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APPENDIX A Hanford Site Spent Nuclear Fuel Management Program

Department of Energy Programmatic
Spent Nuclear Fuel Management
and
Idaho National Engineering Laboratory
Environmental Restoration and
Waste Management Programs
Final Environmental Impact Statement
Volume 1
Appendix A
Hanford Site
Spent Nuclear Fuel Management Program
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1. INTRODUCTION

The U.S. Department of Energy (DOE) is currently deciding the direction of it mental restoration and waste management programs at the Idaho National Engineering tory (INEL) for the next 10 years. Pertinent to this decision is establishing polic environmentally sensitive and safe transport, storage, and management of spent nucl (SNF). To develop these policies, it is necessary to revisit or examine the availab

As a part of the DOE complex, the Hanford Site not only has a large portion o nationwide DOE-owned inventory of SNF, but also is a participant in the DOE decisio management and ultimate disposition of SNF. Efforts in this process at Hanford incl ment of several options for stabilizing, transporting, and storing all or portions SNF at the Hanford Site. Such storage and management of SNF will be in a safe and s manner until a final decision is made for ultimate disposition of SNF. The Hanford affected by the alternative chosen.

Five alternatives involving the Hanford Site are being considered for managem SNF inventory: 1) the No Action Alternative, 2) the Decentralization Alternative, 3 1993 Planning Basis Alternative, 4) the Regionalization Alternative, and 5) the Cen Alternative. All alternatives will be carefully designed to avoid environmental deg to provide protection to human health and safety at the Hanford Site and surroundin For Hanford, these alternatives are briefly summarized below:

- No Action Alternative -- The No Action Alternative would preclude any a tional transportation of SNF to or from Hanford but could include activ maintain safe and secure materials and facilities. Hanford SNF would co to be managed in the current mode and upgrade of existing facilities wo only as required to ensure safety and security.
- Decentralization Alternative -- The Decentralization Alternative would that DOE-owned fuel be managed at the location where it is removed from reactor. Hanford SNF would be safely stored, with some limited onsite r tion of SNF. To accommodate this mission, existing facilities would be and new storage systems would be constructed.
- 1992/1993 Plannin~ Basis -- SNF would continue to be managed in the cur mode, which includes upgrades, fuel stabilization, transport of some SN either INEL or Savannah River Site for storage, and construction of an age facility at Hanford.
- Regionalization Alternative -- The Regionalization Alternative contains that range from storing all SNF west of the Mississippi River including SNF, to shipping all Hanford SNF offsite to either INEL or the Nevada T Existing facilities would be upgraded and new storage systems construct the Decentralization Alternative for SNF storage at Hanford, or packagi ties would be constructed as in the Centralization (Minimum) Alternativ site shipment.
- Centralization Alternative -- The Centralization Alternative has two ma options. Either all Hanford SNF would be shipped offsite to another loc

where all SNF would be centralized (minimum option), or the Hanford Sit would become the centralized location (maximum option) for all DOE SNF stored until ultimate disposition.

The Spent Fuel Working Group Report (DOE 1993a) identified deficiencies relat existing SNF management at the various DOE sites. Most of these deficiencies result radation of the fuel and the facilities that store fuel because of the age of these fuel storage conditions. Corrective actions to the identified deficiencies for each the Hanford Site, are listed in DOE (1994a). Hanford Site corrective actions import EIS include the following:

1. alternative containerization of fuel stored in the 105-KE Basin to isolate a way of fuel constituents to the environment

2. preparation of a K Basins EIS and issuance of the record of decision to provi agement of SNF in the K Basins at the Hanford Site (SNF storage siting and co tion, path forward for ultimate disposition, etc.)

3. removal of all fuel and sludge from the K Basins by December 2002 based on th Basins EIS record of decision

4. technical evaluation and characterization of N Reactor fuel to support develo the K Basins EIS

5. removal of fuel from the Fast Flux Test Facility; the Plutonium and Uranium R through EXtraction (PUREX) Plant; the 308 Building; the 324, 325, and 327 bui T Plant; and the 200-West Area Low-Level Burial Grounds to support prolonged economic, environmentally sound management of those fuels.

On-going corrective actions with prior National Environmental Policy Act (NEPA age, such as containerization of fuel in the 105-KE Basin, are included in the No A tive. Other corrective actions are included within the scope of each of the remaini alternatives. The impacts of continued fuel and facility degradation in the No Acti Alternative are not fully quantified, although it is generally recognized that prol the existing facilities for an additional 40-year period might represent unacceptab reflected in DOE (1993a).

The Hanford Site portion of this EIS was prepared according to the National E mental Policy Act (NEPA) of 1969, as amended; the Council on Environmental Quality regulations (40 CFR Part 1500-1308) for the implementation of the NEPA; and DOE reg tions (10 CFR 1021) that supplement the CEO regulations. This document discusses fi natives for the management and storage of SNF, the affected environment, and potent impacts of the alternatives.

