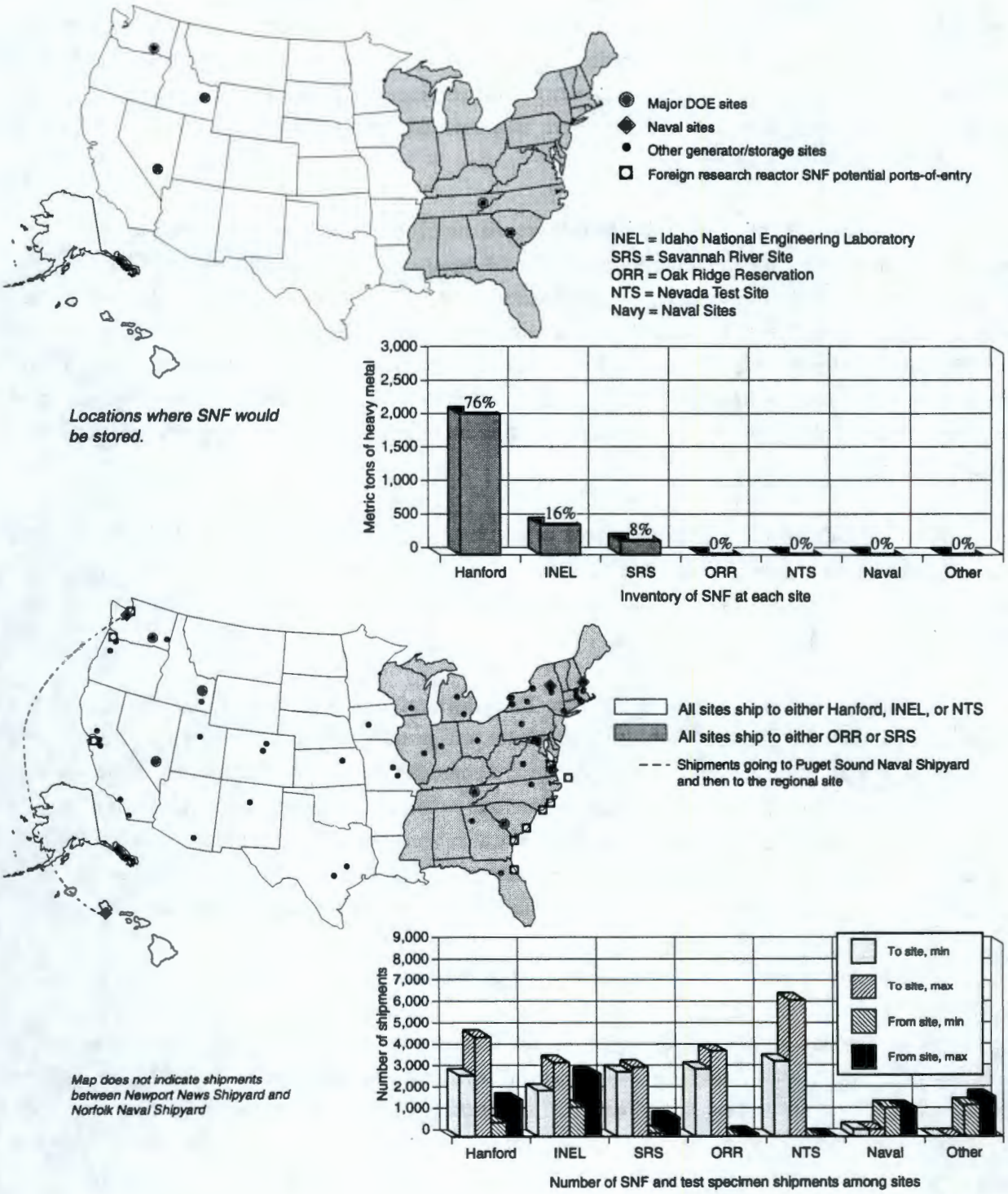


Figure 3-5. Spent nuclear fuel distribution, location, and inventory for the Regionalization B subalternative.

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

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

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

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

3.1.4.2 Idaho National Engineering Laboratory.

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

Regionalization B Subalternative—If the Idaho National Engineering Laboratory were selected as the Western Regional Site for implementation of the Regionalization B subalternative, SNF from western locations would be shipped to the Idaho National Engineering

Laboratory. The western facilities would characterize, stabilize, and can the SNF in containers compatible with dry storage at the Idaho Chemical Processing Plant at the Idaho National Engineering Laboratory. Naval SNF removed from Naval reactors would be transported to the Expended Core Facility at the Idaho National Engineering Laboratory for examination. Following examination, the SNF would be transferred to the Idaho Chemical Processing Plant for interim storage.

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

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

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

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

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

3.1.4.3 Savannah River Site.

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

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

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

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

3.1.4.4 Oak Ridge Reservation.

Regionalization A Subalternative—Under this subalternative, the Oak Ridge Reservation would not receive SNF and would ship its aluminum-clad, stainless steel-clad, and other fuel to the Savannah River Site.

Regionalization B Subalternative—If the Oak Ridge Reservation were selected as the Eastern Regional Site for implementation of the Regionalization B subalternative, the eastern locations would transport SNF to the Oak Ridge Reservation for storage. In addition, Naval SNF might be transported to the Oak Ridge Reservation if the Eastern Regional Site were selected for Naval fuel. SNF currently stored at other DOE facilities would arrive at the Oak Ridge Reservation fully stabilized. New non-DOE domestic, foreign research reactor, and Naval SNF would arrive in a condition necessary for safe transportation but uncanned. This fuel would be stabilized, prepared, and canned at the Oak Ridge Reservation to ensure safe interim storage. Research and development activities at the Oak Ridge Reservation would increase from current

levels. A new SNF management complex would be built, including (a) an SNF receiving and canning facility, (b) a technology development facility, (c) an interim dry storage area, and (d) an expended core facility similar to the one at the Idaho National Engineering Laboratory.

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

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

If the Oak Ridge Reservation were not selected as the Eastern Regional Site, almost all SNF at the Oak Ridge Reservation would be shipped to the Savannah River Site. Some SNF might not be shipped until a stabilization process is developed because of the current inability to stabilize some SNF for transport.

3.1.4.5 Nevada Test Site. The Regionalization A subalternative would not affect the Nevada Test Site because fuel is not currently stored onsite and fuel would not be shipped to the site.

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

The SNF receiving and canning facility would receive SNF cask shipments from offsite and prepare the SNF for dry storage. A pool storage area would be included in this facility for cooling SNF, as necessary, before dry storage. The technology development facility would be

used to investigate the applicability of dry storage technologies and pilot-scale technology development for disposal of the various types of SNF. The interim dry storage area would consist of passive storage modules designed to safely store the SNF for 40 years. Naval fuel would be examined at the new expended core facility at the Nevada Test Site before interim storage.

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

3.1.4.6 Naval Nuclear Propulsion Program.

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

Regionalization B Subalternative. Under this subalternative, Naval reactors would continue to be defueled and refueled, and the SNF would be sent to either the Western or the Eastern Regional Site for examination and storage.

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

3.1.4.7 Other Generator/Storage Locations. Under the Regionalization A subalternative, the activities at the other generator and storage locations are the same as indicated for the 1992/1993 Planning Basis alternative. The exact destination of SNF shipped would vary depending on the fuel type under Subalternative A and on the generation/storage location under Subalternative B.

3.1.5 Centralization

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

Centralization Alternative

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

- Existing SNF would be shipped to the centralized site.
- Naval fuel would be shipped to, examined, and stored at the centralized site.
- Projected SNF receipts would be shipped to the centralized site.
- Fuels at existing DOE sites would be stabilized as needed before shipment. Other SNF would be stabilized as required for storage at the centralized site.
- Facility upgrade/replacement and new storage capacity would be provided at the centralized site; stabilization facilities would be provided at the shipping sites.
- Research and development would be undertaken for SNF management, including stabilization technology.

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

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

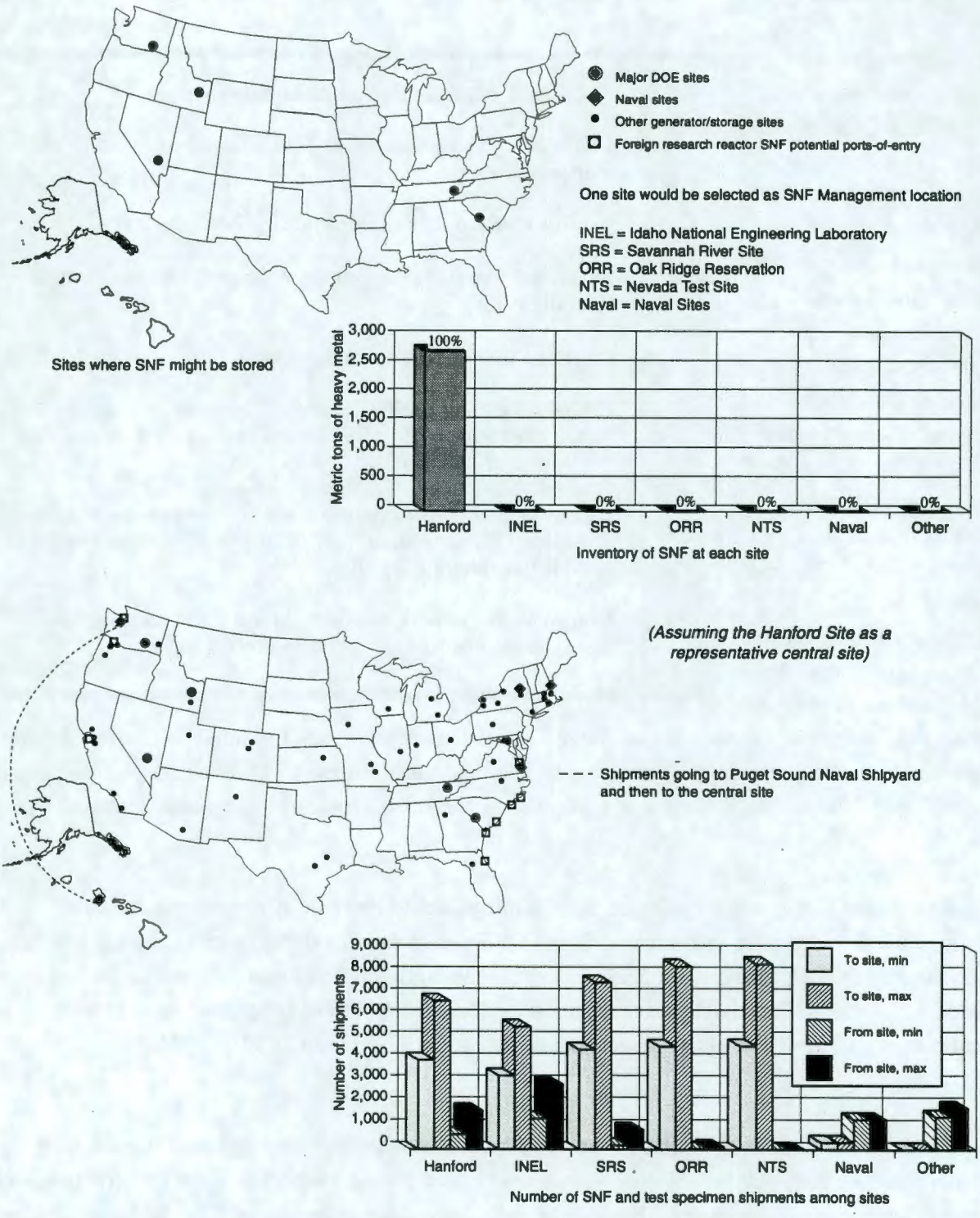


Figure 3-6. Spent nuclear fuel distribution, location, and inventory for the Centralization alternative.

3.1.5.1 Hanford Site. Under the Centralization alternative, Option A, DOE-controlled and Naval reactor SNF would be transported to the Hanford Site. This would require the completion of the upgrades, increases, and replacements of storage capacity identified for the existing inventory under the Decentralization alternative, as well as of the additional capacity within those facilities or new facilities to accommodate the SNF from the other sites and possibly a stabilization facility.

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

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

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

DOE would complete an expanded dry fuels storage facility, which would include a new canning and characterization facility similar to the one described for the 1992/1993 Planning Basis alternative. In addition, the initiation of other new facility projects would be the same as those described for the 1992/1993 Planning Basis alternative.

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

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

As under the No Action alternative, the CPP-603 Underwater Fuel Storage Facility pool inventory would be transferred to existing dry storage facilities until it is shipped offsite. The dry fuels storage facility would not be built. SNF-related facilities at the Idaho National Engineering

Laboratory would be closed, except for facilities directly supporting operating reactors, such as the Advanced Test Reactor canal or the Argonne National Laboratory-West Fuel Cycle Facility.

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

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

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

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

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

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

3.1.5.4 Oak Ridge Reservation. If Option D were selected under the Centralization alternative, the Oak Ridge Reservation would receive DOE SNF stabilized and canned to the extent necessary for safe transportation. The SNF might need to be uncanned, stabilized, prepared, and recanned at the Oak Ridge Reservation, however, to ensure safe interim storage.

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

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

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

If the Oak Ridge Reservation were not selected as the centralization site, then almost all SNF at the Oak Ridge Reservation would be shipped to the centralization site.

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

The SNF receiving and canning facility would receive SNF cask shipments from offsite and prepare the SNF for dry storage. A pool storage area would be included in this facility for cooling SNF before it is placed into dry storage, as necessary. The applicability of dry storage technologies and pilot-scale technology development for disposal of the various types of SNF would be investigated in the technology development facility. The interim dry storage area would

consist of passive storage modules designed to safely store the SNF for 40 years. Naval SNF would be examined at the expended core facility before interim storage.

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

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

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

3.2 Alternatives Eliminated from Detailed Analysis

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

3.2.1 Examine or Store Spent Nuclear Fuel in Foreign Facilities

The design and operating characteristics of the fuel for Naval reactors and certain portions of other SNF are classified. As such, they are not releasable to foreign interests without going through a complex procedure prescribed in the Atomic Energy Act and strict U.S. Nuclear Regulatory Commission licensing requirements. Some of these classified design details and characteristics are obvious from the physical form of the fuel, and others could be learned from detailed examination or analyses. In addition, the fuel for Naval and DOE reactors utilizes enriched uranium, so transfer to other nations would be contrary to the goals and requirements of the Treaty for the Non-Proliferation of Nuclear Weapons. These factors, along with others such as the security required for foreign shipment and storage, make this alternative impractical. Based on these considerations, this alternative was eliminated from detailed analysis.

3.2.2 Leave Naval Spent Nuclear Fuel in Nuclear-Powered Ships

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

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

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

3.2.3 Alternate Sites for the Management of Spent Nuclear Fuel

An alternative SNF site selection process was undertaken to identify alternatives to the three major DOE sites—Hanford Site, Idaho National Engineering Laboratory, and Savannah River Site. The candidate sites evaluated, site selection screening process, and results are presented in the *Alternate Site Selection Decision Process Report* (DOE 1994d). This study concluded that the uncertainties regarding Department of Defense sites together with their lack of SNF facilities and expertise made these additional Department of Defense sites less attractive as site alternatives. The alternative SNF site selection process resulted in the addition of the Nevada Test Site and Oak Ridge Reservation as potential regionalization and centralization sites for SNF management. The Oak Ridge Reservation represented a reasonable alternative site to the Savannah River Site for regionalization of Eastern-based SNF and the Nevada Test Site represented a reasonable alternative site to the Idaho National Engineering Laboratory or Hanford sites for regionalization of Western-based SNF. These two sites also represented options for centralization of all SNF management activities. However, the DOE does not consider the Nevada Test Site to be a preferred site for the management of SNF because of the State of Nevada's current role as the host site for the Yucca Mountain Site Characterization Project and the Nevada Test Sites's lack of current SNF handling experience. Despite this nonpreferred

status, for purposes of conducting a thorough National Environmental Policy Act analysis, the Nevada Test Site provides a contrast to other potential sites because it represents a site that has no existing SNF infrastructure. Non-DOE sites were eliminated from further analysis.

3.2.4 Processing Spent Nuclear Fuel at Commercial Facilities

Historically, most SNF within the DOE complex was reprocessed to recover plutonium and uranium for defense purposes. Improvements in East-West relations have eliminated the need to further produce and recover uranium and plutonium for defense purposes. Accordingly, DOE has terminated most defense material production and reprocessing operations and is phasing-out the remainder of operations. The reprocessing of SNF for recovery of uranium and plutonium was, therefore, eliminated from further consideration for SNF management.

Domestic commercial facilities are not available for SNF processing for interim storage and, therefore, were not considered. Foreign commercial facilities may be available for SNF processing, but they could not be used for the majority of SNF types in the DOE inventory because of United States Government policy and other important technical considerations. Particularly, current nonproliferation policy limits or precludes transfer of highly enriched uranium abroad. Therefore, foreign processing of DOE's SNF was also not considered in this EIS. However, future site-specific National Environmental Policy Act reviews may consider foreign processing for a limited number of specific fuel types should foreign processing be identified as technically feasible, of a cost benefit to the United States taxpayer, and consistent with United States Government policy during preparation of the site-specific National Environmental Policy Act documents.

3.3 Comparison of Alternatives

As discussed in Chapter 5 and the site-specific appendices, the environmental consequences and, therefore, differences among the five SNF management alternatives addressed in Section 3.1 would be small or negligible. The comparison of alternatives in this section concentrates on (1) the areas in which the public has expressed considerable interest and (2) programmatic factors important to DOE decisionmaking. The following factors were selected for comparison:

- Number of SNF shipments among sites
- Public health effects
- SNF-related employment
- Generation of radioactive waste

- Impact on DOE or Navy missions

- Cost of implementation.

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

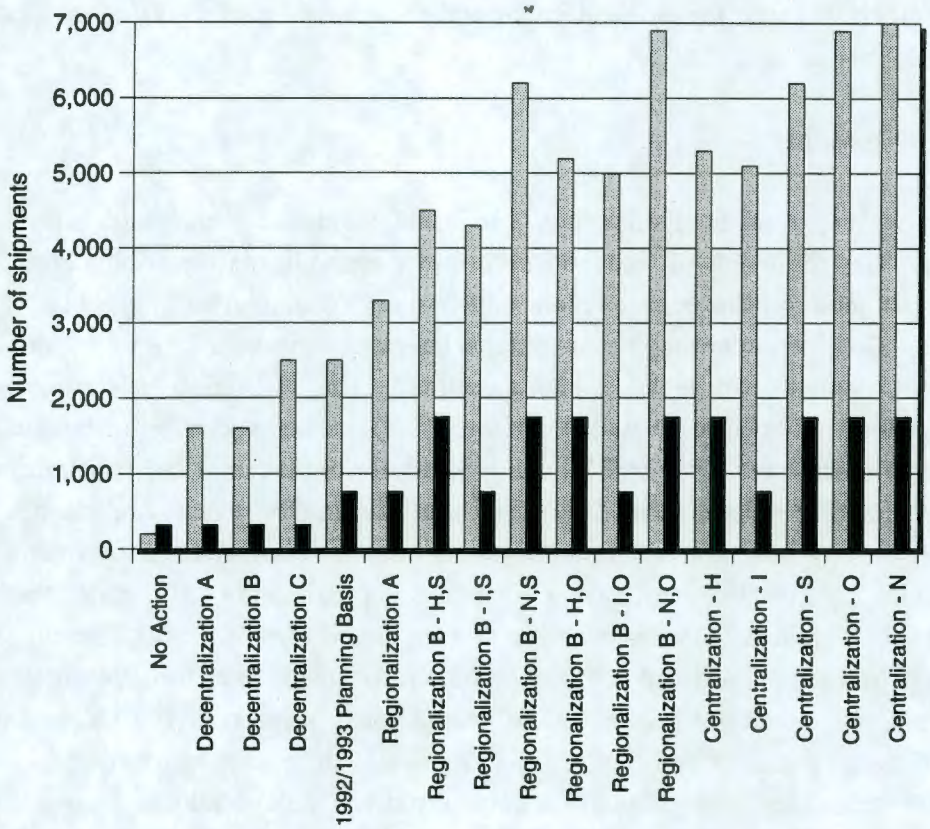
3.3.1 Number of Shipments

Figure 3-7 shows the number of shipments that would occur under each alternative. Figure 3-7 also quantifies shipments of test specimens under each alternative. Shipments of Naval test specimens are included here because of their contribution to cumulative impacts of Naval SNF transportation. Details concerning Naval test specimens and methodologies for calculating impacts of specimen shipments can be found in Appendix D. The No Action alternative would involve a limited number of Naval spent fuel shipments (200) and test specimen shipments (320). The Decentralization alternative, 1992/1993 Planning Basis alternative, and Regionalization A subalternative mostly involve shipments to DOE sites from the smaller reactor and storage sites and from the Naval sites to DOE sites. These shipments range in number from approximately 1,900 shipments under Decentralization Options A or B to approximately 4,100 under the Regionalization A subalternative. Decentralization Option C and the 1992/1993 Planning Basis alternative have approximately 2,800 and 3,300 shipments respectively over the 40-year period. For the Regionalization B subalternatives and the Centralization options, SNF is shipped to one or two sites. For these alternatives and options, the number of shipments range from approximately 5,100 under the Regionalization B subalternative (Idaho National Engineering Laboratory and Savannah River Site) to a high of about 8,800 under the Centralization Option E (centralization at the Nevada Test Site). The number of shipments is summarized in Table 3-6. A more detailed discussion can be found in Appendices D and I. The public health effects from such shipments are discussed in the next section.

3.3.2 Public Health Effects

This section discusses the public health effects from radiation exposure and traffic accidents under DOE's SNF Management Program (see Section 5.1.1.4 for basic information regarding assessment methods). These effects are estimated to be small, as shown by Figures 3-8, 3-9, and 3-10. The three sources of radiation exposure are (1) normal site operations, (2) transportation, and (3) accidents. Under all alternatives, the estimated number of latent cancer fatalities from the operation of the entire DOE SNF management system over a 40-year period would range from approximately zero to about two latent cancer fatalities.

3.3.2.1 Normal Operations. In general, the greatest radiation exposure from normal SNF site activities and incident free transportation results when large quantities of SNF are



Key:

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Decentralization B: Limited examination of Naval fuels at Puget Sound Naval Shipyard
Decentralization C: Full examination of Naval fuels at Idaho National Engineering Laboratory with SNF stored at Naval sites
Regionalization A: Regionalization by fuel type
Regionalization B: Regionalization by location

Site initials:
H: Hanford Site
I: Idaho National Engineering Laboratory
S: Savannah River Site
O: Oak Ridge Reservation
N: Nevada Test Site

Spent fuel
Test specimens[a]

a. Test specimens are small quantity fuel samples shipped for laboratory analysis

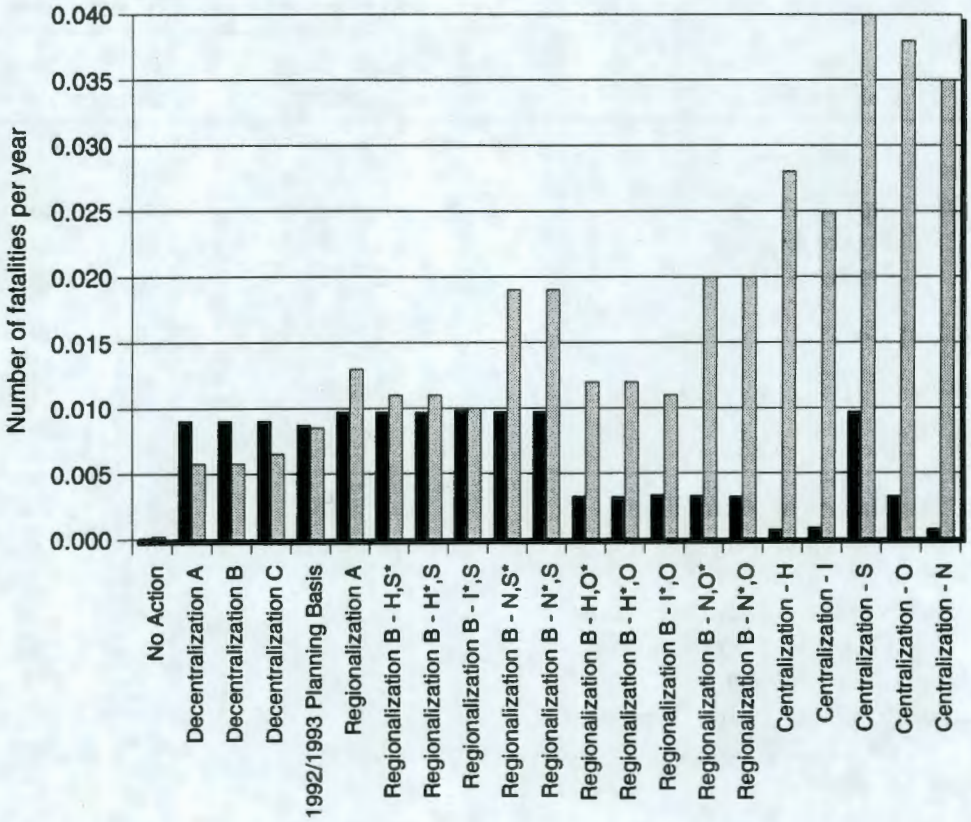
Figure 3-7. Number of spent nuclear fuel and test specimen shipments between the years 1995 and 2035.

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

Alternative		Maximum number of shipments	
		Spent fuel shipments[a]	Test specimen shipments[b]
No Action		200	320
Decentralization	Option A	1,600	320
	Option B	1,600	320
	Option C	2,500	320
1992/1993 Planning Basis		2,500	760
Regionalization A		3,300	760
Regionalization B			
Hanford Site/Savannah River Site		4,500	1,750
Idaho National Engineering Laboratory/Savannah River Site		4,300	760
Nevada Test Site/Savannah River Site		6,200	1,750
Hanford Site/Oak Ridge Reservation		5,200	1,750
Idaho National Engineering Laboratory/Oak Ridge Reservation		5,000	760
Nevada Test Site/Oak Ridge Reservation		6,900	1,750
Centralization			
Hanford Site		5,300	1,750
Idaho National Engineering Laboratory		5,100	760
Savannah River Site		6,200	1,750
Oak Ridge Reservation		6,900	1,750
Nevada Test Site		7,000	1,750

a. Naval SNF shipments by rail and DOE SNF by truck.

b. Test specimens by truck.



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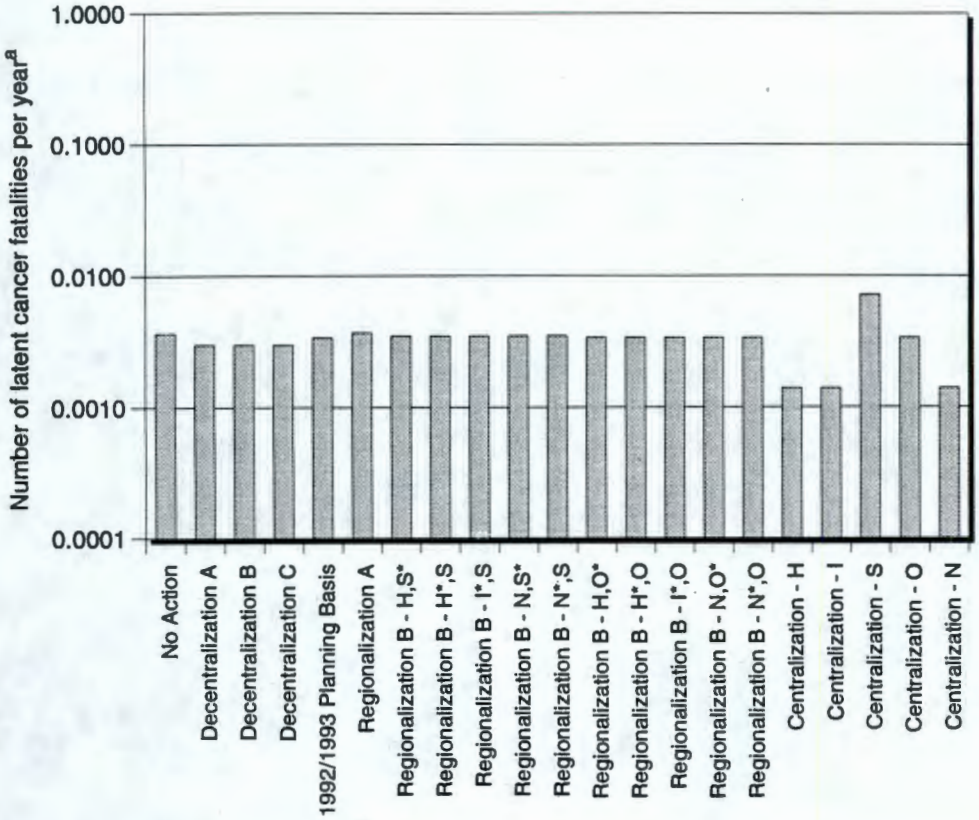
■ Operations
▨ Transportation[a]

* Location of Expended Core Facility

a. Total fatalities are the sum of the estimated number of radiation-related latent cancer fatalities for workers and the general population plus the estimated number of nonradiological fatalities from vehicular emissions.

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



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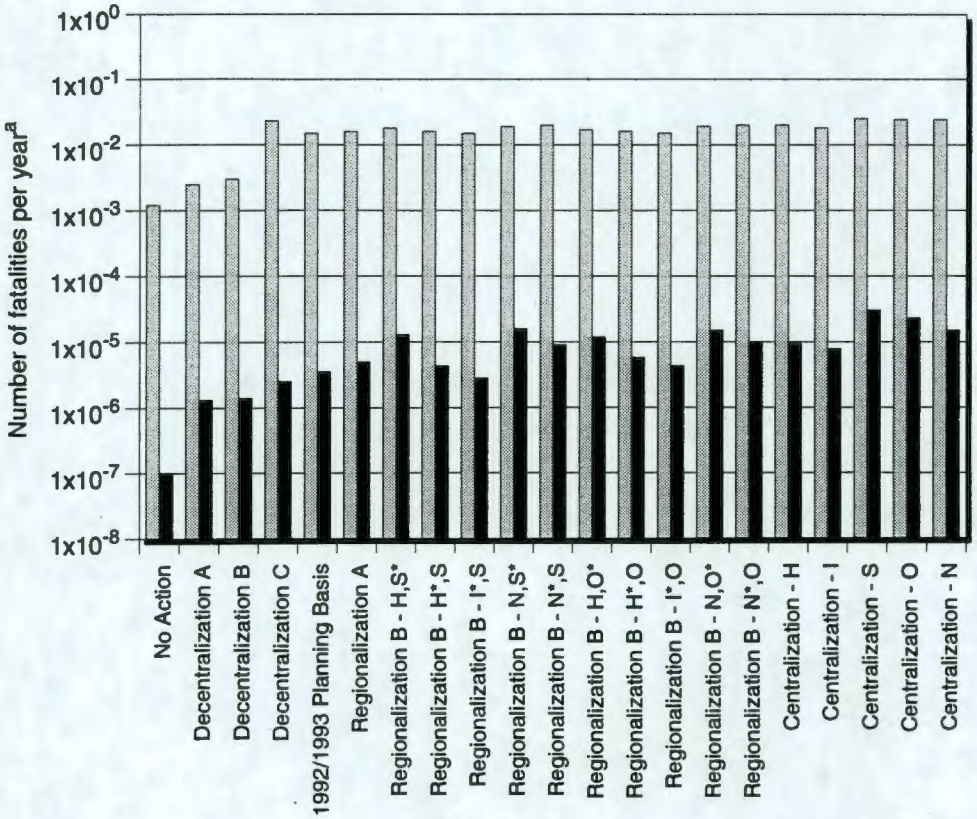
- N: Nevada Test Site

* Location of Expended Core Facility
a. Facility risks are based on the product of the probability and consequences of the respective maximum foreseeable facility accident for each alternative and expressed in latent cancer fatalities per year.

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



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Traffic fatality risk
Radiological risk

* Location of Expended Core Facility

a. Radiological risk is in terms of latent cancer fatalities per year from spent nuclear fuel shipments; traffic fatalitiy risk is in terms of estimated nonradiological traffic accident fatalities per year from spent nuclear fuel shipments

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

transported among sites, such as under the Regionalization B subalternative or Centralization alternative. Under incident-free transportation, as noted in Table 3-7, the estimated total fatalities are less than two for all alternatives, with the highest estimates associated with the Centralization options. This reflects the higher number of shipments associated with these options.

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

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

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

- Zero latent cancer fatalities form normal facility operations and facility accidents
- Zero latent cancer fatalities from transportation accidents
- Zero latent cancer fatalities from most incident-free transportation scenarios; up to two latent cancer fatalities under the Centralization options
- Up to about 1 fatality from a nonradiological traffic accident.

A more detailed discussion of accidents is found in Chapter 5.

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

Under various alternatives, the total labor force involved in SNF management could decrease by 85 to 130 jobs or increase by more than 2,100 jobs averaged over the period 1995 to 2005, as compared to the 1995 baseline. This labor force is the sum of permanent employment in operating or maintaining new facilities and shorter term construction jobs. Figures 3-11 and 3-12 characterizes the range of SNF jobs under each alternative. The number of jobs related to SNF

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

	Minimum[a,b] total fatalities	Maximum[b,c] total fatalities
No Action	0.0089	0.0089
Decentralization	0.076	0.26
1992/1993 Planning Basis	0.10	0.34
Regionalization A (fuel type)	0.12	0.50
Regionalization B (geography)		
Idaho National Engineering Laboratory and Savannah River Site	0.11	0.41
Idaho National Laboratory and Oak Ridge Reservation	0.11	0.44
Hanford Site and Savannah River Site	0.12	0.44
Hanford Site and Oak Ridge Reservation	0.12	0.48
Nevada Test Site and Savannah River Site	0.14	0.75
Nevada Test Site and Oak Ridge Reservation	0.13	0.81
Centralization		
at Hanford Site	0.19	1.1
at Idaho National Engineering Laboratory	0.17	0.99
at Savannah River Site	0.20	1.6
at Oak Ridge Reservation	0.17	1.5
at Nevada Test Site	0.21	1.4

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

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

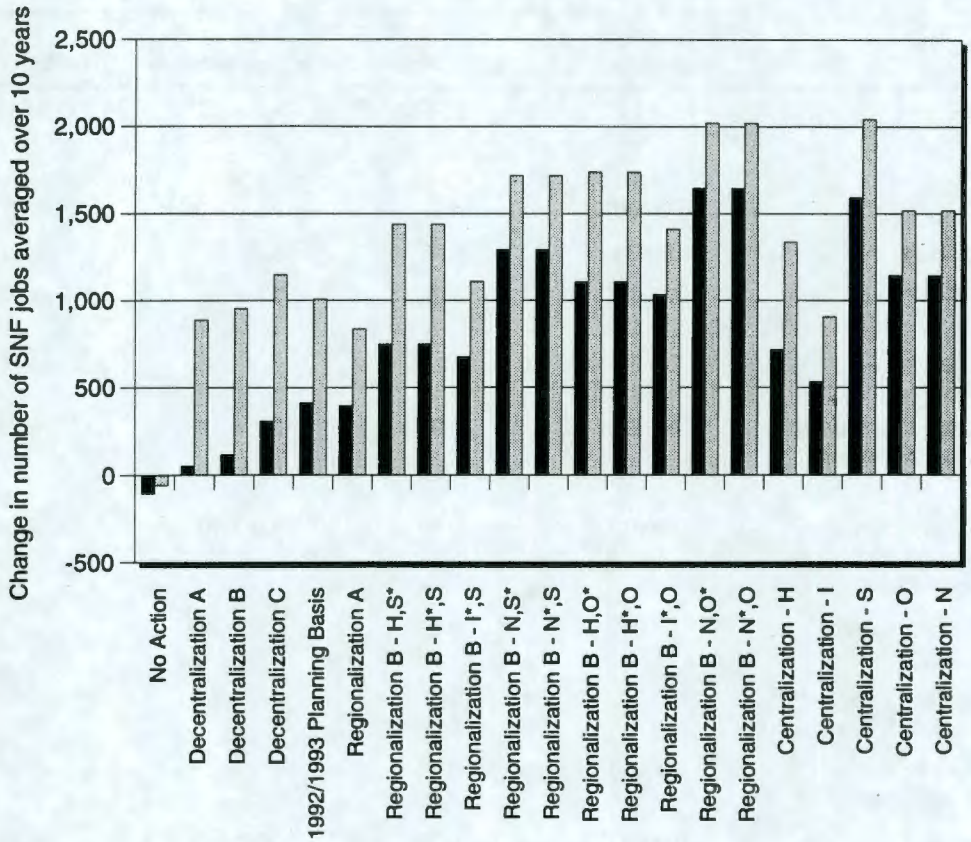
c. The maximum total fatalities are associated with shipment of DOE fuel by truck, Naval SNF shipments are by both truck (onsite) and rail (offsite).

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

Alternative	Truck Accident Risks[a]		Rail Accident Risks[a]	
	Latent cancer fatalities	Traffic fatalities	Latent cancer fatalities	Traffic fatalities
No Action	4.1×10^{-6}	0.047	4.1×10^{-6}	0.047
Decentralization[b]	5.0×10^{-5} to 0.0001	0.1 to 0.92	1.3×10^{-5} to 6.4×10^{-5}	0.12 to 0.93
1992/1993 Planning Basis	0.00014	0.58	6.9×10^{-5}	0.59
Regionalization A (fuel type)	0.0002	0.62	7.8×10^{-5}	0.60
Regionalization B (geography)				
Idaho National Engineering Laboratory and Savannah River Site	0.00011	0.60	5.8×10^{-5}	0.59
Idaho National Engineering Laboratory and Oak Ridge Reservation	0.00017	0.60	6.0×10^{-5}	0.59
Hanford Site and Savannah River Site	0.00052	0.71	0.00045	0.67
Hanford Site and Oak Ridge Reservation	0.00047	0.68	0.00034	0.65
Nevada Test Site and Savannah River Site	0.00036	0.78	0.00017	0.72
Nevada Test Site and Oak Ridge Reservation	0.00041	0.78	0.00017	0.73
Centralization				
at Hanford Site	0.00037	0.79	0.00013	0.74
at Idaho National Engineering Laboratory	0.00031	0.73	9.3×10^{-5}	0.69
at Savannah River Site	0.0012	1.0	0.00053	0.81
at Oak Ridge Reservation	0.0009	0.94	0.00038	0.76
at Nevada Test Site	0.00059	0.94	0.00021	0.86

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

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



Key:

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Site initials:
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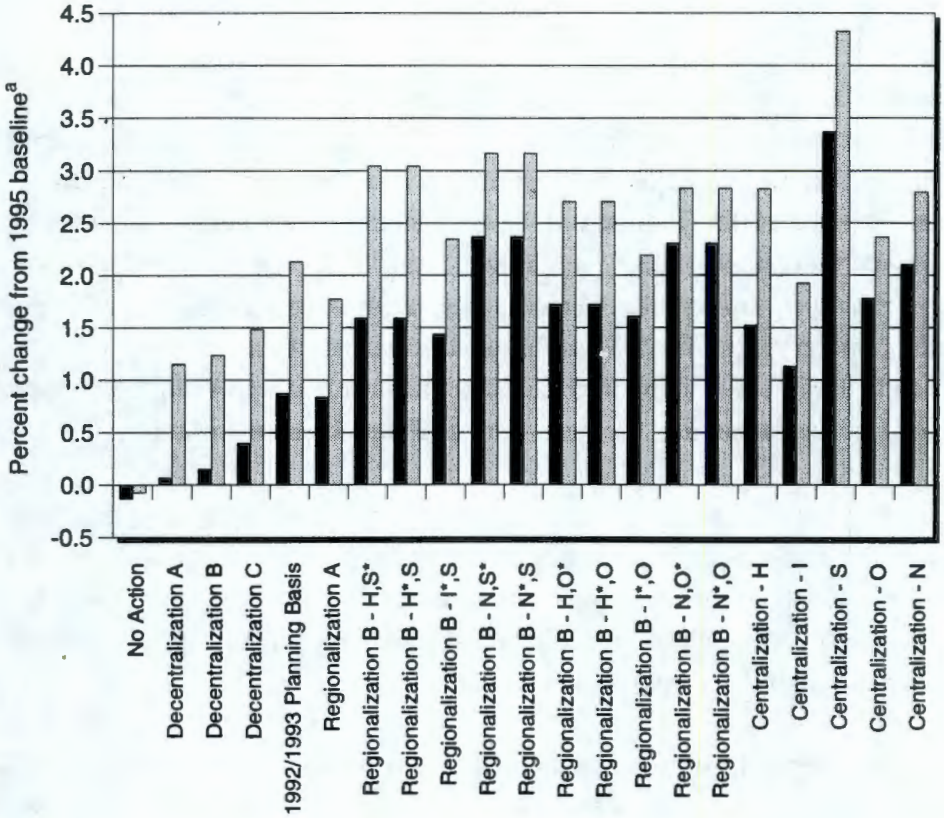
Min[a]
Max[a]

* Location of Expended Core Facility
a. The maximum values occur with processing; the minimum values occur without processing.

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



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■ Min[b]
▨ Max[b]

* Location of Expended Core Facility

a. 1995 baseline is the sum of the employment at all sites involved in that alternative

b. The maximum values occur with processing; the minimum values occur without processing

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

management is small compared with the total number of jobs (2 to 4.5 percent) at the sites that would be involved in SNF management. SNF management-related jobs account for less than 4.5 percent of total employment at the sites and less than 8 percent of employment at any one site.

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

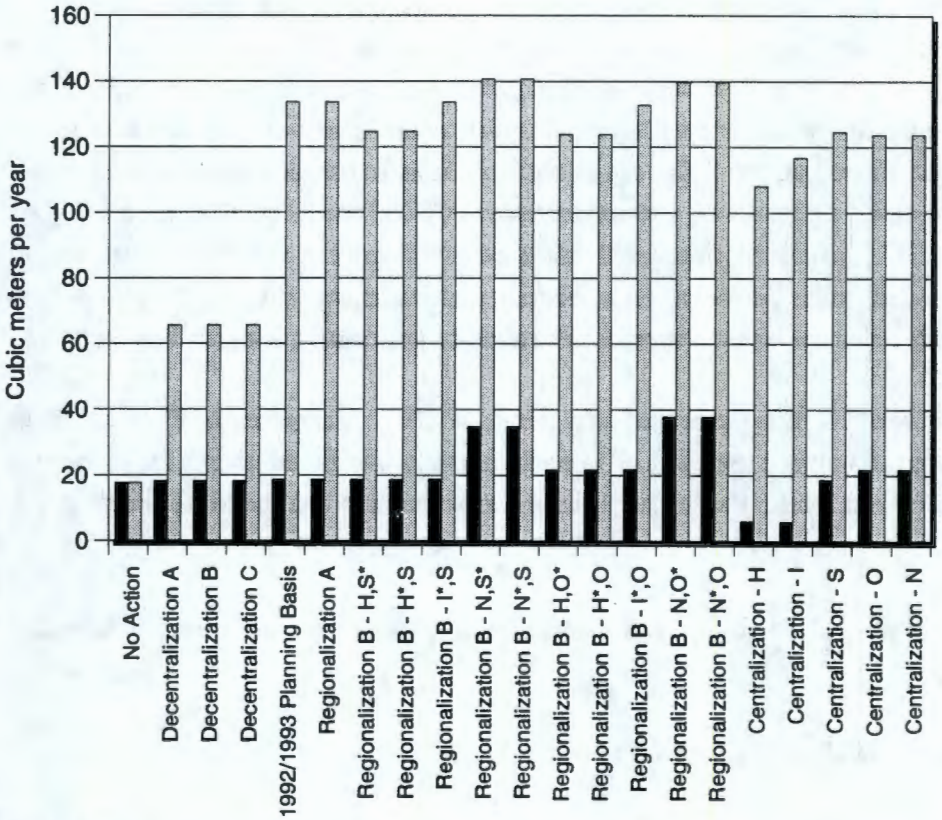
Under the No Action alternative, employment would not increase substantially at any site, and the closure of the Expended Core Facility at the Idaho National Engineering Laboratory would result in a net loss of just over 500 jobs involved in SNF management following closure. The maximum number of jobs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

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

A more detailed discussion of socioeconomic impacts can be found in Chapter 5.

3.3.4 Generation of Radioactive Wastes

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



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- N: Nevada Test Site

■ Min[a]
▒ Max[a]

* Location of Expended Core Facility

a. The maximum values occur with processing; the minimum values occur without processing

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

stabilization activities. As a result, under the No Action alternative fewer than 20 cubic meters per year (26 cubic yards per year) of transuranic wastes would be generated from SNF management nationwide because SNF would not be stabilized. Under the other alternatives, where stabilization activities are assumed to occur, it is estimated that between 20 and 50 cubic meters (26 and 65 cubic yards) of high-level waste and between 20 and 100 cubic meters (26 and 131 cubic yards) of transuranic waste would be generated each year (Figure 3-13). The lower generation rates would occur in the Decentralization alternative, where small amounts of SNF would be shipped among major DOE sites (and stabilization for shipment would not be necessary). For other alternatives, greater amounts of SNF would be shipped among sites; therefore, more SNF would require stabilization before shipment and more waste would be generated. The difference between the minimum and maximum volume of waste generated results principally from the contribution attributable to processing for stabilization.

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

A more detailed discussion of radioactive waste generation under each alternative can be found in Chapter 5.

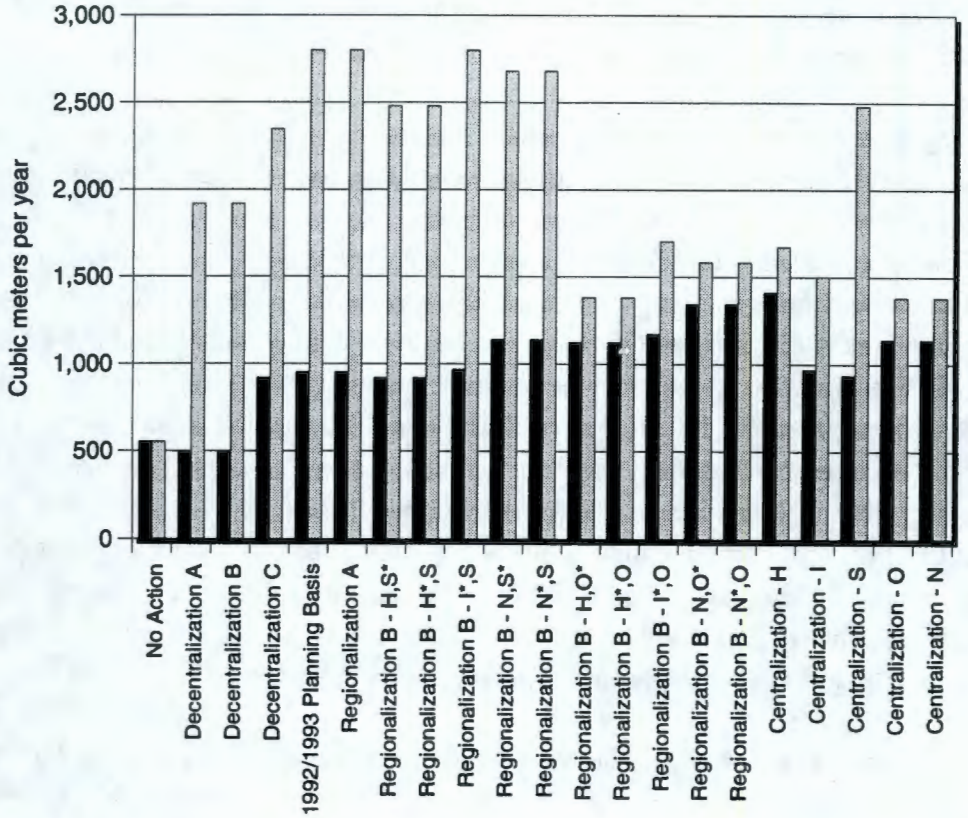
3.3.5 Impacts on DOE and Navy Missions

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

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

Additionally, no new facilities or new research and development would occur. DOE's ability to safely store SNF would be impacted by being unable to build new facilities or conduct research and development for improved storage methods. The No Action alternative would not permit development of processing and other technologies except for those underway as of June 1995.

Under the No Action alternative, DOE would not satisfy its obligations associated with SNF from university reactors, other research reactors, and special-case commercial SNF. Also, under the No Action alternative, DOE might not be able to fulfill agreements with states or



Key:

Decentralization A: No examination of Naval fuels
Decentralization B: Limited examination of Naval fuels at Puget Sound Naval Shipyard
Decentralization C: Full examination of Naval fuels at Idaho National Engineering Laboratory with SNF stored at Naval sites
Regionalization A: Regionalization by fuel type
Regionalization B: Regionalization by location

Site initials:
- H: Hanford Site
- I: Idaho National Engineering Laboratory
- S: Savannah River Site
- O: Oak Ridge Reservation
- N: Nevada Test Site

■ Min [a]
▒ Max [a]

* Location of Expended Core Facility

a. The maximum values occur with processing; the minimum values occur without processing

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

other Federal agencies that involve SNF except those specific actions already in progress. Failure to meet the terms of these agreements would expose DOE to adverse legal actions. In addition, DOE would not proceed, as it has proposed, to renew a policy of accepting returned foreign research reactor fuel that contains United States origin uranium (see Section 1.2.4). These mission impacts could be avoided under any alternative but the No Action alternative.

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

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

- The design of new reactors having extended lifetimes
- Continued safety of Naval reactors
- Improvements in nuclear fuel performance and ship operational performance
- The operation of existing Naval reactors by providing confirmation of their proper design and allowing maximum depletion of their fuel.

Although it is difficult to quantify the benefits of an outstanding safety record and improved operational characteristics, increased core life yields an economic advantage—a reduction in the number of reactor cores that must be procured and in the number of refuelings that must

be performed. It also results in less SNF being generated. Another advantage is the increased on-line availability of nuclear-powered ships with life-of-ship fuel, which would reduce the number of ships required. About $5 billion would be saved if life-of-ship fuels are developed, based on an assumed force structure of fewer than 100 nuclear-powered ships by 2005.

3.3.6 Cost of Implementation

To determine if there are significant cost differences between EIS alternatives, DOE is developing a cost evaluation that it expects to complete and make available to the public before the Record of Decision. This evaluation will allow near-term SNF decisions to be made with consideration of long-term (life-cycle) implications. For each alternative, the cost evaluation will consider capital cost for upgrades to existing facilities and new facilities, operation and maintenance costs for existing and new facilities, decontamination and decommissioning costs for new facilities, and SNF transportation costs. While this evaluation will focus on SNF management costs, it will also address total system life-cycle costs including final disposition alternatives such as repository disposal. The results of the evaluation will be considered by DOE in preparing the Record of Decision.

3.3.7 U.S. Nuclear Regulatory Commission Licensing Standards

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

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4. AFFECTED ENVIRONMENT

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

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

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

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

4.1 Hanford Site

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

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

Approximately 6 percent of the Hanford Site is occupied by operational facilities. Waste management and SNF processing activities and waste storage occurs near the center of the site. Eight retired plutonium production reactors and the N Reactor are located on the south side of the Columbia River, and the nuclear research and development laboratories are located in the southeastern part of the site near the city of Richland. The majority of Hanford's SNF is stored in basins in 100-KW and 100-KE. The Fast Flux Test Facility is located in the east-central area of the site. The remaining area is undeveloped land that provides for buffer zones for the operating areas. The Hanford Site is a Superfund site, listed on the National Priority List.

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

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

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

The Hanford Site is on a low-lying, modified alluvial plain of the Columbia River. Altitudes range from about 105 meters (345 feet) in the southeast part to about 245 meters (804 feet) in the northwest corner. The site is bounded to the east by the Columbia River and

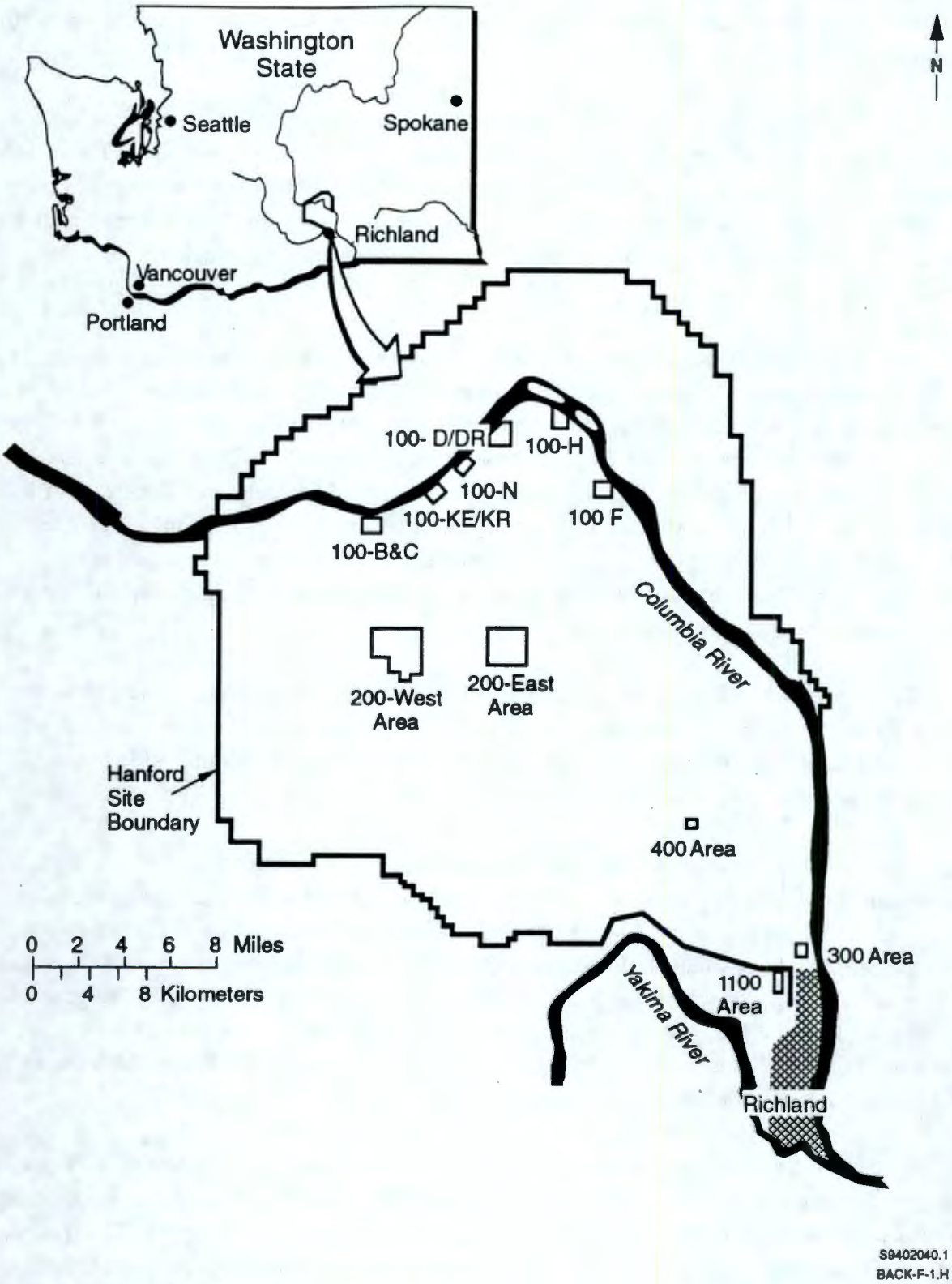


Figure 4-1. Hanford Site location and site map.

the White Bluffs of the Ringold Formation, to the southeast by the confluence of the Yakima and Columbia Rivers and the city of Richland, to the west by the Rattlesnake Hills, and to the north by the Saddle Mountain.

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

The area of the Hanford Site is historically of low seismicity. The site is in a Uniform Building Code Seismic Risk Zone 2 (Zone 0 represents little damage, and Zone 3 is subject to the greatest seismic risk). Known faults in the area have not generated earthquakes. The largest seismic shock near the Hanford Site on record was approximately 4.5 to 5.0 on the Richter scale and Modified Mercalli Intensity of V; it was recorded in Corfu, 35 kilometers (22 miles) north of the site in 1918. A Modified Mercalli Intensity V quake occurred in 1973. Many lower intensity earthquakes have occurred in the Columbia Plateau and on the Hanford Site as part of "earthquake swarms," which are clusters of several small earthquakes occurring over a short period of time.

The Hanford Site is located approximately 161 kilometers (100 miles) to the east of the Cascade Range, which includes several volcanic vents. The great distance eliminates the potential for lava flows from these volcanoes to reach the site. The foreseeable volcanic effects at the Hanford Site are limited to windborne volcanic ash.

The general climate of the Hanford Site is hot and dry in summer and cool in winter. The average annual precipitation is 16 centimeters (6.3 inches), most of which falls during the winter. On average, thunderstorms occur 11 days per year, mostly during the summer. Tornadoes are extremely rare, occurring within 160 kilometers (100 miles) of the site about once in 3 years. Air quality at the site is good—well within ambient air quality standards set by the U.S. Environmental Protection Agency and the State of Washington. The nearest Class I Area (areas where degradation of air quality is to be severely restricted) to the site is at Goat Rocks Wilderness Area, 145 kilometers (90 miles) from the site.

Two rivers pass through the site or form part of its boundary. The Columbia River passes through the northern part of the site and forms part of the eastern boundary. The average daily flow of this river is 3,400 cubic meters per second (120,100 cubic feet per second). The Yakima River, with an average flow of 104 cubic meters per second (3,673 cubic feet per second), forms part of the southeastern border of the site. Wastewaters are discharged to a number of small lakes and streams on the northern part of the site, and two intermittent creeks form the

remainder of the surface waters on the site. The flood areas of these rivers and streams include some site areas where facilities are located, but flooding is well-controlled by upstream dams on the Columbia River. Minor flooding (away from facilities) occurs from other watercourses. While specific information on the 100-year floodplain has not been defined, the projected extent of the maximum probable flood, which is greater than the area of inundation expected from a 100-year flood, would not impact SNF facilities.

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

The water supply at the Hanford Site and for the nearby Tri-Cities is the Columbia River. In 1991, the combined water use for Richland, Pasco, and Kennewick was 4.3×10^7 cubic meters (11.38 billion gallons). Richland and Kennewick derive a portion of their water used from nearby groundwater wells and rely on groundwater as a sole source of water from November through March each year.

Although not a source of drinking water, groundwater in unconfined aquifers under the Hanford Site contains concentrations of tritium that exceed the U.S. Environmental Protection Agency drinking water standards and nitrate concentrations that have exceed the U.S. Environmental Protection Agency nitrate standards. Other parameters have been well within the U.S. Environmental Protection Agency limits.

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

The Hanford Site is a shrub steppe environment dominated by cheatgrass, but it includes 10 different types of plant communities. This plant environment supports 12 species of amphibians and reptiles, 125 species of birds, and 39 species of mammals. Deer and elk are the major large animals, and coyotes are the major mammalian predators. Wetlands of varying size exist along the Columbia River and support extensive stands of willows, grasses, aquatic plants, and other plants. Four threatened or endangered plants classified by the State of Washington exist on the site, as well as seven species of threatened or endangered birds or mammals and one insect species. The insect species and three of the bird species are federally listed. These plants and animals are not known to occur in the vicinity of the proposed SNF facilities site.

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

For 1989, the collective radiation dose to about 6,000 radiation workers amounted to 619 person-rem for an average worker dose of approximately 100 millirem per year. The collective dose to the population within 80 kilometers (50 miles) of the site from site activities was calculated to be 0.8 person-rem in 1992, which amounts to an average dose of 0.002 millirem per person per year. The dose to the maximally exposed offsite individual was calculated to be 0.02 millirem per year. For perspective, collective dose to the same population from natural background radiation was calculated to be about 100,000 person-rem from an average individual dose of 300 millirem per year.

For human health and safety, one parameter of interest is radiation exposure, especially exposure associated with the storage of SNF. In 1989, about 9,000 individuals were monitored at the Hanford Site. Of those monitored, 6,000 received a measurable radiation dose, with an average annual dose equivalent of 0.1 rem (100 millirem) per individual with measurable doses. This dose is well below the DOE Order 5480.11 dose limit of 5 rem per year and the DOE Administration Control Level of 2 rem per year for occupational exposure.

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

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

High-level radioactive waste has been accumulating at the Hanford Site since 1944 in 149 single-shell tanks—no new waste has been added since 1980. Twenty-eight double-shell tanks are also in use. Transuranic wastes were disposed of onsite before 1970 in unlined trenches. Projected volumes of transuranic waste for 1995 are 172 cubic meters (225 cubic yards) from SNF management activities. Mixed low-level waste totaling 16,745 cubic meters (21,902 cubic yards) was buried at the Hanford Site from 1987 to 1991. Another 4,225 cubic meters (5,526 cubic yards) of mixed waste has accumulated in storage. In 1992, 56,245 kilograms (124,000 pounds) of mixed low-level waste was generated. From 1944 to 1991, approximately 558,916 cubic meters (731,030 cubic yards) of low-level waste was buried at the Hanford Site. In 1991, 5,300 cubic

meters (6,932 cubic yards) of low-level waste was generated at the Hanford Site. In 1992, 619,268 kilograms (1,365,000 pounds) of hazardous waste was generated. Mixed wastes are 99 percent tank wastes at the Hanford Site resulting from 108 different waste streams. Hazardous wastes generated in 1995 from SNF are expected to total 2.2 cubic meters (2.9 cubic yards). In 1992, industrial solid waste totaled 22,213 cubic meters (29,054 cubic yards) and asbestos totaled 1,017 cubic meters (1,330 cubic yards). A total of 1,484 hazardous chemicals are reported at the Hanford Site at over 783 locations, and they are found in 2,926 different hazardous materials. In 1992, the Emergency Planning and Community Right-to-Know Act reporting threshold was exceeded for 53 hazardous chemicals.

4.2 Idaho National Engineering Laboratory

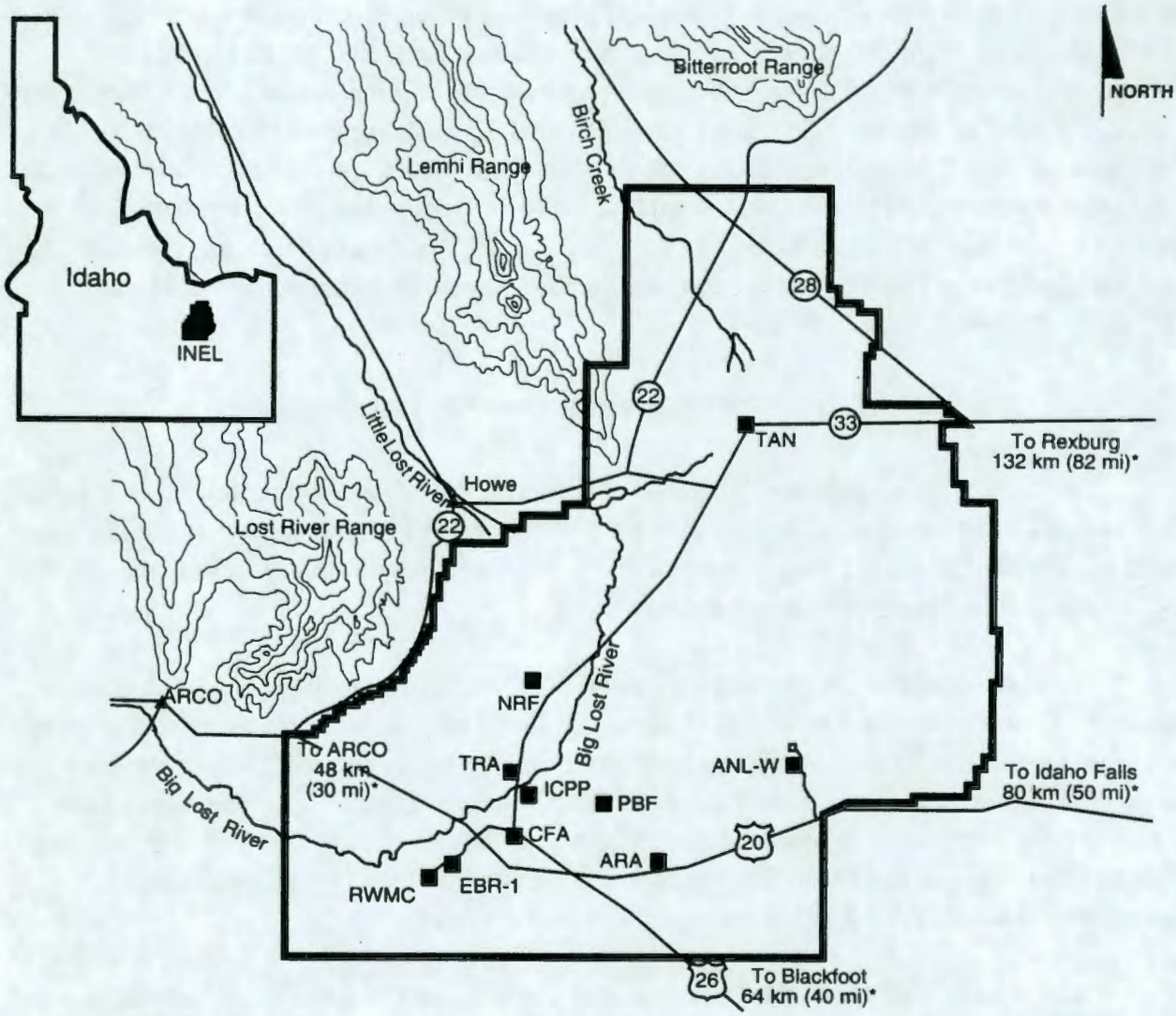
This section summarizes environmental characterization information on the Idaho National Engineering Laboratory site. This information has been used to evaluate impacts at the site under various alternatives for management of SNF. More detailed information characterizing this site is presented in Appendix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

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

Categories of land use at the Idaho National Engineering Laboratory include facility operations, grazing, general open space, and infrastructure such as roads. About 2 percent of the total Idaho National Engineering Laboratory site area [46 square kilometers (11,400 acres)] is used for facilities and operations. The Idaho National Engineering Laboratory is a Superfund site, listed on the National Priority List.

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

During fiscal year 1990, the Idaho National Engineering Laboratory directly employed approximately 11,100 personnel, accounting for almost 12 percent of the total regional employment. Approximately 38,000 persons, or 17 percent of the total regional population, were directly supported by employment associated with the operation of the Idaho National Engineering Laboratory. In 1992, the total direct Idaho National Engineering Laboratory



*Miles from Central Facilities Area

Legend:

ARA	Auxiliary Reactor Area
ANL-W	Argonne National Laboratory-West
CFA	Central Facilities Area
EBR-1	Experimental Breeder Reactor - I
ICPP	Idaho Chemical Processing Plant
NRF	Naval Reactors Facility
PBF	Power Burst Facility
RWMC	Radioactive Waste Management Complex
TAN	Test Area North
TRA	Test Reactor Area

Miles 0 2 4 6 8
Kilometers 0 4 8 12

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

employment was approximately 11,600 jobs. The total number of jobs at the Idaho National Engineering Laboratory are projected to decrease to approximately 10,100 in fiscal year 1995.

More than 1,500 prehistoric and historic archaeological resources have been identified in the Idaho National Engineering Laboratory area, but only 4 percent of the site has been surveyed, mostly near major facility areas. The resources identified include prehistoric and historic sites and isolates. Although not formally evaluated, these sites are considered potentially eligible for nomination to the *National Register of Historic Places*; the isolates have been categorized as unlikely to meet eligibility requirements. The Experimental Breeder Reactor No. 1 is listed on the *National Register of Historic Places*, and other structures could potentially be listed. The Shoshone-Bannock Tribes are the region's primary Native American residents. Because they believe the land is sacred, the entire Idaho National Engineering Laboratory reserve is potentially culturally important to them because the area contains prehistoric artifacts and natural features that have religious and cultural significance. DOE has committed to additional interaction and exchange of information with the Shoshone-Bannock Tribes at the Fort Hall Reservation.

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

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

The Eastern Snake River Plain is on an aseismic area that is adjacent to the seismically active Intermountain Seismic Belt and Centennial Tectonic Belt and lies in Uniform Building Code Seismic Risk Zones 2B and 3. The largest recorded earthquake in the Centennial Tectonic Belt occurred on October 28, 1983 (near Borah Peak, Idaho), and had a magnitude of 7.3 on the Richter scale. The epicenter was about 90 to 100 kilometers (56 to 68 miles) from the site. The largest recorded earthquake within the Intermountain Seismic Belt surface wave (Richter scale magnitude 7.5) occurred on August 17, 1959 (near Hebgan Lake, Montana), with an epicenter 145 kilometers (90 miles) northeast of the site. In addition to these earthquakes, a total of 29 earthquakes greater than magnitude 5.5 have occurred within 322 kilometers (200 miles) of the site since 1884. The Idaho National Engineering Laboratory lies in a potentially active but long-time dormant volcanic area. The conditional probability of basaltic volcanism affecting a south-central area of the site is 1 incident in 40,000 to 100,000 years. The probability of volcanic impact

on site facilities further north is estimated to be less than one incident in every million years or longer.

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

The general climate of the site is characterized by average seasonal temperatures that range from -7.3°C (18.8°F) in winter to 18.2°C (64.8°F) in summer, with an annual average temperature of about 5.6°C (42°F). Annual precipitation is light, averaging 221.2 millimeters (8.71 inches). Snowfall averages 701 millimeters (27.6 inches) per year.

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

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

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

The types and amounts of nonradiological emissions from Idaho National Engineering Laboratory facilities and activities are similar to those of other industrial complexes of similar size. Baseline concentrations from criteria and hazardous/toxic air pollutants are within applicable standards and guidelines. Radioactive emissions occur from site facilities; the calculated annual dose to the maximally exposed offsite individual is 0.056 millirem.

Essentially no surface water bodies drain the Idaho National Engineering Laboratory—all creeks and streams arise in the mountains and much of their water is diverted for irrigation.

There is little flow of water onsite. Water that does reach the site through the Big Lost River flows past the Test Reactor Area/Idaho Chemical Processing Plant area before going below ground or may be diverted by an onsite dam during heavy flows onto the southern part of the site. The remainder of the water infiltrates near Test Area North. All rivers and streams are intermittent. No surface water runs off of the site.

Depths to the water table at the site range from 61 meters (200 feet) in the north to 274 meters (900 feet) in the south. Flows in the largely unconfined Snake River Plain Aquifer are generally to the southwest. Groundwater flows at speeds ranging from 1.5 to 6.1 meters per day (5 to 25 feet per day). Water consumption data are available. The water quality of the aquifer is generally good, and it is designated a sole source aquifer. Iodine-129 exceeded the U.S. Environmental Protection Agency drinking water maximum contaminant level during 1981 but has remained below the currently proposed maximum contaminant level since 1986. Cobalt-60 exceeded the proposed maximum contaminant level in the Test Area North disposal well in 1987. Tritium, strontium-90, and cesium-137 exceeded proposed maximum contaminant levels in localized areas in 1988. Plutonium-238, plutonium-239, plutonium-240, and americium-241 have not been detected above proposed maximum contaminant levels. Extremely low concentrations of iodine-129 and tritium have migrated offsite, but both concentrations are well below the proposed maximum contaminant levels.

Of the nonradioactive metals, only total chromium has exceeded maximum contaminant levels established by the Safe Drinking Water Act. Other inorganic metals and salts have remained within the requirements of the Safe Drinking Water Act. Carbon tetrachloride, chloroform, 1,1-dichloroethylene, cis-1,2-dichloroethylene, trans-1, 2-dichloroethylene, tetrachloroethylene, trichlorethylene, and vinyl chloride have exceeded maximum contaminant levels at various times over the last 5 years. Of these organics, carbon tetrachloride and trichlorethylene have the highest average concentrations with values more than two orders of magnitude above maximum contaminant levels.

Total consumption of water at the Idaho National Engineering Laboratory averages 0.25 cubic meters per second (8.8 cubic feet per second). DOE holds a Federal Reserved Water Right for the Idaho National Engineering Laboratory, which permits a groundwater pumping capacity of 2.3 cubic meters per second (80 cubic feet per second), though this capacity is not utilized. The site's priority on water rights dates back to the establishment of the Idaho National Engineering Laboratory. The area inundated by a probable maximum flood in the vicinity of Mackay Dam, 75 kilometers (45 miles) northeast of the Idaho National Engineering Laboratory, coupled with a dam failure, probably exceeds the areas expected to be inundated by 100- and 500-year floods of the Big Lost River at the Idaho National Engineering Laboratory. Analyses indicate that the shallow depths and low flow velocities resulting from the Mackay probable maximum flood and dam failure would not have a significant impact on Idaho National Engineering Laboratory facilities.

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

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

No Federal- or State-listed plant species occur at the site, but 10 plant species identified by the U.S. Bureau of Land Management, the U.S. Forest Service, or the Idaho Native Plant Society as sensitive, rare, or unique are known to occur there. These species are not generally located near any facilities and are uncommon on the Idaho National Engineering Laboratory because they require unique microhabitats.

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

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

Delta Airlines provides Idaho Falls with jet aircraft passenger and cargo service. Horizon and Skywest provide commuter service to both the Idaho Falls and Pocatello airports; Federal Express provides cargo service.

Recorded doses from 1987 to 1991 were used as a baseline for comparison with SNF management operations for the next 40 years. The average annual occupational dose to individuals with measurable doses was 0.156 rem, giving an average collective dose of 298 person-rem.

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

The water supply for the Idaho National Engineering Laboratory site is provided by a system of about 30 wells, with pumps and storage tanks. The average combined pumpage from the Idaho National Engineering Laboratory site wells from 1987 through 1991 was 7.36 billion liters per year (1.94 billion gallons per year), calculated based on the cumulative volumes of water withdrawn from the wells.

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

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

No high-level liquid waste resulting from reprocessing activities has been generated at the Idaho National Engineering Laboratory since 1992; however, certain other processes generate waste classified and handled as high-level waste. These sources generated 1,200 cubic meters in 1993. From 1989 through 1992, an average of approximately 48.5 cubic meters of mixed low-level waste was generated annually. From 1989 through 1992, an average of approximately 46.5 cubic meters of low-level waste was generated annually.

Since 1988, minor amounts of onsite-generated transuranic waste have been handled at the Idaho National Engineering Laboratory for interim storage. About 102,000 cubic meters are stored or buried at the Idaho National Engineering Laboratory. The average annual volume of hazardous waste shipped offsite from 1988 through 1991 was approximately 180 cubic meters. The average annual volume of industrial and commercial solid waste disposed of at the Central

Facilities Area landfill from 1988 through 1992 was approximately 52,000 cubic meters (68,000 cubic yards).

4.3 Savannah River Site

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

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

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

Approximately 735 square kilometers (181,500 acres) of the Savannah River Site is undeveloped, and 90 percent of this area (more than 650 square kilometers) is forest land. The Savannah River Forest Station (a branch of the U.S. Forest Service) manages the forested areas, many of which are pine plantations, under a cooperative agreement with DOE. Facilities that previously produced defense nuclear materials occupy approximately 5 percent of the total Savannah River Site land area. The remaining area consists of wetlands, ponds, and reservoirs.

Approximately 90 percent of the Savannah River Site work force lives in six counties around the site (Aiken, Allendale, Bamberg, and Barnwell Counties in South Carolina and Richmond and Columbia Counties in Georgia). In 1990, employment at the Savannah River Site was 20,230, representing approximately 10 percent of the employment in the six-county region of influence. Employment at the Savannah River Site grew to 23,351 in fiscal year 1992, with a payroll of more than $1.1 billion.

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

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

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

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

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

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

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

The partially mapped Pen Branch Fault, which spans the central portion of the Savannah River Site, is considered to be Cretaceous/Tertiary (140 million to 1.6 million years) reactivation of a northern boundary fault of the Triassic age Dunbarton basin. There is no evidence to indicate that the Pen Branch Fault is a capable fault as defined by the U.S. Nuclear Regulatory Commission. Surface mapping, subsurface boring, and geophysical investigations have not identified any faulting of the sedimentary strata at the Savannah River Site that would have an effect on facilities.

The closest offsite fault system of significance is the Augusta Fault Zone, approximately 40 kilometers (25 miles) from the Savannah River Site. In this fault zone, the Belair Fault has experienced the most recent movement, but it is not considered capable of generating major earthquakes. There is no conclusive evidence of recent displacement along any fault within

320 kilometers (200 miles) of the Savannah River Site, with the possible exception of the buried faults in the epicentral area of the 1886 Charleston, South Carolina, earthquake, approximately 145 kilometers (90 miles) away.

Two major earthquakes have occurred within 320 kilometers (200 miles) of the site: (1) the Charleston earthquake of 1886, which had an estimated Richter scale magnitude of 6.8, and (2) the Union County, South Carolina, earthquake of 1913, with an estimated Richter magnitude of 6.0, which occurred about 160 kilometers (100 miles) from the site. In June 1985, a minor earthquake with a local Richter scale magnitude of 2.6 and a focal depth of 1.0 kilometer (0.60 mile) occurred at the Savannah River Site. An earthquake with a local Richter scale magnitude of 2.0 occurred on the site on August 5, 1988, but was not felt by onsite workers.

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

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

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

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

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

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

Two distinct hydrogeologic systems underlie the Savannah River Site: (1) the southeastern Coastal Plain province, where a wedge of unconsolidated sediments of Late Cretaceous and Tertiary origin contains the major aquifer systems of the area, and (2) the Piedmont Province, where groundwater occurs in mudstones and sandstones within Paleozoic metamorphic and igneous basement rock. The vadose zone ranges in thickness from approximately 40 meters (130 feet) in the northernmost portion of the site to the surface in areas where the water table intersects wetlands or streams.

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

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

Industrial solvents, metals, tritium, or other constituents used or generated at the site have contaminated the groundwater over 5 to 10 percent of the Savannah River Site. Contaminated groundwater generally underlies only a few facilities, and the contaminants detected reflect the material and processes used in these facilities. Contamination of groundwater in an aquifer supplying drinking water has occurred in one localized area: a production well in the Midville/McQueen Branch Aquifer (formerly known as the Tuscaloosa Formation) contains low concentrations of trichloroethylene.

The aquifers underlying the Savannah River Site sustain single-well yields of about 10.2 million liters per day (2.7 million gallons per day). Current site usage from this source is about 11.9 billion liters per year (3.15 billion gallons per year) from about 100 production wells. The Savannah River Site draws approximately 75.7 billion liters per year (20 billion gallons per year) of cooling water from the Savannah River. Water rights are not at issue at the site.

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

Plant communities adapted to dry conditions occur on more northern, upland areas of the Savannah River Site (this area is sometimes referred to as the Aiken Plateau). The most common community types on the northern half of the Savannah River Site are longleaf pine

plantations and longleaf pine-turkey oak sandhills. Wetter areas along streams support different groups of plant species, including loblolly pine and bottomland hardwood forest communities. Other aquatic habitats, such as ponds, marshes, river swamps, and Carolina bays add considerable botanical diversity to the Savannah River Site.

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

In 1992, the Savannah River Site hunters (chosen by lottery from a large pool of applicants) harvested 1,519 deer and 186 feral hogs. The purpose of these hunts is to keep deer and feral hog populations in check and to reduce the number of animal-vehicle accidents on the site. The Savannah River Site measures each animal killed during the hunts for radioactivity. The maximum measurement of cesium-137 in a Savannah River Site deer was 22.4 picocuries per gram; the average was 6.4 picocuries per gram. For hogs, the maximum value was 22.9 picocuries per gram, and the average was 3.5 picocuries per gram. The estimated maximum dose received by a Savannah River Site hunter was 49 millirem per year. This estimate assumed a hunter whose entire meat consumption for the year consisted of the Savannah River Site deer.

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

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

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

Atmospheric releases of tritium accounted for more than 90 percent of the estimated offsite population dose.

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

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

Average annual wastewater discharge volume at the Savannah River Site is about 2 million liters per day (528,400 gallons per day), which is about 50 percent of capacity. The Savannah River Site Centralized Sanitary Wastewater Treatment Facility processes most of the domestic effluent onsite, along with five smaller onsite sanitary treatment plants.

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

4.4 Nevada Test Site

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

The Nevada Test Site is located in southwestern Nevada in southern Nye County. The Nevada Test Site is bordered on three sides by the Nellis Air Force Base Bombing and Gunnery Range (see Figure 4-4). The Nellis Range serves as a buffer zone between Nevada Test Site test areas and land open to the public. The Nellis Air Force Base Range (including the Tonopah

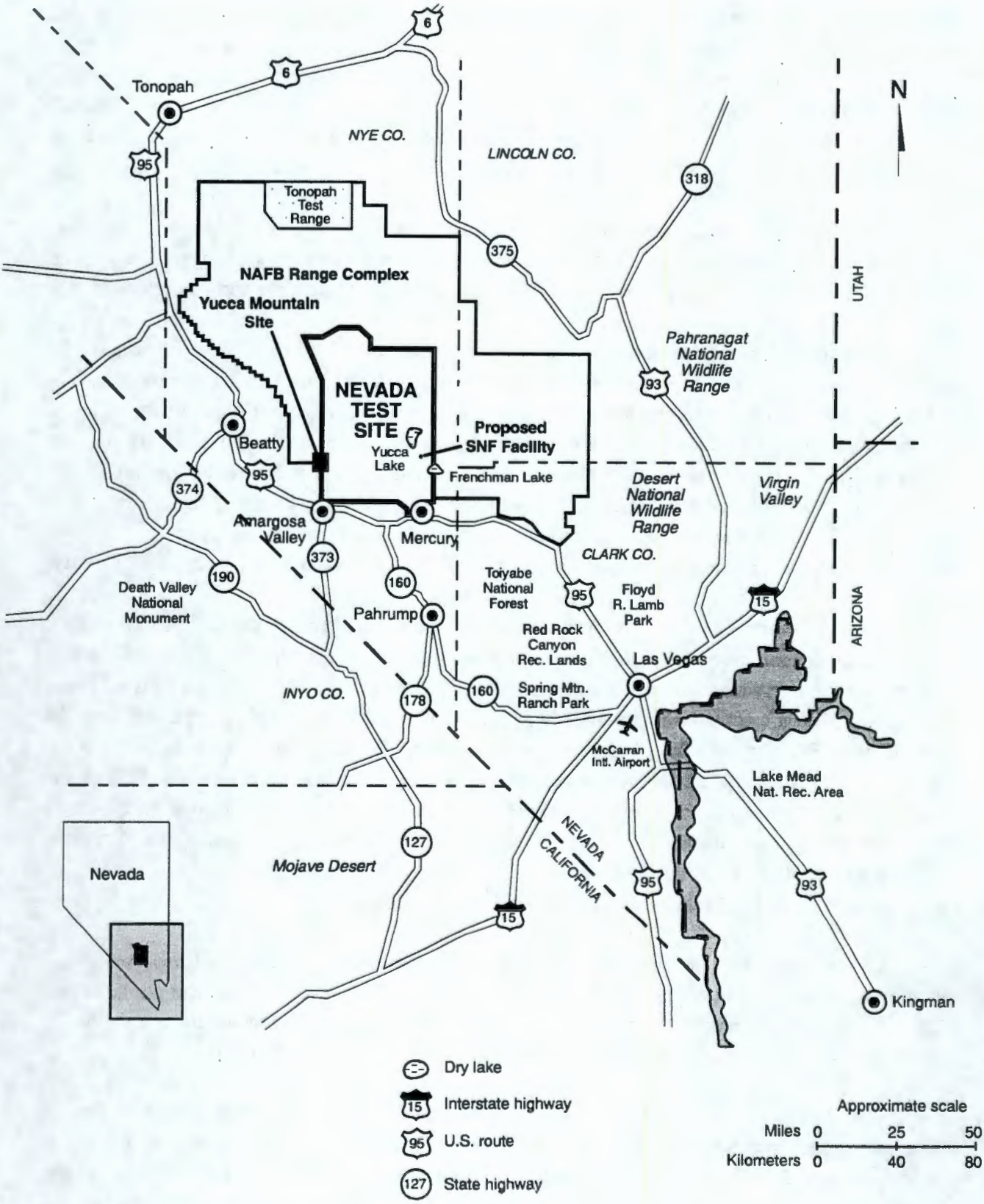


Figure 4-4. Nevada Test Site location and site map.

Test Range) and the Nevada Test Site comprise 14,166 square kilometers (5,470 square miles), making this one of the largest contiguous, unpopulated land areas in the United States. The Nevada Test Site has been used for underground weapons testing and as a nonnuclear test area. Congress has mandated that the Federal Government pursue the development of mined geologic repositories for the permanent disposal of SNF and high-level waste and has directed DOE to study the Yucca Mountain, Nevada, site to determine whether it is a suitable site.

The majority of the land within a 320-kilometer (200-mile) radius of the Nevada Test Site is managed by the U.S. Bureau of Land Management and used for livestock grazing. The area is surrounded by recreational areas used for activities such as hunting, fishing, and camping.

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

On the Nevada Test Site, 916 prehistoric sites and 34 prehistoric/historic sites have been recorded and recommended as eligible for the *National Register of Historic Places.* The Nevada State Historic Preservation Office has concurred that 82 prehistoric and 1 prehistoric/historic sites are eligible. Historic activities began in 1849 with the Emigrant Trail, mining camps, and later the settlements of Bullfrog-Goldfield, Las Vegas, and Tonopah. Southern Nevada, including parts of what is now the Nevada Test Site, was inhabited by peoples of the Southern Paiute and Shoshone Tribes. Areas in the northern portion of the Nevada Test Site, including the Pahute and Rainier Mesas, contain sites of cultural affiliation to these peoples. However, no known Native American resources are located within the areas proposed for SNF facilities. Some late Pleistocene terrestrial vertebrate fossils also occur in the area, notably at Tule Springs.

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

The Nevada Test Site is located in the southern part of the Great Basin section of the Basin and Range Physiographic Province. Local geology is characterized by mountains of Precambrian and Paleozoic sedimentary rocks and Tertiary volcanic tuffs and lavas separated by alluvial, topographically closed valleys. Sedimentary rocks are complex, folded, and faulted carbonates in the upper and lower parts and shale and sandstone in the middle section. Volcanic

rocks are predominantly Tertiary tuffs with some basalts and scattered granitic plutons. Potential geologic resources within the site boundaries include silver, gold, tungsten molybdenum, zeolites, barite, and fluorite.

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

The climate in the Nevada Test Site region is characterized by high solar radiation, limited precipitation, low humidity, and large diurnal temperature ranges. At Area 6, elevation 1,003 meters (3,290 feet), the mean daily minimum and maximum temperatures are -6.1 to 10.6°C (21 to 51°F) in January, and 14 to 36°C (57 to 96°F) in July. Average precipitation ranges from 15 to 23 centimeters (6 to 9 inches) at the site.

DOE maintains an extensive network of air sampling stations for radiological parameters such as particulates, reactive gases, tritium, and noble gases. Nonradiological air pollutants are within State and Federal standards. The majority of radioactive effluents at the Nevada Test Site have resulted from underground nuclear tests. Monitoring of airborne particulates, noble gases, and tritiated water vapor on the Nevada Test Site has indicated onsite concentrations that were generally not statistically different from background concentrations. External gamma exposure monitoring has indicated that the gamma environment has been consistent from year to year. No Nevada Test Site-related radioactivity has been detected offsite at any air sampling station.

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

The hydrogeology of the Nevada Test Site is characterized by great depths to the groundwater table of 200 to 500 meters (660 to 1,640 feet) and slow velocity in the saturated and unsaturated zones. Flow velocities in these systems range from 1.8 to 183 meters (6 to 600 feet) per year. Six major aquifers occur in the area, including some perched groundwater. Regional groundwater flow is from the north and northeast toward the regional discharge area near Ash Meadows in the Amargosa Desert.

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

The Nevada Test Site derives its complete water supply from the groundwater aquifers underlying the area. Water in southern Nevada (excluding the Las Vegas urban area) is used chiefly for irrigation and to a lesser extent for livestock watering and municipal supply.

The Nevada Test Site lies in a transition area between the Mojave and Great Basin Deserts, supporting flora and fauna from both areas. About 2 percent of the area has been disturbed. Natural vegetation occurs in nine plant communities dominated by creosote bush, blackbrush, hopsage-desert thorn, sagebrush, saltbush, pinyon pine, and juniper. Introduced weedy species such as cheatgrass and Russian thistle are common.

Approximately 273 vertebrate wildlife species have been observed onsite including 33 species of reptiles, 190 species of birds, and 50 species of mammals. Common species include reptiles, rodents, raptors, and wild horses. A number of game and fur-bearing species are found on the Nevada Test Site, but hunting and trapping are not permitted.