2. BACKGROUND

2.1 Hanford Site Overview

2.1.1 Site Description

The U.S. Department of Energy's Hanford Site lies within the semiarid Pasco Ba
in southeastern Washington State (Figure- 2.1). The Hanford Site occu- pies an are
(560 square miles) north of the confluence of the Yakima River with the Columbia Ri
50 kilometers (30 miles) north to south and 40 kilometers (24 - miles) east to west
public access, provides a buffer for the smaller areas previously used for producti
rials, and currently used for research, waste management and disposal, and environm
tion; only about 6 percent of the land area has been disturbed and is actively used
through the northern part of the Hanford Site, and turning south, it forms part of
The Yakima River runs near the southern boundary and joins the Columbia River south
bounds the Hanford Site on the southeast. Rattlesnake Mountain, the Yakima Ridge,
southwestern and western boundary. The Saddle Mountains form the northern boundary
east-west ridges, Gable Butte and Gable Mountain, rise above the plateau of the cen
Underneath the Hanford Site are ancient basaltic flows with basaltic outcroppings o
of sand and gravel from ancient periods of flooding and glacial epochs. Adjoining
are principally range and agricultural land. The cities of Richland, Kennewick, an
population center and are located southeast of the Hanford Site.

The Hanford Site is listed on the National Priorities List under the Comprehen
ronmental Response, Compensation, and Liability Act. The site encompasses more tha
units and four groundwater contamination plumes that have been grouped into 78 oper
has complementary characteristics of such parameters as geography, waste characteri
and relationship of contaminant plumes. This grouping into operable units allows fo
nomies of scale to reduce the cost and the number of characterization investigation
dial actions that will be required for the
Figure 2-1. Hanford Site and vicinity. Hanford Site to complete cleanup efforts.
4.1. Current maps showing the locations of the operable units can be obtained from

2.1.2 History

The Hanford Site was acquired by the federal government in 1943. For more tha
facilities were dedicated primarily to the production of plutonium for national def
the resulting wastes. In later years, programs at the Hanford Site were diversifie
development for advanced reactors, renewable energy technologies, waste disposal technologies, and cleanup of contamination from past practices.

2.1.3 Mission

The new mission for Hanford emphasizes these components:

- Waste management of stored defense wastes and the handling, storage, and
posal of radioactive,
hazardous, mixed, or sanitary wastes from current operations.
- Environmental restoration of approximately 1,500 inactive radioactive, ha
sites and about 100 surplus facilities.
- Research and development in energy, health, safety, environmental science
lar sciences,
environmental restoration, and waste management.
- Technology development of new environmental restoration and waste managem
nologies, including site characterization and assessment methods; waste m
mization, treatment, and remediation technology; and education outreach p

The DOE has set a goal of cleaning up Hanford's waste sites and bringing its f
local, state, and federal environmental laws by 2018.

2.1.4 Management

The Hanford Site is owned by the federal government and managed by the U.S. De ment of Energy, Richland Operation's Office (DOE-RL). Westinghouse Hanford Company operations and engineering contractor. Pacific Northwest Laboratory, which is oper by Battelle Memorial Institute, manages the research and technology laboratories. Hanford Company and a team of contractors became DOE's environmental restoration co

2.2 Regulatory Framework

The policy of DOE-RL is to carry out its operations in compliance with all app eral laws and regulations, state laws and regulations, presidential executive order Environmental regulatory authority over the Hanford Site is vested both in federal cies, primarily the U.S. Environmental Protection Agency (EPA), and in Washington S cies, primarily the Department of Ecology. Significant environmental laws and regu vant to the management of SNF at Hanford are discussed in this section. First, maj relevant federal and Washington State statutes are listed. Next, the specific topi ciated with spent nuclear fuel are discussed with appropriate citations to federal regulations. U.S. Department of Energy Orders will not be cited in this discussio not regulations. However, DOE Orders do delineate specific DOE procedures and prov for implementation of federal environmental, safety, and health regulations. DOE O rules, and requirements that supplement the federal regulations for the design and operation of existing facilities to ensure safe and environmentally sound operation that environmental restoration and waste management activities at Hanford are gover Facility Agreement and Consent Order (Tri-Party Agreement), which includes detailed federal jurisdiction, as well as specific goals for site management and cleanup. T Party Agreement (January 1994) contains specific milestones (M-34) related to the m Site.