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

Twenty-five federally and State-listed threatened, endangered, and other special status species have been identified on and in the vicinity of the Nevada Test Site, including 9 birds, 2 reptiles, 1 fish, 2 mammals, and 11 plant species. Seventeen species have been observed directly on the Nevada Test Site. The remaining eight species are transient species that occur as they migrate through the area. As defined in the Endangered Species Act, no critical habitat for threatened or endangered species exists on the Nevada Test Site. Federally endangered species

include the American peregrine falcon, bald eagle, and Devil's Hole pupfish. The federally threatened species is the desert tortoise.

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

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

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

Background radiation exposure and releases of radionuclides to the environment from Nevada Test Site operations provide the sources of radiation exposure to people in the Nevada Test Site region. The estimated dose-equivalent during 1991 for the population within 80 kilometers (50 miles) of the Nevada Test Site was 1.6×10^{-5} millirem. The average dose was 1.66×10^{-5} millirem in 1991 for a person at the Nevada Test Site boundary. This dose is well below the National Emission Standards for Hazardous Air Pollutants standard of 10 millirem per year and is a very small percentage of the background dose.

From 1988 to 1992, water use at the Nevada Test Site varied from a high of 134 liters per second (2,125 gallons per minute) in 1989, to a low of 71 liters per second (1,132 gallons per minute) in 1992. Significant changes in consumption are not anticipated.

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

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

Total nonradioactive waste generated at the Nevada Test Site in 1992 included approximately 90,000 kilograms (100 tons) of Resource Conservation and Recovery Act hazardous waste, 218,000 kilograms (240 tons) of hazardous non-Resource Conservation and Recovery Act waste, and 2,472 kilograms (2.7 tons) Toxic Substances Control Act waste.

4.5 Oak Ridge Reservation

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

The Oak Ridge Reservation is comprised of forested lands, public lands, buffer zones, the Oak Ridge National Environmental Research Park, and three operations areas: Y-12 Plant, Oak Ridge National Laboratories, and the K-25 Site (formerly the Oak Ridge Gaseous Diffusion Plant) (see Figure 4-5). Except for the City of Oak Ridge, adjacent to the Oak Ridge Reservation, bordering land uses are predominantly rural, including residences, small farms, forest, and pasture.

Most of the industrial and commercial development, by energy-related companies in support of the Oak Ridge Reservation, has occurred in the City of Oak Ridge in Anderson County. Regional economic linkages at the Oak Ridge Reservation occur primarily with Anderson, Knox, and Roane Counties where most of the offsite contractors, labor, and capital are located. Employment at the Oak Ridge Reservation in 1990 was 17,082 people, and it is projected to decrease to approximately 16,980 by the year 1999.

There are 30 identified archaeological sites and 28 cemeteries on the Oak Ridge Reservation. The first Euroamericans settled in the area in the late 1700s. Nine structures have been evaluated that satisfy the criteria for inclusion in the *National Register of Historic Places.* Historic sites include the old graphic reactor, Freels Cabin, and two churches. Twenty prehistoric sites have been identified, mostly on the Clinch River, many of which show multiple occupations. Invertebrate fossils remains are also found in early Cambrian to early Mississippian aged formations underlying the Oak Ridge Reservation. In the early 1700s, the Overhill Cherokee lived in the area of the Oak Ridge Reservation. These Native Americans were forcibly moved to Oklahoma in 1836. While the Cherokee may retain cultural affiliation with their ancestral home, there are no known Native American resources on the proposed site for SNF facilities.

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

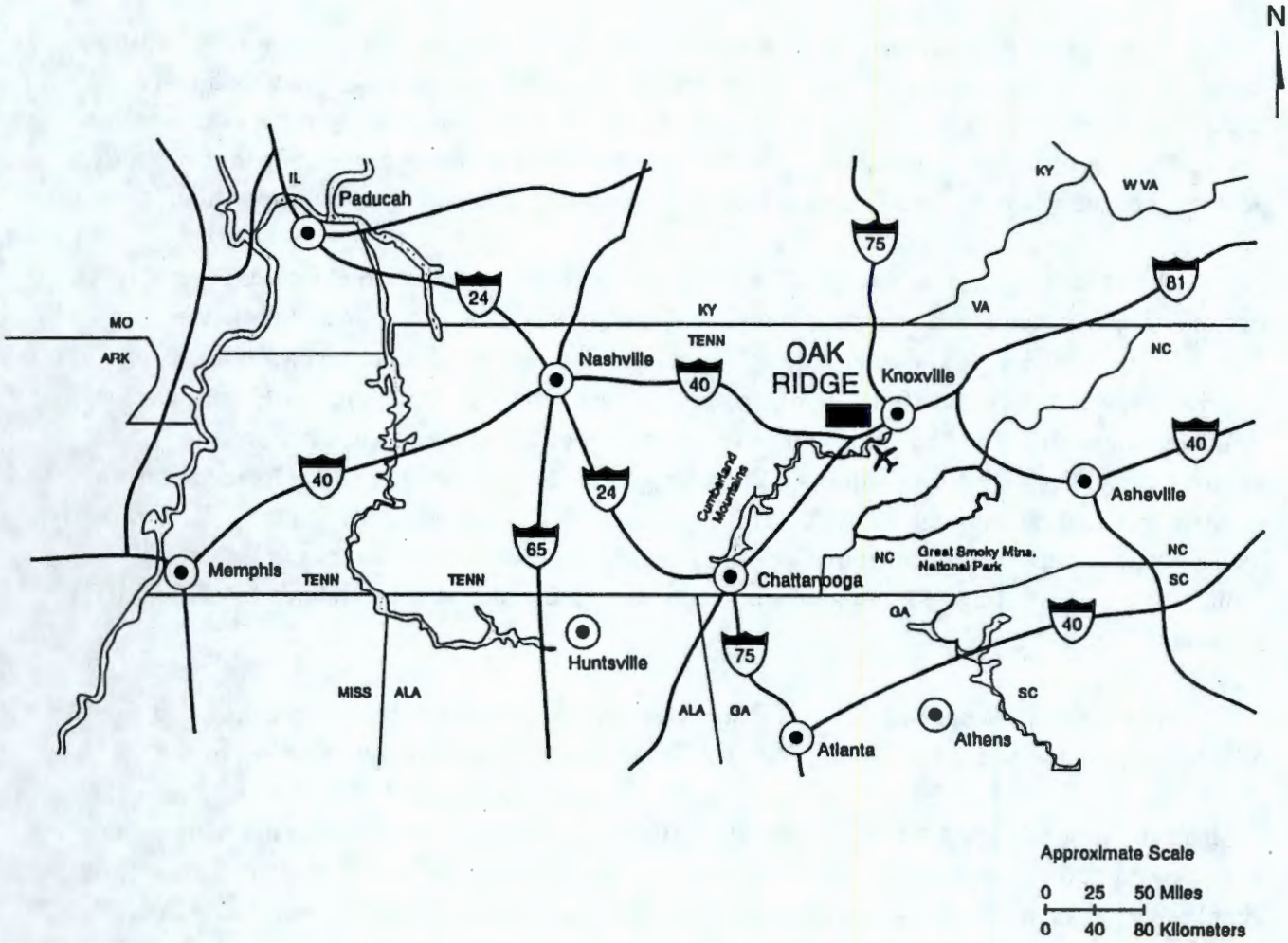


Figure 4-5. Oak Ridge Reservation location and site map.

The Oak Ridge Reservation lies entirely within the western portion of the Valley and Ridge Province, near the boundary with the Cumberland Plateau. This province is characterized by numerous linear ridges and valleys. There are three regional thrust faults in the area. From 1811 to 1975, five major earthquakes have affected the Oak Ridge Reservation area, but none has been at an intensity that caused severe damage. There is no evidence of any volcanic activity in the area for more than 1 million years.

The climate of the region is characterized by moderate to high precipitation in all seasons, high humidity, low winds, and low diurnal temperature ranges. At Oak Ridge, mean annual precipitation was 54 inches (137 centimeters) from 1961 to 1990. Mean daily temperatures range from 2.6°C (36°F) in January to 24.8°C (76.7°F) in July. Daytime winds are usually southwesterly, while night-time winds are northeasterly averaging 2 meters per second (4.4 miles per hour).

A network of air monitoring stations at the Oak Ridge Reservation measures several types of uranium particulates, heavy metals, and several materials released by a Toxic Substances Control Act incinerator. The total dose of 1.4 millirem per year to the maximally exposed individual is well within the 10 millirem per year National Emission Standards for Hazardous Air Pollutants standard. The estimated collective committed effective dose equivalent to the approximately 880,000 persons within 80 kilometers (50 miles) of the Oak Ridge Reservation was approximately 40 person-rem for 1991. This represents about 0.01 percent of the 260,000 person-rem that the surrounding population might receive from all sources of natural radiation. The Oak Ridge Reservation site meets the State and Federal standards for all criteria pollutants.

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

Geologic units of the Oak Ridge Reservation comprise two hydrologic groups: (1) the Knox Aquifer, formed by the Knox Group and Maynardsville Limestone and (2) the Oak Ridge Reservation aquitards, which includes other geologic units of the area including sandstones, siltstones, and shales. The Knox Aquifer has solution conduits that store and transmit relatively large volumes of water, while the aquitards are controlled by fractures and transmit limited amounts of water. The aquifer is the primary source of sustained stream flow on the Oak Ridge Reservation, and it shows no evidence of contaminant migration. However, some flowpaths of the Knox Aquifer lead to discharge points outside the Oak Ridge Reservation boundary. Because of the abundance of surface water in the area, groundwater wells are not common. Groundwater

quality is good above 300 meters (1,000 feet), but it has high total dissolved solids at depth. Groundwater in Bear Valley Creek near Y-12 contains hazardous chemicals and radionuclide contamination.

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

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

Wetlands have been identified on the Oak Ridge Reservation based primarily on the National Wetland Inventory maps. Lacustrine wetlands occur associated with reservoirs and forested riverine, and palustrine wetlands occur along the Poplar, White Oak, and Bear Creeks and the Clinch River. Commercial fishing occurs adjacent to the Oak Ridge Reservation for catfish and carp. Sport fishing for bass, catfish, and other warm-water fish is also popular.

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

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

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

The Oak Ridge Reservation released chemicals and small quantities of radionuclides to the environment from operations in 1992. The calculated total dose of 3.3 millirem per year from 1992 operations to the maximally exposed individual is well within the 10 millirem per year limit established by the National Emission Standards for Hazardous Air Pollutants. An extensive groundwater monitoring network on the Oak Ridge Reservation has revealed concentrations of radioactivity above U.S. Environmental Protection Agency drinking water standards (15 picocuries per liter for gross alpha activity and 50 picocuries per liter for gross beta activity). Surface waters, raw milk, fish tissue, and worker exposure are routinely monitored in the area.

Low-level, hazardous, mixed, and nonhazardous wastes are managed at the Y-12 Plant and the Oak Ridge National Laboratory. The plant does not generate or manage SNF, high-level waste, or transuranic waste. Waste management at the Y-12 Plant and the Oak Ridge National Laboratory includes onsite waste treatment, onsite waste disposal, offsite waste disposal, and onsite waste storage. Liquid and solid hazardous wastes are disposed of offsite. Some low-level radioactive wastes are disposed of onsite.

4.6 Naval Sites

This section presents summary environmental characterization information on the Naval sites that have been evaluated under various alternatives for management or examination of Naval SNF. This information has been used to evaluate impacts at the site under various alternatives for management of SNF. More detailed information characterizing these sites is presented in Appendix D, under separate cover.

The average annual radiation exposure for each Naval shipyard radiation worker is 0.26 rem (NNPP 1993). The average lifetime accumulated exposure for shipyard workers is 1.2 rem (NNPP 1993).

4.6.1 Puget Sound Naval Shipyard

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

Puget Sound Naval Shipyard is on 132 hectares (327 acres) of highly developed land. The waterfront dry dock area is the high-security portion of the shipyard where most production activities take place. This area includes production shops, administration, and some public works and supply functions. The upland area of the shipyard provides services to military personnel including housing, retail goods and services, recreation, counseling, dental care, and other support services. The industrial support area in the southwestern portion of the shipyard includes several

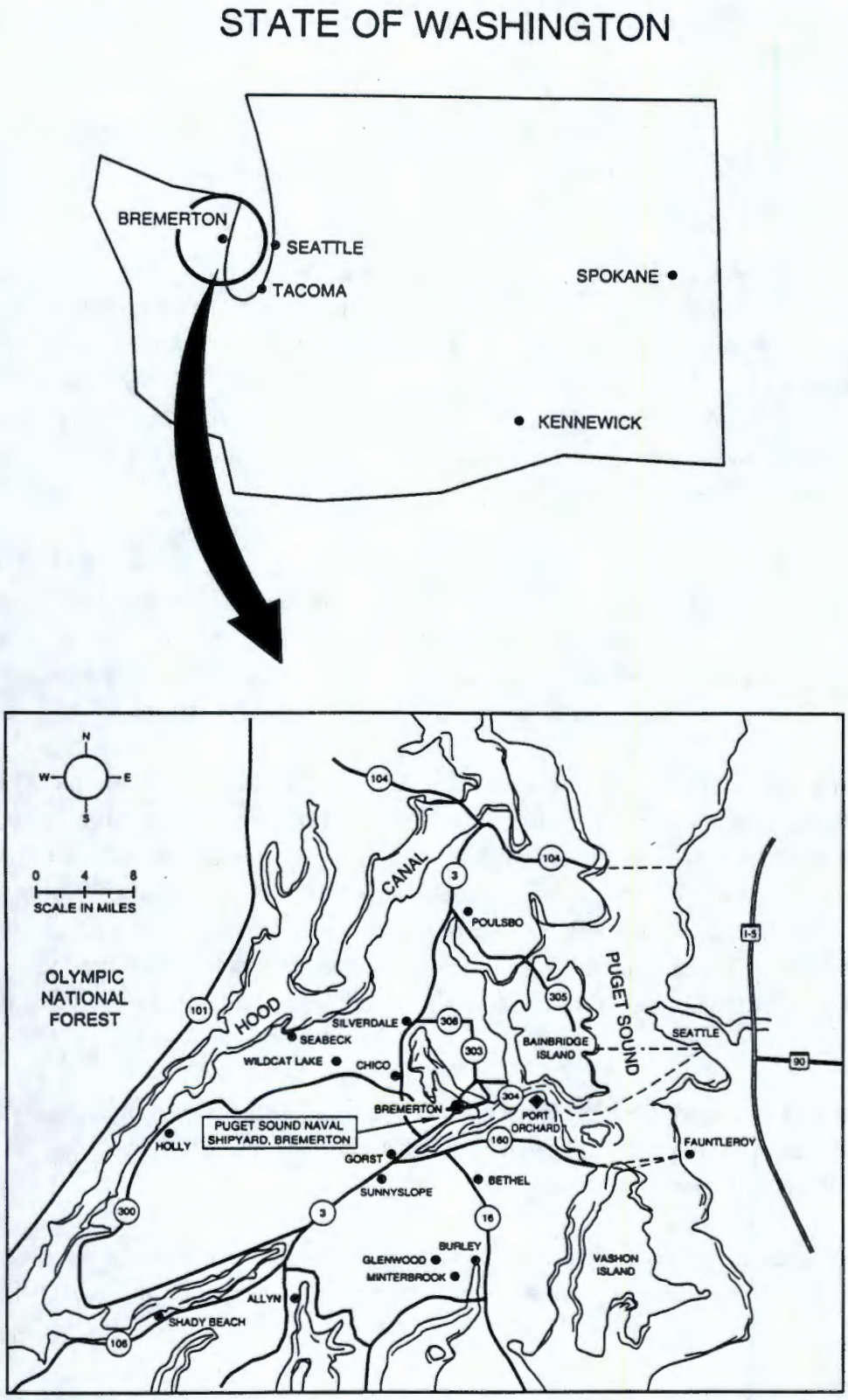


Figure 4-6. Puget Sound Naval Shipyard location and vicinity map.

piers for homeported ships and inactive fleet, the power plant, warehouses, a steel yard, public works shops, and parking.

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

There are no prehistoric archaeological sites identified at the shipyard. There are four National Registered Historical Districts and one National Historic Landmark within the boundaries of the shipyard. Until the mid 1880s, Kitsap County was inhabited by several Native American tribes of the Salish language group who lived on the shores of Puget Sound. For about 100 years, the principal settlement of the Suquamish Tribe lay along the west shore of Agate Passage. There are no Native American properties or ceremonial sites in the shipyard areas where SNF activities would be conducted.

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

The site lies within Uniform Building Code Seismic Risk Zone 3. There have been approximately 200 earthquakes in the area since 1840, most of which caused little or no damage. The most recent earthquakes of high magnitude were near Olympia [64 kilometers (40 miles) from Bremerton] in 1949 (7.1 on the Richter scale) and near Seattle in 1965 (6.5 on the Richter scale). The central Puget Sound area could experience an earthquake of intensity 7.5 on the Richter scale. There has been no known surface faulting in conjunction with earthquakes in the shipyard region. Potential hazards from volcanism are minimal and limited to windborne volcanic ash.

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

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

The Code of Federal Regulations (40 CFR Part 81) states that the Air Quality Control Region for this site is better than national standards for total suspended particulate matter and sulfur dioxide. The area has no specific classification for ozone, carbon monoxide, and nitrogen

dioxide. The nearest Class I Area is the Olympic National Park, approximately 24 kilometers (15 miles) from the site.

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

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

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

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

The annual airborne emissions from the site do not result in any measurable radiation exposure to the general public. Emissions of radionuclides from the site result in an effective dose equivalent of less than 0.0001 rem per year to any member of the general public. In addition, normal activities associated with current Naval nuclear operations at the site do not result in the intentional discharge of any radioactive liquid effluent. Environmental monitoring programs conducted by the site and independent U.S. Environmental Protection Agency monitoring of shipyard sites have shown that the operations at the site have had no adverse impacts on public health or safety.

4.6.2 Norfolk Naval Shipyard

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

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

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

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

The general climate of the area is mild and moist, with predominant winds from the south to southwest. In summer, afternoon thunderstorms are very common. Thunderstorms occasionally spawn isolated tornadoes throughout the region, but they move through the area rapidly along with storm centers. Hurricanes and tidal flooding are not uncommon; tornados are infrequent.

The Code of Federal Regulations (40 CFR Part 81) states that the Air Quality Control Region that includes this site is in marginal nonattainment for ozone and is better than national standards for total suspended particulate matter and sulfur dioxide. The area has no specific classification for carbon monoxide and nitrogen dioxide. The nearest Class I Area is the Swanquarter National Wilderness Area, which is approximately 160 kilometers (100 miles) from the site.

Norfolk Naval Shipyard is located on the Southern Branch of the Elizabeth River in a highly industrialized area of the city of Portsmouth, Virginia, 13 kilometers (8 miles) upstream from the confluence of the James and Elizabeth Rivers. The Southern Branch is a deep water

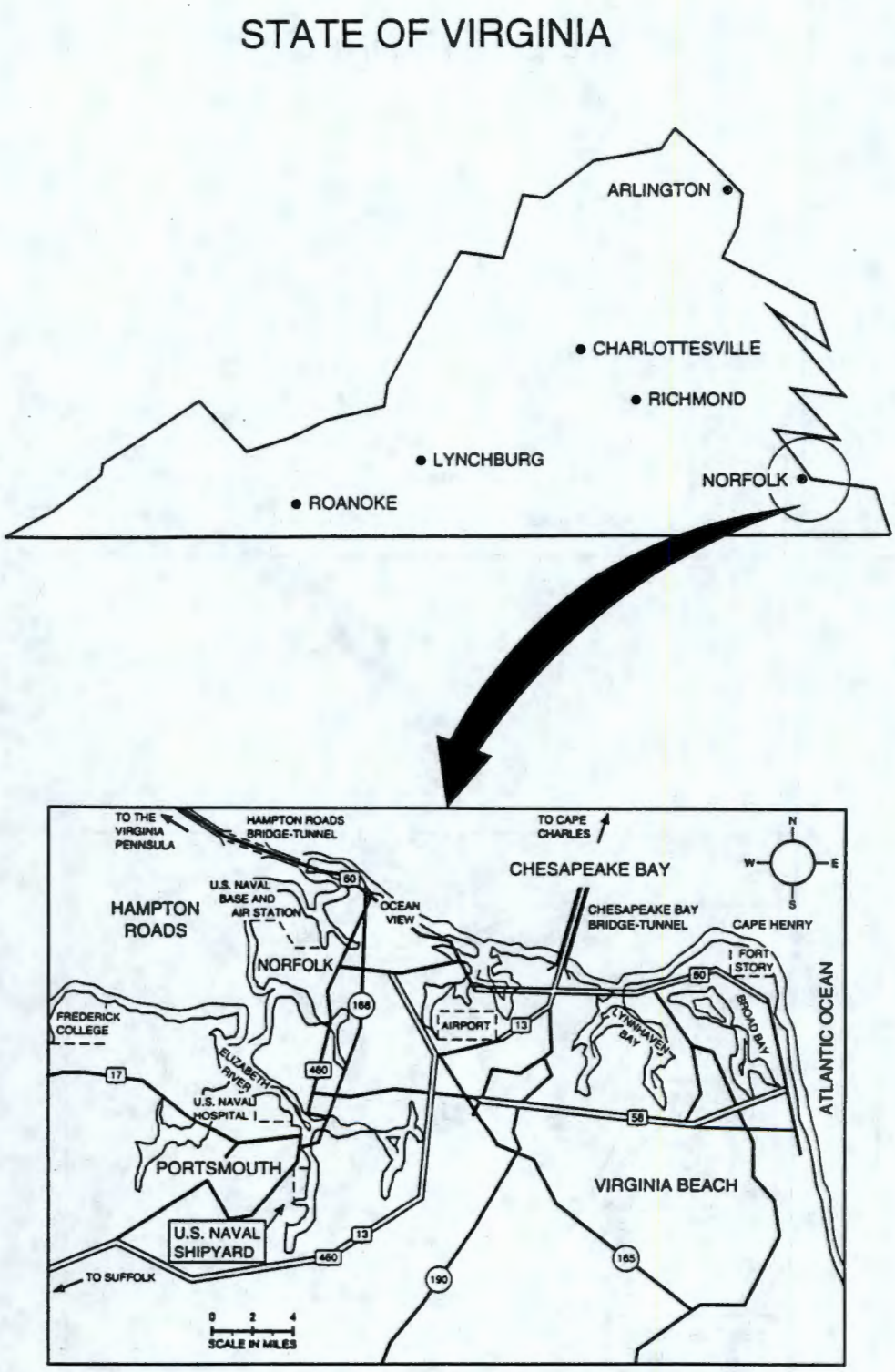


Figure 4-7. Norfolk Naval Shipyard location and vicinity map.

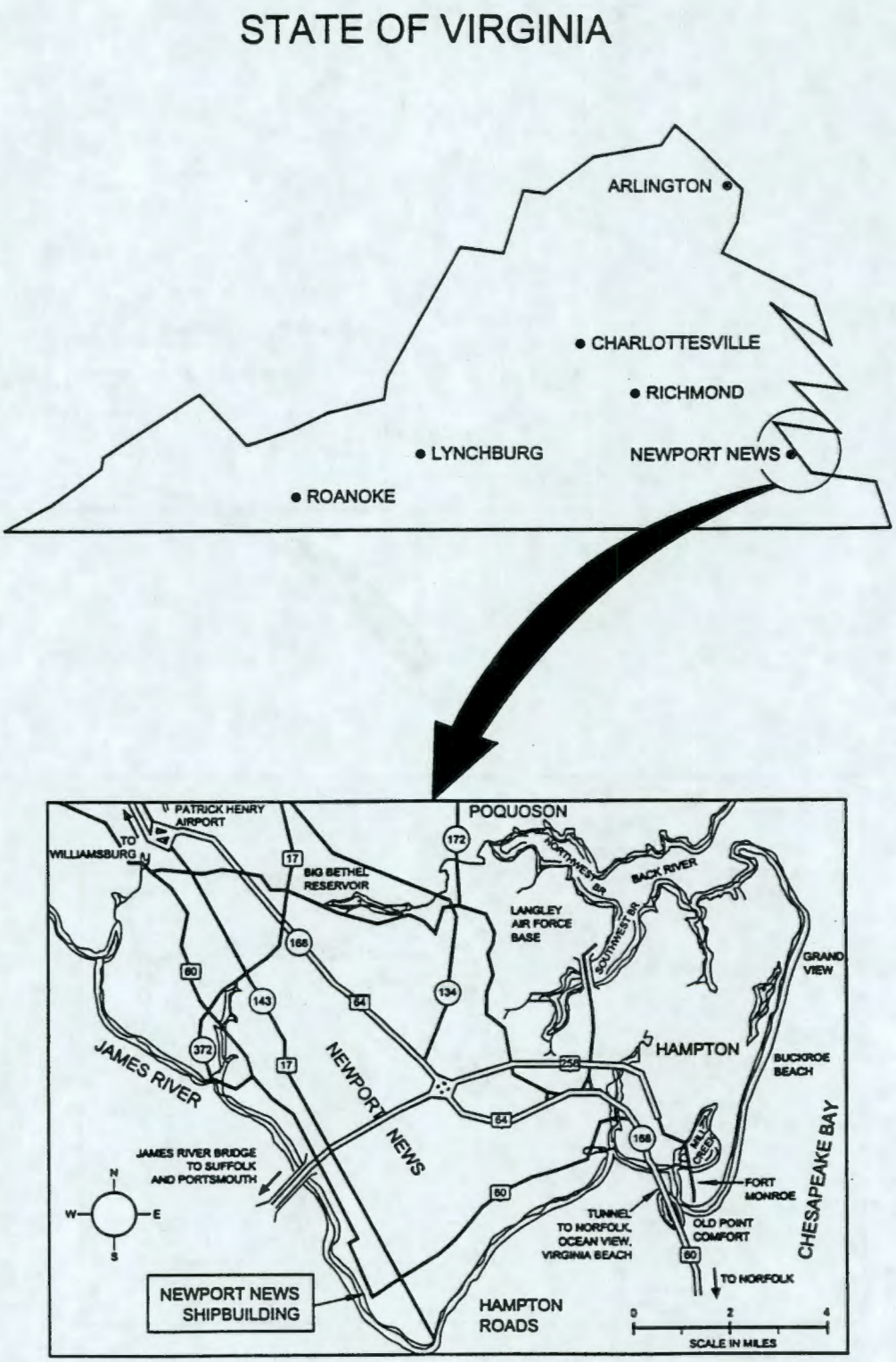


Figure 4-8. Newport News Shipyard location and vicinity map.

river that provides access to heavy industry in the vicinity of the shipyard. The Southern Branch is brackish and is not a source of drinking water.

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

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

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

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

The annual airborne emissions from the site do not result in any measurable radiation exposure to the general public. Emissions of radionuclides from the site result in an effective dose equivalent of less than 0.0001 rem per year to any member of the general public. In addition, normal activities associated with current Naval nuclear operations at the site do not result in the intentional discharge of any radioactive liquid effluent. Environmental monitoring programs conducted by the site and independent U.S. Environmental Protection Agency monitoring of shipyard sites have shown that the operations at the site have had no adverse impacts on public health or safety.

4.6.3 Portsmouth Naval Shipyard

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

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

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

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

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

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

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

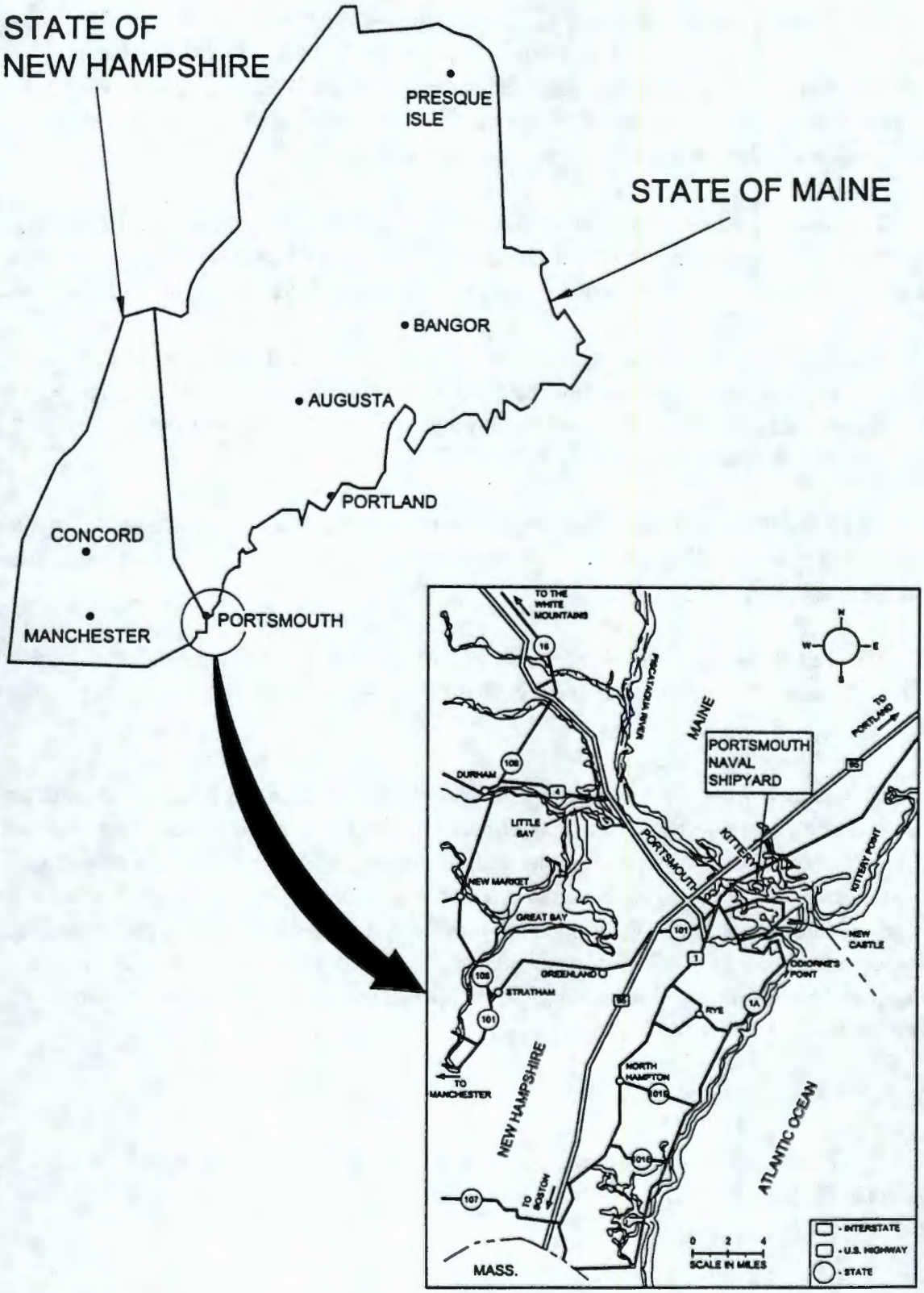


Figure 4-9. Portsmouth Naval Shipyard location and vicinity map.

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

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

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

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

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

The annual airborne emissions from the site do not result in any measurable radiation exposure to the general public. Emissions of radionuclides from the site result in an effective dose equivalent of less than 0.0001 rem per year to any member of the general public. In addition, normal activities associated with current Naval nuclear operations at the site do not result in the intentional discharge of any radioactive liquid effluent. Environmental monitoring programs conducted by the site and independent U.S. Environmental Protection Agency monitoring of shipyard sites have shown that the operations at the site have had no adverse impacts on public health or safety.

4.6.4 Pearl Harbor Naval Shipyard

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

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

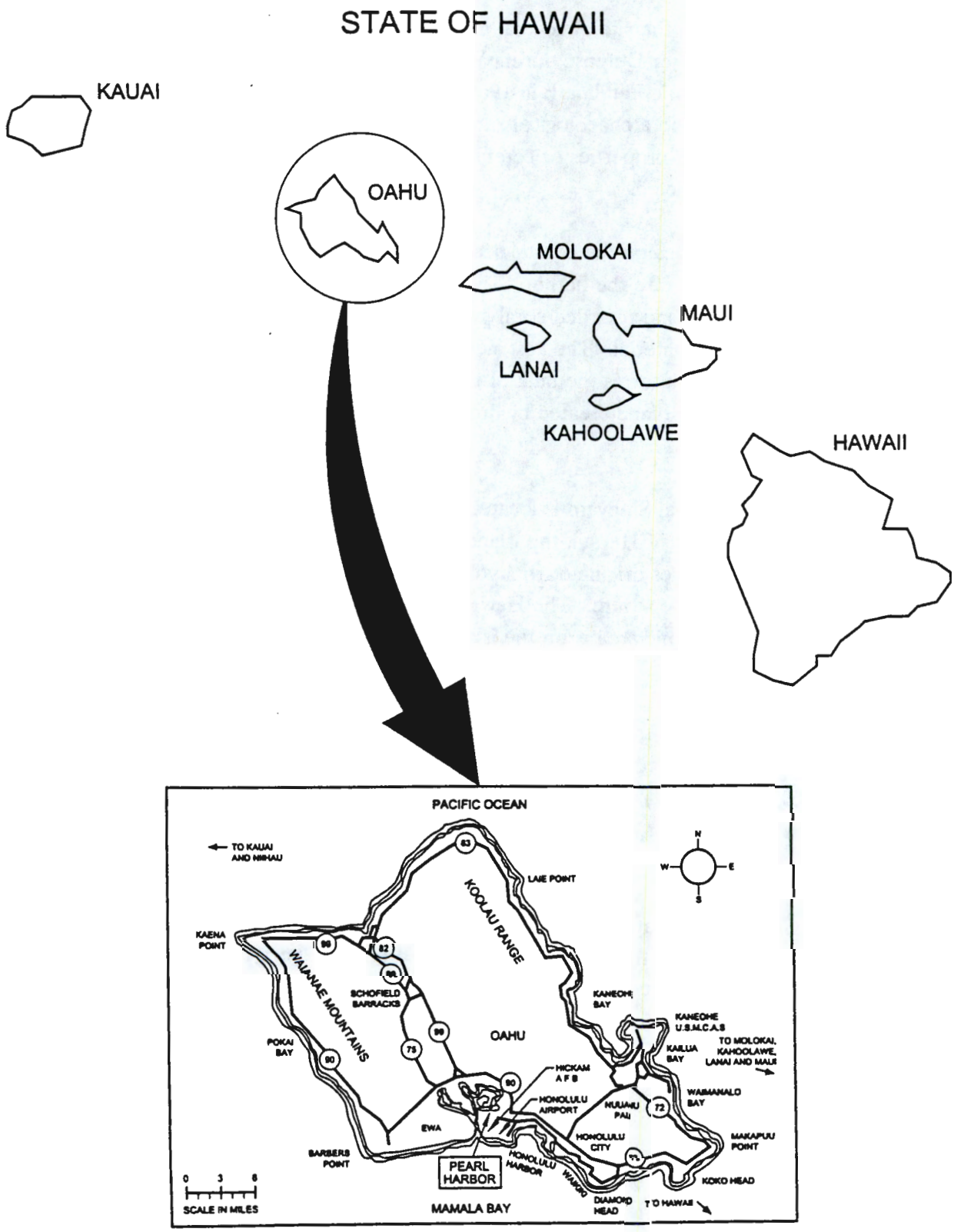


Figure 4-10. Pearl Harbor Naval Shipyard location and vicinity map.

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

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

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

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

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

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

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

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

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

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

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

The annual airborne emissions from the site do not result in any measurable radiation exposure to the general public. Emissions of radionuclides from the site result in an effective dose equivalent of less than 0.0001 rem per year to any member of the general public. In addition, normal activities associated with current Naval nuclear operations at the site do not result in the intentional discharge of any radioactive liquid effluent. Environmental monitoring programs conducted by the site and independent U.S. Environmental Protection Agency monitoring of shipyard sites have shown that the operations at the site have had no adverse impacts on public health or safety.

4.6.5 Kesselring Site

The Kenneth A. Kesselring Site is located about 24 kilometers (15 miles) north of the City of Schenectady, New York, and 13 kilometers (8 miles) west of Saratoga Springs (see Figure 4-11). It contains three operating Naval nuclear propulsion prototype plants and support

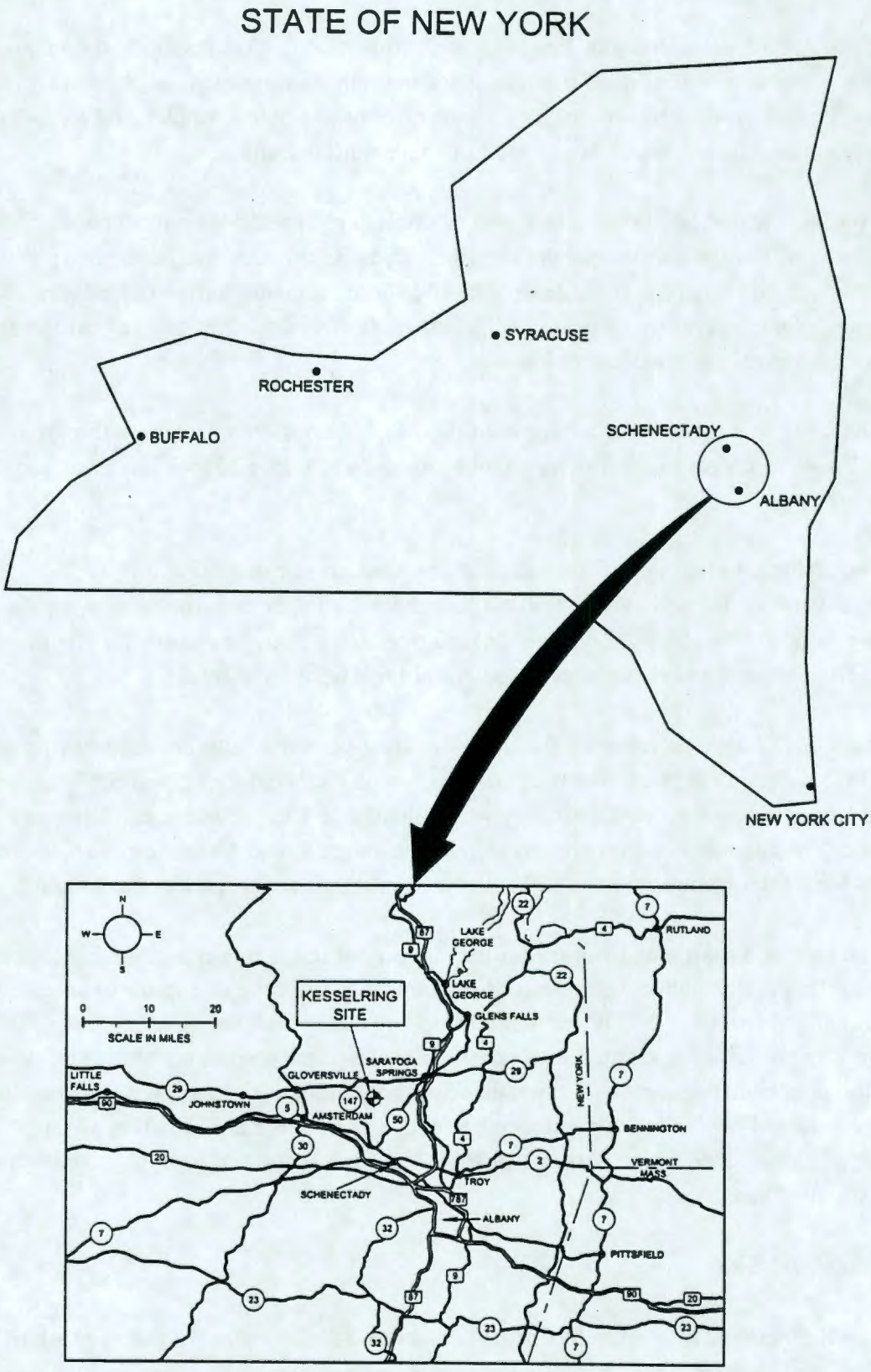


Figure 4-11. Kesselring Site location and vicinity map.

facilities. The site also includes one prototype plant that is being permanently shut down and one prototype that has been permanently shut down. All operating facilities are located in a secure area near the center of the 1,578-hectare (3,900-acre) reservation.

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

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

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

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

The general climate of the site is cold in winter and cool to warm in summer. Winds originate mostly from the west or northwest during the winter, but come from the south in the warmer months. Wind velocities are moderate and generally average less than 4.5 meters per second (10 miles per hour). Destructive winds [greater than 36 meters per second (80 miles per hour)] occur infrequently, and tornadoes are rare.

The Code of Federal Regulations (40 CFR Part 81) states that the Air Quality Control Region that includes this site is in marginal nonattainment for ozone and is better than national standards for total suspended particulate matter and sulfur dioxide. The area has no specific

classification for carbon monoxide and nitrogen dioxide. The nearest Class I Area is at Lye Brook Wilderness, Suarderland, Vermont, which is 74 kilometers (46 miles) from the site.

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

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

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

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

The annual airborne emissions from the site do not result in measurable radiation exposure to the general public. Emissions of radionuclides from the site result in an effective dose equivalent of less than 0.0001 rem per year to any member of the general public. In addition, normal activities associated with current Naval nuclear operations at the site do not result in the intentional discharge of any radioactive liquid effluent. Environmental monitoring programs conducted by the site and independent U.S. Environmental Protection Agency monitoring of the site have shown that the operations at the site have had no adverse impacts on public health or safety.

4.7 Other Generator/Storage Locations

In addition to the five major sites, DOE is responsible for the management of SNF generated at several other DOE sites and other locations. These sites include DOE reactors at

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

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

4.7.1 DOE Test and Experimental Reactors

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

4.7.1.1 Brookhaven National Laboratory. Brookhaven National Laboratory is located on a 2,131-hectare (5,265-acre) site on Long Island, New York, approximately 96 kilometers (60 miles) east of New York City, in an area of rapidly growing population. About 410,000 people reside in Brookhaven Township, which houses the Laboratory, and 8,000 people live within 0.8 kilometer (0.5 mile) of the Laboratory boundary.

Tornadoes and hailstorms are extremely rare on Long Island, but thunderstorms are not infrequent, particularly during the summer. The highest windspeeds at Brookhaven National Laboratory have occurred during hurricanes, for example, an estimated 125 miles per hour during Hurricane Carol in September 1954. Facilities have been designed to withstand 54 meters per second (120 miles per hour) winds.

The seismic risk is small, with no active faults in the Long Island area. The area lies in a Zone 1 (minor damage) seismic probability area, and the reactor buildings and associated SNF storage facilities have been built to withstand moderate seismic activity.

Groundwater flow under the Laboratory site is complex, moving in different directions in different sections of the site, but generally with a velocity estimated to range from 30 to 45 centimeters per day (12 to 18 inches per day), flowing either toward the Peconic River or in deeper layers recharging the Atlantic Ocean.

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

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

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

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

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

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

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

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

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

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

4.7.1.4 Argonne National Laboratory-East. Argonne National Laboratory-East occupies about a 690-hectare (1,700-acre) site located in DuPage County, about 36 kilometers (22.5 miles) southwest of downtown Chicago. The site is surrounded by a 826-hectare (2,040-acre) green belt forest preserve operated by DuPage County. The 1990 population of Chicago was about 2.78 million, and of DuPage County (one of the fastest growing counties in metropolitan Illinois), about 781,700.

The climate in the Argonne National Laboratory-East area is characterized as continental, with an average annual precipitation of 80 centimeters (31 inches), mostly in spring and summer associated with thunderstorm activity. The area experiences about 40 thunderstorms annually, occasionally accompanied by hail, damaging winds, or tornadoes. The theoretical probability of a tornado strike at Argonne National Laboratory-East is about one every 1,200 years, although the site was struck by tornadoes in 1976 and 1978, with minor damage.

The Argonne National Laboratory-East site is located above about a 30-meter (98-foot) thick glacial till deposit on top of dolomite bedrock. There is one significant local fault in the Argonne National Laboratory-East vicinity, the Sandwich Fault, about 31 kilometers (19 miles) from the site. The site is in Seismic Zone 1.

The Argonne National Laboratory-East site contains a number of small ponds and surface streams that enter the Des Plaines River about 2.1 kilometers (1.3 miles) southeast of the site center. Groundwater is extracted from the underlying dolomites in DuPage County.

4.7.2 Domestic Research and Test Reactors

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

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

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

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

used by commuters to and from the downtown Washington, D.C., area and suburban residential areas.

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

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

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

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

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

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

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

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

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

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

4.7.3 Spent Nuclear Fuel from Special Nuclear Power Plants

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

4.7.3.1 West Valley Demonstration Project. The West Valley Demonstration Project occupies an 81-hectare (200-acre) site formerly housing the first United States commercial nuclear fuel processing plant, within a larger 1,335-hectare (3,300-acre) site known as the Western New York Nuclear Service Center. The Center is located in Cattaraugus County, a rural area of western New York State, about 50 kilometers (31 miles) south of Buffalo, New York, and 40 kilometers (25 miles) east of Lake Erie. The 1990 population of Cattaraugus County was about 84,200.

The climate at the West Valley Demonstration Project site is characterized as influenced by cold and dry polar continental air in the winter and humid air in the summer. The mean annual precipitation (meltwater equivalent) of 110 centimeters per year (42 inches per year), which includes an average of 300 centimeters (120 inches) of snow per year. Average monthly windspeeds at the site range from 3.4 meters per second (7.6 miles per hour) in January to 1.7 meters per second (3.8 miles per hour) in July.

The West Valley Demonstration Project is situated on the western edge of an upland plateau at an elevation of approximately 430 meters (1,400 feet) within the Buttermilk Creek drainage basin. No significant seismic activity has been identified in the vicinity of the Center. The closest geologic structure associated with seismic activity is the Clarendon-Linden Fault zone, located approximately 30 kilometers (18 miles) east of the site. The site is located in Seismic Zone 1.

The Western New York Nuclear Service Center lies within the Cattaraugus Creek watershed, which empties into Lake Erie about 43 kilometers (27 miles) south of Buffalo. Buttermilk Creek, a tributary off Cattaraugus Creek, roughly bisects the Nuclear Service Center and drains the entire site's watershed area of about 13.7 square kilometers (5.3 square miles). The steep gradients of the streams that drain the site provide rapid discharge of runoff.

4.7.3.2 Fort St. Vrain. The Fort St. Vrain site is located in Weld County in northeastern Colorado, approximately 5.6 kilometers (3.5 miles) northwest of the town of Platteville, 0.8 kilometer (0.5 mile) west of the South Platte River, and 56 kilometers (35 miles) north of Denver. The Fort St. Vrain site consists of 906 hectares (2,238 acres) with an exclusion area for the Fort St. Vrain power plant of 2.59 square kilometers (1 square mile). Based on the 1980 census, the population within a 8-kilometer (5-mile) radius of the site was estimated to be 3,148, with 1,662 residing in the town of Platteville (USBC 1982). Most of the land in the immediate area of the site is disturbed, agricultural land.

The general climate around the Fort St. Vrain site is generally mild. In this semi-arid region, the precipitation averages 25 to 38 centimeters (10 to 15 inches) a year, mostly from thunderstorms in late spring and summer. Northeastern Colorado has moderate thunderstorm activity. The region typically experiences 5 tornadoes per year per 259 square kilometers (10,000 square miles), with peak tornado activity occurring during the month of June. A study of tornadoes in the area concluded that 161 kilometer per hour (100 mile per hour) winds should constitute maximum wind forces to be expected at Fort St. Vrain.

The Fort St. Vrain site is located on the east flank of the Colorado Front Range, a complexly faulted anticlinal arch. Numerous faults and smaller folds are superimposed on the arch and are related to the uplift of the Front Range. The Fort St. Vrain site has not experienced any observed earthquake activity. A field examination of the area produced no

evidence of recent movement along any of the known faults. The closest area of recent activity is about 40 kilometers (25 miles) south of the site. The site is located in Seismic Zone 1.

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

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

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

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

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

5. ENVIRONMENTAL CONSEQUENCES

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

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

This chapter is organized into seven sections. The disciplines (topical areas) studied that result in potential impacts, are of general public interest, or may help to discriminate among sites are described for alternatives discussed further in Section 5.1. In general, the consequences presented in Section 5.1 relate to socioeconomic impacts, electricity use, waste generation, and radiological and transportation impacts. The disciplines that were studied that showed negligible impacts or clearly did not discriminate among sites or alternatives are discussed in Section 5.2. Sections 5.3 through 5.7 address cumulative impacts, unavoidable adverse environmental effects, the relationship between short-term use and long-term productivity, irreversible and irretrievable commitments of resources, and mitigation measures, respectively.

The level of site-specific detail presented in Sections 5.1 and 5.2 is commensurate with the size of the SNF inventory and the number and types of sites where SNF would be stored. Therefore, the analyses of the major DOE and Naval sites are more detailed than the analyses for the other generator/storage locations that would have limited inventories under the No Action and Decentralization alternatives. There are five major DOE sites that are or may be responsible for managing the great majority of SNF: the Hanford Site, the Idaho National Engineering Laboratory, the Savannah River Site, the Oak Ridge Reservation, and the Nevada Test Site. The DOE does not consider the Nevada Test Site to be a preferred site for the management of SNF because of the State of Nevada's current role as the host site for the Yucca Mountain Site Characterization Project and the Nevada Test Sites's lack of current SNF handling experience. Minor sites are the university and government reactor sites and the three facilities that store small

quantities of SNF for which DOE has responsibility: West Valley Demonstration Project, Babcock and Wilcox, and Fort St. Vrain.

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

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

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

5.1 Environmental Consequences of Key Discriminator Disciplines

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

5.1.1 Background

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

5.1.1.1 Socioeconomics. Socioeconomic impacts are defined in terms of direct and secondary effects. Direct effects include changes in site employment and expenditures resulting from SNF-related construction and operation. Secondary effects include changes that result from regional purchases, nonpayroll expenditures, and payroll spending by site employees. For the

major DOE sites, existing projections (regardless of SNF management decisions) indicate that jobs will be lost during the next few years for all sites except the Nevada Test Site. Potential SNF management impacts onsite and regional employment were considered in light of this decreasing trend.

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

With employment as an indicator, small changes in population are anticipated, creating minimal changes in demand on regional supporting infrastructures. The number of direct jobs that would be created under each alternative as a result of SNF management activities was estimated for each site. The employment graphs shown on Figures 5-1 through 5-9 represent the 10-year average of the incremental change in direct employment resulting from SNF management. Secondary effects such as the need for additional housing and improved community services are discussed if an impact is indicated. Details on the socioeconomic impact analysis as well as the baseline projections from which comparisons were made are provided in Appendices A through F.

5.1.1.2 Utilities (Electricity). New facilities (or the restarting of idle facilities) would result in increased demands on water, power, and sewage. Water and sewage requirements are considered minimal and are discussed in Section 5.2.9. However, power consumption under some of the alternatives would exceed existing capacity at certain sites and is discussed in more detail in this section. Electricity requirements by site and by alternative vary significantly depending on whether a site is processing or storing SNF. For example, at the Hanford Site, the annual power use from SNF management activities could vary from 0 megawatt-hours per year (No Action alternative) when storing only to a maximum of about 130,000 megawatt-hours per year (Centralization alternative) when processing (Appendix K). In addition, the operation of an expended core facility consumes approximately 10,000 megawatt-hours per year of electricity. Therefore, the power requirements would be highest under alternatives where both processing and operating an expended core facility occur simultaneously. The graphs of electricity use in

Figures 5-1 through 5-9 show the maximum and minimum incremental change in power consumption that would result from implementation of the alternative. Current capacities and baseline usage of utilities and energy from which comparisons are made are discussed in Appendices A through F.

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

5.1.1.4 Occupational and Public Health and Safety.

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

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

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 processes decrease the dose rate with the passage of time. The dose from internal exposure is calculated over 50 years following the initial exposure.

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

Radiation can also cause a variety of ill-health effects in people. The most significant ill-health effect to depict the consequences of environmental and occupational radiation exposures is induction of latent cancer fatalities. This effect is referred to as latent cancer fatalities because the cancer may take many years to develop and for death to occur, and may never actually be the cause of death.

The collective (or population) dose to an exposed population is calculated by summing the estimated doses received by each member of the exposed population. This total dose received by the exposed population is measured in person-rem. For example, if 1,000 people each received a dose of 1 millirem (0.001 rem), the collective dose is 1,000 persons × 0.001 rem = 1.0 person-rem. Alternatively, the same collective dose (1.0 person-rem) results from 500 people each of whom received a dose of 2 millirem (500 persons × 2 millirem = 1 person-rem).

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

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

Sometimes, calculations of the number of latent cancer fatalities associated with radiation exposure do not yield whole numbers, and, especially in environmental applications, may yield

numbers less than 1.0. For example, if a population of 100,000 were exposed as above, but to a total dose of only 0.001 rem, the collective dose would be 100 person-rem, and the corresponding estimated number of latent cancer fatalities would be 0.05 (100,000 persons × 0.001 rem × 0.0005 latent cancer fatalities/person-rem = 0.05 latent fatal cancers).

How should one interpret a nonintegral number of latent cancer fatalities, such as 0.05? The answer is to interpret the result as a statistical estimate. That is, 0.05 is the *average* number of deaths that would result if the same exposure situation were applied to many different groups of 100,000 people. In most groups, nobody (0 people) would incur a latent cancer fatality from the 0.001 rem dose each member would have received. In a small fraction of the groups, 1 latent fatal cancer would result; in exceptionally few groups, 2 or more latent fatal cancers would occur. The *average* number of deaths over all the groups would be 0.05 latent fatal cancers (just as the average of 0, 0, 0, and 1 is ¼, or 0.25). The most likely outcome is 0 latent cancer fatalities.

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

1 person × 0.3 rem/year × 72 years × 0.0005 latent cancer fatalities/person-rem
= 0.011 latent cancer fatalities.

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

The factors presented above and used in this EIS to relate radiation exposures to latent cancer fatalities are based on the *1990 Recommendations of the International Commission on Radiation Protection* (ICRP 1991). These factors are consistent with those used by the U.S. Nuclear Regulatory Commission in its rulemaking *Standards for Protection Against Radiation* (56 Federal Register 23363, May 21, 1991). The factors apply where the dose to an individual is less than 20 rem and the dose rate is less than 10 rem per hour. At doses greater than 20 rem, the factors used to relate radiation doses to latent cancer fatalities are doubled. At much higher doses, prompt effects, rather than latent cancer fatalities, may be the primary concern. Unusual accident situations that may result in high radiation doses to individuals are considered special cases.

In addition to latent cancer fatalities, other health effects could result from environmental and occupational exposures to radiation. These effects include nonfatal cancers among the

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

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

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

b. Source: ICRP (1991).

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

exposed population and genetic effects in subsequent generations. Table 5-1 shows the dose-to-effect factors for these potential effects as well as for latent cancer fatalities. For simplicity, this EIS presents estimated effects of radiation only in terms of latent cancer fatalities. The nonfatal cancers and genetic effects are less probable consequences of radiation exposure, and in some respects less serious. Estimates of the total detriment due to radiation exposure may be obtained from the estimates of latent cancer fatalities presented in this EIS by multiplying the latent cancer fatalities by 1.4 (0.00056 ÷ 0.0004) for workers and by 1.46 (0.00073 ÷ 0.0005) for the general public.

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

During SNF interim storage, trace quantities of radioactive isotopes (principally gases and particulate fission products) may also be released to the environment from severely corroded SNF. These releases would result in small doses to the workers in the immediate vicinity of the

SNF and, through atmospheric dispersion, would ultimately result in very small doses to members of the nearby general population.

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

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

Risk—Another concept important to the presentation of results in this EIS is the concept of risk. Risk is most important when presenting accident analysis results. The chance that an accident might occur during the conduct of an operation is called the probability of occurrence. An event that is certain to occur has a probability of 1.0 (as in 100 percent certainty). The probability of occurrence of an accident is less than one because accidents, by definition, are not certain to occur. If an accident is expected to happen once every 5 years, the frequency (and probability) of occurrence is 0.2 per year (1 occurrence ÷ 5 years = 0.2 occurrences per year).

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

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

A frame of reference for the risks from accidents associated with SNF management alternatives can be developed in the same way. For an average resident in the vicinity of the Idaho National Engineering Laboratory, the risk of a latent cancer fatality caused by the water draining from the expended core facility after a large earthquake would be approximately 1 chance in 9 billion (see Chapter 5 of Appendix D). This risk can be compared to the risks of death from other accidental causes to gain a perspective. For example, the risk of dying from a motor vehicle accident is about 1 chance in 80. Similarly, the risk of death for the average American from fires is approximately 1 chance in 500, and for death from accidental poisoning, the risk is about 1 chance in 1,000 (NNPP 1993).

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

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

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

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

Accident consequences were analyzed utilizing radioactive and toxic material release estimates for each accident. The downwind concentrations of materials released in accidents were then calculated for a range of potential receptor locations and potential doses to individuals or

people at those locations evaluated. Doses were evaluated for (a) an individual 100 meters (328 feet) downwind of the facility location where the release occurs, (b) a hypothetical resident at the site boundary nearest to the facility where the release occurs (called the maximally exposed offsite individual), and (c) the general population within 80 kilometers (50 miles) of the release location. The potential impacts to workers in the immediate vicinity of the accident were analyzed qualitatively.

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

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

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

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

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

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

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

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

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

5.1.2 No Action Alternative

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

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

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

Since there would be minimal actions taken to stabilize fuel under the No Action alternative, the frequency of an SNF-related radiation accident could increase as the stored fuels deteriorated. The lack of structural integrity of the fuel in some cases could result in an increase in handling-related accidents. In addition, releases from stored fuels could increase, increasing population doses, as the number of cladding failures increased. Releases associated with accidents and cladding failures are intrinsically difficult to predict, and thus have not been incorporated in the quantitative analysis of radiation doses.

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

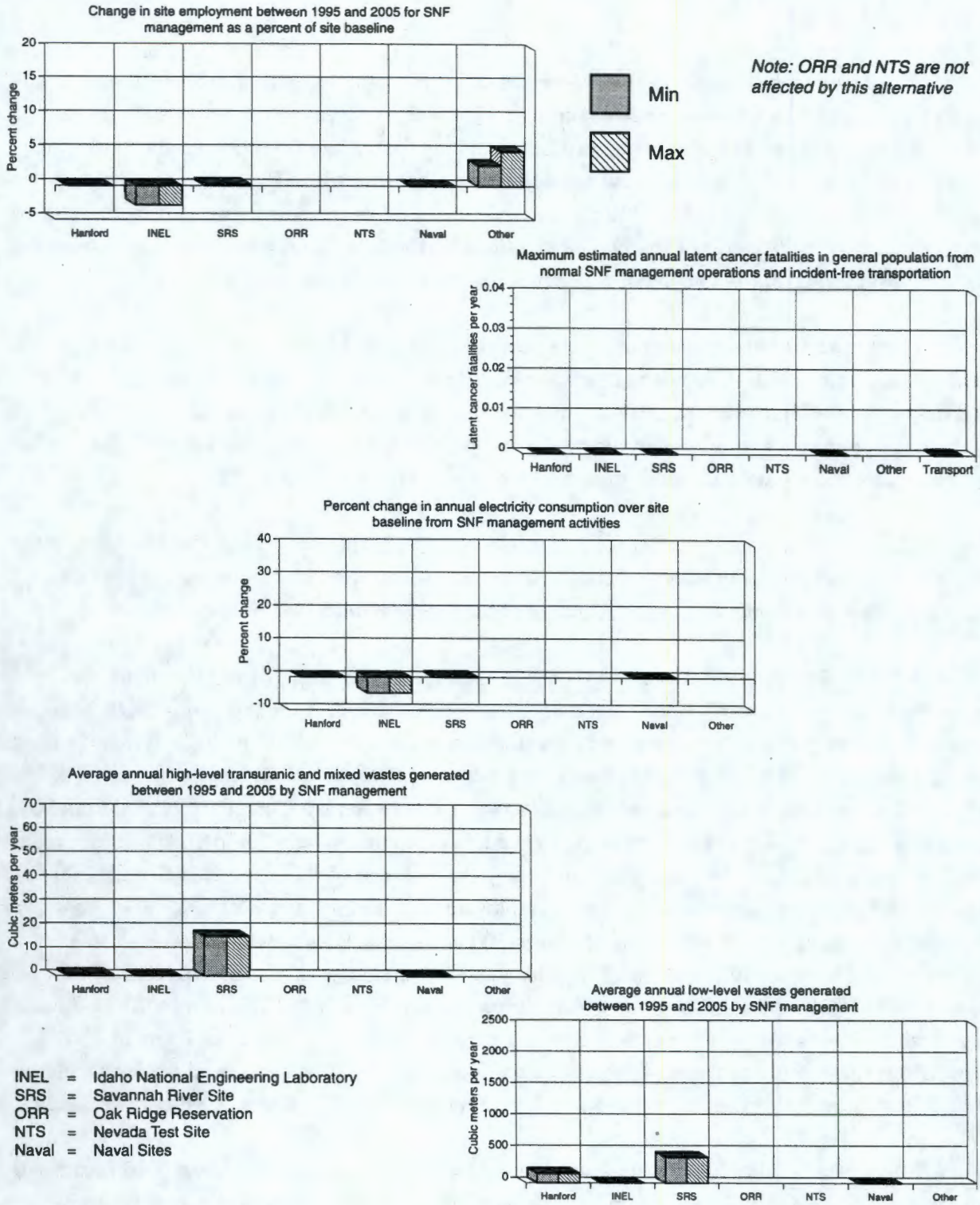


Figure 5-1. Summary of impacts for the No Action alternative. The maximum incremental change from baseline is illustrated in graphs. Input data summarized in Appendix K.

of accidents could be greater because of the proximity of a larger population at many of the potential storage sites.

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

Under the No Action alternative, no new research would be initiated on appropriate technologies for converting fuels to an acceptable form for ultimate disposition and no new facilities would be built over the next 40 years for that purpose. This makes the No Action alternative appear to be more environmentally acceptable than the other alternatives when in fact this research is simply delayed until after the time period covered by this EIS.

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

5.1.2.1 Socioeconomics. As shown in Figure 5-1, the graph of the maximum incremental change in employment from SNF management activities for the major DOE sites except the Idaho National Engineering Laboratory, indicates there would be little socioeconomic impact associated with the No Action alternative between 1995 and 2005. Implementation of the No Action alternative would result in the shutdown of the Expended Core Facility at the Idaho National Engineering Laboratory, resulting in the loss of approximately 500 permanent jobs from a region with a relatively low population and few jobs. Closure of the Expended Core Facility would initially result in an increase in direct employment at the facility by 50 jobs over 3 years to handle the shipment of containers, but then the 500-person work force would decrease to a caretaker work force of 10 (Appendix D). This would be a change of about 5 percent of the Idaho National Engineering Laboratory work force. At the Hanford and Savannah River Sites, there would either be no change or less than a 1 percent increase in direct employment, respectively, from implementation of the No Action alternative. The peak employment would be 50 additional workers at the Savannah River Site, approximately 0.2 percent of the 1995 baseline.

Naval sites would require very few additional workers to secure the Naval SNF in storage and monitor its condition. The incremental labor required for SNF management at the Naval sites would be drawn from the existing work force and would be insignificant with respect to current employment levels at those sites. At the university and other Government reactors, there would be a need for security and maintenance personnel for reactors that would shut down. While this would not be an increase in employment at those sites because the staff required to

run the reactors would no longer be required, it would be an increase in the staff that would be involved directly in SNF management. Across all sites, there would be a decrease in employment of less than 0.1 percent of the total sites' work force. Therefore, implementation of the No Action alternative would have no socioeconomic effect on a nationwide scale.

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

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

At the Naval sites, implementation of the No Action alternative would result in the production of limited amounts of solid municipal wastes and low-level radioactive waste. Wastes produced from the storage of Naval SNF would be controlled and managed in accordance with existing site management programs.

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

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

alternative. The estimated population doses to the general population are illustrated in Figure 5-1.

Radiological Impacts From Accidents—

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

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

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

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

Workers (perhaps 6 to 12) in the immediate vicinity of the cask drop accident could receive higher than routine doses although they would likely be within DOE's 5 rem per year guidelines. For that accident, workers could be near the cask when it drops and receive direct radiation and inhale airborne fission products.

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

The secondary impacts associated with the K Basin cask drop would be somewhat lower but similar in nature.

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

The highest risk to the general population is associated with the melting of a small number of assemblies as a result of a major earthquake and hot cell breach at the Hot Fuel Examination Facility. The estimated probability of this accident is about 1 chance in 100,000 per year of operation. General population consequences are estimated to be approximately 7 latent cancer fatalities, with a probability of a latent cancer fatality in the maximally exposed offsite individual of 2.5×10^{-3}.

The highest risk to workers is an inadvertent nuclear criticality in the Idaho Chemical Processing Plant CPP-603 Underwater Fuel Storage Facility, which has an estimated probability of 1 chance in 10,000 per year of operation.

The estimated risk in the general population, taking into account the probability of occurrence of this accident, is 7.0×10^{-5} latent cancer fatalities per year. The estimated probability of a latent cancer fatality in a worker approximately 100 meters (about 330 feet) downwind of the accident would be 3.9×10^{-5}. The estimated risk for a worker is 4.0×10^{-8} latent cancer fatalities per year.

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

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

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

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

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

A worker downwind of the accident is estimated to receive a dose which corresponds to an estimated probability of 4.8×10^{-6} latent cancer fatalities. The estimated risk for a worker is 7.7×10^{-7} latent cancer fatalities per year.

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

Potential secondary impacts identified for the SNF-related accidents (Table 5-25 of Appendix C) are land contamination around the site of the accident, with minor contamination

outside of the immediate facility area. This would not likely require cleanup of more than 4 hectares (10 acres).

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

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

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

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

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

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

Other Generator/Storage Locations. Accident analyses were evaluated for these facilities. These accidents included (a) handling accidents that result in fuel drops with potential for fuel cladding breaches that could release portions of the more volatile fission products, such as noble gases and iodine, (b) accidental nuclear criticalities, (c) building collapse due to natural phenomena or external events such as major earthquakes or aircraft crashes, and (d) release of contaminated storage pool water. The analysis of these accidents indicated that they were similar in kind and consequence to those described for the major DOE sites and are therefore not presented for each of the 57 other generator/storage locations. For the No Action alternative, no accidents related to SNF management were identified for the Nevada Test Site because no SNF is currently managed at the site. Two accidents were evaluated for No Action at the Oak Ridge Reservation. The first involves a dropped drum during refueling at the High Flux Isotope Reactor fuel pool. This accident results in an estimated 9.2×10^{-6} latent cancer fatalities to the worker and 1.7 latent cancer fatalities to the general population with a risk to the worker of 9.2×10^{-10} and to the general population of 1.7×10^{-4}. A beyond design basis accident at the High Flux Isotope Reactor results from a roof collapse triggered by a tornado. This accident could cause 3.1×10^{-4} latent cancer fatalities at a risk of 3.1×10^{-8}.

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

The maximum reasonably foreseeable chemical accident at SNF management facilities at the Hanford Site could result in the release of polychlorinated biphenyls and sulfuric acid at the 105-KE and 105-KW Basins. Should these releases occur, workers and the general public travelling adjacent to the accident could be subjected to chemical concentrations that might cause fatalities or serious health effects (Emergency Response Planning Guideline-3). The general public at the reservation boundary would be subjected to approximately 20 percent or less of the guideline value.

A maximum reasonably foreseeable chemical accident at the Idaho Chemical Processing Plant would be expected to release chlorine and nitric acid. Should such an event occur, workers would be subjected to chemical concentrations that might cause fatalities or serious health effects. The general public at the site boundary would be subjected to approximately 7 percent or less of the guideline value. The expected concentration on public access adjacent to the spill would be approximately 30 percent of the guideline value. Since these accidents would occur in each of

the alternatives evaluated and do not discriminate among alternatives, they are not discussed further.

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

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

5.1.2.6 Transportation.

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

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

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

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

Onsite transportation of SNF would occur under the No Action alternative at the Hanford Site, the Idaho National Engineering Laboratory, and the Savannah River Site. The maximum reasonably foreseeable accident for this alternative occurs at the Idaho National Engineering Laboratory, with a latent cancer fatality risk of about 7.5×10^{-7} for a rural population zone and about 1.1×10^{-5} for a suburban population zone. In the extremely unlikely event that this accident occurred under stable (worst-case) weather conditions, it could result in six latent cancer fatalities in a rural population, such as around the Idaho National Engineering Laboratory, within 80 kilometers (50 miles) of the accident, or 85 latent cancer fatalities in a suburban population zone. For comparison, the rural population zone would be expected to experience 350 cancer fatalities and the suburban population zone would experience 42,000 cancer fatalities from other causes.

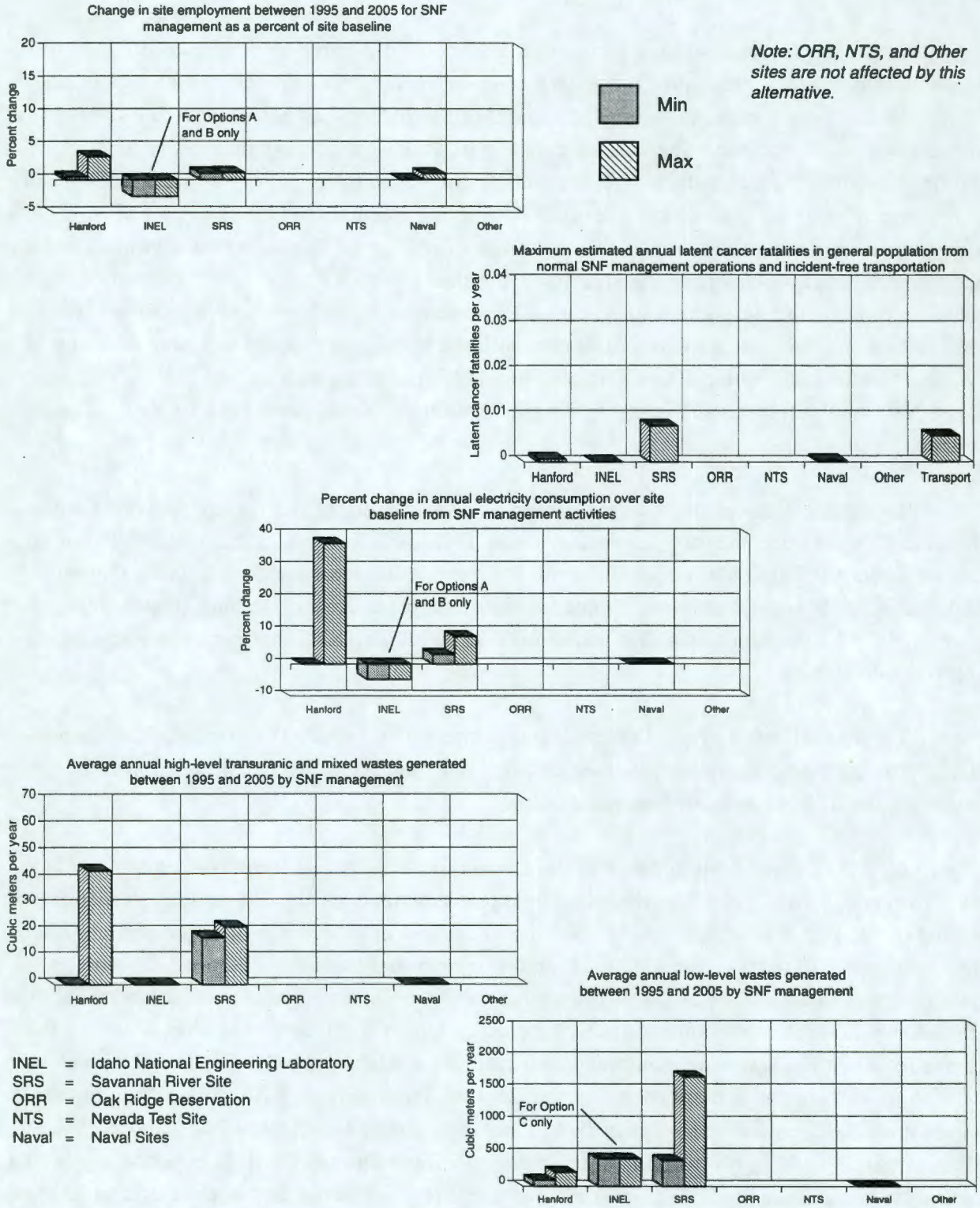
5.1.3 Decentralization Alternative

Under the Decentralization alternative, SNF currently stored or generated at DOE sites would remain at those sites, and SNF generated by university, other Government reactors, and foreign research reactors would be shipped to either the Idaho National Engineering Laboratory or the Savannah River Site. Special-case commercial SNF would be shipped to the Idaho National Engineering Laboratory. Storage facilities would be upgraded or replaced at DOE sites to improve the safe and secure storage of SNF. Existing research and development of technologies improving the safe and secure storage of SNF at DOE sites would continue, and new projects would commence. The Navy would either store SNF at or near the point of refueling or defueling (Option A), ship about 10 percent of its SNF to the Puget Sound Naval Shipyard for limited examinations and storage with the remainder stored at or near the point of fueling or defueling (Option B), or ship all Naval SNF to the Expended Core Facility at the Idaho National Engineering Laboratory for examination and then ship it back to Naval sites for storage (Option C).

The implications of this alternative would be the closure of the Expended Core Facility at the Idaho National Engineering Laboratory under Options A and B and the modification of an existing facility at Puget Sound Naval Shipyard to provide limited examination under Option B. Major DOE sites might build new storage facilities to replace existing facilities or to accept newly generated SNF from other sites. Degraded fuels at the major DOE sites might be stabilized to improve safe storage.

The sites affected by the Decentralization alternative include the Hanford Site, Idaho National Engineering Laboratory, Savannah River Site, and Naval sites. The environmental consequences at these sites are described below.

5.1.3.1 Socioeconomics. For the Decentralization A and B options, one socioeconomic consequence would be similar to that described for the No Action alternative—the closing of the Expended Core Facility resulting in the loss of an average of approximately 240 direct jobs over 10 years at the Idaho National Engineering Laboratory (Figure 5-2), with an ultimate loss of about 500 jobs. This represents a decrease in employment at the Idaho National Engineering Laboratory of approximately 5 percent. Under the Decentralization C option, the Expended Core Facility would continue to operate at the Idaho National Engineering Laboratory with no socioeconomic consequence. At the Hanford and Savannah River Sites, this alternative would result in significant new construction, employing an additional 80 to 740 workers at the Hanford Site and 50 to 600 workers at the Savannah River Site over a 10-year period depending on the options chosen for SNF management at those sites. The higher value reflects an increase above baseline site employment of approximately 4 percent at the Hanford Site and approximately 3 percent at the Savannah River Site. The peak in employment would be an additional 1,100 workers at the Hanford Site, approximately 6 percent of the 1995 baseline.



INEL = Idaho National Engineering Laboratory
SRS = Savannah River Site
ORR = Oak Ridge Reservation
NTS = Nevada Test Site
Naval = Naval Sites

Figure 5-2. Summary of impacts for the Decentralization alternative. The maximum incremental change from baseline is illustrated in all graphs. Input data summarized in Appendix K.

Increases in construction activity over the short-term at the Hanford Site could strain the housing market and put additional demands on school capacity. Operations after the construction period would have very small consequences through the overall project time frame. No secondary effects on the local community are expected at the Savannah River Site.

At the Naval sites, the Decentralization alternative would require construction workers and laborers to construct fuel storage areas and to staff these areas, but it is anticipated that these workers would come from the sites or the local area, and there would not be a significant socioeconomic impact on the surrounding communities. Nevertheless, staff required would be a 1.3 percent increase over existing Naval site staffing.

5.1.3.2 Utilities (Electricity). Figure 5-2 illustrates the minimum and maximum incremental change in power use with respect to existing site usage from implementing the Decentralization alternative. As previously discussed in Section 5.1.1.2, the variation in power use by site shown on this graph reflects whether processing occurs or not. As an example, if the Hanford site were to choose a storage option over a processing option, the power required for the storage option would be less than 1 percent of the overall site use; however, if a processing option were selected then power use could increase to 34 percent above existing site use (see Appendix K). At each of the sites, the increase in electricity consumption could be accommodated with the existing site electric power infrastructure. At Hanford, if a processing option were selected, an extension of existing utilities in the 200 Area to the project area would be necessary. The maximum potential electricity usage shown at the Savannah River Site is associated with the processing option that requires operation of the F- and H-Canyons. These have operated for many years, and onsite and offsite utilities are adequate for their operation. At the Idaho National Engineering Laboratory, the principal differences among options are due to the operation or shutdown of the Expended Core Facility as was discussed in Section 5.1.2.2.

5.1.3.3 Materials and Waste Management. The minimum and maximum volumes of high-level, transuranic, mixed and low-level wastes that would be generated by SNF management activities over the next 10 years relative to the baseline are shown in Figure 5-2. It is estimated that the combined volume of high-level, transuranic, and mixed waste generated annually, if processing options were implemented, would range from approximately 22 to 110 cubic meters per year at the Savannah River Site and Hanford, respectively. In contrast, if wet storage options for N Reactor fuel were selected at Hanford then no high-level, transuranic, or mixed waste would be expected to be generated. Figure 5-2 also illustrates the volume of low-level waste that would be generated from implementation of the Decentralization options. It should be noted that the volume of low-level waste increases if a processing option is selected at either the Hanford Site or the Savannah River Site. Additional volumes of low-level waste would be generated at the Savannah River Site from the limited receipt of SNF shipments from offsite and by the addition of a new canning facility. Low-level waste would only be generated at the Idaho National Engineering Laboratory under the Decentralization alternative, where the Expended

Core Facility would continue to operate. Operation of an Expended Core Facility results in the annual production of approximately 430 cubic meters (526 cubic yards) of low-level waste (Appendix D).

At the Naval sites, implementation of the Decentralization alternative would have the same impact as that described in Section 5.1.2.3 for the No Action alternative because interim storage would be at the Naval sites under both alternatives.

5.1.3.4 Radiological Impacts. Radiological exposures to both workers and the public from normal operations for the Decentralization alternative are estimated to be small, similar to the No Action alternative, with the principal differences associated with possible implementation of the processing options at the Hanford and Savannah River Sites because of higher radionuclide releases to the atmosphere. This increases the offsite population doses and potential for latent cancer fatalities. Figure 5-2 illustrates the estimated latent cancer fatalities associated with SNF operations at the major sites. The estimated latent cancer fatalities from 40 years of SNF operation is less than one for each site.

Hanford Site—The Decentralization alternative considers several options for construction of new facilities at Hanford, including a new wet storage facility for N Reactor SNF and a new dry storage facility for fuels currently stored at other onsite locations. A second option for implementation of the Decentralization alternative at Hanford is processing of the N Reactor SNF followed by dry storage.

Under this alternative, one of the highest risk SNF-related accidents identified for the No Action alternative remains—the spent fuel cask drop at a wet storage facility. Because of the locations of the new storage facility, both the consequences and risks associated with this accident are reduced to 25 percent of those described under the No Action alternative. The other highest risk accident, the sodium fire in the Fast Flux Test Facility fuel storage area, is no longer applicable since the Fast Flux Test Facility SNF would be moved to a new dry storage facility.

Potential accidents at the proposed new facilities include a severe cask impact followed by a fire at a new dry storage facility and a uranium metal fire at a new facility for processing N Reactor SNF. Appendix A indicates that the cask impact and fire accident scenario presents the highest estimated risk to both the onsite workers and the general public of the accident scenarios identified for this alternative at Hanford.

For the severe cask impact accident, the estimated probability is 6 in 1,000,000 per year of operation. The estimated population dose, using very conservative meteorology, corresponds to 81 latent cancer fatalities in the general population within 80 kilometers (50 miles). The estimated risk per year, taking into account the probability of occurrence of this accident, is

4.9×10^{-4} latent cancer fatalities per year in the general population. The potential dose to the maximally exposed offsite individual, assuming no protective action, corresponds to an estimated probability of a latent cancer fatality of 2.5×10^{-4}.

An onsite individual approximately 100 meters (about 330 feet) downwind of the accident who remains within the plume while the fire burns could receive a high, though not fatal, dose. Since a fire is also involved, the close-in dose is highly dependent on the meteorological conditions at the time, the amount of plume rise that is generated by the heat from the fire, the exact location of the accident relative to buildings, etc. An individual 100 meters (about 330 feet) downwind is estimated to receive a dose that is sufficient to cause immediate health impacts, but is probably not likely to be lethal. This dose corresponds to an estimated worker probability of a latent cancer fatality of 9.4×10^{-2}. The estimated risk for a worker is 5.6×10^{-7} latent cancer fatalities per year.

Workers in the immediate vicinity of this accident could receive very high doses that could be lethal unless they immediately evacuated the area of the accident. There are likely to be two time scales for releases associated with this accident: immediately following the accident and while the fire burns. Nearby workers may not be able to avoid the immediate radiological impacts but could likely evacuate the area and avoid most of the fire-related radiological releases unless incapacitated by the accident.

Potential secondary impacts identified for the severe cask impact with fire accident (Table 5.15-2 of Appendix A) include possible restriction of use of the Hanford Reach of the Columbia River for recreation, potential loss of crops, moderate environmental contamination in the vicinity of the facility and near offsite environs, temporary restriction on land use for agriculture, possible short-term restriction on fishing access, and cleanup costs.

Idaho National Engineering Laboratory—Under the Decentralization alternative at the Idaho National Engineering Laboratory, the same highest risk SNF-related accidents identified with the No Action alternative are expected to remain. The accident risks would be the same as in the No Action alternative.

Savannah River Site—The Decentralization alternative considers several options for SNF management at the Savannah River Site, including wet storage (Option 2b), new facilities for dry storage (Option 2a), and processing the SNF followed by dry storage (Option 2c), which were not considered under the No Action alternative.

The highest risk accident for both the general population and workers, however, is the fuel assembly breach accident that was discussed under the No Action alternative.

The accident frequency is expected to be about 0.35 fuel assembly breaches per year of operation with implementation of this alternative. The risks to the general public and workers are estimated to be 3×10^{-3} and 1.7×10^{-6} latent cancer fatalities per year of operation, respectively.

Naval Facilities—The accident risks for the three subalternatives are evaluated for the Naval facilities under the Decentralization alternative: (a) decentralization with SNF retained at the shipyards and the Kesselring Site without examination of the SNF; (b) decentralization with limited examination at Puget Sound Naval Shipyard; and (c) decentralization with performance assessment examination at the Expended Core Facility at the Idaho National Engineering Laboratory followed by storage at Naval sites. Attachment F of Appendix D presents a full discussion of the accident risks at each of the Naval sites.

The accident risks associated with this alternative are the same as with the No Action alternative, with the highest risk accident being an aircraft crash into a dry storage container. The consequences and risks of this maximum risk accident are the same as those described under the No Action alternative.

Other Generator/Storage Locations—For the Decentralization alternatives, the accident risks at the Oak Ridge Reservation and other SNF interim storage sites that do not ship their SNF elsewhere are expected to be similar to the accident risks under the No Action alternative.

5.1.3.5 Nonradiological Accidents. The maximum reasonably foreseeable chemical accident at the Idaho National Engineering Laboratory, Savannah River Site, Naval sites, and other generator/storage locations would be similar to those described under the No Action alternative. An accident at the wet storage facility on the Hanford Site could release sulfuric acid vapor and subject workers to up to 130 percent of the chemical concentrations that are associated with fatalities or serious health effects.

5.1.3.6 Transportation.

Shipments—Under the Decentralization alternative, university, foreign, and non-DOE research reactors would ship SNF to the Idaho National Engineering Laboratory and the Savannah River Site. In addition, Naval SNF shipments would be equal to or greater than those under the No Action alternative, depending on the choice of subalternative with respect to fuel examination options. Onsite shipments at major DOE sites would occur to relocate SNF from one facility to another for stabilization or storage.

Incident-Free Transportation—For the Decentralization alternative, the incident-free transportation of SNF was estimated to result in total fatalities that ranged from 0.076 to 0.26 over the 40-year period 1995 through 2035. These fatalities represent the sum of the

estimated number of radiation-related latent cancer fatalities and the estimated number of nonradiological fatalities from vehicular emissions.

The reason for a range of fatalities was because of three factors: (1) different examination options for Naval SNF (see Appendix D), (2) the option of using truck or rail transport for DOE SNF (see Appendix I), and (3) different SNF management options at the Savannah River Site (see Appendix C). Navy shipments would be made using a combination of truck and rail; DOE shipments were assumed to be made using 100 percent truck or 100 percent rail.

The estimated number of radiation-related latent cancer fatalities for transportation workers ranged from 0.019 to 0.064, the estimated number of radiation-related latent cancer fatalities for the general population ranged from 0.033 to 0.16, and the estimated number of nonradiological fatalities from vehicular emissions ranged from 0.024 to 0.039 for this alternative.

Onsite shipments of SNF were estimated to result in 0.0025 to 0.0036 fatalities. Offsite shipments of SNF were estimated to result in 0.074 to 0.26 fatalities. These fatalities also represent the sum of the estimated number of radiation-related latent cancer fatalities and the estimated number of nonradiological fatalities from vehicular emissions.

Transportation Accidents—The cumulative transportation accident risks over the 40-year operational period are estimated to be in the range of 5.5×10^{-5} to 0.0001 latent cancer fatalities, and 0.1 to 0.92 traffic fatalities, if all SNF were transported by truck. If all SNF were transported by rail, the corresponding risks are estimated to be in the range of 1.3×10^{-5} to 6.4×10^{-5} latent cancer fatalities, and 0.12 to 0.93 traffic fatalities. The range of fatality estimates reflects the different fuel examination options for Naval SNF (see Appendix D).

The maximum reasonably foreseeable offsite transportation accident involves shipment of Naval SNF and has a probability of occurrence between 1×10^{-6} and 1×10^{-7} per year. If it occurred in an urban population zone, the estimated latent cancer fatalities range from 0.012 to 0.065. It is estimated that latent cancer fatalities in a suburban or rural population zone range from 0.002 to 1.7.

Onsite transportation of SNF would occur under the Decentralization alternative at the Hanford Site, the Idaho National Engineering Laboratory, and the Savannah River Site. The maximum reasonably foreseeable accident for this alternative occurs at the Idaho National Engineering Laboratory, and the potential impacts are the same as those described under the No Action alternative.

5.1.4 1992/1993 Planning Basis Alternative

Under the 1992/1993 Planning Basis alternative, SNF currently stored at major DOE sites would remain at those sites, and newly generated SNF from DOE, university, and other Government reactors would be shipped to the Idaho National Engineering Laboratory or the Savannah River Site for storage. Special-case commercial SNF and Naval SNF would be shipped to the Idaho National Engineering Laboratory for storage. Existing research and development of technologies improving the safe and secure storage of SNF at DOE sites would continue, and new projects would commence. Examination of Naval fuels would be conducted at the Expended Core Facility at the Idaho National Engineering Laboratory.

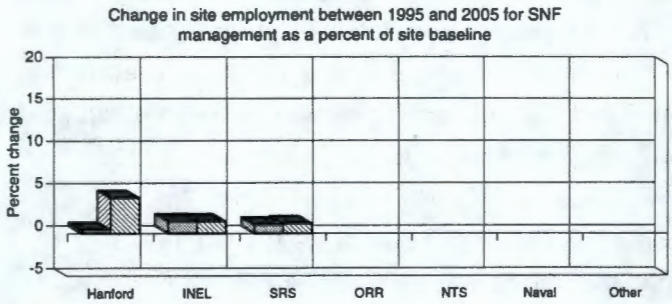
The implications of this alternative for major DOE sites would be similar to those described for the Decentralization alternative. New storage facilities would be built at the major DOE sites to replace existing facilities or to accept newly generated SNF from other sites. Degraded fuels at the Savannah River Site and the Hanford Site might be stabilized to improve safe storage.

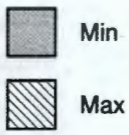
The sites that would be affected by the 1992/1993 Planning Basis alternative are the Hanford Site, Idaho National Engineering Laboratory, and Savannah River Site. The environmental consequences at these sites are described below.

5.1.4.1 Socioeconomics. Implementation of the 1992/1993 Planning Basis alternative would not have a significant socioeconomic impact at any of the major DOE or Naval sites (Figure 5-3). The impacts at the Hanford and Savannah River Sites would be the same as that described for the Decentralization alternative in Section 5.1.3.1 and shown on Figure 5-2. Proposed new construction and maintenance activities at the Idaho National Engineering Laboratory would result in the addition of approximately 130 workers over 10 years, less than a 1 percent increase above projected site employment. The peak employment at Hanford would be the same as that described for the Decentralization alternative, a maximum of about 740 additional workers at the Hanford Site, an increase of approximately 5 percent above the 1995 baseline.

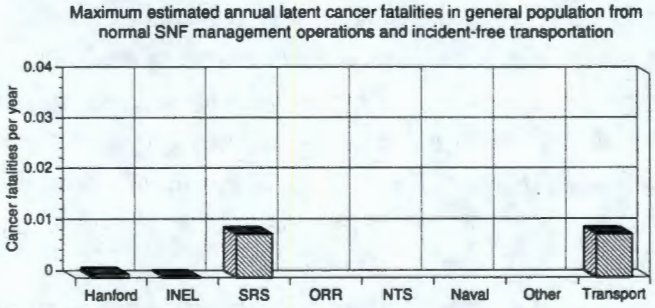
There would be no socioeconomic impact at the Naval sites because current practices would not be altered. Storage facilities would not need to be constructed at the individual Naval sites, and no employment would be generated at Naval sites.

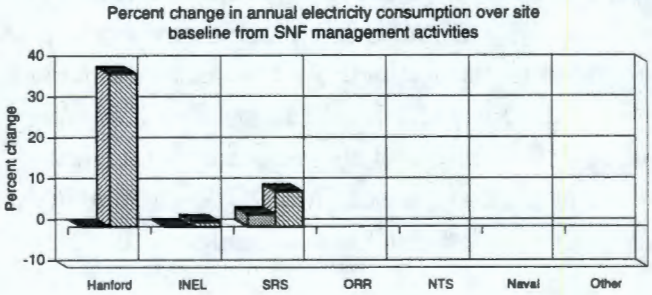
5.1.4.2 Utilities (Electricity). The minimum and maximum change in power use from implementing the 1992/1993 Planning Basis alternative with respect to the site baseline is shown in Figure 5-3. The impact on power consumption at the sites is the same as that described for the Decentralization alternative in Section 5.1.3.2 (compare to Figure 5-2) except at the Idaho

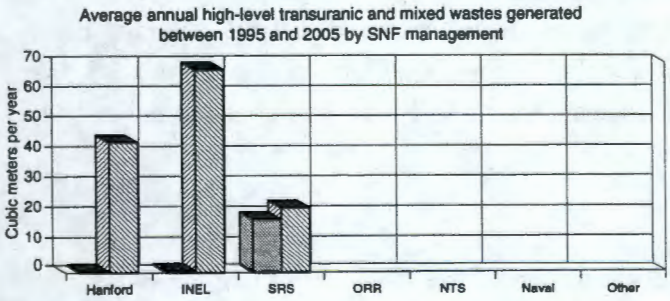


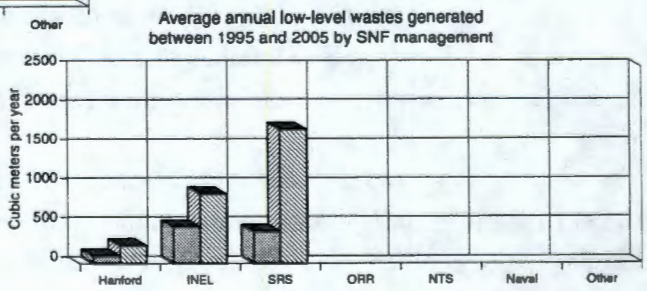


Note: ORR, NTS, Naval, and Other sites are not affected by this alternative.









INEL = Idaho National Engineering Laboratory
SRS = Savannah River Site
ORR = Oak Ridge Reservation
NTS = Nevada Test Site
Naval = Naval Sites

Figure 5-3. Summary of impacts for the 1992/1993 Planning Basis alternative. The maximum incremental change from baseline is illustrated in all graphs. Input data summarized in Appendix K.

National Engineering Laboratory. The variation in power use over site baseline use at the Savannah River and Hanford Sites reflects whether a storage or processing option is selected for SNF management. The increase in power use at the Idaho National Engineering Laboratory is because of the Actinide Recycle Demonstration Project. If processing options were implemented at Hanford, an extension of existing utilities to the project area would be necessary.

5.1.4.3 Materials and Waste Management. Figure 5-3 illustrates the combined average annual volumes of high-level, transuranic, and mixed wastes and of low-level wastes that would be generated over the next 10 years as a result of SNF management activities with implementation of the 1992/1993 Planning Basis alternative. The volume of low-level waste and the combined volume of high-level, transuranic, and mixed waste would be similar to the volumes generated under the Decentralization alternative for the Hanford and Savannah River Sites (compare Figures 5-2 and 5-3). The minimum and maximum values shown for these sites reflect whether a storage option or a processing option is implemented, respectively.

At the Idaho National Engineering Laboratory, implementation of the 1992/1993 Planning Basis alternative would result in the generation of high-level, transuranic, and mixed wastes. These wastes would be generated by the Actinide Recycle Demonstration Project. The volume of low-level waste generated at the Idaho National Engineering Laboratory would be from the construction and operation of new storage and characterization facilities at the site. Adequate storage capacity exists at the site for these wastes until 2005, when additional capacity would be expected to be required for managing low-level waste (Appendix B).

5.1.4.4 Radiological Impacts. Radiological exposures to both workers and the public from normal SNF management operations and onsite accidents for the 1992/1993 Planning Basis alternative are essentially the same as estimated for the Decentralization option. Figure 5-3 illustrates the estimated latent cancer fatalities associated with SNF operations at the major sites.

SNF Facility Accidents—

Hanford Site. The implementation of the 1992/1993 Planning Basis alternative at the Hanford Site would not result in accident risks significantly different from those identified for the Decentralization alternative (Section 5.15 of Appendix A).

Idaho National Engineering Laboratory. The implementation of the 1992/1993 Planning Basis alternative at Idaho National Engineering Laboratory would not result in accident risks significantly different from those identified for the Decentralization alternative (Section 5.15 of Appendix B). The estimated frequency of fuel handling accidents, however, would change.

Savannah River Site. The implementation of the 1992/1993 Planning Basis alternative at the Savannah River Site would not result in accident consequence estimates

that differ from those identified under the Decentralization alternative (Section 5.15 and Attachment A of Appendix C). Because of increases in amount of SNF handled, the accident frequencies are expected to increase.

The accident frequency for the highest risk accident, the fuel assembly breach, is expected to be about 0.40 fuel assembly breaches per year of operation with implementation of this alternative. This results in estimated risk to the general public and worker of 3.4×10^{-3} and 1.9×10^{-6} latent cancer fatalities per year of operation, respectively.

Naval Facilities. With implementation of the 1992/1993 Planning Basis alternative for Naval facilities, all storage and examination activities occur at the Idaho National Engineering Laboratory. The maximum risk accident at this facility is not the maximum risk accident at the Idaho National Engineering Laboratory, so it is not discussed further in this volume. See Attachment F of Appendix D for details.

Other Generator/Storage Locations. For the 1992/1993 Planning Basis alternative, the accident risks at the Oak Ridge Reservation and other SNF interim storage sites that do not ship their SNF elsewhere would be similar to the accident risks under the No Action alternative.

5.1.4.5 Nonradiological Accidents. The maximum reasonably foreseeable chemical accident at the Idaho National Engineering Laboratory, Savannah River Site, and other generator/storage locations would be similar to those described under the No Action alternative. The Hanford Site accidents would be similar to those in the Decentralization alternative.

Two independent accidents have been evaluated to describe the maximum reasonably foreseeable chemical hazards during the operation of the Expended Core Facility at the Idaho National Engineering Laboratory. Such a release could subject workers to chemical concentrations that could cause fatalities or serious health effects, but would not subject the public to such concentrations.

5.1.4.6 Transportation.

Shipments—Under the 1992/1993 Planning Basis alternative, university, foreign, and non-DOE research reactors would ship SNF to the Idaho National Engineering Laboratory and the Savannah River Site. Commercial SNF stored at the West Valley Demonstration Project and graphite SNF stored at the Fort St. Vrain site would be shipped to the Idaho National Engineering Laboratory. DOE research reactor SNF stored at various DOE sites would be shipped to the Idaho National Engineering Laboratory and the Savannah River Site. Naval SNF would be shipped from Naval shipyards to the Expended Core Facility and irradiated test specimens would be shipped between the Expended Core Facility and offsite locations. Onsite transportation would relocate SNF from one facility to another for stabilization or storage.

Incident-Free Transportation—For the 1992/1993 Planning Basis alternative, the incident-free transportation of SNF was estimated to result in total fatalities that ranged from 0.10 to 0.34 over the 40-year period 1995 through 2035. These fatalities were the sum of the estimated number of radiation-related latent cancer fatalities and the estimated number of nonradiological fatalities from vehicular emissions.

The reason for a range of fatalities was due to two factors: (1) the option of using truck or rail transport for DOE SNF (see Appendix I) and (2) different SNF management options at the Savannah River Site (see Appendix C). Navy shipments would be made using a combination of truck or rail; DOE shipments were assumed to be made using 100 percent truck or 100 percent rail.

The estimated number of radiation-related latent cancer fatalities for transportation workers ranged from 0.022 to 0.082, the estimated number of radiation-related latent cancer fatalities for the general population ranged from 0.036 to 0.22, and the estimated number of nonradiological fatalities from vehicular emissions ranged from 0.035 to 0.044.

Onsite shipments of SNF were estimated to result in 0.0028 to 0.0036 fatality. Offsite shipments of SNF were estimated to result in 0.10 to 0.33 fatality. These fatalities were also the sum of the estimated number of radiation-related latent cancer fatalities and the estimated number of nonradiological fatalities from vehicular emissions.

Transportation Accidents—The cumulative transportation accident risks over the 40-year operational period are estimated to be 0.00014 latent cancer fatalities and 0.58 traffic fatalities if all SNF were transported by truck. If all SNF were transported by rail, the corresponding risks are estimated to be 6.9×10^{-5} latent cancer fatality and 0.59 traffic fatality.

The maximum reasonably foreseeable offsite transportation accident involves a rail shipment of commercial SNF in a suburban population zone under neutral (average) weather conditions. The accident has a probability of occurrence of about 1.9×10^{-7} per year and could result in an estimated 7 latent cancer fatalities in the exposed population. For comparison, the same population would be expected to experience about 100,000 cancer fatalities from other causes. The probability of this accident occurring in an urban population zone is less than 1×10^{-7} per year. In a rural population zone, the accident consequences are estimated to be about 0.2 latent cancer fatalities.

Onsite transportation of SNF would occur under the 1992/1993 Planning Basis alternative at the Hanford Site, the Idaho National Engineering Laboratory, and the Savannah River Site. The maximum reasonably foreseeable accident for this alternative occurs at the Idaho National Engineering Laboratory, and the potential impacts are the same as those described under the No Action alternative.

5.1.5 Regionalization Alternative

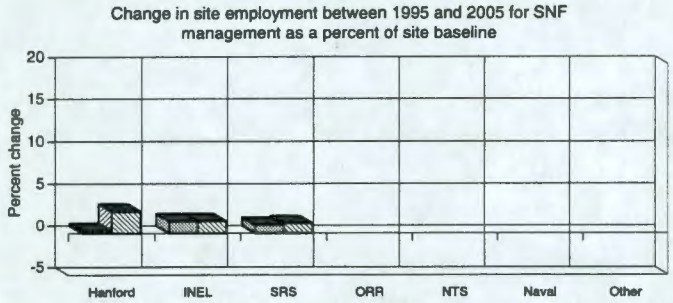
There are two subalternatives under the Regionalization alternative: the Regionalization A subalternative would relocate SNF according to fuel type; the Regionalization B subalternative would relocate SNF according to location.

Under the Regionalization A subalternative, certain types of SNF from other DOE sites, and SNF from university, and other Government reactors, special-case commercial SNF, and foreign research reactor SNF would be shipped to either the Idaho National Engineering Laboratory or the Savannah River Site for storage. Existing research and development of technologies improving the safe and secure storage of SNF at DOE sites would continue, and new projects would commence. Naval SNF would be examined at the Expended Core Facility at the Idaho National Engineering Laboratory, then stored at the Idaho Chemical Processing Plant.

The implications of Subalternative A are essentially the same as those of the 1992/1993 Planning Basis alternative because there would be minor differences in the amounts of fuel shipped to each destination under these alternatives (see Figure 5-4).

Under the Regionalization B subalternative, however, two regional sites would be selected, and SNF would be moved to one site or the other. In the west, either the Hanford Site, the Idaho National Engineering Laboratory, or the Nevada Test Site would be the regional site; in the east, either the Savannah River Site or the Oak Ridge Reservation would be designated. SNF stored or generated west of the Mississippi River would be shipped to the Western Regional Site, and SNF stored or generated east of the Mississippi River would be shipped to the Eastern Regional Site. An expended core facility would be built at either the Eastern or Western Regional Site (unless the Western Regional Site were the Idaho National Engineering Laboratory, in which case no new facility would be required). Research and development would be conducted at the regional sites.

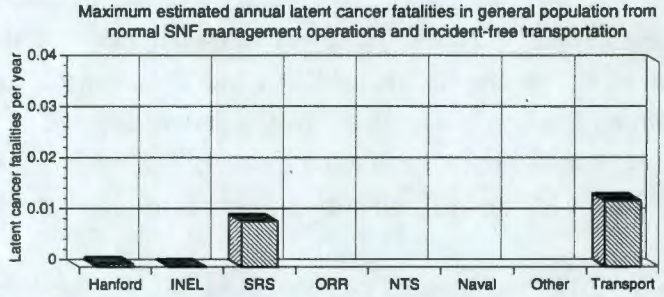
Regionalization B affects more sites than Regionalization A. Only one site would have SNF management responsibility in the east and in the west, and thus SNF management activities would be phased out at those sites not selected as regional sites. If the Idaho National Engineering Laboratory were not selected as the Western Regional Site, the Expended Core Facility in Idaho would be closed, and a new facility would be built at either the Eastern or Western Regional Site. If the Oak Ridge Reservation were chosen as the Eastern Regional Site, SNF now at Savannah River would be shipped to the Oak Ridge Reservation. This would require the development of new storage facilities at the Reservation. Some fuels might need to be stabilized before shipment. If the Savannah River Site were selected as the Eastern Regional Site, there would be few differences between this subalternative and the Regionalization A subalternative except that an expended core facility might be built at the site. In the west, shipment of Hanford SNF to another site would require stabilization of the N Reactor fuels, the

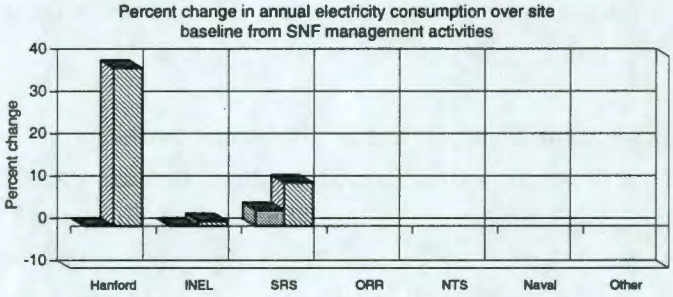


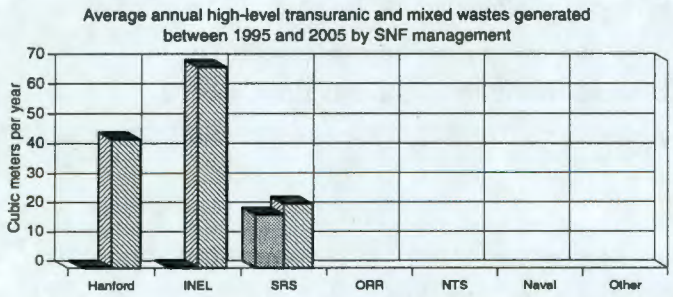
Min

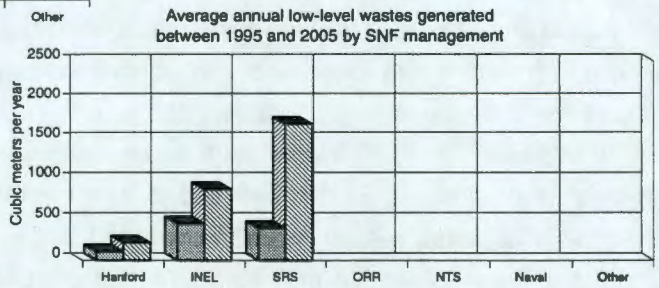
Max

Note: ORR, NTS, Naval, and Other sites are not affected by this subalternative.









INEL = Idaho National Engineering Laboratory
SRS = Savannah River Site
ORR = Oak Ridge Reservation
NTS = Nevada Test Site
Naval = Naval Sites

Figure 5-4. Summary of impacts for the Regionalization A subalternative. The maximum incremental change from baseline is illustrated in all graphs. Input data summarized in Appendix K.

great majority of the SNF now stored there. Some Idaho National Engineering Laboratory fuels would also require stabilization if they were shipped to another site. New SNF management facilities would be required at any Western Regional Site selected because of the large volumes of SNF that would be received.

This alternative would affect only the five major DOE sites. The environmental consequences at these sites are described below.

5.1.5.1 Socioeconomics. Under the Regionalization A subalternative, the socioeconomic impacts at the Idaho National Engineering Laboratory would be the same as those described for the 1992/1993 Planning Basis alternative described in Section 5.1.4.1. The peak employment under the Regionalization A subalternative would be an additional 470 workers at the Hanford Site, approximately 3 percent above the 1995 baseline. Implementation of the Regionalization A subalternative would have no socioeconomic consequences at either the Oak Ridge Reservation or the Nevada Test Site because this would result in no changes to existing operations at either site.

Impacts of the Regionalization A subalternative on the Naval sites would be the same as that described for the 1992/1993 Planning Basis alternative since Naval SNF would be shipped to the Expended Core Facility in Idaho for examination and storage at the Idaho National Engineering Laboratory.

If either the Hanford Site, Idaho National Engineering Laboratory, or the Savannah River Site were not selected as a regional site under the Regionalization B subalternative, there would be an eventual reduction in employment equal to existing employment for SNF management at these sites. This would add to the currently predicted loss of jobs at each of these sites. In the short term, additional jobs would be required to prepare SNF for shipment offsite (see Figure 5-5). The closure of the Expended Core Facility at the Idaho National Engineering Laboratory, however, would lead to a short-term loss of jobs as well, increasing the rate of job loss at that site.

Sites that were selected as regional sites would have generally increased employment over baseline levels (see Figure 5-6). Site employment levels would also increase at whatever site an expended core facility were constructed (Figure 5-7). Employment at the Oak Ridge Reservation and Nevada Test Site would increase if these sites were chosen as the Eastern and Western Regional Sites. Operation of storage facilities at both the Oak Ridge Reservation and Nevada Test Site could ultimately result in the creation of approximately 500 jobs per year at both sites, a 3-percent increase above current site employment at Oak Ridge Reservation and an 8-percent increase above current site employment at the Nevada Test Site without the expended core facility or a 7- and 16-percent increase with an expended core facility, respectively (Figure 5-6). The peak annual employment from implementation of the Regionalization B

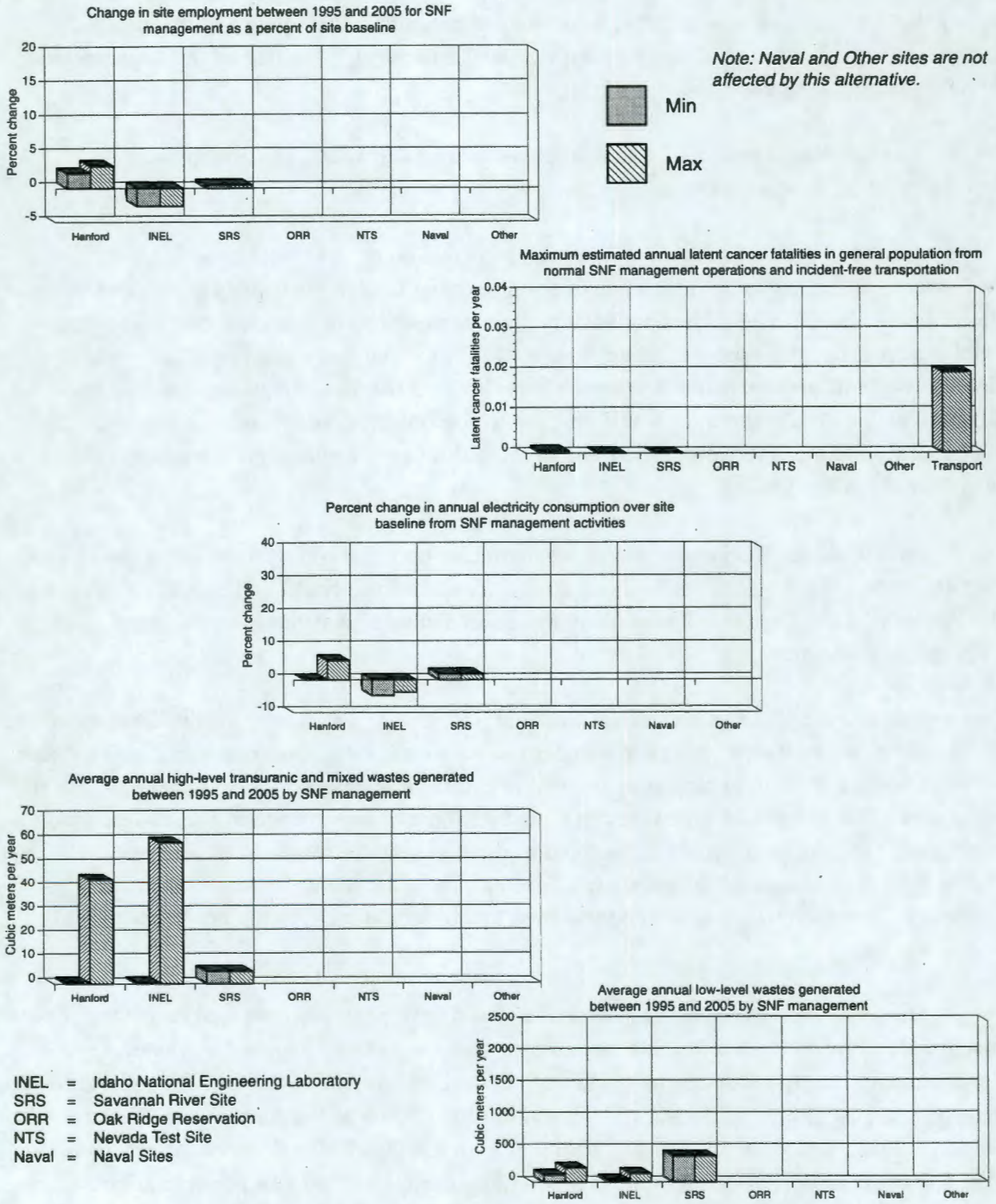
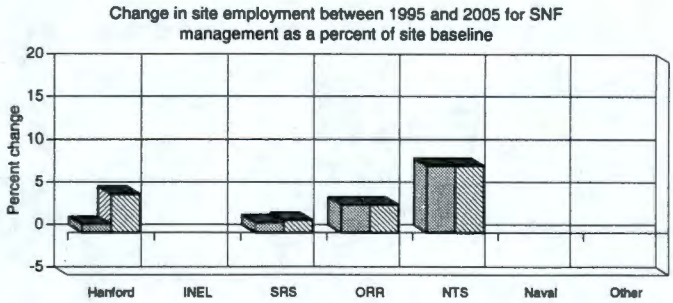


Figure 5-5. Summary of impacts for the Regionalization B subalternative if the site is not selected as the regional site. The maximum incremental change from baseline is illustrated in all graphs. Input data summarized in Appendix K.

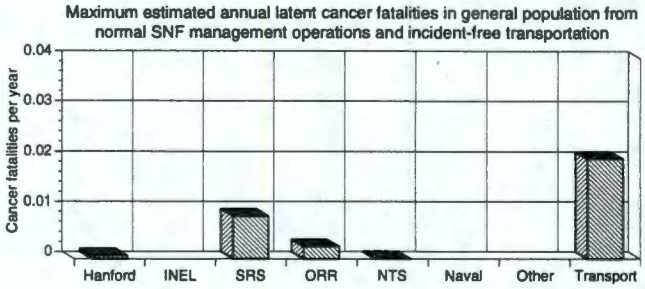


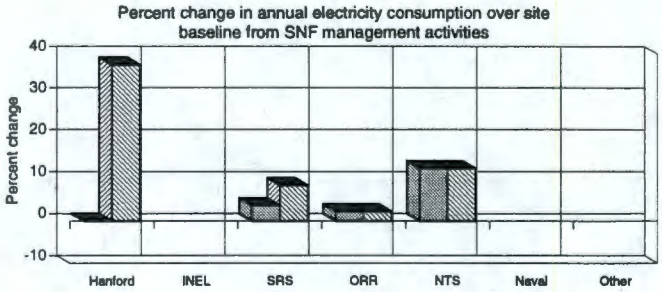
Note: Naval and Other sites are not affected by this alternative.

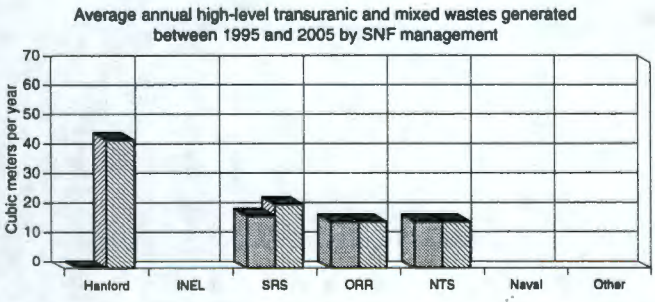
Min

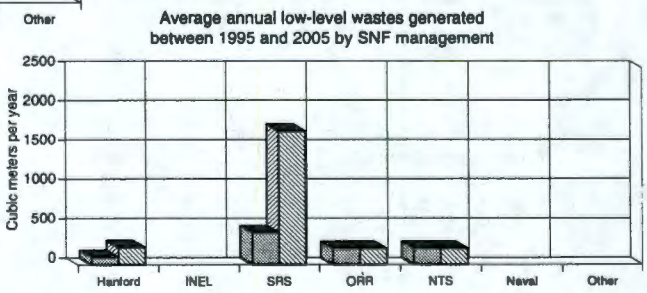
Max

There are no cases where the INEL would be selected and not have the Expended Core Facility



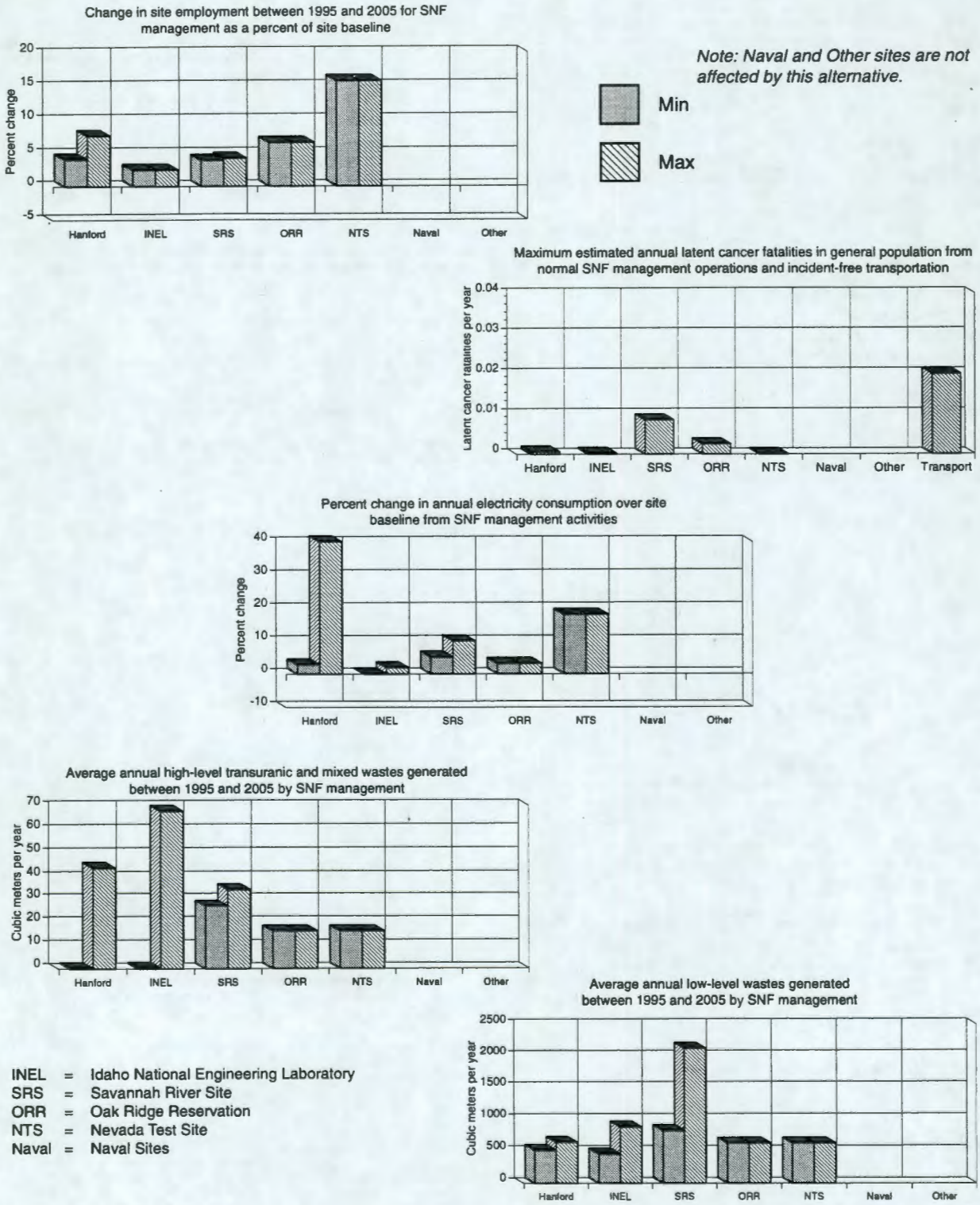






INEL = Idaho National Engineering Laboratory
SRS = Savannah River Site
ORR = Oak Ridge Reservation
NTS = Nevada Test Site
Naval = Naval Sites

Figure 5-6. Summary of impacts for the Regionalization B subalternative if sites are selected as a regional site and do not have the expended core facility. The maximum incremental change from baseline is illustrated in all graphs. Input data summarized in Appendix K.



INEL = Idaho National Engineering Laboratory
SRS = Savannah River Site
ORR = Oak Ridge Reservation
NTS = Nevada Test Site
Naval = Naval Sites

Figure 5-7. Summary of impacts for the Regionalization B subalternative if sites are selected as a regional site and have the expended core facility. The maximum incremental change from baseline is illustrated in graphs. Input data summarized in Appendix K.

subalternative would be an additional 1,100 workers at the Nevada Test Site, an increase of approximately 16 percent above the projected 1995 baseline. However, this employment level would only be sustained over 2 years (Appendix F). The effects of this increased employment would produce minimal socioeconomic impacts at both locations.

For the Naval sites, implementing the Regionalization B subalternative would have no socioeconomic consequences.

5.1.5.2 Utilities (Electricity). As shown in Figure 5-4, implementation of the Regionalization A subalternative would have the same impact on power consumption as the 1992/1993 Planning Basis alternative (compare Figures 5-3 and 5-4). There would be no effect on power consumption at the Oak Ridge Reservation, Nevada Test Site, or Naval sites from implementation of the Regionalization A subalternative.

Figures 5-5, 5-6, and 5-7 illustrate the minimum and maximum change from baseline site power use from implementing the Regionalization B subalternative with and without an expended core facility and if the site were not selected as the regional site. Regionalization at the Hanford Site or the Nevada Test Site would produce an impact on power consumption at these sites.

Figure 5-5 illustrates the impact on power consumption if a site were not selected as a regional site. The increase in electricity consumption at the Hanford Site and the Savannah River Site reflects the power required to prepare or process the SNF for shipment as required. The decrease in power consumption at the Idaho National Engineering Laboratory would be from shutdown of the Expended Core Facility.

Figure 5-6 shows the minimum and maximum percent change, without an expended core facility, over baseline site power consumption if a site were selected as a regional center. At the Hanford Site and Savannah River Site the power consumption increases slightly with shipment of Naval fuel to the site. Regionalization at the Oak Ridge Reservation would result in a small (less than 5 percent) increase in electric power demand. The site electricity supply at each of these sites is more than adequate. However, regionalization at the Nevada Test Site would increase power consumption about 13 percent above existing site usage and would require additional transmission lines or another substation at the site (see Appendices F and K).

The Regionalization B subalternative with an expended core facility onsite is illustrated in Figure 5-7. The electricity requirements at each of the major DOE sites would increase with the addition of an expended core facility for examination of Naval SNF. Power consumption at the Nevada Test Site would increase approximately 18 percent above baseline and about 40 percent at Hanford if the processing (figure maximum) option were selected. The storage only options (figure minimum) at the Hanford site would result in only a 0.03-percent increase in electricity consumption. The Nevada Test Site would require additional transmission lines or another

substation to handle additional loads. The increased load could be handled at the Savannah River Site, and relatively minor increases would occur at the Idaho National Engineering Laboratory.

5.1.5.3 Materials and Waste Management. Figures 5-4 through 5-7 illustrate the effects of implementing the different Regionalization subalternatives: Regionalization A, Regionalization B with SNF shipped offsite, Regionalization B without an expended core facility located at the selected site, and Regionalization B with an expended core facility located at the selected site. The annual average waste volumes generated from SNF management activities at a nonselected site would decrease over the next 10 years, but at the selected sites the annual generation rate of waste from SNF management activities would increase with implementation of the Regionalization subalternative. The construction of an expended core facility at any site would also increase the annual volume of low-level waste generated.

The annual waste volumes generated from SNF management activities associated with the Regionalization A subalternative are illustrated in Figure 5-4. The effects of the Regionalization A subalternative are similar to those described for the 1992/1993 Planning Basis alternative in Section 5.1.4.3 (compare Figures 5-3 and 5-4).

Figure 5-5 illustrates the effect of not being selected as a regional center. In comparison to the Decentralization and 1992/1993 Planning Basis alternatives, the annual generation rate of high-level, transuranic, mixed and low-level wastes would ultimately decrease at the affected site since the SNF inventory would be shipped offsite. However, characterization and stabilization activities prior to shipment would generate transient increases in waste volumes.

The effect of being selected as a regional center without a replacement expended core facility is illustrated in Figure 5-6. Implementation of this Regionalization B subalternative has similar effects at the Hanford Site and the Savannah River Site as the 1992/1993 Planning Basis alterative. The Oak Ridge Reservation and the Nevada Test Site would generate waste from SNF management activities under the subalternative. Regionalization at either of these two sites would be expected to generate approximately 16 cubic meters (21 cubic yards) of transuranic waste and approximately 200 cubic meters (260 cubic yards) of low-level waste annually from operating an SNF management complex.

Figure 5-7 illustrates the effect on annual waste volume generation of being selected as a regional center with the addition of an expended core facility to examine Naval SNF. The addition of the expended core facility has no effect on the annual volume of high-level, transuranic, or mixed waste generated, but increases the volume of low-level waste that would have to be managed at any site.

The effects from implementing either of the Regionalization subalternatives at the Naval sites would be the same as that described for the 1992/1993 Planning Basis alternatives in Section 5.1.4.3.

5.1.5.4 Radiological Impacts. Radiological exposures to both workers and the public for the Regionalization A subalternative would to be similar to the 1992/1993 Planning Basis alternative. These are not discussed further in this section. Figure 5-4 illustrates the potential latent cancer fatalities to the population within 80 kilometers (50 miles) from SNF operations at the major sites for the Regionalization A subalternative.

Radiological exposures to both workers and the public for the Regionalization B subalternative would to be similar to the 1992/1993 Planning Basis alternative if the Savannah River Site, the Idaho National Engineering Laboratory, or the Hanford Site were selected as regional sites. Figures 5-5, 5-6, and 5-7 illustrate the potential latent cancer fatalities to the population within 80 kilometers (50 miles) from SNF operations for the Regionalization B subalternative if SNF is shipped offsite, or if the site is selected as the regional site without and with the expended core facility, respectively.

For any of the Regionalization subalternatives, the maximum estimated latent cancer fatalities in the general population from normal operations is estimated to be 7.6×10^{-3}, well below levels of significance.

SNF Facility Accidents—

Hanford Site. Accident risks under the Regionalization A subalternative are the same as those for the Decentralization alternative. The selection of the Hanford Site as the regional site would not result in accident risks significantly different from those identified for the Decentralization alternative (Section 5.15 of Appendix A) although higher activity under this subalternative increases the annual frequency of accidents. The probability of the cask impact and fire accident scenario is estimated to be 7 in 1,000,000 if the Hanford Site were selected as a regional site.

Selecting a different site as the regional site reduces the estimated accident risks from those identified for the Decentralization alternative because the existing wet storage facilities would be shut down and the amount of SNF handled at the dry storage facility changes slightly. The accident probability for the dry storage cask impact and fire is estimated to be 5 in 1,000,000 such that the estimated risk from this, the highest risk accident, is 4.1×10^{-4} latent cancer fatalities in the general population per year of operation.

Idaho National Engineering Laboratory. Accident risks under the Regionalization A subalternative are the same as those for the 1992/1993 Planning Basis

alternative. The selection of the Idaho National Engineering Laboratory as a regional site under the Regionalization B subalternative would not result in accident risks significantly different from those identified for the Decentralization alternative except for those associated with the resumption of processing at the Idaho Chemical Processing Plant CPP-666 facility (Section 5.15 of Appendix B). The estimated frequency of fuel handling accidents would change slightly.

Additional accidents (identified in Section 5.15 of Appendix B), associated with operation of the Idaho Chemical Processing Plant, include an inadvertent nuclear criticality during processing, a hydrogen explosion in the Idaho Chemical Processing Plant dissolver, and the inadvertent dissolution of 30-day cooled SNF in the Idaho Chemical Processing Plant dissolver. The criticality accident presents the highest onsite risk related to processing to a worker at 100 meters (about 330 feet) for this subalternative, with an estimated 4.6×10^{-3} latent cancer fatalities, at an accident frequency of 1 in 1,000 per year, corresponding to an estimated risk to a worker of 4.6×10^{-6} latent cancer fatalities per year of operation.

Savannah River Site. Accident risks under the Regionalization A subalternative are the same as those for the 1992/1993 Planning Basis alternative. The implementation of the Regionalization B subalternative at the Savannah River Site, including the three options of dry storage, wet storage, and processing followed by dry storage, would not result in accidents significantly different from those identified for the same options under the Decentralization alternative (Section 5.15 and Attachment A of Appendix C). Because of an increase in the amount of SNF handled, however, the accident frequency for some accidents increases.

The accident frequency for the highest risk accident, a fuel assembly breach, is expected to be about 0.41 fuel assembly breaches per year of operation with implementation of this alternative . This results in a proportional increase in risk to the general public and the workers. The estimated risk of latent cancer fatalities in the general public and onsite worker are 7.2×10^{-3} and 4×10^{-6} per year of operation. With regionalization elsewhere, the highest risk accident is still the fuel assembly breach with an estimated risk approximately the same as with the No Action alternative.

Naval Facilities. The accident risks associated with implementation of the Regionalization alternative at sites other than the Idaho National Engineering Laboratory are presented in detail in Attachment F of Appendix D. That evaluation considered the accidents associated with operation of an expended core facility and wet and dry storage facilities at the Hanford Site, the Savannah River Site, the Oak Ridge Reservation, and the Nevada Test Site. Accidents evaluated were the same set of accidents identified for the Decentralization alternative. The maximum risk accidents, for either the general population and workers at sites where the expended core facility might be located if they are associated with the expended core facility, are discussed under the affected sites.

Oak Ridge Reservation. The Oak Ridge Reservation would not be affected by the Regionalization A subalternative. The implementation of the Regionalization B subalternative at the Oak Ridge Reservation is expected to be similar to implementation of the Centralization alternative, except that less storage requirements would be needed. Section 5.15 (Part 3) of Appendix F indicates that the accident consequences would be similar for both alternatives and that it is reasonable to assume that the accident consequences and risks described for the Centralization alternative envelop the Regionalization alternative.

A wide range of accident scenarios were considered, including accidents initiated by operational events, external hazards such as aircraft crashes, and natural phenomena such as earthquakes. The highest risk SNF-related accidents identified are (a) a fuel assembly breach as a result of dropping the assembly, objects falling on the assembly, or cutting into the fuel portion of the assembly, (b) a dropped fuel cask, (c) a severe impact that results in breach of a transport cask and fire, (d) an aircraft crash into the SNF dry storage facility, (e) an aircraft crash into the SNF dry cell facility, (f) a wind-driven missile impact into storage casks, and (g) and aircraft crash into a water storage pool.

The highest risk to the general population is a fuel assembly breach, with an estimated frequency of 0.16 per year. General population consequences are estimated to be approximately 2.1×10^{-2} latent cancer fatalities per year. The estimated risk to the general population, taking into account the probability of occurrence of this accident, is 3.4×10^{-3} latent cancer fatalities per year. The estimated maximum latent cancer fatalities to the maximally exposed individual is 3.1×10^{-6}.

The dropped fuel cask accident has the maximum risk to workers with an estimated frequency of less than 1 in 10,000 per year. A worker downwind of the accident is estimated to receive a dose which corresponds to an estimated probability of 1.9×10^{-3} latent cancer fatalities. The estimated risk for a worker is 1.9×10^{-7} latent cancer fatalities per year.

Workers in the immediate vicinity of the cask drop accident could receive very high doses; however, the doses would not result in a fatality. For that accident, workers could be expected to be very near the cask when it drops and receive both direct radiation as well as inhale airborne fission products. Workers would be expected to quickly evacuate the area and thus reduce their potential radiation exposure.

Nevada Test Site. The implementation of the Regionalization B subalternative at the Nevada Test Site is also expected to be similar to implementation of the Centralization alternative, except that storage requirements would be less. Section 5.15 (Part 2) of Appendix F indicates that the accident consequences would be similar for both alternatives and that it is reasonable to assume that the accident consequences and risks described for the Centralization alternative envelop the Regionalization alternative.

A wide range of accident scenarios were considered for the Centralization alternative, which also apply to the Regionalization B subalternative, including accidents initiated by operational events, external hazards such as aircraft crashes, and natural phenomena such as earthquakes. The highest risk SNF-related accidents identified for the Nevada Test Site are a fuel assembly breach (highest risk to the general public) and a dropped fuel cask (highest risk to workers).

The fuel assembly breach is the highest risk to the general population with an estimated frequency of 0.16 per year and an estimated offsite population dose corresponding to 6.6×10^{-4} latent cancer fatalities. The estimated risk to the general population, taking into account the probability of occurrence of this accident, is 1.1×10^{-4} latent cancer fatalities per year. The potential dose to the maximally exposed offsite individual corresponds to a probability of a latent cancer fatality of 6.5×10^{-8}.

The dropped fuel cask accident is the highest risk accident to workers with an estimated frequency of less than 1 in 10,000 per year. A worker approximately 100 meters (330 feet) downwind of the accident would have a probability of a latent cancer fatality of 1.9×10^{-3}. The estimated risk to a worker is 1.9×10^{-7} latent cancer fatalities per year of operation.

Workers in the immediate vicinity of the cask drop accident could receive very high doses; however, the doses would not result in a fatality. For that accident, workers could be expected to be very near the cask when it drops and receive both direct neutron and gamma radiation as well as inhale airborne fission products. Workers would be expected to quickly evacuate the area and thus reduce their potential radiation exposure.

Other Generator/Storage Locations. For the Regionalization subalternatives, the accident risks are expected to be similar to the accident risks under the No Action alternative.

5.1.5.5 Nonradiological Accidents. The maximum reasonably foreseeable chemical accident at the Idaho Engineering National Laboratory, the Savannah River Site, and other generator/storage locations would be similar to those described under the No Action alternative. An accident during the operation of a wet storage facility at the Hanford Site could release sulfuric acid and subject workers to fatalities or serious health effects.

Two independent accidents have been evaluated to describe the maximum reasonably foreseeable chemical accident during the operation of the expended core facility at each of its potential locations. Such a release could subject workers to chemical concentrations that could cause fatalities or serious health effects but would not subject the public to such concentrations except at potential locations on the Oak Ridge Reservation and adjacent to the Savannah River Site.

5.1.5.6 Transportation.

Regionalization A (By Fuel Type)—

Shipments. Under the Regionalization A subalternative, the same SNF types are shipped as under the 1992/1993 Planning Basis alternative with differences occurring in the destinations of some SNF based on fuel type. Onsite shipments would relocate SNF for continued safe storage or stabilization.

Incident-Free Transportation. For the Regionalization A subalternative, the incident-free transportation of SNF was estimated to result in total fatalities that ranged from 0.12 to 0.50 over the 40-year period 1995 through 2035. These fatalities represent the sum of the estimated number of radiation-related latent cancer fatalities and the estimated number of nonradiological fatalities from vehicular emissions.

The reason for a range of fatalities was due to two factors: (1) the option of using truck or rail transport for DOE SNF (see Appendix I) and (2) different SNF management options at the Savannah River Site (see Appendix C). Navy shipments would be made using a combination of truck and rail; DOE shipments were assumed to be made using 100 percent truck or 100 percent rail.

The estimated number of radiation-related latent cancer fatalities for transportation workers ranged from 0.025 to 0.13, the estimated number of radiation-related latent cancer fatalities for the general population ranged from 0.047 to 0.33, and the estimated number of nonradiological fatalities from vehicular emissions ranged from 0.040 to 0.051.

Onsite shipments of SNF were estimated to result in 0.0025 to 0.0034 fatalities. Offsite shipments of SNF were estimated to result in 0.12 to 0.49 fatalities. These fatalities also represent the sum of the estimated number of radiation-related latent cancer fatalities and the estimated number of nonradiological fatalities from vehicular emissions.

Transportation Accidents. The cumulative transportation accident risks over the 40-year operational period are estimated to be 0.0002 latent cancer fatality and 0.62 traffic fatality if all SNF were transported by truck. If all SNF were transported by rail, the corresponding risks are estimated to be 7.8×10^{-5} latent cancer fatality and 0.60 traffic fatality.

As in the 1992/1993 Planning Basis alternative, the maximum reasonably foreseeable offsite transportation accident involves a rail shipment of commercial SNF in a suburban population zone under neutral (average) weather conditions. The accident has a probability of occurrence of about 2.7×10^{-7} per year and the consequences are the same as those described under the 1992/1993 Planning Basis alternative.

Onsite transportation of SNF would occur under the Regionalization A subalternative at the Hanford Site, the Idaho National Engineering Laboratory, and the Savannah River Site. The maximum reasonably foreseeable accident for this alternative occurs at the Idaho National Engineering Laboratory, and the potential impacts are the same as those described under the No Action alternative.

Regionalization B (By Geography)—

Shipments. Under the Regionalization B subalternative, the same SNF types are shipped as under the 1992/1993 Planning Basis alternative with differences occurring in the destinations of the SNF based on geographical considerations. Non-Naval SNF originating from western United States locations or ports are shipped to the Idaho National Engineering Laboratory, the Hanford Site, or the Nevada Test Site. Non-Naval SNF originating from eastern United States locations or ports are shipped to the Savannah River Site or the Oak Ridge Reservation. Naval SNF would not be split on an east-west basis because the Navy would operate a facility for examining Naval SNF at one of the DOE sites. Onsite shipments at major DOE sites may relocate SNF from one facility or another for continued safe storage or stabilization, if applicable.

Incident-Free Transportation. For the six Regionalization B subalternatives, the incident-free transportation of SNF was estimated to result in total fatalities that ranged from 0.11 to 0.41 (Idaho National Engineering Laboratory and the Savannah River Site subalternative) to 0.13 to 0.81 (Nevada Test Site and the Oak Ridge Reservation subalternative). The other four subalternatives would result in fatalities between these two subalternatives. These fatalities were over the 40-year period 1995 through 2035 and represent the sum of the estimated number of radiation-related latent cancer fatalities and the estimated number of nonradiological fatalities from vehicular emissions.

The reason for a range of fatalities was due to two factors: (1) the option of using truck or rail transport for DOE SNF (see Appendix I) and 2) the six regionalization options. Navy shipments would be made using a combination of truck or rail; DOE shipments were assumed to be made using 100 percent truck or 100 percent rail.

For regionalization at the Idaho National Engineering Laboratory and the Savannah River Site, the estimated number of radiation-related latent cancer fatalities for transportation workers ranged from 0.026 to 0.10, the estimated number of radiation-related latent cancer fatalities for the general population ranged from 0.039 to 0.27, and the estimated number of nonradiological fatalities from vehicular emissions ranged from 0.041 to 0.036.

For regionalization at the Nevada Test Site and the Oak Ridge Reservation, the estimated number of radiation-related latent cancer fatalities for transportation workers ranged from 0.036 to 0.19, the estimated number of radiation-related latent cancer fatalities for the general

population ranged from 0.052 to 0.55, and the estimated number of nonradiological fatalities from vehicular emissions ranged from 0.045 to 0.066.

For regionalization at the Idaho National Engineering Laboratory and the Savannah River Site, onsite shipments of SNF were estimated to result in 0.0028 to 0.0036 fatalities. Offsite shipments of SNF were estimated to result in 0.10 to 0.41 fatalities. These fatalities also represent the sum of the estimated number of radiation-related latent cancer fatalities and the estimated number of nonradiological fatalities from vehicular emissions.

For regionalization at the Nevada Test Site and the Oak Ridge Reservation, onsite SNF shipments were estimated to result in 0.0023 fatalities. Offsite shipments of SNF were estimated to result in 0.13 to 0.80 fatalities. These fatalities also represent the sum of the estimated number of radiation-related latent cancer fatalities and the estimated number of nonradiological fatalities from vehicular emissions.

Transportation Accidents—Cumulative accident risks for transportation by truck range from 0.00011 latent cancer fatalities and 0.60 traffic fatalities for regionalization at the Idaho National Engineering Laboratory and the Savannah River Site, to 0.00041 latent cancer fatalities and 0.78 traffic fatalities for regionalization at the Nevada Test Site and the Oak Ridge Reservation. Cumulative accident risks for transportation by rail range from 5.8×10^{-5} latent cancer fatalities and 0.59 traffic fatalities for regionalization at the Idaho National Engineering Laboratory and the Savannah River Site, to 0.00017 latent cancer fatalities and 0.73 traffic fatalities for regionalization at the Nevada Test Site and the Oak Ridge Reservation.

As in the 1992/1993 Planning Basis alternative, the maximum reasonably foreseeable offsite transportation accident involves a rail shipment of commercial SNF in a suburban population zone under neutral (average) weather conditions. The accident has a probability of occurrence that ranges from about 2.6×10^{-7} per year for regionalization at the Hanford Site and the Savannah River Site, to about 4.2×10^{-7} per year for regionalization at the Nevada Test Site and the Oak Ridge Reservation. Accident consequences are the same for each subalternative and are the same as those described under the 1992/1993 Planning Basis alternative.

Onsite transportation of SNF would occur under the Regionalization B subalternative at the Hanford Site, the Idaho National Engineering Laboratory, and the Savannah River Site. The maximum reasonably foreseeable accident for this subalternative occurs at the Idaho National Engineering Laboratory, and the potential impacts are the same as those described under the No Action alternative.

5.1.6 Centralization Alternative

Under this alternative, all stored and newly generated SNF would be shipped to and stored at one of five sites: the Hanford Site, the Idaho National Engineering Laboratory, the Savannah River Site, the Oak Ridge Reservation, or the Nevada Test Site. SNF management activities at unselected sites would cease. All SNF-related research and development activities would be conducted at the selected site, and the expended core facility would also be located there.

The implications of this alternative are similar to those of the Regionalization B subalternative for western sites, but if an eastern site were selected, considerably greater volumes of SNF would be stored there than under any other alternative because the site would receive fuels from the Hanford Site and the Idaho National Engineering Laboratory. Therefore, substantially larger storage facilities would be needed under this alternative than under any other. New facilities with the largest capacity for SNF would be built at the Oak Ridge Reservation and the Nevada Test Site because they do not now have the capacity to accept additional fuels and do not currently store significant volumes of SNF. The environmental consequences at these sites are described below.

5.1.6.1 Socioeconomics. The Centralization alternative would result in the largest socioeconomic impact in terms of the number of direct jobs created (or lost) on a local basis by SNF management activities (see Figure 5-7). The change in site employment would range from a decrease of less than 3 percent of total site employment at the Idaho National Engineering Laboratory to a maximum increase of about 16 percent above existing site employment at the Nevada Test Site when an expended core facility were constructed at the site. The intensity of this impact at the major DOE sites would depend on whether the SNF management programs used existing personnel or required workers to move into the region, and on future actions at each site competing for the available labor pool. Under Centralization where the site is selected, the peak in employment would occur at the Savannah River Site where an additional 2,700 workers would be required for the proposed SNF management activities, an increase of approximately 8 percent above the projected 1995 baseline. Where the site is not selected, the peak in employment would be an additional 580 workers at the Hanford Site or approximately 3 percent above the projected 1995 baseline. If either the Hanford Site, Idaho National Engineering Laboratory, or the Savannah River Site were not selected as a central site under the Centralization alternative, there would ultimately be a reduction in employment equal to existing employment for SNF management at these sites. This would add to the forecast loss of jobs at each of these sites. In the short term, additional jobs would be required to prepare SNF for shipment offsite (see Figure 5-5). The closure of the Expended Core Facility at the Idaho National Engineering Laboratory, however, would lead to a long-term loss of jobs as well, increasing the rate of job loss at that site.

Sites that were selected as central sites would have generally increased employment over baseline levels (see Figure 5-6).

The secondary effects of employment could result in an increased demand for housing at the Nevada Test Site and potentially at the Oak Ridge Reservation.

5.1.6.2 Utilities (Electricity). The effect on power consumption from implementing the Centralization alternative would be generally similar to that described for the Regionalization B subalternatives where the SNF is shipped offsite or where the SNF is shipped to the regional site except at the Savannah River Site. Power consumption increases by about 8 percent over the site baseline usage at the Savannah River Site from the construction and operation of additional wet storage facilities under the Centralization alternative. Figures 5-8 and 5-9 illustrate the Centralization impacts for the two cases: if a site were selected or not selected as the central site (compare with Figures 5-5 and 5-7). The impacts would be the same as those described in Section 5.1. Thus, for example, electric power requirements with centralization at the Nevada Test Site would stress the site electrical power distribution capacity, which would be similar to Regionalization B subalternative at the Nevada Test Site with a replacement expended core facility also located at that site (Figure 5-6).

Under the Centralization alternative at Hanford, the power consumption would rise by approximately 3 percent if SNF was only stored and could rise as much as 40 percent if processing was required. While the increase in power required for processing appears large (as a percent of baseline) when compared to the Savannah River Site, much of the difference is the result of a higher Savannah River Site baseline power consumption.

5.1.6.3 Materials and Waste Management. The Centralization alternative would have similar effects at the major DOE sites to those described in Section 5.1.5.3 for the Regionalization alternative (compare with Figures 5-5 and 5-7). If a site were not selected as the central site, the annual volume of waste generated from SNF management activities would ultimately decrease; however, transient activities to stabilize and package the fuel could be substantial. The site selected as the central site would increase the annual volume of wastes generated from SNF management activities. The increase in waste would not necessarily be proportional to the larger amount of SNF being managed onsite because the originating sites would characterize and can their fuel before shipment so it could be placed directly into storage at the receiving site. The waste volumes would be generated from transferring fuel from water pools at some sites, from characterizing and canning small amounts of new fuel, and from operating the expended core facility. Figures 5-8 and 5-9 show the effects of not being selected as well as being selected as the central site for SNF management activities.

5.1.6.4 Radiological Impacts. For the Centralization alternative, the radiological impacts from both normal operations and accidents at both the originating site and the central

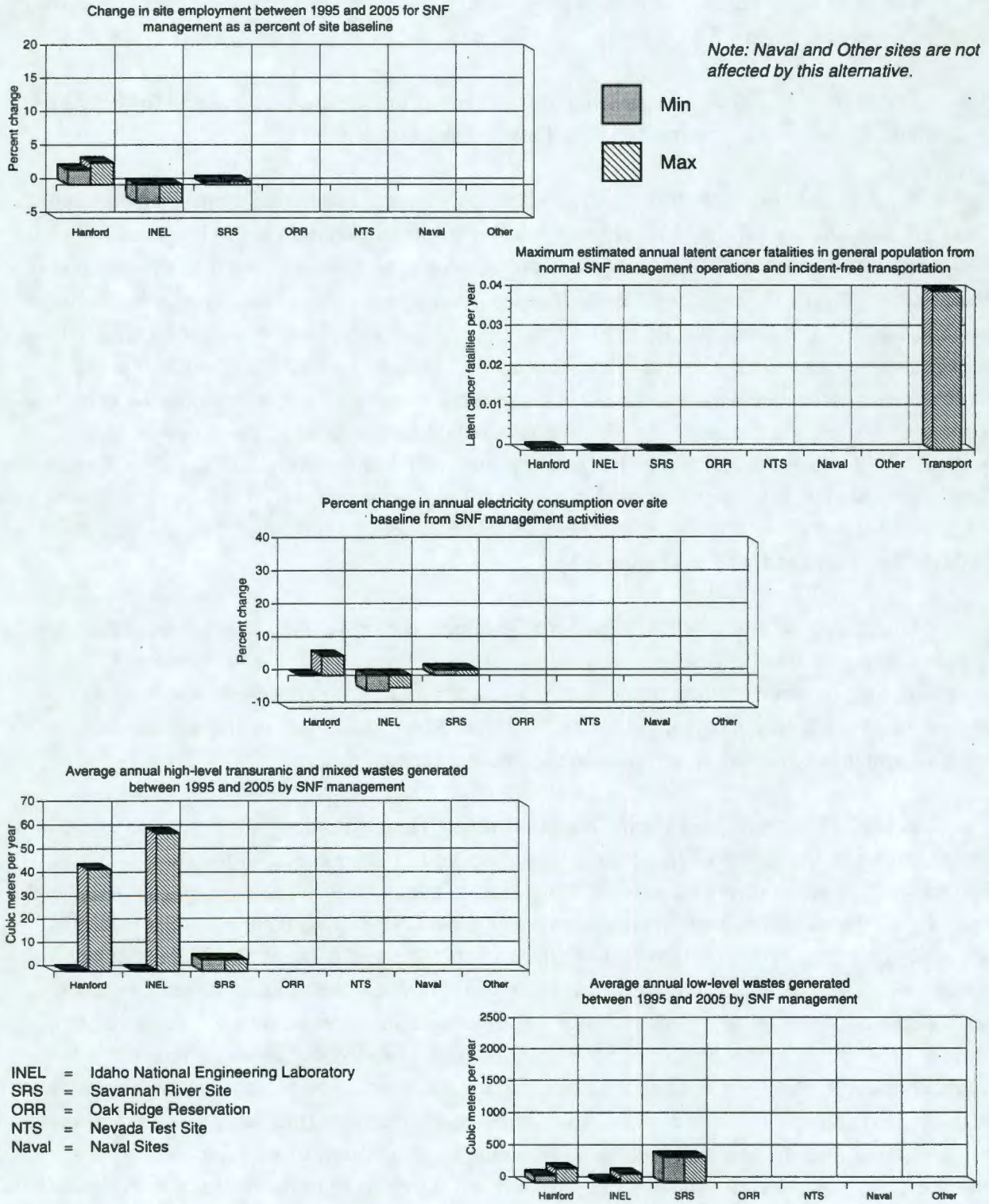
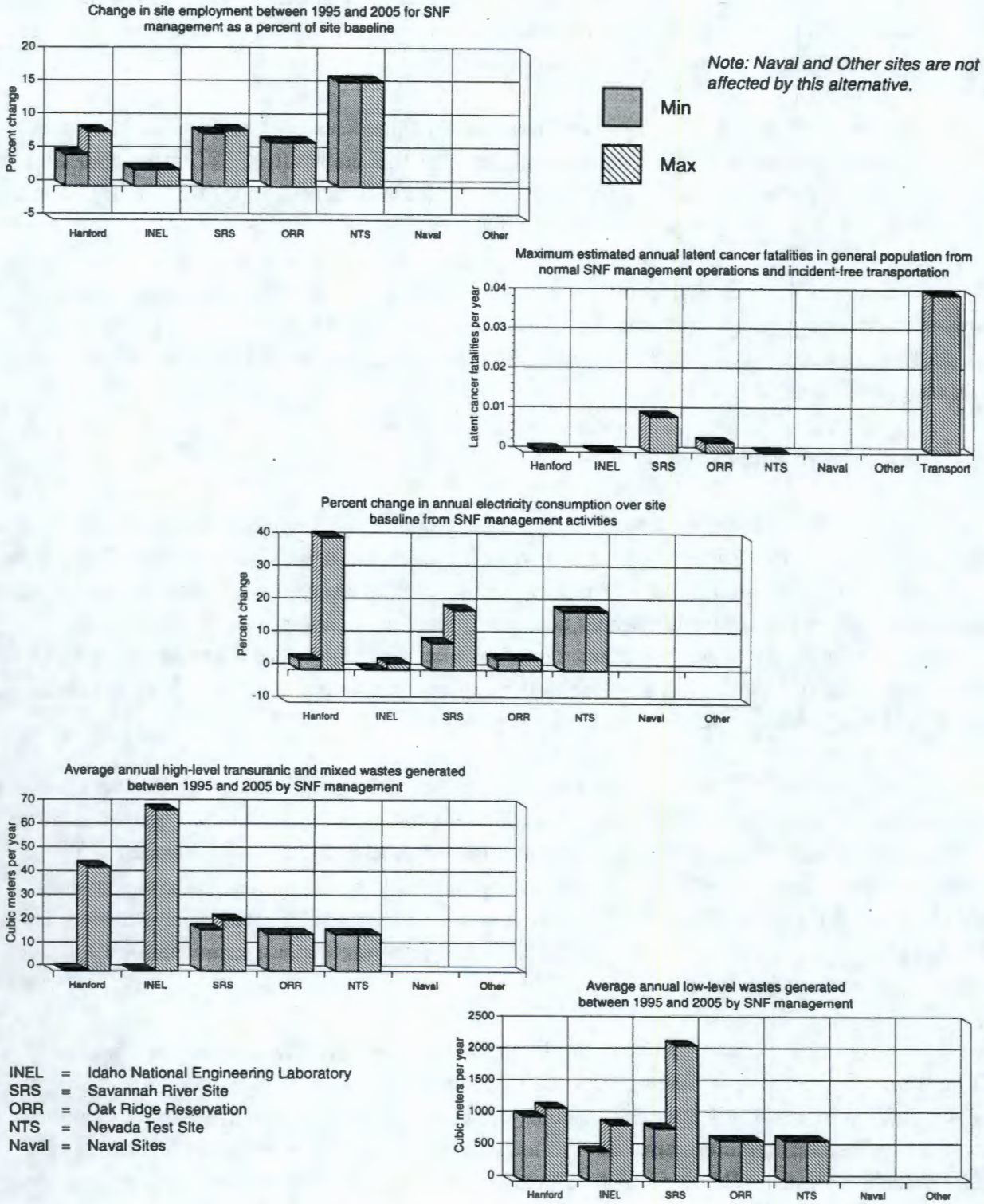


Figure 5-8. Summary of impacts for the Centralization option if sites are not selected as a central site. The maximum incremental change from baseline is illustrated in graphs. Input data summarized in Appendix K.



INEL = Idaho National Engineering Laboratory
SRS = Savannah River Site
ORR = Oak Ridge Reservation
NTS = Nevada Test Site
Naval = Naval Sites

Figure 5-9. Summary of impacts for the Centralization option if sites are selected as a central site and have the expended core facility. The maximum incremental change from baseline is illustrated in graphs. Input data summarized in Appendix K.

storage site are expected to be low and similar in magnitude. Accident analysis for both existing and proposed SNF interim storage facilities indicates that the probabilities of accidents with the potential for significant impacts are extremely low.

Figure 5-7 illustrates the estimated latent cancer fatalities among the population within 80 kilometers (50 miles) from SNF operations at each of the major sites. For each major site, this figure includes the potential impacts associated with site SNF operations with centralization at another site as well as with centralization at that site.

Accident risks from SNF activities are principally due to handling and storage activities and are therefore expected to be similar for each of the centralization sites. The principal differences are due to activities at the existing SNF sites necessary to prepare the SNF for shipment to the central site.

SNF Facility Accidents—

Hanford Site. The implementation of the Centralization alternative at the Hanford site is expected to result in accident risks for some accidents slightly different from those identified for the Decentralization alternative (Section 5.15 of Appendix A). The amount of SNF handled at the dry storage facility would be greater, resulting in an increase in the accident probability for the dry storage cask impact and fire to approximately 8 in 1,000,000. The estimate of risk from this, the highest risk accident to the general population, is 6.5×10^{-4} latent cancer fatalities in the general population per year of operation.

Implementation of the Centralization alternative (or Regionalization B) elsewhere reduces the estimates of accident risks from those identified for the Decentralization alternative because the existing wet storage facilities would be shut down and the amount of SNF handled at the dry storage facility changes slightly. The accident probability for the dry storage cask impact and fire is anticipated to decrease slightly, to approximately 5 in 1,000,000. This yields an estimated risk for this, highest risk accident to a worker, of 7.5×10^{-7} potential latent cancer fatalities in workers per year of operation.

Idaho National Engineering Laboratory. The implementation of the Centralization alternative at Idaho National Engineering Laboratory is estimated in Section 5.15 of Appendix B to result in additional accident scenarios and accident risks from those identified for the Decentralization alternative due to the assumed resumption of chemical processing of SNF at Idaho Chemical Processing Plant Building CPP-666. The SNF-related accident risks from accidents in other facilities remains approximately the same as with the Decentralization alternative. The estimated frequency of fuel handling accidents would change slightly.

Additional accidents are identified in Section 5.15 of Appendix B associated with operation of the Idaho Chemical Processing Plant. They include an inadvertent nuclear criticality

during processing, a hydrogen explosion in the Idaho Chemical Processing Plant dissolver, and the inadvertent dissolution of 30-day cooled SNF in the Idaho Chemical Processing Plant dissolver. The estimated risk from the highest risk accident related to processing, an inadvertent nuclear criticality, is 2.8×10^{-6} potential latent cancer fatalities to the general population per year of operation. This criticality accident also presents the highest onsite risk related to processing to a worker at 100 meters (330 feet), an estimated risk of 4.6×10^{-6} latent cancer fatalities per year of operation.

Savannah River Site. The implementation of the Centralization alternative at the Savannah River Site, including the three options of dry storage, wet storage, and processing followed by dry storage, is assessed in Section 5.15 and Attachment A of Appendix C to result in accidents not significantly different from those identified for the same options under the Decentralization alternative. Because of an increase in the amount of SNF handled, however, the accident frequency for some accidents does increase.

The accident frequency for the highest risk accident, a fuel assembly breach, is expected to be about 0.85 fuel assembly breaches per year of operation with implementation of this alternative. The estimated risk of latent cancer fatalities in the general public and worker are 7.2×10^{-3} and 4×10^{-6} per year of operation. With centralization elsewhere, the highest risk accident is still the fuel assembly breach with an estimated risk approximately the same as with the No Action alternative.

Oak Ridge Reservation. The accident risks associated with implementation of the Centralization alternative at the Oak Ridge Reservation are presented in detail in Section 5.15 (Part 3) of Appendix F. These accident risks are summarized under the Regionalization B alternative.

Nevada Test Site. The accident risks associated with implementation of the Centralization alternative at the Nevada Test Site are presented in detail in Section 5.15 (Part 2) of Appendix F. These accident risks are summarized under the Regionalization B alternative.

Other Generator/Storage Locations. The accident risks under the Centralization alternative are expected to be the same as the accident risks under the No Action alternative.

5.1.6.5 Nonradiological Accidents. Abnormal operational events could result in the release of toxic or hazardous substances from the centralized facility or from SNF management facilities at the Other Storage/Generator sites prior to the shipment of SNF to the central site. The events that would be expected to exceed exposure guidelines would be similar to those described under the 1992/1993 Planning Basis alternative.

Two independent accidents have been evaluated to describe the maximum reasonably foreseeable chemical hazard during the operation of the expended core facility at each of its potential locations. Such a release could subject workers to chemical concentrations that would exceed the Emergency Response Planning Guideline value but would not subject the public to such concentrations except at potential locations on the Oak Ridge Reservation and adjacent to the Savannah River Site.

5.1.6.6 Transportation.

Shipments—Under the Centralization alternative, all stored and newly generated SNF would be shipped to one of five sites: the Hanford Site, the Idaho National Engineering Laboratory, the Savannah River Site, the Oak Ridge Reservation, or the Nevada Test Site.

Incident-Free Transportation—For the five Centralization alternative sites, the incident-free transportation of SNF was estimated to result in total fatalities that ranged from 0.17 to 0.99 for centralization at the Idaho National Engineering Laboratory to 0.20 to 1.6 for centralization at the Savannah River Site. These fatalities were over the 40-year period 1995 through 2035 and represent the sum of the estimated number of radiation-related latent cancer fatalities and the estimated number of nonradiological fatalities from vehicular emissions.

The reason for a range of fatalities was due to two factors: (1) the option of using truck or rail transport for DOE SNF (see Appendix I) and (2) the five centralization options. Navy shipments would be made using a combination of truck and rail; DOE shipments were assumed to be made using 100 percent truck or 100 percent rail.

For centralization at the Idaho National Engineering Laboratory the estimated number of radiation-related latent cancer fatalities for transportation workers ranged from 0.040 to 0.24, the estimated number of radiation-related latent cancer fatalities for the general population ranged from 0.066 to 0.70, and the estimated number of nonradiological cancer fatalities from vehicular emissions ranged from 0.047 to 0.062.

For centralization at the Savannah River Site the estimated number of radiation-related latent cancer fatalities for transportation workers ranged from 0.047 to 0.39, the estimated number of radiation-related latent cancer fatalities for the general population ranged from 0.086 to 1.1, and the estimated number of nonradiological fatalities from vehicular emissions ranged from 0.069 to 0.071.

For centralization at the Idaho National Engineering Laboratory, onsite shipments of SNF were estimated to result in 0.0025 fatalities. Offsite shipments of SNF were estimated to result in 0.17 to 0.99 fatalities. These fatalities were also the sum of the estimated number of radiation-related latent cancer fatalities and the estimated number of nonradiological fatalities from vehicular emissions.

For centralization at the Savannah River Site, onsite shipments of SNF were estimated to result in 0.0026 to 0.0035 fatalities. Offsite shipments of SNF were estimated to result in 0.20 to 1.6 fatalities. These fatalities were also the sum of the estimated number of radiation-related latent cancer fatalities and the estimated number of nonradiological fatalities from vehicular emissions.

Transportation Accidents—Cumulative accident risks for transportation by truck range from 0.00031 latent cancer fatalities and 0.73 traffic fatalities for Centralization at the Idaho National Engineering Laboratory, to 0.0012 latent cancer fatalities and 1.0 traffic fatalities for Centralization at the Savannah River Site. Cumulative accident risks for transportation by rail range from 9.3×10^{-5} latent cancer fatalities and 0.69 traffic fatalities for Centralization at the Idaho National Engineering Laboratory, to 0.00021 latent cancer fatalities and 0.86 traffic fatalities for Centralization at the Nevada Test Site.

For Centralization at either the Hanford Site or the Idaho National Engineering Laboratory, the maximum reasonably foreseeable offsite transportation accident involves a rail shipment of commercial SNF in a suburban population zone under neutral (average) weather conditions. The accident has a probability of occurrence of about 5×10^{-7} per year and the consequences are the same as those described under the 1992/1993 Planning Basis alternative.

For Centralization at the Oak Ridge Reservation or the Nevada Test Site, the maximum reasonably foreseeable offsite transportation accident involves a rail shipment of special-case commercial SNF in an urban population zone under neutral (average) weather conditions. The accident has a probability of occurrence of about 1×10^{-7} per year and could result in an estimated 36 latent cancer fatalities in the exposed population for Oak Ridge Reservation; for the Nevada Test Site, the accident would result in approximately 7 latent cancer fatalities. For comparison, the same population would be expected to experience about 540,000 cancer fatalities from other causes. The probability of this accident occurring under stable (worst-case) weather conditions is less than 1×10^{-7} per year. In a suburban or rural population zone, the accident consequences are estimated to be 6 and 0.2 latent cancer fatalities, respectively.

For Centralization at the Savannah River Site, the bounding offsite transportation accident involves a rail shipment of commercial SNF in a suburban population zone under stable (worst-case) weather conditions. The accident has a probability of occurrence of about 1.7×10^{-7} per year and could result in an estimated 55 latent cancer fatalities in the exposed population. For comparison, the same population would be expected to experience about 42,000 cancer fatalities from other causes. The probability of this accident occurring in an urban population zone is less than 1×10^{-7} per year. In a rural population zone, the accident consequences would be approximately 3 percent of the suburban zone consequences.

Centralization alternative

Onsite transportation of SNF would occur under the Centralization alternative at the Hanford Site, the Idaho National Engineering Laboratory, and the Savannah River Site. The bounding accident among the three sites occurs at the Idaho National Engineering Laboratory, and the potential impacts are the same as those described under the No Action alternative.

Table 5-2 summarizes the comparison of incident-free transportation fatalities for each of the SNF management alternatives. Table 5-3 provides the comparison of transportation accident risks for each of the SNF management alternatives.

Table 5-2. Comparison of incident-free transportation total fatalities for alternatives over the 40-year period.

	Minimum[a,b] total fatalities	Maximum[b,c] total fatalities
No Action	0.0089	0.0089
Decentralization	0.076	0.26
1992/1993 Planning Basis	0.10	0.34
Regionalization A (fuel type)	0.12	0.50
Regionalization B (geography)		
Idaho National Engineering Laboratory and Savannah River Site	0.11	0.41
Idaho National Laboratory and Oak Ridge Reservation	0.11	0.44
Hanford Site and Savannah River Site	0.12	0.44
Hanford Site and Oak Ridge Reservation	0.12	0.48
Nevada Test Site and Savannah River Site	0.14	0.75
Nevada Test Site and Oak Ridge Reservation	0.13	0.81
Centralization		
at Hanford Site	0.19	1.1
at Idaho National Engineering Laboratory	0.17	0.99
at Savannah River	0.20	1.6
at Oak Ridge	0.17	1.5
at Nevada Test Site	0.21	1.4

a. The minimum total fatalities are associated with shipment of DOE fuel by rail, Naval SNF shipments are by both truck (onsite) and rail (offsite).

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

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

Table 5-3. Comparison of estimated transportation accident risks for alternatives over the 40-year period.

Alternative	Truck Accident Risks[a]		Rail Accident Risks[a]	
	Latent cancer fatalities	Traffic fatalities	Latent cancer fatalities	Traffic fatalities
No Action	4.1×10^{-6}	0.047	4.1×10^{-6}	0.047
Decentralization[b]	5.0×10^{-5} to 0.0001	0.1 to 0.92	1.3×10^{-5} to 6.4×10^{-5}	0.12 to 0.93
1992/1993 Planning Basis	0.00014	0.58	6.9×10^{-5}	0.59
Regionalization A (fuel type)	0.0002	0.62	7.8×10^{-5}	0.60
Regionalization B (geography)				
Idaho National Engineering Laboratory and Savannah River Site	0.00011	0.60	5.8×10^{-5}	0.59
Idaho National Engineering Laboratory and Oak Ridge Reservation	0.00017	0.60	6.0×10^{-5}	0.59
Hanford Site and Savannah River Site	0.00052	0.71	0.00045	0.67
Hanford Site and Oak Ridge Reservation	0.00047	0.68	0.00034	0.65
Nevada Test Site and Savannah River Site	0.00036	0.78	0.00017	0.72
Nevada Test Site and Oak Ridge Reservation	0.00041	0.78	0.00017	0.73
Centralization				
at Hanford Site	0.00037	0.79	0.00013	0.74
at Idaho National Engineering Laboratory	0.00031	0.73	9.3×10^{-5}	0.69
at Savannah River	0.0012	1.0	0.00053	0.81
at Oak Ridge	0.0009	0.94	0.00038	0.76
at Nevada Test Site	0.00059	0.94	0.00021	0.86

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

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

5.2 Issues Not Discussed in Detail

This section discusses potential impacts for issues not discussed in detail that are small and do not distinguish among alternatives and about which the public may have general interest. The discussion for each discipline generally concentrates on sites and alternatives that have the largest expected impacts, demonstrating that the environmental consequences for that discipline are not of sufficient importance to be given strong consideration in the programmatic decisionmaking process.

5.2.1 Land Use

The proposed alternatives would not result in major impacts on land use at either the DOE or the Naval sites. The largest amount of land that would be disturbed at any of the DOE sites would be 53 hectares (130 acres) at the Hanford Site. This would occur under the Centralization alternative and would take less than 0.5 percent of the land at that site. Less than 6.5 hectares (16 acres) of land would be required at the Naval sites for the No Action alternative for the storage of SNF on railcars, and no additional land outside of the existing sites would be required. At all SNF sites, new facilities would be located near existing facilities or new facilities would be built on previously disturbed or industrialized land. Because less than 0.5 percent of the land at any of the DOE sites would be needed and the current land use at the Naval sites would not change, land use was determined not to be a discriminating factor (discriminator) among sites or alternatives and is not considered further in this volume. Detail on land use impacts is presented in Appendices A through F. The EIS does not explicitly consider land that is currently used for SNF operations or land that might or might not be made available for other uses under some alternatives.

5.2.2 Cultural Resources

Cultural, archaeological, historic, and architectural resources are defined as prehistoric and historic sites, districts, structures, and evidence of human use that are considered to be important to a culture, subculture, or a community for scientific, traditional, religious, or other reasons.

Most of the major DOE sites and some of the Naval sites contain areas of archaeological, cultural, or historical interest. Direct impacts to archaeological resources would be associated with ground disturbance activities. Indirect impacts would result from improved visitor access, changes in land status, or other actions that would limit future scientific investigation. Although the major DOE sites have not been surveyed completely, the locations for the construction of proposed new facilities have generally been evaluated for their cultural importance. No known cultural resources would be affected by construction under any of the proposed alternatives. Specific surveys would be conducted before beginning any construction to determine the impacts to cultural resources. As described in Section 5.7.3, if cultural resources (for example, prehistoric

or historic artifacts) were encountered during construction, earth-moving activities would stop and the State Historic Preservation Officer would be contacted immediately. If Native American or Native Hawaiian resources were to be involved, their leaders would also be contacted. Impacts to cultural resources were determined not to be an important discriminator among sites and alternatives; therefore, they are not considered further in this chapter. Details on cultural impacts are given in Appendices A through F.

5.2.3 Aesthetic and Scenic Resources

At all DOE sites, any proposed new SNF management facilities would be located far from areas with public access. Where new facilities would be visible to the public, similar facilities are already visible. At Naval sites, SNF storage locations would be located at existing industrial facilities. Aesthetic and scenic resources would not be significantly affected by SNF management activities and are not considered further in this chapter. Discussion of impacts on aesthetic and scenic resources are contained in Appendices A through F.

5.2.4 Geologic Resources

None of the sites has known significant geologic resources that would be affected by the alternatives. Except for the potential existence of gold, tungsten, and molybdenum at the Nevada Test Site, geologic resources at the candidate sites consist of surficial sand, gravel, or clay deposits that have low economic value. The alternatives that involve constructing new facilities would result in disturbing or extracting surface deposits to construct the facilities. New construction would increase the use of surface deposits (that is, sand and gravel deposits), but because of the large volume of these materials on the sites, the impact is expected to be small.

All of the major DOE sites have experienced earthquakes, but they have low seismic potential. Because any new facility would be constructed to meet current seismic design criteria (for example, seismic standard) for a given area, seismic concerns are not a discriminating factor among sites. Details on site geology are provided in Appendices A through F.

5.2.5 Air Quality

SNF management activities under some alternatives would result in slightly increased releases of pollutants to the atmosphere. At the major DOE sites the projected emissions from SNF management activities would not contribute to nonattainment of state or Federal Standards. There would be no impact on nonradiological ambient air quality at the Naval sites (Appendix D). Construction activities at several different sites are expected to cause short-term, minor increases in fugitive dust emissions, but the use of standard dust suppression techniques are expected to mitigate this problem. These particulate emissions could temporarily affect visibility in localized areas but would not cause nonattainment of state or Federal standards. Because SNF

management activities are not expected to cause either radiological or nonradiological air quality impacts to exceed state or Federal standards at any site for any alternative considered, or to significantly affect air quality in any other respect, air quality impacts are not discussed further in this chapter. The potential radiological impacts on health are discussed in Section 5.1. The computer models used for evaluating air quality impacts, and detailed results are discussed in Appendices A through F.

5.2.6 Water Resources

The proposed alternatives would have minor impacts on water resources. Compared to existing activities at all sites, additional water consumption would be minor and would relate primarily to the increased demand of a larger work force because SNF water pools use recycled water. There would be net increases in employment at the Oak Ridge Reservation, and the Nevada Test Site; however, water resources would not be expected to be appreciably affected under any alternative. Nevertheless, at the Nevada Test Site, where available water is limited, a cumulative water supply impact is possible. The effects of groundwater withdrawal from the Ash Meadows sub-basin at the Nevada Test Site to support a proposed SNF facility on groundwater yields and the subsequent effect on aquifer integrity are unknown and require additional study. Some potential also exists for minor, short-term impacts of sedimentation during construction at the Oak Ridge Reservation and the Savannah River Site.

Storing SNF in water pools creates a potential for radiological groundwater contamination through undetected leaks or accidents that breach containment systems. Releases to groundwater caused by accidental minor breaches of leak containment systems are very small compared with accidental minor releases, which are presented in Appendices A through F under Occupational and Public Health and Safety. Water resources are discussed in detail in Appendices A through F.

5.2.7 Ecological Resources

The major DOE sites under consideration are located on large reservations that are predominantly "natural." The Naval sites, on the other hand, are generally much smaller with significant industrial infrastructure. Similarly, the majority of the other generator and storage sites are in urban or suburban settings, where natural flora and fauna are limited to species that have developed a tolerance to human activities. Therefore, the largest impacts to ecological resources are expected to occur at the five major DOE sites where undisturbed or semi-disturbed natural areas could be converted to industrial activity. Under any of the alternatives involving the construction of new facilities at DOE sites, individuals or small populations of some wildlife species may be disturbed, displaced, or destroyed.

The development of new DOE facilities would affect some natural habitats. The size of the areas affected would be small in relation to the size of the sites and the size of remaining natural habitats. The type of habitats affected would vary but would be typical of the regional area in which the sites are located. The habitat losses would probably not affect any threatened or endangered species or critical habitats. As described in Section 5.7.7, mitigation plans would be developed in consultation with the appropriate agencies if any threatened or endangered species were identified on the project site. Habitat fragmentation is not expected because new facilities would be constructed adjacent to existing facilities. Because minor impacts to ecological resources would occur at all sites for all alternatives involving construction, ecology is not considered a significant discriminator among sites and, therefore, is not discussed further in this chapter. Appendices A through F present a detailed discussion of ecological impacts.

5.2.8 Noise

The construction of SNF management facilities at any of the sites would generate noise levels consistent with light industrial activity. However, at the major DOE sites, noise generated onsite does not propagate offsite at levels that would affect the general population. Noise at the Naval sites is primarily from truck and car traffic, shiploading, and diesel-powered equipment. Noise impact analyses at the Naval sites indicate that noise from construction or operation of facilities would not cause the ambient noise levels to exceed U.S. Environmental Protection Agency or state guidelines. Construction would occur at the Naval sites under the No Action and Decentralization alternatives. Noise impacts are expected to be comparable at the major DOE sites for all alternatives except for the No Action alternative, which does not involve construction of new facilities. Because these new facilities would be located in industrialized areas, however, no impacts are expected. Because noise impacts are minor and do not differentiate among the sites or the alternatives, they are not considered further in this chapter. Details on the noise impact analyses are provided in Appendices A through F.

5.2.9 Utilities and Energy

New facilities (or the restarting of idle facilities) would result in increased demands on water, power, and sewage. The greatest resource requirements would result from implementation of the Centralization alternative. Based on available data, the increased water usage would range from less than 1 percent at the Idaho National Engineering Laboratory to a maximum of less than 5 percent above existing site usage at the Savannah River Site. Electricity requirements are discussed in Section 5.1. The increase in sewage generation resulting from implementation of the alternatives would range from less than 1 percent at the Idaho National Engineering Laboratory to a maximum of 9 percent at the Savannah River Site. A central sewage treatment system would have to be constructed for the SNF facilities at the Nevada Test Site under the Regionalization and Centralization alternatives if the Nevada Test Site were selected as a regional or central site.

The existing system capacities at all sites could manage the estimated changes in utility usage rates for water. Appendices A through F provide details on utilities and energy consumption.

5.3 Cumulative Impacts

A cumulative impact on the environment results from the incremental impact of the action when added to other past, present, and reasonably foreseeable actions. "Other" actions include DOE projects at the potentially affected sites not related to SNF management, as well as projects proposed by other Government agencies, private businesses, or individuals. This type of an assessment is important because significant cumulative impacts can result from several smaller actions that by themselves do not have significant impacts. The programmatic cumulative impacts from implementation of the DOE SNF Management Program are discussed in Section 5.3.1. The site-specific cumulative impacts are described in Section 5.3.2.

5.3.1 Programmatic Cumulative Impacts

On a nationwide basis, the implementation of any of the SNF Management Program alternatives would not be expected to significantly contribute to cumulative impacts. There would be a small change in regional employment, little use of nonrenewable resources, low radiological emissions, and a low rate of radioactive waste generation. Under most alternatives, subalternatives, and options, the activities required for SNF management would be very small in comparison to other non-SNF-related activities already underway at almost all sites where SNF would be stored. Even in those alternatives where there would be large changes in nonrenewable resource use at one or more sites (Regionalization by location or Centralization), on a national scale, increases at the selected regional or central site would be compensated for by changes at nonselected sites, so the net change is very small.

Reasonably foreseeable projects that could contribute to cumulative impacts are identified for each of the DOE and Naval sites in Appendices A, B, C, D, and F. For the major DOE sites, these projects are primarily associated with environmental restoration and waste management activities, one of the priorities being given to site management, and are being covered by the Environmental Restoration and Waste Management Programmatic EIS and site-specific EISs. It is expected that SNF management activities would have consistently smaller impacts than the environmental restoration and waste management activities, and that the overall impact of SNF management would not contribute significantly to cumulative impacts on either a regional or a nationwide basis.

The transport of DOE and Naval SNF over highways and railways is only one of the sources of radiological dose to the general public. The potential transport of commercial SNF for disposal in a repository, assumed to be in Nevada for purposes of analysis, the proposed transport of transuranic wastes to the Waste Isolation Pilot Plant in New Mexico, and the expected

transport of radioisotopes used in medicine and other activities all would contribute to public exposures. Available historical data and projected future doses are summarized in Appendix I.

During analysis, the potential for significant cumulative impacts to other resources was considered; none were found. Cumulative impacts are described qualitatively because programmatic considerations do not require detailed information that depends on specific facility location or design. More detailed cumulative effects analysis will be performed for any actions that are proposed in the course of implementing programmatic SNF management decisions.

5.3.2 Site-Specific Cumulative Impacts

All of the sites contain facilities unrelated to SNF that may continue to operate throughout the duration of the SNF interim management program (approximately 40 years). Impacts from both construction and operation of SNF facilities would be cumulative with the impacts of existing and planned facilities or actions such as environmental restoration and waste management activities unrelated to SNF. Cumulative effects involving site-specific projects that are planned to occur simultaneously with SNF management activities at the major DOE sites are discussed in the site appendices. Not all planned facilities were factored into the assessment of cumulative impacts pending funding approval or resolution of DOE policy issues.

The following sections discuss cumulative impacts to those environmental resources identified in Appendices A through F. During analysis, the potential for significant cumulative impacts to other environmental resources (that is, geologic resources, aesthetic and scenic resources, and cultural resources) was evaluated; none were found.

5.3.2.1 Land Use. Implementation of any of the SNF alternatives at the major DOE sites would have a minimal cumulative impact with respect to either the available land onsite or to the continued mission of the sites. The largest proportion of any site that would be required for all sitewide activities is less than 1 percent of the total site area.

5.3.2.2 Socioeconomics. Depending on the economic status and outlook for an area, SNF activities coupled with other actions could have the potential to strain or overburden the socioeconomic resources of certain areas, particularly if either the Regionalization or Centralization alternatives were selected with an expended core facility located at the site. For example, these cumulative effects could contribute to housing shortages and the need for additional schools.

Each site is anticipating an overall decline in site employment over the next few years; therefore, the existing work force could be reassigned to SNF management activities. However, it was assumed that the construction activities associated with the proposed SNF management alternatives would require the in-migration of construction workers. Although these construction

activities are short-term with a duration of a few years, when addressed cumulatively with other reasonably foreseeable activities, there could be a socioeconomic impact in the communities surrounding the Hanford Site, the Nevada Test Site, and the Oak Ridge Reservation. For example, at the Hanford Site cumulative employment, housing requirements, and needs for schools would increase by from 1 to 3 percent over those based on present Hanford employment for SNF management activities only.