2.2.1 Significant Federal and State Laws

Significant federal and state environmental and nuclear materials management l cable to the Hanford Site include the following (grouped by federal and state and l Federal Laws

- American Antiquities Act (16 U.S.C. 431-433)
- American Indian Religious Freedom Act (42 U.S.C. 1996)
- Archaeological and Historic Preservation Act (16 U.S.C. 469-469c)
- Archaeological Resources Protection Act (16 U.S.C. 470aa-470ll)
- Atomic Energy Act (AEA) (42 U.S.C. 2011 et seq.)
- Bald and Golden Eagle Protection Act (16 U.S.C 668-668d)
- Clean Air Act (CAA) as amended by the Clean Air Act Amendments of 1990 (4
- Clean Water Act (CWA) (33 U.S.C. 1251 et seq.)
- Comprehensive Conservation Study of the Hanford Reach of the Columbia Riv
- Comprehensive Environmental Response, Compensation, and Liability Act (CE Superfund Amendments and Reauthorization Act (SARA) (42 U.S.C. 9601 et seq.)

- Emergency Planning and Community Right-to-Know Act of 1986 (42 U.S.C. 110
- Endangered Species Act (16 U.S.C. 1531-1534)
- Energy Reorganization Act of 1974 (ERA) (42 USC 5801 et seq.)
- Federal Facilities Compliance Act (PL 102-386)
- Fish and Wildlife Coordination Act (16 U.S.C. 661-666c)
- Hazardous Materials Transportation Act (HMTA) (49 USC 1801 et seq.)
- Migratory Bird Treaty Act (16 U.S.C 703-711)
- National Environmental Policy Act (NEPA) (42 U.S.C. 4321 et seq.)
- National Historic Preservation Act (16 U.S.C. 470-470w-6)
- Native American Graves Protection and Repatriation Act (NAGPRA) (25 U.S.C
- Nuclear Waste Policy Act (NWPA) (42 U.S.C. 10101 et seq.)
- Pollution Prevention Act of 1990 (42 U.S.C. 13101 et seq.)
- Resource Conservation and Recovery Act (RCRA) as amended by the Hazardous Amendments (42 U.S.C. 6901 et seq.)
- Safe Drinking Water Act (SDWA) (42 U.S.C. 300f et seq.)
- Toxic Substances Control Act (15 U.S.C. 2601 et seq.)
- Wild and Scenic Rivers Act (16 U.S.C. 1274 et seq.)

State Laws

- Washington Archaeological and Historic Preservation Code (RCW Chapter 27.
- Washington Clean Air Act of 1967 (RCW Chapter 70.94 et seq.)
- Washington Hazardous Waste Management Act of 1976 (RCW Chapter 70.105 et
- Washington Model Toxics Control Act (RCW Chapter 70.105D).
- Washington Water Pollution Control Act (RCW 90.48 et seq.).

2.2.2 Environmental Standards for Spent Nuclear Fuel Storage Facilities

Design and performance standards for the construction and operation of SNF sto ties arise from the Atomic Energy Act, Nuclear Waste Policy Act, Clean Water Act, a parallel state implementation statutes, and other major environmental/nuclear activ ties statutes. A general listing of regulations promulgated under these authoritie included in this discussion of the regulatory framework; relevant regulations will priate in the topical discussions that follow.

2.2.2.1 General Environmental Requirements for Construction and Operation.

Design and construction of new facilities, modification of existing facilities, and ties would be conducted in accordance with applicable state and federal environment lations. Special consideration with respect to operations of SNF management facili discussed in the following sections.

Columbia River water would be used to serve a wet SNF storage facility. The D federally reserved water withdrawal rights with respect to its Hanford operations. application to the Washington State Department of Ecology on July 7, 1987, as a mat withdrawal rights from the Columbia River for site characterization activities rela Waste Isolation Project. It may be appropriate to maintain this protocol with Wash withdrawals from the river.

Operation of SNF facilities may involve the generation of waste materials or u waste materials to the environment. The Pollution Prevention Act requires preventi at the source whenever feasible. Reporting and cleanup of spills from an SNF facil (40 CFR 300, "National Oil and Hazardous Substances Pollution Contingency Plan"), w hazardous substances into the environment, including radioactive substances.

Shipment of SNF is governed by Department of Transportation hazardous material 179 (under the authority of the Hazardous Materials Transportation Act), which appl labeling, and shipment of hazardous materials offsite, including radioactive materi standards for packaging and transporting radioactive materials are governed by U.S. (NRC) standards established in 10 CFR Part 71, "Packaging of Radioactive Material portation of Radioactive Material Under Certain Conditions."

2.2.2.2 Resource Conservation and Recovery Act. The status of SNF with respect to RCRA is discussed

in Volume 1. Most of the authority to administer the RCRA program, including treat standards, and permit requirements, has been delegated by EPA to the State of Washi action (cleanup). Washington State RCRA (WSHWMA) Dangerous Waste Regulations are f Administrative Code). Generally, RCRA does not apply to source material, special n material, SNF, or radioactive-only wastes. Should SNF be processed into or comming defined by Subtitle C of RCRA, then the generation, treatment, storage, and disposa portion of such mixed waste would be subject to EPA regulations in 40 CFR 260-268 a

2.2.2.3 Effluents. Regulations in 40 CFR 122 (and also in 40 CFR 125 and 129) apply to the dis-

charge of pollutants from any point source into waters of the United States. A Nat System (NPDES) permit is required for such discharges, which would include any effl facility into the Columbia River. The EPA has not yet delegated to the State of Wa issue NPDES permits at the Hanford Site. At 40 CFR 121 the regulations provide for activity requiring a federal CWA water permit, i.e., an NPDES permit or a discharge permit, will not violate state water quality standards.