Impacts to socioeconomic resources associated with implementation of proposed SNF actions at the Idaho National Engineering Laboratory, the Savannah River Site, the Naval sites, and other generator sites are not expected to be sufficient to have a cumulative effect on the regional social infrastructure within each site's region of influence.

5.3.2.3 Air Quality. The available data in Appendices A through F indicate that the cumulative air emissions from the Savannah River Site, Idaho National Engineering Laboratory, and Naval sites, including those from the proposed SNF management alternatives, would not exceed the limits for nonradioactive air pollutants and would not threaten to exceed the limits for nonradioactive pollutants or the 40 CFR Part 61 limit of 10 millirem per year for radioactive emissions.

5.3.2.4 Biotic Resources. Construction of the proposed SNF facilities in addition to other planned activities could disturb as much as 150 hectares (360 acres) of terrestrial habitat at the Idaho National Engineering Laboratory. No impacts to biotic resources are expected at the Idaho National Engineering Laboratory, the Savannah River Site, or the Oak Ridge Reservation. However, construction activities at the Nevada Test Site and the Hanford Site could result in habitat loss for either Federal and state candidate species or federally listed threatened species. For example, at the Hanford Site the cumulative impact from planned activities including construction related to SNF management could result in habitat loss for Federal and state candidate species (for example, loggerhead shrike, sage sparrows, burrowing owls, pygmy rabbits). At the Nevada Test Site, the proposed SNF facilities would be constructed within the range of the desert tortoise, a federally listed threatened species. Therefore, the proposed SNF management activities in addition to other planned actions could result in a small cumulative loss of habitat for the desert tortoise.

5.3.2.5 Occupational and Public Health. The sources of radiation exposure to individuals consist of natural background radiation from cosmic, terrestrial, and internal body sources; medical radiation; and radiation from manmade sources, including consumer and industrial products, nuclear facilities, and weapons test fallout. At the Savannah River Site for example, natural background radiation contributes about 82 percent of the dose received by an average member of the population within 80 kilometers (50 miles) of the site, medical exposure accounts for 15 percent of the annual dose, and the combined doses from weapons test fallout, consumer and industrial products, and air travel account for approximately 3 percent. DOE

nuclear facilities at the Savannah River Site account for less than 0.1 percent of the total radiation exposure.

The radiological impacts from SNF management operations are exposures to both workers and the general public from normal operations and the risk of additional radiation exposures due to accidents. The major concerns with these exposures are whether the doses are sufficient to cause immediate harm and how much they will increase the probabilities, among the exposed population, of latent cancer fatalities, nonfatal cancers, and genetic effects. Of further concern is that these SNF management-related exposures are in addition to those exposures and risks affecting the same workers and members of the general public from other sources. The cumulative impact of both the SNF-related increment and other possible sources is also a concern.

Cumulative Impacts on the Work Force—

Normal Radioactive Emissions. Data available for each of the sites (see Appendices A through F) indicate that over the 40-year planning period, the cumulative radioactive emissions from the existing, the potential SNF management activities, and reasonably foreseeable future site activities at any of the sites would not be expected to result in an additional latent cancer fatality among the general population surrounding the site. Among workers at the sites, the cumulative normal radioactive impacts from existing site operations and the potential SNF management activities are predicted to result in collective doses to the onsite workers ranging from 36 to 6,800 person-rem over the 40-year planning period. Using the conversion factor of 0.0004 latent cancer fatalities per person-rem, the highest collective dose corresponds to approximately three additional latent cancers among the work force as result of exposures over the evaluation period.

The principal regulatory limit affecting emissions from DOE and Naval sites is the Clean Air Act standard (40 CFR Part 61, Subpart H for DOE; Subpart I for the Navy) for airborne radionuclide emissions from DOE facilities. This rule limits airborne emissions to those amounts that would not cause any member of the public to receive in any year an effective dose equivalent of more than 10 millirem per year. Implementation of any of the alternatives at any of the sites is not expected to result in normal releases exceeding this limit. The Naval sites have demonstrated to the U.S. Environmental Protection Agency that, at 0.1 millirem per year, they are at 1 percent of the limit and operation of SNF management facilities is not expected to change that conclusion.

Overall, at each of the sites under consideration, the cumulative impact to the local and general population from existing, proposed SNF management activities, and reasonably foreseeable environmental restoration and waste management activities from radioactive releases from site operations is expected to result in few if any additional latent cancer fatalities among the general population.

Cumulative Impacts on the Site Work Force—The cumulative impact of selection of either of the alternatives coupled with the existing and reasonably foreseeable actions has the potential to increase the radiological exposure to workers at the sites shipping and receiving the SNF. For both the shipping and receiving sites, the routine exposure to the workers is expected to increase because much of the dose to the workers is associated with SNF handling operations.

Because occupational worker exposures are easily monitored and controlled to levels a factor of ten or more below the current standards, the overall average exposure per worker is expected to remain approximately constant at each of the SNF shipping and receiving sites with each of the alternatives. However, with options that involve more SNF activities, the number of SNF-related workers is expected to increase, thus increasing the collective radiation dose to the site work force. As reported in Appendices A through F and summarized in Appendix K, the increases in collective dose to the work force varies from site to site and with the alternatives. At the Savannah River Site for example, the increases due to SNF-related actions range from 1.2×10^{-5} to 720 person-rem above the site baseline of 380 person-rem. The maximum SNF-related increase is equivalent to approximately one additional latent cancer fatality among the work force.

5.3.2.6 Transportation.

Radiological Impacts—The cumulative radiological impacts of transportation would consist of radiation-related latent cancer fatalities from (a) historical shipments of SNF to the Hanford Site, Idaho National Engineering Laboratory, Savannah River Site, Oak Ridge Reservation, and Nevada Test Site for the period 1943 through 1995, (b) shipments associated with the alternatives evaluated in this EIS, (c) shipments associated with other reasonably foreseeable actions, and (d) the general transport of radioactive material by U.S. Nuclear Regulatory Commission and Agreement State licensees and DOE. (Historical spent fuel accidents are discussed in Section I-8 of Appendix I.) The general transport of radioactive material includes SNF shipments, radioactive waste shipments, and radiopharmaceutical shipments and was estimated for the period 1943 through 2035. Two major reasonably foreseeable actions that may involve extensive transport of radioactive materials are (a) the shipment of commercial SNF and defense high-level waste to a geologic repository, assumed to be located in Nevada for the purposes of analysis and (b) proposed shipments of transuranic waste to the Waste Isolation Pilot Plant in New Mexico. Historical shipments of SNF to the Idaho National Engineering Laboratory include Naval SNF shipments.

The results of the radiological transportation cumulative impacts analysis are summarized in Table 5-4 and more details are contained in Appendix I. Over the 93-year period from 1943 through 2035, the total number of radiation-related latent cancer fatalities was estimated to be 290, or approximately three latent cancer fatalities per year. General transport of radioactive

Table 5-4. Summary of transportation radiological cumulative impacts.

Category of shipment[a]	Occupational latent cancer fatalities	General population latent cancer fatalities
Historical SNF[b]	0.080	0.055
SNF shipments for all alternatives		
Truck	0.00060-0.39	0.00017-1.1
Train	0.00060-0.048	0.00017-0.085
Reasonably foreseeable actions[c]		
Truck	4.4	25
Train	0.33	0.85
General transportation (1943 to 2035)[d]	120	140
Total cancer fatalities[e]	130	160

a. See Appendix I for more details.

b. Shipments to Hanford Site, Idaho National Engineering Laboratory, Savannah River Site, Oak Ridge Reservation, and Nevada Test Site. Includes shipments of Naval SNF to the Idaho National Engineering Laboratory.

c. Shipments to the geologic repository, the Waste Isolation Pilot Plant, and submarine reactor compartment and foreign research reactor SNF shipments.

d. Shipments are a combination of truck and train.

e. Numbers may not sum due to rounding.

material accounted for about 90 percent of these radiation-related latent cancer fatalities. The radiation-related latent cancer fatalities would be indistinguishable from other cancer fatalities and would be 0.001 percent of the total number of cancer fatalities that would be expected to occur. The radiation-related latent cancer fatalities associated with the alternatives evaluated in this EIS would be 5×10^{-6} percent of the total number of cancer fatalities that would be expected to occur.

Traffic Accident Impacts—Fatalities involving the shipment of radioactive materials for 1971 through 1993 were surveyed based on data in the Radioactive Material Incident Report database. This database contains information on radioactive materials transportation incidents and accidents from the U.S. Department of Transportation, U.S. Nuclear Regulatory Commission, DOE, state radiation control offices, and media coverage. From 1971 through 1993, 21 traffic accidents involving 36 fatalities have occurred. These fatalities resulted from traffic

accidents and were not associated with the radioactive nature of the cargo. No radiological fatalities because of transportation accidents have ever occurred in the United States. During the same time period, over 1,000,000 persons were killed in traffic accidents in the United States.

For the alternatives evaluated in this EIS, about one traffic accident fatality was estimated to occur. During the 40-year time period from 1995 through 2035 evaluated in this EIS, approximately 1,600,000 persons would be killed in traffic accidents in the United States.

5.3.2.7 Energy/Utilities. Under certain SNF management alternatives, energy or utility requirements for SNF management in combination with other present for future projects, could stress or exceed the existing capacity at a site. The existing energy and capacity would be adequate for the SNF management alternatives at all sites except the Hanford Site and the Nevada Test Site.

The existing power supply at the Hanford Site would be only marginally able to meet peak demand for one processing option. If all SNF were shipped to the Hanford Site under the Centralization alternative, then existing utilities including water mains, power lines, sewage facilities, and telephone lines would need to be extended to the project area. Therefore, if the Centralization alternative was implemented in addition to other power-intensive activities (for example, operating a vitrification plant), existing capacity would be exceeded.

If the Centralization alterative were implemented at the Nevada Test Site, additional transmission lines might need to be constructed. In addition, a central sewage treatment facility would have to be constructed at the Nevada Test Site if SNF management activities were implemented under the Regionalization and Centralization alternatives. Water supplies at the Nevada Test Site have been developed from local groundwater sources within the Ash Meadows Sub-basin. Existing withdrawals of groundwater from this sub-basin already exceed its perennial yield (Appendix F). SNF management facilities at this site would result in the need for additional water.

5.3.2.8 Waste Generation. The volume of waste produced from the SNF management alternatives is expected to be a small addition to waste volumes generated during other site activities. In particular, environmental restoration activities at the major DOE sites are expected to produce large quantities of radioactive, hazardous, and mixed wastes. Even though the anticipated waste volume from SNF management activities is expected to be small, when addressed cumulatively with other reasonable foreseeable waste-generating activities, waste storage capacity could be affected at some sites.

Waste volumes generated from SNF management activities are expected to be small with respect to the waste volumes generated from other site activities. For purposes of analysis, it was assumed that future generation rates would be the same as the current annual generation rate for

high-level, transuranic, and low-level waste. This approach is conservative, since the future waste volumes do not include those that will be generated from environmental restoration activities at any site except at the Idaho National Engineering Laboratory. At the Idaho National Engineering Laboratory, the maximum total waste volume (high-level, transuranic, and low-level waste) generated from SNF management activities was compared with current and future generation rates. This comparison indicated that with current generation rates, the SNF management alternatives would generate wastes at an annual rate of 1.6 percent above current baseline; if the waste volumes generated from environmental restoration activities are considered, then the annual waste volume generated from SNF management activities would be less than 1 percent of the future waste volumes generated onsite.

To evaluate the adequacy of existing storage capacity, waste volumes generated from the SNF management alternatives were compared to current generation rates at the major DOE sites. At the Navy sites, the rate of low-level waste generation would be small and not stress existing capacity. No mixed, transuranic, or high-level waste would be generated from SNF activities at the Navy sites (Appendix D).

At the major DOE sites, low-level waste generated from SNF management activities would range from less than 1 percent to approximately 5 percent above baseline generation rates at the Idaho National Engineering Laboratory and the Savannah River Site, respectively. Adequate storage capacity exists at all sites except at the Idaho National Engineering Laboratory where beyond the year 2005 low-level waste storage capacity may be strained (Appendix B).

The volume of transuranic waste that could be generated from SNF management activities ranges from less than 1 percent to 100 percent above baseline at the Idaho National Engineering Laboratory and the Nevada Test Site, respectively. This percentage is high at both Nevada Test Site and the Oak Ridge Reservation because neither of these sites is currently generating transuranic waste and because both sites have projected that future transuranic waste volumes will only be produced by SNF management activities. However, adequate storage capacity exists at both sites.

The volume of high-level waste generated from SNF management activities has been estimated to range from approximately 1 percent to 100 percent above current site baselines at the Idaho National Engineering Laboratory and the Savannah River Site, respectively. Again, the percentage is high at the Savannah River Site because essentially no high-level waste is currently being generated onsite, but with processing approximately 2 cubic meters per year (3 cubic meters per year) of high-level waste could be generated. Adequate storage capacity exists at the sites. No high-level waste would be generated at either the Nevada Test Site or the Oak Ridge Reservation.

5.4 Adverse Effects That Cannot Be Avoided

Adverse impacts would result, no matter the alternative, from radiation exposure associated with maintaining facilities that are at or near the end of their design life, until completion of the construction of new facilities. However, these exposures would be kept within applicable regulatory requirements and other applicable guidelines and would be controlled to levels that are as low as reasonably achievable. Implementation of any alternative except the No Action alternative would increase the volume of radioactive waste, in particular, low-level waste generated at the major DOE sites. Under the action-based alternatives, where SNF is transported or shipped to other sites, there is a small increased potential for exposure to the general population when the SNF is in transit.

Under the No Action alternative, there would be several adverse effects that could not be avoided. These include the continuation of the environmentally degraded state of the three major DOE sites because existing facilities would deteriorate further. Naval and research reactor SNF would be stored near population centers potentially increasing the consequences of an SNF handling or management accident. This alternative also presents a greater personnel requirement for managing SNF interim storage facilities (under other alternatives, the apparently higher personnel requirement is for additional management activities that would not be done under the No Action alternative—they are not just related to storage facilities). In addition, the shut-down of research reactors that could not store SNF onsite would result in the loss of several hundred reactor operator and research positions.

Under the Regionalization by location and Centralization alternatives, one or more major DOE sites would ship all of its SNF to another major DOE site, the facilities at the shipping sites would be shut down, and facilities at the receiving site(s) would be built. This would cause the relocation of many jobs associated with SNF management and duplicate some existing facilities. While new facilities are generally required at each DOE site under many alternatives, there are existing facilities that can be used for storage at major sites that would be shut down prior to the end of their useful design life.

The construction and operation of any of the facilities under consideration for storage of SNF would result in some adverse impacts to the environment. Although location-dependent, changes in project design and other methods of mitigation (for example, sound engineering practices during construction) would eliminate, avoid, or minimize these impacts. In general, most of the adverse impacts would be of short duration and would result from the construction of proposed facilities. For example, noise, atmospheric emissions, fugitive dust, sediment runoff, and solid waste would be expected to increase during construction. Section 5.7 discusses mitigation measures that would be used to control or minimize impacts to the environment. See Appendices A through F for site-specific discussion on adverse effects that cannot be avoided.

5.5 Relationship Between Short-Term Use of the Environment and the Maintenance and Enhancement of Long-Term Productivity

Implementation of any of the SNF management alternatives would cause some adverse impacts to the environment and permanently commit certain resources. This section describes the relationship between short-term influences from implementation of an SNF management alternative and the associated long-term effects.

The proposed alternatives for SNF management would require the short-term use of multiple resources; for example, energy, materials of construction, and labor in order to achieve the objective of safely securing SNF to minimize the risk to workers, the public, and to the environment. For example, if no action were taken, degradation of the fuel and SNF facilities would occur with the potential for releases to the environment. Releases to the environment could contaminate land near the point of storage, thereby reducing the potential future use. By consolidating and containing the SNF at specific locations, the potential for impacting the environment is reduced at the other locations. After implementation of a comprehensive SNF management strategy, those areas currently used for SNF management could be released to allow other productive use, such as for research or technology development.

The premature shutdown of research reactors due to a lack of sufficient SNF interim storage space under the No Action alternative could have an impact upon the national and regional communities in which they are located. Most of these reactors are the only regional source of radiopharmaceuticals and often they are important centers of medical and biological research. The sites where these reactors are located, many of them universities, are unique training facilities for students in many fields of research and development: materials science, environmental science, physics, biology, and electronics.

In the medical arena, research reactors have proven to be vital to cancer therapy, diagnostic imaging, studies of the biological effects of radiation and other important medical applications. Demand for medically important radioisotopes would not decrease merely because the source was shut off. The continued demand for radioisotopes would be met by placing orders with remaining reactors, which may be farther away from the place where they are needed. Many medically important isotopes (for example, iodine-131) have such short half-lives that the amount shipped must include enough to allow for radioactive decay during shipment. Therefore, shutdown of reactors would result in the need to produce and ship larger quantities of radiopharmaceuticals.

Shutdown of research reactors could produce an impact on commercial enterprises that are engaged in the doping of silicon crystals through neutron irradiation. The doped silicon chips are widely used in electronic components such as the computers used in automobile engines.

Graduates trained at these facilities contribute to a wide variety of nuclear industries and to Government agencies involved with monitoring nuclear technology, for example, regulatory agencies, Federal and international inspections, hardware for inspections, and remote monitoring.

Development of new SNF interim management facilities would commit lands to those uses from the time of construction through cessation of operations. At that time, these facilities could be converted to other uses or decontaminated, decommissioned, and the site restored to its original land use. Existing SNF management facilities could also be converted to other uses or the lands restored following their decommissioning.

See Appendices A through F for site-specific discussions on the relationship between short-term use of the environment and the maintenance and enhancement of long-term productivity.

5.6 Irreversible and Irretrievable Commitment of Resources

The irreversible and irretrievable commitment of resources resulting from the construction and operation of SNF management facilities would involve materials that could not be recovered or recycled, or resources that would be consumed or reduced to unrecoverable forms. For example, the construction and operation of an SNF facility at any of the locations under consideration would consume irretrievable amounts of electrical energy, fuel, construction materials, and miscellaneous chemicals. Some construction materials are recyclable and, therefore, should not be considered irreversible and irretrievable commitments of resources. Furthermore, some of the resources would be irretrievable because of the nature of the commitment or the cost of reclamation. For example, human resources used for the construction and operation of the proposed SNF facilities would be irretrievably lost since these resources would be unavailable for use in other work activity areas. On the whole, however, SNF management is not particularly resource intensive. See Appendices A through F for site-specific discussions on irreversible and irretrievable commitments of resources.

5.7 Mitigation Measures

This section summarizes mitigation measures that DOE[a] could implement to control or reduce impacts to the environment. These measures would be reviewed and revised as

a. Because this is an EIS issued by the DOE, it contains language concerning compliance with applicable environmental requirements, taking appropriate mitigative measures to reduce environmental impacts, and other matters phrased in the context of DOE as the party taking the actions. As a cooperative agency, and since Navy sites are also evaluated in this EIS, the Navy will also ensure compliance with applicable environmental requirements and take other appropriate measures for its facilities in a consistent and appropriate fashion.

appropriate, depending on the specific actions to be taken at a facility, the level of impact, and other pertinent factors.

Mitigation measures are generally the same for all alternatives and are summarized by resource category below. Although the environmental effects described in Sections 5.1 through 5.3 may not require mitigation, the range of potential mitigation actions is described below. For all sites, impacts to land use and aesthetic and scenic resources would be negligible; therefore, mitigation measures for these attributes would not be required.

5.7.1 Pollution Prevention

Implementation of the SNF management alternatives would generate waste with the potential for releases to air and water. To control both the volume of waste generated and to reduce impacts on the environment, pollution prevention practices would be implemented.

DOE is responding to Executive Order 12856, Federal Compliance with Right to Know Laws and Pollution Prevention Requirements, and associated DOE orders and guidelines by reducing the use of toxic chemicals; improving emergency planning, response, and accident notification; and encouraging the development and use of clean technologies and the testing of innovative pollution prevention technologies. Pollution prevention programs have been implemented at each site. Program components include waste minimization, source reduction and recycling, and procurement practices that preferentially procure products made from recycled materials. Portions of the pollution prevention program have been implemented at the existing DOE and Naval sites for nearly 10 years. For example, the waste minimization program at the Savannah River Site has decreased the amount of all waste types generated by material substitutions.

The SNF Program would be incorporated into these actions. Implementation of the pollution prevention plans would mitigate impacts of wastes generated during SNF management activities.

5.7.2 Socioeconomics

The SNF management alternatives would require additional workers for construction, stabilization, monitoring, and maintenance of SNF. This would produce a socioeconomic effect depending on the available site work force, regional labor pool, and community infrastructure. Minor socioeconomic impacts are anticipated from implementation of the SNF management alternatives; the mitigation measures described below could be used to further minimize the effect on the community.

Construction and operation-related activities resulting in increased labor and capital requirements could be reduced by coordinating with local communities and county planning agencies. Effective planning would address changes in community services, housing, infrastructure, utilities, and transportation. DOE would coordinate, in an appropriate manner, with the local and regional planning agencies to address impacts on the work force and community infrastructure. This could be facilitated through the development of citizen advisory boards.

Other socioeconomic mitigation measures could include increases in payments in lieu of taxes to mitigate increased cost in public services that could occur. The timing of certain activities that have been proposed to proceed concurrently could also be adjusted to mitigate socioeconomic impacts.

5.7.3 Cultural Resources

Impacts to cultural resources would generally occur during construction and earth-moving activities associated with the SNF management alternatives. Areas of proposed ground disturbance would be assessed for the potential to contain important archaeological and paleontological resources. For archaeological resources, mitigation measures would be defined in consultation with the appropriate State Historic Preservation Officer, Advisory Council for Historic Preservation, affected Native American tribes, and Native Hawaiians and could include a Memorandum of Agreement between DOE and these agencies. An example of a mitigation measure for archaeological resources would be avoidance or data recovery prior to construction. Other measures would be necessary to mitigate potential impacts to values of Native American or Native Hawaiian populations, including involvement in the selection of a mitigation strategy for impacts to archaeological sites, spiritual geographical features, and land use. This could include the SNF Program's participation in liaison programs to understand Native American or Native Hawaiian concerns.

For paleontological resources, assessments could include literature searches, surface surveys, and consultation with recognized paleontological experts in the region or limited test excavations in geologically similar disturbed areas. If significant paleontological resources were identified, a mitigation plan for recovery, stabilization, and caring of the resources would be implemented before construction.

For example, at the Hanford Site, certain site activities would have the potential to adversely affect prehistoric archaeological sites. In this case, the specific activity plans would be reviewed to determine potential effects before initiation of activities. The activity will then be designed to avoid these sites. If avoidance of these sites would not be possible, mitigation measures would be developed in conjunction with the appropriate state agencies and Native American tribes.

To avoid impacts during operation such as unauthorized artifact collection, workers would be educated through programs and briefing sessions to inform personnel of applicable laws and regulations for site protection. These educational programs would stress the importance of cultural resources and specifics of the laws and regulations for site protection.

5.7.4 Soils

Soils could be affected from implementation of the SNF management alternatives if there were leaks or a release to soils as a result of SNF activities. DOE would appropriately remediate any soils contaminated from SNF management activities.

5.7.5 Air Resources

Certain actions under the SNF management alternatives would impact air quality. For example, the construction of new facilities could negatively impact air quality through the emission of fugitive dusts and from pollutants from diesel- and gasoline-powered equipment. The increase in offsite ambient levels would be small because of the large distance to the nearest public access, and use of the mitigation measures described below would further minimize the potential impact.

DOE would meet applicable regulations regarding the maintenance of air quality from both radiological and nonradiological emission sources. DOE does not foresee impacts to air quality from SNF management that would warrant mitigation measures beyond those employed consistent with good construction, engineering, and operations, and management practices.

5.7.6 Water Resources

The implementation of some of the SNF management alternatives would require larger volumes of water for the stabilization of SNF. DOE would control water consumption through the appropriate application of water recycling, water conservation measures and equipment, stormwater catchment basins, and worker training programs. Constant process monitoring and mass-balance and design to current standards, including double-wall confinement of all vessels and piping, would be included in design and operating standards by DOE to limit potential operational releases from a SNF processing or storage facility to essentially zero.

5.7.7 Ecological Resources

Implementation of the SNF management alternatives could impact terrestrial resources, wetlands, aquatic resources, and threatened and endangered species either directly by earth-moving activities that disturb habitat or indirectly through construction activities that result in increased runoff into wetlands or aquatic environments.

To mitigate potential impacts to endangered, candidate, or state-identified sensitive species, preconstruction surveys would be completed to determine the presence of these species or their habitat. If protected species or primary habitat for these species are located near or within an area to be disturbed, DOE would evaluate the project design and other program activities to determine if modifications would mitigate potential negative impacts. DOE would consult with the U.S. Fish and Wildlife Service to develop the most appropriate action-specific mitigation measures.

Wetland habitat would be delineated in accordance with applicable Corps of Engineers procedures and wetlands located near proposed activities would be avoided. However, if avoidance were not possible, specific mitigation measures would be developed in consultation with the Corps of Engineers. For example, mitigation could include construction of new wetland acreage equivalent to the acreage of disturbed wetland habitat or enhancement of existing wetland habitat at another location onsite.

5.7.8 Noise

Construction and operation from SNF management would result in the generation of noise consistent with light industrial activity. DOE does not foresee impacts to noise from SNF management that would warrant mitigation measures beyond those employed consistent with good construction engineering, operational, and management practices.

Noise impacts to the public and other noise-sensitive receptors could be reduced by providing noise buffer areas between sources and receptors, constructing noise walls and other attenuation structures, and limiting the emissions to daytime periods.

5.7.9 Traffic and Transportation

The number of workers in SNF management activities under some of the alternatives would add to the current work force and to additional commuting traffic. At sites with increasing traffic concerns, roads could be widened with the addition of lanes or implementation of traffic demand management. DOE would also consider using high-occupancy vehicles (such as vans or buses), implementing car-pooling or ride-sharing programs, or staggering schedules to reduce the potential for increased traffic congestion. See Section 5.7.12 for discussion of transportation accident mitigation.

5.7.10 Occupational and Public Health and Safety

Implementation of the SNF management alternatives would increase the potential for radiation exposure either through direct exposure or through air emissions. Although these effects are small, as discussed in Section 5.2, the as low as reasonably achievable principle would

be used for controlling radiation exposure of workers and the public. Pollution prevention practices would be implemented to avoid or reduce production of potentially harmful substances. Waste minimization would be practiced to reduce the toxicity and volume of secondary wastes to be managed. Furthermore, sites would update their current worker training, emergency planning, emergency preparedness, and emergency response programs as needed to address new SNF management actions for the protection of both workers and the public.

5.7.11 Site Utilities and Support Services

The SNF management alternatives would put increased demands on utilities at the sites. Under certain alternatives, additional transmission lines or substations would need to be added to the infrastructure and, at the Nevada Test Site, a sewage treatment facility would need to be constructed. However, DOE could reduce the need for certain utilities (such as water and electricity) through the implementation of resource conservation, pollution prevention, and energy efficiency measures.

5.7.12 Accidents

The potential exists for an accident associated with either the handling or transportation of SNF with the consequence being a significant release of radioactive or other hazardous materials to the environment. Although the probability is very small, as discussed in Section 5.2, each of the locations considered for SNF management have emergency action plans and equipment to respond to accidents and other emergencies. These plans include training of workers, local emergency response agencies (such as fire departments), and the public; communication systems and protocols; readiness drills; and mutual aid agreements. The plans would be updated to cover any new SNF facilities and activities. DOE would coordinate activities with state and local agencies to establish and implement an appropriate emergency response training program for potential accidents.

6. LIST OF PREPARERS

This EIS was prepared under the supervision of the DOE Idaho Operations Office. The organizations and individuals who contributed to the preparation of this document are listed below accompanied by each person's project role and level of experience and training. Table 6-1 at the end of this section summarizes, for each contributor, the chapters of the EIS for which inputs were prepared.

U.S. Department of Energy Idaho Operations Office

Thomas L. Wichmann, Manager EIS, U.S. DOE
- U.S. Naval Nuclear Propulsion Program Graduate
- Light Water Breeder Reactor/Expended Core Facility Project Officer
- S1W Naval Nuclear Reactor Prototype Project Officer
- Years of Experience: 24
- EIS Project Manager

Kathleen B. Whitaker, Public Affairs Specialist
- BA, 1973, English, University of Utah
- Years of Experience: 16
- EIS Deputy Project Manager

Vicki L. Johnson, General Engineer
- AS, 1984, Mechanical Engineering, Olympic College
- EIT, 1987, State of Washington
- DoD Nuclear Fluid Systems Mechanical Engineering Qualification
- Years of Experience: 15
- Volume 1 Manager

John E. Medema, Health Physicist
- BS, Biology, Central Michigan University
- MS, Biology, Central Michigan University
- Years of Experience: 14
- Volume 2 Manager
- Analytical Lead-Spent Nuclear Fuel and Materials and Waste Management

Mary V. Willcox, Physical Scientist
- BS, 1990, Chemistry, University of New Mexico
- Years of Experience: 4
- EIS Technical Sections Manager

Robert Brown, PE, General Engineer
BS, Electrical Engineering
MA, Business Administration
Years of Experience: 23
Analytical Lead-Utilities and Energy

Robert Creed, Jr., PG, Physical Scientist/Geologist
AS, 1980, Geology, Santa Barbara City College
AS, 1980, Geoscience Technology, Santa Barbara City College
BA, 1983, Earth Sciences, University of California, Santa Cruz
Years of Experience: 6
Analytical Lead-Geology and Water Resources

John A. Herritt, Health Physicist
BS, 1968, Physics, Pennsylvania State University
MS, 1976, Nuclear Physics, Pennsylvania State University
Years of Experience: 12
Analytical Lead-Occupational Health and Safety

Mark W. Howard, Packaging and Transportation Program Manager
BS, 1989, Mechanical Engineering, University of Idaho
Years of Experience: 5
Analytical Lead-Traffic and Transportation, Transportation Accidents

Mary McKnight, Attorney
BA, 1982, Communications, University of Nebraska
JD, 1989, Creighton University
Years of Experience: 5
Analytical Lead—Consultations, Laws, and Requirements

Paul Martin, Environmental Protection Specialist
BA, English
BS, Wildlife
Years of Experience: 20
Analytical Lead-Land Use

Mark S. Pellechi, PE, Nuclear Engineer
BS, 1979, Nuclear Engineering, Polytechnic Institute of New York
Years of Experience: 15
Analytical Lead-Accident Analysis

Ralph W. Russell, Environmental Engineer
BS, 1970, Chemical Engineering, Texas A&M University
Years of Experience: 17
Analytical Lead-Air Resources, Air Quality

Roger Twitchell, Physical Scientist
BS, 1977, Botany, Weber State College
Years of Experience: 17
Analytical Lead-Cultural Resources, Ecological Resources

C. Brooks Weingartner, Environmental Engineer
BS, 1988, Geological Engineering, Montana Tech.
MS, 1991, Environmental Engineering, Montana Tech.
Years of Experience: 3
Analytical Lead-Socioeconomics

Science Applications International Corporation

Dee H. Walker Vice President Technical Staff Consultant	BS, Chemical Engineering MS, Chemical Engineering PhD, Chemical Engineering Years of Experience: 39	SAIC Project Manager
Barry Nichols Vice President	BS, Natural Science Years of Experience: 26	Volume 1 Manager
Robert D. Thomson Assistant Vice President	BS, Zoology MS, Ecology Years of Experience: 19	Volume 1 Deputy Manager
Robert H. Cole Senior Environmental Scientist	BA, Mathematics MA, Environmental Studies Years of Experience: 14	Analyst-Environmental Consequences
Mark A. Dagel Senior Hydrogeologist	BS, Geology MS, Geological Sciences Years of Experience: 10	Analyst-Cumulative Impacts
Thomas D. Enyeart, CHP Senior Staff Scientist	BS, Physics MS, Nuclear Engineering MS, Environmental Engineering Years of Experience: 18	Analyst-Transportation Accident Analysis Analyst-Waste and Materials
R. Kingsley House, PE, Technical Staff Consultant	BS, Mechanical Engineering MS, Engineering Science/ Nuclear Option Years of Experience: 34	Technical Support Coordinator

Scot R. Imus Senior Environmental Scientist	BS, Physical Geography MS, Forest Management Years of Experience: 17	Analyst-Affected Environmental, Impacts, and Cumulative Impacts
Irene Johnson Environmental/ Socioeconomic Analyst	BS, Economics MA, Economics Years of Experience: 5	Analyst-Socioeconomic Impacts
Robert A. Kelly Senior Project Manager	BS, Biology PhD, Zoology/Ecology Years of Experience: 23	Analyst-Environmental Consequences
Steven J. Maheras, CHP Environmental Health Physicist	BA, Zoology MS, Health Physics PhD, Health Physics Years of Experience: 10	Analyst-Transportation Analyst-Incident-Free Transportation Dose Assessments
Mark D. Otis, CHP Environmental Health Health Physicist	BS, Physics MS, Radiation Health PhD, Radioecology Years of Experience: 22	Analyst-Human Health Effects
Douglas Outlaw Senior Project Manager	BS, Nuclear Physics MS, Nuclear Physics PhD, Nuclear Physics Years of Experience: 25	Analyst-Radiological Impacts
Angela Sewall Environmental Geoscientist	BA, Earth Science MS, Geoscience Years of Experience: 6	Analyst-Cumulative Impacts
Brenda Shim Economist	BA, Economics/International Area Studies Years of Experience: 2	Analyst-Socioeconomics
Donald C. Slaughterbeck Senior Engineer	BS, Mechanical Engineering MS, Mechanical Engineering Years of Experience: 27	Analyst-Accident Analysis
Patricia Swain Senior Scientist	BS, Geological Engineering MS, Geology Years of Experience: 18	Analyst-Environment Consequences
Jane Tallman Junior Engineer	BS, Mechanical Engineering Years of Experience: 1	Analyst-Traffic and Transportation
Jeffrey Weiler Division Manager	BA, Political Science MS, Resource Economics/ Environmental Management Years of Experience: 22	Analytical Lead-Various Sections

William Wuest Program Manager	MS, Public Administration Years of Experience: 30	Analyst-Environmental Consequences
Kenneth D. Bulmahn, PE Consultant Consulting Engineer	BS, Mechanical Engineering Years of Experience: 20	Analytical Lead-Spent Nuclear Fuel, High-Level Waste

Ecology and Environment, Inc.

Wendy Green Environmental Planner	MPA, Public Affairs Years of Experience: 9	Public Information Coordinator

Halliburton NUS Corporation

Edward Agoston Senior Hydrologist	BS, Geology MS, Geology Years of Experience: 8	Analyst-Geology
Adel A. Bakr Executive Hydrologist	BS, Geology and Physics MS, Isotope Hydrology PhD, Groundwater Hydrology Years of Experience: 31	Analyst-Geology and Water Resources
Fred R. Bingaman, III Junior Analyst	BA, Economics Years of Experience: 4	Analyst-Materials and Waste Management
Teresa L. Brandt Senior Project Administrator	Years of Experience: 13	Analyst-References, Acronyms and Abbreviations, Glossary
James T. Chaconas, CPSS Senior Soil Scientist	BS, Agronomy Years of Experience: 16	Analyst-Geology, Water Resources, Ecology
Steven J. Connor Consulting Health Physicist Halliburton NUS EIS Manager	BS, Physics MS, Physics Years of Experience: 20	Analyst-Introduction, Affected Environment, Environmental Consequences
William J. Craig Principal Investigator	BS, Forestry MS, Planning Years of Experience: 17	Halliburton NUS EIS Project Manager
Karin Crandall Environmental Scientist	BA, Chemistry Years of Experience: 15	Analyst-Air Resources
James Cross Assistant Analyst	BS, Management Information Systems Years of Experience: 6	Analyst-Introduction, Site Overview, SNF Alternatives, Effects, Impacts

James M. Doenges Halliburton NUS Deputy Project Manager	BS, Biology MS, Biology Years of Experience: 9	Analyst-Cumulative Impacts, Mitigation
J. Peyton Doub Environmental Scientist	BS, Plant Sciences MS, Botany Years of Experience: 7	Analyst-Overview
Kevin S. Dunn Environmental Scientist	BS, Geology Years of Experience: 9	Analyst-Geology, Water Resources
Alan A. Eckmyre Environmental Engineer	BE, Nuclear Engineering BS, Business Administration Years of Experience: 23	Analyst-Materials and Waste Management
Lawrence L. Greenfield Senior Environmental Scientist	BS, Soil Science Years of Experience: 16	Analyst-Occupational Health, Materials and Waste Management
Kristine A. Gunther Assistant Environmental Scientist	BA, Economics MA, Business Administration Years of Experience: 2	Analyst-Land Use, Socioeconomics, Cultural Resources, Aesthetic and Scenic Resources, Site Services
Ernest C. Harr, Jr. Consulting Environmental Scientist	BS, Zoology Years of Experience: 14	Coordinator-Spent Nuclear Fuel Management
Richard H. Holder Program Manager	BS, Electrical Engineering MS, Electrical Engineering MBA, Business Years of Experience: 27	Halliburton NUS Project Manager
Dale T. Huls Nuclear Regulatory/ Analyst Engineer	BS, Mechanical Engineering Years of Experience: 14	Analyst-Accident Analysis
William Hurt	BS, Mechanical Engineering Years of Experience: 19	Analyst-Alternatives
Merance A. Jacaruso Environmental Analyst	Years of Experience: 1	Analyst-Land Use and Socioeconomics
Thomas L. Jentz Consulting Health Physicist	BS, Health Physics Years of Experience: 23	Coordinator-Appendix E
Kathy A. Landkrohn Environmental Scientist	BS, Biology Years of Experience: 18	Analyst-SNF Management at DOE Research Reactors
Richard A. Martineit Executive Engineer	BS, Nuclear Science Years of Experience: 26	Analyst-SNF Management at DOE Research Reactors
Kevin M. Meehan Nuclear Safety Engineer	BS, Mechanical Engineering Years of Experience: 3	Analyst-Accidents

Louise S. Moore Environmental Planner	BA, Geography Years of Experience: 12	Analyst-Cultural Resources
Philip R. Moore Environmental Scientist	BA, English MS, Wildlife and Fisheries Biology Years of Experience: 14	Analytical Lead-Ecology
Aparajita S. Morrison Staff Health Physicist	BS, Health Physics Years of Experience: 9	Analyst-Background, Occupational and Public Health and Safety
Richard S. Nugent Principal Investigator Halliburton NUS EIS Manager	BS, Biology MS, Biology PhD, Marine Science Years of Experience: 25	Analyst-Alternatives, Utilities and Energy, Aesthetics and Scenic Resources
Richard F. Orthen, Jr. Consulting Health Physicist	BS, Chemistry Years of Experience: 13	Analyst-Occupational Health and Safety
Ricky C. Petty Associate Meteorologist	BS, Atmospheric Science Years of Experience: 12	Analyst-Air Resources
Hans Renner Senior Engineering Consultant	BS, Mechanical Engineering MS, Mechanical Engineering Years of Experience: 32	Analyst-SNF Management at Domestic Research Reactors
Julie B. Schilling Analyst	BA, Psychology MA, Public Administration Years of Experience: 12	Analyst-Aesthetic and Scenic Resources, Utilities and Energy
Timothy J. Schott Meteorologist/Assistant Environmental Scientist	BS, Meteorology Years of Experience: 8	Analyst-Air Resources, Occupational Health and Safety
Julie A. Sechen Junior Scientist	BA, Biology Years of Experience: 2	Analyst-Cultural Resources
Michael Septoff	BS, Meteorology MS, Meteorology Years of Experience: 26	Analyst-Air Resources
Ronald J. Smith, CHP Principal Health Physicist	BS, Physics MS, Environmental Engineering Years of Experience: 7	Analyst-Traffic and Transportation
Robin A. Summerhill Associate Ecologist/ Scientist	BS, Environmental Studies Years of Experience: 6	Analyst-Site Overview, Alternatives, Impacts, Effects

Rao S. Tammara Consulting Scientist	BS, Mathematics, Chemistry, Physics MS, Chemical/Nuclear Engineering/Plant Design MS, Environmental Engineering Years of Experience: 20	Analyst-Traffic and Transportation
Alan L. Tolin Hydrologist	BE, Chemical Engineering MS, Chemical Engineering Years of Experience: 23	Analyst-Occupational and Public Health and Safety
Steven M. Varner Engineer	BS, Civil Engineering MA, Architecture	Analyst-Traffic and Transportation, Facility and Transportation Accidents
Gilbert H. Waldman Nuclear Engineer	BS, Nuclear Engineering Years of Experience: 1	Analyst-Occupational and Public Health and Safety
Robert H. Werth Principal Environmental Scientist	BA, Physics Years of Experience: 17	Analyst-Noise

Jason Associates Corporation

Daniel A. Reny	BS, Applied Physics Years of Experience: 14	Analyst-Accident Analysis

Pacific Northwest Laboratory

Rosanne L. Aaberg	BS, Chemical Engineering Years of Experience: 17	Analyst-Dose Calculations
John C. Abbott	BA, Geography MS, Conservation of Natural Resources Years of Experience: 17	Analyst-Affected Environment and Environmental Impacts
John M. Alvis, Jr.	BS, Nuclear Engineering MS, Nuclear Engineering Years of Experience: 6	Analyst-Facility Descriptions
Larry K. Berg	BS, Meteorology Years of Experience: 1	Analyst-Meteorology
Frances M. Berting	BA, Physics MA, Physics PhD, Materials Science Years of Experience: 42	Analyst-Fuel Inventories

Charles A. Brandt	BS, Zoology PhD, Zoology Years of Experience: 10	Analyst-Ecological Characterization
Mitchel E. Cunningham	BS, Nuclear Engineering MS, Nuclear Engineering Years of Experience: 17	Analyst-Spent Nuclear Fuel Management
Colbert E. Cushing Deputy Project Manager	BS, Fisheries Management MS, Limnology PhD, Limnology Years of Experience: 34	Analyst-Ecological Resources
Phillip M. Daling	BS, Physical Metallurgy Years of Experience: 10	Analyst-Transportation Impacts
James F. Donaghue	BS, Civil Engineering JD Years of Experience: 9	Analyst-Materials and Waste Management
Elizabeth A. Flores	BS, Environmental and Plant Science MA, Environmental Studies Years of Experience: 12	Analyst-Materials and Waste Management
Stephen Gajewski	BA English BA Psychology JD Years of Experience: 14	Analyst-Regulatory Framework and Requirements
Clifford S. Glantz	BS, Physics and Atmospheric Sciences MS, Atmospheric Sciences Years of Experience: 12	Analyst-Nonradiological Air Quality Impacts
Richard J. Guenther	BS, Engineering Physics MS, Nuclear Engineering PhD, Nuclear Engineering Years of Experience: 15	Analyst-Alternatives and Facilities Descriptions
George V. Last	BS, Geology Years of Experience: 18	Analyst-Cultural Resources and Land Use
John P. McDonald	AAS, Computer Science AS, Arts and Science BS, Geology Years of Experience: 4	Analyst-Water Quality and Related Consequences
Emmett Moore Project Manager	BS, Chemistry PhD, Physical Chemistry Years of Experience: 20	Project Manager

Iral C. Nelson Deputy Project Manager	BS, Mathematics MA, Physics Years of Experience: 38	Analyst-Environmental Consequences
Ronald C. Phillips	BS, Biology MS, Botany PhD, Botany Years of Experience: 37	Analyst-Geology and Water Resources
Kathleen Rhoads	BS, Microbiology MS, Radiological Sciences Years of Experience: 19	Analyst-Air Quality and Accident Analysis
Chikashi Sato	BS, Chemical Engineering MS, Environmental Health Engineering PhD, Environmental Engineering Years of Experience: 13	Analyst-Water Quality and Related Consequences
Dillard B. Shipler	BS, Mathematics and Science MS, Physics Years of Experience: 30	Analyst-Introduction and Review
Donna J. Stucky	BA, Economics MS, Agricultural Economics Years of Experience: 2	Analyst-Socioeconomics
Betty Tegner	BA, English MA, English Years of Experience: 5	Technical Editing
Gene Whelan	BS, Civil Engineering MS, Mechanics and Hydraulics Years of Experience: 17	Analyst-Water Quality and Related Consequences
Mona K. Wright	BA, Anthropology MA, Anthropology Years of Experience: 15	Analyst-Cultural Resources and Land Use

Naval Nuclear Propulsion Program

Donald P. Alf Head, Reactor Safety and Containment Branch	BS, Electrical Engineering MS, Electrical Engineering Years of Experience: 26	Analyst-Transportation and Facility Safety
Donald P. Doherty Deputy Director, Reactor Materials Division	BS, General Engineering MS, Nuclear Engineering Years of Experience: 33	Analyst-Expended Core Facility

Richard A. Guida, PE Associate Director for Regulatory Affairs	BS, Electrical Engineering MS, Nuclear Engineering MBA, Business Years of Experience: 21	Analyst-Coordinator Naval Nuclear Fuel Management Program
Craig S. Hansen Manager Finance and Administration, Naval Reactors-ID	BA, Operations Management Years of Experience: 7	EIS Project Office Liaison
Raymond F. Kulbitskas Head, Emergency Planning Branch	BChE, Chemical Engineering ME, Chemical Engineering Years of Experience: 29	Analyst-Transportation and Accidents
Michael A. Kuprenas Deputy Manager, Non-prototype Operations, Naval Reactors-ID	BS, Chemical Engineering Years of Experience: 12	Analyst-Spent Nuclear Fuel Management
Lisa S. Megargle Special Assistant to the Associate Director for Regulatory Affairs	BS, Operations Research and Industrial Engineering ME, Civil Engineering Years of Experience: 4	Analyst-Assistant Coordinator, Nuclear Fuel Management Program
Barry K. Miles Head, Transportation and Certification Branch	BS, Chemical Engineering MS, Administration Years of Experience: 24	Analyst-Shipping Container and Shipyard Operations
Andrew N. Richardson Environmental Assistant, Naval Reactors-ID	Naval Reactor Power School Naval Reactors Technical Assistant Qualification Years of Experience: 19	Analyst-Idaho National Engineering Laboratory Naval Reactors
Jeffrey M. Steele, PE Head, Radioactive Waste Disposal and Emissions Control Branch	BA, Biochemistry MA, Biochemistry Years of Experience: 16	Analyst-Naval Nuclear Propulsion Program
Robert H. Steele Director, Reactor Materials Division	BS, Metallurgical Engineering MS, Metallurgical Engineering Years of Experience: 36	Analyst-Naval Fuel Research and Development, Expended Core Facility

Table 6-1. Contributors to Volume 1 of the DOE Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Environmental Impact Statement.

	Chapter										Appendix										
Contributor	ES	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F	G	H	I	J	K
Department of Energy																					
Thomas L. Wichmann	×	×	×	×		×					×	×	×	×	×	×				×	×
Kathleen B. Whitaker	×	×	×	×			×	×	×												
Vicki Johnson	×	×	×	×	×	×	×	×	×		×	×	×	×	×	×	×	×		×	
Mary V. Willcox	×	×	×	×	×	×					×	×	×	×	×	×			×	×	×
Robert Brown											×	×	×	×	×	×					
Robert Creed, Jr.											×	×	×	×	×	×					
John A. Herritt											×	×	×	×	×	×					
Mark W. Howard											×	×	×	×	×	×			×		
Mary McKnight								×													
Paul Martin											×	×	×	×	×	×					
John E. Medema											×	×	×	×	×	×					
Mark S. Pellechi											×	×	×	×	×	×					
Ralph W. Russell											×	×	×	×	×	×					
Roger Twitchell								×			×	×	×	×	×	×					
C. Brooks Weingartner											×	×	×	×	×	×					
Science Applications International Corporation																					
Dee Walker	×	×	×	×																×	
Barry Nichols	×	×	×	×		×													×	×	×
Robert D. Thomson	×	×	×	×	×	×															×
Ken Bulmahn				×	×	×														×	

Table 6-1. (continued).

Contributor	Chapter										Appendix										
	ES	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F	G	H	I	J	K
Robert Cole				×		×		×	×												
Mark A. Dagel						×															
Thomas D. Enyeart					×	×						×							×		
R. Kingsley House											×	×	×		×						
Scot R. Imus					×	×															
Irene Johnson											×	×	×								
Robert A. Kelly	×	×	×	×	×	×															×
Steven J. Maheras						×													×		
Mark D. Otis						×															
Douglas Outlaw		×		×		×													×	×	×
Angela Sewall						×															
Brenda Shim												×									
Donald C. Slaughterbeck						×					×	×	×	×	×	×					
Patricia Swain						×															
Jane B. Tallman																			×		
Jeffrey Weiler					×		×	×	×								×	×			
William Wuest						×															
Ecology and Environment, Inc.																					
Wendy Green								×													
Halliburton NUS																					
Edward Agoston													×								
Adel A. Bakr												×	×								

Table 6-1. (continued).

Contributor	Chapter										Appendix										
	ES	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F	G	H	I	J	K
Fred R. Bingaman, III												×				×					
Teresa L. Brandt															×	×					
James T. Chaconas																×					
Steven J. Connor												×									
William J. Craig													×								
Karin Crandall													×								
James Cross																×					
James Doenges												×									
J. Peyton Doub																×					
Kevin S. Dunn																×					
Alan A. Eckmyre													×								
Lawrence L. Greenfield																×					
Kristine F. Gunther												×	×								
Ernest C. Harr, Jr.															×	×					
Richard H. Holder						×	×					×	×		×	×					
Dale T. Huls													×								
William Hurt												×									
Merance A. Jacaruso																×					
Thomas L. Jentz												×									
Kathy A. Landkrohn															×						
Richard A. Martineit															×						
Kevin. M. Meehan												×									
Louise S. Moore													×		×						

Table 6-1. (continued).

Contributor	Chapter										Appendix										
	ES	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F	G	H	I	J	K
Philip R. Moore																					
Aparajita S. Morrison												×									
Richard S. Nugent													×								
Richard F. Orthen, Jr.												×	×								
Ricky C. Petty																×					
Hans Renner															×						
Julie B. Schilling																×					
Timothy J. Schott																×					
Julie A. Sechen																×					
Michael Septoff												×									
Ronald Smith													×								
Robin A. Summerhill																×					
Rao S. Tammara												×									
Alan L. Tolin																×					
Steven M. Varner																×					
Gilbert H. Waldman																×					
Robert H. Werth													×			×					
Jason Associates Corporation																					
Daniel A. Reny												×									
Pacific Northwest Laboratory																					
Rosanne L. Aabert											×										

Table 6-1. (continued).

Contributor	Chapter										Appendix										
	ES	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F	G	H	I	J	K
John C. Abbott											×										
John M. Alvis, Jr.											×										
Larry K. Berg											×										
Frances M. Berting											×										
Charles A. Brandt											×										
Mitchel E. Cunningham											×										
Colbert E. Cushing											×										
Phillip M. Daling											×										
James F. Donaghue											×										
Elizabeth A. Flores											×										
Stephen Gajewski											×										
Clifford S. Glantz											×										
Richard J. Guenther											×										
George V. Last											×										
John P. McDonald											×										
Emmett Moore											×										
Iral C. Nelson											×										
Ronald C. Phillips											×										
Kathleen Rhoads											×										
Chikashi Sato											×										
Dillard B. Shipler											×										
Donna J. Stucky											×										
Betty Tegner											×										

Table 6-1. (continued).

Contributor	Chapter										Appendix										
	ES	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F	G	H	I	J	K
Gene Whelan											×										
Mona K. Wright											×										
Naval Nuclear Propulsion Program																					
Donald P. Alf														×							
Donald P. Doherty														×							
Richard A. Guida	×	×	×	×	×	×	×	×	×		×	×	×	×	×	×	×	×	×	×	×
Craig S. Hansen	×	×	×	×	×	×	×	×	×		×	×	×	×	×	×	×	×	×	×	×
Raymond F. Kulbitskas														×							
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7. CONSULTATIONS, LAWS, AND REQUIREMENTS

7.1 Consultation

Certain Federal laws, such as the Endangered Species Act, the Fish and Wildlife Coordination Act, and the National Historic Preservation Act, require consultation and coordination with other governmental entities. These consultation and coordination requirements will commence and be completed as site-specific SNF management projects and decisions are proposed. To the extent that this EIS supports existing site-specific proposals, those consultations and coordination efforts are explained in Volume 2 or the site-specific appendices.

7.2 Laws and Requirements

This section identifies and summarizes the major laws, regulations, executive orders, and DOE orders that may apply to the programmatic alternatives for SNF.

Section 7.2.1 discusses the major Federal statutes that impose environmental protection and compliance requirements upon DOE. In addition, there may be other Federal, state, and local measures applicable to the SNF Management Program because Federal law delegates enforcement or implementation authority to state or local agencies. These state- and local-specific requirements are addressed in the site-specific appendices. Section 7.2.2 addresses environmentally-related presidential executive orders that clarify issues of national policy and set guidelines under which Federal agencies, including DOE, must act. DOE implements its responsibilities for protection of public health, safety, and the environment through a series of departmental orders that are mandatory for operating contractors of DOE-owned facilities. Section 7.2.3 discusses those DOE orders related to environmental, health, and safety protection. Hazardous and radioactive materials transportation regulations are summarized in Section 7.2.4.

7.2.1 Federal Environmental Statutes and Regulations

National Environmental Policy Act of 1969, as amended (42 USC §4321 et seq.)
The National Environmental Policy Act establishes a national policy promoting awareness of the environmental consequences of the activity of humans on the environment and promoting consideration of the environmental impacts during the planning and decisionmaking stages of a project. The National Environmental Policy Act requires all agencies of the Federal Government to prepare a detailed statement on the environmental effects of proposed major Federal actions that may significantly affect the quality of the human environment.

This EIS has been prepared in response to these National Environmental Policy Act requirements and policies. It discusses reasonable alternatives and their potential environmental

consequences of proposed SNF activities at various locations in the country and has been prepared in accordance with the Council on Environmental Quality Regulations for implementing the procedural provisions of the National Environmental Policy Act Implementing Procedures (40 CFR Parts 1500 through 1508) and DOE National Environmental Policy Act Implementing Procedures (10 CFR Part 1021).

Atomic Energy Act of 1954, as amended (42 USC §2011 et seq.). The Atomic Energy Act of 1954 authorizes DOE to establish standards to protect health or minimize dangers to life or property with respect to activities under its jurisdiction. Through a series of DOE orders, DOE has established an extensive system of standards and requirements to ensure safe operation of its facilities.

The Atomic Energy Act and the Reorganization Plan No. 3 of 1970 [5 USC (app. at 1343)] and other related statutes gave the U.S. Environmental Protection Agency responsibility and authority for developing generally applicable environmental standards for protection of the general environment from radioactive material. The U.S. Environmental Protection Agency has promulgated several regulations under this authority, among which are the Environmental Radiation Protection Standards for the Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Wastes, at 40 CFR Part 191.

Nuclear Waste Policy Act of 1982, as amended, (42 USC §10101-10270). The Act authorizes the Federal agencies to develop a geologic repository for the permanent disposal of SNF and high-level radioactive waste. The Act specifies the process for selecting a repository site and constructing, operating, closing, and decommissioning the repository. The Act also establishes programmatic guidance for these activities.

Clean Air Act, as amended (42 USC §7401 et seq.). The Clean Air Act, as amended, is intended to "protect and enhance the quality of the Nation's air resources so as to promote the public health and welfare and the productive capacity of its population." Section 118 of the Clean Air Act, as amended, requires that each Federal agency, such as DOE, with jurisdiction over any property or facility that might result in the discharge of air pollutants, comply with "all Federal, state, interstate, and local requirements" with regard to the control and abatement of air pollution.

The Act requires the U.S. Environmental Protection Agency to establish National Ambient Air Quality Standards as necessary to protect public health, with an adequate margin of safety, from any known or anticipated adverse effects of a regulated pollutant (42 USC §7409). The Act also requires establishment of national standards of performance for new or modified stationary sources of atmospheric pollutants (42 USC §7411) and requires specific emission increases to be evaluated so as to prevent a significant deterioration in air quality (42 USC §7470). Hazardous air pollutants, including radionuclides, are regulated separately

(42 USC §7412). Air emissions are regulated by the U.S. Environmental Protection Agency in 40 CFR Parts 50 through 99. In particular, radionuclide emissions are regulated under the National Emission Standard for Hazardous Air Pollutants Program (see 40 CFR Part 61).

Safe Drinking Water Act, as amended [42 USC §300 (F) et seq.]. The primary objective of the Safe Drinking Water Act, as amended, is to protect the quality of the public water supplies and all sources of drinking water. The implementing regulations, administered by the U.S. Environmental Protection Agency unless delegated to the states, establish standards applicable to public water systems. They promulgate maximum contaminant levels, including those for radioactivity, in public water systems, which are defined as public water systems that serve at least 15 service connections used by year-round residents or regularly serve at least 25 year-round residents. Safe Drinking Water Act requirements have been promulgated by the U.S. Environmental Protection Agency in 40 CFR Parts 100 through 149. For radioactive material, the regulations specify that the average annual concentration of man-made radionuclides in drinking water as delivered to the user by such a system shall not produce a dose equivalent to the total body or an internal organ greater than 4 millirem per year beta activity. Other programs established by the Safe Drinking Water Act include the Sole Source Aquifer Program, the Wellhead Protection Program, and the Underground Injection Control Program.

Clean Water Act, as amended (33 USC §1251 et seq.). The Clean Water Act, which amended the Federal Water Pollution Control Act, was enacted to "restore and maintain the chemical, physical and biological integrity of the Nation's water." The Clean Water Act prohibits the "discharge of toxic pollutants in toxic amounts" to navigable waters of the United States. Section 313 of the Clean Water Act, as amended, requires all branches of the Federal Government engaged in any activity that might result in a discharge or runoff of pollutants to surface waters to comply with Federal, state, interstate, and local requirements.

In addition to setting water quality standards for the Nation's waterways, the Clean Water Act supplies guidelines and limitations for effluent discharges from point-source discharges and provides authority for the U.S. Environmental Protection Agency to implement the National Pollutant Discharge Elimination System permitting program. The National Pollutant Discharge Elimination System program is administered by the Water Management Division of the U.S. Environmental Protection Agency pursuant to regulations in 40 CFR Part 122 et seq. Idaho has not applied for National Pollutant Discharge Elimination System authority from the U.S. Environmental Protection Agency. Thus, all National Pollutant Discharge Elimination System permits required for the Idaho National Engineering Laboratory are obtained by DOE through the U.S. Environmental Protection Agency Region 10 (40 CFR Part 122 et seq.).

Sections 401 and 405 of the Water Quality Act of 1987 added Section 402(p) to the Clean Water Act. Section 402(p) requires that the Environmental Protection Act establish regulations for issuing permits for stormwater discharges associated with industrial activity. Although any

stormwater discharge associated with industrial activity requires a National Pollutant Discharge Elimination System permit application, regulations implementing a separate stormwater permit application process have not yet been adopted by the U.S. Environmental Protection Agency.

Resource Conservation and Recovery Act, as amended (42 USC §6901 et seq.). The treatment, storage, or disposal of hazardous and nonhazardous waste is regulated under the Solid Waste Disposal Act, as amended by the Resource Conservation and Recovery Act and the Hazardous and Solid Waste Amendments of 1984. Pursuant to Section 3006 of the Act, any state that seeks to administer and enforce a hazardous waste program pursuant to the Resource Conservation and Recovery Act may apply for U.S. Environmental Protection Agency authorization of its program. The U.S. Environmental Protection Agency regulations implementing the Resource Conservation and Recovery Act are found in 40 CFR Parts 260 through 280. These regulations define hazardous wastes and specify hazardous waste transportation, handling, treatment, storage, and disposal requirements.

The regulations imposed on a generator or a treatment, storage, and/or disposal facility vary according to the type and quantity of material or waste generated, treated, stored, and/or disposed of. The method of treatment, storage, and/or disposal also impacts the extent and complexity of the requirements (see also Section 7.2.5).

Comprehensive Environmental Response, Compensation, and Liability Act, as amended (42 USC §9601 et seq.). The Comprehensive Environmental Response, Compensation, and Liability Act, as amended, provides a statutory framework for the cleanup of waste sites containing hazardous substances and—as amended by the Superfund Amendments and Reauthorization Act—provides an emergency response program in the event of a release (or threat of a release) of a hazardous substance to the environment. Using the Hazard Ranking System, Federal and private sites are ranked and may be included on the National Priorities List. The Comprehensive Environmental Response, Compensation, and Liability Act, as amended, requires such Federal facilities having such sites to undertake investigations and remediation as necessary. The Act also includes requirements for reporting releases of certain hazardous substances in excess of specified amounts to state and Federal agencies.

Emergency Planning and Community Right-to-Know Act of 1986 (42 USC §11001 et seq.) (also known as "SARA Title III"). Under Subtitle A of this Act, Federal facilities, including those owned by DOE, provide various information (such as inventories of specific chemicals used or stored and releases that occur from these sites) to the State Emergency Response Commission and to the Local Emergency Planning Committee to ensure that emergency plans are sufficient to respond to unplanned releases of hazardous substances. Implementation of the provisions of this Act began voluntarily in 1987, and inventory and annual emissions reporting began in 1988 based on 1987 activities and information. DOE also requires

compliance with Title III as matter of Agency policy. The requirements for this Act were promulgated by the U.S. Environmental Protection Agency in 40 CFR Parts 350 through 372.

Toxic Substances Control Act (15 USC §2601 et seq.). The Toxic Substances Control Act provides the U.S. Environmental Protection Agency with the authority to require testing of chemical substances, both new and old, entering the environment, and regulates them where necessary. The law supplements existing toxic substance laws such as §112 of the Clean Air Act and §307 of the Clean Water Act. The Toxic Substances Control Act came about because there were no general Federal regulations for the potential environmental or health effects of the thousands of new chemicals developed each year before they were introduced into the public or commerce. The Toxic Substances Control Act also regulates the treatment, storage, and disposal of certain toxic substances not regulated by Resource Conservation and Recovery Act or other statutes, particularly polychlorinated biphenyls, chlorofluorocarbons, and asbestos.

Federal Facility Compliance Act. The Federal Facility Compliance Act, enacted on October 6, 1992, waives sovereign immunity for fines and penalties for Resource Conservation and Recovery Act violations at Federal facilities. However, a provision postpones fines and penalties after 3 years for mixed waste storage prohibition violations at DOE sites and requires DOE to prepare plans for developing the required treatment capacity for mixed waste stored or generated at each facility. Each plan must be approved by the host state or the U.S. Environmental Protection Agency, after consultation with other affected states, and a consent order must be issued by the regulator requiring compliance with the plan. The Federal Facility Compliance Act further provides that the DOE will not be subject to fines and penalties for land disposal restriction storage prohibition violations for mixed waste as long as it is in compliance with such an approved plan and consent order and meets all other applicable regulations.

National Historic Preservation Act, as amended (16 USC §470 et seq.). The National Historic Preservation Act, as amended, provides that sites with significant national historic value be placed on the *National Register of Historic Places*. There are no permits or certifications required under the Act. However, if a particular Federal activity may impact a historic property resource, consultation with the Advisory Council on Historic Preservation will generally generate a Memorandum of Agreement, including stipulations that must be followed to minimize adverse impacts. Coordinations with the State Historic Preservation officer are also undertaken to ensure that potentially significant sites are properly identified and appropriate mitigative actions are implemented.

Archaeological Resource Protection Act, as amended (16 USC §470aa et seq.). This Act requires a permit for any excavation or removal of archaeological resources from public or Indian lands. Excavations must be undertaken for the purpose of furthering archaeological knowledge in the public interest, and resources removed are to remain the property of the United

States. Consent must be obtained from the Indian tribe owning lands on which a resource is located before issuance of a permit, and the permit must contain terms or conditions requested by the tribe.

Native American Grave Protection and Repatriation Act of 1990 (25 USC §3001). This law directs the Secretary of Interior to guide responsibilities in repatriation of Federal archaeological collections and collections held by museums receiving Federal funding that are culturally affiliated to Native American tribes. Major actions to be taken under this law include (a) establishing a review committee with monitoring and policy-making responsibilities, (b) developing regulations for repatriation, including procedures for identifying lineal descent or cultural affiliation needed for claims, (c) oversight of museum programs designed to meet the inventory requirements and deadlines of this law, and (d) developing procedures to handle unexpected discoveries of graves or grave goods during activities on Federal or tribal land.

American Indian Religious Freedom Act of 1978 (42 USC §1996). This act reaffirms Native American religious freedom under the First Amendment and sets United States policy to protect and preserve the inherent and constitutional right of American Indians to believe, express, and exercise their traditional religions. The act requires that Federal actions avoid interfering with access to sacred locations and traditional resources that are integral to the practice of religions.

Religious Freedom Restoration Act of 1993 (42 USC §2000bb et seq.). This Act prohibits the Government, including Federal departments, from substantially burdening the exercise of religion unless the Government demonstrates a compelling governmental interest and the action furthers a compelling Government interest and is the least restrictive means of furthering that interest.

Endangered Species Act, as amended (16 USC §1531 et seq.). The Endangered Species Act, as amended, is intended to prevent the further decline of endangered and threatened species and to restore these species and their habitats. The Act is jointly administered by the U.S. Departments of Commerce and the Interior. Section 7 of the Act requires consultation with the U.S. Fish and Wildlife Service to determine whether endangered and threatened species or their critical habitats are known to be in the vicinity of the proposed action.

Migratory Bird Treaty Act, as amended (16 USC §703 et seq.). The Migratory Bird Treaty Act, as amended, is intended to protect birds that have common migration patterns between the United States and Canada, Mexico, Japan, and Russia. It regulates the harvest of migratory birds by specifying things such as the mode of harvest, hunting seasons, and bag limits. The Act stipulates that it is unlawful at any time, by any means, or in any manner to "kill . . . any migratory bird." Although no permit for this project is required under the Act, DOE is required to consult with the U.S. Fish and Wildlife Service regarding impacts to migratory birds and to

evaluate ways to avoid or minimize these effects in accordance with the U.S. Fish and Wildlife Service Mitigation Policy.

Bald and Golden Eagle Protection Act, as amended (16 USC §668-668d). The Bald and Golden Eagle Protection Act makes it unlawful to take, pursue, molest, or disturb bald (American) and golden eagles, their nests, or their eggs anywhere in the United States (Section 668, 668c). A permit must be obtained from the U.S. Department of the Interior to relocated a nest that interferes with resource development or recovery operations.

Wild and Scenic Rivers Act, as amended (16 USC 1271 et seq. 71:8301 et seq.). The Wild and Scenic Rivers Act, as amended, protects certain selected rivers of the Nation, which possess outstanding scenic, recreational, geological, fish and wildlife, historical, cultural, or other similar values. These rivers are to be preserved in a free-flowing condition to protect water quality and other vital national conservation purposes. The purpose of the Act is to institute a national wild and scenic rivers system, to designate the initial rivers that are a part of that system, and to develop standards for the addition of new rivers in the future.

Occupational Safety and Health Act of 1970, as amended (29 USC §651 et seq.). The Occupational Safety and Health Act establishes standards to enhance safe and healthful working conditions in places of employment throughout the United States. The Act is administered and enforced by the Occupational Safety and Health Administration, a U.S. Department of Labor agency. While the Occupational Safety and Health Administration and the U.S. Environmental Protection Agency both have a mandate to reduce exposures to toxic substances, the Occupational Safety and Health Administration's jurisdiction is limited to safety and health conditions that exist in the workplace environment. In general, under the Act, it is the duty of each employer to furnish all employees a place of employment free of recognized hazards likely to cause death or serious physical harm. Employees have a duty to comply with the occupational safety and health standards and all rules, regulations, and orders issued under the Act. Occupational Safety and Health Administration regulations (published in Title 29 of the Code of Federal Regulations) establish specific standards telling employers what must be done to achieve a safe and healthful working environment. DOE places emphasis on compliance with these regulations at DOE facilities and prescribes through DOE orders the Occupational Safety and Health Act standards that contracts shall meet, as applicable to their work at Government-owned, contractor-operated facilities (DOE Order 5480.1B, 5483.1A). DOE keeps and makes available the various records of minor illnesses, injuries, and work-related deaths as required by Occupational Safety and Health Administration regulations.

Noise Control Act of 1972, as amended (42 USC §4901 et seq.). Section 4 of the Noise Control Act of 1972, as amended, directs all Federal agencies to carry out "to the fullest extent within their authority" programs within their jurisdictions in a manner that furthers a national policy of promoting an environment free from noise that jeopardizes health and welfare.

7.2.2 Executive Orders

Executive Order 12088 (Federal Compliance with Pollution Control Standards) (October 13, 1978), as amended by Executive Order 12580 (January 23, 1987) Federal Compliance with Pollution Control Standards, directs Federal agencies, including DOE, to comply with applicable administrative and procedural pollution control standards established by, but not limited to, the Clean Air Act, the Noise Control Act, the Clean Water Act, the Safe Drinking Water Act, the Toxic Substances Control Act (15 USC §2061 et seq.), and the Resource Conservation and Recovery Act.

Executive Order 11593 (National Historic Preservation) (May 13, 1971) directs Federal agencies, including DOE, to locate, inventory, and nominate properties under their jurisdiction or control the *National Register of Historic Places* if those properties qualify. This process requires DOE to provide the Advisory Council on Historic Preservation the opportunity to comment on the possible impacts of the proposed activity on any potential eligible or listed resources.

Executive Order 11514 (National Environmental Policy Act) directs Federal agencies to continually monitor and control their activities to protect and enhance the quality of the environment and to develop procedures to ensure that fullest practicable provision of timely public information and understanding of the Federal plans and programs with environmental impact to obtain the views of interested parties. The DOE has issued regulations (10 CFR Part 1021) and DOE Order 5440.1E for compliance with this executive order.

Executive Order 11988 (Floodplain Management) directs Federal agencies to establish procedures to ensure that the potential effects of flood hazards and floodplain management are considered for any action undertaken in a floodplain and that floodplain impacts be avoided to the extent practicable.

Executive Order 11990 (Protection of Wetlands) directs governmental agencies to avoid, to the extent practicable, any short-and long-term adverse impacts on wetlands wherever there is a practicable alternative.

Executive Order 12344 (Naval Nuclear Propulsion Program) [enacted as permanent law by Public Law 98-525 (42 USC §7158)] prescribes the authority and responsibility of the Naval Nuclear Propulsion Program, a joint Navy/DOE organization, for matters pertaining to Naval nuclear propulsion. These responsibilities include all environmental and occupational safety and health aspects of the program.

Executive Order 12580 (Superfund Implementation) delegates to the heads of executive departments and agencies the responsibility for undertaking remedial actions for releases, or threatened releases that are not on the National Priority List and removal actions other than

emergencies where the release is from any facility under the jurisdiction or control of executive departments and agencies.

Executive Order 12856 (Right to Know Laws and Pollution Prevention Requirements) This order directs all Federal agencies to reduce and report toxic chemicals entering any wastestream; improve emergency planning, response, and accident notification; and encourage clean technologies and testing of innovative prevention technologies. The executive order also provides that Federal agencies are persons for purposes of the Emergency Planning and Community Right-to-Know Act (SARA Title III), which obliges agencies to meet the requirements of the Act.

Executive Order 12898 (Environmental Justice) This order directs Federal agencies to achieve environmental justice by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations in the United States and its territories and possessions. The order creates an Interagency Working Group on Environmental Justice and directs each Federal agency to develop strategies within prescribed time limits to identify and address environmental justice concerns. The order further directs each Federal agency to collect, maintain, and analyze information on the race, national origin, income level, and other readily accessible and appropriate information for areas surrounding facilities or sites expected to have a substantial environmental, human health, or economic effect on the surrounding populations, when such facilities or sites become the subject of a substantial Federal environmental administrative or judicial action and to make such information publicly available.

7.2.3 Department of Energy Regulations and Orders

Through the authority of the Atomic Energy Act, DOE is responsible for establishing a comprehensive health, safety, and environmental program for its facilities. The regulatory mechanisms through which DOE manages its facilities are the promulgation of regulations and the issuance of DOE orders.

The DOE regulations are generally found in Title 10 of the Code of Federal Regulations. These regulations address such areas as energy conservation, administrative requirements and procedures, nuclear safety, and classified information. For purposes of this EIS, relevant regulations include 10 CFR Part 834, Radiation Protection of the Public and the Environment; 10 CFR Part 835, Occupational Radiation Protection; 10 CFR Part 1021, Compliance with the National Environmental Policy Act; and 10 CFR Part 1022, Compliance with Floodplains/ Wetlands Environmental Review Requirements.

DOE orders generally set forth policy and the programs and internal procedures for implementing those policies. The major DOE orders pertaining to the eventual construction and

operation of SNF facilities within the DOE Complex are listed in Table 7-1. The following sections provide a brief discussion of selected orders:

DOE Order 5440.1E, National Environmental Policy Act Compliance Program. This order establishes authorities and responsibilities of DOE officials and sets forth internal procedures for implementing the National Environmental Policy Act. This order was issued by DOE on November 10, 1992.

DOE Order 5480.1B, Environment Safety and Health Program for Department of Energy Operations. This order establishes the Environment, Safety and Health Program for DOE operations.

7.2.4 Hazardous and Radioactive Materials Transportation Regulations

Transportation of hazardous and radioactive materials, substances, and wastes are governed by the U.S. Department of Transportation, U.S. Nuclear Regulatory Commission, and U.S. Environmental Protection Agency regulations. These regulations may be found in 49 CFR Parts 171 through 178, 49 CFR Parts 383 through 397, 10 CFR Parts 71, and 40 CFR Part 262, respectively.

U.S. Department of Transportation regulations contain requirements for identifying a material as hazardous or radioactive. These regulations interface with those of the U.S. Nuclear Regulatory Commission or U.S. Environmental Protection Agency regulations for identifying material, but the U.S. Department of Transportation hazardous material regulations govern the hazard communication (such as marking, hazard labelling, vehicle placarding, and emergency response telephone number) and shipping requirements (such as required entries on shipping papers or U.S. Environmental Protection Agency waste manifests).

U.S. Nuclear Regulatory Commission regulations applicable to radioactive materials transportation are found in 10 CFR Part 71, which includes detailed packaging design requirements and package certification testing requirements. Complete documentation of design and safety analysis and results of the required testing is submitted to the U.S. Nuclear Regulatory Commission to certify the package for use. This certification testing involves the following components: heat, physical drop onto an unyielding surface, water submersion, puncture by dropping package onto a rigid spike, and gas tightness. Some of the required tests simulate maximum credible accident conditions.

Table 7-1. DOE orders relevant to the DOE Spent Nuclear Fuel Management Program.

DOE Order	Subject
1300.2A	Department of Energy Technical Standards Program (5-19-92)
1360.2B	Unclassified Computer Security Program (5-18-92)
1540.2	Hazardous Material Packaging for Transport-Administrative Procedures (9-30-86; Chg. 1, 12-19-88)
3790.1B	Federal Employee Occupational Safety and Health Program (1-7-93)
4330.4A	Maintenance Management Program (10-17-90)
4700.1	Project Management System (3-6-87)
5000.3B	Occurrence Reporting and Utilization of Operations Information (4-9-92)
5400.1	General Environmental Protection Program (11-9-88; Chg. 1, 6-29-90)
5400.2A	Environmental Compliance Issue Coordination (Errata 1-31-89)
5400.3	Hazardous and Radioactive Mixed Waste Program (2-22-89)
5400.4	Comprehensive Environmental Response, Compensation, and Liability Act Requirements (10-6-89)
5400.5	Radiation Protection of the Public and the Environment (2-8-90; Chg. 2, 1-7-93)
5440.1E	National Environmental Policy Act Compliance Program (11-10-92)
5480.1B	Environmental, Safety and Health Program for DOE Operations (9-23-86; Chg. 4, 3-27-90)
5480.3	Safety Requirements for the Packaging and Transportation of Hazardous Materials, Hazardous Substances, and Hazardous Wastes (7-9-85)
5480.4	Environmental Protection, Safety, and Health Protection Standards (5-15-84; Chg. 4, 1-7-93)
5480.5	Safety of Nuclear Facilities (9-23-86)
5480.6	Safety of Department of Energy-Owned Nuclear Reactors (09-23-86)
5480.7A	Fire Protection (2-17-93)
5480.8A	Contractor Occupational Medical Program (6-26-92)
5480.9	Construction Safety and Health Program (11-18-87)
5480.10	Contractor Industrial Hygiene Program (6-26-85)
5480.11	Radiation Protection for Occupational Workers (12-21-88; Chg. 2, 6-29-90)
5480.15	Department of Energy Laboratory Accreditation Program for Personnel Dosimetry (12-14-87)
5480.17	Site Safety Representatives (10-05-88)

Table 7-1. (continued).

DOE Order	Subject
5480.18A	Accreditation of Performance-Based Training for Category A Reactors and Nuclear Facilities (07-19-91)
5480.19	Conduct of Operations Requirements for DOE Facilities (7-9-90; Chg. 1, 5-18-92)
5480.20	Personnel Selection, Qualification, Training, and Staffing Requirements at DOE Reactor and Nonreactor Nuclear Facilities (2-20-91)
5480.21	Unreviewed Safety Questions (12-24-91)
5480.22	Technical Safety Requirements (2-25-92; Chg. 1, 9-15-92)
5480.23	Nuclear Safety Analysis Reports (4-10-92)
5480.24	Nuclear Criticality Safety (8-12-92)
5480.27	Equipment Qualification for Reactor and Nonreactor Nuclear Facilities (1-15-93)
5480.28	National Phenomena Hazards Mitigation (1-15-93)
5480.31	Startup and Restart of Nuclear Facilities (9-15-93)
5481.1B	Safety Analysis and Review System (9-23-86; Chg. 1, 5-19-87)
5482.1B	Environment, Safety, and Health Appraisal Program (9-23-86; Chg. 1, 11-18-91)
5483.1A	Occupational Safety and Health Program for DOE Contractor Employees at Government-Owned, Contractor-Operated Facilities (6-22-83)
5484.1	Environmental Protection, Safety, and Health Protection Information Reporting Requirements (2-21-81; Chg. 7, 10-17-90)
5500.1B	Emergency Management System (4-30-91; Chg. 1, 4-30-91)
5500.2B	Emergency Categories, Classes, and Notification and Reporting Requirements (4-30-91; Chg. 1, 2-27-92)
5500.3A	Planning and Preparedness for Operational Emergencies (4-30-91; Chg. 1, 2-27-92)
5500.4A	Public Affairs Policy and Planning Requirements for Emergencies (6-8-92)
5500.7B	Emergency Operating Records Protection Program (10-23-91)
5500.10	Emergency Readiness Assurance Program (4-30-91; Chg. 1, 2-27-92)
5630.11A	Safeguards and Security Program (12-7-92)
5630.12A	Safeguards and Security Inspection and Evaluation Program (6-23-92)
5700.6C	Quality Assurance (8-21-91)
5820.2A	Radioactive Waste Management (9-26-88)
6430.1A	General Design Criteria (4-6-89)

U.S. Environmental Protection Agency regulations pertaining to hazardous waste transportation are found in 40 CFR Part 262. These regulations deal with the use of the U.S. Environmental Protection Agency waste manifest, which is the shipping paper for transporting Resource Conservation and Recovery Act hazardous waste.

7.2.5 Current Status of Spent Nuclear Fuel

Historically, DOE chemically reprocessed SNF to recover valuable products and fissionable materials, and as such, the SNF was not a solid waste under the Resource Conservation and Recovery Act.

World events have resulted in significant changes in DOE's direction and operations. In particular, in April 1992 DOE announced the phase-out of reprocessing for the recovery of special nuclear materials. With these changes, DOE's focus on most of its SNF has changed from reprocessing and recovery of materials to storage and ultimate disposition. This in turn has created uncertainty in regard to the regulatory status of some of DOE's SNF relative to the Resource Conservation and Recovery Act.

DOE has initiated discussion with the U.S. Environmental Protection Agency on the potential applicability of the Resource Conservation and Recovery Act to SNF. Further discussions with U.S. Environmental Protection Agency Headquarters and regional offices and state regulators are ongoing to develop a path forward toward meeting any Resource Conservation and Recovery Act requirements that might apply.

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Appendix A: Hanford Site Spent Nuclear Fuel Management Program

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Appendix B: Idaho National Engineering Laboratory Spent Nuclear Fuel Management Program

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Appendix C: Savannah River Site Spent Nuclear Fuel Management Program

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Appendix D: Naval Spent Nuclear Fuel Management

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Appendix E: Spent Nuclear Fuel Management Programs at Other Generator/Storage Locations

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Appendix F: Nevada Test Site and Oak Ridge Reservation Spent Nuclear Fuel Management Programs

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Appendix G
Acronyms/Abbreviations

CFR	Code of Federal Regulations
DOE	U.S. Department of Energy
EIS	environmental impact statement
EA	environmental assessment
ECF	Expended Core Facility
EIS	Environmental Impact Statement
HS	Hanford Site
INEL	Idaho National Engineering Laboratory
MEI	maximally exposed individiual
NNPP	Naval Nuclear Propulsion Program
NTS	Nevada Test Site
ORR	Oak Ridge Reservation
PEIS	Programmatic Environmental Impact Statement
SNF	spent nuclear fuel
SRS	Savannah River Site
TRIGA	training, research, and isotope reactors built by General Atomic
MTHM	metric tons of heavy metal

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Appendix H
Glossary

Terms in this glossary are defined based on the context in which they are used in this EIS.

100-year flood A flood event of such magnitude it occurs, on average, every 100 years (equates to a 1 percent probability of occurring in any given year).

500-year flood A flood event of such magnitude it occurs, on average, every 500 years (equates to a 0.2 percent probability of occurring in any given year).

abnormal condition Any deviation from normal conditions.

accident An unplanned sequence of events that results in undesirable consequences.

actinide Any of a series of chemically similar, mostly synthetic, radioactive elements with atomic numbers ranging from actinium-89 through lawrencium-103.

alpha-emitter A radioactive substance that decays by releasing an alpha particle.

alpha-low-level waste Waste that was previously classified as transuranic waste but has a transuranic concentration lower than the currently established limit for transuranic waste. Low-level waste requires additional controls and special handling. This waste stream cannot be accepted for onsite disposal under the current waste acceptance criteria; therefore, it is special-case waste.

alpha particle A positively charged particle ejected spontaneously from the nuclei of some radioactive elements. It is identical to a helium nucleus that has a mass number of 4 and an electrostatic charge of +2.

as low as reasonably achievable (ALARA) A process by which a graded approach is applied to maintaining dose levels to workers and the public, and releases of radioactive materials to the environment as low as reasonably achievable.

atomic number The number of positively charged protons in the nucleus of an atom and the number of electrons on an electrically neutral atom.

background radiation Radiation from cosmic sources; naturally occurring radioactive materials, including radon (except as a decay product of source or special nuclear material), and global fallout as it exists in the environment from the testing of nuclear explosive devices.

baseline For purposes of this EIS, the conditions projected to exist in June 1995, the scheduled date for the Record of Decision, against which the environmental consequences of the various alternatives are evaluted.

beta-emitter A radioactive substance that decays by releasing a beta particle.

beta particle A charged particle emitted from a nucleus during radioactive decay, with a mass equal to 1/1837 that of a proton. A negatively charged beta particle is identical to an electron. A positively charged beta particle is called a positron.

boiling water reactor A type of nuclear reactor that uses fission heat to generate steam in the reactor to drive turbines and generate electricity.

breeder reactor A type of nuclear reactor that creates more fissionable fuel than it uses.

by-product material (a) Any radioactive material (except special nuclear material) yielded in, or made radioactive by, exposure to the radiation incident to the process of producing or utilizing special nuclear material, and (b) the tailings or wastes produced by the extraction or concentration of uranium or thorium from any ore processed primarily for its source material content [Atomic Energy Act 11(e)]. By-product material is exempt from regulation under the Resource Conservation Recovery Act.

calcination The process of converting high-level waste to unconsolidated granules or powder (also called calcining).

calcine The material produced by a calcination.

canning The process of placing spent nuclear fuel in canisters to retard corrosion, contain radioactive releases, or control geometry.

characterization The determination of waste composition and properties, whether by review of process knowledge, nondestructive examination or assay, or sampling and analysis, generally done for the purpose of determining appropriate storage, treatment, handling, transportation, and disposal requirements.

cladding The outer jacket of fuel elements and targets usually made of aluminum, stainless steel, or zirconium-aluminum alloy, used to prevent fuel corrosion and retain fission products during reactor operation, or to prevent releases into the environment during storage.

co-located workers Workers in a fixed population outside the day-to-day process safety management controls of a given facility area. In practice, this fixed population is normally the workers at an independent facility area located some distance from the reference facility area.

committed dose equivalent (H_{50}) The dose equivalent to organs or tissues of reference that will be received from an intake of radioactive material by an individual during the 50-year period following the intake. The International Commission on Radiological Protection defines this as the committed equivalent dose.

committed effective dose equivalent ($H_{E,50}$) The sum of the products of the weighting factors applicable to each of the body organs or tissues that are irradiated and the committed dose equivalent to these organs or tissues. The International Commission on Radiological Protection defines this as the committed effective dose.

Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) A Federal law (also known as "Superfund") that provides a comprehensive framework to deal with past or abandoned hazardous materials. The Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) provides for liability, compensation, cleanup, and emergency response for hazardous substances released into the environment that could endanger public health, welfare, or the environment, as well as the cleanup of inactive hazardous waste disposal sites. CERCLA has jurisdiction over any release or threatened release of any "hazardous substance" to the environment. Under CERCLA, the definition of "hazardous" is much broader than under the Resource Conservation and Recovery Act, and the hazardous substance need not be a waste. If a site meets the CERCLA requirements for designation, it is ranked along with other "Superfund" sites and listed on the National Priorities List. This ranking and listing is the U. S. Environmental Protection Agency's way of determining which sites have the highest priority for cleanup.

contact-handled waste Packaged waste whose external surface dose rate does not exceed 200 mrem per hour.

contamination The deposition of unwanted radioactive material on the surfaces of structures, areas, objects, or personnel.

coolant A gas or liquid circulated through a nuclear reactor to remove or transfer heat.

core The central portion of a nuclear reactor containing the fuel elements, moderator, neutron poisons, and support structures.

curie (Ci) The basic unit used to describe the intensity of radioactivity in a sample of material. The curie is equal to 37 billion disintegrations per second, which is approximately the rate of decay of 1 gram of radium. A curie is also a quantity of any radionuclide that decays at a rate of 37 billion disintegrations per second.

decay, radioactive The decrease in the amount of any radioactive material with the passage of time, due to the spontaneous emission from the atomic nuclei of either alpha or beta particles, often accompanied by gamma radiation. (See half-life; radioactive.)

decommissioning The process of removing a facility from operation, followed by decontamination, entombment, dismantlement, or conversion to another use.

decontamination The actions taken to reduce or remove substances that pose a substantial present or potential hazard to human health or the environment, such as radioactive contamination from facilities, soil, or equipment by washing, chemical action, mechanical cleaning or other techniques.

degraded (spent nuclear fuel) Spent nuclear fuel whose external cladding has cracked, pitted, corroded, or potentially allows the leakage of radioactive materials.

DOE orders Requirements internal to the U.S. Department of Energy (DOE) that establish DOE policy and procedures, including those for compliance with applicable laws.

DOE site boundary A geographic boundary within which public access is controlled and activities are governed by the U.S. Department of Energy (DOE) and its contractors, not by local authorities. Based on the definition of exclusion zone, a public road traversing a DOE site is considered to be within the DOE site boundary if DOE or the site contractor has the capability to control the road at any time necessary.

dosage The concentration-time profile for exposure to toxicological hazards.

dose (or radiation dose) A generic term that means absorbed dose, dose equivalent, effective dose equivalent, committed dose equivalent, committed effective dose equivalent, or total effective dose equivalent, as defined elsewhere in this glossary.

dry storage Storage of spent nuclear fuel in environments where the fuel is not immersed in liquid for purposes of cooling and/or shielding.

effective dose equivalent (EDE) The sum of the products of the dose equivalent to the organ or tissue and the weighting factors applicable to each of the body organs or tissues that are irradiated. It includes the dose from radiation sources internal and/or external to the body and is expressed in units of rem. The International Commission on Radiation Protection defines this as the effective dose.

enriched uranium Uranium that has greater amounts of the fissionable isotope uranium-235 than occurs naturally. Naturally occurring uranium is 0.72 percent uranium-235.

environmental monitoring The process of sampling and analysis of environmental media in and around a facility being monitored for the purpose of (a) confirming compliance with performance objectives and (b) early detection of any contamination entering the environment to facilitate timely remedial action.

existing facilities Facilities that are projected to exist as of the Record of Decision for this EIS, scheduled for June 1995.

external accident Accidents initiated by manmade energy sources not associated with operation of a given facility. Examples include airplane crashes, induced fires, transportation accidents adjacent to a facility, and so forth.

facility worker Any worker whose day-to-day activities are controlled by process safety management programs and a common emergency response plan associated with a facility or facility area. This definition includes any individual within a facility/facility area or its 0.4-mile exclusion zone. This definition can also include those transient individuals or small populations outside the exclusion zone but inside the radius defined by the maximally exposed co-located worker if reasonable efforts to account for such people have been made in the facility or facility area emergency plan. For facility accident analyses, the facility worker is defined as an individual located 100 meters (328 feet) downwind of the facility location where an accidental release occurs.

fissile material Although sometimes used as a synonym for fissionable material, this term has acquired a more restricted meaning; namely, any material fissionable by thermal (slow) neutrons. The three primarily fissile materials are uranium-233, uranium-235, and plutonium-239.

fission The splitting of a nucleus into at least two other nuclei and the release of a relatively large amount of energy. Two or three neutrons are usually released during this type of transformation.

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

fissionable material Commonly used as a synonym for fissile material, the meaning of this term has been extended to include material that can be fissioned by fast neutrons, such as uranium-238.

gamma-emitter A radioactive substance that decays by releasing gamma radiation.

gamma ray (gamma radiation) High-energy, short wavelength electromagnetic radiation (a packet of energy) emitted from the nucleus. Gamma radiation frequently accompanies alpha and beta emissions and always accompanies fission. Gamma rays are very penetrating and are best stopped or shielded against by dense materials, such as lead or uranium. Gamma rays are similar to x-rays, but are usually more energetic.

geologic repository A system that is intended to be used for, or may be used for, the disposal of radioactive waste or spent nuclear fuel in excavated geologic media. A geologic repository includes (a) the geologic repository operations area, and (b) the portion of the geologic setting that provides isolation. A near-surface disposal area is not a geologic repository.

groundwater Generally, all water contained in the ground. Water held below the water table available to freely enter wells.

grouting Grouting is the process of immobilizing or fixing solid forms of waste so they can be more safely stored or disposed.

half-life The time in which half the atoms of a particular radioactive substance disintegrate to another nuclear form. Measured half-lives vary from millionths of a second to billions of years. Also called physical half-life.

hazardous chemical A term defined under the Occupational Safety and Health Act and the Emergency Planning and Community Right-to-Know Act as any chemical which is a physical hazard or a health hazard.

hazardous material A substance or material, including a hazardous substance, which has been determined by the U. S. Secretary of Transportation to be capable of posing an unreasonable risk to health, safety, and property when transported in commerce.

hazardous substance Any substance that when released to the environment in an uncontrolled or unpermitted fashion becomes subject to the reporting and possible response provisions of the Clean Water Act and the Comprehensive Environmental Response, Compensation, and Liability Act.

hazardous waste Under the Resource Conservation and Recovery Act, a solid waste, or combination of solid wastes, which because of its quantity, concentration, or physical, chemical, or

infectious characteristics may (a) cause, or significantly contribute to an increase in mortality or an increase in serious irreversible, or incapacitating reversibile, illness; or (b) pose a substantial present or potential hazard to human health or the environment when improperly treated, stored, transported, or disposed of, or otherwise managed. Source, special nuclear material, and byproduct material, as defined by the Atomic Energy Act, are specifically excluded from the definition of solid waste.

heterogeneous Pertaining to a substance having different characteristics in different locations. A synonym is nonuniform.

high-efficiency particulate air (HEPA) filter A filter with an efficiency of at least 99.95 percent used to separate particles from air exhaust streams prior to releasing that air into the atmosphere.

high-level waste The highly radioactive waste material that results from the reprocessing of spent nuclear fuel, including liquid waste produced directly from reprocessing and any solid waste derived from the liquid that contains a combination of transuranic and fission product nuclides in quantities that require permanent isolation. High-level waste may include other highly radioactive material that the U. S. Nuclear Regulatory Commission, consistent with existing law, determines by rule requires permanent isolation.

hot cell/hot cell facility A heavily shielded enclosure for handling and processing (by remote means or automatically), or storing highly radioactive materials.

hydrogeology The study of the geological factors relating to water.

hydrology The study of water, including groundwater, surface water, and rainfall.

incineration The efficient burning of combustible solid and liquid wastes to destroy organic constituents and reduce the volume of the waste. Incinerators are designed to burn with an extremely high efficiency. The greater the burning efficiency, the cleaner the air emission. Incineration of radioactive materials does not destroy the radionuclides but does significantly reduce the volume of these wastes. High-efficiency particulate air (HEPA) filters are used to prevent radionuclides and heavy metals from going out of the stack and into the atmosphere.

inconel A metal alloy containing nickel, chromium, and iron, which exhibits good resistance to corrosion in aqueous environments.

interim action (NEPA) An action which may be undertaken while work on a required program EIS is in progress, and the action is not covered by an existing program statement. An interim action may not be undertaken unless such action: (a) is justified independently of the program;

(b) is itself accompanied by an adequate EIS or has undergone other NEPA review; and (c) will not prejudice the ultimate decision on the program. Interim action prejudices the ultimate decision on the program when it tends to determine subsequent development or limit alternatives.

intermittent surface water A stream, creek, or river which does not contain water during part or all of the year.

internal accidents Accidents that are initiated by man-made energy sources associated with the operation of a given facility. Examples include process explosions, fires, spills, criticalities, and so forth.

involved worker Workers that would be involved in a proposed action as opposed to workers that would be on the site of a proposed action but not involved in the action.

isotope One of two or more atoms with the same number of protons, but different numbers of neutrons, in their nuclei. Thus, carbon-12, carbon-13, and carbon-14 are isotopes of the element carbon, the numbers denoting the approximate atomic weights. Isotopes have very nearly the same chemical properties, but often different physical properties (for example, carbon-12 and -13 are stable, carbon-14 is radioactive.

life cycle The entire time period from generation to permanent disposal or elimination of waste.

liquid metal cooled breeder reactor A reactor that creates more fissionable material than it consumes and uses liquid metal as a coolant. Liquid sodium is a common metal used to cool this type of reactor.

liquid metal fast breeder reactor A reactor that operates using a type of fission known as fast fission where the neutrons that are used to split the atoms are not slowed down or moderated as is usually the case with normal fission. It creates more fissionable material than it consumes and uses liquid metal as a coolant. Liquid sodium is a common metal used to cool this type of reactor.

long-term storage The storage of hazardous waste (a) onsite (a generator site) for a period of 90-days or greater, other than in a satellite accumulation area, or (b) offsite in a properly managed treatment, storage, or disposal facility for any period of time.

low-level waste Waste that contains radioactivity and is not classified as high-level waste, transuranic waste, or spent nuclear fuel. Test specimens of fissionable material irradiated for research and development only, and not for the production of power or plutonium, may be classified as low-level waste, provided the concentration of transuranic elements is less than 100 nanocuries per gram.

major radionuclides The radioisotopes that together comprise 95 percent of the total curie content of a waste package by volume and have a half-life of at least 1 week. Radionuclides that are important to a facility's radiological performance assessment and/or a safety analysis and are listed in the facility's waste acceptance criteria are considered major radionuclides.

management (of spent nuclear fuel) Emplacing, operating, and administering facilities, transportation systems, and procedures in order to ensure safe and environmentally responsible handling and storage of spent nuclear fuel pending (and in anticipation of) a decision on ultimate disposition.

maximally exposed co-located worker (MCW) A hypothetical individual defined to allow dose or dosage comparison with numerical criteria for co-located workers. This individual is located at whichever is the greater of 0.4 miles from the facility area boundary (that is, the exclusion zone boundary) or 75 percent of the distance to the nearest independent facility area (that is, the low population zone boundary). The MCW is irrelevant if the DOE site boundary is closer than the MCW location.

maximally exposed individual (MEI) A hypothetical individual defined to allow dose or dosage comparison with numerical criteria for the public. This individual is located at the point on the DOE site boundary nearest to the facility in question. Sometimes called maximally exposed offsite individual (MOI).

maximally exposed offsite individual (MOI) A hypothetical individual defined to allow dose or dosage comparison with numerical criteria for the public. This individual is located at the point on the DOE site boundary nearest to the facility in question. Sometimes called the maximally exposed individual (MEI).

maximum contaminant level (MCL) Under the Safe Drinking Water Act, the maximum permissible concentrations of specific constituents in drinking water that is delivered to any user of a public water system that serves 15 or more connections and 25 or more people. The standards set as maximum contaminant levels take into account the feasibility and cost of attaining the standard.

metric tons of heavy metal (MTHM) Quantities of unirradiated and spent nuclear fuel and targets are traditionally expressed in terms of metric tons of heavy metal (typically uranium), without the inclusion of other materials, such as cladding, alloy materials, and structural materials. A metric ton is 1,000 kilograms, which is equal to about 2,200 pounds.

millirem One thousandth of a rem (see rem).

nanocurie One billionth of a curie (see curie).

National Priorities List (NPL) A formal listing of the nation's most hazardous waste sites, as established under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), that have been identified for remediation.

natural phenomena accidents Accidents that are initiated by phenomena such as earthquakes, tornadoes, floods, and so forth.

near-surface disposal Disposal in the uppermost portion of the earth, approximately 30 meters. Near-surface disposal includes disposal in engineered facilities that may be built totally or partially above-grade provided that such facilities have protective earthen covers. A near-surface disposal facility is not considered a geologic repository.

nitrogen oxides (NO_x) Gases formed in great part from atmospheric nitrogen and oxygen when combustion takes place under conditions of high temperature and high pressure; considered a major air pollutant. Two major nitrogen oxides, nitric oxide (NO) and nitrogen dioxide (NO_2) are important airborne contaminants. In the presence of sunlight, nitric oxide combines with atmospheric oxygen to produce nitrogen dioxide, which in high enough concentrations can cause lung damage.

normal conditions All activities associated with a facility mission, whether operation, maintenance, storage, and so forth, which are carried out within a defined envelope. This envelope can be design process conditions, performance in accordance with procedure, and so forth.

normal operation All normal conditions and those abnormal conditions that frequency estimation techniques indicate occur with a frequency greater than 0.1 events per year.

NO_x. A generic term used to describe the oxides of nitrogen (see nitrogen oxides).

nuclear criticality A self-sustaining chain reaction, which releases neutrons and energy, and generates radioactive byproduct material.

nuclear fuel Materials that are fissionable and can be used in nuclear reactors to make energy.

nuclide A general term referring to all known isotopes, both stable (279) and unstable (about 5,000), of the chemical elements.

off-link doses Doses to members of the public within 800 meters (2,625 feet) of a road or railway.

offsite facility A facility located at a different site or location than the shipper.

on-link doses Doses to members of the public sharing a road or railway.

onsite The same or geographically contiguous property that may be divided by public or private right-of-way, provided the entrance and exit between the properties is at a cross-roads intersection, and access is by crossing as opposed to going along the right-of-way. Non-contiguous properties owned by the same person but connected by a right-of-way that he/she controls and to which the public does not have access is also considered onsite property.

onsite facilities Buildings and other structures, their functional systems and equipment, and other fixed systems and equipment installed onsite.

operator The organization that operates a facility.

perennial stream A water course that flows year-round.

performance objectives Parameters within which a facility must perform to be considered acceptable.

permeability The degree of ease with which water can pass through a rock or soil.

playa The shallow central basin of a desert plain in which water gathers and then evaporates.

picocurie One trillionth of a curie (see curie).

pollutant migration The movement of a contaminant away from its initial source.

pollution prevention The use of any process, practice, or product that reduces or eliminates the generation and release of pollutants, hazardous substances, contaminants and wastes, including those that protect natural resources through conservation or more efficient utilization.

polychlorinated biphenyls (PCBs) A class of chemical substances formerly manufactured as an insulating fluid in electrical equipment that is highly toxic to aquatic life. In the environment, PCBs exhibit many of the characteristics of dichloro diphenyl trichloroethane (DDT); they persist in the environment for a long time and accumulate in animals.

population dose The overall dose to the offsite population.

porosity (n) Porosity is an index of relative pore volume. It is the total unit volume of the soil or rock divided into the void volume.

pressurized water reactor A nuclear power reactor that uses water under pressure as a coolant. The water boiled to generate steam is in a separate system.

probable maximum flood The largest flood for which there is any reasonable expectancy in a specific area. The probable maximum flood is normally several times larger than the largest flood of record.

process knowledge The set of information that is used by trained and qualified individuals who are cognizant of the origin, use, and location of waste-generating materials and processes in sufficient detail so as to certify the identity of the waste.

processing (of spent nuclear fuel) Applying a chemical or physical process designed to alter the characteristics of the spent nuclear fuel matrix.

production reactor A nuclear reactor which is used to irradiate target material to produce special nuclear material or byproduct material.

public Anyone outside the DOE site boundary at the time of an accident or during normal operation. With respect to accidents analyzed in this EIS, anyone outside the DOE site boundary at the time of an accident.

rad The special unit of absorbed dose. One rad is equal to an absorbed dose of 100 ergs/gram.

radiation (ionizing radiation) Alpha particles, beta particles, gamma rays, x-rays, neutrons, high-speed electrons, high-speed protons, and other particles capable of producing ions. Radiation, as it is used here, does not include non-ionizing radiation such as radio- or microwaves, or visible, infrared, or ultraviolet light.

radiation worker A worker who is occupationally exposed to ionizing radiation and receives specialized training and radiation monitoring devices to work in such circumstances.

radioactive waste Waste that is managed for its radioactive content.

radioactivity The property or characteristic of material to spontaneously "disintegrate" with the emission of energy in the form of radiation. The unit of radioactivity is the curie (or becquerel).

radioisotope An unstable isotope of an element that decays or disintegrates spontaneously, emitting radiation. Approximately 5,000 natural and artificial radioisotopes have been identified.

radiological survey The evaluation of the radiation hazard accompanying the production, use, or existence of radioactive materials under a specific set of conditions. Such evaluation

customarily includes a physical survey of the disposition of materials and equipment, measurements or estimates of the levels of radiation that may be involved, and a sufficient knowledge of processes affecting these materials to predict hazards resulting from unexpected or possible changes in materials or equipment.

radionuclide See radioisotope.

Record of Decision (ROD) A public document that records the final decision(s) concerning a proposed action. The Record of Decision is based in whole or in part on information and technical analysis generated either during the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) process or the National Environmental Policy Act (NEPA) process, both of which take into consideration public comments and community concerns.

recycling Recycling techniques are characterized as use, reuse, and reclamation techniques (resource recovery). Use or reuse involves the return of a potential waste material either to the originating process as a substitute for an input material or to another process as an input material. Reclamation is the recovery of a useful or valuable material from a waste stream. Recycling allows potential waste materials to be put to a beneficial use rather than going to treatment, storage or disposal.

regulated substances A general term used to refer to materials other than radionuclides that are regulated by Federal, State, (or possibly local) requirements.

rem The dosage of an ionizing radiation that will cause the same biological effect as one roentgen of x-ray or gamma-ray exposure.

remote-handled waste Packaged waste whose external surface dose rate exceeds 200 millirem per hour.

remote handling The handling of wastes from a distance so as to protect human operators from unnecessary exposure.

repository A permanent deep geologic disposal facility for high-level or transuranic wastes and spent nuclear fuel.

reprocessing (of spent nuclear fuel) Processing of reactor irradiated nuclear material (primarily spent nuclear fuel) to recover fissile and fertile material, in order to recycle such materials primarily for defense programs. Historically, reprocessing has involved aqueous chemical separations of elements (typically uranium or plutonium) from undesired elements in the fuel.

research reactor A nuclear reactor used for research and development.

Resource Conservation and Recovery Act (RCRA) A Federal law addressing the management of waste. Subtitle C of the law addresses hazardous waste under which a waste must either be "listed" on one of the U. S. Environmental Protection Agency's (EPA's) hazardous waste lists or meet one of EPA's four hazardous characteristics of ignitability, corrosivity, reactivity, or toxicity, as measured using the toxicity characterization leaching procedure (TCLP). Cradle-to-grave management of wastes classified as RCRA hazardous wastes must meet stringent guidelines for environmental protection as required by the law. These guidelines include regulation of transportation, treatment, storage, and disposal of RCRA defined hazardous waste. Subtitle D of the law addresses the management of nonhazardous, nonradioactive, solid waste such as municipal wastes.

retrieval The process of recovering wastes that have been stored or disposed of onsite so they may be appropriately characterized, treated, and disposed of.

risk Quantitative expression of possible loss that considers both the probability that a hazard causes harm and the consequences of that event.

safety analysis report A report, prepared in accordance with DOE Orders 5481.1B and 5480.23, that summarize the hazards associated with the operation of a particular facility and defines minimum safety requirements.

sanitary waste Liquid or solid wastes that are generated as a result of routine operations of a facility and are not considered hazardous or radioactive.

saturated zone That part of the earth's crust in which all naturally occuring voids are filled with water.

scaling factor A multiplier that allows the inference of one radionuclide concentration from another that is more easily measured.

segregation The process of separating (or keeping separate) individual waste types and/or forms in order to facilitate their cost-effective treatment and storage or disposal.

seiche A wave that oscillates in partially or totally enclosed bodies of water from a few minutes to a few hours, caused by seismic or atmospheric disturbances.

sole source aquifer A designation granted by the U. S. Environmental Protection Agency when groundwater from a specific aquifer supplies at least 50 percent of the drinking water for the area overlying the aquifer. Sole source aquifers have no alternative source or combination of

sources which could physically, legally, and economically supply all those who obtain their drinking water from the aquifer. Sole source aquifers are protected from federally financially assisted activities determined to be potentially unhealthy for the aquifer.

solid waste Any garbage, refuse, or sludge from a waste treatment plant, water supply treatment plant, or air pollution control facility and other discarded material, including solid, liquid, semisolid, or contained gaseous material resulting from industrial, commercial, mining, and agricultural operations and from community activities. It does not include solid or dissolved material in domestic sewage, or solid or dissolved materials in irrigation return flows or industrial discharges, which are point sources subject to permits under Section 402 of the Federal Water Pollution Control Act, as amended, or source, special nuclear, or byproduct material as defined by the Atomic Energy Act of 1954, as amended [Public Law 94-580, 1004(27) (Resource Conservation and Recovery Act)].

solvents Liquid chemicals, usually organic compounds, that are capable of dissolving another substance. Exposure to some organic solvents can produce toxic effects on body tissues and processes.

source material (a) Uranium, thorium, or any other material that is determined by the Nuclear Regulatory Commission pursuant to the provisions of the Atomic Energy Act of 1954, Section 61, to be source material; or (b) ores containing one or more of the foregoing materials, in such concentration as the Nuclear Regulatory Commission may by regulation determine from time-to-time [Atomic Energy Act 11(z)]. Source material is exempt from regulation under to Resource Conservation and Recovery Act.

SO_x A generic term used to describe the oxides of sulfur. The combination of sulfur oxides with water vapor produces acid rain (see sulfur oxides).

special nuclear material (a) Plutonium or uranium enriched in the isotope 233 or in the isotope 235, and any other material that the U. S. Nuclear Regulatory Commission, pursuant to the provisions of the Atomic Energy Act of 1954, Section 51, determines to be special nuclear material; or (b) any material artificially enriched by any of the foregoing, but does not include source material. Special nuclear material is exempt from regultion under the Resource Conservation and Recovery Act (RCRA).

specimen A small sample of material (fuel or non-fuel) inserted into a reactor for testing to characterize the material's performance. Test specimens may be constructed of plant materials, reactor structural materials, or fuel materials.

spent nuclear fuel Fuel that has been withdrawn from a nuclear reactor following irradiation, the constituent elements of which have not been separated. For the purposes of this EIS, spent

nuclear fuel also includes uranium/neptunium target materials, blanket subassemblies, pieces of fuel, and debris.

stabilization (of spent nuclear fuel) Actions taken to further confine or reduce the hazards associated with spent nuclear fuel, as necessary for safe management and environmentally responsible storage for extended periods of time. Activities which may be necessary to stabilize spent nuclear fuel include canning, processing, and passivation.

stakeholder Any person or organization with an interest in or affected by DOE activities. Stakeholders may include representatives from Federal agencies, State agencies, Congress, Native American Tribes, unions, educational groups, industry, environmental groups, other groups, and members of the general public.

storage The collection and containment of waste or spent nuclear fuel in such a manner as not to constitute disposal of the waste or spent nuclear fuel for the purposes of awaiting treatment or disposal capacity (that is, not short-term accumulation).

subsurface The area below the land surface (including the vadose zone and aquifers).

sulfur oxides Pungent, colorless gases formed primarily by the combustion of fossil fuels; considered major air pollutants; sulfur oxides may damage the respiratory tract as well as vegetation (see SO_x).

target A tube, rod, or other form containing material that, on being irradiated in a nuclear reactor would produce a designed end product (that is, uranium-238 produces plutonium-239 and neptunium-237 produces plutonium-238).

total effective dose equivalent The sum of the external dose equivalent (for external exposures) and the committed effective dose equivalent (for internal exposures).

transient A change in the reactor coolant system temperature and/or pressure. Transients can be caused by adding or removing neutron poisons, by increasing or decreasing the electrical load on the turbine generator, or by accident conditions.

transuranic waste Waste containing more than 100 nanocuries of alpha-emitting transuranic isotopes, with half-lives greater than 20 years, per gram of waste, except for (a) high-level radioactive waste; (b) waste that the U. S. Department of Energy has determined, with the concurrence of the Administrator of the U. S. Environmental Protection Agency, do not need the degree of isolation required by 40 CFR 191; or (c) waste that the U. S. Nuclear Regulatory Commission has approved for disposal on a case-by-case basis in accordance with 10 CFR 61.

transuranium radionuclide Any radionuclide having an atomic number greater than 92.

tsunami A huge ocean wave caused by an underwater earthquake or a volcanic eruption.

ultimate disposition The final step in which a material is either processed for some use or disposed of.

vadose zone The zone between the land surface and the water table. Saturated bodies, such as perched groundwater, may exist in the vadose zone. Also called the zone of aeration and the unsaturated zone.

vitrification The process of immobilizing waste material that results in a glass-like solid.

volatile organic compound (VOC) Chemical containing mainly carbon, hydrogen, and oxygen that readily evaporates at ambient temperature. Exposure to some organic compounds can produce toxic effects on body tissue and processes.

vulnerabilities Conditions or weaknesses that may lead to radiation exposure to the public, unnecessary or increased exposure to the workers, or release of radioactive materials to the environment. For example, some DOE facilities have had leakage from spent fuel storage pools, excessive corrosion of fuel causing increased radiation levels in the pool, or degradation of handling systems. Vulnerabilities are also caused by loss of institutional controls, such as cessation of facility funding or reductions in facility maintenance and control.

waste acceptance criteria (WAC) The requirements specifying the characteristics of waste and waste packaging acceptable to a waste receiving facility; and the documents and processes the generator needs to certify that waste meets applicable requirements.

waste certification A process by which a waste generator certifies that a given waste or waste stream meets the waste acceptance criteria of the facility to which the generator intends to ship waste for treatment, storage, or disposal. Certification is accomplished by a combination of waste characterization, documentation, quality assurance, and periodic audits of the certification program.

waste characterization See characterization.

Waste Isolation Pilot Plant (WIPP) A facility near Carlsbad, New Mexico, authorized to demonstrate safe disposal of defense-generated transuranic waste in a deep geologic medium.

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

waste management facility All contiguous land, structures, other appurtenances, and improvements on the land, used for treating, storing, or disposing of waste or spent nuclear fuel. A facility may consist of several treatment, storage, or disposal operational units (for example, one or more landfills, surface impoundments, or combinations of them).

waste management program A systematic approach to organize, direct, document, and assess activities associated with waste generation, treatment, storage, or disposal. A waste management program consists of all the functional elements, organizations, and activities that comprise the system needed to properly manage waste. These functions and activities can be performed by various organizations.

waste management systems assessment A systems assessment of the entire low-level waste management (or all of waste management) structure/program at a given site that considers treatment, storage, disposal, as well as on- and offsite points of generation with an emphasis on optimization of all aspects of the operations, including, but not limited to, protection of human health and the environment, regulatory compliance, and cost effectiveness.

waste minimization An action that economically avoids or reduces the generation of waste by source reduction, by reducing the toxicity of hazardous waste, by improving energy usage, or by recycling. These actions will be consistent with the general goal of minimizing present and future threats to human health, safety, and the environment.

water pool A type of facility usually used for the storage of irradiated nuclear materials and spent fuel. The water shields the material being stored while allowing it to be accessible for handling. Sometimes referred to as a water pit.

wet storage Storage of spent nuclear fuel in a pool of water, generally for the purposes of cooling and/or shielding.

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Appendix I

Offsite Transportation of Spent Nuclear Fuel

I-1 INTRODUCTION

This appendix summarizes the methods and results of analysis for determining the environmental impacts of spent nuclear fuel (SNF) transportation on public highways and rail systems outside the boundaries of U.S. Department of Energy (DOE) sites (offsite). The impacts are presented by alternative and include doses and health effects.

This appendix does not address the impacts of SNF transportation within the boundaries of DOE sites (onsite). Onsite transportation impacts are addressed in site-specific Appendices A through F. This appendix addresses offsite shipments of Naval-type SNF stored at the Idaho Chemical Processing Plant as of June 1995 to storage locations at other sites as identified by certain alternatives. Shipments of Naval SNF from shipyards and prototypes to the equivalent Expended Core Facility at the alternative sites are addressed in this EIS in Appendix D, along with shipments of Naval test specimens.

This appendix also includes the impacts of shipments of foreign research reactor SNF from the six ports identified in the Implementation Plan as representative points of entry (Hampton Roads, Virginia; Charleston, South Carolina; Savannah, Georgia; Seattle-Tacoma, Washington; Portland, Oregon; and Oakland, California) to sites as identified in the alternatives. The ocean-going portion of foreign research reactor SNF shipments and a detailed evaluation of port activities are not assessed in this EIS, but will be assessed in the Foreign Research Reactor SNF EIS.

The impacts of historical shipments of SNF to the Hanford Site, Idaho National Engineering Laboratory, Savannah River Site, Oak Ridge Reservation, and the Nevada Test Site and cumulative transportation impacts are also discussed in this appendix. The historical impacts and cumulative impacts include shipments of Naval SNF and test specimens.

I-2 TRANSPORTATION REGULATIONS

The regulatory standards for packaging and transport of SNF are designed to achieve four primary objectives:

- Protect persons and property from radiation emitted from packages during transportation, by specific limitations on the allowable radiation levels

- Provide proper containment of the SNF in the package (achieved by packaging design requirements based on performance-oriented packaging integrity tests and environmental criteria)

- Prevent nuclear criticality (an unplanned nuclear chain reaction that may occur as a result of concentrating too much fissile material in one place)

- Provide physical protection against theft and sabotage during transit.

The U.S. Department of Transportation regulates the transportation of hazardous materials (including SNF) in interstate commerce by land, air, and on navigable water. As outlined in a 1979 Memorandum of Understanding with the U.S. Nuclear Regulatory Commission, the U.S. Department of Transportation specifically regulates the carriers of SNF and the conditions of transport, such as routing, handling and storage, and vehicle and driver requirements. The U.S. Department of Transportation also regulates the labeling, classification and marking of all SNF packages.

The U.S. Nuclear Regulatory Commission regulates the packaging and transport of SNF for its licensees, which includes commercial shippers of SNF. In addition, under an agreement with the U.S. Department of Transportation, the U.S. Nuclear Regulatory Commission sets the standards for packages containing fissile materials and SNF.

The DOE, through its management directives, orders, and contractual agreements, assures the protection of public health and safety by imposing on its transportation activities standards equivalent to those of the U.S. Department of Transportation and the U.S. Nuclear Regulatory Commission. The DOE has authority, granted by a 1973 Memorandum of Understanding between the U.S. Department of Transportation and the Atomic Energy Commission, to certify DOE-owned SNF packages. The DOE may design, procure, and certify its own SNF packages to be used by the DOE and its contractors if the packages provide equivalent safety to that provided in 10 CFR Part 71.

The U.S. Department of Transportation also has requirements that help to reduce transportation impacts. For example, there are requirements for drivers, packaging, labeling,

marking, and placarding. There are also requirements that specify the maximum dose rate associated with radioactive material shipments, which help to reduce incident-free transportation doses.

The Federal Emergency Management Agency is responsible for establishing policies for, and coordinating civil emergency management, planning and interaction with Federal executive agencies that have emergency response functions in the event of a SNF transportation incident. The Federal Emergency Management Agency coordinates Federal and state participation in developing emergency response plans and is responsible for the development of the interim Federal Radiological Emergency Response Plan. The Federal Radiological Emergency Response Plan is designed to coordinate Federal support to state and local governments, upon request, during the event of a SNF transportation incident.

The Interstate Commerce Commission is responsible for the regulation of the economic aspects of SNF transportation for land shipments. The commission issues operating authorities to carriers and also monitors and approves freight rates.

Spent nuclear fuel is transported in Type B packages, which are designed and constructed to retain their radioactive contents in both normal and severe accident conditions.

Under normal conditions a cask must withstand:

- Hot (100°F) and Cold (-40°F)
- External pressure changes from 3.5 to 20 pounds per inch
- Normal vibration experienced during transportation
- Simulated rainfall of 2 inches per hour for 1 hour
- Free fall from 1 to 4 feet, depending on the package weight
- Water immersion-compression tests
- Impact of a 13 pound steel cylinder with rounded ends dropped from 40 inches onto the most vulnerable surface of the cask.

Under accident conditions a cask must withstand:

- Free drop for 30 feet onto an unyielding surface in a way most likely to cause damage to the cask

- Free drop from 40 inches onto the end of a 6-inch diameter vertical steel bar
- Exposure for not less than 30 minutes to temperatures of 1475°F
- Immersion in at least 3 feet of water for 8 hours in an orientation most likely to result in leakage.

Compliance with these requirements is demonstrated by using a combination of simple calculational methods, computer modeling techniques, or full-scale or scale-model testing of casks.

I-3 SNF TRANSPORTATION MODES AND ROUTES

I-3.1 SNF Transportation Routing Models

To assess incident-free and transportation accident impacts, route characteristics were determined for each of the origins and destinations associated with SNF shipments. Each origin represents a facility that generates or stores SNF that must be transported, and each destination represents a facility that stores SNF. For offsite shipments, representative highway and rail routes were analyzed using the routing computer codes HIGHWAY (Johnson et al. 1993a) and INTERLINE (Johnson et al. 1993b). The routes were calculated conforming to current routing practices and applicable routing regulations and guidelines. Route characteristics include total shipment distance between each origin and destination and the fractions of travel in rural, suburban, and urban population density zones (see Table I-1). The HIGHWAY and INTERLINE routing computer codes are described below.

The HIGHWAY computer code predicts highway routes for transporting radioactive materials within the United States. The HIGHWAY database is a computerized road atlas that currently describes approximately 240,000 miles of roads. A complete description of the Interstate Highway System, United States highways, most of the principal state highways, and a number of local and community highways are identified in the database. The HIGHWAY computer code calculates routes that maximize the use of interstate highways. This feature allows the user to predict routes for shipment of radioactive materials that conform to U.S. Department of Transportation regulations (as specified in 49 CFR Part 177). The routes calculated conform to applicable guidelines and regulations; therefore, they represent routes that could be used. However, they may not be the actual routes used in the future. The code is updated periodically to reflect current road conditions, and it has been benchmarked against reported mileage and observations of commercial truck firms.

The INTERLINE computer code is designed to simulate routing of the United States rail system. The INTERLINE database consists of 94 separate subnetworks and represents various competing rail companies in the United States. The database used by INTERLINE was originally based on Federal Railroad Administration data and reflected the United States railroad system in 1974. The database has since been expanded and modified over the past two decades. The routes used for this study used the standard assumptions in the INTERLINE computer code that simulate the selection process railroads use to direct shipments of radioactive material. Currently, there are no specific routing regulations for transporting radioactive material by rail. INTERLINE is updated periodically to reflect current track conditions, and it has been benchmarked against reported mileage and observations of commercial rail firms.

Table I-1. Transportation distances between facilities for spent nuclear fuel shipments.

Route		Miles	Rural (%)	Suburban (%)	Urban (%)
	Truck routes				
Idaho National Engineering Laboratory	Hanford Site	599.0	91.3	7.6	1.1
Idaho National Engineering Laboratory	Nevada Test Site	712.0	82.8	13.7	3.5
Idaho National Engineering Laboratory	Savannah River Site	2311.0	82.8	15.6	1.6
Idaho National Engineering Laboratory	Oak Ridge Reservation	2048.0	86.8	12.0	1.2
Idaho National Engineering Laboratory	Brookhaven National Laboratory	2437.0	81.7	15.9	2.5
Idaho National Engineering Laboratory	Argonne National Laboratory-East	1582.0	91.2	8.2	0.6
Idaho National Engineering Laboratory	Los Alamos National Laboratory	1144.0	88.7	9.8	1.4
Idaho National Engineering Laboratory	Sandia National Laboratories - Albuquerque	1168.0	88.6	9.8	1.6
Hanford Site	Nevada Test Site	1128.0	86.5	10.9	2.6
Hanford Site	Savannah River Site	2727.0	84.3	14.2	1.5
Hanford Site	Oak Ridge Reservation	2464.0	87.8	11.0	1.2
Hanford Site	Brookhaven National Laboratory	2853.0	83.3	14.5	2.3
Hanford Site	Argonne National Laboratory-East	1998.0	91.5	7.8	0.7
Hanford Site	Los Alamos National Laboratory	1560.0	89.8	8.8	1.3
Hanford Site	Sandia National Laboratories - Albuquerque	1584.0	89.7	8.8	1.4
Nevada Test Site	Savannah River Site	2414.0	83.1	15.1	1.8
Nevada Test Site	Oak Ridge Reservation	2151.0	86.9	11.5	1.6
Nevada Test Site	Brookhaven National Laboratory	2670.0	82.3	15.1	2.6
Nevada Test Site	Argonne National Laboratory-East	1815.0	91.0	8.0	1.0
Nevada Test Site	Los Alamos National Laboratory	997.0	93.2	5.7	1.1
Nevada Test Site	Sandia National Laboratories - Albuquerque	909.0	93.8	4.8	1.4
Savannah River Site	Oak Ridge Reservation	379.0	59.1	38.5	2.4
Savannah River Site	Brookhaven National Laboratory	897.0	58.4	36.6	4.9
Savannah River Site	Argonne National Laboratory-East	892.0	68.8	29.3	1.9
Savannah River Site	Los Alamos National Laboratory	1742.0	80.0	17.9	2.1
Savannah River Site	Sandia National Laboratories - Albuquerque	1644.0	80.1	17.8	2.1
Savannah River Site	Lawrence Livermore National Laboratory	2750.0	80.1	16.8	3.1
Oak Ridge Reservation	Brookhaven National Laboratory	821.0	56.9	37.9	5.2

Table I-1. (continued).

	Route	Miles	Rural (%)	Suburban (%)	Urban (%)
Oak Ridge Reservation	Argonne National Laboratory-East	584.0	67.0	30.1	2.9
Oak Ridge Reservation	Los Alamos National Laboratory	1480.0	84.9	13.3	1.7
Oak Ridge Reservation	Sandia National Laboratories - Albuquerque	1382.0	85.4	12.9	1.7
	Train routes				
Idaho National Engineering Laboratory	Hanford Site	658.0	91.4	7.1	1.4
Idaho National Engineering Laboratory	Nevada Test Site	756.0	92.8	5.9	1.3
Idaho National Engineering Laboratory	Savannah River Site	2407.0	82.8	15.2	2.0
Idaho National Engineering Laboratory	Oak Ridge Reservation	2055.0	90.7	7.8	1.5
Idaho National Engineering Laboratory	Brookhaven National Laboratory	2607.0	71.3	22.6	6.1
Idaho National Engineering Laboratory	Argonne National Laboratory-East	1655.0	93.4	6.0	0.6
Idaho National Engineering Laboratory	Los Alamos National Laboratory	1179.0	92.2	6.8	1.0
Idaho National Engineering Laboratory	Sandia National Laboratories - Albuquerque	1247.0	91.0	7.6	1.4
Hanford Site	Nevada Test Site	1302.0	93.0	5.9	1.1
Hanford Site	Savannah River Site	2953.0	84.7	13.5	1.8
Hanford Site	Oak Ridge Reservation	2601.0	91.2	7.4	1.3
Hanford Site	Brookhaven National Laboratory	3153.0	75.1	19.7	5.2
Hanford Site	Argonne National Laboratory-East	2200.0	93.3	6.0	0.7
Hanford Site	Los Alamos National Laboratory	1725.0	92.5	6.5	0.9
Hanford Site	Sandia National Laboratories - Albuquerque	1793.0	91.7	7.1	1.2
Nevada Test Site	Savannah River Site	2839.0	84.5	13.5	1.9
Nevada Test Site	Oak Ridge Reservation	2487.0	91.4	7.2	1.5
Nevada Test Site	Brookhaven National Laboratory	3039.0	74.6	20.0	5.4
Nevada Test Site	Argonne National Laboratory-East	2348.0	92.8	6.4	0.8
Nevada Test Site	Los Alamos National Laboratory	1169.0	92.8	5.9	1.3
Nevada Test Site	Sandia National Laboratories - Albuquerque	1065.0	94.6	4.5	0.9
Savannah River Site	Oak Ridge Reservation	417.0	68.8	29.8	1.4
Savannah River Site	Brookhaven National Laboratory	1239.0	48.0	37.4	14.5
Savannah River Site	Argonne National Laboratory-East	976.0	64.3	31.6	4.0
Savannah River Site	Los Alamos National Laboratory	2252.0	80.3	17.5	2.1

Table I-1. (continued).

	Route	Miles	Rural (%)	Suburban (%)	Urban (%)
Savannah River Site	Sandia National Laboratories - Albuquerque	2315.0	79.9	18.1	2.1
Oak Ridge Reservation	Brookhaven National Laboratory	1152.0	39.5	44.7	15.8
Oak Ridge Reservation	Argonne National Laboratory-East	648.0	70.7	25.3	4.0
Oak Ridge Reservation	Los Alamos National Laboratory	1686.0	88.9	9.3	1.8
Oak Ridge Reservation	Sandia National Laboratories - Albuquerque	1749.0	87.9	10.3	1.8
	Truck routes				
Fort St. Vrain Nuclear Generating Station	Savannah River Site	1636.0	78.9	19.1	2.0
Fort St. Vrain Nuclear Generating Station	Hanford Site	1108.0	92.5	6.7	0.7
Fort St. Vrain Nuclear Generating Station	Idaho National Engineering Laboratory	692.0	92.3	7.1	0.5
Fort St. Vrain Nuclear Generating Station	Oak Ridge Reservation	1372.0	84.1	14.3	1.6
Fort St. Vrain Nuclear Generating Station	Nevada Test Site	852.0	90.2	7.9	1.9
	Train routes				
Fort St. Vrain Nuclear Generating Station	Savannah River Site	1853.0	77.3	20.1	2.7
Fort St. Vrain Nuclear Generating Station	Hanford Site	1218.0	94.8	4.6	0.6
Fort St. Vrain Nuclear Generating Station	Idaho National Engineering Laboratory	672.0	96.0	3.5	0.4
Fort St. Vrain Nuclear Generating Station	Oak Ridge Reservation	1526.0	87.0	10.9	2.1
Fort St. Vrain Nuclear Generating Station	Nevada Test Site	1104.0	95.4	3.8	0.8
	Truck routes				
Savannah River Site	Port-Hampton Roads, VA	505.0	71.2	27.0	1.9
Savannah River Site	Port-Seattle-Tacoma, WA	2900.0	85.1	13.8	1.2
Savannah River Site	Port-Charleston, SC	209.0	73.1	24.8	2.2
Savannah River Site	Port-Savannah, GA	265.0	78.8	20.8	0.5
Savannah River Site	Port-Oakland, CA	2791.0	79.5	17.0	3.5
Savannah River Site	Port-Portland, OR	2849.0	84.4	14.0	1.6
Hanford Site	Port-Hampton Roads, VA	2903.0	85.0	13.3	1.7
Hanford Site	Port-Seattle-Tacoma, WA	226.0	76.8	20.9	2.3
Hanford Site	Port-Charleston, SC	2862.0	85.5	13.2	1.3
Hanford Site	Port-Savannah, GA	2804.0	84.9	13.7	1.4

Table I-1. (continued).

	Route	Miles	Rural (%)	Suburban (%)	Urban (%)
Hanford Site	Port-Oakland, CA	875.0	78.1	17.8	4.1
Hanford Site	Port-Portland, OR	236.0	86.0	10.7	3.4
Idaho National Engineering Laboratory	Port-Hampton Roads, VA	2487.0	83.7	14.5	1.8
Idaho National Engineering Laboratory	Port-Seattle-Tacoma, WA	793.0	88.3	10.5	1.1
Idaho National Engineering Laboratory	Port-Charleston, SC	2446.0	84.2	14.4	1.3
Idaho National Engineering Laboratory	Port-Savannah, GA	2388.0	83.6	15.0	1.5
Idaho National Engineering Laboratory	Port-Oakland, CA	963.0	84.5	11.0	4.4
Idaho National Engineering Laboratory	Port-Portland, OR	721.0	90.2	8.1	1.6
Oak Ridge Reservation	Port-Hampton Roads, VA	548.0	70.3	27.3	2.3
Oak Ridge Reservation	Port-Seattle-Tacoma, WA	2636.0	88.4	10.7	0.8
Oak Ridge Reservation	Port-Charleston, SC	408.0	70.8	27.5	1.8
Oak Ridge Reservation	Port-Savannah, GA	456.0	67.1	31.1	1.8
Oak Ridge Reservation	Port-Oakland, CA	2563.0	86.3	10.7	3.0
Oak Ridge Reservation	Port-Portland, OR	2585.0	87.7	11.0	1.3
Nevada Test Site	Port-Hampton Roads, VA	2590.0	83.9	14.0	2.1
Nevada Test Site	Port-Seattle-Tacoma, WA	1322.0	85.5	12.1	2.4
Nevada Test Site	Port-Charleston, SC	2549.0	84.5	14.0	1.6
Nevada Test Site	Port-Savannah, GA	2492.0	83.8	14.4	1.7
Nevada Test Site	Port-Oakland, CA	719.0	81.9	10.6	7.5
Nevada Test Site	Port-Portland, OR	1250.0	86.4	10.8	2.8
	Train routes				
Savannah River Site	Port-Hampton Roads, VA	529.0	74.3	24.1	1.6
Savannah River Site	Port-Seattle-Tacoma, WA	3123.0	81.1	16.1	2.8
Savannah River Site	Port-Charleston, SC	140.0	83.9	13.6	2.5
Savannah River Site	Port-Savannah, GA	114.0	87.9	10.9	1.2
Savannah River Site	Port-Oakland, CA	3192.0	79.2	16.7	4.1
Savannah River Site	Port-Portland, OR	3154.0	82.0	15.4	2.6
Hanford Site	Port-Hampton Roads, VA	3187.0	83.8	13.6	2.7
Hanford Site	Port-Seattle-Tacoma, WA	416.0	73.7	20.1	6.2
Hanford Site	Port-Charleston, SC	3059.0	84.5	13.7	1.8

Table I-1. (continued).

	Route	Miles	Rural (%)	Suburban (%)	Urban (%)
Hanford Site	Port-Savannah, GA	3091.0	85.3	13.2	1.4
Hanford Site	Port-Oakland, CA	986.0	78.5	15.8	5.7
Hanford Site	Port-Portland, OR	239.0	82.1	13.4	4.5
Idaho National Engineering Laboratory	Port-Hampton Roads, VA	2641.0	81.8	15.2	3.0
Idaho National Engineering Laboratory	Port-Seattle-Tacoma, WA	976.0	85.8	10.8	3.4
Idaho National Engineering Laboratory	Port-Charleston, SC	2513.0	82.6	15.3	2.1
Idaho National Engineering Laboratory	Port-Savannah, GA	2545.0	83.6	14.8	1.6
Idaho National Engineering Laboratory	Port-Oakland, CA	1102.0	90.0	7.6	2.4
Idaho National Engineering Laboratory	Port-Portland, OR	785.0	92.6	5.8	1.6
Oak Ridge Reservation	Port-Hampton Roads, VA	689.0	62.2	36.3	1.6
Oak Ridge Reservation	Port-Seattle-Tacoma, WA	2795.0	84.6	12.8	2.6
Oak Ridge Reservation	Port-Charleston, SC	581.0	65.2	33.3	1.5
Oak Ridge Reservation	Port-Savannah, GA	587.0	66.2	32.1	1.7
Oak Ridge Reservation	Port-Oakland, CA	2686.0	89.4	8.5	2.1
Oak Ridge Reservation	Port-Portland, OR	2827.0	85.5	12.1	2.4
Nevada Test Site	Port-Hampton Roads, VA	3073.0	83.6	13.6	2.8
Nevada Test Site	Port-Seattle-Tacoma, WA	1620.0	89.3	8.4	2.3
Nevada Test Site	Port-Charleston, SC	2945.0	84.3	13.7	2.0
Nevada Test Site	Port-Savannah, GA	2977.0	85.2	13.2	1.5
Nevada Test Site	Port-Oakland, CA	860.0	75.1	17.7	7.2
Nevada Test Site	Port-Portland, OR	1429.0	93.5	5.3	1.2
	Truck routes				
Savannah River Site	Cornell University	896.0	66.5	32.3	1.2
Savannah River Site	Georgia Institute of Technology	197.0	61.1	34.5	4.4
Savannah River Site	Idaho State University	2248.0	82.7	15.7	1.5
Savannah River Site	Iowa State University	1175.0	77.9	21.0	1.2
Savannah River Site	Kansas State University	1121.0	72.3	25.1	2.7
Savannah River Site	Manhattan College	830.0	62.1	35.2	2.7
Savannah River Site	Massachusetts Institute of Technology	1040.0	53.2	39.7	7.0
Savannah River Site	North Carolina State University	318.0	68.0	31.4	0.6

Table I-1. (continued).

	Route	Miles	Rural (%)	Suburban (%)	Urban (%)
Savannah River Site	Ohio State University	708.0	69.6	29.6	0.7
Savannah River Site	Oregon State University	2937.0	83.7	14.6	1.7
Savannah River Site	Pennsylvania State University	849.0	69.6	29.5	0.9
Savannah River Site	Purdue University	768.0	70.0	29.2	0.8
Savannah River Site	Reed College	2849.0	84.4	14.0	1.6
Savannah River Site	Rensselaer Polytechnique Institute	955.0	64.3	34.5	1.2
Savannah River Site	Rhode Island Nuclear Science Center	1009.0	55.0	38.5	6.5
Savannah River Site	State University of New York - Buffalo	1001.0	68.8	29.8	1.5
Savannah River Site	Texas A&M University	1099.0	70.6	26.7	2.7
Savannah River Site	University of Arizona	1926.0	79.4	19.1	1.6
Savannah River Site	University of California - Irvine	2406.0	79.6	17.9	2.5
Savannah River Site	University of Florida	496.0	73.4	26.0	0.6
Savannah River Site	University of Illinois	803.0	73.9	24.6	1.5
Savannah River Site	University of Lowell	1045.0	53.1	40.2	6.8
Savannah River Site	University of Maryland	589.0	65.9	31.0	3.1
Savannah River Site	University of Michigan	903.0	62.7	34.8	2.5
Savannah River Site	University of Missouri - Columbia	858.0	70.6	27.0	2.3
Savannah River Site	University of Missouri - Rolla	835.0	71.2	26.9	1.9
Savannah River Site	University of New Mexico	1653.0	80.1	17.7	2.1
Savannah River Site	University of Texas	1169.0	71.4	26.6	1.9
Savannah River Site	University of Utah	2127.0	82.3	16.0	1.7
Savannah River Site	University of Virginia	478.0	73.1	25.9	1.0
Savannah River Site	University of Wisconsin	1038.0	67.9	29.4	2.8
Savannah River Site	Washington State University	2699.0	84.8	14.1	1.2
Savannah River Site	Worcester Polytechnique Institute	1002.0	54.2	38.8	7.1
	Train routes				
Savannah River Site	Cornell University	1098.0	61.2	33.7	5.1
Savannah River Site	Georgia Institute of Technology	221.0	65.5	28.3	6.2
Savannah River Site	Idaho State University	2323.0	81.7	16.2	2.1
Savannah River Site	Iowa State University	1281.0	66.8	28.4	4.8
Savannah River Site	Kansas State University	1274.0	69.3	27.0	3.7
Savannah River Site	Manhattan College	1156.0	51.1	37.0	11.9
Savannah River Site	Massachusetts Institute of Technology	1223.0	50.6	36.6	12.8
Savannah River Site	North Carolina State University	385.0	78.6	20.1	1.3

Table I-1. (continued).

	Route	Miles	Rural (%)	Suburban (%)	Urban (%)
Savannah River Site	Ohio State University	726.0	73.6	25.0	1.4
Savannah River Site	Oregon State University	3381.0	84.4	13.7	1.9
Savannah River Site	Pennsylvania State University	963.0	65.5	29.6	4.9
Savannah River Site	Purdue University	903.0	64.6	32.4	3.0
Savannah River Site	Reed College	3154.0	82.0	15.4	2.6
Savannah River Site	Rensselaer Polytechnique Institute	1044.0	52.3	34.9	12.8
Savannah River Site	Rhode Island Nuclear Science Center	1252.0	50.6	37.0	12.4
Savannah River Site	State University of New York - Buffalo	1051.0	65.1	30.8	4.1
Savannah River Site	Texas A&M University	1194.0	66.5	29.1	4.4
Savannah River Site	University of Arizona	2245.0	79.4	17.5	3.1
Savannah River Site	University of California - Irvine	3180.0	82.1	15.3	2.6
Savannah River Site	University of Florida	328.0	84.7	13.6	1.7
Savannah River Site	University of Illinois	1028.0	67.7	28.6	3.7
Savannah River Site	University of Lowell	1239.0	51.6	37.2	11.2
Savannah River Site	University of Maryland	669.0	67.8	27.6	4.6
Savannah River Site	University of Michigan	913.0	68.2	29.2	2.5
Savannah River Site	University of Missouri - Columbia	1011.0	66.6	29.5	4.0
Savannah River Site	University of Missouri - Rolla	966.0	65.3	30.7	4.0
Savannah River Site	University of New Mexico	2315.0	79.9	18.1	2.1
Savannah River Site	University of Texas	1314.0	71.8	23.6	4.6
Savannah River Site	University of Utah	2378.0	80.3	17.5	2.2
Savannah River Site	University of Virginia	637.0	75.1	22.8	2.2
Savannah River Site	University of Wisconsin	1092.0	62.7	32.0	5.3
Savannah River Site	Washington State University	2864.0	81.4	16.0	2.5
Savannah River Site	Worcester Polytechnique Institute	1176.0	52.1	35.8	12.1
	Truck routes				
Hanford Site	Cornell University	2730.0	82.7	15.4	1.9
Hanford Site	Georgia Institute of Technology	2550.0	85.6	13.0	1.4
Hanford Site	Idaho State University	546.0	90.2	8.1	1.7
Hanford Site	Iowa State University	1703.0	92.6	6.6	0.8
Hanford Site	Kansas State University	1624.0	92.8	6.5	0.7
Hanford Site	Manhattan College	2786.0	85.0	13.5	1.5
Hanford Site	Massachusetts Institute of Technology	2986.0	81.5	17.0	1.6
Hanford Site	North Carolina State University	2862.0	83.2	15.5	1.3

Table I-1. (continued).

	Route	Miles	Rural (%)	Suburban (%)	Urban (%)
Hanford Site	Ohio State University	2342.0	88.3	10.6	1.1
Hanford Site	Oregon State University	324.0	79.5	16.3	4.2
Hanford Site	Pennsylvania State University	2578.0	86.2	12.7	1.1
Hanford Site	Purdue University	2111.0	90.0	8.9	1.1
Hanford Site	Reed College	236.0	86.0	10.7	3.4
Hanford Site	Rensselaer Polytechnique Institute	2819.0	82.0	16.1	1.9
Hanford Site	Rhode Island Nuclear Science Center	2965.0	81.2	15.9	2.9
Hanford Site	State University of New York - Buffalo	2534.0	84.8	13.4	1.8
Hanford Site	Texas A&M University	2212.0	88.7	9.7	1.6
Hanford Site	University of Arizona	1699.0	80.2	14.7	5.0
Hanford Site	University of California - Irvine	1270.0	79.3	14.5	6.2
Hanford Site	University of Florida	2894.0	84.1	14.6	1.4
Hanford Site	University of Illinois	2033.0	91.2	8.0	0.8
Hanford Site	University of Lowell	2991.0	81.4	17.1	1.5
Hanford Site	University of Maryland	2753.0	84.7	13.8	1.5
Hanford Site	University of Michigan	2227.0	87.0	11.8	1.2
Hanford Site	University of Missouri - Columbia	1870.0	90.6	8.3	1.1
Hanford Site	University of Missouri -Rolla	2082.0	88.4	10.2	1.4
Hanford Site	University of New Mexico	1593.0	89.7	8.8	1.5
Hanford Site	University of Texas	2216.0	87.0	11.5	1.5
Hanford Site	University of Utah	643.0	87.5	10.6	1.9
Hanford Site	University of Virginia	2757.0	86.1	12.4	1.5
Hanford Site	University of Wisconsin	1943.0	88.2	10.8	1.0
Hanford Site	Washington State University	361.0	87.3	11.6	1.1
Hanford Site	Worcester Polytechnique Institute	2948.0	82.2	16.3	1.5
	Train routes				
Hanford Site	Cornell University	2842.0	81.0	15.4	3.6
Hanford Site	Georgia Institute of Technology	2732.0	86.3	12.3	1.4
Hanford Site	Idaho State University	602.0	92.2	6.6	1.2
Hanford Site	Iowa State University	1788.0	93.7	5.6	0.7
Hanford Site	Kansas State University	1743.0	95.4	4.1	0.6
Hanford Site	Manhattan College	3070.0	77.0	19.1	3.9
Hanford Site	Massachusetts Institute of Technology	3105.0	77.5	18.7	3.8
Hanford Site	North Carolina State University	3172.0	83.8	14.6	1.7

Table I-1. (continued).

	Route	Miles	Rural (%)	Suburban (%)	Urban (%)
Hanford Site	Ohio State University	2482.0	86.1	11.0	2.9
Hanford Site	Oregon State University	340.0	70.6	22.2	7.2
Hanford Site	Pennsylvania State University	2760.0	79.3	16.7	4.0
Hanford Site	Purdue University	2359.0	90.8	8.0	1.1
Hanford Site	Reed College	239.0	82.1	13.4	4.5
Hanford Site	Rensselaer Polytechnique Institute	2934.0	78.6	17.3	4.0
Hanford Site	Rhode Island Nuclear Science Center	3166.0	76.0	19.6	4.4
Hanford Site	State University of New York - Buffalo	2637.0	81.7	14.6	3.7
Hanford Site	Texas A&M University	2954.0	85.2	11.2	3.7
Hanford Site	University of Arizona	1804.0	80.2	14.5	5.4
Hanford Site	University of California - Irvine	1528.0	88.2	8.6	3.2
Hanford Site	University of Florida	3138.0	85.5	13.0	1.5
Hanford Site	University of Illinois	2158.0	93.0	6.0	1.0
Hanford Site	University of Lowell	3095.0	77.6	18.6	3.9
Hanford Site	University of Maryland	2900.0	82.6	13.7	3.8
Hanford Site	University of Michigan	2369.0	85.7	11.4	2.9
Hanford Site	University of Missouri - Columbia	1948.0	94.1	5.3	0.6
Hanford Site	University of Missouri - Rolla	2246.0	89.1	9.3	1.6
Hanford Site	University of New Mexico	1796.0	91.5	7.2	1.2
Hanford Site	University of Texas	2473.0	89.8	8.9	1.3
Hanford Site	University of Utah	774.0	89.6	8.8	1.7
Hanford Site	University of Virginia	2902.0	83.9	13.4	2.7
Hanford Site	University of Wisconsin	2210.0	88.9	9.2	1.9
Hanford Site	Washington State University	251.0	86.0	9.4	4.5
Hanford Site	Worcester Polytechnique Institute	3089.0	77.2	18.7	4.1
	Truck routes				
Idaho National Engineering Laboratory	Cornell University	2314.0	80.9	17.1	2.1
Idaho National Engineering Laboratory	Georgia Institute of Technology	2134.0	84.2	14.4	1.4
Idaho National Engineering Laboratory	Idaho State University	65.0	83.7	12.5	3.9
Idaho National Engineering Laboratory	Iowa State University	1287.0	92.5	6.8	0.7
Idaho National Engineering Laboratory	Kansas State University	1208.0	92.8	6.7	0.5

Table I-1. (continued).

	Route	Miles	Rural (%)	Suburban (%)	Urban (%)
Idaho National Engineering Laboratory	Manhattan College	2370.0	83.6	14.8	1.6
Idaho National Engineering Laboratory	Massachusetts Institute of Technology	2570.0	79.6	18.7	1.6
Idaho National Engineering Laboratory	North Carolina State University	2446.0	81.5	17.2	1.3
Idaho National Engineering Laboratory	Ohio State University	1926.0	87.3	11.6	1.1
Idaho National Engineering Laboratory	Oregon State University	809.0	87.2	10.7	2.2
Idaho National Engineering Laboratory	Pennsylvania State University	2162.0	84.9	14.0	1.1
Idaho National Engineering Laboratory	Purdue University	1695.0	89.3	9.6	1.1
Idaho National Engineering Laboratory	Reed College	721.0	90.2	8.1	1.6
Idaho National Engineering Laboratory	Rensselaer Polytechnique Institute	2403.0	80.1	17.9	2.0
Idaho National Engineering Laboratory	Rhode Island Nuclear Science Center	2549.0	79.3	17.5	3.2
Idaho National Engineering Laboratory	State University of New York - Buffalo	2118.0	83.2	14.8	2.0
Idaho National Engineering Laboratory	Texas A&M University	1796.0	87.7	10.5	1.7
Idaho National Engineering Laboratory	University of Arizona	1301.0	83.8	12.9	3.3
Idaho National Engineering Laboratory	University of California - Irvine	942.0	79.8	13.8	6.4
Idaho National Engineering Laboratory	University of Florida	2478.0	82.6	16.0	1.4
Idaho National Engineering Laboratory	University of Illinois	1617.0	90.8	8.5	0.7
Idaho National Engineering Laboratory	University of Lowell	2575.0	79.5	18.9	1.5
Idaho National Engineering Laboratory	University of Maryland	2337.0	83.3	15.2	1.6
Idaho National Engineering Laboratory	University of Michigan	1811.0	85.6	13.2	1.2
Idaho National Engineering Laboratory	University of Missouri - Columbia	1454.0	90.0	8.9	1.1
Idaho National Engineering Laboratory	University of Missouri - Rolla	1666.0	87.3	11.3	1.5
Idaho National Engineering Laboratory	University of New Mexico	1177.0	88.6	9.8	1.6

Table I-1. (continued).

	Route	Miles	Rural (%)	Suburban (%)	Urban (%)
Idaho National Engineering Laboratory	University of Texas	1800.0	85.7	12.7	1.6
Idaho National Engineering Laboratory	University of Utah	227.0	77.7	18.9	3.4
Idaho National Engineering Laboratory	University of Virginia	2341.0	85.0	13.5	1.5
Idaho National Engineering Laboratory	University of Wisconsin	1612.0	89.8	9.2	1.0
Idaho National Engineering Laboratory	Washington State University	652.0	91.9	7.3	0.8
Idaho National Engineering Laboratory	Worcester Polytechnique Institute	2532.0	80.4	18.0	1.6
	Train routes				
Idaho National Engineering Laboratory	Cornell University	2296.0	78.1	17.6	4.2
Idaho National Engineering Laboratory	Georgia Institute of Technology	2186.0	84.5	13.9	1.6
Idaho National Engineering Laboratory	Idaho State University	56.0	82.5	13.2	4.3
Idaho National Engineering Laboratory	Iowa State University	1242.0	93.9	5.4	0.7
Idaho National Engineering Laboratory	Kansas State University	1197.0	96.3	3.2	0.4
Idaho National Engineering Laboratory	Manhattan College	2524.0	73.5	21.9	4.6
Idaho National Engineering Laboratory	Massachusetts Institute of Technology	2559.0	74.1	21.5	4.4
Idaho National Engineering Laboratory	North Carolina State University	2626.0	81.8	16.4	1.8
Idaho National Engineering Laboratory	Ohio State University	1936.0	84.1	12.5	3.4
Idaho National Engineering Laboratory	Oregon State University	878.0	87.2	9.7	3.1
Idaho National Engineering Laboratory	Pennsylvania State University	2214.0	75.9	19.4	4.7
Idaho National Engineering Laboratory	Purdue University	1813.0	90.1	8.7	1.2
Idaho National Engineering Laboratory	Reed College	785.0	92.6	5.8	1.6
Idaho National Engineering Laboratory	Rensselaer Polytechnique Institute	2388.0	75.3	19.9	4.8
Idaho National Engineering Laboratory	Rhode Island Nuclear Science Center	2620.0	72.4	22.5	5.1

Table I-1. (continued).

	Route	Miles	Rural (%)	Suburban (%)	Urban (%)
Idaho National Engineering Laboratory	State University of New York - Buffalo	2091.0	78.7	16.9	4.4
Idaho National Engineering Laboratory	Texas A&M University	1920.0	89.6	9.4	1.0
Idaho National Engineering Laboratory	University of Arizona	1376.0	90.8	7.3	1.9
Idaho National Engineering Laboratory	University of California - Irvine	982.0	85.4	10.0	4.5
Idaho National Engineering Laboratory	University of Florida	2592.0	83.8	14.6	1.6
Idaho National Engineering Laboratory	University of Illinois	1612.0	92.9	6.0	1.1
Idaho National Engineering Laboratory	University of Lowell	2549.0	74.2	21.3	4.5
Idaho National Engineering Laboratory	University of Maryland	2354.0	80.1	15.5	4.4
Idaho National Engineering Laboratory	University of Michigan	1823.0	83.4	13.0	3.6
Idaho National Engineering Laboratory	University of Missouri - Columbia	1402.0	94.4	5.1	0.5
Idaho National Engineering Laboratory	University of Missouri - Rolla	1619.0	92.6	6.1	1.3
Idaho National Engineering Laboratory	University of New Mexico	1250.0	90.8	7.8	1.4
Idaho National Engineering Laboratory	University of Texas	1927.0	88.8	9.8	1.4
Idaho National Engineering Laboratory	University of Utah	228.0	80.7	15.6	3.7
Idaho National Engineering Laboratory	University of Virginia	2357.0	81.8	15.1	3.1
Idaho National Engineering Laboratory	University of Wisconsin	1664.0	87.5	10.3	2.2
Idaho National Engineering Laboratory	Washington State University	876.0	92.2	6.2	1.6
Idaho National Engineering Laboratory	Worcester Polytechnique Institute	2544.0	73.8	21.5	4.7
	Truck routes				
Oak Ridge Reservation	Cornell University	821.0	65.7	33.2	1.1
Oak Ridge Reservation	Georgia Institute of Technology	202.0	53.2	45.1	1.8
Oak Ridge Reservation	Idaho State University	1985.0	86.8	12.0	1.2
Oak Ridge Reservation	Iowa State University	900.0	75.2	23.4	1.5
Oak Ridge Reservation	Kansas State University	857.0	78.6	19.2	2.2

Table I-1. (continued).

	Route	Miles	Rural (%)	Suburban (%)	Urban (%)
Oak Ridge Reservation	Manhattan College	754.0	60.9	36.4	2.7
Oak Ridge Reservation	Massachusetts Institute of Technology	965.0	51.6	41.1	7.4
Oak Ridge Reservation	North Carolina State University	408.0	54.5	43.7	1.8
Oak Ridge Reservation	Ohio State University	400.0	67.7	31.1	1.2
Oak Ridge Reservation	Oregon State University	2674.0	86.8	11.7	1.5
Oak Ridge Reservation	Pennsylvania State University	774.0	69.1	30.1	0.8
Oak Ridge Reservation	Purdue University	460.0	68.6	30.2	1.3
Oak Ridge Reservation	Reed College	2585.0	87.7	11.0	1.3
Oak Ridge Reservation	Rensselaer Polytechnique Institute	879.0	63.4	35.5	1.1
Oak Ridge Reservation	Rhode Island Nuclear Science Center	933.0	53.4	39.8	6.8
Oak Ridge Reservation	State University of New York - Buffalo	744.0	61.9	35.6	2.5
Oak Ridge Reservation	Texas A&M University	1004.0	81.5	17.2	1.3
Oak Ridge Reservation	University of Arizona	1782.0	83.2	15.1	1.7
Oak Ridge Reservation	University of California - Irvine	2209.0	86.0	10.9	3.0
Oak Ridge Reservation	University of Florida	546.0	65.4	33.1	1.5
Oak Ridge Reservation	University of Illinois	516.0	68.0	29.9	2.2
Oak Ridge Reservation	University of Lowell	970.0	51.4	41.5	7.1
Oak Ridge Reservation	University of Maryland	537.0	70.2	27.2	2.6
Oak Ridge Reservation	University of Michigan	595.0	57.8	38.5	3.7
Oak Ridge Reservation	University of Missouri - Columbia	594.0	79.0	19.5	1.5
Oak Ridge Reservation	University of Missouri - Rolla	571.0	80.2	19.0	0.9
Oak Ridge Reservation	University of New Mexico	1391.0	85.4	12.9	1.7
Oak Ridge Reservation	University of Texas	1026.0	76.9	20.9	2.2
Oak Ridge Reservation	University of Utah	1864.0	86.6	12.1	1.3
Oak Ridge Reservation	University of Virginia	402.0	72.8	26.4	0.8
Oak Ridge Reservation	University of Wisconsin	730.0	66.1	30.0	3.9
Oak Ridge Reservation	Washington State University	2435.0	88.3	10.8	0.9
Oak Ridge Reservation	Worcester Polytechnique Institute	927.0	52.5	40.0	7.5
	Train routes				
Oak Ridge Reservation	Cornell University	935.0	60.9	32.8	6.3
Oak Ridge Reservation	Georgia Institute of Technology	228.0	47.1	50.9	2.0
Oak Ridge Reservation	Idaho State University	1996.0	89.9	8.5	1.6
Oak Ridge Reservation	Iowa State University	954.0	71.7	22.0	6.3
Oak Ridge Reservation	Kansas State University	948.0	82.2	14.7	3.1

Table I-1. (continued).

	Route	Miles	Rural (%)	Suburban (%)	Urban (%)
Oak Ridge Reservation	Manhattan College	1164.0	54.3	39.1	6.6
Oak Ridge Reservation	Massachusetts Institute of Technology	1199.0	56.1	37.7	6.2
Oak Ridge Reservation	North Carolina State University	511.0	60.9	36.9	2.2
Oak Ridge Reservation	Ohio State University	406.0	66.9	27.8	5.3
Oak Ridge Reservation	Oregon State University	3055.0	90.0	8.4	1.6
Oak Ridge Reservation	Pennsylvania State University	822.0	55.2	37.4	7.3
Oak Ridge Reservation	Purdue University	495.0	74.4	22.6	3.0
Oak Ridge Reservation	Reed College	2827.0	85.5	12.1	2.4
Oak Ridge Reservation	Rensselaer Polytechnique Institute	1028.0	55.9	36.8	7.3
Oak Ridge Reservation	Rhode Island Nuclear Science Center	1259.0	53.5	39.0	7.5
Oak Ridge Reservation	State University of New York - Buffalo	731.0	57.7	34.9	7.4
Oak Ridge Reservation	Texas A&M University	1013.0	80.0	18.6	1.5
Oak Ridge Reservation	University of Arizona	2103.0	85.1	12.9	2.0
Oak Ridge Reservation	University of California - Irvine	2615.0	88.0	9.5	2.5
Oak Ridge Reservation	University of Florida	634.0	68.2	29.9	1.9
Oak Ridge Reservation	University of Illinois	592.0	75.4	21.3	3.3
Oak Ridge Reservation	University of Lowell	1189.0	56.2	37.4	6.4
Oak Ridge Reservation	University of Maryland	582.0	53.9	40.4	5.6
Oak Ridge Reservation	University of Michigan	591.0	63.3	30.1	6.6
Oak Ridge Reservation	University of Missouri - Columbia	695.0	82.5	14.2	3.3
Oak Ridge Reservation	University of Missouri - Rolla	640.0	82.3	14.4	3.3
Oak Ridge Reservation	University of New Mexico	1749.0	87.9	10.3	1.8
Oak Ridge Reservation	University of Texas	1045.0	75.7	22.1	2.1
Oak Ridge Reservation	University of Utah	2051.0	88.0	10.3	1.7
Oak Ridge Reservation	University of Virginia	451.0	53.6	44.1	2.3
Oak Ridge Reservation	University of Wisconsin	765.0	67.1	25.5	7.4
Oak Ridge Reservation	Washington State University	2536.0	85.3	12.4	2.3
Oak Ridge Reservation	Worcester Polytechnique Institute	1183.0	55.2	37.9	6.9
	Truck routes				
Nevada Test Site	Cornell University	2547.0	81.7	16.1	2.2
Nevada Test Site	Georgia Institute of Technology	2238.0	84.4	13.8	1.7
Nevada Test Site	Idaho State University	649.0	82.5	13.8	3.6
Nevada Test Site	Iowa State University	1520.0	92.0	6.8	1.2
Nevada Test Site	Kansas State University	1312.0	92.5	6.4	1.1

Table I-1. (continued).

	Route	Miles	Rural (%)	Suburban (%)	Urban (%)
Nevada Test Site	Manhattan College	2603.0	84.1	14.0	1.8
Nevada Test Site	Massachusetts Institute of Technology	2802.0	80.5	17.7	1.8
Nevada Test Site	North Carolina State University	2549.0	81.9	16.5	1.6
Nevada Test Site	Ohio State University	2098.0	85.8	12.3	2.0
Nevada Test Site	Oregon State University	1245.0	81.8	13.5	4.7
Nevada Test Site	Pennsylvania State University	2395.0	85.3	13.3	1.4
Nevada Test Site	Purdue University	1928.0	89.3	9.2	1.5
Nevada Test Site	Reed College	1250.0	86.4	10.8	2.8
Nevada Test Site	Rensselaer Polytechnique Institute	2636.0	81.0	16.9	2.2
Nevada Test Site	Rhode Island Nuclear Science Center	2782.0	80.1	16.6	3.2
Nevada Test Site	State University of New York - Buffalo	2350.0	83.8	14.0	2.2
Nevada Test Site	Texas A&M University	1852.0	85.6	11.9	2.5
Nevada Test Site	University of Arizona	723.0	85.0	11.1	3.9
Nevada Test Site	University of California - Irvine	364.0	76.1	11.6	12.4
Nevada Test Site	University of Florida	2582.0	82.9	15.4	1.7
Nevada Test Site	University of Illinois	1850.0	90.6	8.3	1.1
Nevada Test Site	University of Lowell	2808.0	80.3	17.9	1.8
Nevada Test Site	University of Maryland	2509.0	82.3	15.5	2.2
Nevada Test Site	University of Michigan	2044.0	86.1	12.4	1.5
Nevada Test Site	University of Missouri - Columbia	1557.0	89.9	8.5	1.6
Nevada Test Site	University of Missouri - Rolla	1769.0	87.4	10.7	1.8
Nevada Test Site	University of New Mexico	918.0	93.8	4.8	1.5
Nevada Test Site	University of Texas	1662.0	86.5	10.5	3.0
Nevada Test Site	University of Utah	487.0	85.0	11.4	3.6
Nevada Test Site	University of Virginia	2444.0	85.2	13.0	1.8
Nevada Test Site	University of Wisconsin	1857.0	90.5	8.2	1.3
Nevada Test Site	Washington State University	1286.0	86.6	11.1	2.4
Nevada Test Site	Worcester Polytechnique Institute	2765.0	81.2	17.0	1.8
	Train routes				
Nevada Test Site	Cornell University	2727.0	80.7	15.5	3.8
Nevada Test Site	Georgia Institute of Technology	2618.0	86.1	12.3	1.6
Nevada Test Site	Idaho State University	700.0	93.6	5.4	1.0
Nevada Test Site	Iowa State University	1674.0	94.0	5.1	0.9
Nevada Test Site	Kansas State University	1628.0	95.8	3.5	0.7

Table I-1. (continued).

	Route	Miles	Rural (%)	Suburban (%)	Urban (%)
Nevada Test Site	Manhattan College	2956.0	76.6	19.3	4.1
Nevada Test Site	Massachusetts Institute of Technology	2990.0	77.0	19.0	4.0
Nevada Test Site	North Carolina State University	3058.0	83.6	14.7	1.8
Nevada Test Site	Ohio State University	2367.0	86.0	11.0	3.1
Nevada Test Site	Oregon State University	1400.0	79.8	14.7	5.4
Nevada Test Site	Pennsylvania State University	2646.0	78.9	16.9	4.2
Nevada Test Site	Purdue University	2245.0	90.9	7.8	1.3
Nevada Test Site	Reed College	1429.0	93.5	5.3	1.2
Nevada Test Site	Rensselaer Polytechnique Institute	2820.0	78.2	17.5	4.3
Nevada Test Site	Rhode Island Nuclear Science Center	3051.0	75.6	19.9	4.6
Nevada Test Site	State University of New York - Buffalo	2522.0	81.4	14.7	3.9
Nevada Test Site	Texas A&M University	1967.0	92.0	6.6	1.4
Nevada Test Site	University of Arizona	818.0	90.6	7.4	2.0
Nevada Test Site	University of California -Irvine	424.0	78.0	13.8	8.2
Nevada Test Site	University of Florida	3024.0	85.3	13.1	1.6
Nevada Test Site	University of Illinois	2044.0	93.2	5.6	1.2
Nevada Test Site	University of Lowell	2980.0	77.2	18.8	4.1
Nevada Test Site	University of Maryland	2786.0	82.3	13.7	4.0
Nevada Test Site	University of Michigan	2255.0	85.5	11.3	3.2
Nevada Test Site	University of Missouri - Columbia	1833.0	94.4	4.8	0.7
Nevada Test Site	University of Missouri - Rolla	2050.0	93.0	5.7	1.4
Nevada Test Site	University of New Mexico	1065.0	94.6	4.5	0.9
Nevada Test Site	University of Texas	2358.0	89.9	8.7	1.4
Nevada Test Site	University of Utah	528.0	98.0	1.8	0.2
Nevada Test Site	University of Virginia	2788.0	83.7	13.4	2.9
Nevada Test Site	University of Wisconsin	2096.0	88.9	9.0	2.1
Nevada Test Site	Washington State University	1520.0	93.2	5.6	1.2
Nevada Test Site	Worcester Polytechnique Institute	2975.0	76.8	18.9	4.3
	Truck routes				
West Valley Demonstration Plant	Savannah River Site	883.0	70.3	28.5	1.2
West Valley Demonstration Plant	Hanford Site	2556.0	84.6	13.7	1.7
West Valley Demonstration Plant	Idaho National Engineering Laboratory	2140.0	83.0	15.2	1.8

Table I-1. (continued).

	Route	Miles	Rural (%)	Suburban (%)	Urban (%)
West Valley Demonstration Plant	Oak Ridge Reservation	766.0	62.2	36.0	1.8
West Valley Demonstration Plant	Nevada Test Site	2373.0	83.7	14.3	2.0
Babcock & Wilcox	Savannah River Site	455.0	71.0	28.2	0.9
Babcock & Wilcox	Hanford Site	2738.0	85.9	12.7	1.4
Babcock & Wilcox	Idaho National Engineering Laboratory	2322.0	84.7	13.8	1.5
Babcock & Wilcox	Oak Ridge Reservation	350.0	65.4	33.8	0.8
Babcock & Wilcox	Nevada Test Site	2491.0	84.0	14.5	1.5
	Train routes				
West Valley Demonstration Plant	Savannah River Site	1217.0	62.8	32.4	4.9
West Valley Demonstration Plant	Hanford Site	2654.0	78.3	18.0	3.7
West Valley Demonstration Plant	Idaho National Engineering Laboratory	2108.0	74.9	20.5	4.7
West Valley Demonstration Plant	Oak Ridge Reservation	889.0	64.5	30.1	5.5
West Valley Demonstration Plant	Nevada Test Site	2554.0	80.8	15.1	4.0
Babcock & Wilcox	Savannah River Site	661.0	76.8	21.5	1.6
Babcock & Wilcox	Hanford Site	2879.0	84.2	13.1	2.7
Babcock & Wilcox	Idaho National Engineering Laboratory	2333.0	82.1	14.8	3.2
Babcock & Wilcox	Oak Ridge Reservation	386.0	48.0	49.6	2.4
Babcock & Wilcox	Nevada Test Site	2765.0	84.0	13.1	2.9
Three Mile Island	Idaho National Engineering Laboratory	2315.0	75.8	19.6	4.6
	Truck routes				
Pleasanton, CA	Idaho National Engineering Laboratory	969.0	84.0	12.2	3.8
Pleasanton, CA	Hanford Site	881.0	77.5	19.1	3.4
Pleasanton, CA	Savannah River Site	2768.0	80.1	16.8	3.1
Pleasanton, CA	Oak Ridge Reservation	2532.0	87.0	10.5	2.5
Pleasanton, CA	Nevada Test Site	697.0	84.3	9.6	6.1
Gaithersburg, MD	Idaho National Engineering Laboratory	2316.0	83.9	14.9	1.2
Gaithersburg, MD	Hanford Site	2732.0	85.3	13.5	1.2
Gaithersburg, MD	Savannah River Site	597.0	66.8	30.7	2.5
Gaithersburg, MD	Oak Ridge Reservation	536.0	70.6	27.4	2.0
Gaithersburg, MD	Nevada Test Site	2488.0	82.9	15.2	1.9

Table I-1. (continued).

	Route	Miles	Rural (%)	Suburban (%)	Urban (%)
San Ramon, CA	Idaho National Engineering Laboratory	962.0	84.4	12.0	3.6
San Ramon, CA	Hanford Site	874.0	77.9	18.9	3.2
San Ramon, CA	Savannah River Site	2775.0	80.0	16.9	3.1
San Ramon, CA	Oak Ridge Reservation	2538.0	86.8	10.5	2.6
San Ramon, CA	Nevada Test Site	694.0	83.7	9.9	6.3
Midland, MI	Idaho National Engineering Laboratory	1902.0	82.9	15.8	1.3
Midland, MI	Hanford Site	2318.0	84.7	14.0	1.3
Midland, MI	Savannah River Site	036.0	58.9	37.9	3.2
Midland, MI	Oak Ridge Reservation	719.0	52.7	42.7	4.6
Midland, MI	Nevada Test Site	2135.0	83.6	14.8	1.6
San Diego, CA	Idaho National Engineering Laboratory	976.0	78.8	17.1	4.1
San Diego, CA	Hanford Site	1352.0	76.3	16.0	7.7
San Diego, CA	Savannah River Site	2345.0	81.0	17.0	2.0
San Diego, CA	Oak Ridge Reservation	2193.0	84.1	13.8	2.1
San Diego, CA	Nevada Test Site	398.0	73.9	19.8	6.3
Denver, CO	Idaho National Engineering Laboratory	717.0	91.2	7.9	0.9
Denver, CO	Hanford Site	1133.0	91.8	7.2	1.0
Denver, CO	Savannah River Site	1613.0	79.2	18.9	1.9
Denver, CO	Oak Ridge Reservation	1340.0	84.5	14.1	1.5
Denver, CO	Nevada Test Site	819.0	90.7	7.5	1.8
McClellan AFB, CA	Idaho National Engineering Laboratory	875.0	88.6	8.8	2.6
McClellan AFB, CA	Hanford Site	830.0	80.5	17.0	2.6
McClellan AFB, CA	Savannah River Site	2780.0	84.4	13.7	1.9
McClellan AFB, CA	Oak Ridge Reservation	2517.0	87.8	10.5	1.6
McClellan AFB, CA	Nevada Test Site	735.0	81.1	11.2	7.6
	Train routes				
Pleasanton, CA	Idaho National Engineering Laboratory	965.0	85.6	10.4	4.0
Pleasanton, CA	Hanford Site	1002.0	77.5	16.0	6.4
Pleasanton, CA	Savannah River Site	3170.0	79.6	16.5	3.8
Pleasanton, CA	Oak Ridge Reservation	3029.0	83.5	13.4	3.1
Pleasanton, CA	Nevada Test Site	838.0	76.2	17.4	6.3
Gaithersburg, MD	Idaho National Engineering Laboratory	2335.0	80.5	15.4	4.0
Gaithersburg, MD	Hanford Site	2881.0	83.0	13.6	3.4
Gaithersburg, MD	Savannah River Site	659.0	68.4	27.7	3.8

Table I-1. (continued).

	Route	Miles	Rural (%)	Suburban (%)	Urban (%)
Gaithersburg, MD	Oak Ridge Reservation	819.0	59.4	37.3	3.3
Gaithersburg, MD	Nevada Test Site	2767.0	82.7	13.7	3.6
San Ramon, CA	Idaho National Engineering Laboratory	965.0	85.6	10.4	4.0
San Ramon, CA	Hanford Site	1002.0	77.5	16.0	6.4
San Ramon, CA	Savannah River Site	3170.0	79.6	16.6	3.8
San Ramon, CA	Oak Ridge Reservation	3029.0	83.5	13.4	3.1
San Ramon, CA	Nevada Test Site	838.0	76.2	17.4	6.3
Midland, MI	Idaho National Engineering Laboratory	1961.0	82.3	14.2	3.5
Midland, MI	Hanford Site	2507.0	84.7	12.4	2.9
Midland, MI	Savannah River Site	996.0	65.9	31.2	2.9
Midland, MI	Oak Ridge Reservation	645.0	58.4	37.3	4.3
Midland, MI	Nevada Test Site	2392.0	84.5	12.4	3.1
San Diego, CA	Idaho National Engineering Laboratory	1076.0	82.6	11.4	6.0
San Diego, CA	Hanford Site	1622.0	86.2	9.5	4.3
San Diego, CA	Savannah River Site	3274.0	81.3	15.6	3.1
San Diego, CA	Oak Ridge Reservation	2709.0	86.8	10.0	3.1
San Diego, CA	Nevada Test Site	518.0	73.4	15.9	10.7
Denver, CO	Idaho National Engineering Laboratory	708.0	94.7	4.6	0.6
Denver, CO	Hanford Site	1254.0	94.1	5.2	0.7
Denver, CO	Savannah River Site	2125.0	77.0	20.5	2.6
Denver, CO	Oak Ridge Reservation	1560.0	85.0	12.6	2.3
Denver, CO	Nevada Test Site	1140.0	94.6	4.4	0.9
McClellan AFB, CA	Idaho National Engineering Laboratory	853.0	90.3	7.8	1.9
McClellan AFB, CA	Hanford Site	890.0	81.0	14.3	4.7
McClellan AFB, CA	Savannah River Site	3160.0	79.4	16.7	3.9
McClellan AFB, CA	Oak Ridge Reservation	2747.0	87.8	10.2	2.0
McClellan AFB, CA	Nevada Test Site	827.0	75.4	17.7	6.9

I-3.2 Spent Nuclear Fuel Shipments

In the transportation analyses, SNF was divided into a number of categories: (a) commercial, (b) DOE research, (c) foreign research reactor, (d) graphite, (e) N Reactor, (f) Naval-type, (g) Savannah River Site production reactor, and (h) university research reactor. More details on these fuel types may be found in Appendix J of Volume 1 of this EIS. The estimated number of SNF shipments are presented by fuel type, origin-destination pair, and transport mode for each alternative in Tables I-2 and I-3 (Heiselmann 1994). At this time, insufficient data exist to determine the transport mode (truck or rail) that for all shipments. Therefore, the number of truck or rail shipments was based on either 100 percent shipment by truck or 100 percent shipment by rail, to bound potential impacts.

The shipments in this appendix include offsite shipments of Naval-type SNF stored at the Idaho Chemical Processing Plant as of June 1995 to storage locations at other sites as identified in the alternatives. Shipments of Naval SNF from shipyards and prototypes to the equivalent Expended Core Facility at the alternative sites are addressed in Appendix D of Volume 1 of this EIS, along with shipments of Naval test specimens.

This appendix also includes shipments of foreign research reactor SNF from the six ports identified in the Implementation Plan as representative points of entry (Hampton Roads, Virginia; Charleston, South Carolina; Savannah, Georgia; Seattle-Tacoma, Washington; Portland, Oregon; and Oakland, California) to sites as identified in the alternatives. The ocean-going portion of foreign research reactor SNF shipments and a detailed evaluation of port activities are not assessed in this EIS, but will be assessed in the Foreign Research Reactor SNF EIS.

The No Action alternative, considers only shipments of Naval SNF and test specimens. These shipments are addressed in Appendix D of Volume 1 of this EIS. For the Decentralization alternative, university research reactor, foreign research reactor, and non-DOE research reactor SNF would be transported to the Idaho National Engineering Laboratory or the Savannah River Site.

For the 1992/1993 Planning Basis alternative, commercial, DOE research, and graphite SNF would be transported to the Idaho National Engineering Laboratory or the Savannah River Site. University research reactor, foreign research reactor, and non-DOE research reactor SNF would also continue to be transported to the Idaho National Engineering Laboratory or the Savannah River Site.

For the Regionalization alternatives, SNF would be consolidated based on fuel type or geography. More shipments of SNF would occur than for the 1992/1993 Planning Basis alternative and all types of SNF would be transported. For the Regionalization by Fuel Type alternative, N Reactor SNF, Naval-type SNF, and Savannah River Site production reactor SNF

and targets would not be transported. Generally, aluminum SNF would be transported to the Savannah River Site and stainless steel SNF would be transported to the Idaho National Engineering Laboratory. For the Regionalization by Geography alternative, SNF from west of the Mississippi River would be transported to the Hanford Site, the Idaho National Engineering Laboratory, or the Nevada Test Site. SNF from east of the Mississippi River would be transported to the Savannah River Site or the Oak Ridge Reservation.

For the Centralization alternatives, all SNF would be transported to the Hanford Site, the Idaho National Engineering Laboratory, the Savannah River Site, the Oak Ridge Reservation, or the Nevada Test Site. The primary difference between these alternatives, in terms of shipments, is the shipment of N Reactor SNF, Naval-type SNF, and Savannah River Site production reactor SNF and targets. For Centralization at the Idaho National Engineering Laboratory, the Savannah River Site, the Oak Ridge Reservation, or the Nevada Test Site, N Reactor SNF would be transported from the Hanford Site. For Centralization at the Hanford Site, the Idaho National Engineering Laboratory, the Oak Ridge Reservation, or the Nevada Test Site, Savannah River Site production reactor SNF and targets would be transported. For Centralization at the Hanford Site, the Savannah River Site, the Oak Ridge Reservation, or the Nevada Test Site, Naval-type SNF would be transported from the Idaho National Engineering Laboratory. For Centralization at the Oak Ridge Reservation or the Nevada Test Site, N Reactor SNF, Naval-type SNF, and Savannah River Site production reactor SNF and targets would be transported.

Table I-2. Spent nuclear fuel shipments for the Decentralization, 1992/1993 Planning Basis, Regionalization by Fuel Type, and Centralization alternatives.