The EPA drinking water standards in 40 CFR 141, "National Primary Drinking Wat Columbia River water at community water supply intakes downstream of the Hanford Si Code 173-200 sets water quality standards for groundwater, and WAC 173-201 establis standards for the State of Washington.

Department of Ecology regulations in WAC 173-216 establish a state permit prog monly referred to as the 216 program, for the discharge of waste materials from ind mercial, and municipal operations into ground and surface waters of the state. Dis ered by NPDES or WAC 173-218 (Underground Injection Control Program) permits are ex The DOE has agreed to meet the requirements of the 216 program at the Hanford Site

2.2.2.4 Air Quality. Hazardous emission standards in 40 CFR 61, "National Emission Standards for

Hazardous Air Pollutants," provide for the control of the emission of hazardous pol standards in 40 CFR 61, Subpart H, "National Emission Standards for Emissions of Ra from Department of Energy Facilities," apply specifically to the emission of radion Approval to construct a new facility or to modify an existing one may be required b not yet delegated this approval authority to the State of Washington for the Hanfor

The Clean Air Act Amendments of 1990 require the addition of 189 substances to pollutants to be regulated on a schedule that extends to 1999. The hazardous air p radionuclides. The amendments require the identification of source categories and control technology (maximum available control technology) for each of these polluta the definition of a major source because total emissions from Hanford may exceed th per year for any combination of listed hazardous air pollutants (emission standards measure for radionuclides will be promulgated in the future). This means that emis become subject to permitting and reporting requirements and to installation require control technology. A new SNF storage facility may be subject to the maximum avai requirements for new sources.

Washington State Department of Health regulations in WAC 246-247, "Monitoring Quality and Emission Standards for Radionuclides," contain standards and permit req radionuclides to the atmosphere from DOE facilities based on Department of Ecology "Ambient Air Quality Standards and Emission Limits for Radionuclides."

The local air authority, Benton County Clean Air Authority, enforces General R pertains to detrimental effects, fugitive dust, incineration products, odor, opacit emissions. Benton County Clean Air Authority has been delegated authority to enfor

2.2.3 Protection of Public Health

Numerical standards for protection of the public from releases to the environm and appear in the Code of Federal Regulations. The most significant of the regulat following paragraphs.

Clean Air Act standards found in 40 CFR 61.92 apply to releases of radionuclides to the atmosphere from DOE facilities and state as follows:

> Emissions of radionuclides [other than radon-220 and radon-222] to the ambient of Energy facilities shall not exceed those amounts that would cause any membe receive in any year an effective dose equivalent of 10 millirem/year.

Safe Drinking Water standards found in 40 CFR 141.16 apply indirectly to relea nuclides from DOE facilities to the extent that the releases impact community water

> The average annual concentration of beta particle and photon radioactivity fro in drinking water shall not produce an annual dose equivalent to the body or a than 4 millirem/year.

Also, maximum contaminant levels in community water systems of 5 pico- curies and radium-228, and maximum contaminant levels of 15 picocuries per liter of gross including radium-226 but excluding radon and uranium, are specified in 40 CFR 141. corresponds to a dose of 4 millirem per year is 20,000 picocuries per liter.

2.2.4 Species Protection

Regulations of the Endangered Species Act, the Bald and Golden Eagle Protectio Treaty Act in 50 CFR 10-24, 222, 225-227, 402, and 450-453 apply to the Hanford Sit requires a biological assessment to identify any threatened or endangered species l proposed action.

2.2.5 Floodplains and Wetlands

Executive Order 11988, "Floodplain Management," Executive Order 11990, "Protec CFR 1022, require an assessment of the effects of DOE actions on floodplains and we directed at the protection of water quality and habitat.

2.2.6 Cultural and Historic Preservation

Requirements of the National Historic Preservation Act in 36 CFR 800, the Amer 25 CFR 261 and 43 CFR 3, and the Archaeological Resources Protection Act and the Am Act in 43 CFR 7 apply to the protection of historic and cultural properties, includ those discovered during excavation and construction. The American Indian Religious American Graves Protection and Repatriation Act also provide for certain rights of traditional areas of worship and religious significance.