Origin	Destination	Decentralization		1992/1993 Planning Basis		Regionalization by Fuel Type		Centralization									
								HS		SRS		INEL		ORR		NTS	
		truck	rail	truck	rail	truck	rail	truck	rail	truck	rail	truck	rail	truck	rail	truck	rail
Naval-Type																	
INEL	HS							383	104								
	NTS															383	104
	ORR													383	104		
	SRS									383	104						
Savannah River Production																	
SRS	HS							484	97								
	INEL											484	97				
	ORR													484	97		
	NTS															484	97
ORR	SRS					1	1										
Hanford Production																	
HS	INEL											1192	605				
	SRS									1192	605						
	ORR													1192	605		
	NTS															1192	605
ORR	INEL					1	1										

Table I-2. (continued)

Origin	Destination	Decentralization		1992/1993 Planning Basis		Regionalization by Fuel Type		Centralization									
								HS		SRS		INEL		ORR		NTS	
		truck	rail	truck	rail	truck	rail	truck	rail	truck	rail	truck	rail	truck	rail	truck	rail
Graphite																	
FSV	HS							247	35								
	INEL			247	35	247	35					247	35				
	SRS									247	35						
	ORR													247	35		
	NTS															247	35
INEL	HS							120	17								
	SRS									120	17						
	ORR													120	17		
	NTS															120	17
Domestic non-DOE																	
AFRRI	HS							3	3								
	INEL	3	3	3	3	3	3					3	3				
	SRS									3	3						
	ORR													3	3		
	NTS															3	3
USGS	HS							6	6								
	INEL	6	6	6	6	6	6					6	6				
	SRS									6	6						
	ORR													6	6		
	NTS															6	6

Table I-2. (continued)

Origin	Destination	Decentralization		1992/1993 Planning Basis		Regionalization by Fuel Type		Centralization									
								HS		SRS		INEL		ORR		NTS	
		truck	rail	truck	rail	truck	rail	truck	rail	truck	rail	truck	rail	truck	rail	truck	rail
Domestic non-DOE																	
NIST	HS							185	185								
	INEL											185	185				
	SRS	185	185	185	185	185	185			185	185						
	ORR													185	185		
	NTS															185	185
USAF	HS							3	3								
	INEL	3	3	3	3	3	3					3	3				
	SRS									3	3						
	ORR													3	3		
	NTS															3	3
DOW	HS							3	3								
	INEL	3	3	3	3	3	3					3	3				
	SRS									3	3						
	ORR													3	3		
	NTS															3	3
GE	HS							4	4								
	INEL	4	4	4	4							4	4				
	SRS					4	4			4	4						
	ORR													4	4		
	NTS															4	4

Table I-2. (continued)

Origin	Destination	Decentralization		1992/1993 Planning Basis		Regionalization by Fuel Type		Centralization									
								HS		SRS		INEL		ORR		NTS	
		truck	rail	truck	rail	truck	rail	truck	rail	truck	rail	truck	rail	truck	rail	truck	rail
Domestic non-DOE																	
GA	HS							8	8								
	INEL	8	8	8	8	8	8					8	8				
	SRS									8	8						
	ORR													8	8		
	NTS															8	8
AERO	HS							3	3								
	INEL	3	3	3	3	3	3					3	3				
	SRS									3	3						
	ORR													3	3		
	NTS															3	3
Universities																	
Universities	HS							519	519								
	INEL	261	261	261	261	116	116					519	519				
	SRS	258	258	258	258	403	403			519	519						
	ORR													519	519		
	NTS															519	519

Table I-2. (continued)

Origin	Destination	Decentralization		1992/1993 Planning Basis		Regionalization by Fuel Type		Centralization									
								HS		SRS		INEL		ORR		NTS	
		truck	rail	truck	rail	truck	rail	truck	rail	truck	rail	truck	rail	truck	rail	truck	rail
Commercial																	
WVDP	HS							83	4								
	INEL			83	4	83	4					83	4				
	SRS									83	4						
	ORR													83	4		
	NTS															83	4
B&W	HS							2	2								
	INEL			2	2	2	2					2	2				
	SRS									2	2						
	ORR													2	2		
	NTS															2	2
ORR	HS							7	2								
	INEL					7	2					7	2				
	SRS									7	2						
	NTS															7	2
SRS	HS							27	5								
	INEL					27	5					27	5				
	ORR													27	5		
	NTS															27	5
HS	INEL					6	2					6	2				
	SRS									6	2						
	ORR													6	2		

Table I-2. (continued)

Origin	Destination	Decentralization		1992/1993 Planning Basis		Regionalization by Fuel Type		Centralization									
								HS		SRS		INEL		ORR		NTS	
		truck	rail	truck	rail	truck	rail	truck	rail	truck	rail	truck	rail	truck	rail	truck	rail
	NTS															6	2
Commercial																	
ANL-E	HS							1	1								
	INEL					1	1					1	1				
	SRS									1	1						
	ORR													1	1		
	NTS															1	1
INEL	HS							370	74								
	SRS									370	74						
	ORR													370	74		
	NTS															370	74
DOE Research																	
ORR	HS							113	24								
	INEL					46	10					113	24				
	SRS			67	14	67	14			113	24						
	NTS															113	24
BNL	HS							71	14								
	INEL			35	7							71	14				
	SRS			35	7	71	14			71	14						
	ORR													71	14		
	NTS															71	14

Table I-2. (continued)

Origin	Destination	Decentralization		1992/1993 Planning Basis		Regionalization by Fuel Type		Centralization									
								HS		SRS		INEL		ORR		NTS	
		truck	rail	truck	rail	truck	rail	truck	rail	truck	rail	truck	rail	truck	rail	truck	rail
DOE Research																	
SNL	HS							27	6								
	INEL			12	3	12	3					27	6				
	SRS			15	3	15	3			27	6						
	ORR													27	6		
	NTS															27	6
LANL	HS							17	4								
	INEL			17	4	17	4					17	4				
	SRS									17	4						
	ORR													17	4		
	NTS															17	4
ANL-E	HS							10	2								
	INEL			10	2	10	2					10	2				
	SRS									10	2						
	ORR													10	2		
	NTS															10	2
HS	INEL			5	1	518	39					518	39				
	SRS									518	39						
	ORR													518	39		
	NTS															518	39

Table I-2. (continued)

Origin	Destination	Decentralization		1992/1993 Planning Basis		Regionalization by Fuel Type		Centralization									
								HS		SRS		INEL		ORR		NTS	
		truck	rail	truck	rail	truck	rail	truck	rail	truck	rail	truck	rail	truck	rail	truck	rail
DOE Research																	
INEL	HS							1003	165								
	SRS					114	23			1003	165						
	ORR													1003	165		
	NTS															1003	165
SRS	HS							353	71								
	INEL					94	19					353	71				
	ORR													353	71		
	NTS															353	71
Foreign																	
Ports of Entry	HS							651	651								
	SRS	324	324	324	324	577	577			651	651						
	INEL	327	327	327	327	74	74					651	651				
	ORR													651	651		
	NTS															651	651
	TOTAL	1,385	1,385	1,913	1,467	2,724	1,569	4,703	2,012	5,555	2,485	4,543	2,298	6,299	2,632	6,419	2,658

Table I-2. (continued)

Origin	Destination	Decentralization		1992/1993 Planning Basis		Regionalization by Fuel Type		Centralization									
								HS		SRS		INEL		ORR		NTS	
		truck	rail	truck	rail	truck	rail	truck	rail	truck	rail	truck	rail	truck	rail	truck	rail

Acronyms

AERO	Aerotest San Ramon, CA
AFRRI	Armed Forces Radiobiology Research Institute Bethesda, MD
ANL-E	Argonne National Laboratory-East
B&W	Babcock & Wilcox Company Lynchburg, VA
BNL	Brookhaven National Laboratory
DOE	Department of Energy
DOW	Dow North America Midland, MI
FSV	Fort St. Vrain Nuclear Generating Station
GA	General Atomics San Diego, CA
GE	General Electric Pleasanton, CA
HS	Hanford Site
INEL	Idaho National Engineering Laboratory
LANL	Los Alamos National Laboratory
NIST	National Institute of Standards and Technology Gaithersburg, MD
NTS	Nevada Test Site
ORR	Oak Ridge Reservation
SNL	Sandia National Laboratories
SRS	Savannah River Site
USAF	United States Air Force McClellan, CA
USGS	United States Geological Survey Denver, CO
WVDP	West Valley Demonstration Project

Note: Shipments represent 100% transport by truck or 100% transport by rail.

Table I-3. Spent nuclear fuel shipments for the Regionalization by Geography alternatives.

Origin	Destination	Regionalization by Geography											
		HS and SRS		INEL and SRS		NTS and SRS		HS and ORR		INEL and ORR		NTS and ORR	
		truck	rail	truck	rail	truck	rail	truck	rail	truck	rail	truck	rail
Naval-Type													
INEL	HS	383	104					383	104				
	NTS					383	104					383	104
	ORR												
	SRS												
Savannah River Production													
SRS	HS												
	INEL												
	ORR							484	97	484	97	484	97
	NTS												
ORR	SRS												
Hanford Production													
HS	INEL			1192	605					1192	605		
	SRS												
	ORR												
	NTS					1192	605					1192	605
ORR	INEL												

Table I-3. (continued)

Origin	Destination	Regionalization by Geography											
		HS and SRS		INEL and SRS		NTS and SRS		HS and ORR		INEL and ORR		NTS and ORR	
		truck	rail	truck	rail	truck	rail	truck	rail	truck	rail	truck	rail
Graphite													
FSV	HS	247	35					247	35				
	INEL			247	35					247	35		
	SRS												
	ORR												
	NTS					247	35					247	35
INEL	HS	120	17					120	17				
	SRS												
	ORR												
	NTS					120	17					120	17
Domestic non-DOE													
AFRRI	HS												
	INEL												
	SRS	3	3	3	3	3	3						
	ORR							3	3	3	3	3	3
	NTS												
USGS	HS	6	6					6	6				
	INEL			6	6					6	6		
	SRS												
	ORR												
	NTS					6	6					6	6

Table I-3. (continued)

Origin	Destination	Regionalization by Geography											
		HS and SRS		INEL and SRS		NTS and SRS		HS and ORR		INEL and ORR		NTS and ORR	
		truck	rail	truck	rail	truck	rail	truck	rail	truck	rail	truck	rail
Domestic non-DOE													
NIST	HS												
	INEL												
	SRS	185	185	185	185	185	185						
	ORR							185	185	185	185	185	185
	NTS												
USAF	HS	3	3					3	3				
	INEL			3	3					3	3		
	SRS												
	ORR												
	NTS					3	3					3	3
DOW	HS												
	INEL												
	SRS	3	3	3	3	3	3						
	ORR							3	3	3	3	3	3
	NTS												
GE	HS	4	4					4	4				
	INEL			4	4					4	4		
	SRS												
	ORR												
	NTS					4	4					4	4

Table I-3. (continued)

Origin	Destination	Regionalization by Geography											
		HS and SRS		INEL and SRS		NTS and SRS		HS and ORR		INEL and ORR		NTS and ORR	
		truck	rail	truck	rail	truck	rail	truck	rail	truck	rail	truck	rail
Domestic non-DOE													
GA	HS	8	8					8	8				
	INEL			8	8					8	8		
	SRS												
	ORR												
	NTS					8	8					8	8
AERO	HS	3	3					3	3				
	INEL			3	3					3	3		
	SRS												
	ORR												
	NTS					3	3					3	3
Universities													
Universities	HS	209	209					209	209				
	INEL			209	209					209	209		
	SRS	310	310	310	310	310	310						
	ORR							310	310	310	310	310	310
	NTS					209	209					209	209

Table I-3. (continued)

Origin	Destination	Regionalization by Geography											
		HS and SRS		INEL and SRS		NTS and SRS		HS and ORR		INEL and ORR		NTS and ORR	
		truck	rail	truck	rail	truck	rail	truck	rail	truck	rail	truck	rail
Commercial													
WVDP	HS												
	INEL												
	SRS	83	4	83	4	83	4						
	ORR							83	4	83	4	83	4
	NTS												
B&W	HS												
	INEL												
	SRS	2	2	2	2	2	2						
	ORR							2	2	2	2	2	2
	NTS												
ORR	HS												
	INEL												
	SRS	7	2	7	2	7	2						
	NTS												
SRS	HS												
	INEL												
	ORR							27	5	27	5	27	5
	NTS												
HS	INEL			6	2					6	2		
	SRS												
	ORR												
	NTS					6	2					6	2

Table I-3. (continued)

Origin	Destination	Regionalization by Geography											
		HS and SRS		INEL and SRS		NTS and SRS		HS and ORR		INEL and ORR		NTS and ORR	
		truck	rail	truck	rail	truck	rail	truck	rail	truck	rail	truck	rail
Commercial													
ANL-E	HS												
	INEL												
	SRS	1	1	1	1								
	ORR							1	1	1	1	1	1
	NTS					1	1						
INEL	HS	370	74					370	74				
	SRS												
	ORR												
	NTS					370	74					370	74
DOE Research													
ORR	HS												
	INEL												
	SRS	113	24	113	24	113	24						
	NTS												
BNL	HS												
	INEL												
	SRS	71	14	71	14	71	14						
	ORR							71	14	71	14	71	14
	NTS												

Table I-3. (continued)

Origin	Destination	Regionalization by Geography											
		HS and SRS		INEL and SRS		NTS and SRS		HS and ORR		INEL and ORR		NTS and ORR	
		truck	rail	truck	rail	truck	rail	truck	rail	truck	rail	truck	rail
DOE Research													
SNL	HS	27	6					27	6				
	INEL			27	6					27	6		
	SRS												
	ORR												
	NTS					27	6					27	6
LANL	HS	17	4					17	4				
	INEL			17	4					17	4		
	SRS												
	ORR												
	NTS					17	4					17	4
ANL-E	HS												
	INEL												
	SRS	10	2	10	2	10	2						
	ORR							10	2	10	2	10	2
	NTS												
HS	INEL			518	39					518	39		
	SRS												
	ORR												
	NTS					518	39					518	39

Table I-3. (continued)

Origin	Destination	Regionalization by Geography											
		HS and SRS		INEL and SRS		NTS and SRS		HS and ORR		INEL and ORR		NTS and ORR	
		truck	rail	truck	rail	truck	rail	truck	rail	truck	rail	truck	rail
DOE Research													
INEL	HS	1003	165					1003	165				
	SRS												
	ORR												
	NTS					1003	165					1003	165
SRS	HS												
	INEL												
	ORR							353	71	353	71	353	71
	NTS												
Foreign													
Ports of Entry	HS	203	203					203	203				
	SRS	448	448	448	448	448	448						
	INEL			203	203					203	203		
	ORR							448	448	448	448	448	448
	NTS					203	203					203	203
	TOTAL	3,839	1,839	3,679	2,125	5,555	2,485	4,583	1,986	4,423	2,272	6,299	2,632

Table I-3. (continued)

Origin	Destination	Regionalization by Geography											
		HS and SRS		INEL and SRS		NTS and SRS		HS and ORR		INEL and ORR		NTS and ORR	
		truck	rail	truck	rail	truck	rail	truck	rail	truck	rail	truck	rail

Acronyms

AERO	Aerotest San Ramon, CA	INEL	Idaho National Engineering Laboratory
AFRRI	Armed Forces Radiobiology Research Institute Bethesda, MD	LANL	Los Alamos National Laboratory
ANL-E	Argonne National Laboratory-East	NIST	National Institute of Standards and Technology Gaithersburg, MD
B&W	Babcock & Wilcox Company Lynchburg, VA	NTS	Nevada Test Site
BNL	Brookhaven National Laboratory	ORR	Oak Ridge Reservation
DOE	Department of Energy	SNL	Sandia National Laboratories
DOW	Dow North America Midland, MI	SRS	Savannah River Site
FSV	Fort St. Vrain Nuclear Generating Station	USAF	United States Air Force McClellan, CA
GA	General Atomics San Diego, CA	USGS	United States Geological Survey Denver, CO
GE	General Electric Pleasanton, CA	WVDP	West Valley Demonstration Project
HS	Hanford Site		

Note: Shipments represent 100% transport by truck or 100% transport by rail.

I-4 INCIDENT-FREE TRANSPORTATION RISKS FOR SPENT NUCLEAR FUEL

I-4.1 Methodology

Radiological dose during normal, incident-free transportation of SNF results from exposure to the external radiation field that surrounds the shipping containers. The dose is a function of the number of people exposed, their proximity to the containers, their length of time of exposure, and the intensity of the radiation field surrounding the containers.

Radiological impacts were determined for crew workers and the general population during normal, incident-free transportation. For truck shipments, the crew were the drivers of the shipment vehicle. For rail shipments, the crew were workers in close proximity to the shipping containers during inspection or classification of railcars. The general population was persons within 800 meters (2,625 feet) of the road or railway (off-link), persons sharing the road or railway (on-link), and persons at stops.

Collective doses for the crew and general population were calculated using the RADTRAN 4 computer code (Neuhauser and Kanipe 1992). SNF was assigned a dose rate of 14 millirem per hour at 1 meter (3.28 feet) from the shipping container. This dose rate yields a dose rate of 10 millirem per hour at 2 meters (6.56 feet) from the vehicle, which is the regulatory maximum based on an exclusive use vehicle (see Madsen et al. 1986). A dose rate of 1 millirem per hour at 1 meter (3.28 feet) was used for Naval-type SNF shipments, based on measured dose rates from previous Naval SNF shipments. Three population density zones (rural, suburban, and urban) were used. These zones correspond to mean population densities of 6, 719, and 3,861 persons per square kilometer, respectively (Neuhauser and Kanipe 1992).

Calculating the collective doses is based on developing unit risk factors. Unit risk factors provide an estimate of the impact from transporting one shipment of radioactive material over a unit distance of travel in a given population density zone. The unit risk factors may be combined with routing information, such as the shipment distances in various population density zones, to determine the risk for a single shipment (a shipment risk factor) between a given origin and destination. Cashwell et al. (1986) contains a detailed explanation of the use of unit risk factors.

Unit risk factors were developed based on travel within rural, suburban, and urban population zones using RADTRAN 4, using default data (see Neuhauser and Kanipe 1992). Table I-4 contains the unit risk factors for offsite truck and rail shipments of SNF. Table I-5 contains the unit risk factors for offsite truck and rail shipments of Naval-type SNF. Shipment risk factors were also developed for offsite shipments by combining the unit risk factors with routing information derived from the HIGHWAY and INTERLINE computer codes.

Table I-4. Incident-free unit risk factors for offsite truck and rail shipments of spent nuclear fuel.

Mode	Exposure group	Unit risk factors (person-rem per kilometer)[a]		
		Rural	Suburban	Urban
Truck				
	Occupational	4.6×10^{-5}	1.0×10^{-4}	1.7×10^{-4}
	General population			
	Off-link[b]	1.2×10^{-7}	1.6×10^{-5}	1.1×10^{-4}
	On-link[c]	5.0×10^{-6}	1.5×10^{-5}	1.5×10^{-4}
	Stops	1.2×10^{-4}	1.2×10^{-4}	1.2×10^{-4}
	General population total	1.3×10^{-4}	1.5×10^{-4}	3.8×10^{-4}
Rail				
	Occupational[d]	1.0×10^{-5}	1.0×10^{-5}	1.0×10^{-5}
	General population			
	Off-link[b]	1.7×10^{-7}	3.3×10^{-5}	2.9×10^{-4}
	On-link[c]	6.6×10^{-8}	8.5×10^{-7}	2.4×10^{-6}
	Stops[e]	4.8×10^{-6}	4.8×10^{-6}	4.8×10^{-6}
	General population total	5.0×10^{-6}	3.8×10^{-5}	3.0×10^{-4}

a. The methodology, equations, and data used to develop the unit risk factors are discussed in Madsen et al. (1986) and Neuhauser and Kanipe (1992). Cashwell et al. (1986) contains a detailed explanation of the use of unit risk factors.
b. Off-link general population were persons within 800 meters (2,625 feet) of the road or railway.
c. On-link general population were persons sharing the road or railway.
d. The nonlinear component of incident-free rail dose for crew workers because of railcar inspections and classifications is 0.011 person-rem per shipment. Ostmeyer (1986) contains a detailed explanation of the rail exposure model.
e. The nonlinear component of incident-free rail dose for the general population because of railcar inspections and classifications is 0.0087 person-rem per shipment. Ostmeyer (1986) contains a detailed explanation of the rail exposure model.

Table I-5. Incident-free unit risk factors for truck and rail shipments of naval-type spent nuclear fuel.

Mode	Exposure group	Unit risk factors (person-rem per kilometer)[a]		
		Rural	Suburban	Urban
Truck				
	Occupational	1.5×10^{-5}	3.3×10^{-5}	5.4×10^{-5}
	General population			
	Off-link[b]	8.8×10^{-9}	1.2×10^{-6}	7.7×10^{-6}
	On-link[c]	3.6×10^{-7}	1.0×10^{-6}	1.1×10^{-5}
	Stops	4.3×10^{-6}	4.3×10^{-6}	4.3×10^{-6}
	General population total	4.7×10^{-7}	6.5×10^{-6}	2.3×10^{-5}
Rail				
	Occupational[d]	7.2×10^{-7}	7.2×10^{-7}	7.2×10^{-7}
	General population			
	Off-link[b]	1.2×10^{-8}	2.3×10^{-6}	2.1×10^{-5}
	On-link[c]	4.7×10^{-9}	6.1×10^{-8}	1.7×10^{-7}
	Stops[e]	3.4×10^{-7}	3.4×10^{-7}	3.4×10^{-7}
	General population total	3.6×10^{-7}	2.7×10^{-6}	2.1×10^{-5}

a. The methodology, equations, and data used to develop the unit risk factors are discussed in Madsen et al. (1986) and Neuhauser and Kanipe (1992). Cashwell et al. (1986) contains a detailed explanation of the use of unit risk factors.
b. Off-link general population were persons within 800 meters (2,625 feet) of the road or railway.
c. On-link general population were persons sharing the road or railway.
d. The nonlinear component of incident-free rail dose for crew workers because of railcar inspections and classifications is 0.00080 person-rem per shipment. Ostmeyer (1986) contains a detailed explanation of the rail exposure model.
e. The nonlinear component of incident-free rail dose for the general population because of railcar inspections and classifications is 0.00062 person-rem per shipment. Ostmeyer (1986) contains a detailed explanation of the rail exposure model.

Incident-free nonradiological fatalities were also evaluated using unit risk factors. The nonradiological unit risk factor for truck transport used in this analysis was 1.0×10^{-7} fatalities per kilometer (Rao et al. 1982); for train transport, the nonradiological unit risk factor was 1.3×10^{-7} fatalities per kilometer (Rao et al. 1982). These unit risk factors account for the fatalities associated with emission of particulates and sulfur dioxide, and they are applicable only to the urban population zone (Rao et al. 1982). The distance used in the nonradiological analyses must be doubled to reflect the round trip distance because these impacts occur whether or not the shipment contains SNF.

I-4.1.1 Maximally Exposed Individual Exposure Scenarios

Maximum individual doses were calculated using the RISKIND computer code (Yuan et al. 1993). The maximum individual doses for the routine transport offsite were estimated for transportation workers, as well as members of the general population. For rail shipments, the three general population scenarios were (a) a railyard worker working at a distance of 10 meters (32.8 feet) from the shipping container for 2 hours, (b) a resident living 30 meters (98.4 feet) from the rail line where the shipping container was being transported, and (c) a resident living 200 meters (656.2 feet) from a rail stop where the shipping container was sitting for 20 hours. For train shipments, the maximum exposed transportation worker was an individual in a railyard who spent a time- and distance-weighted average of 0.16 hours inspecting, classifying, and repairing railcars (Wooden 1986).

For offsite truck shipments, the three scenarios for the general population were: (a) a person caught in traffic and located 1 meter (3.28 feet) away from the surface of the shipping container for one-half hour, (b) a resident living 30 meters (98.4 feet) from the highway used to transport the shipping container, and (c) a service station worker working at a distance of 20 meters (65.6 feet) from the shipping container for 2 hours. The hypothetical maximum exposed individual radiological doses were accumulated over the 40-year period. However, for the situation involving an individual caught in traffic next to a truck, the radiological exposures were calculated for only one event because it was considered unlikely that the same individual would be caught in traffic next to all containers for all shipments. For truck shipments, the maximum exposed transportation worker is the driver who was assumed to drive shipments for up to 2,000 hours per year.

I-4.2 Results of Calculations

This section summarizes the results of the incident-free transportation analyses for SNF shipments that occur outside the boundaries of U.S. Department of Energy sites (offsite). These results do not include the impacts of SNF shipments within the boundaries of U.S. Department of Energy sites (onsite). Onsite transportation impacts are addressed in site-specific Appendices A, B, C, D, and F of this EIS.

This section includes the impacts of offsite shipments of Naval-type SNF stored at the Idaho Chemical Processing Plant as of June 1995 to storage locations at other U.S. Department of Energy sites, as identified in the alternatives. Shipments of Naval SNF and test specimens are addressed in Appendix D of this EIS.

I-4.2.1 Impacts from the No Action Alternative

Under the No Action alternative, the only offsite transportation of SNF involves shipments of Naval SNF and test specimens. These shipments are addressed in Appendix D of this EIS.

I-4.2.2 Impacts from the Decentralization Alternative

For the Decentralization alternative, the incident-free transportation of SNF was estimated to result in less than one fatality expected over the 40-year period 1995 through 2035 (see Table I-6). The statistically estimated fatalities were the sum of the estimated number of radiation-related latent cancer fatalities and the estimated number of nonradiological fatalities from vehicular emissions. A range of fatalities occurs because of the option of using truck or rail transport for SNF shipments.

The estimated number of radiation-related latent cancer fatalities for transportation workers ranged from 0.016 to 0.056. The estimated number of radiation-related latent cancer fatalities for the general population ranged from 0.033 to 0.16. The estimated number of nonradiological fatalities from vehicular emissions ranged from 0.0089 to 0.018.

I-4.2.3 Impacts from the 1992/1993 Planning Basis Alternative

For the 1992/1993 Planning Basis alternative, the incident-free transportation of SNF was estimated to result in total fatalities that ranged from 0.071 to 0.31 over the 40-year period 1995 through 2035 (see Table I-7). These fatalities were the sum of the estimated number of radiation-related latent cancer fatalities and the estimated number of nonradiological fatalities from vehicular emissions. Again, a range of fatalities occurred because of the option of using truck or rail transport for SNF shipments.

The estimated number of radiation-related latent cancer fatalities for transportation workers ranged from 0.017 to 0.076. The estimated number of radiation-related latent cancer fatalities for the general population ranged from 0.035 to 0.22. The estimated number of nonradiological fatalities from vehicular emissions ranged from 0.010 to 0.019.

Table I-6. Cumulative doses and health effects from incident-free transportation of spent nuclear fuel for the Decentralization alternative (1995 to 2035).

	Spent nuclear fuel type							
	University[a]		Foreign[b]		DOE[c,d]		Total	
	Truck	Rail	Truck	Rail	Truck	Rail	Truck	Rail
Occupational								
Maximum individual dose (rem)	60	1.8	75	2.2	25	0.73	160	4.7
Collective dose (person-rem)	59	16	63	19	15	5.0	140	40
Estimated latent cancer fatalities	0.024	0.0064	0.025	0.0076	0.0060	0.0020	0.056	0.016
General population								
Maximum individual dose (rem)	0.21	0.87	0.26	1.1	0.088	0.36	0.56	2.3
Collective dose (person-rem)	140	29	150	29	18	8.0	310	66
Estimated latent cancer fatalities	0.070	0.015	0.075	0.015	0.0090	0.0040	0.16	0.033
Estimated nonradiological fatalities[e]	0.0025	0.0058	0.0052	0.0098	0.0012	0.0025	0.0089	0.018

a. Maheras (1994a).

b. Maheras (1994b).

c. Maheras (1994c).

d. DOE spent nuclear fuel includes special case commercial, DOE research, other domestic research, graphite, N Reactor, Naval-type, and Savannah River production reactor spent nuclear fuel (see Tables I-2, I-3).

e. Occupational incident-free nonradiological fatalities are included with the general population incident-free nonradiological fatalities.

Table I-7. Cumulative doses and health effects from incident-free transportation of spent nuclear fuel for the 1992/1993 Planning Basis alternative (1995 to 2035).

	Spent nuclear fuel type							
	University[a]		Foreign[b]		DOE[c,d]		Total	
	Truck	Rail	Truck	Rail	Truck	Rail	Truck	Rail
Occupational								
Maximum individual dose (rem)	43	1.8	54	2.2	62	1.0	160	5.0
Collective dose (person-rem)	59	16	63	19	66	7.3	190	42
Estimated latent cancer fatalities	0.024	0.0064	0.025	0.0076	0.026	0.0029	0.076	0.017
General population								
Maximum individual dose (rem)	0.21	0.87	0.26	1.1	0.30	0.50	0.78	2.4
Collective dose (person-rem)	140	29	150	29	140	12	430	70
Estimated latent cancer fatalities	0.070	0.015	0.075	0.015	0.070	0.0060	0.22	0.035
Estimated nonradiological fatalities[e]	0.0025	0.0058	0.0052	0.0098	0.0027	0.0032	0.010	0.019

a. Maheras (1994a).

b. Maheras (1994b).

c. Maheras (1994c).

d. DOE spent nuclear fuel includes special case commercial, DOE research, other domestic research, graphite, N Reactor, Naval-type, and Savannah River production reactor spent nuclear fuel (see Tables I-2, I-3).

e. Occupational incident-free nonradiological fatalities are included with the general population incident-free nonradiological fatalities.

I-4.2.4 Impacts from the Regionalization Alternative

I-4.2.4.1 Impacts from the Regionalization by Fuel Type Alternative. For the Regionalization by Fuel Type alternative, the incident-free transportation of SNF was estimated to result in total fatalities that ranged from 0.092 to 0.47 over the 40-year period 1995 through 2035 (see Table I-8). These fatalities were the sum of the estimated number of radiation-related latent cancer fatalities and the estimated number of nonradiological fatalities from vehicular emissions. The reason for a range of fatalities was because of the option of using truck or rail transport for SNF shipments.

The estimated number of radiation-related latent cancer fatalities for transportation workers ranged from 0.020 to 0.12. The estimated number of radiation-related latent cancer fatalities for the general population ranged from 0.046 to 0.33. The estimated number of nonradiological fatalities from vehicular emissions ranged from 0.015 to 0.026.

I-4.2.4.2 Impacts from the Regionalization by Geography Alternatives. For the six Regionalization by Geography alternatives, the incident-free transportation of spent nuclear fuel was estimated to result in total fatalities that ranged from 0.075 to 0.38 for regionalization at the Idaho National Engineering Laboratory and the Savannah River Site to 0.091 to 0.76 for regionalization at the Nevada Test Site and the Oak Ridge Reservation (see Tables I-9 through I-14). These fatalities were over the 40-year period 1995 through 2035 and were the sum of the estimated number of radiation-related latent cancer fatalities and the estimated number of nonradiological fatalities from vehicular emissions.

The reason for a range of fatalities was because of two factors: (a) the option of using truck or rail transport for SNF shipments, and (b) the six regionalization by geography options.

For regionalization at the Idaho National Engineering Laboratory and the Savannah River Site, the estimated number of radiation-related latent cancer fatalities for transportation workers ranged from 0.021 to 0.096. The estimated number of radiation-related latent cancer fatalities for the general population ranged from 0.038 to 0.27. The estimated number of nonradiological fatalities from vehicular emissions ranged from 0.011 to 0.016.

For regionalization at the Nevada Test Site and the Oak Ridge Reservation, the estimated number of radiation-related latent cancer fatalities for transportation workers ranged from 0.028 to 0.18. The estimated number of radiation-related latent cancer fatalities for the general population ranged from 0.046 to 0.55. The estimated number of nonradiological fatalities from vehicular emissions ranged from 0.017 to 0.029.

Table I-8. Cumulative doses and health effects from incident-free transportation of spent nuclear fuel for the Regionalization by Fuel Type subalternative (1995 to 2035).

	Spent nuclear fuel type							
	University[a]		Foreign[b]		DOE[c,d]		Total	
	Truck	Rail	Truck	Rail	Truck	Rail	Truck	Rail
Occupational								
Maximum individual dose (rem)	30	1.8	38	2.2	91	1.3	160	5.3
Collective dose (person-rem)	54	15	86	24	150	11	290	50
Estimated latent cancer fatalities	0.022	0.0060	0.034	0.0096	0.060	0.0044	0.12	0.020
General population								
Maximum individual dose (rem)	0.21	0.87	0.26	1.1	0.63	0.67	1.1	2.6
Collective dose (person-rem)	120	33	200	41	340	17	660	91
Estimated latent cancer fatalities	0.060	0.017	0.10	0.021	0.17	0.0085	0.33	0.046
Estimated nonradiological fatalities[e]	0.0026	0.0068	0.0079	0.015	0.0049	0.0041	0.015	0.026

a. Maheras (1994a).

b. Maheras (1994b).

c. Maheras (1994c).

d. DOE spent nuclear fuel includes special case commercial, DOE research, other domestic research, graphite, N Reactor, Naval-type, and Savannah River production reactor spent nuclear fuel (see Tables I-2, I-3).

e. Occupational incident-free nonradiological fatalities are included with the general population incident-free nonradiological fatalities.

Table I-9. Cumulative doses and health effects from incident-free transportation of spent nuclear fuel for the Regionalization by Geography at the Hanford Site and the Savannah River Site subalternative (1995 to 2035).

	Spent nuclear fuel type							
	University[a]		Foreign[b]		DOE[c,d]		Total	
	Truck	Rail	Truck	Rail	Truck	Rail	Truck	Rail
Occupational								
Maximum individual dose (rem)	22	1.8	27	2.2	110	2.3	160	6.3
Collective dose (person-rem)	60	17	40	15	140	13	240	45
Estimated latent cancer fatalities	0.024	0.0068	0.016	0.0060	0.056	0.0052	0.096	0.018
General population								
Maximum individual dose (rem)	0.21	0.87	0.26	1.1	1.1	1.1	1.6	3.1
Collective dose (person-rem)	140	30	91	24	320	18	550	72
Estimated latent cancer fatalities	0.070	0.015	0.046	0.012	0.16	0.0090	0.28	0.036
Estimated nonradiological fatalities[e]	0.0025	0.0061	0.0036	0.0072	0.0051	0.0042	0.011	0.018

a. Maheras (1994a).

b. Maheras (1994b).

c. Maheras (1994c).

d. DOE spent nuclear fuel includes special case commercial, DOE research, other domestic research, graphite, N Reactor, Naval-type, and Savannah River production reactor spent nuclear fuel (see Tables I-2, I-3).

e. Occupational incident-free nonradiological fatalities are included with the general population incident-free nonradiological fatalities.

Table I-10. Cumulative doses and health effects from incident-free transportation of spent nuclear fuel for the Regionalization by Geography at the Idaho National Engineering Laboratory and the Savannah River Site subalternative (1995 to 2035).

	Spent nuclear fuel type							
	University[a]		Foreign[b]		DOE[c,d]		Total	
	Truck	Rail	Truck	Rail	Truck	Rail	Truck	Rail
Occupational								
Maximum individual dose (rem)	23	1.8	28	2.2	110	3.2	160	7.2
Collective dose (person-rem)	54	15	41	16	140	21	240	52
Estimated latent cancer fatalities	0.022	0.0060	0.016	0.0064	0.056	0.0084	0.096	0.021
General population								
Maximum individual dose (rem)	0.21	0.87	0.26	1.1	1.0	1.6	1.5	3.6
Collective dose (person-rem)	120	28	94	22	320	25	530	75
Estimated latent cancer fatalities	0.060	0.014	0.047	0.011	0.16	0.013	0.27	0.038
Estimated nonradiological fatalities[e]	0.0023	0.0056	0.0041	0.0064	0.0042	0.0044	0.011	0.016

a. Maheras (1994a).

b. Maheras (1994b).

c. Maheras (1994c).

d. DOE spent nuclear fuel includes special case commercial, DOE research, other domestic research, graphite, N Reactor, Naval-type, and Savannah River production reactor spent nuclear fuel (see Tables I-2, I-3).

e. Occupational incident-free nonradiological fatalities are included with the general population incident-free nonradiological fatalities.

Table I-11. Cumulative doses and health effects from incident-free transportation of spent nuclear fuel for the Regionalization by Geography at the Nevada Test Site and the Savannah River Site subalternative (1995 to 2035).

	Spent nuclear fuel type							
	University[a]		Foreign[b]		DOE[c,d]		Total	
	Truck	Rail	Truck	Rail	Truck	Rail	Truck	Rail
Occupational								
Maximum individual dose (rem)	15	1.8	19	2.2	130	4.4	160	8.4
Collective dose (person-rem)	56	17	48	17	330	34	430	68
Estimated latent cancer fatalities	0.022	0.0068	0.019	0.0068	0.13	0.014	0.17	0.027
General population								
Maximum individual dose (rem)	0.21	0.87	0.26	1.1	1.8	2.2	2.3	4.2
Collective dose (person-rem)	130	29	110	22	770	37	1000	88
Estimated latent cancer fatalities	0.065	0.015	0.055	0.011	0.39	0.019	0.50	0.044
Estimated nonradiological fatalities[e]	0.0027	0.0059	0.0046	0.0059	0.020	0.0060	0.027	0.018

a. Maheras (1994a).

b. Maheras (1994b).

c. Maheras (1994c).

d. DOE spent nuclear fuel includes special case commercial, DOE research, other domestic research, graphite, N Reactor, Naval-type, and Savannah River production reactor spent nuclear fuel (see Tables I-2, I-3).

e. Occupational incident-free nonradiological fatalities are included with the general population incident-free nonradiological fatalities.

Table I-12. Cumulative doses and health effects from incident-free transportation of spent nuclear fuel for the Regionalization by Geography at the Hanford Site and the Oak Ridge Reservation subalternative (1995 to 2035).

	Spent nuclear fuel type							
	University[a]		Foreign[b]		DOE[c,d]		Total	
	Truck	Rail	Truck	Rail	Truck	Rail	Truck	Rail
Occupational								
Maximum individual dose (rem)	18	1.8	23	2.2	120	2.8	160	6.8
Collective dose (person-rem)	56	16	42	16	170	16	270	48
Estimated latent cancer fatalities	0.022	0.0064	0.017	0.0064	0.068	0.0064	0.11	0.019
General population								
Maximum individual dose (rem)	0.21	0.87	0.26	1.1	1.4	1.4	1.9	3.4
Collective dose (person-rem)	130	26	95	28	380	22	610	76
Estimated latent cancer fatalities	0.065	0.013	0.048	0.014	0.19	0.011	0.31	0.038
Estimated nonradiological fatalities[e]	0.0024	0.0044	0.0041	0.0076	0.0060	0.0045	0.013	0.017

a. Maheras (1994a).

b. Maheras (1994b).

c. Maheras (1994c).

d. DOE spent nuclear fuel includes special case commercial, DOE research, other domestic research, graphite, N Reactor, Naval-type, and Savannah River production reactor spent nuclear fuel (see Tables I-2, I-3).

e. Occupational incident-free nonradiological fatalities are included with the general population incident-free nonradiological fatalities.

Table I-13. Cumulative doses and health effects from incident-free transportation of spent nuclear fuel for the Regionalization by Geography at the Idaho National Engineering Laboratory and the Oak Ridge Reservation subalternative (1995 to 2035).

	Spent nuclear fuel type							
	University[a]		Foreign[b]		DOE[c,d]		Total	
	Truck	Rail	Truck	Rail	Truck	Rail	Truck	Rail
Occupational								
Maximum individual dose (rem)	19	1.8	24	2.2	120	3.7	160	7.7
Collective dose (person-rem)	50	15	43	17	170	24	260	56
Estimated latent cancer fatalities	0.020	0.0060	0.017	0.0068	0.068	0.0096	0.10	0.022
General population								
Maximum individual dose (rem)	0.21	0.87	0.26	1.1	1.3	1.8	1.8	3.8
Collective dose (person-rem)	110	23	98	26	380	30	590	79
Estimated latent cancer fatalities	0.055	0.012	0.049	0.013	0.19	0.015	0.30	0.040
Estimated nonradiological fatalities[e]	0.0023	0.0039	0.0046	0.0067	0.0050	0.0047	0.012	0.015

a. Maheras (1994a).

b. Maheras (1994b).

c. Maheras (1994c).

d. DOE spent nuclear fuel includes special case commercial, DOE research, other domestic research, graphite, N Reactor, Naval-type, and Savannah River production reactor spent nuclear fuel (see Tables I-2, I-3).

e. Occupational incident-free nonradiological fatalities are included with the general population incident-free nonradiological fatalities.

Table I-14. Cumulative doses and health effects from incident-free transportation of spent nuclear fuel for the Regionalization by Geography at the Nevada Test Site and the Oak Ridge Reservation subalternative (1995 to 2035).

	Spent nuclear fuel type							
	University[a]		Foreign[b]		DOE[c,d]		Total	
	Truck	Rail	Truck	Rail	Truck	Rail	Truck	Rail
Occupational								
Maximum individual dose (rem)	13	1.8	17	2.2	130	4.9	160	8.9
Collective dose (person-rem)	52	16	50	18	360	37	460	71
Estimated latent cancer fatalities	0.021	0.0064	0.020	0.0072	0.14	0.015	0.18	0.028
General population								
Maximum individual dose (rem)	0.21	0.87	0.26	1.1	2.1	2.4	2.6	4.4
Collective dose (person-rem)	120	25	110	26	830	41	1100	92
Estimated latent cancer fatalities	0.060	0.013	0.055	0.013	0.42	0.021	0.55	0.046
Estimated nonradiological fatalities[e]	0.0026	0.0042	0.0051	0.0063	0.021	0.0063	0.029	0.017

a. Maheras (1994a).

b. Maheras (1994b).

c. Maheras (1994c).

d. DOE spent nuclear fuel includes special case commercial, DOE research, other domestic research, graphite, N Reactor, Naval-type, and Savannah River production reactor spent nuclear fuel (see Tables I-2, I-3).

e. Occupational incident-free nonradiological fatalities are included with the general population incident-free nonradiological fatalities.

I-4.2.5 Impacts from the Centralization Alternatives

For the five Centralization alternatives, the incident-free transportation of spent nuclear fuel was estimated to result in total fatalities that ranged from 0.14 to 0.96 for centralization at the Idaho National Engineering Laboratory to 0.16 to 1.5 for centralization at the Savannah River Site (see Tables I-15 through I-19). These fatalities were over the 40-year period 1995 through 2035 and were the sum of the estimated number of radiation-related latent cancer fatalities and the estimated number of nonradiological fatalities from vehicular emissions.

The reason for a range of fatalities was because of two factors: (a) the option of using truck or rail transport for SNF shipments, and (b) the five Centralization options.

For centralization at the Idaho National Engineering Laboratory, the estimated number of radiation-related latent cancer fatalities for transportation workers ranged from 0.035 to 0.24. The estimated number of radiation-related latent cancer fatalities for the general population ranged from 0.065 to 0.70. The estimated number of nonradiological fatalities from vehicular emissions ranged from 0.022 to 0.037.

For centralization at the Savannah River Site, the estimated number of radiation-related latent cancer fatalities for transportation workers ranged from 0.039 to 0.38. The estimated number of radiation-related latent cancer fatalities for the general population ranged from 0.080 to 1.1. The estimated number of nonradiological fatalities from vehicular emissions ranged from 0.036 to 0.038.

Table I-15. Cumulative doses and health effects from incident-free transportation of spent nuclear fuel for the Centralization at the Hanford Site alternative (1995 to 2035).

	Spent nuclear fuel type							
	University[a]		Foreign[b]		DOE[c,d]		Total	
	Truck	Rail	Truck	Rail	Truck	Rail	Truck	Rail
Occupational								
Maximum individual dose (rem)	18	1.8	22	2.2	120	2.8	160	6.8
Collective dose (person-rem)	100	26	130	33	430	32	660	91
Estimated latent cancer fatalities	0.040	0.010	0.052	0.013	0.17	0.013	0.26	0.036
General population								
Maximum individual dose (rem)	0.21	0.87	0.26	1.1	1.4	1.4	1.9	3.4
Collective dose (person-rem)	250	38	320	53	990	45	1600	140
Estimated latent cancer fatalities	0.13	0.019	0.16	0.027	0.50	0.023	0.80	0.070
Estimated nonradiological fatalities[e]	0.0028	0.0068	0.0084	0.020	0.013	0.012	0.024	0.039

a. Maheras (1994a).

b. Maheras (1994b).

c. Maheras (1994c).

d. DOE spent nuclear fuel includes special case commercial, DOE research, other domestic research, graphite, N Reactor, Naval-type, and Savannah River production reactor spent nuclear fuel (see Tables I-2, I-3).

e. Occupational incident-free nonradiological fatalities are included with the general population incident-free nonradiological fatalities.

Table I-16. Cumulative doses and health effects from incident-free transportation of spent nuclear fuel for the Centralization at the Idaho National Engineering Laboratory alternative (1995 to 2035).

	Spent nuclear fuel type							
	University[a]		Foreign[b]		DOE[c,d]		Total	
	Truck	Rail	Truck	Rail	Truck	Rail	Truck	Rail
Occupational								
Maximum individual dose (rem)	18	1.8	23	2.2	120	3.8	160	7.8
Collective dose (person-rem)	86	22	120	30	380	36	590	88
Estimated latent cancer fatalities	0.034	0.0088	0.048	0.012	0.15	0.014	0.24	0.035
General population								
Maximum individual dose (rem)	0.21	0.87	0.26	1.1	1.4	1.9	1.8	3.8
Collective dose (person-rem)	210	33	280	48	880	49	1400	130
Estimated latent cancer fatalities	0.11	0.017	0.14	0.024	0.44	0.025	0.70	0.065
Estimated nonradiological fatalities[e]	0.0025	0.0060	0.0082	0.019	0.011	0.012	0.022	0.037

a. Maheras (1994a).

b. Maheras (1994b).

c. Maheras (1994c).

d. DOE spent nuclear fuel includes special case commercial, DOE research, other domestic research, graphite, N Reactor, Naval-type, and Savannah River production reactor spent nuclear fuel (see Tables I-2, I-3).

e. Occupational incident-free nonradiological fatalities are included with the general population incident-free nonradiological fatalities.

Table I-17. Cumulative doses and health effects from incident-free transportation of spent nuclear fuel for the Centralization at the Savannah River Site alternative (1995 to 2035).

	Spent nuclear fuel type							
	University[a]		Foreign[b]		DOE[c,d]		Total	
	Truck	Rail	Truck	Rail	Truck	Rail	Truck	Rail
Occupational								
Maximum individual dose (rem)	15	1.8	19	2.2	130	4.4	160	8.4
Collective dose (person-rem)	53	15	77	22	830	60	960	97
Estimated latent cancer fatalities	0.021	0.0060	0.031	0.0088	0.33	0.024	0.38	0.039
General population								
Maximum individual dose (rem)	0.21	0.87	0.26	1.1	1.8	2.2	2.3	4.1
Collective dose (person-rem)	110	34	180	38	1900	85	2200	160
Estimated latent cancer fatalities	0.055	0.017	0.090	0.019	0.95	0.043	1.1	0.080
Estimated nonradiological fatalities[e]	0.0025	0.0071	0.0074	0.013	0.028	0.016	0.038	0.036

a. Maheras (1994a).

b. Maheras (1994b).

c. Maheras (1994c).

d. DOE spent nuclear fuel includes special case commercial, DOE research, other domestic research, graphite, N Reactor, Naval-type, and Savannah River production reactor spent nuclear fuel (see Tables I-2, I-3).

e. Occupational incident-free nonradiological fatalities are included with the general population incident-free nonradiological fatalities.

Table I-18. Cumulative doses and health effects from incident-free transportation of spent nuclear fuel for the Centralization at the Oak Ridge Reservation alternative (1995 to 2035).

	Spent nuclear fuel type							
	University[a]		Foreign[b]		DOE[c,d]		Total	
	Truck	Rail	Truck	Rail	Truck	Rail	Truck	Rail
Occupational								
Maximum individual dose (rem)	13	1.8	17	2.2	130	4.9	160	8.9
Collective dose (person-rem)	42	13	71	22	750	58	860	93
Estimated latent cancer fatalities	0.017	0.0052	0.028	0.0088	0.30	0.023	0.34	0.037
General population								
Maximum individual dose (rem)	0.21	0.87	0.26	1.1	2.1	2.4	2.6	4.4
Collective dose (person-rem)	91	25	170	36	1800	67	2100	130
Estimated latent cancer fatalities	0.046	0.013	0.085	0.018	0.90	0.034	1.1	0.065
Estimated nonradiological fatalities[e]	0.0021	0.0046	0.0065	0.010	0.021	0.012	0.030	0.027

a. Maheras (1994a).

b. Maheras (1994b).

c. Maheras (1994c).

d. DOE spent nuclear fuel includes special case commercial, DOE research, other domestic research, graphite, N Reactor, Naval-type, and Savannah River production reactor spent nuclear fuel (see Tables I-2, I-3).

e. Occupational incident-free nonradiological fatalities are included with the general population incident-free nonradiological fatalities.

Table I-19. Cumulative doses and health effects from incident-free transportation of spent nuclear fuel for the Centralization at the Nevada Test Site alternative (1995 to 2035).

	Spent nuclear fuel type							
	University[a]		Foreign[b]		DOE[c,d]		Total	
	Truck	Rail	Truck	Rail	Truck	Rail	Truck	Rail
Occupational								
Maximum individual dose (rem)	13	1.8	16	2.2	130	5.0	160	9.0
Collective dose (person-rem)	94	25	130	34	590	52	810	110
Estimated latent cancer fatalities	0.038	0.010	0.052	0.014	0.24	0.021	0.32	0.044
General population								
Maximum individual dose (rem)	0.21	0.87	0.26	1.1	2.1	2.5	2.6	4.4
Collective dose (person-rem)	230	37	310	52	1400	63	1900	150
Estimated latent cancer fatalities	0.12	0.019	0.16	0.026	0.070	0.032	0.95	0.075
Estimated nonradiological fatalities[e]	0.0033	0.0067	0.011	0.019	0.029	0.014	0.043	0.040

a. Maheras (1994a).

b. Maheras (1994b).

c. Maheras (1994c).

d. DOE spent nuclear fuel includes special case commercial, DOE research, other domestic research, graphite, N Reactor, Naval-type, and Savannah River production reactor spent nuclear fuel (see Tables I-2, I-3).

e. Occupational incident-free nonradiological fatalities are included with the general population incident-free nonradiological fatalities.

I-5 SPENT NUCLEAR FUEL TRANSPORTATION ACCIDENT RISKS AND MAXIMUM REASONABLY FORESEEABLE CONSEQUENCES

I-5.1 Methodology

The offsite SNF transportation accident analysis considers the impacts of accidents during the transportation of SNF by truck or rail. SNF is transported in specially designed casks that meet U.S. Department of Transportation and U.S. Nuclear Regulatory Commission Type B packaging specifications (10 CFR Part 71).

Under accident conditions, impacts to human health and the environment may result from the release and dispersal of radioactive material. Because of the rigorous design specifications for SNF shipping casks, the U.S. Nuclear Regulatory Commission has estimated that casks will withstand 99.4 percent of truck or rail accidents without sustaining damage sufficient to breach the cask (Fischer et al. 1987). The 0.6 percent of accidents that could potentially breach the cask are represented by a spectrum of accident severities and radioactive release conditions. Accident analysis methodology has been developed by the U.S. Nuclear Regulatory Commission for calculating the probabilities and consequences from this spectrum of unlikely accidents, but it is not possible to predict where along the shipping route such accidents might occur.

To provide DOE and the public a reasonable assessment of SNF transportation accident impacts, two types of analyses were performed. First, an accident risk assessment was performed that takes into account the probabilities and consequences of a spectrum of accident severities using methodology developed by the U.S. Nuclear Regulatory Commission (Fischer et al. 1987). The accident risk assessment used route-specific information for accident rates and population densities. For the spectrum of accidents considered in the analysis, accident consequences in terms of collective dose to the population within 80 kilometers (50 miles) were multiplied by the accident probabilities to yield dose risk using the RADTRAN 4 computer code. Second, to represent the maximum reasonably foreseeable impacts to individuals and populations should an accident occur, radiological consequences were calculated for an accident of maximum credible severity in each population zone. An accident is considered credible if its probability of occurrence is greater than 1×10^{-7} per year. The accident consequence assessment for maximally exposed individuals and population groups was performed using the RISKIND computer code.

An important variable in the assessment of impacts from SNF transportation accidents is the type of SNF. A wide range of SNF types exists within the DOE complex with significant differences in radioactive material content, fuel material design, cladding design, reactor operating history, and storage (cooling time) history. These differences among SNF types translate into different radioactive material release characteristics under accident conditions. To account for the variation in SNF types, analyses were performed for the following representative SNF types: (a) Naval reactor fuels, (b) Savannah River Production Reactor fuels, (c) Hanford N Reactor fuels,

(d) graphite fuels, (e) special case commercial reactor fuels, (f) university research/test reactor fuels, (g) DOE research/test reactor fuels, (h) foreign research reactor fuels, and (i) non-DOE research reactor fuels.

The impacts for specific alternatives were calculated in units of dose (person-rem) for each origin and destination pair associated with each representative SNF type. The impacts are further expressed as health risks in terms of latent cancer fatalities in exposed populations. The health risk conversion factors used were derived from International Commission on Radiological Protection Publication 60 (ICRP 1991).

I-5.1.1 Accident Rates

For calculating accident shipment-risk factors, state-level accident rates were taken from data provided in Saricks and Kvitek (1991) for rail and heavy combination trucks. For truck transportation, separate accident rates were used for rural, suburban, and urban population density zones in each state. One average accident rate was used for each state for rail transportation. For truck transport, accident fatality risks were based on state-level rates for interstate highways in urban and rural areas (Saricks and Kvitek 1991). Accident fatality risks for rail transportation were calculated using a nationwide average rate of 2.64×10^{-8} fatalities per rail-kilometer (Cashwell 1986).

I-5.1.2 Accident Severity Categories and Conditional Probabilities

Accident severity categories for potential SNF transportation accidents are described in a U.S. Nuclear Regulatory Commission report commonly referred to as the Modal Study (Fischer et al. 1987). The Modal Study classification scheme for both truck and rail transportation is shown in Figure I-1. Severity is described as a function of the magnitudes of the mechanical forces (impact) and thermal forces (fire) to which a cask may be subjected during an accident. Because all accidents can be described in these terms, severity is independent of the specific accident sequence. In other words, any sequence of events that results in an accident in which a cask is subjected to forces within a certain range of values is assigned to the accident severity category associated with that range. The accident severity scheme is designed to take into account all credible transportation accidents, including accidents with low probability but high consequences and those with high probability but low consequences.

The severity category matrix represents a set of scenarios defined by a combination of mechanical and thermal forces. A conditional probability is assigned in each category as shown in Figure I-2. For example, Category R(1,1) accidents are the least severe but most frequent, whereas Category R(4,5) accidents are very severe but very infrequent. To determine the expected frequency of each severity category, the conditional probability in each category was multiplied by the baseline accident rate. Each population density zone has a distinct baseline

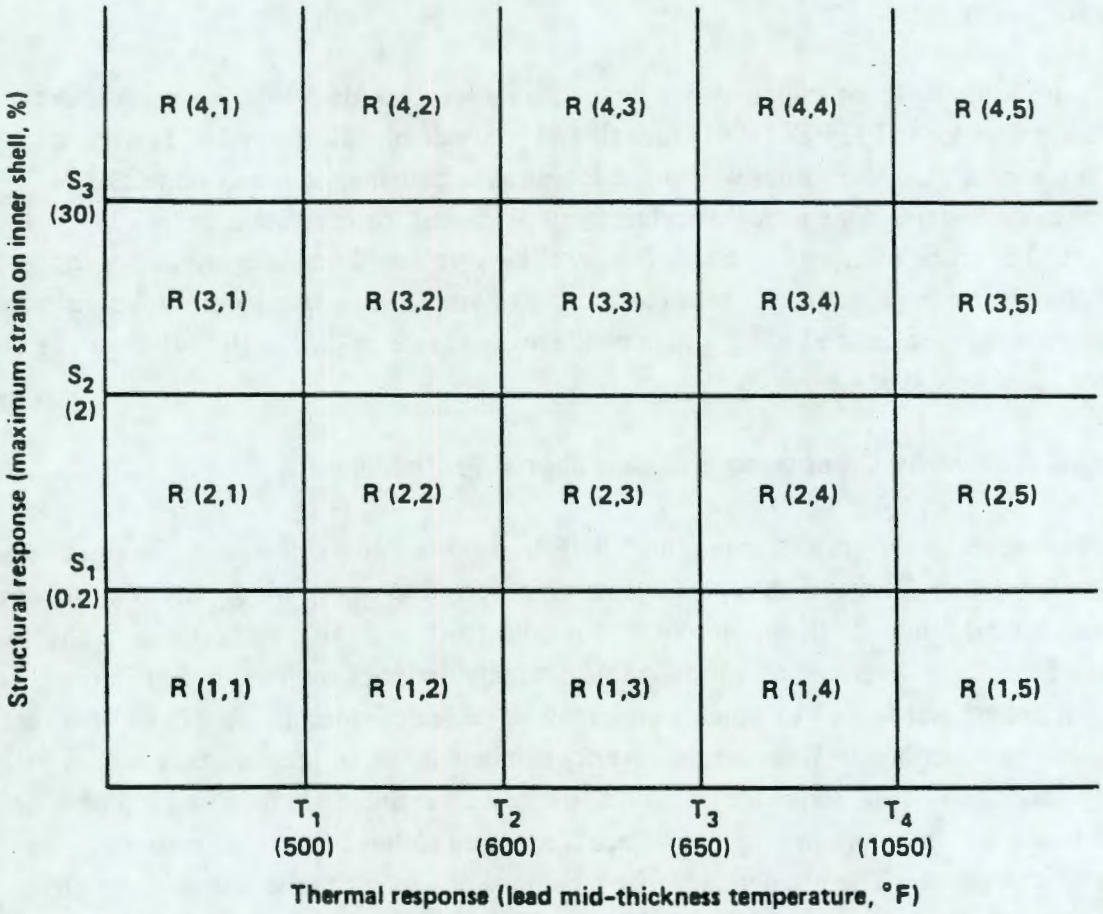

Figure I-1. Matrix of cask response regions for combined mechanical and thermal loads. (Source: Fischer et al. 1987)

Legend:

(P_t) = Probability of occurrence assuming a truck accident occurs.
(P_r) = Probability of occurrence assuming a rail accident occurs.

Structural Response (maximum strain on inner shell, %)	T_1 (500)	T_2 (600)	T_3 (650)	T_4 (1050)	
S_3 (30)	R(4,1) (P_t)1.532×10^{-7} (P_r)1.786×10^{-9}	R(4,2) 3.926×10^{-14} 3.290×10^{-13}	R(4,3) 1.495×10^{-14} 2.137×10^{-13}	R(4,4) 7.681×10^{-16} 1.644×10^{-13}	R(4,5) $<1 \times 10^{-16}$ 3.459×10^{-14}
S_2 (2)	R(3,1) (P_t)1.7984×10^{-3} (P_r)5.545×10^{-4}	R(3,2) 1.574×10^{-7} 1.021×10^{-7}	R(3,3) 2.034×10^{-7} 6.634×10^{-8}	R(3,4) 1.076×10^{-7} 5.162×10^{-8}	R(3,5) 4.873×10^{-8} 5.296×10^{-8}
S_1 (0.2)	R(2,1) (P_t)3.8192×10^{-3} (P_r)2.7204×10^{-3}	R(2,2) 2.330×10^{-7} 5.011×10^{-7}	R(2,3) 3.008×10^{-7} 3.255×10^{-7}	R(2,4) 1.592×10^{-7} 2.531×10^{-7}	R(2,5) 7.201×10^{-8} 1.075×10^{-8}
	R(1,1) (P_t)0.994316 (P_r)0.993962	R(1,2) 1.687×10^{-5} 1.2275×10^{-3}	R(1,3) 2.362×10^{-5} 7.9511×10^{-4}	R(1,4) 1.525×10^{-5} 6.140×10^{-4}	R(1,5) 9.570×10^{-6} 1.249×10^{-4}

Thermal Response (lead midthickness temperature, °F)

Figure I-2. Fraction of truck and rail accidents expected within each severity category, assuming an accident occurs. (Source: Fischer et al. 1987).

accident rate and distribution of accident severities related to differences in average vehicle velocity, traffic density, and other factors, including rural, suburban, or urban location.

For the accident risk assessment, accident risk was generically defined as the consequences of an accident multiplied by the probability of the occurrence of that accident, an approach consistent with the methodology suggested by the existing RADTRAN computer code. Accident unit-risk factors were calculated using the RADTRAN 4 computer code, then summed over the accident conditional probabilities and route characteristics for the origin and destination pairs to yield risk per shipment estimates. These accident risk factors take into account the entire spectrum of credible transportation accidents, including low probability accidents that have high consequences and high probability accidents that have low consequences.

For the maximum reasonably foreseeable accident consequence assessment, the doses were assessed for populations and individuals assuming the most severe accident scenario with a probability greater than 1×10^{-7} per year. In terms of the radioactivity released to the environment, the most severe credible accident is represented by eight accident severity categories [R(4,1)-R(4,5) and R(1,5)-R(3,5)]. Each of the eight most severe accident categories result in the same total release of radioactive material, but the conditional probabilities of occurrence vary. Therefore, the accident consequence assessment is based on a maximum reasonably foreseeable release of radioactivity with a conditional probability that is the sum of the conditional probabilities of the eight most severe accident categories. Accidents of this severity are extremely rare, occurring approximately once per 100,000 truck or 10,000 rail accidents involving a SNF shipment.

I-5.1.3 Atmospheric Conditions

Because it is impossible to predict the specific location of an offsite transportation accident, generic atmospheric conditions were selected for the risk and consequence assessments. For accident risk assessment, neutral weather conditions (Pasquill Stability Class D) were assumed. Neutral weather conditions are typified by moderate windspeeds, vertical mixing within the atmosphere, and good dispersion of atmospheric contaminants. Because neutral meteorological conditions compose the most frequently occurring atmospheric stability condition in the United States, these conditions are most likely to be present in the event of an accident involving a SNF shipment. On the basis of observations from National Weather Service surface meteorological stations at over 300 locations in the United States, on an annual average, neutral conditions (Pasquill Class C and D) occur 50 percent of the time, while stable (Pasquill Class E and F) and unstable (Pasquill Class A and B) conditions occur 33 percent and 17 percent of the time, respectively (Doty et al. 1976). The neutral category predominates in all seasons, but most frequently in the winter (nearly 60 percent of the observations). For the accident consequence assessment, doses were assessed under both neutral (Class D with 4 meters per second windspeed) and stable (Class F with 1 meter per second windspeed) atmospheric conditions.

Stable weather conditions are typified by low windspeeds, very little vertical mixing within the atmosphere, and poor dispersion of atmospheric contaminants. Class F meteorology in combination with windspeeds of 1 meter per second generally occur no more than 5 percent of the time. Results calculated for neutral conditions represent the most likely consequences and the results for stable conditions represent a worst-case weather situation.

I-5.1.4 Population Density Zones

Three population density zones (rural, suburban, and urban) were used for the offsite population risk assessment. These zones respectively correspond to mean population densities of 6, 719, and 3,861 persons per square kilometer. The three population density zones are based on an aggregation of the 12 population density zones provided in the HIGHWAY and INTERLINE output. For calculating, population density information was generated at the state level and used as RADTRAN input for the origin and destination pairs.

I-5.1.5 Exposure Pathways

Radiological doses were calculated for an individual located near the scene of the accident and for populations within 50 miles (80 kilometers) of the accident. Rural, suburban, and urban population densities were assessed. Dose calculations considered a variety of exposure pathways, including inhalation and direct exposure (cloudshine) from the passing cloud, ingestion from contaminated crops, direct exposure (groundshine) from radioactivity deposited on the ground, and inhalation of resuspended radioactive particles from the ground.

I-5.1.6 Health Risk Conversion Factors

The health risk conversion factors used to estimate expected latent cancer fatalities from radiological exposures were derived from International Commission on Radiological Protection Publication 60 (ICRP 1991): 5.0×10^{-4} and 4.0×10^{-4} latent fatal cancer cases per person-rem for members of the public and workers, respectively.

I-5.2 Spent Nuclear Fuel Characterization and Radioactive Release Characteristics

I-5.2.1 Characterization of Representative Spent Nuclear Fuel Types

Shipments of Naval reactor SNF are addressed in Appendix D of Volume 1 of this EIS, with the exception of Naval-type SNF that has been transferred from the U.S. Navy to the DOE and is currently in storage at the Idaho National Engineering Laboratory Idaho Chemical Processing Plant. Characterization data for Naval-type SNF were derived from Appendix D of Volume 1 of this EIS.

Savannah River Site production reactor SNF was assumed to include both the spent driver fuel used to power the production reactors, as well as the quantities of irradiated plutonium target material currently in storage at the Savannah River Site. Spent driver fuel stored at the Savannah River Site includes fuel used in tritium and plutonium production. Analysis of these two fuel types showed that typical tritium production SNF contains a higher fission product and transuranic inventory than plutonium production SNF. Analysis of the characteristics of typical irradiated plutonium target material also showed that the radionuclide inventory would be bounded by the inventory in spent tritium production driver fuel. Therefore, for analysis purposes, both spent driver fuel and irradiated plutonium target material at the Savannah River Site was assumed to have the characteristics of spent tritium production driver fuel. Table I-20 shows the radionuclide inventory developed to represent Savannah River Site production reactor SNF based on published reports (WSRC 1991; WSRC 1990).

Characterization data for Hanford N Reactor SNF were based on Mark 1A fuel irradiated to an average burnup of 3,000 megawatt-days per metric ton uranium and assuming 10 years cooling time since removal from the reactor. The 10-year cooling time is conservative because the Hanford N Reactor was last operated in 1987 and SNF of this type is expected to be at least ten years old by the time shipments would begin. Table I-21 shows the radionuclide inventory used to represent Hanford N Reactor SNF.

Most of the graphite SNF under the responsibility of the DOE is from the Fort St. Vrain reactor owned by Public Service of Colorado. Some Fort St. Vrain SNF is already in storage at the Idaho National Engineering Laboratory, but most SNF is still in storage at the Fort St. Vrain site awaiting shipment to a DOE facility. In addition to the Fort St. Vrain SNF, smaller amounts of other graphite SNF are currently in storage at the Idaho National Engineering Laboratory. Characteristics for graphite SNF are, therefore, based on Fort St. Vrain SNF. Table I-22 shows the radionuclide inventory used to represent graphite reactor SNF based on six Fort St. Vrain fuel blocks irradiated to an average burnup of 70,000 megawatt-days per metric ton uranium and assuming a cooling time of 1,600 days (PSC 1993). The 1,600 day (about 4.3 years) cooling time is conservative because the Fort St. Vrain reactor was shut down in August 1989, and shipments will not be made before June 1995.

SNF from various commercial reactors is currently in storage at various DOE sites, mostly at the Idaho National Engineering Laboratory. Special case commercial SNF currently in storage at the Idaho National Engineering Laboratory includes core debris from the damaged Three Mile Island, Unit 2 reactor. Commercial SNF includes both boiling water reactor and pressurized water reactor SNF. Pressurized water reactor SNF was chosen as most representative because it is most prevalent and typically contains the highest levels of radioactivity (Fischer et al. 1987). Table I-23 shows the radionuclide inventory used to represent commercial SNF based on one pressurized water reactor fuel assembly irradiated to an average burnup of 33,000 megawatt-days per metric ton uranium and assuming a cooling time of 10 years (Fischer et al. 1987). The

Table I-20. Radionuclide inventory for representative Savannah River Site production reactor spent nuclear fuel.[a]

Isotope	Inventory (curie)
H-3	1.21×10^1
Kr-85	2.62×10^2
Sr-90	3.21×10^3
Y-90	3.21×10^3
Ru-106	7.64×10^0
Rh-106	7.64×10^0
Cs-134	1.48×10^2
Cs-137	3.18×10^3
Ba-137m	3.01×10^3
Ce-144	1.51×10^1
Pr-144	1.51×10^1
Pm-147	1.07×10^2
Pu-238	6.84×10^1
Pu-239	7.69×10^1
Pu-240	5.23×10^1
Pu-241	9.52×10^1
Am-241	1.97×10^0

a. Inventory based on one fuel assembly from a tritium producing charge, 10 years cooling out of reactor.

Table I-21. Radionuclide inventory for representative Hanford N Reactor spent nuclear fuel.[a]

Isotope	Inventory (curie per metric ton uranium)
H-3	3.09×10^1
Kr-85	5.89×10^2
Sr-90	6.80×10^3
Y-90	6.80×10^3
Ru-106	5.56×10^1
Sb-125	1.26×10^2
Cs-134	1.49×10^2
Cs-137	8.39×10^3
Ba-137m	7.94×10^3
Ce-144	3.24×10^1
Pm-147	2.24×10^3
Pu-238	5.06×10^1
Pu-239	1.10×10^2
Pu-240	5.97×10^1
Pu-241	4.47×10^3
Am-241	9.33×10^1

a. Inventory based on Mark IA N Reactor fuel, 10 years cooling out of reactor, average burnup 3,000 megawatt-days per metric ton uranium.

Table I-22. Radionuclide inventory for representative Fort St. Vrain reactor graphite spent nuclear fuel.[a]

Isotope	Inventory (curie)
Kr-85	2,352
Sr-90	15,660
Rh-106	594
Ru-106	594
Sb-125	336
Cs-134	7,452
Cs-137	16,524
Ce-144	3,768
Pr-144	3,768
Pm-147	6,324
Sm-151	54
Eu-154	948
Eu-155	138
U-232	18
U-233	24
Pu-238	420
Pu-241	306

a. Inventory based on six Fort St. Vrain fuel blocks, 1600 days cooling out of reactor, average burnup of 70,000 megawatt-days per metric ton uranium.

Table I-23. Radionuclide inventory for representative special case commercial spent nuclear fuel.[a]

Isotope	Inventory (curie)
Co-60	6.28×10^{2}
Kr-85	2.23×10^{3}
Sr-90	2.75×10^{4}
Y-90	2.73×10^{4}
Ru-106	2.52×10^{2}
I-129	1.48×10^{-2}
Cs-134	4.85×10^{3}
Cs-137	3.85×10^{4}
Ba-137m	3.62×10^{4}
Ce-144	9.01×10^{1}
Pu-238	1.36×10^{3}
Pu-239	1.67×10^{2}
Pu-240	2.06×10^{2}
Pu-241	4.32×10^{4}
Am-241	9.66×10^{2}
Cm-244	6.90×10^{2}

a. Inventory based on one pressurized water reactor fuel assembly, 10 years cooling out of reactor, average burnup 33,000 megawatt-days per metric ton uranium.

10-year cooling time is conservative because the majority of special case commercial SNF currently in storage at DOE sites will be at least 10 years old by June 1995.

Domestic university research and test reactors represent a variety of reactor types and fuel designs. High-enriched training, research, and isotope reactor (TRIGA) SNF was chosen as representative of university reactor SNF because it is one of the largest groups of university SNF to be transported and because it is a rod type fuel that would be expected to have the highest release of fission products under severe accident conditions. The radionuclide inventory of high-enriched TRIGA fuel was calculated using the ORIGEN2 computer code (Croff 1980) assuming a 17-year reactor operating cycle based on operation of the Texas A&M University TRIGA reactor. Table I-24 shows the radionuclide inventory representative of university research and test reactor SNF based on 19 TRIGA fuel rods irradiated to an average burnup of 20.2 percent and assuming a cooling time of 1 year.

DOE research and test reactors are also represented by a variety of reactor types and fuel designs. Experimental Breeder Reactor No. 2 Mark-5 SNF was chosen as representative of DOE research and test reactors because the reactor at the Idaho National Engineering Laboratory is one of the few DOE research and test reactors still operating. Mark-5 fuel is the current generation of Experimental Breeder Reactor No. 2 fuel types. The high plutonium content of Mark-5 fuel increases the relative hazard of the radionuclide inventory compared to other DOE SNF types. The radionuclide inventory of the Mark-5 fuel was calculated using the ORIGEN2 computer code assuming a typical Experimental Breeder Reactor No. 2 operating cycle. Table I-25 shows the radionuclide inventory representative of DOE research and test reactor SNF based on one Mark-5 fuel assembly irradiated to a burnup of 7.88 percent and assuming a cooling time of 1 year.

Foreign research and test reactor types and fuel designs also are widely variable. Australian HIFAR SNF was chosen as representative of this group because of its high enrichment and high burnup, which results in high fission product inventories in the spent fuel. The radionuclide inventory was calculated using the ORIGEN2 computer code assuming high-enriched (80 percent) aluminum plate-type fuel elements irradiated at a peak reactor power level of 10 megawatts to an average fuel burnup of 40 percent. Table I-26 shows the radionuclide inventory representative of foreign research and test reactor SNF after a cooling time of 3 years.

Non-DOE research reactor types are generally similar to domestic university research and test reactors. Therefore, TRIGA reactor SNF was also chosen as representative of non-DOE research reactor SNF.

Table I-24. Radionuclide inventory for representative university research/test reactor spent nuclear fuel.[a]

Isotope	Inventory (curie)	Isotope	Inventory (curie)
H-3	3.25×10^{0}	Cs-137	9.72×10^{2}
Kr-85	8.60×10^{1}	Ba-137M	9.20×10^{2}
Sr-89	4.28×10^{1}	Ce-141	3.86×10^{0}
Sr-90	9.30×10^{2}	Ce-144	1.47×10^{3}
Y-90	9.30×10^{2}	Pr-144	1.47×10^{3}
Y-91	9.77×10^{1}	Pm-147	8.81×10^{2}
Zr-95	1.48×10^{2}	U-235	4.00×10^{-3}
Nb-95	3.20×10^{2}	U-236	5.50×10^{-3}
Ru-103	7.47×10^{0}	Pu-238	1.00×10^{0}
Rh-103M	6.74×10^{0}	Pu-239	1.57×10^{-1}
Ru-106	1.36×10^{2}	Pu-240	6.70×10^{-2}
Te-125M	4.11×10^{0}	Pu-241	5.88×10^{0}
Te-127	2.08×10^{0}	Am-241	4.57×10^{-2}
Te-127M	2.12×10^{0}	Cm-242	1.81×10^{-1}
Cs-134	1.10×10^{2}		

a. Inventory based on 19 TRIGA fuel rods (70 percent enrichment; 122 g/rod uranium-235 beginning-of-life), 1 year cooling out of reactor, 20.2 percent average burnup.

Table I-25. Radionuclide inventory for representative DOE research/test reactor spent nuclear fuel.[a]

Isotope	Inventory (curie per assembly)	Isotope	Inventory (curie per assembly)
H-3	7.98×10^{0}	Te-127	3.32×10^{1}
Mn-54	7.48×10^{3}	Te-129m	1.14×10^{0}
Fe-55	6.12×10^{2}	Cs-134	9.15×10^{1}
Co-58	1.25×10^{2}	Cs-137	1.04×10^{3}
Co-60	3.55×10^{0}	Ba-137m	9.80×10^{2}
Kr-85	9.75×10^{1}	Ce-141	1.49×10^{1}
Sr-89	1.45×10^{2}	Ce-144	7.76×10^{3}
Sr-90	7.23×10^{2}	Pr-144m	1.11×10^{2}
Y-90	7.23×10^{2}	Pr-144	7.76×10^{3}
Y-91	3.67×10^{2}	Pm-147	2.65×10^{3}
Zr-95	7.00×10^{2}	Sm-151	2.91×10^{1}
Nb-95	1.52×10^{3}	Eu-155	1.00×10^{2}
Ru-103	4.88×10^{1}	U-235	2.90×10^{-3}
Rh-103m	4.40×10^{1}	U-236	3.34×10^{-3}
Ru-106	3.65×10^{3}	Pu-238	1.48×10^{0}
Rh-106	3.65×10^{3}	Pu-239	4.05×10^{1}
Sn-123	2.48×10^{1}	Pu-240	3.61×10^{1}
Sb-125	1.21×10^{2}	Pu-241	1.39×10^{3}
Te-125m	2.96×10^{1}	Am-241	4.74×10^{0}
Te-127m	3.37×10^{1}		

a. Inventory based on EBR-II Mark-5 fuel, 1 year cooling out of reactor, total burnup of 317 megawatt-days.

Table I-26. Radionuclide inventory for representative foreign research/test reactor spent nuclear fuel.[a]

Isotope	Inventory (curie)	Isotope	Inventory (curie)
H-3	6.94×10^{1}	Pr-144M	4.57×10^{2}
Kr-85	1.91×10^{3}	Pm-147	2.84×10^{4}
Sr-90	1.70×10^{4}	Sm-151	3.09×10^{1}
Y-90	1.70×10^{4}	Eu-154	3.82×10^{2}
Zr-95	1.24×10^{1}	Eu-155	1.99×10^{2}
Nb-95	2.75×10^{1}	U-235	2.34×10^{-2}
Ru-106	4.16×10^{3}	U-236	7.08×10^{-2}
Rh-106	4.16×10^{3}	U-238	1.51×10^{-3}
Sb-125	4.96×10^{2}	Np-237	5.94×10^{-3}
Te-125M	1.21×10^{2}	Pu-238	5.64×10^{0}
Cs-134	3.03×10^{3}	Pu-239	5.58×10^{-1}
Cs-137	1.76×10^{4}	Pu-240	3.41×10^{-1}
Ba-137M	1.67×10^{4}	Pu-241	1.45×10^{1}
Ce-144	3.81×10^{4}	Am-241	7.66×10^{-2}
Pr-144	3.81×10^{4}		

a. Inventory based on 120 Australian HIFAR fuel elements, 3 years cooling out of reactor, average 40 percent burnup.

I-5.2.2 Radioactive Release Characteristics

Radiological consequences were calculated by assigning cask release fractions to each accident severity category for each chemically and physically distinct radioisotope. The release fraction is defined as the fraction of the radioactivity in the cask that could be released from the cask in a given severity of accident. Release fractions vary according to SNF type and the physical/chemical properties of the radioisotopes. Most solid radionuclides in SNF are nonvolatile and are, therefore, relatively nondispersible. Gaseous radionuclides, such as krypton-85, are relatively easy to release if the fuel cladding and cask are compromised.

Representative cask release fractions were developed for each of the representative SNF types. The U.S. Nuclear Regulatory Commission Modal Study developed release fractions for commercial pressurized-water reactor SNF. The Modal Study release fractions, shown in Table I-27, are based on best engineering judgment and are conservative for most SNF types. For this analysis, the release fractions recommended in the Modal Study were applied only to commercial pressurized-water reactor SNF and TRIGA SNF, both of which are rod-type fuels. Because of the significant differences in fuel designs and the availability of more appropriate fuel-specific release characterization data, less conservative release fractions were applied to the other representative SNF types.

Release fractions for aluminum fuels (aluminum alloy fuel, aluminum cladding) were based on laboratory measurements of release fractions from aluminum fuels at high temperatures (Shibata et al. 1984) and the U.S. Nuclear Regulatory Commission Modal Study (Fischer et al. 1987). Because of the lower melting point of aluminum compared to metals used in other metallic fuels, the aluminum fuel release fractions are considered bounding for metallic fuels (that is, Savannah River Production Reactor, Hanford N Reactor, EBR-II Mark 5, and Australia HIFAR SNF). Release fractions for the aluminum and other metallic fuel types are listed in Table I-28.

Release fractions for graphite fuels, specifically Fort St. Vrain SNF, were based on engineering analyses. Fort St. Vrain fuel is in the form of carbide particles, encased within a highly retentive four-layer ceramic coating. Stress analysis tests have shown that the fuel particles can withstand stresses well in excess of those that might be encountered in severe accidents. Thermal diffusion across the ceramic barrier under extreme temperature conditions is the only significant mechanism for release of fission products from intact Fort St. Vrain fuel. Fuel particles that have failed during reactor operation (less than 1 percent of the inventory) are vulnerable to vaporization and impact-induced releases of particulates, but volatile fission products would have been released within the extreme thermal environment of the operating reactor. Table I-29 summarizes the release fractions applied to Fort St. Vrain SNF, assuming 1 percent fuel failure during reactor operations.

Table I-27. Release fractions for transportation accidents involving special case commercial, university, and non-DOE research reactor spent nuclear fuel types for the U.S. Nuclear Regulatory Commission Modal Study cask response regions.

	Release fraction[a]				
Cask response region	Inert gas	Iodine	Cesium	Ruthenium	Particulates
R(1,1)	0.0	0.0	0.0	0.0	0.0
R(1,2),R(1,3)	9.9×10^{-3}	7.5×10^{-5}	6.0×10^{-6}	8.1×10^{-7}	6.0×10^{-8}
R(2,1),R(2,2),R(2,3)	3.3×10^{-2}	2.5×10^{-4}	2.0×10^{-5}	2.7×10^{-6}	2.0×10^{-7}
R(1,4),R(2,4),R(3,4)	3.9×10^{-1}	4.3×10^{-3}	2.0×10^{-4}	4.8×10^{-5}	2.0×10^{-6}
R(3,1),R(3,2),R(3,3)	3.3×10^{-1}	2.5×10^{-3}	2.0×10^{-4}	2.7×10^{-5}	2.0×10^{-6}
R(1,5),R(2,5),R(3,5), R(4,5),R(4,1),R(4,2), R(4,3),R(4,4)	6.3×10^{-1}	4.3×10^{-2}	2.0×10^{-3}	4.8×10^{-4}	2.0×10^{-5}

a. U.S. Nuclear Regulatory Commission Modal Study (Fischer et al. 1987).

Table I-28. Release fractions for transportation accidents involving aluminum and metallic spent nuclear fuel types[a] for the U.S. Nuclear Regulatory Commission Modal Study cask response regions.

	Release fraction[b]				
Cask response region	Inert gas	Iodine	Cesium	Ruthenium	Particulates
R(1,1)	0.0	0.0	0.0	0.0	0.0
R(1,2),R(1,3)	9.9×10^{-3}	1.1×10^{-7}	3.0×10^{-8}	4.1×10^{-9}	3.0×10^{-10}
R(2,1),R(2,2),R(2,3)	3.3×10^{-2}	3.5×10^{-7}	1.0×10^{-7}	1.4×10^{-8}	1.0×10^{-9}
R(1,4),R(2,4),R(3,4)	3.9×10^{-1}	6.0×10^{-6}	1.0×10^{-6}	2.4×10^{-7}	1.0×10^{-8}
R(3,1),R(3,2),R(3,3)	3.3×10^{-1}	3.5×10^{-6}	1.0×10^{-6}	1.4×10^{-7}	1.0×10^{-8}
R(1,5),R(2,5),R(3,5), R(4,5),R(4,1),R(4,2), R(4,3),R(4,4)	6.3×10^{-1}	6.0×10^{-5}	1.0×10^{-5}	2.4×10^{-6}	1.0×10^{-7}

a. These release fractions are applicable to the following SNF types:
   1. N Reactor
   2. Savannah River Site production reactor
   3. DOE research/test reactor
   4. Foreign research/test reactor

b. Derived from Shibata et al. (1984) and U.S. Nuclear Regulatory Commission Modal Study (Fischer et al. 1987).

Table I-29. Release fractions for transportation accidents involving graphite spent nuclear fuel for the U.S. Nuclear Regulatory Commission Modal Study cask response regions.

	Release fraction					
Cask response region	Inert gas[a]	Strontium, cerium[b]	Antimony[c]	Cesium[b]	Ruthenium, rhodium[c]	Particulates[d]
R(1,1)	0.0	0.0	0.0	0.0	0.0	0.0
R(1,2),R(1,3),R(1,4), R(2,1),R(2,2),R(2,3), R(2,4),R(3,1),R(3,2), R(3,3),R(3,4),R(4,1), R(4,2),R(4,3),R(4,4)	5.3×10^{-3}	3.7×10^{-7}	1.0×10^{-6}	2.4×10^{-7}	7.3×10^{-8}	1.0×10^{-9}
R(1,5),R(2,5),R(3,5), R(4,5)	1.2×10^{-2}	5.0×10^{-6}	1.0×10^{-6}	9.1×10^{-6}	7.3×10^{-8}	1.0×10^{-9}

a. Thermally induced, from NUREG/CR-0722, Table 40, all fuel (Lorenz et al. 1980).

b. Empirical data from the Fort St. Vrain Final Safety Analysis Report, Rev. 8, Table A.3-1 (PSC 19xx).

c. Thermally induced semivolatiles from incore failed fuel; 1 percent fuel failure, 100 percent respirable; release fraction from Lorenz et al. (1980).

d. Impact induced nonvolatiles, 1 percent incore failed fuel, 5 percent respirable, release fraction of 2×10^{-6} from Wilmot (1981).

I-5.3 Results of Calculations

I-5.3.1 Impacts from the No Action Alternative

There are no offsite shipments of DOE, university, foreign, or non-DOE research reactor SNF under this alternative. Consequently, there are no transportation accident impacts. The limited number of Naval fuel shipments made under the No Action alternative are covered in Appendix D of this EIS.

I-5.3.2 Impacts from the Decentralization Alternative

The SNF shipments included under this alternative are those of domestic university, foreign, and non-DOE research reactor SNF to the Idaho National Engineering Laboratory and Savannah River Site. Naval fuel shipments made under different options of the Decentralization alternative are covered in Appendix D of this EIS. Shipments are expected to be made by truck, but the impact analysis also assessed transportation by rail. The same shipping cask was assumed to be used for both truck and rail shipments, and a single shipping cask was assumed for each shipment.

The cumulative accident risk for transportation by truck was calculated to be 4.7×10^{-5} latent cancer fatality and 0.056 traffic fatality. The cumulative accident risk measures the total impact of transportation accidents over the entire shipment campaign (1995 to 2035). The cumulative accident risk for transportation by rail was calculated to be 9.5×10^{-6} latent cancer fatality and 0.072 traffic fatality. Table I-30 summarizes the transportation accident risks for the Decentralization alternative.

As shown in Table I-31, the maximum reasonably foreseeable transportation accident has a probability of occurrence of about 3.7×10^{-7} per year for a rural population zone. Under normal (neutral) weather conditions, the total population dose is estimated to be about 1.3 person-rem, which would be expected to result in less than one latent cancer fatality in the exposed population. For comparison, the same population would be expected to experience about 840 latent fatal cancers from other causes. The probability of this accident occurring in an urban or suburban population zone, or occurring under stable weather conditions in any population zone, is less than 1×10^{-7} per year.

I-5.3.3 Impacts from the 1992/1993 Planning Basis Alternative

This alternative includes the shipment of five types of SNF. It assumes that the Fort St. Vrain SNF currently in storage in Colorado is transported to the Idaho National Engineering Laboratory. Likewise, special case commercial SNF currently stored at West Valley is transported to the Idaho National Engineering Laboratory. DOE research and test reactor SNF is transported to either the Idaho National Engineering Laboratory or Savannah River Site, with

Table I-30. SNF transportation accident risks for the Decentralization alternative (1995 to 2035).

Transport mode	Dose risk (person-rem)	Latent Cancer fatalities[a]	Traffic fatalities[b]
Truck	0.093	4.7×10^{-5}	0.056
Rail	0.019	9.5×10^{-6}	0.072

a. Estimated number of latent fatal cancers as a result of radiation dose from transportation accidents.

b. Estimated number of fatalities from nonradiological effect of transportation accident, for example, physical impact.

Table I-31. Health effects from maximum reasonably foreseeable offsite SNF transportation accident under the Decentralization alternative (1995 to 2035).

Alternative: Decentralization
Maximum reasonably foreseeable accident: University research reactor SNF shipment by rail
Population zone: Rural[a]
Maximum reasonably foreseeable accident probability: 3.7×10^{-7} per year with neutral meteorology, less than 1×10^{-7} per year with stable meteorology

Doses and health effects	Transport mode	Population		Maximum exposed individual	
		Neutral[b]	Stable[c]	Neutral[b]	Stable[c]
Dose	Rail	1.3 person-rem	(e)	0.032 rem	(e)
Latent cancer fatalities[d]	Rail	0.00065	(e)	1.6×10^{-5}	(e)

a. The maximum reasonably foreseeable accident occurs in a rural population zone. The probability of the accident occurring in an urban or suburban population zone is less than 1×10^{-7} per year.

b. Neutral meteorological conditions occur greater than 50 percent of the time.

c. Stable meteorological conditions occur less than 5 percent of the time and result in less atmospheric dispersion of radioactivity released to the atmosphere.

d. Results expressed as the estimated number of latent fatal cancers expected in the impacted population as a result of the radiation dose; for the maximally exposed individual, results express the probability of latent fatal cancer as a result of the radiation dose. Fatal cancer risk factor: 5×10^{-4} fatal cancers per person-rem (ICRP 1991).

e. Consequences not developed for accidents with probabilities less than 1×10^{-7} per year.

most going to the Idaho National Engineering Laboratory. Shipments of university, foreign, and non-DOE research reactor SNF are split between the Idaho National Engineering Laboratory and the Savannah River Site. Shipments could be by truck or rail, so the analysis addresses the two extremes of all shipments by truck or all shipments by rail.

The cumulative accident risk for transportation by truck was calculated to be 0.0001 latent cancer fatality and 0.074 traffic fatality. The cumulative accident risk measures the total impact of transportation accidents over the entire shipment campaign (1995 to 2035). The cumulative accident risk for transportation by rail was calculated to be 2.9×10^{-5} latent cancer fatality and 0.076 traffic fatality. Table I-32 summarizes the transportation accident risks for the 1992/1993 Planning Basis alternative.

The maximum reasonably foreseeable transportation accident involves a rail shipment of special case commercial SNF. The accident has a probability of occurrence of about 1.2×10^{-7} per year for a suburban population zone. Under normal (neutral) weather conditions, the total population dose is estimated to be about 13,000 person-rem (average dose of 26 millirem per person), which could result in an estimated seven latent fatal cancers in the exposed population. For comparison, the same population would be expected to experience about 100,000 latent fatal cancers from other causes. The probability of this accident occurring in an urban population zone, or occurring under stable weather conditions in any population zone, is less than 1×10^{-7} per year. Table I-33 summarizes the doses and health effects from the maximum reasonably foreseeable consequence assessment.

1.5.3.4 Impacts from the Regionalization Alternative

This alternative includes two subalternatives: Regionalization by Fuel Type and Regionalization by Geography. Under the Regionalization by Fuel Type subalternative, the same SNF types are transported as in the 1992/1993 Planning Basis alternative with differences occurring in the destinations of some SNF based on fuel type. DOE research and test reactor SNF is transported to either the Idaho National Engineering Laboratory or the Savannah River Site, with most SNF going to the Idaho National Engineering Laboratory. Graphite-type and special case commercial SNF is transported to the Idaho National Engineering Laboratory. As with the 1992/1993 Planning Basis alternative, shipments could be by truck or rail, and the analysis evaluates impacts assuming either of two extremes: all shipments by truck or all shipments by rail.