2.3 Spent Nuclear Fuel Management Program

This section presents a summary of current plans, as of December 1994, for the the Hanford site. The following SNF and associated facilities are at Hanford (Berg

- N Reactor SNF- Zircaloy-clad metallic uranium fuel stored in water in the basins and exposed to air in the Plutonium and Uranium Recovery through Ex Plant dissolver cells A, B, and C.
- Single-pass reactor SNF - aluminum-clad metallic uranium fuel stored in wa and 105-KW basins and stored in water in the PUREX basin.
- Shippingport Core II SNF - Zircaloy-clad uranium dioxide fuel stored in wa Canyon Pool Cell 4.
- Fast Flux Test Facility (FFTF) SNF - stainless steel-clad fuel stored in 1 FFTF, consisting mostly of plutonium and uranium oxide fuel, but also uran plutonium metals, and carbide and nitride fuel.
- Miscellaneous commercial and experimental SNF - consisting mainly of Zirca dioxide fuel stored in air in the 324, 325, and 327 buildings; TRIGA (trai isotope reactors built by General Atomics) fuel stored in water in the 308 miscellaneous fuel stored in air-filled shielded containers at the 200-Wes grounds; and aluminum-clad, uranium-aluminum alloy fuel stored in air in t Finishing Plant.

Plans for management of Hanford SNF are included in the Hanford Spent Nuclear F Recommended Path Forward (Fulton 1994) and the Spent Nuclear Fuel Project Technical Fiscal Year 1995 (WHC 1995). It should be noted, however, that the SNF management evolve since these documents were issued or drafted. Similarly, Hanford site-speci documentation that will be required to support the Hanford SNF management program c Spent nuclear fuel EISs that are being prepared or that will be prepared include th Hanford site- specific K Basins EIS. The programmatic EIS will lead to a record of scheduled to be published in June 1995. That record of decision will specify what which DOE sites, Naval Reactor Propulsion Program sites, or other sites. The K Bas result in a record of decision that specifies where and how to relocate, stabilize, Reactor and single-pass reactor SNF from the K Basins to address the urgent need to environmental vulnerabilities. The K Basins EIS record of decision will address ma a 40-year period or until ultimate disposition.

During negotiations on the Fourth Amendment to the Tri-Party Agreement (TPA), Washington Department of Ecology, and the EPA agreed to an enforceable milestone th issuing that record of decision by June 1996. The record of decision on the K Basi on the programmatic EIS record of decision. Other environmental documentation (EAs prepared for any proposed actions related to SNF that are not specifically covered or in the K Basins EIS.

Assuming the EISs are prepared as planned, the Hanford SNF management plan woul implement management approaches that will provide safe, cost-effective storage of S facilities. Activities to identify, and then implement, the SNF management approac

- Issuing the records of decision that are expected to result from the progr K Basin EIS.
- Achieving accord with the TPA or renegotiating activities and milestones,
- Providing facilities for SNF management as necessary to implement the EIS

decision. SNF remaining onsite, as a result of the programmatic EIS recor be placed in wet or dry storage in the 200-East Area until a decision on u has been made.

- Identifying and developing pathways for ultimate disposition of the SNF.
- Providing facilities and systems for preparing SNF for ultimate dispositio N Reactor and single-pass reactor SNF would be stabilized, as necessary, Basins EIS record of decision. It is possible this stabilized form woul oxide. Suitability of other SNF for ultimate disposition in its current demonstrated, but it is possible that FFTF and Shippingport SNF may not stabilization.

While the SNF management approach is being defined, the following key, near-ter existing facilities are being implemented or are planned:

- Upgrading water treatment systems and retrieving sludges from the basins'
- Performing necessary safety and security upgrades (e.g., water systems) to life until SNF removal can be accomplished.
- Transferring SNF from liquid-sodium storage at the FFTF to dry storage in casks. This activity would be integrated with FFTF deactivation.
- Transferring small quantities of SNF between existing facilities where dee comply with other Hanford requirements.

Discussion of the SNF inventory and plans for managing that inventory are prov sections. Planned SNF management activities are summarized in Table 2-1. Addition storage facilities are in Chapter 3.

2.3.1 N Reactor Spent Nuclear Fuel

N Reactor SNF is stored in three facilities (Bergsman 1994):

- 952 metric tons of uranium in 3815 closed canisters in the 105-KW Basin. basin has only low levels of radionuclide contamination.
- 1144 metric tons of uranium in 3666 open canisters in the 105-KE Basin. T basin is contaminated with radionuclides, and there is a thick layer of sl floor.
- 0.3 metric tons of uranium in the form of intact Mark IV fuel elements and stored in air on the floor of PUREX dissolver cells A, B, and C.

Until recently, plans included 1) containerizing the fuel and sludge stored in Mark II (sealed) canisters; and 2) transferring the spent fuel in PUREX to the 105- it in the basin. Alternative approaches to each of these plans, including alternat and sludge at the 105-KE Basin, expedited fuel removal from the K Basins and dry s have been evaluated, and a path forward for these materials selected. PUREX SNF wo K Basins and subsequently managed with the existing K Basins SNF inventory pending Expedited fuel removal from the K Basins has been selected in lieu of containerizat to worker safety and/or the environment. The 105-K Basins SNF would be relocated t the 200 Area, pending completion of the K Basins EIS. The impacts associated with path forward are within the envelope of impacts analyzed in this EIS.

Table 2-1. Summary of planned spent nuclear fuel management activities. In addi data relevant to assuring continued safe storage and developing plans for future ac commitments to the Defense Nuclear Facilities Safety Board have set a date of Decem removal of the SNF from the 105-K Basins.

Other N Reactor SNF, which may be recovered as a result of N Basin deactivatio transferred to the 105-K Basins. A small quantity of this material (less than 0.5 fragments and chips is suspected to be in the sludge at the bottom of N Basin.

2.3.2 Single-Pass Reactor Spent Nuclear Fuel

The single-pass reactor SNF consists of residual fuel elements from the 105-KW
105-KE reactors, plus residual elements from the clean-out of the 105-C and 105-D s
Currently, 138 elements [0.4 metric tons of uranium (MTU)] are stored in the 105-KE
(0.1) are stored in the 105-KW Basin. In addition, four buckets filled with 779 s
elements are stored in the PUREX storage basin.

It was planned that the single-pass reactor fuel stored in PUREX would be trans
Basin, containerized, and possibly transferred to the 105-KW Basin before the previ
SNF EIS record of decision would be issued. Activities to implement this action we
1995). In parallel, alternative dry storage of this fuel was considered, consisten
evaluation for N Reactor fuel at PUREX. To enable expeditious deactivation of the
the Hanford Site cleanup mission and because of the minimal impacts associated with
to the 105-K Basins, shipment to the 105-K Basins was selected as the preferred app
SNF until issuance and implementation of the K Basins EIS record of decision. The
directly to the 105-KW Basin instead of the 105-KE Basin and would be stored in a m
requirements of the selected storage basin. The impacts associated with implementa
are within the envelope of impacts analyzed in this EIS.

2.3.3 Fast Flux Test Facility Spent Nuclear Fuel

The SNF from FFTF is stored in the following four FFTF locations, all of which
cooling:

- the reactor core with a capacity of approximately(a) 82 fuel assemblies
- in-vessel storage with a capacity of 54 fuel assemblies
- interim decay storage with a capacity of 112 fuel assemblies and a limitat
per assembly
- the Fuel Storage Facility with a capacity of 380 fuel assemblies(b) and a
kilowatts per assembly.

The 1993 inventory of irradiated SNF at FFTF consists of fuel from 329 assembli
non-irradiated driver fuel assemblies exist. Some irradiated fuel assemblies have
the fuel now placed in 40 Ident 69 containers or in the Interim Examination and Mai
irradiated fuel has been shipped offsite, but is expected to be returned to Hanford

The DOE plans to transfer FFTF spent nuclear fuel from the liquid sodium-cooled
into dry storage casks. These interim storage casks would hold six or seven assemb
of an initial ten casks has been scheduled for August 1995 and an environmental ass
has been submitted (Bergsman 1995). The majority of the casks would be sited in th
may be sited at the Plutonium Finishing Plant because of requirements for additiona
small fraction of the FFTF SNF is sodium bonded, and may be shipped directly offsit
dry storage casks if the decision in this EIS is to relocate these materials to ano

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a. Capacity for each core-loading varies.
b. The Fuel Storage Facility actually has a capacity of 466 fuel assemblies, but is
to only 380 because of criticality requirements.

2.3.4 Shippingport Core II Spent Nuclear Fuel

The Shippingport Core II spent nuclear fuel is stored in water in the 221-T Bui
Pool Cell 4. The 72 standard blanket assemblies will remain in basin storage in T
NEPA review is completed to enable implementation of dry storage or transfer offsit

review will not be initiated until issuance of the record of decision for this EIS. blanket assembly is also stored in air in the T-Plant.)

2.3.5 Miscellaneous Spent Nuclear Fuel

A variety of miscellaneous spent nuclear fuel is stored in the 300 Area, Pluton and low-level burial grounds (Bergsman 1994). Specific actions that have been iden follow:

- The spent nuclear fuel stored in air in the 324, 325, and 327 buildings (m light-water reactor fuel, i.e., Zircaloy-clad uranium dioxide) is planned onsite; an environmental assessment for this activity will be prepared. T facility is a dry storage cask.

- TRIGA fuel stored in water in the 308 Building is planned for relocation o so that the 308 Building can be deactivated; an environmental assessment h for this activity. Alternative disposition of the TRIGA fuel may be imple this fuel to the Idaho National Engineering Laboratory (INEL) is assumed i Planning Basis Alternative.