Under Regionalization by Fuel Type, the cumulative accident risk for transportation by truck was calculated to be 0.00016 latent cancer fatality and 0.11 traffic fatality. The cumulative accident risk measures the total impact of transportation accidents over the entire shipment campaign (1995 to 2035). The cumulative accident risk for transportation by rail was calculated to be 3.8×10^{-5} latent cancer fatality and 0.092 traffic fatality. Table I-34 summarizes the transportation accident risk for the Regionalization by Fuel Type subalternative.

Table I-32. SNF transportation accident risks for the 1992/1993 Planning Basis alternative (1995 to 2035).

Transport mode	Dose risk (person-rem)	Latent Cancer fatalities[a]	Traffic fatalities[b]
Truck	0.21	0.0001	0.074
Rail	0.058	2.9×10^{-5}	0.076

a. Estimated number of latent fatal cancers as a result of radiation dose from transportation accidents.

b. Estimated number of fatalities from nonradiological effect of transportation accident, for example, physical impact.

Table I-33. Health effects from maximum reasonably foreseeable offsite SNF transportation accident under the 1992/1993 Planning Basis alternative (1995 to 2035).

Alternative: 1992/1993 Planning Basis
Maximum reasonably foreseeable accident: Special case commercial SNF shipment by rail
Population zone: Suburban[a]
Maximum reasonably foreseeable accident probability: 1.2×10^{-7} per year with neutral meteorology, less than 1.0×10^{-7} per year with stable meteorology

Doses and health effects	Transport mode	Population		Maximum exposed individual	
		Neutral[b]	Stable[c]	Neutral[b]	Stable[c]
Dose	Rail	13,000 person-rem	(e)	54 rem	(e)
Latent cancer fatalities[d]	Rail	7	(e)	0.027	(e)

a. The maximum reasonably foreseeable accident occurs in a suburban population zone. The probability of the accident occurring in an urban population zone is less than 1×10^{-7} per year. In a rural population zone, the dose would be approximately 3 percent of the suburban population dose.

b. Neutral meteorological conditions occur greater than 50 percent of the time.

c. Stable meteorological conditions occur less than 5 percent of the time and result in less atmospheric dispersion of radioactivity released to the atmosphere.

d. Results expressed as the estimated number of latent fatal cancers expected in the impacted population as a result of the radiation dose; for the maximally exposed individual, results express the probability of contracting fatal cancer as a result of the radiation dose. Fatal cancer risk factor: 5×10^{-4} fatal cancers per person-rem (ICRP 1991).

e. Consequences not developed for accidents with probabilities less than 1×10^{-7} per year.

As in the 1992/1993 Planning Basis alternative, the maximum reasonably foreseeable transportation accident involves a rail shipment of special case commercial SNF. The accident has a probability of occurrence of about 2×10^{-7} per year for a suburban population zone. The consequences under normal (neutral) weather conditions are the same as those described under the 1992/1993 Planning Basis alternative. The probability of this accident occurring in an urban population zone, or occurring under stable weather conditions in any population zone, is less than 1×10^{-7} per year. Table I-35 summarizes the doses and health effects from the maximum reasonably foreseeable consequence assessment.

The Regionalization by Geography subalternative contains six separate options, and the transportation impacts of each option have been analyzed for comparison. Under this subalternative, the same SNF types are transported as under the 1992/1993 Planning Basis alternative with differences occurring in the destinations of the SNF based on geographical considerations. Non-Navy SNF originating from western United States locations or ports would be transported to the Idaho National Engineering Laboratory, Hanford Site, or the Nevada Test Site. Non-Navy SNF originating from eastern United States locations or ports would be transported to the Savannah River Site or the Oak Ridge Reservation. Navy SNF would not be split on an east-west basis because the Navy would operate a facility for examining Naval SNF at only one of the DOE sites.

Cumulative accident risks for transportation by truck range from 7.5×10^{-5} latent cancer fatality and 0.088 traffic fatality for Regionalization at the Idaho National Engineering Laboratory and the Savannah River Site, to 0.00027 latent cancer fatality and 0.17 traffic fatality for Regionalization at the Nevada Test Site and the Oak Ridge Reservation. Cumulative accident risks for transportation by rail range from 3.1×10^{-5} latent cancer fatality and 0.073 traffic fatality for Regionalization at the Hanford Site and the Savannah River Site, to 3.2×10^{-5} latent cancer fatality and 0.12 traffic fatality for Regionalization at the Nevada Test Site and the Oak Ridge Reservation.

As in the Regionalization by Fuel Type subalternative, the maximum reasonably foreseeable transportation accident involves a rail shipment of special case commercial SNF. The consequences of the maximum reasonably foreseeable accident are the same for each of the six Regionalization by Geography options. The maximum reasonably foreseeable accident under neutral weather conditions occurs in a suburban population zone because the accident probability for an urban population zone is less than 1×10^{-7} per year. The total population dose is estimated to be about 13,000 person-rem (average dose of 26 millirem per person), which could result in an estimated seven latent fatal cancers in the exposed population. For comparison, the same population would be expected to experience about 100,000 latent fatal cancers from other causes.

Table I-34. SNF transportation accident risks for the Regionalization by Fuel Type subalternative (1995-2035).

Transport mode	Dose risk (person-rem)	Latent Cancer fatalities[a]	Traffic fatalities[b]
Truck	0.32	0.00016	0.11
Rail	0.076	3.8×10^{-5}	0.092

a. Estimated number of latent fatal cancers as a result of radiation dose from transportation accidents.

b. Estimated number of fatalities from nonradiological effect of transportation accident, for example, physical impact.

Table I-35. Health effects from maximum reasonably foreseeable offsite SNF transportation accident under the Regionalization by Fuel Type subalternative (1995 to 2035).

Alternative: Regionalization by Fuel Type
Maximum reasonably foreseeable accident: Special case commercial SNF shipment by rail
Population zone: Suburban[a]
Maximum reasonably foreseeable accident probability: 2.0×10^{-7} per year with neutral meteorology, less than 1×10^{-7} per year with stable meteorology

Doses and health effects	Transport mode	Population		Maximum exposed individual	
		Neutral[b]	Stable[c]	Neutral[b]	Stable[c]
Dose	Rail	13,000 person-rem	(e)	54 rem	(e)
Latent cancer fatalities[d]	Rail	7	(e)	0.027	(e)

a. The maximum reasonably foreseeable accident occurs in a suburban population zone. The probability of the accident occurring in an urban population zone is less than 1×10^{-7} per year. In a rural population zone, the dose would be approximately 3 percent of the suburban population dose.

b. Neutral meteorological conditions occur greater than 50 percent of the time.

c. Stable meteorological conditions occur less than 5 percent of the time and result in less atmospheric dispersion of radioactivity released to the atmosphere.

d. Results expressed as the estimated number of latent fatal cancers expected in the impacted population as a result of the radiation dose; for the maximally exposed individual, results express the probability of contracting fatal cancer as a result of the radiation dose. Fatal cancer risk factor: 5×10^{-4} fatal cancers per person-rem (ICRP 1991).

e. Consequences not developed for accidents with probabilities less than 1×10^{-7} per year.

The maximum reasonably foreseeable accident under stable weather conditions has a probability less than 1×10^{-7} per year for all population zones except rural. A total population dose of 3,500 person-rem was estimated for the rural population zone (average dose of 2 rem per person), which could result in an estimated two latent fatal cancers in the exposed population. For comparison, the same population would be expected to experience about 350 latent fatal cancers from other causes.

The probability of the maximum reasonably foreseeable transportation accident varies slightly among the six Regionalization by Geography options. The maximum reasonably foreseeable accident in a suburban population zone has an estimated probability of occurrence ranging from about 1.8×10^{-7} per year for Regionalization at the Hanford Site and the Savannah River Site, to about 3.4×10^{-7} per year for Regionalization at the Nevada Test Site and the Oak Ridge Reservation. The maximum reasonably foreseeable accident in a rural population zone has an estimated probability of occurrence ranging from about 1.3×10^{-7} per year for Regionalization at the Hanford Site and the Savannah River Site, to about 3.2×10^{-7} per year for Regionalization at the Nevada Test Site and the Oak Ridge Reservation.

Tables I-36 through I-47 summarize the doses and health effects from the accident risk assessment and the maximum reasonably foreseeable consequence assessment for each of the Regionalization by Geography options.

I-5.3.5 Impacts from the Centralization Alternatives

The impacts from centralization at the Hanford Site, Idaho National Engineering Laboratory, Savannah River Site, Oak Ridge Reservation, and the Nevada Test Site are presented in this section.

Centralization at the Hanford Site. Under this alternative, SNF currently stored at other DOE sites, Fort St. Vrain, university, foreign, and non-DOE research reactors is eventually transported to the Hanford site. The analysis evaluates impacts assuming either all shipments by truck or all shipments by rail.

The cumulative accident risk for transportation by truck was calculated to be 0.00031 latent cancer fatality and 0.26 traffic fatality. The cumulative accident risk measures the total impact of transportation accidents over the entire shipment campaign (1995 to 2035). The cumulative accident risk for transportation by rail was calculated to be 7.0×10^{-5} latent cancer fatality and 0.21 traffic fatality. Table I-48 summarizes the transportation accident risks for the Centralization at the Hanford Site alternative.

As in the 1992/1993 Planning Basis and Regionalization alternatives, the maximum reasonably foreseeable transportation accident involves a rail shipment of special case commercial

Table I-36. SNF transportation accident risks for the Regionalization by Geography subalternative (Idaho National Engineering Laboratory and Savannah River Site) (1995 to 2035).

Transport mode	Dose risk (person-rem)	Latent Cancer fatalities[a]	Traffic fatalities[b]
Truck	0.15	7.5×10^{-5}	0.088
Rail	0.036	1.8×10^{-5}	0.079

a. Estimated number of latent fatal cancers as a result of radiation dose from transportation accidents.

b. Estimated number of fatalities from nonradiological effect of transportation accident, for example, physical impact.

Table I-37. Health effects from maximum reasonably foreseeable offsite SNF transportation accident under the Regionalization by Geography subalternative (Idaho National Engineering Laboratory and Savannah River Site) (1995 to 2035).

Alternative: Regionalization by Geography (INEL & SRS)
Maximum reasonably foreseeable accident: Special case commercial SNF shipment by rail
Population zone: Suburban (neutral) and rural (stable)[a]
Maximum reasonably foreseeable accident probability: 2.2×10^{-7} per year with neutral meteorology, 1.8×10^{-7} per year with stable meteorology

Doses and health effects	Transport mode	Population[a]		Maximum exposed individual	
		Neutral[b]	Stable[c]	Neutral[b]	Stable[c]
Dose	Rail	13,000 person-rem	3,500 person-rem	54 rem	180 rem
Latent cancer fatalities[d]	Rail	7	2	0.027	0.09

a. The maximum reasonably foreseeable accident occurs in a suburban population zone under neutral weather conditions. The accident probability is less than 1×10^{-7} per year under stable weather conditions, except in a rural population zone. For urban population zones, the accident probability is less that 1×10^{-7} per year for both neutral and stable weather conditions.

b. Neutral meteorological conditions occur greater than 50 percent of the time.

c. Stable meteorological conditions occur less than 5 percent of the time and result in less atmospheric dispersion of radioactivity released to the atmosphere.

d. Results expressed as the estimated number of latent fatal cancers expected in the impacted population as a result of the radiation dose; for the maximally exposed individual, results express the probability of contracting fatal cancer as a result of the radiation dose. Fatal cancer risk factor: 5×10^{-4} fatal cancers per person-rem (ICRP 1991).

Table I-38. SNF transportation accident risks for the Regionalization by Geography subalternative (Idaho National Engineering Laboratory and Oak Ridge Reservation) (1995 to 2035).

Transport mode	Dose risk (person-rem)	Latent Cancer fatalities[a]	Traffic fatalities[b]
Truck	0.25	0.00013	0.09
Rail	0.04	2.0×10^{-5}	0.084

a. Estimated number of latent fatal cancers as a result of radiation dose from transportation accidents.

b. Estimated number of fatalities from nonradiological effect of transportation accident, for example, physical impact.

Table I-39. Health effects from maximum reasonably foreseeable offsite SNF transportation accident under the Regionalization by Geography subalternative (Idaho National Engineering Laboratory and Oak Ridge Reservation) (1995 to 2035).

Alternative: Regionalization by Geography (INEL & ORR)
Maximum reasonably foreseeable accident: Special case commercial SNF shipment by rail
Population zone: Suburban (neutral) and rural (stable)[a]
Maximum reasonably foreseeable accident probability: 2.7×10^{-7} per year with neutral meteorology, 1.8×10^{-7} per year with stable meteorology

Doses and health effects	Transport mode	Population[a]		Maximum exposed individual	
		Neutral[b]	Stable[c]	Neutral[b]	Stable[c]
Dose	Rail	13,000 person-rem	3,500 person-rem	54 rem	180 rem
Latent cancer fatalities[d]	Rail	7	2	0.027	0.09

a. The maximum reasonably foreseeable accident occurs in a suburban population zone under neutral weather conditions. The accident probability is less than 1×10^{-7} per year under stable weather conditions, except in a rural population zone. For urban population zones, the accident probability is less that 1×10^{-7} per year for both neutral and stable weather conditions.

b. Neutral meteorological conditions occur greater than 50 percent of the time.

c. Stable meteorological conditions occur less than 5 percent of the time and result in less atmospheric dispersion of radioactivity released to the atmosphere.

d. Results expressed as the estimated number of latent fatal cancers expected in the impacted population as a result of the radiation dose; for the maximally exposed individual, results express the probability of contracting fatal cancer as a result of the radiation dose. Fatal cancer risk factor: 5×10^{-4} fatal cancers per person-rem (ICRP 1991).

Table I-40. SNF transportation accident risks for the Regionalization by Geography subalternative (Hanford Site and Savannah River Site) (1995 to 2035).

Transport mode	Dose risk (person-rem)	Latent Cancer fatalities[a]	Traffic fatalities[b]
Truck	0.2	0.0001	0.11
Rail	0.061	3.1×10^{-5}	0.073

a. Estimated number of latent fatal cancers as a result of radiation dose from transportation accidents.

b. Estimated number of fatalities from nonradiological effect of transportation accident, for example, physical impact.

Table I-41. Health effects from maximum reasonably foreseeable offsite SNF transportation accident under the Regionalization by Geography subalternative (Hanford Site and Savannah River Site) (1995 to 2035).

Alternative: Regionalization by Geography (HS & SRS)
Maximum reasonably foreseeable accident: Special case commercial SNF shipment by rail
Population zone: Suburban (neutral) and rural (stable)[a]
Maximum reasonably foreseeable accident probability: 1.8×10^{-7} per year with neutral meteorology, 1.3×10^{-7} per year with stable meteorology

Doses and health effects	Transport mode	Population[a]		Maximum exposed individual	
		Neutral[b]	Stable[c]	Neutral[b]	Stable[c]
Dose	Rail	13,000 person-rem	3,500 person-rem	54 rem	180 rem
Latent cancer fatalities[d]	Rail	7	2	0.027	0.09

a. The maximum reasonably foreseeable accident occurs in a suburban population zone under neutral weather conditions. The accident probability is less than 1×10^{-7} per year under stable weather conditions, except in a rural population zone. For urban population zones, the accident probability is less that 1×10^{-7} per year for both neutral and stable weather conditions.

b. Neutral meteorological conditions occur greater than 50 percent of the time.

c. Stable meteorological conditions occur less than 5 percent of the time and result in less atmospheric dispersion of radioactivity released to the atmosphere.

d. Results expressed as the estimated number of latent fatal cancers expected in the impacted population as a result of the radiation dose; for the maximally exposed individual, results express the probability of contracting fatal cancer as a result of the radiation dose. Fatal cancer risk factor: 5×10^{-4} fatal cancers per person-rem (ICRP 1991).

Table I-42. SNF transportation accident risks for the Regionalization by Geography subalternative (Hanford Site and Oak Ridge Reservation) (1995 to 2035).

Transport mode	Dose risk (person-rem)	Latent Cancer fatalities[a]	Traffic fatalities[b]
Truck	0.31	0.00016	0.11
Rail	0.065	3.3×10^{-5}	0.079

a. Estimated number of latent fatal cancers as a result of radiation dose from transportation accidents.

b. Estimated number of fatalities from nonradiological effect of transportation accident, for example, physical impact.

Table I-43. Health effects from maximum reasonably foreseeable offsite SNF transportation accident under the Regionalization by Geography subalternative (Hanford Site and Oak Ridge Reservation) (1995 to 2035).

Alternative: Regionalization by Geography (HS & ORR)
Maximum reasonably foreseeable accident: Special case commercial SNF shipment by rail
Population zone: Suburban (neutral) and rural (stable)[a]
Maximum reasonably foreseeable accident probability: 2.4×10^{-7} per year with neutral meteorology, 1.4×10^{-7} per year with stable meteorology

Doses and health effects	Transport mode	Population[a]		Maximum exposed individual	
		Neutral[b]	Stable[c]	Neutral[b]	Stable[c]
Dose	Rail	13,000 person-rem	3,500 person-rem	54 rem	180 rem
Latent cancer fatalities[d]	Rail	7	2	0.027	0.09

a. The maximum reasonably foreseeable accident occurs in a suburban population zone under neutral weather conditions. The accident probability is less than 1×10^{-7} per year under stable weather conditions, except in a rural population zone. For urban population zones, the accident probability is less that 1×10^{-7} per year for both neutral and stable weather conditions.

b. Neutral meteorological conditions occur greater than 50 percent of the time.

c. Stable meteorological conditions occur less than 5 percent of the time and result in less atmospheric dispersion of radioactivity released to the atmosphere.

d. Results expressed as the estimated number of latent fatal cancers expected in the impacted population as a result of the radiation dose; for the maximally exposed individual, results express the probability of contracting fatal cancer as a result of the radiation dose. Fatal cancer risk factor: 5×10^{-4} fatal cancers per person-rem (ICRP 1991).

Table I-44. SNF transportation accident risks for the Regionalization by Geography subalternative (Nevada Test Site and Savannah River Site) (1995 to 2035).

Transport mode	Dose risk (person-rem)	Latent Cancer fatalities[a]	Traffic fatalities[b]
Truck	0.44	0.00022	0.17
Rail	0.059	3.0×10^{-5}	0.11

a. Estimated number of latent fatal cancers as a result of radiation dose from transportation accidents.

b. Estimated number of fatalities from nonradiological effect of transportation accident, for example, physical impact.

Table I-45. Health effects from maximum reasonably foreseeable offsite SNF transportation accident under the Regionalization by Geography subalternative (Nevada Test Site and Savannah River Site) (1995 to 2035).

Alternative: Regionalization by Geography (NTS & SRS)
Maximum reasonably foreseeable accident: Special case commercial SNF shipment by rail
Population zone: Suburban (neutral) and rural (stable)[a]
Maximum reasonably foreseeable accident probability: 2.8×10^{-7} per year with neutral meteorology, 3.1×10^{-7} per year with stable meteorology

Doses and health effects	Transport mode	Population[a]		Maximum exposed individual	
		Neutral[b]	Stable[c]	Neutral[b]	Stable[c]
Dose	Rail	13,000 person-rem	3,500 person-rem	54 rem	180 rem
Latent cancer fatalities[d]	Rail	7	2	0.027	0.09

a. The maximum reasonably foreseeable accident occurs in a suburban population zone under neutral weather conditions. The accident probability is less than 1×10^{-7} per year under stable weather conditions, except in a rural population zone. For urban population zones, the accident probability is less that 1×10^{-7} per year for both neutral and stable weather conditions.

b. Neutral meteorological conditions occur greater than 50 percent of the time.

c. Stable meteorological conditions occur less than 5 percent of the time and result in less atmospheric dispersion of radioactivity released to the atmosphere.

d. Results expressed as the estimated number of latent fatal cancers expected in the impacted population as a result of the radiation dose; for the maximally exposed individual, results express the probability of contracting fatal cancer as a result of the radiation dose. Fatal cancer risk factor: 5×10^{-4} fatal cancers per person-rem (ICRP 1991).

Table I-46. SNF transportation accident risks for the Regionalization by Geography subalternative (Nevada Test Site and Oak Ridge Reservation) (1995 to 2035).

Transport mode	Dose risk (person-rem)	Latent Cancer fatalities[a]	Traffic fatalities[b]
Truck	0.54	0.00027	0.17
Rail	0.063	3.2×10^{-5}	0.12

a. Estimated number of latent fatal cancers as a result of radiation dose from transportation accidents.

b. Estimated number of fatalities from nonradiological effect of transportation accident, for example, physical impact.

Table I-47. Health effects from maximum reasonably foreseeable offsite SNF transportation accident under the Regionalization by Geography subalternative (Nevada Test Site and Oak Ridge Reservation) (1995 to 2035).

Alternative: Regionalization by Geography (NTS & ORR)
Maximum reasonably foreseeable accident: Special case commercial SNF shipment by rail
Population zone: Suburban (neutral) and rural (stable)[a]
Maximum reasonably foreseeable accident probability: 3.4×10^{-7} per year with neutral meteorology, 3.2×10^{-7} per year with stable meteorology

Doses and health effects	Transport mode	Population[a]		Maximum exposed individual	
		Neutral[b]	Stable[c]	Neutral[b]	Stable[c]
Dose	Rail	13,000 person-rem	3,500 person-rem	54 rem	180 rem
Latent cancer fatalities[d]	Rail	7	2	0.027	0.09

a. The maximum reasonably foreseeable accident occurs in a suburban population zone under neutral weather conditions. The accident probability is less than 1×10^{-7} per year under stable weather conditions, except in a rural population zone. For urban population zones, the accident probability is less that 1×10^{-7} per year for both neutral and stable weather conditions.

b. Neutral meteorological conditions occur greater than 50 percent of the time.

c. Stable meteorological conditions occur less than 5 percent of the time and result in less atmospheric dispersion of radioactivity released to the atmosphere.

d. Results expressed as the estimated number of latent fatal cancers expected in the impacted population as a result of the radiation dose; for the maximally exposed individual, results express the probability of contracting fatal cancer as a result of the radiation dose. Fatal cancer risk factor: 5×10^{-4} fatal cancers per person-rem (ICRP 1991).

SNF. The accident has a probability of occurrence of about 4.5×10^{-7} per year under neutral (normal) weather conditions and 3.3×10^{-7} per year under stable (worst-case) weather conditions. The consequences are the same as those described under the Regionalization by Geography alternative. Table I-49 summarizes the doses and health effects from the maximum reasonably foreseeable consequence assessment.

Centralization at the Idaho National Engineering Laboratory. Under this alternative, all SNF currently stored at other DOE sites, Fort St. Vrain, and university, foreign, and non-DOE research reactors is eventually transported to the Idaho National Engineering Laboratory. The analysis evaluates impacts assuming either all shipments by truck or all shipments by rail.

The cumulative accident risk for transportation by truck was calculated to be 0.00027 latent cancer fatality and 0.22 traffic fatality. The cumulative accident risk measures the total impact of transportation accidents over the entire shipment campaign (1995 to 2035). The cumulative accident risk for transportation by rail was calculated to be 5.5×10^{-5} latent cancer fatality and 0.18 traffic fatality. Table I-50 summarizes the transportation accident risks for the Centralization at the Idaho National Engineering Laboratory alternative.

As in the 1992/1993 Planning Basis and Regionalization alternatives, the maximum reasonably foreseeable transportation accident involves a rail shipment of special case commercial SNF. The accident has a probability of occurring of about 4.2×10^{-7} per year under neutral (normal) weather conditions and about 3.1×10^{-7} per year under stable (worst-case) weather conditions. The consequences are the same as those described under the Regionalization by Geography alternative. Table I-51 summarizes the doses and health effects from the maximum reasonably foreseeable consequence assessment.

Centralization at Savannah River Site. Under this alternative, SNF currently stored at other DOE sites, Fort St. Vrain, university, foreign, and non-DOE research reactors is eventually transported to the Savannah River Site. The analysis evaluates impacts assuming either all shipments by truck or all shipments by rail.

The cumulative accident risk for transportation by truck was calculated to be 0.00075 latent cancer fatality and 0.41 traffic fatality. The cumulative accident risk measures the total impact of transportation accidents over the entire shipment campaign (1995 to 2035). The cumulative accident risk for transportation by rail was calculated to be 0.00012 latent cancer fatality and 0.21 traffic fatality. Table I-52 summarizes the transportation accident risks for the Centralization at Savannah River Site alternative.

As in the 1992/1993 Planning Basis and Regionalization alternatives, the maximum reasonably foreseeable transportation accident involves a rail shipment of special case commercial

Table I-48. SNF transportation accident risks for the Centralization at the Hanford Site alternative (1995 to 2035).

Transport mode	Dose risk (person-rem)	Latent Cancer fatalities[a]	Traffic fatalities[b]
Truck	0.62	0.00031	0.26
Rail	0.14	7.0×10^{-5}	0.21

a. Estimated number of latent fatal cancers as a result of radiation dose from transportation accidents.

b. Estimated number of fatalities from nonradiological effect of transportation accident, for example, physical impact.

Table I-49. Health effects from maximum reasonably foreseeable offsite SNF transportation accident under the Centralization at the Hanford Site alternative (1995 to 2035).

Alternative: Centralization at the Hanford Site
Maximum reasonably foreseeable accident: Special case commercial SNF shipment by rail
Population zone: Suburban (neutral) and Rural (stable)[a]
Maximum reasonably foreseeable accident probability: 4.5×10^{-7} per year with neutral meteorology, 3.3×10^{-7} per year with stable meteorology

Doses and health effects	Transport mode	Population[a]		Maximum exposed individual	
		Neutral[b]	Stable[c]	Neutral[b]	Stable[c]
Dose	Rail	13,000 person-rem	3,500 person-rem	54 rem	180 rem
Latent cancer fatalities[d]	Rail	7	2	0.027	0.09

a. The maximum reasonably foreseeable accident occurs in a suburban population zone under neutral weather conditions. The accident probability is less than 1×10^{-7} per year under stable weather conditions, except in a rural population zone. For urban population zones, the accident probability is less that 1×10^{-7} per year for both neutral and stable weather conditions.

b. Neutral meteorological conditions occur greater than 50 percent of the time.

c. Stable meteorological conditions occur less than 5 percent of the time and result in less atmospheric dispersion of radioactivity released to the atmosphere.

d. Results expressed as the estimated number of latent fatal cancers expected in the impacted population as a result of the radiation dose; for the maximally exposed individual, results express the probability of contracting fatal cancer as a result of the radiation dose. Fatal cancer risk factor: 5×10^{-4} fatal cancers per person-rem (ICRP 1991).

Table I-50. SNF transportation accident risks for the Centralization at the Idaho National Engineering Laboratory alternative (1995 to 2035).

Transport mode	Dose risk (person-rem)	Latent Cancer fatalities[a]	Traffic fatalities[b]
Truck	0.54	0.00027	0.22
Rail	0.11	5.5×10^{-5}	0.18

a. Estimated number of latent fatal cancers as a result of radiation dose from transportation accidents.

b. Estimated number of fatalities from nonradiological effect of transportation accident, for example, physical impact.

Table I-51. Health effects from maximum reasonably foreseeable offsite SNF transportation accident under the Centralization at the Idaho National Engineering Laboratory alternative (1995 to 2035).

Alternative: Centralization at the Idaho National Engineering Laboratory
Maximum reasonably foreseeable accident: Special case commercial SNF shipment by rail
Population zone: Suburban (neutral) and rural (stable)[a]
Maximum reasonably foreseeable accident probability: 4.2×10^{-7} per year with neutral meteorology, 3.1×10^{-7} per year with stable meteorology

Doses and health effects	Transport mode	Population[a]		Maximum exposed individual	
		Neutral[b]	Stable[c]	Neutral[b]	Stable[c]
Dose	Rail	13,000 person-rem	3,500 person-rem	54 rem	180 rem
Latent cancer facilities[d]	Rail	7	2	0.027	0.09

a. The maximum reasonably foreseeable accident occurs in a suburban population zone under neutral weather conditions. The accident probability is less than 1×10^{-7} per year under stable weather conditions, except in a rural population zone. For urban population zones, the accident probability is less that 1×10^{-7} per year for both neutral and stable weather conditions.

b. Neutral meteorological conditions occur greater than 50 percent of the time.

c. Stable meteorological conditions occur less than 5 percent of the time and result in less atmospheric dispersion of radioactivity released to the atmosphere.

d. Results expressed as the estimated number of latent fatal cancers expected in the impacted population as a result of the radiation dose; for the maximally exposed individual, results express the probability of contracting fatal cancer as a result of the radiation dose. Fatal cancer risk factor: 5×10^{-4} fatal cancers per person-rem (ICRP 1991).

SNF. The maximum reasonably foreseeable accident under neutral (normal) weather conditions occurs in an urban population zone and has a probability of occurrence of about 1.6×10^{-7} per year. A total population dose of 72,000 person-rem was estimated (average dose of 27 millirem per person), which could result in an estimated 36 latent cancer fatalities. For comparison, the same population would be expected to experience about 540,000 latent cancer fatalities from other causes.

The maximum reasonably foreseeable accident under stable (worst-case) weather conditions occurs in a suburban population zone and has a probability of occurring of about 1.1×10^{-7} per year. A total population dose of 110,000 person-rem was estimated (average dose of 0.53 rem per person), which could result in an estimated 55 latent cancer fatalities. For comparison, the same population would be expected to experience about 42,000 latent cancer fatalities from other causes.

Table I-53 summarizes the doses and health effects from the maximum reasonably foreseeable consequence assessment.

Centralization at Oak Ridge Reservation. Under this alternative, SNF currently stored at other DOE sites, Fort St. Vrain, university, foreign, and non-DOE research reactors is eventually transported to the Oak Ridge Reservation. The analysis evaluates impacts assuming either all shipments by truck or all shipments by rail.

The cumulative accident risk for transportation by truck was calculated to be 0.0006 latent cancer fatality and 0.37 traffic fatality. The cumulative accident risk measures the total impact of transportation accidents over the entire shipment campaign (1995 to 2035). The cumulative accident risk for transportation by rail was calculated to be 7.5×10^{-5} latent cancer fatality and 0.19 traffic fatality. Table I-54 summarizes the transportation accident risks for the Centralization at Oak Ridge Reservation alternative.

As in the 1992/1993 Planning Basis and Regionalization alternatives, the maximum reasonably foreseeable transportation accident involves a rail shipment of special case commercial SNF. The maximum reasonably foreseeable accident under neutral (normal) weather conditions occurs in an urban population zone and has a probability of occurring of about 1.0×10^{-7} per year. The accident consequences are the same as those described for the urban zone accident under the Centralization at Savannah River Site alternative.

The maximum reasonably foreseeable accident under stable (worst-case) weather conditions occurs in a rural population zone and has a probability of occurring of about 5.5×10^{-7} per year. The accident consequences are the same as those described for the rural zone accident under the Regionalization by Geography alternative.

Table I-52. SNF transportation accident risks for the Centralization at the Savannah River Site alternative (1995 to 2035).

Transport mode	Dose Risk (person-rem)	Latent Cancer fatalities[a]	Traffic fatalities[b]
Truck	1.5	0.00075	0.41
Rail	0.23	0.00012	0.21

a. Estimated number of latent fatal cancers as a result of radiation dose from transportation accidents.

b. Estimated number of fatalities from nonradiological effect of transportation accident, for example, physical impact.

Table I-53. Health effects from maximum reasonably foreseeable offsite SNF transportation accident under the Centralization at the Savannah River Site alternative (1995 to 2035).

Alternative: Centralization at the Savannah River Site
Maximum reasonably foreseeable accident: Special case commercial SNF shipment by rail
Population zone: Urban (neutral) and Suburban (stable)[a]
Maximum reasonably foreseeable accident probability: 1.6×10^{-7} per year with neutral meteorology, 1.1×10^{-7} per year with stable meteorology

Doses and health effects	Transport mode	Population[a]		Maximum exposed individual	
		Neutral[b]	Stable[c]	Neutral[b]	Stable[c]
Dose	Rail	72,000 person-rem	110,000 person-rem	54 rem	180 rem
Latent cancer fatalities[d]	Rail	36	55	0.027	0.09

a. The maximum reasonably foreseeable accident occurs in an urban population zone under neutral weather conditions. The probability of the accident in an urban zone under stable weather conditions is less than 1×10^{-7} per year. The maximum reasonably foreseeable accident for stable weather conditions occurs in a suburban population zone.

b. Neutral meteorological conditions occur greater than 50 percent of the time.

c. Stable meteorological conditions occur less than 5 percent of the time and result in less atmospheric dispersion of radioactivity released to the atmosphere.

d. Results expressed as the estimated number of latent fatal cancers expected in the impacted population as a result of the radiation dose; for the maximally exposed individual, results express the probability of contracting fatal cancer as a result of the radiation dose. Fatal cancer risk factor: 5×10^{-4} fatal cancers per person-rem (ICRP 1991).

Table I-55 summarizes the doses and health effects from the maximum reasonably foreseeable consequence assessment.

Centralization at Nevada Test Site. Under this alternative, SNF currently stored at ther DOE sites, Fort St. Vrain, university, foreign, and non-DOE research reactors is eventually transported to the Nevada Test Site. The analysis evaluates impacts assuming either all shipments by truck or all shipments by rail.

The cumulative accident risk for transportation by truck was calculated to be 0.00045 latent cancer fatality and 0.33 traffic fatality. The cumulative accident risk measures the total impact of transportation accidents over the entire shipment campaign (1995 to 2035). The cumulative accident risk for transportation by rail was calculated to be 6.5×10^{-5} latent cancer fatality and 0.25 traffic fatality. Table I-56 summarizes the transportation accident risks for the Centralization at Nevada Test Site alternative.

As in the 1992/1993 Planning Basis and Regionalization alternatives, the maximum reasonably foreseeable transportation accident involves a rail shipment of special case commercial SNF. The accident has a probability of occurring of about 4.8×10^{-7} per year under neutral (normal) weather conditions in a suburban population zone and about 4.7×10^{-7} per year under stable (worst-case) weather conditions in a rural population zone. The consequences are the same as those described under the Regionalization by Geography alternative. Table I-57 summarizes the doses and health effects from the maximum reasonably foreseeable consequence assessment.

Table I-54. SNF transportation accident risks for the Centralization at the Oak Ridge Reservation alternative (1995 to 2035).

Transport mode	Dose Risk (person-rem)	Latent Cancer fatalities[a]	Traffic fatalities[b]
Truck	1.2	0.0006	0.37
Rail	0.15	7.5×10^{-5}	0.19

a. Estimated number of latent fatal cancers as a result of radiation dose from transportation accidents.

b. Estimated number of fatalities from nonradiological effect of transportation accident, for example, physical impact.

Table I-55. Health effects from maximum reasonably foreseeable offsite SNF transportation accident under the Centralization at the Oak Ridge Reservation alternative (1995 to 2035).

Alternative: Centralization at the Oak Ridge Reservation
Maximum reasonably foreseeable accident: Special case commercial SNF shipment by rail
Population zone: Urban (neutral) and rural (stable)[a]
Maximum reasonably foreseeable accident probability: 1.0×10^{-7} per year with neutral meteorology, 5.5×10^{-7} per year with stable meteorology

Doses and health effects	Transport mode	Population[a]		Maximum exposed individual	
		Neutral[b]	Stable[c]	Neutral[b]	Stable[c]
Dose	Rail	72,000 person-rem	3,500 person-rem	54 rem	180 rem
Latent cancer fatalities[d]	Rail	36	2	0.027	0.09

a. The maximum reasonably foreseeable accident occurs in an urban population zone under neutral weather conditions. The accident probability under stable weather conditions is less than 1×10^{-7} per year, except in a rural population zone.

b. Neutral meteorological conditions occur greater than 50 percent of the time.

c. Stable meteorological conditions occur less than 5 percent of the time and result in less atmospheric dispersion of radioactivity released to the atmosphere.

d. Results expressed as the estimated number of latent fatal cancers expected in the impacted population as a result of the radiation dose; for the maximally exposed individual, results express the probability of contracting fatal cancer as a result of the radiation dose. Fatal cancer risk factor: 5×10^{-4} fatal cancers per person-rem (ICRP 1991).

Table I-56. SNF transportation accident risks for the Centralization at the Nevada Test Site alternative (1995 to 2035).

Transport mode	Dose Risk (person-rem)	Latent Cancer fatalities[a]	Nonradiological fatalities[b]
Truck	0.9	0.00045	0.33
Rail	0.13	6.5×10^{-5}	0.25

a. Estimated number of latent fatal cancers as a result of radiation dose from transportation accidents.

b. Estimated number of fatalities from nonradiological effect of transportation accident, for example, physical impact.

Table I-57. Health effects from maximum reasonably foreseeable offsite SNF transportation accident under the Centralization at the Nevada Test Site alternative (1995 to 2035).

Alternative: Centralization at the Nevada Test Site
Maximum reasonably foreseeable accident: Special case commercial SNF shipment by rail
Population zone: Suburban (neutral) and Rural (stable)[a]
Maximum reasonably foreseeable accident probability: 4.8×10^{-7} per year with neutral meteorology, 4.7×10^{-7} per year with stable meteorology

Doses and health effects	Transport mode	Population[a]		Maximum exposed individual	
		Neutral[b]	Stable[c]	Neutral[b]	Stable[c]
Dose	Rail	13,000 person-rem	3,500 person-rem	54 rem	180 rem
Latent cancer fatalities[d]	Rail	7	2	0.027	0.09

a. The maximum reasonably foreseeable accident occurs in a suburban population zone under neutral weather conditions. The accident probability is less than 1×10^{-7} per year under stable weather conditions, except in a rural population zone. For urban population zones, the accident probability is less that 1×10^{-7} per year for both neutral and stable weather conditions.

b. Neutral meteorological conditions occur greater than 50 percent of the time.

c. Stable meteorological conditions occur less than 5 percent of the time and result in less atmospheric dispersion of radioactivity released to the atmosphere.

d. Results expressed as the estimated number of latent fatal cancers expected in the impacted population as a result of the radiation dose; for the maximally exposed individual, results express the probability of contracting fatal cancer as a result of the radiation dose. Fatal cancer risk factor: 5×10^{-4} fatal cancers per person-rem (ICRP 1991).

I-6 MITIGATION OF IMPACTS

The impacts of transportation associated with the alternatives may be mitigated in a number of different ways. For example, the routes used for truck shipments may be chosen using U.S. Department of Transportation routing guidelines. These guidelines are designed to reduce the radiological impacts associated with transportation. The guidelines consider as primary factors (a) the radiation exposure from incident-free transport, (b) the risk to general population from an accidental release of radioactive material, and (c) the economic risk from an accidental release of radioactive material. The guidelines consider as secondary factors (a) emergency response effectiveness, (b) evacuation capabilities, (c) location of special facilities such as schools or hospitals, and (d) traffic fatalities and injuries unrelated to the radioactive nature of the cargo.

Potential mitigation is also provided through the use of approved shipment containers. For shipments containing large amounts of radioactivity, such as SNF, Type B containers will be used. These containers are designed to withstand normal transport conditions and hypothetical accident conditions.

If an accident did occur, Federal, state, local, and Tribal authorities are trained in emergency response. For example, the Shoshone-Bannock Tribes, the State of Idaho, Bingham County, Bingham Memorial Hospital, Bannock Regional Medical Center, Pocatello Regional Medical Center, Idaho Power Company, Intermountain Gas Company, and the U.S. Department of Energy participated in a comprehensive, cooperative Transportation Accident Exercise held in Idaho in 1992 (TRANSAX '92).

The U.S. Environmental Protection Agency has developed protective action guides (EPA 1991) and protective actions that are designed to limit doses in the event of a nuclear incident. Use of these guides and actions also mitigates the impacts of transportation accidents involving radioactive material.

I-7 IMPACTS OF USING ALTERNATE PORTS OF ENTRY FOR FOREIGN RESEARCH REACTOR SPENT NUCLEAR FUEL SHIPMENTS

DOE (1994) proposed five ports of entry for urgent-relief acceptance of foreign research reactor SNF: (a) Sunny Point, North Carolina; (b) Wilmington, North Carolina; (c) Jacksonville, Florida; (d) Charleston, South Carolina; and (e) Savannah, Georgia. Charleston, South Carolina; Savannah, Georgia; Hampton Roads, Virginia; Seattle-Tacoma, Washington; Portland, Oregon; and Oakland, California were identified in the Implementation Plan for this EIS and were analyzed in this appendix. This section evaluates the impacts of using Sunny Point, North Carolina; Wilmington, North Carolina; and Jacksonville, Florida, as alternate ports of entry for foreign research reactor SNF.

If Sunny Point, North Carolina, were used as a port of entry instead of the six ports identified in the Implementation Plan, the incident-free collective dose and the accident dose risk for foreign research reactor SNF shipments would increase by approximately 5 percent for truck shipments to the Idaho National Engineering Laboratory, Hanford Site, or Nevada Test Site. For truck shipments to the Savannah River Site, the incident-free collective dose and accident dose risk would decrease by approximately 16 percent. For truck shipments to the Oak Ridge Reservation, the incident-free collective dose and accident dose risk would increase by approximately 2 percent.

For rail shipments from Sunny Point, North Carolina, the incident-free collective dose and accident dose risk for foreign research reactor SNF shipments would increase by approximately 2 percent for shipments to the Idaho National Engineering Laboratory, Hanford Site, or Nevada Test Site. For rail shipments to the Savannah River Site, the incident-free collective dose and accident dose risk would decrease by approximately 24 percent. For rail shipments to the Oak Ridge Reservation, the incident-free collective dose and accident dose risk would increase by approximately 4 percent.

If Wilmington, North Carolina, were used as a port of entry instead of the six ports identified in the Implementation Plan, the incident-free collective dose and the accident dose risk for foreign research reactor SNF shipments would increase by approximately 4 percent for truck shipments to the Idaho National Engineering Laboratory, the Hanford Site, or the Nevada Test Site. For truck shipments to the Savannah River Site, the incident-free collective dose and accident dose risk would decrease by approximately 22 percent. For truck shipments to the Oak Ridge Reservation, the incident-free collective dose and accident dose risk would decrease by approximately 4 percent.

For rail shipments from Wilmington, North Carolina, the incident-free collective dose and accident dose risk for foreign research reactor SNF shipments would increase by less than

1 percent for shipments to the Idaho National Engineering Laboratory, Hanford Site, or Nevada Test Site. For rail shipments to the Savannah River Site, the incident-free collective dose and accident dose risk would decrease by approximately 30 percent. For rail shipments to the Oak Ridge Reservation, the incident-free collective dose and accident dose risk would decrease by less than 1 percent.

If Jacksonville, Florida, were used as a port of entry instead of the six ports identified in the Implementation Plan, the incident-free collective dose and the accident dose risk for foreign research reactor SNF shipments would increase by less than 1 percent for truck shipments to the Idaho National Engineering Laboratory, Hanford Site, or Nevada Test Site. For truck shipments to the Savannah River Site, the incident-free collective dose and accident dose risk would decrease by approximately 21 percent. For truck shipments to the Oak Ridge Reservation, the incident-free collective dose and accident dose risk would increase by less than 1 percent.

For rail shipments from Jacksonville, Florida, the incident-free collective dose and accident dose risk for foreign research reactor SNF shipments would decrease by approximately 7 percent for shipments to the Idaho National Engineering Laboratory, Hanford Site, or Nevada Test Site. For rail shipments to the Savannah River Site, the incident-free collective dose and accident dose risk would decrease by approximately 51 percent. For rail shipments to the Oak Ridge Reservation, the incident-free collective dose and accident dose risk would decrease by approximately 19 percent.

I-8 HISTORICAL SPENT NUCLEAR FUEL TRANSPORTATION ACCIDENTS

Transportation incidents for 1949 through 1970 were surveyed using summary reports prepared by the U.S. Atomic Energy Agency (AEC 1957, Patterson and DeFatta 1962, Patterson and Mehn 1963, AEC 1966, McCluggage 1971). In these summary reports, incidents are classified into six classes based on the extent of radioactive material release (Patterson and DeFatta 1962) and accidents and incidents are not differentiated. For 1949 through 1970, there were 14 incidents involving irradiated fuel elements. No packages approximating a Type B shipping cask were breached as a result of these incidents (McCluggage 1971). Two representative incidents are summarized below.

On November 15, 1960, a tractor-trailer carrying 7 steel-jacketed lead casks containing 25 irradiated fuel elements was involved in an accident with a station wagon. The station wagon was completely demolished and the driver killed. The tractor was badly damaged and the driver suffered a broken hand and abrasions. The irradiated fuel elements were undisturbed. This incident was classified as a Class I radiation release, which means that no radioactive material was released and there was no loss of integrity to the package.

In another case (June 2-6, 1960), leakage of contaminated cooling water from a rail shipment consisting of irradiated fuel elements and some ruptured elements in aluminum cans resulted in contamination of three railroad yards. This incident was classified as a Class IV radiation release, which means that radioactive material was released to the ground or trafficway with no runoff or aerial dispersion. There were no injuries associated with this incident.

Spent nuclear fuel transportation accidents for 1971 through 1993 were surveyed based on data in the Radioactive Materials Incident Report database. This database contains information on radioactive materials transportation incidents and accidents from the U.S. Department of Transportation, U.S. Nuclear Regulatory Commission, U.S. Department of Energy, state radiation control offices, and media coverage of radioactive materials transportation incidents and accidents (Cashwell and McClure 1992). The Radioactive Materials Incident Report database contains information on transportation accidents, handling accidents, and reported incidents; this discussion is limited to transportation accidents involving SNF.

Between 1971 and 1993, there were seven transportation accidents involving SNF. Three of these accidents involved rail shipments and four of these accidents involved truck shipments. These accidents were summarized in Cashwell and McClure (1992). Only one of these accidents resulted in more than minor damage to the SNF cask. On December 8, 1971, a truck transporting a SNF element in a Type B shipping cask on U.S. Highway 25 in Tennessee swerved to avoid a head-on collision with another vehicle and was forced off the road. The driver of the truck was killed by the impact and the SNF cask was thrown into a ditch. The U.S. Department

of Energy Radiological Assistance Team from Oak Ridge, Tennessee, arrived and surveys indicated that the structural integrity of the cask was intact and there was no release of contents.

I-9 CUMULATIVE IMPACTS OF TRANSPORTATION

I-9.1 Radiological Impacts

The cumulative impacts of the transportation of SNF consist of impacts from (a) historical shipments of SNF to the Hanford Site, Savannah River Site, Idaho National Engineering Laboratory, Oak Ridge Reservation, and the Nevada Test Site; (b) the alternatives evaluated in this EIS, (c) other reasonably foreseeable actions that include transportation of radioactive material, and (d) general radioactive materials transportation that is not related to a particular action. The discussion of cumulative transportation impacts concentrates on the cumulative impacts of offsite transportation, because offsite transportation yields potential doses to a greater portion of the general population than does onsite transportation. The collective dose to the general population and workers is the measure used to quantify cumulative transportation impacts. This measure of impact was chosen because it can be directly related to latent cancer fatalities using a cancer risk coefficient and because of the difficulty in identifying a maximally exposed individual for shipments throughout the United States spanning the period 1943 through 2035 (93 years).

Collective doses from historical shipments of SNF to the Hanford Site, Savannah River Site, Oak Ridge Reservation, and the Nevada Test Site were summarized in Jones and Maheras (1994a, 1994b, 1994c, 1994d). Data for these shipments were available for 1971 through 1993 and were linearly extrapolated back to the start of operations at each site, because data before 1971 were not available. For the Hanford Site and Oak Ridge Reservation, the start of operations was 1943; for the Savannah River Site, the start of operations was 1953; and for the Nevada Test Site, the start of operations was 1951. The results of these analyses are summarized in Table I-58.

The historical shipments of SNF to the Idaho National Engineering Laboratory consisted of shipments of Naval SNF and test specimens from 1957 through 1995 (see Attachment A to Appendix D of Volume 1 of this EIS). Extrapolation of Naval shipments was not necessary because a detailed records search accounted for all shipments. Historical SNF also consisted of shipments of other DOE SNF to the Idaho National Engineering Laboratory besides Naval shipments, such as research reactor SNF and special case commercial SNF (Maheras 1994d). Data for these shipments were available for 1973 through 1993 and were linearly extrapolated back to 1953, the start of operations at the Idaho Chemical Processing Plant, because data for 1953 through 1972 were not available. The results of these analyses are also summarized in Table I-58.

There are considerable uncertainties in these historical estimates of collective dose. For example, the population densities and transportation routes used in the dose assessments were based on census data for 1990 and the United States highway and rail system as it existed in 1993.

Table I-58. Cumulative transportation-related radiological collective doses and latent cancer fatalities (1943 to 2035).

Category	Collective occupational dose (person-rem)	Collective general population dose (person-rem)
Historical spent nuclear fuel		
Hanford Site (1943 to 1993)	52	27
Savannah River Site (1953 to 1993)	50	29
Idaho National Engineering Laboratory (1953 to 1993)		
DOE spent nuclear fuel	56	30
Naval spent nuclear fuel	6.0	1.6
Oak Ridge Reservation (1943 to 1993)	35	18
Nevada Test Site[a] (1951 to 1993)	1.4	0.70
Spent nuclear fuel shipments for Alternatives 1-5		
Naval[b]	1.5 to 15	0.34 to 12
DOE truck (100%)[c] (1995 to 2035)	0.0 to 980	0.0 to 2,200
DOE train (100%)[c] (1995 to 2035)	0.0 to 120	0.0 to 170
Reasonably foreseeable actions		
Geologic repository[c,d]		
Truck (100%)	8,600	48,000
Train (100%)	750	740
Waste Isolation Pilot Plant[e]		
Test phase (100% truck)	110	48
Disposal phase		
Truck (100%)	1,800	1,500
Train (maximum)[f]	68	940
Submarine reactor compartment disposal[g]	--	0.053
Foreign research reactor[h] spent nuclear fuel	0.16	0.0017
General transportation		
1943 to 1982	220,000	170,000
1983 to 2035	89,000	98,000

Table I-58. (continued).

Category	Collective occupational dose (person-rem)	Collective general population dose (person-rem)
Summary		
Historical	200	110
Spent nuclear fuel shipments for Alternatives 1-5		
Truck	1.5 to 980	0.34 to 2,200
Train	1.5 to 120	0.34 to 170
Reasonably foreseeable actions		
Truck	11,000	50,000
Train	820	1700
General transportation (1943 to 2035)	310,000	270,000
Total collective dose	320,000	320,000
Total latent cancer fatalities	130	160

a. Shipments from Turkey Point Power Plant in Florida to the Engine Maintenance, Assembly, and Disassembly Facility at the Nevada Test Site.

b. Naval SNF and test specimen shipments based on a combination of truck and rail transport.

c. Shipments based on 100 percent transport by truck or 100 percent transport by rail.

d. Reference: DOE (1986)

e. Reference: DOE (1990)

f. The maximum rail case is based on rail transport where rail access is available and truck transport where rail access is not available.

g. Reference: USN (1984)

h. Reference: DOE (1994). The shipments for this action are limited to a maximum of 15.

Using census data for 1990 overestimates historical collective doses because the United States population has continuously increased over the time covered in these assessments. Basing collective dose estimates on the United States highway and rail system as it existed in 1993 may slightly underestimate doses for shipments that occurred in the 1940s, 1950s, and 1960s, because a larger portion of the transport routes would have been on non-interstate highways where the population may have been slightly closer to the road. Data were not available that correlated transportation routes and population densities for the 1940s, 1950s, 1960s, and 1970s; therefore, it was necessary to use more recent data to make dose estimates. By the 1970s, the structure of the interstate highway system was largely fixed and most shipments would have been made on interstates.

Shipment data were linearly extrapolated for years when data were unavailable, which also results in uncertainty. However, this technique was validated by linearly extrapolating the data in SAIC (1991) for 1973 through 1989 to estimate the number of shipments that took place during the time period 1964 through 1972 (also contained in SAIC 1991). The 1973 through 1989 time period corresponded to the time period when data were available for the Idaho Chemical Processing Plant. The data in SAIC (1991) could not be used directly because only shipment counts are presented for 1964 through 1982 and no origins or destinations were listed for years before 1983. Based on the data in SAIC (1991), linearly extrapolating the data for 1973 through 1989 overestimates the shipments for 1964 through 1972 by 20 percent when compared to the actual shipment counts for 1964 through 1972.

Collective doses for SNF shipments associated with Alternatives 1 through 5 were summarized previously in this appendix and in Appendix D of this EIS (for Naval spent nuclear fuel). For truck shipments, the collective dose to workers ranged from 1.5 person-rem (the No Action Alternative) to 980 person-rem (Centralization at Savannah River), or 0.00060 to 0.39 latent cancer fatalities. Collective dose to the general population ranged from 0.34 person-rem (the No Action Alternative) to 2,200 person-rem (Centralization at Savannah River), or 0.00017 to 1.1 latent cancer fatalities. These doses and latent cancer fatalities include shipments of Naval SNF and test specimens.

For train shipments, the collective dose to workers ranged from 1.5 person-rem (the No Action Alternative) to 120 person-rem (Centralization at Nevada Test Site), or 0.00060 to 0.048 latent cancer fatalities. Collective dose to the general population ranged from 0.34 person-rem (the No Action Alternative) to 170 person-rem (Centralization at Savannah River), or 0.00017 to 0.085 latent cancer fatalities. These doses and latent cancer fatalities include shipments of Naval SNF and test specimens.

Transportation impacts may also result from reasonably foreseeable projects. Two major proposed projects that involve extensive transportation of radioactive material are: (a) shipments of SNF and defense high-level waste to a geologic repository, and (b) shipments of transuranic

waste to the Waste Isolation Pilot Plant, located in Carlsbad, New Mexico. The U.S. Department of Energy is presently determining the suitability of Yucca Mountain, Nevada as a site for a geologic repository for commercial SNF and defense high-level waste; therefore, the geologic repository was assumed to be located in Yucca Mountain, Nevada for the transportation cumulative impacts analysis.

Based on the transportation dose assessments presented in DOE (1986), the worker collective dose for truck shipments to a repository was 8,600 person-rem or 3.4 latent cancer fatalities. The collective dose to the general population from truck shipments to a repository was 48,000 person-rem or 24 latent cancer fatalities. The worker collective dose for train shipments to a repository was 750 person-rem or 0.30 latent cancer fatalities. The collective dose to the general population from train shipments to a repository was 740 person-rem or 0.37 latent cancer fatalities.

Based on the transportation dose assessments presented in DOE (1990), the worker collective dose from truck shipments to the Waste Isolation Pilot Plant was 1,900 person-rem or 0.76 latent cancer fatalities. The collective dose to the general population from truck shipments to the Waste Isolation Pilot Plant was 1,500 person-rem or 0.75 latent cancer fatalities. The worker collective dose from train shipments to the Waste Isolation Pilot Plant was 180 person-rem or 0.072 latent cancer fatalities. The collective dose to the general population from train shipments to the Waste Isolation Pilot Plant was 990 person-rem or 0.50 latent cancer fatalities. These collective doses include the 5-year Test Phase and the 20-year Disposal Phase.

There are two other reasonably foreseeable projects that involve limited transportation of radioactive material: (a) 100 shipments of submarine reactor compartments from the Puget Sound Naval Shipyard to the Hanford Site for burial, and (b) 15 shipments of foreign research reactor SNF from Sunny Point, North Carolina, to the Savannah River Site. The shipment of submarine reactor compartments is an ongoing activity that is not yet completed; therefore, it was categorized as a reasonably foreseeable action. Based on the transportation dose assessment presented in USN (1984), the shipment of submarine reactor compartments was estimated to result in a collective dose of 0.053 person-rem for the general population. Based on the transportation dose assessment presented in DOE (1994), the 15 shipments of foreign research reactor SNF were estimated to result in a collective dose of 0.0017 person-rem to the general population and 0.16 person-rem to workers.

There are also general transportation activities that take place that are unrelated to the alternatives evaluated in this EIS or to reasonably foreseeable actions. Examples of these activities are shipments of radiopharmaceuticals to nuclear medicine laboratories and shipments of commercial low-level radioactive waste to commercial disposal facilities. The U.S. Nuclear Regulatory Commission evaluated these types of shipments based on a survey of radioactive

materials transportation published in 1975 (NRC 1977). Categories of radioactive material evaluated in NRC (1977) included: (a) limited quantity shipments, (b) medical, (c) industrial, (d) fuel cycle, and (e) waste.

The U.S. Nuclear Regulatory Commission estimated that the annual collective worker dose for these shipments was 5,600 person-rem or 2.2 latent cancer fatalities. The annual collective general population dose for these shipments was estimated to be 4,200 person-rem or 2.1 latent cancer fatalities. Because comprehensive transportation doses were not available, these collective dose estimates were used to estimate transportation collective doses for 1943 through 1982 (40 years). These dose estimates included SNF and radioactive waste shipments and truck and rail shipments.

Based on the transportation dose assessments in NRC (1977), the cumulative transportation collective doses for 1943 through 1982 were 220,000 person-rem for workers and 170,000 person-rem for the general population. These collective doses correspond to 88 latent cancer fatalities for workers and 85 latent cancer fatalities for the general population.

In 1983, another survey of radioactive materials transportation in the United States was conducted (Javitz et al. 1985). This survey included U.S. Nuclear Regulatory Commission and Agreement State licensees and the U.S. Department of Energy. Both SNF and radioactive waste shipments were included in the survey. Weiner et al. (1991a and 1991b) used the survey by Javitz et al. (1985) to estimate collective doses from general transportation. The transportation dose assessments in Weiner et al. (1991a and 1991b) were used to estimate transportation doses for 1983 through 2035 (53 years). The interval 1995 through 2035 corresponds to the interval of time associated with the spent nuclear fuel management activities evaluated in this EIS.

Weiner et al. (1991a) evaluated eight categories of radioactive material shipments by truck: (a) industrial, (b) radiography, (c) medical, (d) fuel cycle, (e) research and development, (f) unknown, (g) waste, and (h) other. Based on a median external exposure rate, an annual collective worker dose of 1,400 person-rem and an annual collective general population dose of 1,400 person-rem were estimated. These collective doses correspond to 0.56 and 0.70 latent cancer fatalities per year for workers and the general population, respectively. Over the 53-year time period from 1983 through 2035, the collective worker and general population doses would be 74,000 person-rem or 30 and 37 latent cancer fatalities for workers and the general population, respectively.

Weiner et al. (1991b) also evaluated six categories of radioactive material shipments by plane: (a) industrial, (b) radiography, (c) medical, (d) research and development, (e) unknown, and (6) waste. Based on a median external exposure rate, an annual collective worker dose of 290 person-rem and an annual collective general population dose of 450 person-rem were estimated. These collective doses correspond to 0.12 and 0.23 latent cancer fatalities per year for

workers and the general population, respectively. Over the 53-year time period from 1983 through 2035, the collective worker dose would be 15,000 person-rem and the general population collective dose would be 24,000 person-rem or 6.0 and 12 latent cancer fatalities for workers and the general population, respectively.

Like the historical transportation dose assessments, the estimates of collective doses because of general transportation also exhibit considerable uncertainty. For example, data for 1975 were applied to general transportation activities from 1943 through 1982. This approach probably overestimates doses because the amount of radioactive material that was transported in the 1950s and 1960s was less than the amount shipped in the 1970s. For example, in 1968, the shipping rate for radioactive material packages was estimated to be 300,000 packages per year (Patterson 1968); in 1975 this rate was estimated to be 2,000,000 packages per year (NRC 1977). However, because comprehensive data that would enable a more realistic transportation dose assessment are not available, the dose estimates developed by the U.S. Nuclear Regulatory Commission were used.

The total worker and general population collective doses are summarized in Table I-58. Total collective worker doses from all types of shipments (historical, the alternatives, reasonably foreseeable actions, and general transportation) were estimated to be 320,000 person-rem (130 latent cancer fatalities), for the period of time 1943 through 2035 (93 years). Total general population collective doses were also estimated to be 320,000 person-rem (160 latent cancer fatalities). The majority of the collective dose for workers and the general population was because of general transportation of radioactive material. The total number of latent cancer fatalities over the time period 1943 through 2035 was estimated to be 290. Over this same period of time (93 years), approximately 28,000,000 people would die from cancer, based on 300,000 latent cancer fatalities per year (NRC 1977). It should be noted that the estimated number of transportation-related latent cancer fatalities would be indistinguishable from other latent cancer fatalities, and the transportation-related latent cancer fatalities are 0.0010% of the total number of latent cancer fatalities.

I-9.2 Vehicular Accident Impacts

Fatalities involving the shipment of radioactive materials were surveyed for 1971 through 1993 using the Radioactive Material Incident Report database. For 1971 through 1993, 21 vehicular accidents involving 36 fatalities occurred. These fatalities resulted from vehicular accidents and were not associated with the radioactive nature of the cargo. No radiological fatalities because of transportation accidents have ever occurred in the United States. During the same period of time, over 1,000,000 persons were killed in vehicular accidents in the United States.

For Alternatives 1 through 5, 0.047 to 1.0 vehicular accident fatalities are estimated to occur. During the 40-year time period from 1995 through 2035, approximately 1,600,000 people would be killed in vehicular accidents in the United States.

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Appendix J
Spent Nuclear Fuel Management

This appendix describes a range of technologies potentially available for management of SNF and the status of each technology. The identified technologies support the SNF programmatic objective to define a management path and proceed toward ultimate disposition of all DOE spent fuel. Included are technologies for fuel preparation, for storage (stabilization) or, where appropriate, direct interim storage. The stabilization and direct storage technologies may also be applicable to ultimate disposition in some instances. The stabilization technologies selected for discussion range from the minimal to the extensive stabilization processing technologies that could be applied to prepare the SNF for extended interim storage or for ultimate disposition. In addition, programmatic and institutional factors, which are considerations in the selection of technology options for application, are discussed. Also presented is a brief description of the types of DOE SNF, particularly as their characteristics apply to the technology options.

J-1 BACKGROUND

During the last 40 years, DOE and its predecessor agencies have generated, transported, received, stored, and reprocessed SNF at facilities in the nationwide DOE complex. This SNF was generated from various sources, including DOE production reactors; the Naval Nuclear Propulsion Program reactors; DOE, university, and other research and test reactors; special-case commercial power reactors; and foreign research reactors. Production reactors were constructed and operated at the Hanford and Savannah River Sites to provide special nuclear material and other radioactive isotopes for the DOE's defense programs. These production reactors are no longer operated. Naval Nuclear Propulsion Program reactors and some test and research reactors are still operating. DOE has reprocessed SNF at the Idaho National Engineering Laboratory, Hanford Site, and Savannah River Site to recover fissile materials (uranium-235 and plutonium-239) and other valuable radionuclides.

More than 100,000 metric tons of heavy metal (MTHM) of SNF was produced by DOE and predecessor agencies since 1943. In the past, most of the SNF was chemically processed to recover the fissile materials, largely uranium-235 and plutonium-239, either for the national defense programs or reactor research and development.

With the end of the Cold War, DOE and the U.S. Department of Defense reevaluated the scale of their weapons production, nuclear propulsion, and research missions. Because of the lack of need for additional fissile materials, DOE decided in 1992 to phase out reprocessing for the recovery of fissile materials. Approximately 2,700 MTHM of SNF remains that has not been processed. Additionally, approximately 100 MTHM of DOE SNF is expected to be generated in

the next 40 years. This DOE SNF, which is in a wide range of enrichments and physical conditions, is stored at various locations in the United States and overseas. This material requires management until a decision regarding its ultimate disposition is reached.

Most of the existing fuel is currently stored in 10- to 40-year-old water pools (designed for temporary storage of SNF until it could be reprocessed) at several locations at the Hanford Site, Idaho National Engineering Laboratory, and Savannah River Site. Smaller quantities are stored at approximately 60 locations nationwide, including 55 non-DOE U.S. research reactor facilities. The vulnerabilities associated with the storage of SNF are identified in a recent DOE report to the Secretary of Energy entitled, *Spent Fuel Working Group Report on Inventory and Storage of the Department's Spent Nuclear Fuel and Other Reactor Irradiated Nuclear Materials and Their Environment, Safety, and Health Vulnerabilities* (DOE 1993). A DOE plan of action (Phases I and II) to address these vulnerabilities has been issued (DOE 1994a, 1994b). A final, Phase III plan of action is being prepared for public release in the fall of 1994.

J-2 SPENT NUCLEAR FUEL

Individual fuel elements and assemblies in nuclear reactors are constructed in many configurations, but they generally consist of the fuel matrix, cladding, and structural hardware. The fuel assemblies and structural hardware constitute the reactor core. Section 1.1.2 of Volume I presents a summary description of SNF.

The fuel matrix contains the fissile material (typically uranium as a metal, a metal alloy, or an oxide). For water-cooled reactors, the matrix form is typically plates or cylindrical pellets. Typically, for gas-cooled reactors, the matrix is particles, which are an oxide or carbide composite of the fuel material encapsulated by a ceramic coating.

Cladding materials surrounding the fuel matrix serve two principal functions:

1. Protection of the fuel matrix from corrosion by the fluid that removes heat from the reactor core

2. Containment of radioactive fission products generated within the fuel during reactor operation.

The degree and rate of cladding corrosion varies with reactor design.

The structural hardware serves both to support the fuel assemblies and to maintain a fixed geometry for the fissile materials in the reactor core. For example, structural materials fix the location of the fuel elements relative to one another in a fuel assembly and also fix the location of the fuel assemblies relative to one another in the reactor core. Structural hardware also provides mechanical support for the assemblies and the core, as well as providing defined paths for cooling of the core. These functions are essential to control the nuclear reactions in the reactor core and to ensure that adequate cooling is provided to all heat-generating regions of the reactor core.

The characteristics of the fuel elements in a reactor are tailored to the purpose of the reactor system. Two examples, important to SNF management, are discussed below. One example is for fuel with high-integrity cladding and the other is for fuel with lesser cladding integrity. Integrity refers to the corrosion resistance of the fuel to the reactor coolant and/or to its corrosion resistance in the environment in which it is stored.

- High-Integrity Fuels Used in Naval Reactors and Nuclear Power Plants. Naval fuels use highly enriched uranium, while nuclear power plant fuels generally use low-enrichment uranium. These types of reactors use water for cooling the fuel assemblies. The reactors are operated at high coolant temperatures and pressures.

The design objectives associated with commercial fuel and these reactor types are to maximize power output and minimize time spent refueling. For Naval reactors, other design objectives are also critical: ability to withstand battleshock, ability to preclude release of any fission products because operating personnel must live and work in close proximity to the reactor, and ability to change reactor power levels quickly so the ship can alter speed when needed. As a result, the cladding materials are selected to be very corrosion resistant at high temperatures. (A zirconium alloy is used.) Long-term fuel element integrity is emphasized. From the standpoint of SNF management, such fuel element designs are well-suited for direct storage of the SNF (either wet or dry) without additional stabilization. However, aggressive (concentrated) chemical and/or mechanical means are required to remove cladding if fuel processing is considered as an option for stabilization.

- Savannah River Production Reactor Fuels (and targets). The Savannah River Site production reactors also use water for cooling fuel assemblies. However, the reactors were operated at relatively low temperatures and essentially at atmospheric pressure. The design of these production reactor cores was optimized for production of special nuclear materials and other valuable radioactive isotopes. Fuel irradiation times were generally on the order of a few months. Fuel element cooling times prior to reprocessing were relatively short because the fuel elements were designed for special nuclear materials production and recovery. A high degree of corrosion resistance for the cladding was not part of the design. Aluminum cladding was selected so that the fuel elements could be dissolved for processing by less highly concentrated chemical solutions than for fuel with higher integrity cladding. Therefore this fuel type is not as suitable for direct storage as are the higher integrity fuels.

The DOE-owned SNF represents a broad spectrum of fuel element designs, both for the fuel matrix material and the cladding. To provide perspective, the characteristics of the principal types of DOE SNF are briefly discussed below. Inventories for the various types (current and projected), in units of MTHM, are summarized in Table J-1, along with a qualitative statement regarding fuel element enrichment and cladding integrity.

Category 1—Naval Fuel

This SNF type includes the fuel from the Naval Nuclear Propulsion Program, including fuel from submarines, surface vessels, and prototype reactors. Naval fuel is highly enriched and is

Table J-1. Spent nuclear fuel inventories and corrosion resistance.

SNF category	Reactor type	Existing inventory (MTHM)	Projected new SNF inventory for the next 40 years (MTHM)	Total projected inventory (MTHM)	Cladding corrosion resistance	Enrichment
1	Naval reactors	10	55	65	High	High
2	Production reactors, with aluminum-clad fuel; also aluminum-clad fuel from research and development reactors	190	18	210	Medium	High and low
3	Production reactors, zirconium-alloy-clad fuel	2100	0	2100	Medium to low	Low
4	High-temperature gas-cooled reactor fuel	28	0	28	High	High
5	Commercial research and development fuel	160	0	160	Variable	Variable
6a	Experimental, stainless-steel-clad fuel	110	12	120	Variable	Variable
6b	Experimental zirconium-alloy-clad fuel	77	0.1	77	Medium	Variable
6c	Miscellaneous fuel	0.04	0	0.04	--	--

clad with a zirconium alloy. This fuel design is structurally strong (able to withstand battleshock loads well in excess of 50 times the force of gravity); the cladding is highly corrosion-resistant (no release of fission products); and the fuel is designed to operate for more than 20 years.

Category 2—Aluminum-clad Production Reactor Fuel

The principal source of DOE aluminum-clad SNF was target and driver fuel for the Savannah River Site defense production reactors. The driver fuel is highly enriched aluminum-uranium alloy clad with aluminum. Most of the targets are depleted uranium metal (containing less uranium-235 than natural uranium), also clad with aluminum. Corrosion resistance of the cladding is moderate. Aluminum cladding is susceptible to corrosion when stored in water pools with poor water quality. With proper water quality, this fuel has been stored for more than 20 years without cladding corrosion problems. Also, this category is used for SNF from the Advanced Test Reactor at the Idaho National Engineering Laboratory, some domestic and foreign research reactors SNF, and some production reactor fuel at the Hanford Site.

Some of the fuel and targets have been in storage in water pools (with poor water quality) since 1989. Fuel is showing signs of corrosion and targets are heavily corroded.

Category 3—Zirconium-clad Production Reactor Fuel

All fuel in this category is from the Hanford Site N-Reactor. It consists of low-enriched uranium alloy fuel matrix, clad with a zirconium alloy. The fuel irradiation times were such that relatively large concentrations of plutonium were produced.

Some of the N-Reactor spent fuel has been in storage for a number of years and a number of fuel elements have holes in the cladding (breached), which permits corrosion of the fuel matrix. One result is contamination of the water in the storage pools at the Hanford Site. With respect to fuel with breached cladding, it is known that the irradiated metallic uranium can undergo reactions with water to produce uranium hydrides. The hydrided, irradiated uranium can be pyrophoric (subject to spontaneous burning) if it is permitted to dry out and is exposed to air (BNFL 1994). The potential pyrophoric nature of the fuel is an important consideration as management strategies for this fuel (including stabilization and transportation) are evaluated.

Category 4—High-temperature Gas-cooled Graphite Reactor Fuel

Graphite-matrix fuel was primarily used in two gas-cooled, commercial reactors: Fort St. Vrain and Peach Bottom. This type of fuel consists of small pellets of highly enriched uranium-carbide fuel surrounded by layers of pyrolytic carbon and by protective layers of other carbide compounds which serve as the primary cladding. The pellets are dispersed in much larger

graphite structures which provide neutron moderation and secondary containment. The fuel has high corrosion resistance when stored dry. However, the fuel is not amenable to wet storage.

Category 5—Commercial Reactor Research and Development Fuel

DOE has participated in numerous commercial reactor and spent fuel safety investigations. These activities have resulted in accumulations by DOE of spent fuel elements from a number of commercial reactors. Typically, this SNF consists of zirconium-alloy-clad, low-enriched uranium oxide fuels. Many of these elements were examined in DOE analytical facilities; others were used in test reactors to study fuel behavior in simulated accidents. The damaged core from the Three Mile Island-Unit 2 reactor was investigated extensively by DOE, under cooperative research and development agreements, at several DOE sites. This fuel is also included in this category.

Category 6—Test and Experimental Reactor Fuels

This is a category of fuels of broad description. The fuels range from low to high enrichment and encompass metal, metal alloy, and oxide fuel matrices. The fuel can be divided into three categories.

Category 6a—Stainless-steel-clad Fuels from Experimental Reactors

Uranium enrichments are generally high, but low-enrichment fuels are included as well. Fuel matrices consist of uranium-zirconium hydride, uranium dioxide, plutonium oxide, plutonium alloy, uranium carbide, uranium metal, and uranium alloys. The principal sources of fuel in this category are the Experimental Breeder Reactor-II, Zero Power Physics Reactor, Hanford Fast Flux Test Facility, and the blanket assemblies from the FERMI reactor.

Category 6b—Zirconium-alloy-clad Spent Nuclear Fuel from Experimental Reactors

Typically, fuel in this category has a uranium dioxide fuel matrix, but there is uranium-molybdenum alloy fuel also in this inventory. Enrichment can be either high or low. Most of this SNF originated at the Shippingport Power Reactor where the light water breeder reactor concept was tested. Some thorium and uranium-233 fuels are found in this category.

Category 6c—Miscellaneous Fuel

Fuel in this miscellaneous category is derived mainly from the Molten Salt Reactor Experiment at the Oak Ridge National Laboratory. That fuel is now stored in the salt storage tanks beneath the reactor.

J-3 SPENT NUCLEAR FUEL INTERIM MANAGEMENT OPTIONS

In 1992, the Secretary of Energy directed the Department to develop an integrated long-term SNF management program. The program is assessing DOE's current SNF inventory and SNF storage facilities, integrating DOE's many existing SNF activities into one program, developing an integrated decisionmaking and policy basis for SNF operations, and ensuring that all issues associated with SNF are resolved safely and cost-effectively.

Until ultimate disposition is determined, it is not possible to define the SNF characteristics suitable for ultimate disposition. Pending selection of an ultimate disposition, SNF must be maintained in safe storage. Solutions to the storage questions may require changes in management strategies for these fuels, including such options as the construction of new facilities and stabilization of certain fuels.

Technologies for SNF management are required to ensure safe, environmentally sound, and economic management until ultimate disposition is implemented. There are a number of technology options available for accomplishing these objectives. Key design factors to be considered include the fuel design, the structural integrity of the fuel, the degree of corrosion of the cladding, fuel enrichment, and the chemical stability of the cladding and the fuel matrix. The principal technology option categories for storage are outlined in a general way on a flow chart, Figure J-1.

The options for SNF management include direct storage (high-integrity fuels) or SNF stabilization in preparation for continued storage. Technologies included under SNF stabilization are containerization, processing without separation of fissile materials, and processing in which there is separation of the fissile material. The status of technologies for each of the approaches will be discussed in Section J-4. Related institutional factors associated with implementing the various management approaches will be discussed in Section J-5.

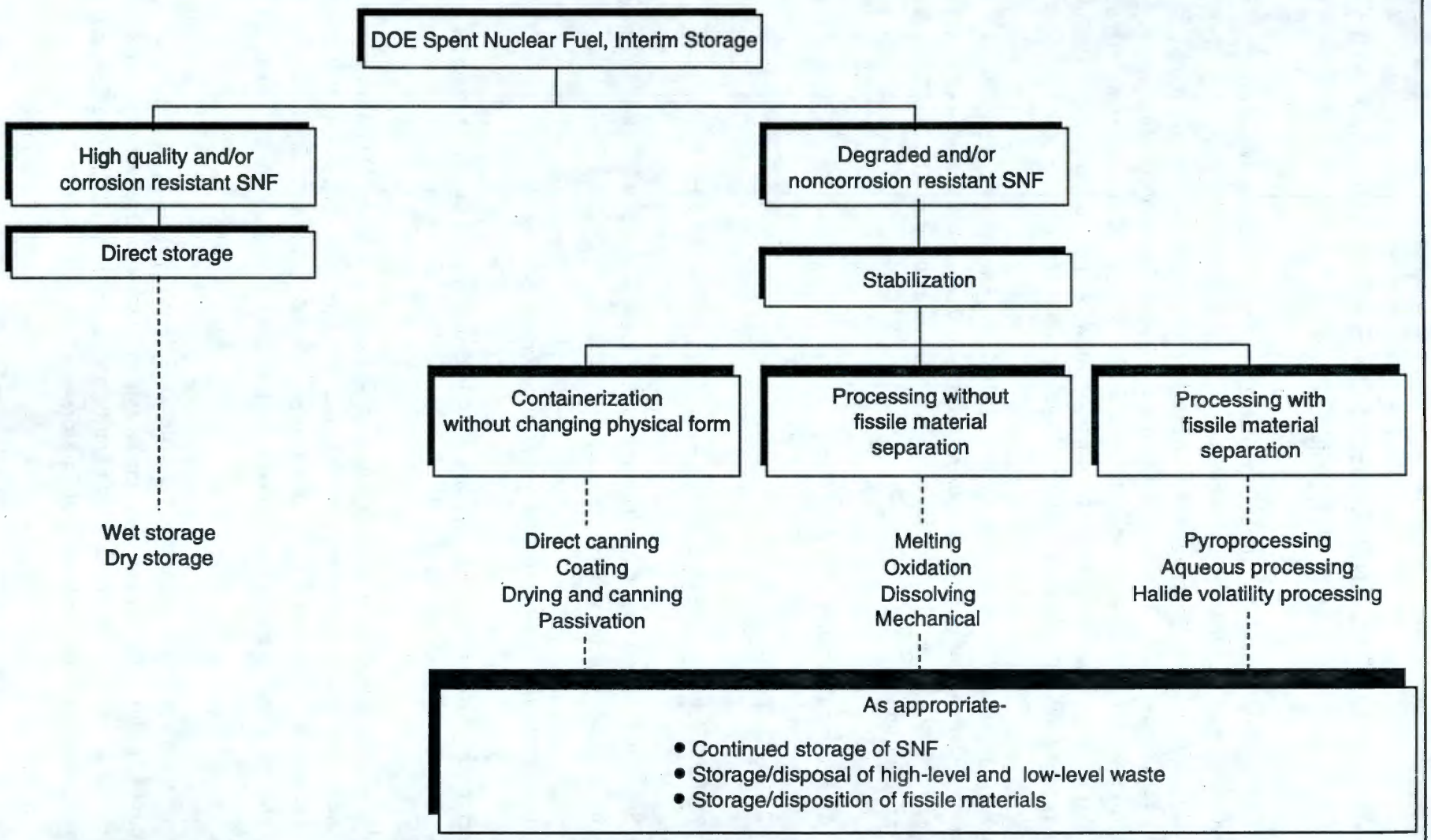

Figure J-1. Technology options for preparing spent nuclear fuel for interim storage.

J-4 SUMMARY OF TECHNOLOGIES FOR SPENT NUCLEAR FUEL MANAGEMENT

In 1992, DOE had proposed to engage in research and development activities for technology development and demonstration required to assure that SNF could be appropriately prepared for disposition in a geologic repository. Any such repository is not expected to be available until after the year 2010. Therefore, DOE has changed its focus in this effort to develop the upfront work necessary to better define the SNF research and development program. However, DOE is utilizing a system approach to technology development for preparing SNF for safe interim storage and ultimate disposition in a geologic repository.

Figure J-1 summarizes the technology options available for preparing SNF for interim storage. Indicated under each of the four general categories on the figure is a range of representative technology options. This section describes technology options listed on Figure J-1 and discusses the following:

- The option (describes what it involves)
- Applicable fuel types
- Maturity (demonstrated technology, early stages, or developmental)
- Status of commercial and foreign applications/development that may be applicable to DOE SNF management
- References that contain more detail on the technology.

When evaluating SNF management options, criticality control is an important factor, particularly for SNF with enriched uranium fuel.

Criticality considerations apply for both direct storage and stabilization. The storage system should meet applicable requirements governing nuclear criticality, which specify that the system be designed to ensure that a nuclear criticality is not possible unless at least two independent (concurrent or sequential) changes occur in the systems essential to the control of nuclear criticality.

Also important in selecting management options for SNF is the characterization of the fuel type and the fuel's physical condition. For specific types of fuel, characterization may be necessary to determine the extent of stabilization required and/or the most suitable stabilization process to transition the particular SNF into interim storage.

J-4.1 Direct Storage

Direct storage means storing SNF in essentially the same physical form in which it is removed from the reactor (that is, little or limited stabilization of the fuel elements). Fuel that has high-integrity cladding is amenable to direct storage provided criticality issues can be adequately addressed for the planned storage interval (IAEA 1988). Specific examples are Naval SNF and SNF removed from most types of commercial nuclear electric generating stations (both in the United States and foreign countries).

If a reactor that has operated at high power has fuel removed soon after shutdown (within weeks), the level of heat generation associated with fission product decay is sufficient to damage and possibly melt the fuel if the fuel is not adequately cooled. In addition, radiation levels are high both from decaying fission products and from radionuclides in the irradiated structural materials (200 to 10,000 rem). Thus, both effective cooling and effective shielding of the stored SNF are essential. Common practice is to place the SNF in a water pool, for at least a period of time, following removal from the reactor. The level of heat generation and of radioactive decay associated with SNF decreases with time after removal from the reactor. With the passage of time, it is possible and may be desirable to transfer SNF from a wet to a dry storage mode because, in general, the costs and potential environmental safety and health vulnerabilities associated with dry storage are less than those associated with wet storage (Lopez 1994, Taylor and Shikashio 1993). The status of wet and dry storage technologies is discussed in the following two subsections.

J-4.1.1 Wet Storage

Water pools (or water pits) are part of the design of nearly all nuclear reactor facilities. They are used to provide a storage location for SNF as it is removed from the reactor. The pools are usually designed to store the inventory of fuel removed from a reactor over period of a number of years. Pool depth is sufficient to provide shielding for personnel working in the region of the water pool. The water pool system normally includes a subsystem for water chemistry control with a purpose of maintaining the conditions of the water in the pool so that cladding corrosion is minimized, the water in the pool is clean enough so that SNF can be viewed underwater during fuel movement and fuel removal operations, and chloride content is controlled so pool liner integrity is maintained. The water pools are usually of concrete construction and are usually lined with stainless steel so as to minimize the potential accumulation of radioactivity on or under the surface of the concrete pool walls.

Wet storage systems generally have more heat removal capability than dry storage systems because heat transfer to liquids is more efficient than to gases, such as air or nitrogen.

Design, construction, and operation of water pools for SNF storage is a mature technology option for DOE and for commercial nuclear power plants (Takáts 1994). Wet storage system design modifications usually center around re-racking the fuel in a pool to permit more fuel to be stored in a given pool. Fuel element spacing in rack designs are carefully analyzed to ensure there is an adequate margin relative to criticality prevention for existing or contemplated SNF to be stored in the racks in the water pool.

J-4.1.2 Dry Storage Systems

In a dry storage system, cooling is provided by heat transfer to the inner wall of the storage system with eventual heat rejection to the air surrounding the storage system. Dry storage systems are mature technologies that are being applied for DOE SNF and for SNF at United States commercial and foreign nuclear electric generating systems (Schneider et al. 1992).

Dry storage system options generally are of three types: (1) stand-alone modular casks, (2) modular vault arrays, and (3) multiple-unit vault storage systems. Hot cells are also employed but are not generally considered cost-efficient for storing significant quantities of SNF. Multiple examples of each of these three types have been built and are storing SNF at the present time in DOE, commercial, and foreign applications.

1. Stand-Alone Modular Casks. A number of large stand-alone casks are available in the DOE system and in commercial applications. The casks are top- or end-loading, made from a variety of materials, and have been developed primarily in North America and Europe (Monthey and Bergsman 1994). Some cask designs are licensed for offsite transport of SNF and others are used principally for onsite fuel movement.

   There are also a variety of smaller stand-alone casks that are designed primarily for onsite transportation and storage of specific irradiated fuels and other materials. The safety basis documentation for these casks can be found in accompanying safety analysis reports (for example, Saito 1992).

2. Modular Vault Arrays. A second type of dry storage system uses a basic concrete housing with an arrangement of openings in the concrete. Canisters containing fuel are placed in the openings. The concrete housing provides supplementary shielding and prohibits unauthorized access to the SNF. Depending on the design, fuel can be stored either vertically or horizontally in canisters.

3. Multiple-Unit Vault Storage Systems. Multiple vault systems tend to be large facilities that contain cask unloading stations, fuel handling cells, ventilation systems, and office space (Carter 1994). In the main storage area array, fuel

assemblies or fuel assemblies in canisters are stored vertically in floor wells topped with shielded plugs. Insertion or removal of a canister containing the fueled component is accomplished using a shielded, floor-supported machine or a wall-mounted, unshielded bridge crane.

J-4.2 Containerization

Some SNF has deteriorated due to past storage conditions, fuel damage during operation or destructive tests, or use of cladding materials that are quite susceptible to deterioration if placed in prolonged wet storage without adequate protection. To provide adequate protection for the public, the environment, and the facility workers, containerization technologies have been employed (a) to add additional containment to the SNF, (b) to provide a passivating environment for the spent fuel (a passivating environment is one in which corrosion is minimized), or (c) to place the spent fuel into an inert atmosphere to retard or eliminate the fuel-element deterioration process. These technologies are described below.

J-4.2.1 Direct Canning

Direct canning is the technology whereby the spent fuel is placed into an engineered metal canister which then is usually sealed. This technology (called overpacking) is usually done in a water pool. It is used as a temporary corrective action if the spent fuel is found to be releasing fission products. Further refinements include blowing the water out of the overpack canister while it is still under water and then evacuating the canister (vacuum) to evaporate the remaining water. An inert gas, such as helium or nitrogen, can also be added. Another refinement to this technology involves adding a chemical for passivation to the water inside the canister to retard the corrosion of the spent fuel by the water. This approach has been accomplished at the K-West Basin at the Hanford Site. Small vents in the lid of the can, which allow release of gases generated by radiolysis or corrosion, have also been used.

Direct canning can also be carried out in a shielded, dry cell having remote handling capabilities. The spent fuel is brought into the remote cell and dried, either by normal drip-drying or by employing heating ovens to expedite the drying process. The spent fuel can be visually inspected in the remote cell and then placed into a metal canister that is welded closed. Inert gas can be added; high quality inspection of the closed canister is also possible.

This technology has been used extensively throughout DOE and foreign countries for research fuels. The commercial industry has not done a significant amount of direct canning because the commercial nuclear fuels have been designed for high integrity and so do not require an overpack.

J-4.2.2 Passivation

The passivation approach is applicable to SNF that may contain regions that could undergo adverse chemical reactions if exposed to air or moisture during dry storage. Passivation increases the stability of the fuel by reducing its reaction rate with air or other oxidants, so that if the fuel were inadvertently exposed to air during dry storage the heat generated would be less than the minimum heat dissipation rate, thus minimizing the chances of a fuel fire or rapid adverse chemical reactions. This process could potentially be used to stabilize metallic fuel with damaged cladding such as Hanford Site N-Reactor fuel.

Passivation could also include preparatory steps such as SNF cleaning, drying, and heating in a controlled environment to remove any bound water or to potentially remove or oxidize uranium hydride. The process first involves fuel cleaning. When cleaning is completed, a flow of dry inert gas is introduced around the fuel, which is maintained at the predetermined elevated temperature. A small concentration of oxidant is introduced into the flowing inert gas. Reactive regions of the fuel matrix react with the small amount of oxidant at the elevated temperature to oxidize them and make them nonreactive. When process instrumentation indicates that the reaction rate between the oxidant and the fuel (in the controlled environment) is sufficiently low, the fuel is cooled down and appropriately packaged. The fuel packaging must restrain the fuel from excessive movement to prevent the formation or exposure of new highly reactive fuel regions.

A passivation process has been used on metallic fuel in a laboratory setting by the British, who considered it to be a potentially viable method to transition their SNF from wet to dry storage. Passivation is being investigated for use on N-Reactor fuel at the Hanford Site.

J-4.2.3 Coating

Coating is a technology whereby the SNF is placed into a metal container, dried to remove any water, and then heated to the casting temperature for particular materials such as lead, copper, or an epoxy. The fuel element is covered with the molten material. The intent is to provide monolithic containment around the fuel element that ensures the SNF will not release any fission products, nor encounter an atmosphere that causes the fuel to degenerate further. To date, this technology has been investigated primarily as an approach for preparing SNF for disposal. Pressing copper around spent fuel at high pressures has been studied by the Swedish government.

J-4.3 Processing Without Fissile Material Separation

Several processes have been proposed and studied to stabilize SNF that do not involve separation of uranium and/or plutonium from the other highly radioactive contaminants. These

processes involve changing of the SNF physical and chemical form to make the volume smaller, the material less reactive, or the material more homogeneous. Materials to assist in preventing nuclear criticality (nuclear poison) may be also introduced into the process. Because none of these methods remove fissile material, the possibility of a nuclear criticality exists for DOE SNF with a fuel matrix of highly enriched uranium-235, unless the uranium-235 is diluted with uranium-238 or a nuclear poison is added to assist in preventing nuclear criticality.

J-4.3.1 Oxidation

An oxidation process can be used for two purposes. It can be used (1) to separate the fuel from the cladding, to minimize the volume of material to be stored or to prepare the fuel matrix to be more easily dissolved or (2) to convert fuel matrix or graphite fuel elements into a stable oxide form.

The decladding options include

AIROX—Holes are drilled into the fuel matrix. Uranium dioxide (UO_2) is oxidized to U_3O_8 by injecting oxygen gas at 400°C (750°F). There is an increase in fuel matrix volume of about 70 percent. The uranium then is reduced back to UO_2 using hydrogen gas. The process is repeated several times until the cladding breaks apart. This process is in the developmental stages.

RAHYD—Holes are drilled into the fuel matrix. Uranium metal is reduced with hydrogen gas at 225°C (435°F) to produce uranium tri-hydride. There is about a 70 percent volume increase. The fuel matrix is then converted back to uranium metal by heating to 780°C (1400°F). The process is repeated several times until the cladding breaks apart. This process is in the developmental stages.

CARBOX—Holes are drilled into the fuel matrix. Oxygen is injected into uranium carbide fuel at 400 to 700°C (750 to 1300°F) to form U_3O_8. There is about an 85 percent volume increase. This process is in the developmental stages.

After the fuel is declad, the fuel matrix material can be consolidated and packaged for storage.

Development work was performed on decladding technologies in the late 1950s and early 1960s in connection with dry SNF reprocessing research at Atomics International.

The fuel elements can also be oxidized to convert the cladding and/or the fuel matrix into oxide form. One example is the burning of the graphite and metal fuels. The oxidized fuel and any ash would contain the uranium, plutonium, and most of the fission products, which then

would be consolidated and packaged for storage. Technology for burning graphite fuels is well developed and has been used at the Idaho National Engineering Laboratory (WINCO 1992b).

J-4.3.2 Chemical Dissolution

The fuel is dissolved chemically by an aggressive acid or base solution. If necessary, a nuclear poison can be added to assist in criticality control. The resultant product is converted into an SNF interim storage form such as a glass, oxide, or ceramic with improved characteristics relative to criticality control. This process applies to all DOE fuel types except graphite fuel. The dissolution technology is well developed (Long 1978) and has been used throughout the DOE complex and in several foreign countries.

J-4.3.3 Mechanical

Several mechanical processes, such as shredding, chopping, grinding, and disassembly, have been proposed to change the configuration of the fuel. The resultant product can be mixed with other material, such as glass formers or depleted uranium, for safe interim storage. All DOE fuel can be treated by this method. Choppers have been used at several DOE facilities, and shredders have been evaluated at the Idaho National Engineering Laboratory for graphite fuel (WINCO 1992).

J-4.4 Processing with Fissile Material Separation

Some SNF that is currently in storage at the Savannah River Site, Hanford Site, or Idaho National Engineering Laboratory shows signs of degraded cladding. Chemical processing may be the most direct way of preventing safety and environmental problems with these fuels that have questionable cladding integrity.

Processing of SNF with separation of fissile materials from high-level waste has a long history of operation. The primary process used for fissile materials separation for DOE SNF, for commercial fuels, and for foreign separations processing has been the PUREX (Plutonium-URanium EXtraction) process or variations of this process. There are other potential processes besides PUREX that are under development for separation of the SNF fissile materials and the high-level waste. The technologies for these separation processes are described below.

J-4.4.1 Aqueous Processing

The primary aqueous extraction processing approach used is called PUREX. Aqueous processing consists of chemically dissolving the fuel in an acid, adjusting the solution pH for stability and uranium extraction, and contacting (mixing) the acid solution with an organic phase, such as kerosene or n-dodecane, usually with tributyl phosphate added (Long 1978,

Benedict 1981). The organic compound forms a complex with the uranyl ion which is extracted into the organic phase, thus separating the uranium from other dissolved constituents of the fuel. Depending on the fuel type, the entire fuel element may be dissolved, or the cladding can be breached by chopping the element to enable the acid to leach the fuel matrix. For the chop-leach approach, there remains undissolved cladding hulls. The acid solutions used in the process are tailored to the fuel type. By adjusting the valence of plutonium, it can be separated from the uranium and/or fission products by a series of water-solution-to-organic-phase extraction steps. The PUREX process is applicable to almost all fuel types, if there is a suitable fuel matrix dissolution (headend) process. A process variation called TRUEX, developed at Argonne National Laboratory, can be used to recover the transuranic elements other than uranium or plutonium.

Aqueous processing of spent fuels utilizing the basic PUREX separation approach is a mature technology and is used world-wide (Leigh 1992). The United States has used PUREX aqueous processing for separating fissile materials from irradiated defense fuels since the 1950s at the Savannah River Site, Hanford Site, and Idaho National Engineering Laboratory. The West Valley Plant in New York, constructed for fissile material extraction from commercial light water reactor fuels, used a PUREX-type process. The United Kingdom, France, and Japan use large-scale aqueous PUREX processing to recover fissile materials from spent fuels. Russia has reprocessed VVER-440 reactor fuels since 1976 utilizing a PUREX process.

J-4.4.2 Pyroprocessing

Pyroprocessing employs rapid anhydrous (or water-free) chemical reactions at high temperature for the extraction of metal from mixtures or concentrates and for refining metallic elements and compounds. The process is an electrochemical process based on passing an electrical current through fused salts. It involves three steps. First, a basket of chopped fuel is made anodic with respect to the electrorefiner crucible, which promotes rapid dissolution of the fuel into the electrolyte salts. These salts float on a pool of liquid cadmium metal. Second, a metallic cathode is introduced into the salts and much of the uranium is deposited on the metallic cathode (which is removed for uranium recovery). Third, a liquid cadmium cathode is then used to collect the remaining uranium, plutonium, and minor actinides. Zirconium and noble metals remain in the molten electrorefiner cadmium pool. Most fission products remain in the electrolyte salts. Cadmium in the liquid cadmium cathode can be distilled leaving the fissile materials and actinides for further disposition as appropriate. The process is being developed at Argonne National Laboratory-West and being demonstrated on a near-commercial pilot-plant scale in the Fuel Cycle Facility at Idaho National Engineering Laboratory using sodium-bonded metallic fuel. In principle, other metallic fuel can be pyroprocessed. This developmental process is unique to DOE (Argonne) with no foreign or commercial counterparts at the present time.

J-4.4.3 Halide Volatility

A dry chloride volatility process is being developed for separation of the nonradioactive constituents, fissile uranium, and other fissile or nonfissile transuranic products in SNF. The process involves complete volatilization of a spent fuel element. Fuel is exposed to chlorine gas at high temperature [greater than 1200°C (2200°F)]. All of the fuel constituents form volatile chlorides. The chloride compounds are separated by scrubbing the gases through a molten zinc chloride bath to remove the fission products and transuranic radionuclides. The fission products and transuranic radionuclides are recovered by evaporating away the zinc chloride. The remaining chloride gases are fractionally condensed to separate and recover nonradioactive constituents, uranium, iodine, and krypton. The process produces a single form for ultimate disposition with a significant reduction in volume to be stored. The process can be applied to fuels with almost any of the existing claddings (such as zirconium alloys, aluminum, and stainless steel). For fuels with an oxide fuel matrix, a prevolatilization oxide reduction step would be required.

The process is in the conceptual stage (Christian 1994). Thermodynamic modeling has been completed. Developmental work is being started at the Idaho National Engineering Laboratory with the potential to implement a chloride volatility process in 15 to 20 years.

J-5 SPENT NUCLEAR FUEL INSTITUTIONAL CONSIDERATIONS

This section, in a general way, summarizes potential impacts of institutional considerations on SNF management. The institutional factors include availability of an infrastructure of personnel with knowledge and training in SNF management; facility capacity for SNF operations; and availability of equipment, facilities, railheads, and roadways for shipping of SNF. These factors are important considerations in evaluating and selecting technology options for SNF management.

J-5.1 Availability of Technical Personnel Trained in Spent Nuclear Fuel Management

The management of SNF requires personnel qualified and experienced in a number of appropriate skill areas and operations. The skill areas include proficiency in the design, fabrication, and use of special tooling; specific training in safety and radiation protection; specific understanding of criticality controls; an understanding of SNF and SNF handling and shipping operations; and emergency preparedness capabilities. Most operations involving SNF must be performed remotely in hot cells.

The disciplines specific to SNF management include mechanical and structural engineering, construction engineering, radiation protection, nuclear safety, industrial safety, chemistry, and nuclear physics.

J-5.2 Availability of Facilities for Spent Nuclear Fuel Management Operations

Important facilities factors to be considered in SNF management include availability and adequacy of existing facilities for storing and stabilizing of SNF and the design requirements for new facilities. Important factors when evaluating existing facilities include fuel type to be handled, fuel integrity, type of storage (for example, wet or dry), stabilization requirements, capacity and condition of dry storage facilities, and any conditioning or processing that could be required for ultimate disposition.

J-5.3 Transportation or Shipping of Spent Nuclear Fuel

Important factors relating to transportation (shipping) of SNF include availability of shielded casks, availability of cask handling cranes with adequate capacity, status of licenses and permits for a particular site, availability of transport equipment and loading and unloading facilities, availability of qualified roadways and/or railheads, and vehicle tracking and communications capabilities.

J-5.4 Safeguards and Security

The management of SNF typically requires rigorous safeguards and security controls to protect the fissile material within the SNF from diversion. In addition, protection of personnel, the public, and environment must be maintained. These requirements result in specific safeguards and security criteria that include access control to areas where SNF is handled, stored, and processed and the maintenance of controlled databases to account for fuels and their inventory of fissile materials.

J-5.5 Current Federal and State Agreements

DOE has entered into agreements with State governments that apply to SNF sites. The DOE agreement with the State of New York provides that the SNF will be removed from the West Valley Site to another DOE site. An agreement between the DOE, the Navy, and the State of Idaho regarding the Idaho National Engineering Laboratory site provides for removal of SNF from underwater storage in the north and middle basins of Building CPP-603 by the end of 1996 and from the south basin of this facility by the end of 2000. There is also an agreement between the DOE, the U.S. Environmental Protection Agency, and the State of Washington regarding the Hanford Site which requires the removal of SNF and pool sludge from the Building 105-K basins.

J-5.6 Maintaining Flexibility Until Ultimate Disposition is Available

Some stabilization technologies for storage may be undesirable if they could potentially make a later conversion to an acceptable form for ultimate disposition very difficult. For example, SNF stabilized for interim storage could be precluded from ultimate disposition by certain possible acceptance criteria. In such an instance, reconstitution of the SNF could be required before ultimate disposition, with associated costs of reconstitution.

J-6 REFERENCES

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Appendix K
Environmental Consequences Data

This appendix presents data that were used to discuss environmental consequences and to generate the graphics used in comparing environmental consequences among alternatives (in Chapter 3) and among alternatives and sites (in Chapter 5). These data are taken from Volume 1 Appendices A through F and converted as required to different units or time periods. To understand the technical basis and context for each of the reported data elements, refer to the appropriate site appendix:

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

The appendix contains (a) a key to alternatives, (b) a summary of data by alternative, and (c) a summary of data by alternative and site. The key to alternatives defines the site combinations represented by the subalternatives and options and relates these to the columns in Tables K-1 and K-2. The summary of data by alternative in Table K-1 presents the summed (or maximum) impacts across all sites involved in that alternative, subalternative, and option. The summary of data by alternative and site in Table K-2 presents data for each site that is affected by that alternative, subalternative, and option. Those sites not affected by a particular option are not shown.

Ten categories of data, numbered in the first column of the attached tables, were used to develop the discussions and graphs in Chapter 5 and are summarized by discipline below.

1. Land Use—The value presented is an estimate of the amount of additional acreage that would be disturbed if a particular alternative was implemented. Minimum and maximum values were provided for options within each alternative where available. The maximum percent of the total site area that would be dedicated to SNF management activities was also calculated. Land use impacts are discussed in Section 5.2.1 of Volume 1. A detailed discussion on land use is provided in Appendices A through F.

2. Employment Related to SNF Management—The values presented are the projected 10-year average changes in site employment related to proposed SNF management activities for the period from 1995 to 2005. Minimum and maximum values were calculated where data were available. Baseline site employment refers to the sitewide employment at June 1995, inclusive of those employed in SNF management activities. The maximum percent

of baseline site employment represents the maximum incremental change in sitewide employment that might occur because of the proposed SNF management activities. SNF-related employment is discussed by alternative in Section 5.1 of Volume 1. A detailed analysis of socioeconomic impacts is provided in Appendices A through F.

3. Population Collective Dose—The radiation dose that would be received by the population within 80 kilometers (50 miles) of each site per year from normal operations. It is derived from data in the site appendices and represents the dose for the maximum option within each alternative. Because of the differences in methods used to generate the data, the estimated SNF management doses are sometimes higher than total site doses. The SNF management doses were developed by modeling releases from existing and proposed facilities, and sitewide doses were determined by a combination of modeling of existing facilities and monitoring data. The monitoring data are more accurate, while the modeling approach overestimates expected dose, making the expected dose higher than would probably be realized. Population collective doses are described by alternative in Section 5.1, Chapter 5 of Volume 1.

4. Maximally Exposed Individual (MEI)—The MEI is a hypothetical person located down wind at the site boundary closest to the facilities that might have radiation releases. The MEI doses are calculated by modeling releases from existing and proposed facilities from normal operations. Data on the MEI doses can be found in Appendices A through F and represents the dose for the maximum option within each alternative.

5. Worker Dose—The dose that would be received by workers at facilities, based on expected radiation levels at those facilities for normal operations. Sitewide worker doses are based on historical monitoring of workers. These values are not particularly useful in comparing among sites or alternatives as worker doses are controlled by limiting worker involvement in activities that could result in exposures to radiation. Both individual doses and collective doses to workers are taken from Appendices A through F.

6. Water Use—The values represent an estimate of the change in annual consumption of water (in millions of gallons) that may result from the proposed SNF management activities for a given alternative. Minimum and maximum values are provided where available. The baseline water use is the annual water consumption for a site for all operations. The maximum percent of baseline site water represents the annual maximum incremental change in water use that would occur because of the proposed SNF management activities. Water impacts are discussed in Section 5.2.6, Chapter 5 of Volume 1. A detailed discussion of water use and related consequences is provided in Appendices A through F.

7. Electricity Use—The values represent an estimate of the change in annual power consumption (in megawatt-hours per year) that would result from the proposed SNF management activities for a given alternative. Minimum and maximum values are provided where available. The baseline site electricity use is the annual power consumption for a site for all operations. The maximum percent of site electricity use represents the annual maximum incremental change in power consumption that would occur because of the proposed SNF management activities. Electricity use is discussed by alternative in Section 5.1, Chapter 5 of Volume 1. A detailed discussion of electricity use is provided in Appendices A through F.

8. Sewage—The values represent an estimate of the change in annual rate of wastewater generation (in millions of gallons) that would result from the proposed SNF management activities for a given alternative. Minimum and maximum values are provided where available. The baseline site sewage value represents the annual volume of wastewater generated from total site operations. The maximum percent of baseline site sewage represents the annual maximum incremental change in wastewater generation that would occur because of the proposed SNF management activities. Wastewater generation is discussed in Section 5.2.9 of Volume 1. A detailed discussion of wastewater generation is provided in Appendices A through F.

9. Waste Volume Estimates (high-level, transuranic, mixed, and low-level waste)—The annual generation rate of these waste types (in cubic meters per year) from the proposed SNF management activities is provided. These values represent 10-year cumulative generation rates divided by ten. Minimum and maximum values are provided where available. The waste volumes are discussed by alternative in Section 5.1 of Volume 1. A detailed discussion of the waste-generating activities at each site is provided in Appendices A through F.

10. Facility Accidents—For accidents, the individual and collective dose values in the tables represent the consequences for the accident having the highest radiological risk (dose times frequency, not necessarily the highest dose) to the public or to workers. The accidents selected for reporting are not necessarily the same for workers and the general population. In each category, the accident with the highest risk was selected, which may be different for workers and the general population. Doses and risks in Table K-2 are the maximum values from each alternative in Table K-1. Accident analyses reported in this summary are based on SNF management-related activities only and are found in the site appendices. Doses from accidents are described by alternative in Section 5.1 of Volume 1.

11. Transportation—For incident-free transportation, the values in Table K-2 represent the total annual average fatalities from shipments of SNF for each alternative. Total fatalities are the sum of radiation-related latent cancer fatalities for transportation workers and the

general population, plus nonradiological fatalities from vehicular emissions. These data are an aggregate of the data presented in Appendices A, B, C, D, and I. For transportation accident risks, two sets of data are presented in Table K-2 for each alternative. The estimated risks of cancer fatalities represent the radiological risk from transportation accidents. The estimated risk of traffic fatalities represent the nonradiological risk from traffic accidents. Both quantities are on an annual average basis. These data are an aggregate of the data presented in Appendices D and I.

The data in Table K-1 have been rounded to two significant figures, the greatest number of significant figures that can be justified with this analysis. Zero values indicate no impact for that parameter. In the summary table by alternatives, however, missing site data are treated as zeroes, so the impacts for given alternatives can be understated. Missing data are indicated by blanks. Missing values exist only where impacts are expected to be very small or trivial, so the magnitude of underestimation is probably also small.

Table K-1 shows the magnitude of differences between alternatives is very low. To understand observed differences between alternatives, Chapter 5 of this EIS should be consulted. Differences between sites within an alternative require examination of the site specific appendices for the reasons noted above.

Key to Alternatives and Sites

No Action: Very limited SNF shipments, limited upgrades to facilities, limited stabilization.

Decentralization: Non-DOE sites (except Navy) ship to DOE sites, some upgrades to facilities, stabilization.

Option A: No examination of Naval SNF
Option B: Limited examination of Naval SNF at Puget Sound Naval Shipyard
Option C: Full examination of Naval SNF at Idaho National Engineering Laboratory; SNF returned to Navy sites for storage

1992/1993 Planning Basis: New SNF shipped to Idaho National Engineering Laboratory or Savannah River Site, facility upgrades and expansion, stabilization.

Regionalization: SNF shipped to regional sites, facility upgrades and expansion, stabilization.

Subalternative A: SNF to Idaho National Engineering Laboratory or Savannah River Site depending on fuel type
Subalternative B: SNF to Western or Eastern Regional Site depending on location

Option	Western Regional Site	Eastern Regional Site	Expended Core Facility location
1E	Hanford Site	Savannah River Site	Savannah River Site
1W	Hanford Site	Savannah River Site	Hanford Site
2W	Idaho National Engineering Laboratory	Savannah River Site	Idaho National Engineering Laboratory
3E	Nevada Test Site	Savannah River Site	Savannah River Site
3W	Nevada Test Site	Savannah River Site	Nevada Test Site
4E	Hanford Site	Oak Ridge Reservation	Oak Ridge Reservation
4W	Hanford Site	Oak Ridge Reservation	Hanford Site
5W	Idaho National Engineering Laboratory	Oak Ridge Reservation	Idaho National Engineering Laboratory
6E	Nevada Test Site	Oak Ridge Reservation	Oak Ridge Reservation
6W	Nevada Test Site	Oak Ridge Reservation	Nevada Test Site

Centralization: SNF shipped to central site, facility upgrades and expansion, stabilization.

Option A: Hanford Site is the central site
Option B: Idaho National Engineering Laboratory is the central site
Option C: Savannah River Site is the central site
Option D: Oak Ridge Reservation is the central site
Option E: Nevada Test Site is the central site

Hanford	Hanford Site
INEL	Idaho National Engineering Laboratory
SRS	Savannah River Site
ORR	Oak Ridge Reservation
NTS	Nevada Test Site
Navy	Navy shipyards and prototype locations
Other	Small DOE, other government, and university research reactor sites

Table K-1. Summary of impacts by alternatives and by site.

		Hanford	INEL	SRS	ORR	NTS	Naval	Other
Alternative		No-Action	No-Action	No-Action	No-Action	No-Action	No-Action	No-Action
Subalternative								
Option	Units							
Land for new facilities, minimum	Acres	0	1	0			16	0
Land for new facilities, maximum	Acres	0	1	0			16	12
Site area	Acres	358,400	570,914	198,000			6,055	0
Percent of site area, maximum		0.00	0.00	0.00			0.26	10.00
SNF-related employment, minimum	Person-years per year	0	-236	50			8	72
SNF-related employment, maximum	Person-years per year	0	-236	50			8	120
Baseline site employment	Person-years per year	17,870	9,290	20,055			30,050	2,400
Percent of baseline site employment, minimum		0.00	-2.54	0.25			0.03	3.00
Percent of baseline site employment, maximum		0.00	-2.54	0.25			0.03	5.00
Estimated maximum latent cancer fatalities in 80-km population, SNF management	Latent cancer fatalities per year	1.5E-5	5.0E-5	2.3E-9			2.3E-5	
Estimated maximum latent cancer fatalities in 80-km population, site operations	Latent cancer fatalities per year	4.0E-4	4.0E-5	4.4E-3			1.2E-4	
Estimated maximum probability of latent cancer fatalities in MEI, SNF management	Latent cancer fatalities per year	1.3E-9	2.8E-8	4.0E-14			1.5E-6	
Estimated maximum probability of latent cancer fatalities in MEI, site operations	Latent cancer fatalities per year	1.0E-8	2.8E-8	6.5E-8			1.5E-6	
Estimated maximum probability of latent cancer fatality in worker, SNF management	Latent cancer fatalities per year	1.6E-4	1.1E-5	4.0E-5			2.3E-6	
Maximum probability of latent cancer fatality in worker, site operations	Latent cancer fatalities per year	2.7E-5	1.0E-5	8.8E-5			4.8E-5	
Water use, SNF management, minimum	Million gallons per year	0	-3	9			0	
Water use, SNF management, maximum	Million gallons per year	0	-3	9			0	
Baseline water use, site operations	Million gallons per year	3,963	1,717	23,300			9,859	
Maximum percent of baseline site water use		0.00	-0.17	0.04			0.00	
Electricity use, SNF management, minimum	Megawatt-hours per year	0	-9,900	1,400			0	
Electricity use, SNF management, maximum	Megawatt-hours per year	0	-9,746	1,400			0	
Baseline site electricity use	Megawatt-hours per year	340,000	208,000	660,000			411,067	
Percent of site electricity use, minimum		0.00	-4.76	0.21			0.00	
Percent of site electricity use, maximum		0.00	-4.69	0.21			0.00	
Sewage, SNF management, minimum	Million gallons per year	1	0	9			0	
Sewage, SNF management, maximum	Million gallons per year	1	0	9			0	
Baseline site sewage	Million gallons per year	55	143	182			0	
Percent of baseline site sewage, maximum		1.90	0.00	4.95				

Table K-1. (continued).

		Hanford	INEL	SRS	ORR	NTS	Naval	Other
Alternative		No-Action	No-Action	No-Action	No-Action	No-Action	No-Action	No-Action
Subalternative								
Option	Units							
High level waste, SNF management, minimum	Cubic meters per year	0	0	0			0	
High level waste, SNF management, maximum	Cubic meters per year	0	0	0			0	
Transuranic waste, SNF management, minimum	Cubic meters per year	0	0	17			0	
Transuranic waste, SNF management, maximum	Cubic meters per year	0	0	17			0	
Mixed waste, SNF management, minimum	Cubic meters per year	1	0	0			0	
Mixed waste, SNF management, maximum	Cubic meters per year	1	0	0			0	
Low level waste, SNF management, minimum	Cubic meters per year	150	0	400			0	
Low level waste, SNF management, maximum	Cubic meters per year	150	0	400			0	
High-level, transuranic, and mixed wastes generated, minimum	Cubic meters per year	1	0	17			0	
High-level, transuranic, and mixed wastes generated, maximum	Cubic meters per year	1	0	17			0	
Estimated maximum latent cancer fatalities in 80-km population from maximum risk accident	Latent cancer fatalities	3.7E+1	7.0E+0	8.5E-3			2.6E+1	
Estimated maximum risk of latent cancer fatalities in 80-km population from maximum risk accident	Latent cancer fatalities per year	3.7E-3	7.0E-5	1.4E-3			2.6E-4	
Estimated maximum worker latent cancer fatalities from maximum risk accident	Latent cancer fatalities	1.4E-3	3.9E-5				7.4E-2	1.0E-6
Estimated maximum risk of worker latent cancer fatalities from maximum risk accident	Latent cancer fatalities per year	1.4E-7	4.0E-8				7.4E-8	

Table K-1. (continued).

		Hanford	INEL	SRS	ORR	NTS	Naval	Other
Alternative		Decentralization	Decentralization	Decentralization	Decentralization	Decentralization	Decentralization	Decentralization
Subalternative								
Option	Units	A	A	A	A	A	A	A
Land for new facilities, minimum	Acres	11	1	0			16	
Land for new facilities, maximum	Acres	18	1	0			16	
Site area	Acres	358,400	570,914	198,000			6,055	
Percent of site area, maximum		0.01	0.00	0.00				
SNF-related employment, minimum	Person-years per year	80	-236	200			8	
SNF-related employment, maximum	Person-years per year	638	-236	215			272	
Baseline site employment	Person-years per year	17,870	9,290	20,055			30,050	
Percent of baseline site employment, minimum		0.45	-2.54	1.00			0.03	
Percent of baseline site employment, maximum		3.57	-2.54	1.07			0.91	
Estimated maximum latent cancer fatalities in 80-km population, SNF management	Latent cancer fatalities per year	6.3E-4	5.0E-5	8.0E-3			3.5E-4	
Estimated maximum latent cancer fatalities in 80-km population, site operations	Latent cancer fatalities per year	4.0E-4	4.0E-5	4.4E-3			4.3E-4	
Estimated maximum probability of latent cancer fatalities in MEI, SNF management	Latent cancer fatalities per year	1.1E-8	3.0E-8	2.0E-7			1.5E-6	
Estimated maximum probability of latent cancer fatalities in MEI, site operations	Latent cancer fatalities per year	5.0E-5	2.8E-8	6.5E-8			1.5E-6	
Estimated maximum probability of latent cancer fatality in worker, SNF management	Latent cancer fatalities per year	2.0E-4	1.1E-5	6.0E-5			2.3E-6	
Maximum probability of latent cancer fatality in worker, site operations	Latent cancer fatalities per year	2.7E-5	1.0E-5	8.8E-5			4.8E-5	
Water use, SNF management, minimum	Million gallons per year	1	-3	15			0	
Water use, SNF management, maximum	Million gallons per year	40	-3	96			0	
Baseline water use, site operations	Million gallons per year	3,963	1,717	23,300			9,859	
Maximum percent of baseline site water use		1.00	-0.17	0.41			0.00	
Electricity use, SNF management, minimum	Megawatt-hours per year	100	-9,900	19,400			0	
Electricity use, SNF management, maximum	Megawatt-hours per year	127,000	-9,746	56,400			0	
Baseline site electricity use	Megawatt-hours per year	340,000	208,000	660,000			411,067	
Percent of site electricity use, minimum		0.03	-4.76	2.94			0.00	
Percent of site electricity use, maximum		37.35	-4.69	8.55			0.00	
Sewage, SNF management, minimum	Million gallons per year	1	0	13			0	
Sewage, SNF management, maximum	Million gallons per year	3	0	13			0	
Baseline site sewage	Million gallons per year	55	143	182			0	
Percent of baseline site sewage, maximum		5.71	0.00	7.14				

Table K-1. (continued).

		Hanford	INEL	SRS	ORR	NTS	Naval	Other
Alternative		Decentralization	Decentralization	Decentralization	Decentralization	Decentralization	Decentralization	Decentralization
Subalternative								
Option	Units	A	A	A	A	A	A	A
High level waste, SNF management, minimum	Cubic meters per year	0	0	0			0	
High level waste, SNF management, maximum	Cubic meters per year	23	0	2			0	
Transuranic waste, SNF management, minimum	Cubic meters per year	0	0	18			0	
Transuranic waste, SNF management, maximum	Cubic meters per year	20	0	20			0	
Mixed waste, SNF management, minimum	Cubic meters per year	0	0	0			0	
Mixed waste, SNF management, maximum	Cubic meters per year	1	0	0			0	
Low level waste, SNF management, minimum	Cubic meters per year	94	0	400			0	
Low level waste, SNF management, maximum	Cubic meters per year	220	0	1,700			0	
High-level, transuranic, and mixed wastes generated, minimum	Cubic meters per year	0	0	18			0	
High-level, transuranic, and mixed wastes generated, maximum	Cubic meters per year	44	0	22			0	
Estimated maximum latent cancer fatalities in 80-km population from maximum risk accident	Latent cancer fatalities	8.1E+1	7.0E+0	8.5E-3			2.6E+1	
Estimated maximum risk of latent cancer fatalities in 80-km population from maximum risk accident	Latent cancer fatalities per year	4.9E-4	7.0E-5	3.0E-3			2.6E-4	
Estimated maximum worker latent cancer fatalities from maximum risk accident	Latent cancer fatalities	9.4E-2	3.9E-5	4.8E-6			7.4E-2	
Estimated maximum risk of worker latent cancer fatalities from maximum risk accident	Latent cancer fatalities per year	5.7E-7	4.0E-8	1.7E-6			7.4E-8	

Table K-1. (continued).

		Hanford	INEL	SRS	ORR	NTS	Naval	Other	Transport
Alternative		Decentralization	Decentralization	Decentralization	Decentralization	Decentralization	Decentralization	Decentralization	Decentralization
Subalternative									
Option	Units	B	B	B	B	B	B	B	B
Land for new facilities, minimum	Acres	11	1	0			16		
Land for new facilities, maximum	Acres	18	1	0			16		
Site area	Acres	358,400	570,914	198,000			6,055		
Percent of site area, maximum		0.01	0.00	0.00					
SNF-related employment, minimum	Person-years per year	80	-236	200			73		
SNF-related employment, maximum	Person-years per year	638	-236	215			337		
Baseline site employment	Person-years per year	17,870	9,290	20,055			30,050		
Percent of baseline site employment, minimum		0.45	-2.54	1.00			0.24		
Percent of baseline site employment, maximum		3.57	-2.54	1.07			1.12		
Estimated maximum latent cancer fatalities in 80-km population, SNF management	Latent cancer fatalities per year	6.3E-4	5.0E-5	8.0E-3			3.5E-4		5.8E-3
Estimated maximum latent cancer fatalities in 80-km population, site operations	Latent cancer fatalities per year	4.0E-4	4.0E-5	4.4E-3			4.3E-4		
Estimated maximum probability of latent cancer fatalities in MEI, SNF management	Latent cancer fatalities per year	1.1E-8	3.0E-8	2.0E-7			1.5E-6		
Estimated maximum probability of latent cancer fatalities in MEI, site operations	Latent cancer fatalities per year	5.0E-5	2.8E-8	6.5E-8			1.5E-6		
Estimated maximum probability of latent cancer fatality in worker, SNF management	Latent cancer fatalities per year	2.0E-4	1.1E-5	6.0E-5			2.3E-6		
Maximum probability of latent cancer fatality in worker, site operations	Latent cancer fatalities per year	2.7E-5	1.0E-5	8.8E-5			4.8E-5		
Water use, SNF management, minimum	Million gallons per year	1	-3	15			0		
Water use, SNF management, maximum	Million gallons per year	40	-3	96			0		
Baseline water use, site operations	Million gallons per year	3,963	1,717	23,300			9,859		
Maximum percent of baseline site water use		1.00	-0.17	0.41			0.00		
Electricity use, SNF management, minimum	Megawatt-hours per year	100	-9,900	19,400			0		
Electricity use, SNF management, maximum	Megawatt-hours per year	127,000	-9,746	56,400			0		
Baseline site electricity use	Megawatt-hours per year	340,000	208,000	660,000			411,067		
Percent of site electricity use, minimum		0.03	-4.76	2.94			0.00		
Percent of site electricity use, maximum		37.35	-4.69	8.55			0.00		
Sewage, SNF management, minimum	Million gallons per year	1	0	13			0		
Sewage, SNF management, maximum	Million gallons per year	3	0	13			0		
Baseline site sewage	Million gallons per year	55	143	182			0		
Percent of baseline site sewage, maximum		5.71	0.00	7.14					

Table K-1. (continued).

		Hanford	INEL	SRS	ORR	NTS	Naval	Other	Transport
Alternative		Decentralization	Decentralization	Decentralization	Decentralization	Decentralization	Decentralization	Decentralization	Decentralization
Subalternative									
Option	Units	B	B	B	B	B	B	B	B
High level waste, SNF management, minimum	Cubic meters per year	0	0	0			0		
High level waste, SNF management, maximum	Cubic meters per year	23	0	2			0		
Transuranic waste, SNF management, minimum	Cubic meters per year	0	0	18			0		
Transuranic waste, SNF management, maximum	Cubic meters per year	20	0	20			0		
Mixed waste, SNF management, minimum	Cubic meters per year	0	0	0			0		
Mixed waste, SNF management, maximum	Cubic meters per year	1	0	0			0		
Low level waste, SNF management, minimum	Cubic meters per year	94	0	400			0		
Low level waste, SNF management, maximum	Cubic meters per year	220	0	1,700			0		
High-level, transuranic, and mixed wastes generated, minimum	Cubic meters per year	0	0	18			0		
High-level, transuranic, and mixed wastes generated, maximum	Cubic meters per year	44	0	22			0		
Estimated maximum latent cancer fatalities in 80-km population from maximum risk accident	Latent cancer fatalities	8.1E+1	7.0E+0	8.5E-3			2.6E+1		
Estimated maximum risk of latent cancer fatalities in 80-km population from maximum risk accident	Latent cancer fatalities per year	4.9E-4	7.0E-5	3.0E-3			2.6E-4		1.0E-4
Estimated maximum worker latent cancer fatalities from maximum risk accident	Latent cancer fatalities	9.4E-2	3.9E-5	4.8E-6			7.4E-2		
Estimated maximum risk of worker latent cancer fatalities from maximum risk accident	Latent cancer fatalities per year	5.7E-7	4.0E-8	1.7E-6			7.4E-8		

Table K-1. (continued).

		Hanford	INEL	SRS	ORR	NTS	Naval	Other
Alternative		Decentralization	Decentralization	Decentralization	Decentralization	Decentralization	Decentralization	Decentralization
Subalternative								
Option	Units	C	C	C	C	C	C	C
Land for new facilities, minimum	Acres	11	1	0			16	
Land for new facilities, maximum	Acres	18	1	0			16	
Site area	Acres	358,400	570,914	198,000				
Percent of site area, maximum		0.01	0.00	0.00				
SNF-related employment, minimum	Person-years per year	80	20	200			8	
SNF-related employment, maximum	Person-years per year	638	20	215			272	
Baseline site employment	Person-years per year	17,870	9,290	20,055			30,050	
Percent of baseline site employment, minimum		0.45	0.22	1.00			0.03	
Percent of baseline site employment, maximum		3.57	0.22	1.07			0.91	
Estimated maximum latent cancer fatalities in 80-km population, SNF management	Latent cancer fatalities per year	6.3E-4	5.1E-5	8.0E-3			3.5E-4	
Estimated maximum latent cancer fatalities in 80-km population, site operations	Latent cancer fatalities per year	4.0E-4	4.0E-5	4.4E-3			4.3E-4	
Estimated maximum probability of latent cancer fatalities in MEI, SNF management	Latent cancer fatalities per year	1.1E-8	3.0E-8	2.0E-7			1.5E-6	
Estimated maximum probability of latent cancer fatalities in MEI, site operations	Latent cancer fatalities per year	5.0E-5	2.8E-8	6.5E-8			1.5E-6	
Estimated maximum probability of latent cancer fatality in worker, SNF management	Latent cancer fatalities per year	2.0E-4	1.1E-5	6.0E-5			2.3E-6	
Maximum probability of latent cancer fatality in worker, site operations	Latent cancer fatalities per year	2.7E-5	1.0E-5	8.8E-5			4.8E-5	
Water use, SNF management, minimum	Million gallons per year	1	0	15			0	
Water use, SNF management, maximum	Million gallons per year	40	0	96			0	
Baseline water use, site operations	Million gallons per year	3,963	1,717	23,300			9,859	
Maximum percent of baseline site water use		1.00	0.00	0.41			0.00	
Electricity use, SNF management, minimum	Megawatt-hours per year	100	100	19,400			0	
Electricity use, SNF management, maximum	Megawatt-hours per year	127,000	254	56,400			0	
Baseline site electricity use	Megawatt-hours per year	340,000	208,000	660,000			411,067	
Percent of site electricity use, minimum		0.03	0.05	2.94			0.00	
Percent of site electricity use, maximum		37.35	0.12	8.55			0.00	
Sewage, SNF management, minimum	Million gallons per year	1	0	13			0	
Sewage, SNF management, maximum	Million gallons per year	3	0	13			0	
Baseline site sewage	Million gallons per year	55	143	182			0	
Percent of baseline site sewage, maximum		5.71	0.00	7.14				

Table K-1. (continued).

		Hanford	INEL	SRS	ORR	NTS	Naval	Other
Alternative		Decentralization	Decentralization	Decentralization	Decentralization	Decentralization	Decentralization	Decentralization
Subalternative								
Option	Units	C	C	C	C	C	C	C
High level waste, SNF management, minimum	Cubic meters per year	0	0	0			0	
High level waste, SNF management, maximum	Cubic meters per year	23	0	2			0	
Transuranic waste, SNF management, minimum	Cubic meters per year	0	0	18			0	
Transuranic waste, SNF management, maximum	Cubic meters per year	20	0	20			0	
Mixed waste, SNF management, minimum	Cubic meters per year	0	0	0			0	
Mixed waste, SNF management, maximum	Cubic meters per year	1	0	0			0	
Low level waste, SNF management, minimum	Cubic meters per year	94	425	400			0	
Low level waste, SNF management, maximum	Cubic meters per year	220	425	1,700			0	
High-level, transuranic, and mixed wastes generated, minimum	Cubic meters per year	0	0	18			0	
High-level, transuranic, and mixed wastes generated, maximum	Cubic meters per year	44	0	22			0	
Estimated maximum latent cancer fatalities in 80-km population from maximum risk accident	Latent cancer fatalities	8.1E+1	7.0E+0	8.5E-3			2.6E+1	
Estimated maximum risk of latent cancer fatalities in 80-km population from maximum risk accident	Latent cancer fatalities per year	4.9E-4	7.0E-5	3.0E-3			2.6E-4	
Estimated maximum worker latent cancer fatalities from maximum risk accident	Latent cancer fatalities	9.4E-2	3.2E-3	4.8E-6			7.4E-2	
Estimated maximum risk of worker latent cancer fatalities from maximum risk accident	Latent cancer fatalities per year	5.7E-7	4.0E-8	1.7E-6			7.4E-8	

Table K-1. (continued).

		Hanford	INEL	SRS	ORR	NTS	Naval	Other
Alternative		Planning Basis	Planning Basis	Planning Basis	Planning Basis	Planning Basis	Planning Basis	Planning Basis
Subalternative								
Option	Units							
Land for new facilities, minimum	Acres	11	19	0				
Land for new facilities, maximum	Acres	18	19	0				
Site area	Acres	358,400	570,914	198,000				
Percent of site area, maximum		0.01	0.00	0.00				
SNF-related employment, minimum	Person-years per year	80	133	200				
SNF-related employment, maximum	Person-years per year	638	133	235				
Baseline site employment	Person-years per year	17,870	9,290	20,055				
Percent of baseline site employment, minimum		0.45	1.43	1.00				
Percent of baseline site employment, maximum		3.57	1.43	1.17				
Estimated maximum latent cancer fatalities in 80-km population, SNF management	Latent cancer fatalities per year	6.3E-4	1.0E-4	8.0E-3				
Estimated maximum latent cancer fatalities in 80-km population, site operations	Latent cancer fatalities per year	4.0E-4	4.0E-5	4.4E-3				
Estimated maximum probability of latent cancer fatalities in MEI, SNF management	Latent cancer fatalities per year	1.1E-8	3.2E-8	2.0E-7				
Estimated maximum probability of latent cancer fatalities in MEI, site operations	Latent cancer fatalities per year	5.0E-5	2.8E-8	6.5E-8				
Estimated maximum probability of latent cancer fatality in worker, SNF management	Latent cancer fatalities per year	2.0E-4	1.1E-5	6.0E-5				
Maximum probability of latent cancer fatality in worker, site operations	Latent cancer fatalities per year	2.7E-5	1.0E-5	8.8E-5				
Water use, SNF management, minimum	Million gallons per year	1	1	15				
Water use, SNF management, maximum	Million gallons per year	40	1	96				
Baseline water use, site operations	Million gallons per year	3,963	1,717	23,300				
Maximum percent of baseline site water use		1.00	0.03	0.41				
Electricity use, SNF management, minimum	Megawatt-hours per year	100	176	19,400				
Electricity use, SNF management, maximum	Megawatt-hours per year	127,000	2,279	56,400				
Baseline site electricity use	Megawatt-hours per year	340,000	208,000	660,000				
Percent of site electricity use, minimum		0.03	0.08	2.94				
Percent of site electricity use, maximum		37.35	1.10	8.55				
Sewage, SNF management, minimum	Million gallons per year	1	0	13				
Sewage, SNF management, maximum	Million gallons per year	3	0	13				
Baseline site sewage	Million gallons per year	55	143	182				
Percent of baseline site sewage, maximum		5.71	0.30	7.14				

Table K-1. (continued).

		Hanford	INEL	SRS	ORR	NTS	Naval	Other
Alternative		Planning Basis	Planning Basis	Planning Basis	Planning Basis	Planning Basis	Planning Basis	Planning Basis
Subalternative								
Option	Units							
High level waste, SNF management, minimum	Cubic meters per year	0	0	0				
High level waste, SNF management, maximum	Cubic meters per year	23	31	2				
Transuranic waste, SNF management, minimum	Cubic meters per year	0	0	18				
Transuranic waste, SNF management, maximum	Cubic meters per year	20	36	20				
Mixed waste, SNF management, minimum	Cubic meters per year	0	0	0				
Mixed waste, SNF management, maximum	Cubic meters per year	1	1	0				
Low level waste, SNF management, minimum	Cubic meters per year	94	458	400				
Low level waste, SNF management, maximum	Cubic meters per year	220	881	1,700				
High-level, transuranic, and mixed wastes generated, minimum	Cubic meters per year	0	0	18				
High-level, transuranic, and mixed wastes generated, maximum	Cubic meters per year	44	68	22				
Estimated maximum latent cancer fatalities in 80-km population from maximum risk accident	Latent cancer fatalities	8.1E+1	7.0E+0	8.5E-3				
Estimated maximum risk of latent cancer fatalities in 80-km population from maximum risk accident	Latent cancer fatalities per year	4.9E-4	7.0E-5	3.4E-3				
Estimated maximum worker latent cancer fatalities from maximum risk accident	Latent cancer fatalities	9.4E-2	3.2E-3	4.8E-6				
Estimated maximum risk of worker latent cancer fatalities from maximum risk accident	Latent cancer fatalities per year	5.7E-7	4.0E-8	1.9E-6				

Table K-1. (continued).

		Hanford	INEL	SRS	ORR	NTS	Naval	Other
Alternative		Regionalization	Regionalization	Regionalization	Regionalization	Regionalization	Regionalization	Regionalization
Subalternative		A	A	A	A	A	A	A
Option	Units							
Land for new facilities, minimum	Acres	6	19	0				
Land for new facilities, maximum	Acres	18	19	0				
Site area	Acres	358,400	570,914	198,000				
Percent of site area, maximum		0.01	0.00	0.00				
SNF-related employment, minimum	Person-years per year	62	133	200				
SNF-related employment, maximum	Person-years per year	468	133	235				
Baseline site employment	Person-years per year	17,870	9,290	20,055				
Percent of baseline site employment, minimum		0.35	1.43	1.00				
Percent of baseline site employment, maximum		2.62	1.43	1.17				
Estimated maximum latent cancer fatalities in 80-km population, SNF management	Latent cancer fatalities per year	6.3E-4	1.0E-4	9.0E-3				
Estimated maximum latent cancer fatalities in 80-km population, site operations	Latent cancer fatalities per year	4.0E-4	4.0E-5	4.4E-3				
Estimated maximum probability of latent cancer fatalities in MEI, SNF management	Latent cancer fatalities per year	1.1E-8	3.2E-8	2.0E-7				
Estimated maximum probability of latent cancer fatalities in MEI, site operations	Latent cancer fatalities per year	5.0E-5	2.8E-8	6.5E-8				
Estimated maximum probability of latent cancer fatality in worker, SNF management	Latent cancer fatalities per year	2.0E-4	1.1E-5	6.0E-5				
Maximum probability of latent cancer fatality in worker, site operations	Latent cancer fatalities per year	2.7E-5	1.0E-5	8.8E-5				
Water use, SNF management, minimum	Million gallons per year	1	1	14				
Water use, SNF management, maximum	Million gallons per year	40	1	94				
Baseline water use, site operations	Million gallons per year	3,963	1,717	23,300				
Maximum percent of baseline site water use		1.00	0.04	0.40				
Electricity use, SNF management, minimum	Megawatt-hours per year	100	176	24,400				
Electricity use, SNF management, maximum	Megawatt-hours per year	127,000	2,279	67,400				
Baseline site electricity use	Megawatt-hours per year	340,000	208,000	660,000				
Percent of site electricity use, minimum		0.03	0.08	3.70				
Percent of site electricity use, maximum		37.35	1.10	10.21				
Sewage, SNF management, minimum	Million gallons per year	1	0	13				
Sewage, SNF management, maximum	Million gallons per year	3	0	13				
Baseline site sewage	Million gallons per year	55	143	182				
Percent of baseline site sewage, maximum		5.71	0.28	7.14				

Table K-1. (continued).

		Hanford	INEL	SRS	ORR	NTS	Naval	Other
Alternative		Regionalization	Regionalization	Regionalization	Regionalization	Regionalization	Regionalization	Regionalization
Subalternative		A	A	A	A	A	A	A
Option	Units							
High level waste, SNF management, minimum	Cubic meters per year	0	0	0				
High level waste, SNF management, maximum	Cubic meters per year	23	31	2				
Transuranic waste, SNF management, minimum	Cubic meters per year	0	0	18				
Transuranic waste, SNF management, maximum	Cubic meters per year	20	36	20				
Mixed waste, SNF management, minimum	Cubic meters per year	0	0	0				
Mixed waste, SNF management, maximum	Cubic meters per year	1	1	0				
Low level waste, SNF management, minimum	Cubic meters per year	94	458	400				
Low level waste, SNF management, maximum	Cubic meters per year	220	881	1,700				
High-level, transuranic, and mixed wastes generated, minimum	Cubic meters per year	0	0	18				
High-level, transuranic, and mixed wastes generated, maximum	Cubic meters per year	44	68	22				
Estimated maximum latent cancer fatalities in 80-km population from maximum risk accident	Latent cancer fatalities	8.1E+1	7.0E+0	8.5E-3				
Estimated maximum risk of latent cancer fatalities in 80-km population from maximum risk accident	Latent cancer fatalities per year	4.9E-4	7.0E-5	3.7E-3				
Estimated maximum worker latent cancer fatalities from maximum risk accident	Latent cancer fatalities	9.4E-2	3.2E-3	4.8E-6				
Estimated maximum risk of worker latent cancer fatalities from maximum risk accident	Latent cancer fatalities per year	5.7E-7	4.0E-8	2.1E-6				

Table K-1. (continued).

		Hanford	INEL	SRS	ORR	NTS	Naval	Other
Alternative		Regionalization	Regionalization	Regionalization	Regionalization	Regionalization	Regionalization	Regionalization
Subalternative		B	B	B	B	B	B	B
Option	Units	1W,4W	2W,5W	1E,2E,3E	4E,5E,6E	3W,6W	N/A	N/A
Land for new facilities, minimum	Acres	66	31	0	120	120		
Land for new facilities, maximum	Acres	98	31	30	120	120		
Site area	Acres	358,400	570,914	198,000	34,560	864,000		
Percent of site area, maximum		0.03	0.01	0.02	0.35	0.01		
SNF-related employment, minimum	Person-years per year	734	233	797	1,063	1,063		
SNF-related employment, maximum	Person-years per year	1,366	233	852	1,063	1,063		
Baseline site employment	Person-years per year	17,870	9,290	20,055	16,980	7,091		
Percent of baseline site employment, minimum		4.11	2.51	3.97	6.26	14.99		
Percent of baseline site employment, maximum		7.64	2.51	4.25	6.26	14.99		
Estimated maximum latent cancer fatalities in 80-km population, SNF management	Latent cancer fatalities per year	6.3E-4	2.0E-4	9.0E-3	2.6E-3	4.5E-5		
Estimated maximum latent cancer fatalities in 80-km population, site operations	Latent cancer fatalities per year	4.0E-4	4.0E-5	4.4E-3	2.8E-2	2.5E-6		
Estimated maximum probability of latent cancer fatalities in MEI, SNF management	Latent cancer fatalities per year	1.1E-8	5.2E-8	2.0E-7	3.1E-6	6.5E-8		
Estimated maximum probability of latent cancer fatalities in MEI, site operations	Latent cancer fatalities per year	5.0E-5	2.8E-8	6.5E-8	9.2E-6	5.5E-9		
Estimated maximum probability of latent cancer fatality in worker, SNF management	Latent cancer fatalities per year	2.0E-4	1.1E-5	7.0E-5	2.0E-5	2.0E-5		
Maximum probability of latent cancer fatality in worker, site operations	Latent cancer fatalities per year	2.7E-5	1.0E-5	8.8E-5	1.2E-6	2.0E-6		
Water use, SNF management, minimum	Million gallons per year	6	1	16	6	6		
Water use, SNF management, maximum	Million gallons per year	45	1	16	6	6		
Baseline water use, site operations	Million gallons per year	3,963	1,717	23,300	6,680	1,120		
Maximum percent of baseline site water use		1.12	0.05	0.07	0.09	0.54		
Electricity use, SNF management, minimum	Megawatt-hours per year	10,100	176	34,400	33,000	33,000		
Electricity use, SNF management, maximum	Megawatt-hours per year	137,000	4,279	66,400	33,000	33,000		
Baseline site electricity use	Megawatt-hours per year	340,000	208,000	660,000	1,000,000	183,100		
Percent of site electricity use, minimum		2.97	0.08	5.21	3.30	18.02		
Percent of site electricity use, maximum		40.29	2.06	10.06	3.30	18.02		
Sewage, SNF management, minimum	Million gallons per year	2	0	13	4	4		
Sewage, SNF management, maximum	Million gallons per year	5	0	13	4	4		
Baseline site sewage	Million gallons per year	55	143	182	200	0		
Percent of baseline site sewage, maximum		9.52	0.28	7.14	1.80			

Table K-1. (continued).

		Hanford	INEL	SRS	ORR	NTS	Naval	Other
Alternative		Regionalization	Regionalization	Regionalization	Regionalization	Regionalization	Regionalization	Regionalization
Subalternative		B	B	B	B	B	B	B
Option	Units	1W,4W	2W,5W	1E,2E,3E	4E,5E,6E	3W,6W	N/A	N/A
High level waste, SNF management, minimum	Cubic meters per year	0	0	0	0	0		
High level waste, SNF management, maximum	Cubic meters per year	23	31	2	0	0		
Transuranic waste, SNF management, minimum	Cubic meters per year	0	0	18	16	16		
Transuranic waste, SNF management, maximum	Cubic meters per year	20	36	20	16	16		
Mixed waste, SNF management, minimum	Cubic meters per year	0	0	0	0	0		
Mixed waste, SNF management, maximum	Cubic meters per year	1	1	0	0	0		
Low level waste, SNF management, minimum	Cubic meters per year	520	458	825	628	628		
Low level waste, SNF management, maximum	Cubic meters per year	645	881	2,125	628	628		
High-level, transuranic, and mixed wastes generated, minimum	Cubic meters per year	0	0	18	16	16		
High-level, transuranic, and mixed wastes generated, maximum	Cubic meters per year	44	68	22	16	16		
Estimated maximum latent cancer fatalities in 80-km population from maximum risk accident	Latent cancer fatalities	8.1E+1	7.0E+0	4.8E+0	8.4E+0	1.8E-1		
Estimated maximum risk of latent cancer fatalities in 80-km population from maximum risk accident	Latent cancer fatalities per year	5.7E-4	7.0E-5	3.5E-3	3.4E-3	1.1E-4		
Estimated maximum worker latent cancer fatalities from maximum risk accident	Latent cancer fatalities	9.4E-2	3.2E-3	6.4E-2	6.4E-2	3.2E-3		
Estimated maximum risk of worker latent cancer fatalities from maximum risk accident	Latent cancer fatalities per year	6.6E-7	4.0E-8	2.0E-6	1.9E-7	1.9E-7		

Table K-1. (continued).

		Hanford	INEL	SRS	ORR	NTS	Naval	Other
Alternative		Regionalization	Regionalization	Regionalization	Regionalization	Regionalization	Regionalization	Regionalization
Subalternative		B	B	B	B	B	B	B
Option	Units	1E,4E	N/A	1W,2W,3W	4W,5W,6W	3E,6E	N/A	N/A
Land for new facilities, minimum	Acres	36		0	90	90		
Land for new facilities, maximum	Acres	68		0	90	90		
Site area	Acres	358,400		198,000	34,560	864,000		
Percent of site area, maximum		0.02		0.00	0.26	0.01		
SNF-related employment, minimum	Person-years per year	172		235	501	501		
SNF-related employment, maximum	Person-years per year	804		290	501	501		
Baseline site employment	Person-years per year	17,870		20,055	16,980	7,091		
Percent of baseline site employment, minimum		0.96		1.17	2.95	7.07		
Percent of baseline site employment, maximum		4.50		1.45	2.95	7.07		
Estimated maximum latent cancer fatalities in 80-km population, SNF management	Latent cancer fatalities per year	6.3E-4		9.0E-3	2.5E-3	4.5E-5		
Estimated maximum latent cancer fatalities in 80-km population, site operations	Latent cancer fatalities per year	4.0E-4		4.4E-3	2.8E-2	2.5E-6		
Estimated maximum probability of latent cancer fatalities in MEI, SNF management	Latent cancer fatalities per year	1.1E-8		2.0E-7	3.1E-6	6.5E-8		
Estimated maximum probability of latent cancer fatalities in MEI, site operations	Latent cancer fatalities per year	5.0E-5		6.5E-8	9.2E-6	5.5E-9		
Estimated maximum probability of latent cancer fatality in worker, SNF management	Latent cancer fatalities per year	2.0E-4		7.0E-5	2.0E-5	2.0E-5		
Maximum probability of latent cancer fatality in worker, site operations	Latent cancer fatalities per year	2.7E-5		8.8E-5	1.2E-6	2.0E-6		
Water use, SNF management, minimum	Million gallons per year	3		13	4	4		
Water use, SNF management, maximum	Million gallons per year	42		13	4	4		
Baseline water use, site operations	Million gallons per year	3,963		23,300	6,680	1,120		
Maximum percent of baseline site water use		1.06		0.06	0.05	0.32		
Electricity use, SNF management, minimum	Megawatt-hours per year	100		24,400	23,000	23,000		
Electricity use, SNF management, maximum	Megawatt-hours per year	127,000		56,400	23,000	23,000		
Baseline site electricity use	Megawatt-hours per year	340,000		660,000	1,000,000	183,100		
Percent of site electricity use, minimum		0.03		3.70	2.30	12.56		
Percent of site electricity use, maximum		37.35		8.55	2.30	12.56		
Sewage, SNF management, minimum	Million gallons per year	2		13	4	4		
Sewage, SNF management, maximum	Million gallons per year	5		13	4	4		
Baseline site sewage	Million gallons per year	55		182	200	0		
Percent of baseline site sewage, maximum		9.52		7.14	1.80			

Table K-1. (continued).

		Hanford	INEL	SRS	ORR	NTS	Naval	Other
Alternative		Regionalization	Regionalization	Regionalization	Regionalization	Regionalization	Regionalization	Regionalization
Subalternative		B	B	B	B	B	B	B
Option	Units	1E,4E	N/A	1W,2W,3W	4W,5W,6W	3E,6E	N/A	N/A
High level waste, SNF management, minimum	Cubic meters per year	0		0	0	0		
High level waste, SNF management, maximum	Cubic meters per year	23		2	0	0		
Transuranic waste, SNF management, minimum	Cubic meters per year	0		18	16	16		
Transuranic waste, SNF management, maximum	Cubic meters per year	20		20	16	16		
Mixed waste, SNF management, minimum	Cubic meters per year	0		0	0	0		
Mixed waste, SNF management, maximum	Cubic meters per year	1		0	0	0		
Low level waste, SNF management, minimum	Cubic meters per year	95		400	203	203		
Low level waste, SNF management, maximum	Cubic meters per year	220		1,700	203	203		
High-level, transuranic, and mixed wastes generated, minimum	Cubic meters per year	0		18	16	16		
High-level, transuranic, and mixed wastes generated, maximum	Cubic meters per year	44		22	16	16		
Estimated maximum latent cancer fatalities in 80-km population from maximum risk accident	Latent cancer fatalities	8.1E+1		8.5E-3	2.1E-2	6.6E-4		
Estimated maximum risk of latent cancer fatalities in 80-km population from maximum risk accident	Latent cancer fatalities per year	5.7E-4		3.5E-3	3.4E-3	1.1E-4		
Estimated maximum worker latent cancer fatalities from maximum risk accident	Latent cancer fatalities	9.4E-2		4.8E-6	1.9E-3	1.9E-3		
Estimated maximum risk of worker latent cancer fatalities from maximum risk accident	Latent cancer fatalities per year	6.6E-7		2.0E-6	1.9E-7	1.9E-7		

Table K-1. (continued).

		Hanford	INEL	SRS	ORR	NTS	Naval	Other
Alternative		Regionalization	Regionalization	Regionalization	Regionalization	Regionalization	Regionalization	Regionalization
Subalternative		B	B	B	B	B	B	B
Option	Units	2,3,5,6	1,3,4,6	4,5,6	1,2,3	1,2,4,5	N/A	N/A
Land for new facilities, minimum	Acres	6	1	0				
Land for new facilities, maximum	Acres	12	1	0				
Site area	Acres	358,400	570,914	198,000				
Percent of site area, maximum		0.00	0.00	0.00				
SNF-related employment, minimum	Person-years per year	209	-219	90				
SNF-related employment, maximum	Person-years per year	585	-219	90				
Baseline site employment	Person-years per year	17,870	9,290	20,055				
Percent of baseline site employment, minimum		1.17	-2.36	0.45				
Percent of baseline site employment, maximum		3.27	-2.36	0.45				
Estimated maximum latent cancer fatalities in 80-km population, SNF management	Latent cancer fatalities per year	6.3E-4	4.0E-5	2.3E-9				
Estimated maximum latent cancer fatalities in 80-km population, site operations	Latent cancer fatalities per year	4.0E-4	4.0E-5	4.4E-3				
Estimated maximum probability of latent cancer fatalities in MEI, SNF management	Latent cancer fatalities per year	1.1E-8	3.0E-8	2.0E-7				
Estimated maximum probability of latent cancer fatalities in MEI, site operations	Latent cancer fatalities per year	5.0E-5	2.8E-8	6.5E-8				
Estimated maximum probability of latent cancer fatality in worker, SNF management	Latent cancer fatalities per year	2.0E-4	1.1E-5	5.0E-5				
Maximum probability of latent cancer fatality in worker, site operations	Latent cancer fatalities per year	2.7E-5	1.0E-5	8.8E-5				
Water use, SNF management, minimum	Million gallons per year	20	-3	10				
Water use, SNF management, maximum	Million gallons per year	40	-3	10				
Baseline water use, site operations	Million gallons per year	3,963	1,717	23,300				
Maximum percent of baseline site water use		1.00	-0.15	0.04				
Electricity use, SNF management, minimum	Megawatt-hours per year	0	-9,890	11,400				
Electricity use, SNF management, maximum	Megawatt-hours per year	20,000	-7,721	11,400				
Baseline site electricity use	Megawatt-hours per year	340,000	208,000	660,000				
Percent of site electricity use, minimum		0.00	-4.75	1.73				
Percent of site electricity use, maximum		5.88	-3.71	1.73				
Sewage, SNF management, minimum	Million gallons per year	2	0	10				
Sewage, SNF management, maximum	Million gallons per year	3	0	10				
Baseline site sewage	Million gallons per year	55	143	182				
Percent of baseline site sewage, maximum		4.76	0.14	5.49				

Table K-1. (continued).

		Hanford	INEL	SRS	ORR	NTS	Naval	Other
Alternative		Regionalization	Regionalization	Regionalization	Regionalization	Regionalization	Regionalization	Regionalization
Subalternative		B	B	B	B	B	B	B
Option	Units	2,3,5,6	1,3,4,6	4,5,6	1,2,3	1,2,4,5	N/A	N/A
High level waste, SNF management, minimum	Cubic meters per year	0	0	0				
High level waste, SNF management, maximum	Cubic meters per year	23	27	0				
Transuranic waste, SNF management, minimum	Cubic meters per year	0	0	5				
Transuranic waste, SNF management, maximum	Cubic meters per year	20	32	5				
Mixed waste, SNF management, minimum	Cubic meters per year	0	0	0				
Mixed waste, SNF management, maximum	Cubic meters per year	1	0	0				
Low level waste, SNF management, minimum	Cubic meters per year	110	0	400				
Low level waste, SNF management, maximum	Cubic meters per year	220	133	400				
High-level, transuranic, and mixed wastes generated, minimum	Cubic meters per year	0	0	5				
High-level, transuranic, and mixed wastes generated, maximum	Cubic meters per year	44	59	5				
Estimated maximum latent cancer fatalities in 80-km population from maximum risk accident	Latent cancer fatalities	8.1E+1	7.0E+0	8.5E-3				
Estimated maximum risk of latent cancer fatalities in 80-km population from maximum risk accident	Latent cancer fatalities per year	4.1E-4	7.0E-5	1.4E-3				
Estimated maximum worker latent cancer fatalities from maximum risk accident	Latent cancer fatalities	9.4E-2	3.9E-5	4.8E-6				
Estimated maximum risk of worker latent cancer fatalities from maximum risk accident	Latent cancer fatalities per year	4.7E-7	4.0E-8	7.7E-7				

Table K-1. (continued).

		Hanford	INEL	SRS	ORR	NTS	Naval	Other
Alternative		Centrali-zation	Centrali-zation	Centrali-zation	Centrali-zation	Centrali-zation	Centrali-zation	Centrali-zation
Subalternative								
Option	Units	A	B	C	D	E	N/A	N/A
Land for new facilities, minimum	Acres	116	31	70	120	120		
Land for new facilities, maximum	Acres	123	31	130	120	120		
Site area	Acres	358,400	570,914	198,000	34,560	864,000		
Percent of site area, maximum		0.03	0.01	0.07	0.35	0.01		
SNF-related employment, minimum	Person-years per year	848	233	1,602	1,063	1,063		
SNF-related employment, maximum	Person-years per year	1,464	233	1,677	1,063	1,063		
Baseline site employment	Person-years per year	17,870	9,290	20,055	16,980	7,091		
Percent of baseline site employment, minimum		4.74	2.51	7.99	6.26	14.99		
Percent of baseline site employment, maximum		8.19	2.51	8.36	6.26	14.99		
Estimated maximum latent cancer fatalities in 80-km population, SNF management	Latent cancer fatalities per year	6.3E-4	2.0E-4	9.0E-3	2.6E-3	4.5E-5		
Estimated maximum latent cancer fatalities in 80-km population, site operations	Latent cancer fatalities per year	4.0E-4	4.0E-5	4.4E-3	2.8E-2	2.5E-6		
Estimated maximum probability of latent cancer fatalities in MEI, SNF management	Latent cancer fatalities per year	1.1E-8	5.2E-8	2.0E-7	3.1E-6	6.5E-8		
Estimated maximum probability of latent cancer fatalities in MEI, site operations	Latent cancer fatalities per year	5.0E-5	2.8E-8	6.5E-8	9.2E-6	5.5E-9		
Estimated maximum probability of latent cancer fatality in worker, SNF management	Latent cancer fatalities per year	2.0E-4	1.1E-5	6.0E-4	2.0E-5	2.0E-5		
Maximum probability of latent cancer fatality in worker, site operations	Latent cancer fatalities per year	2.7E-5	1.0E-5	8.8E-5	1.2E-6	2.0E-6		
Water use, SNF management, minimum	Million gallons per year	9	1	23	6	6		
Water use, SNF management, maximum	Million gallons per year	45	1	103	6	6		
Baseline water use, site operations	Million gallons per year	3,963	1,717	23,300	6,680	1,120		
Maximum percent of baseline site water use		1.12	0.05	0.44	0.09	0.54		
Electricity use, SNF management, minimum	Megawatt-hours per year	10,100	176	54,400	33,000	33,000		
Electricity use, SNF management, maximum	Megawatt-hours per year	137,000	4,279	120,400	33,000	33,000		
Baseline site electricity use	Megawatt-hours per year	340,000	208,000	660,000	1,000,000	183,100		
Percent of site electricity use, minimum		2.97	0.08	8.24	3.30	18.02		
Percent of site electricity use, maximum		40.29	2.06	18.24	3.30	18.02		
Sewage, SNF management, minimum	Million gallons per year	2	0	18	4	4		
Sewage, SNF management, maximum	Million gallons per year	5	0	18	4	4		
Baseline site sewage	Million gallons per year	55	143	182	200	0		
Percent of baseline site sewage, maximum		9.52	0.28	9.89	2.00			

Table K-1. (continued).

		Hanford	INEL	SRS	ORR	NTS	Naval	Other
Alternative		Centrali-zation	Centrali-zation	Centrali-zation	Centrali-zation	Centrali-zation	Centrali-zation	Centrali-zation
Subalternative								
Option	Units	A	B	C	D	E	N/A	N/A
High level waste, SNF management, minimum	Cubic meters per year	0	0	0	0	0		
High level waste, SNF management, maximum	Cubic meters per year	23	31	2	0	0		
Transuranic waste, SNF management, minimum	Cubic meters per year	0	0	18	16	16		
Transuranic waste, SNF management, maximum	Cubic meters per year	20	36	20	16	16		
Mixed waste, SNF management, minimum	Cubic meters per year	1	0	0	0	0		
Mixed waste, SNF management, maximum	Cubic meters per year	1	1	0	0	0		
Low level waste, SNF management, minimum	Cubic meters per year	1,010	458	825	628	628		
Low level waste, SNF management, maximum	Cubic meters per year	1,140	881	2,125	628	628		
High-level, transuranic, and mixed wastes generated, minimum	Cubic meters per year	1	0	18	16	16		
High-level, transuranic, and mixed wastes generated, maximum	Cubic meters per year	44	68	22	16	16		
Estimated maximum latent cancer fatalities in 80-km population from maximum risk accident	Latent cancer fatalities	8.1E+1	7.0E+0	4.8E+0	8.4E+0	1.8E-1		
Estimated maximum risk of latent cancer fatalities in 80-km population from maximum risk accident	Latent cancer fatalities per year	6.5E-4	7.0E-5	7.2E-3	3.4E-3	1.1E-4		
Estimated maximum worker latent cancer fatalities from maximum risk accident	Latent cancer fatalities	9.4E-2	3.2E-3	6.4E-2	6.4E-2	3.2E-3		
Estimated maximum risk of worker latent cancer fatalities from maximum risk accident	Latent cancer fatalities per year	7.5E-7	4.0E-8	4.0E-6	1.9E-7	1.9E-7		

Table K-1. (continued).

		Hanford	INEL	SRS	ORR	NTS	Naval	Other
Alternative		Centrali-zation	Centrali-zation	Centrali-zation	Centrali-zation	Centrali-zation	Centrali-zation	Centrali-zation
Subalternative								
Option	Units	B,C,D,E	A,C,D,E	A,B,D,E	A,B,C,E	A,B,C,D	N/A	N/A
Land for new facilities, minimum	Acres	6	1	0				
Land for new facilities, maximum	Acres	12	1	0				
Site area	Acres	358,400	570,914	198,000				
Percent of site area, maximum		0.00	0.00	0.00				
SNF-related employment, minimum	Person-years per year	209	-219	90				
SNF-related employment, maximum	Person-years per year	585	-219	90				
Baseline site employment	Person-years per year	17,870	9,290	20,055				
Percent of baseline site employment, minimum		1.17	-2.36	0.45				
Percent of baseline site employment, maximum		3.27	-2.36	0.45				
Estimated maximum latent cancer fatalities in 80-km population, SNF management	Latent cancer fatalities per year	6.3E-4	4.0E-5	2.3E-9				
Estimated maximum latent cancer fatalities in 80-km population, site operations	Latent cancer fatalities per year	4.0E-4	4.0E-5	4.4E-3				
Estimated maximum probability of latent cancer fatalities in MEI, SNF management	Latent cancer fatalities per year	1.1E-8	3.0E-8	2.0E-7				
Estimated maximum probability of latent cancer fatalities in MEI, site operations	Latent cancer fatalities per year	5.0E-5	2.8E-8	6.5E-8				
Estimated maximum probability of latent cancer fatality in worker, SNF management	Latent cancer fatalities per year	2.0E-4	1.1E-5	5.0E-5				
Maximum probability of latent cancer fatality in worker, site operations	Latent cancer fatalities per year	2.7E-5	1.0E-5	8.8E-5				
Water use, SNF management, minimum	Million gallons per year	20	-3	10				
Water use, SNF management, maximum	Million gallons per year	40	-3	10				
Baseline water use, site operations	Million gallons per year	3,963	1,717	23,300				
Maximum percent of baseline site water use		1.00	-0.15	0.04				
Electricity use, SNF management, minimum	Megawatt-hours per year	0	-9,890	11,400				
Electricity use, SNF management, maximum	Megawatt-hours per year	20,000	-7,721	11,400				
Baseline site electricity use	Megawatt-hours per year	340,000	208,000	660,000				
Percent of site electricity use, minimum		0.00	-4.75	1.73				
Percent of site electricity use, maximum		5.88	-3.71	1.73				
Sewage, SNF management, minimum	Million gallons per year	2	0	10				
Sewage, SNF management, maximum	Million gallons per year	3	0	10				
Baseline site sewage	Million gallons per year	55	143	182				
Percent of baseline site sewage, maximum		4.76	0.14	5.49				

Table K-1. (continued).

		Hanford	INEL	SRS	ORR	NTS	Naval	Other
Alternative		Centrali-zation	Centrali-zation	Centrali-zation	Centrali-zation	Centrali-zation	Centrali-zation	Centrali-zation
Subalternative								
Option	Units	B,C,D,E	A,C,D,E	A,B,D,E	A,B,C,E	A,B,C,D	N/A	N/A
High level waste, SNF management, minimum	Cubic meters per year	0	0	0				
High level waste, SNF management, maximum	Cubic meters per year	23	27	0				
Transuranic waste, SNF management, minimum	Cubic meters per year	0	0	5				
Transuranic waste, SNF management, maximum	Cubic meters per year	20	32	5				
Mixed waste, SNF management, minimum	Cubic meters per year	0	0	0				
Mixed waste, SNF management, maximum	Cubic meters per year	1	0	0				
Low level waste, SNF management, minimum	Cubic meters per year	110	0	400				
Low level waste, SNF management, maximum	Cubic meters per year	220	133	400				
High-level, transuranic, and mixed wastes generated, minimum	Cubic meters per year	0	0	5				
High-level, transuranic, and mixed wastes generated, maximum	Cubic meters per year	44	59	5				
Estimated maximum latent cancer fatalities in 80-km population from maximum risk accident	Latent cancer fatalities	8.1E+1	7.0E+0	8.5E-3				
Estimated maximum risk of latent cancer fatalities in 80-km population from maximum risk accident	Latent cancer fatalities per year	4.1E-4	7.0E-5	1.4E-3				
Estimated maximum worker latent cancer fatalities from maximum risk accident	Latent cancer fatalities	9.4E-2	3.9E-5	4.8E-6				
Estimated maximum risk of worker latent cancer fatalities from maximum risk accident	Latent cancer fatalities per year	4.7E-7	4.0E-8	7.7E-7				

Table K-2. Summary of impacts by alternative.

Alternative		No-Action	Decentrali-zation	Decentrali-zation	Decentrali-zation	Planning Basis	Regionali-zation	Regionali-zation	Regionali-zation	Regionali-zation	Regionali-zation
Subalternative							A	B	B	B	B
Option	Units	No-Action	A	B	C			1E	1W	2W	3E
Land for new facilities, minimum	Acres	17	28	28	28	30	25	37	67	37	97
Land for new facilities, maximum	Acres	29	35	35	35	37	37	99	99	43	133
Site area	Acres	1,133,369	1,133,369	1,127,314	1,127,314	1,127,314	1,127,314	1,127,314	1,127,314	1,127,314	1,991,314
Percent of site area, maximum		0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.01
SNF-related employment, minimum	Person-years per year	-106	52	117	308	413	395	750	750	677	1,288
SNF-related employment, maximum	Person-years per year	-58	889	954	1,145	1,006	836	1,437	1,437	1,108	1,718
Baseline site employment	Person-years per year	79,665	77,265	77,265	77,265	47,215	47,215	47,215	47,215	47,215	54,306
Percent of baseline site employment, minimum		-0.13	0.07	0.15	0.40	0.87	0.84	1.59	1.59	1.43	2.37
Percent of baseline site employment, maximum		-0.07	1.15	1.23	1.48	2.13	1.77	3.04	3.04	2.35	3.16
Estimated maximum latent cancer fatalities in 80-km population, SNF management	Latent cancer fatalities per year	8.8E-5	9.0E-3	9.0E-3	9.0E-3	8.7E-3	9.7E-3	9.7E-3	9.7E-3	9.8E-3	9.7E-3
Estimated maximum latent cancer fatalities in 80-km population, site operations	Latent cancer fatalities per year	5.0E-3	5.3E-3	5.3E-3	5.3E-3	4.8E-3	4.8E-3	4.8E-3	4.8E-3	4.8E-3	4.8E-3
Estimated maximum probability of latent cancer fatalities in MEI, SNF management	Latent cancer fatalities per year	1.5E-6	1.5E-6	1.5E-6	1.5E-6	2.0E-7	2.0E-7	2.0E-7	2.0E-7	2.0E-7	2.0E-7
Estimated maximum probability of latent cancer fatalities in MEI, site operations	Latent cancer fatalities per year	1.5E-6	5.0E-5	5.0E-5	5.0E-5	5.0E-5	5.0E-5	5.0E-5	5.0E-5	5.0E-5	5.0E-5
Estimated maximum probability of latent cancer fatality in worker, SNF management	Latent cancer fatalities per year	1.6E-4	2.0E-4	2.0E-4	2.0E-4	2.0E-4	2.0E-4	2.0E-4	2.0E-4	2.0E-4	2.0E-4
Maximum probability of latent cancer fatality in worker, site operations	Latent cancer fatalities per year	8.8E-5	8.8E-5	8.8E-5	8.8E-5	8.8E-5	8.8E-5	8.8E-5	8.8E-5	8.8E-5	8.8E-5
Water use, SNF management, minimum	Million gallons per year	6	13	13	16	16	16	16	16	34	36
Water use, SNF management, maximum	Million gallons per year	6	133	133	136	136	134	55	55	53	56
Baseline water use, site operations	Million gallons per year	38,839	38,839	38,839	38,839	28,980	28,980	28,980	28,980	28,980	30,100
Maximum percent of baseline site water use		0.02	0.34	0.34	0.35	0.47	0.46	0.19	0.19	0.18	0.19
Electricity use, SNF management, minimum	Megawatt-hours per year	-8,500	9,600	9,600	19,600	19,676	24,676	24,610	24,610	24,576	47,510
Electricity use, SNF management, maximum	Megawatt-hours per year	-8,346	173,654	173,654	183,654	185,679	196,679	185,679	185,679	80,679	101,679
Baseline site electricity use	Megawatt-hours per year	1,619,067	1,619,067	1,619,067	1,619,067	1,208,000	1,208,000	1,208,000	1,208,000	1,208,000	1,391,100
Percent of site electricity use, minimum		-0.52	0.59	0.59	1.21	1.63	2.04	2.04	2.04	2.03	3.42
Percent of site electricity use, maximum		-0.52	10.73	10.73	11.34	15.37	16.28	15.37	15.37	6.68	7.31

Table K-2. (continued).

Alternative		No-Action	Decentrali-zation	Decentrali-zation	Decentrali-zation	Planning Basis	Regionali-zation	Regionali-zation	Regionali-zation	Regionali-zation	Regionali-zation
Subalternative							A	B	B	B	B
Option	Units	No-Action	A	B	C			1E	1W	2W	3E
Sewage, SNF management, minimum	Million gallons per year	10	14	14	14	14	14	15	15	16	19
Sewage, SNF management, maximum	Million gallons per year	10	16	16	16	17	17	18	18	16	20
Baseline site sewage	Million gallons per year	380	380	380	380	380	380	380	380	380	380
Percent of baseline site sewage, maximum		2.64	4.25	4.25	4.25	4.36	4.36	4.86	4.86	4.22	5.21
High level waste, SNF management, minimum	Cubic meters per year	0	0	0	0	0	0	0	0	0	0
High level waste, SNF management, maximum	Cubic meters per year	0	25	25	25	56	56	52	52	56	52
Transuranic waste, SNF management, minimum	Cubic meters per year	17	18	18	18	18	18	18	18	18	34
Transuranic waste, SNF management, maximum	Cubic meters per year	17	40	40	40	76	76	72	72	76	88
Mixed waste, SNF management, minimum	Cubic meters per year	1	0	0	0	1	1	1	1	1	1
Mixed waste, SNF management, maximum	Cubic meters per year	1	1	1	1	2	2	1	1	2	1
Low level waste, SNF management, minimum	Cubic meters per year	550	494	494	919	952	952	920	920	968	1,138
Low level waste, SNF management, maximum	Cubic meters per year	550	1,920	1,920	2,345	2,801	2,801	2,478	2,478	2,801	2,681
High-level, transuranic, and mixed wastes generated, minimum	Cubic meters per year	18	18	18	18	19	19	19	19	19	35
High-level, transuranic, and mixed wastes generated, maximum	Cubic meters per year	18	66	66	66	134	134	125	125	134	141
Estimated maximum latent cancer fatalities in 80-km population from maximum risk accident	Latent cancer fatalities	3.7E+1	8.1E+1	8.1E+1	8.1E+1	8.1E+1	8.1E+1	8.1E+1	8.1E+1	8.1E+1	8.1E+1
Estimated maximum risk of latent cancer fatalities in 80-km population from maximum risk accident	Latent cancer fatalities per year	3.7E-3	3.0E-3	3.0E-3	3.0E-3	3.4E-3	3.7E-3	3.5E-3	3.5E-3	3.5E-3	3.5E-3
Estimated maximum worker latent cancer fatalities from maximum risk accident	Latent cancer fatalities	7.4E-2	9.4E-2	9.4E-2	9.4E-2	9.4E-2	9.4E-2	9.4E-2	9.4E-2	9.4E-2	9.4E-2
Estimated maximum risk of worker latent cancer fatalities from maximum risk accident	Latent cancer fatalities per year	1.4E-7	5.7E-7	5.7E-7	5.7E-7	5.7E-7	5.7E-7	2.0E-6	6.6E-7	4.7E-7	2.0E-6
Estimated maximum total fatalities from incident-free SNF transportation	Fatalities per year	2.2E-4	5.8E-3	5.8E-3	6.5E-3	8.5E-3	1.3E-2	1.1E-2	1.1E-2	1.0E-2	1.9E-2
Estimated maximum risk of cancer fatalities from all transportation accidents	Cancer fatalities per year	1.0E-7	1.3E-6	1.4E-6	2.5E-6	3.5E-6	5.0E-6	1.3E-5	4.3E-6	2.8E-6	1.6E-5
Estimated maximum risk of traffic fatalities from transportation accidents	Fatalities per year	1.2E-3	2.5E-3	3.0E-3	2.3E-2	1.5E-2	1.6E-2	1.8E-2	1.6E-2	1.5E-2	1.9E-2

Table K-2. (continued).

Alternative		Regionalization	Regionalization	Regionalization	Regionalization	Regionalization	Regionalization	Centralization	Centralization	Centralization	Centralization	Centralization
Subalternative		B	B	B	B	B	B					
Option	Units	3W	4E	4W	5W	6E	6W	A	B	C	D	E
Land for new facilities, minimum	Acres	127	157	157	127	217	217	117	37	77	127	127
Land for new facilities, maximum	Acres	133	189	189	133	223	223	124	43	143	133	133
Site area	Acres	1,991,314	1,161,874	1,161,874	1,161,874	2,025,874	2,025,874	1,127,314	1,127,314	1,127,314	1,161,874	1,991,314
Percent of site area, maximum		0.01	0.02	0.02	0.01	0.01	0.01	0.01	0.00	0.01	0.01	0.01
SNF-related employment, minimum	Person-years per year	1,288	1,106	1,106	1,033	1,644	1,644	719	532	1,592	1,143	1,143
SNF-related employment, maximum	Person-years per year	1,718	1,738	1,738	1,409	2,019	2,019	1,335	908	2,042	1,518	1,518
Baseline site employment	Person-years per year	54,306	64,195	64,195	64,195	71,286	71,286	47,215	47,215	47,215	64,195	54,306
Percent of baseline site employment, minimum		2.37	1.72	1.72	1.61	2.31	2.31	1.52	1.13	3.37	1.78	2.10
Percent of baseline site employment, maximum		3.16	2.71	2.71	2.19	2.83	2.83	2.83	1.92	4.33	2.37	2.80
Estimated maximum latent cancer fatalities in 80-km population, SNF management	Latent cancer fatalities per year	9.7E-3	3.2E-3	3.2E-3	3.3E-3	3.3E-3	3.2E-3	6.7E-4	8.3E-4	9.7E-3	3.2E-3	7.2E-4
Estimated maximum latent cancer fatalities in 80-km population, site operations	Latent cancer fatalities per year	4.8E-3	3.2E-2	3.2E-2	3.2E-2	3.2E-2	3.2E-2	4.8E-3	4.8E-3	4.8E-3	3.2E-2	4.8E-3
Estimated maximum probability of latent cancer fatalities in MEI, SNF management	Latent cancer fatalities per year	2.0E-7	3.1E-6	3.1E-6	3.1E-6	3.1E-6	3.1E-6	2.0E-7	2.0E-7	2.0E-7	3.1E-6	2.0E-7
Estimated maximum probability of latent cancer fatalities in MEI, site operations	Latent cancer fatalities per year	5.0E-5	5.0E-5	5.0E-5	5.0E-5	5.0E-5	5.0E-5	5.0E-5	5.0E-5	5.0E-5	5.0E-5	5.0E-5
Estimated maximum probability of latent cancer fatality in worker, SNF management	Latent cancer fatalities per year	2.0E-4	2.0E-4	2.0E-4	2.0E-4	2.0E-4	2.0E-4	2.0E-4	2.0E-4	6.0E-4	2.0E-4	2.0E-4
Maximum probability of latent cancer fatality in worker, site operations	Latent cancer fatalities per year	8.8E-5	8.8E-5	8.8E-5	8.8E-5	8.8E-5	8.8E-5	8.8E-5	8.8E-5	8.8E-5	8.8E-5	8.8E-5
Water use, SNF management, minimum	Million gallons per year	36	17	17	34	37	37	16	31	40	33	33
Water use, SNF management, maximum	Million gallons per year	56	55	55	54	57	57	52	50	140	53	53
Baseline water use, site operations	Million gallons per year	30,100	35,660	35,660	35,660	36,780	36,780	28,980	28,980	28,980	35,660	30,100
Maximum percent of baseline site water use		0.19	0.16	0.16	0.15	0.15	0.15	0.18	0.17	0.48	0.15	0.18
Electricity use, SNF management, minimum	Megawatt-hours per year	47,510	34,610	34,610	34,576	57,510	57,510	11,610	11,576	44,510	34,510	34,510
Electricity use, SNF management, maximum	Megawatt-hours per year	101,679	163,679	163,679	58,679	79,679	79,679	140,679	35,679	132,679	56,679	56,679
Baseline site electricity use	Megawatt-hours per year	1,391,100	2,208,000	2,208,000	2,208,000	2,391,100	2,391,100	1,208,000	1,208,000	1,208,000	2,208,000	1,391,100
Percent of site electricity use, minimum		3.42	1.57	1.57	1.57	2.41	2.41	0.96	0.96	3.68	1.56	2.48
Percent of site electricity use, maximum		7.31	7.41	7.41	2.66	3.33	3.33	11.65	2.95	10.98	2.57	4.07

Table K-2. (continued).

Alternative		Regionalization	Regionalization	Regionalization	Regionalization	Regionalization	Regionalization	Centralization	Centralization	Centralization	Centralization	Centralization
Subalternative		B	B	B	B	B	B					
Option	Units	3W	4E	4W	5W	6E	6W	A	B	C	D	E
Sewage, SNF management, minimum	Million gallons per year	19	16	16	16	20	20	12	13	20	16	16
Sewage, SNF management, maximum	Million gallons per year	20	19	19	17	20	20	15	13	21	17	17
Baseline site sewage	Million gallons per year	380	580	580	580	580	580	380	380	380	580	380
Percent of baseline site sewage, maximum		5.21	3.29	3.29	2.87	3.52	3.52	4.07	3.43	5.48	2.90	4.43
High level waste, SNF management, minimum	Cubic meters per year	0	0	0	0	0	0	0	0	0	0	0
High level waste, SNF management, maximum	Cubic meters per year	52	50	50	54	50	50	50	54	52	50	50
Transuranic waste, SNF management, minimum	Cubic meters per year	34	21	21	21	37	37	5	5	18	21	21
Transuranic waste, SNF management, maximum	Cubic meters per year	88	73	73	77	89	89	57	61	72	73	73
Mixed waste, SNF management, minimum	Cubic meters per year	1	1	1	1	1	1	1	1	1	1	1
Mixed waste, SNF management, maximum	Cubic meters per year	1	1	1	2	1	1	1	2	1	1	1
Low level waste, SNF management, minimum	Cubic meters per year	1,138	1,123	1,123	1,171	1,341	1,341	1,410	968	935	1,138	1,138
Low level waste, SNF management, maximum	Cubic meters per year	2,681	1,381	1,381	1,704	1,584	1,584	1,673	1,501	2,478	1,381	1,381
High-level, transuranic, and mixed wastes generated, minimum	Cubic meters per year	35	22	22	22	38	38	6	6	19	22	22
High-level, transuranic, and mixed wastes generated, maximum	Cubic meters per year	141	124	124	133	140	140	108	117	125	124	124
Estimated maximum latent cancer fatalities in 80-km population from maximum risk accident	Latent cancer fatalities	8.1E+1	8.1E+1	8.1E+1	8.1E+1	8.1E+1	8.1E+1	8.1E+1	8.1E+1	8.1E+1	8.1E+1	8.1E+1
Estimated maximum risk of latent cancer fatalities in 80-km population from maximum risk accident	Latent cancer fatalities per year	3.5E-3	3.4E-3	3.4E-3	3.4E-3	3.4E-3	3.4E-3	1.4E-3	1.4E-3	7.2E-3	3.4E-3	1.4E-3
Estimated maximum worker latent cancer fatalities from maximum risk accident	Latent cancer fatalities	9.4E-2	9.4E-2	9.4E-2	9.4E-2	9.4E-2	9.4E-2	9.4E-2	9.4E-2	9.4E-2	9.4E-2	9.4E-2
Estimated maximum risk of worker latent cancer fatalities from maximum risk accident	Latent cancer fatalities per year	4.7E-7	6.6E-7	6.6E-7	4.7E-7	4.7E-7	4.7E-7	7.5E-7	4.7E-7	4.0E-6	4.7E-7	4.7E-7
Estimated maximum total fatalities from incident-free SNF transportation	Fatalities per year	1.9E-2	1.2E-2	1.2E-2	1.1E-2	2.0E-2	2.0E-2	2.8E-2	2.5E-2	4.0E-2	3.8E-2	3.5E-2
Estimated maximum risk of cancer fatalities from all transportation accidents	Cancer fatalities per year	9.0E-6	1.2E-5	5.8E-6	4.3E-6	1.5E-5	1.0E-5	9.3E-6	7.8E-6	3.0E-5	2.3E-5	1.5E-5
Estimated maximum risk of traffic fatalities from transportation accidents	Fatalities per year	2.0E-2	1.7E-2	1.6E-2	1.5E-2	1.9E-2	2.0E-2	2.0E-2	1.8E-2	2.5E-2	2.4E-2	2.4E-2

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