- Miscellaneous fuel residues in the 200 Area are currently being managed as transuranic waste. The TRIGA SNF at the burial grounds will be relocated grounds retrieval operations.

3. SPENT NUCLEAR FUEL MANAGEMENT ALTERNATIVES

3.1 Description of Alternatives

Five major alternatives are being evaluated for safely storing SNF until ultimate disposition is determined. These five alternatives are 1) No Action, 2) Decentralization (with a subset of local stabilization and storage options), 3) 1992/1993 Planning Basis, 4) Regionalization (with options A, B1, B2, and C), and 5) Centralization (minimum and maximum options). The five alternatives and their impacts are being evaluated concurrently by the sites or agencies potentially affected by these alternatives, including Hanford, Savannah River Site (SRS), Idaho National Engineering Laboratory (INEL), Oak Ridge National Laboratory (ORNL), the Nevada Test Site (NTS), and the Naval Nuclear Propulsion Program.

This chapter describes the spent fuel inventories, activities, and facilities anticipated at Hanford under the various storage alternatives. The inventory of SNF expected to be stored at Hanford under each alternative is summarized in Table 3-1. There are eight types of fuel listed in Table 3-1 to represent the wide variety of SNF currently held at various sites across the United States. In addition, the United States has obligations for some SNF held in foreign countries. The specific kinds of SNF held at Hanford that contribute toward the total SNF inventory are shown in parentheses in column one of Table 3-1. In terms of metric tons of heavy metal, Hanford has about

80 percent of DOE's current SNF inventory, primarily because of the large inventory of spent fuel remaining from the shut-down N Reactor. The Centralization Alternative minimum option is not shown in Table 3-1 because the inventory would eventually be zero at Hanford under this option, as it is in the Regionalization Alternative Option C. An overview of the SNF inventory as of the year 2035, planned activities, and existing and new facilities that may result under each of the five storage alternatives is provided below.

The No Action Alternative described in Subsection 3.1.1 forms the basis for comparison with the remaining four storage alternatives and includes descriptions of the expected activities, and existing storage facilities. Decentralization (Subsection 3.1.2), the 1992/93 Planning Basis (Subsection 3.1.3), Regionalization (Subsection 3.1.4), and Centralization (Subsection 3.1.5) are discussed in the remaining sections.

Table 3-1. Spent nuclear fuel inventory at Hanford under the various storage optio

Fuel type (name of Hanford SNF that is part of this type)	No Action and Decentralization	1992/1993 Planning Basis	Regionalization Ac	Regionalization B1d	Regionalization B2e	R t C t o
Naval SNF	0.00	0.00	0.00	10.23	65.23	0
Savannah River and aluminum-clad	0.00	0.00	0.00	8.76	8.76	0
Hanford (N Reactor and single-pass reactors)	2103.17g	2103.17	2103.17	2103.17	2103.17	0
Graphite	0.00	0.00	0.00	27.60	27.60	0
Commercial miscellaneous fuels	2.30	2.30	0.00	125.18	125.18	0
Experimental, stainless steel clad (FFTF)	11.27	11.23	0.00	90.12	90.12	0
Experimental, Zircaloy clad (Shippingport)	15.70	15.70	0.00	64.84	64.84	0
Experimental, other such as ceramic, liquid/salt, etc.	0.00	0.00	0.00	0.29	0.29	0
TOTALS:	2132.44	2132.40	2103.17	2430.19	2485.19	0

a. MTHM - Metric tons of heavy metal (thorium, uranium, and plutonium as applicabl

b. Source: Wichmann (1995). Quantities of SNF within a given category may be the together several quantities, some large and some small, stored at different locatio are known to within about 1%. Additional digits are shown in the table as a check inventory totals are known to only two significant figures.

c. All Hanford production SNF remains at Hanford. All other SNF goes to INEL (inc commercial, experimental stainless-steel-clad, and TRIGA).

d. All SNF currently located or to be generated in the U.S. west of the Mississipp stored at the Hanford Site, with the exception of Naval SNF.

e. All SNF currently located or to be generated in the U.S. west of the Mississipp SNF are sent to and stored at the Hanford Site.

f. All Hanford Site SNF and all other SNF currently located or to be generated in Mississippi River is sent to and stored at either INEL or NTS. For Hanford, this a to the Centralization Alternative minimum option (SNF is shipped offsite).

g. This represents the post-irradiation (end-of-life) quantity. The pre-irradiati MTHM) is sometimes quoted.

3.1.1 No Action Alternative

Under the No Action Alternative, only those actions that are deemed necessary for continued safe and secure management of the SNF would be conducted. Thus, the existing SNF would be maintained close to its current storage locations, and there would be minimal facility upgrades. Activities required to store SNF safely would continue at each specific site (DOE 1993b).

A description of the anticipated activities that would be necessary under the No Action Alternative is provided in Subsection 3.1.1.1, followed by descriptions of existing facilities (Subsection 3.1.1.2), and any new facilities (Subsection 3.1.1.3). A comprehensive inventory and description of the fuel at Hanford as of January 1993 is given by Bergsman (1994). That report provides detailed information on many of the spent fuel designs and radionuclide inventories.

3.1.1.1 Anticipated Activities. In order to carry out the No Action

Alternative, the following activities would occur at the Hanford Site:

- Characterization of the defense production reactor fuel would proceed to establish the basis for safe storage.
- Fuel and sludge would be containerized at the 105-KE Basin or other onsite location.
- The first 10 dry storage casks would be procured for Fast Flux Test Facility (FFTF) fuel.

Consolidation of SNF from defense production reactors into the 105-KW Basin could occur. Other fuel may be transferred to dry cask storage where required for safety.

3.1.1.2 Description of Existing Facilities. SNF is presently located

in 11 facilities on the Hanford Site: 105-KE and 105-KW Basins at the north end of Hanford in the 100-K Area; T Plant, low-level waste burial grounds, and Plutonium Finishing Plant in the 200 West Area; Plutonium and Uranium Recovery through EXtraction (PUREX) plant in the 200 East Area; FFTF in the 400 Area; and 308, 324, 325, and 327 buildings in the 300 Area in the southeast corner of the site. Continued storage in these facilities is being evaluated because the No Action Alternative includes activities required to ensure safe and secure storage. The Plutonium Finishing Plant and PUREX facilities are excluded from this evaluation because SNF will not remain in those two facilities under any of the alternatives. For the purposes of this analysis, SNF at PUREX is assumed to be relocated to the K Basins.

Most of the facilities at the Hanford Site are decades old, some over 40 years, except for the FFTF and its associated storage buildings. A general description, the capacity for additional storage of SNF, and the means by which SNF can be received or removed from each facility are provided in Table 3-2. The dimensional information is for the actual storage area and not for the entire facility in order to provide a basic idea of the storage area required for that specific inventory of SNF. In many cases, such as the facilities in the 300 Area, only small portions of the actual facilities are used to store the spent fuel.

The K Basins contain the vast majority of the SNF at Hanford. The

T-Plant, 308, 325, and 327 buildings, and the Plutonium Finishing Plant contain small amounts of stored SNF of various kinds. Four FFTF locations contain all the FFTF spent fuel, presently stored in sodium: the Reactor Core, In Vessel Storage, Interim Decay Storage, and Fuel Storage Facility (a building separate from the reactor containment building). The first of 60 new dry storage casks are expected to be available for FFTF fuel by late 1995. The existing facilities have very little additional capacity (see Table 3-2). While there is presently excess capacity in the K Basins, this is expected to be consumed by the planned operations, regardless of the storage alternative chosen.

The accessibility and limits on loading SNF are provided as key factors in movement of any fuel from these facilities to other locations on or offsite. Rail access is available at the facilities storing most of the fuel (K Basins, PUREX, and T Plant); truck shipments would be used for the rest. Acceptable casks and procedures for moving these casks may require evaluation in many cases. Additional details on these facilities are provided by Bergsman (1994), Bergsman (1995), and Monthey (1993).

The changes to the existing facilities that were analyzed under the No Action Alternative of SNF storage are shown in Table 3-3.

Table 3-2. Description of existing facilities (Bergsman 1994; Bergsman 1995).

Facility	Description	Capacity	Access
105-KE Basin	Water storage pool; 38 m x 20 m x 6 m deep; concrete walls and floor; no sealant or liner	75% full, 100% full after containerization	By rail 27 MT crane, fairly restrictive
105-KW Basin	Water storage pool; 38 m x 20 m x 6 m deep; concrete walls and floor; epoxy sealant; no liner	75% full[a]	By rail 27 MT crane, fairly restrictive
T Plant: Cell 4	Water storage pool; 4 m x 8.4 m x 5.8 m deep (water)	50% full	By rail or truck All fuel handling remote
PUREX Plant: East end of 202A Bldg. plus Dissolver Cells A, B, and C	Water storage pool; 9.5 m x 6.1 m x 5.2 m deep; Dissolver Cell sizes vary	No additional capacity	Shipment by rail 36 MT crane
Plutonium Finishing Plant: 2736-ZB Bldg.	Dry storage in 55 gal drum	No additional capacity	Shipment by truck
Fast Flux Test Facility: Reactor in-vessel storage, interim decay storage, and fuel storage facility storage locations	Liquid sodium pool storage (fuel storage facility is separate from reactor containment building, with limit of <1.4kW/assembly)	More than 75% full	By truck 91 MT Crane
200 Area LL Burial Grounds: 218-W-4C Trench 1 and 7; and 218-W-3A Trench 8 and S6	Dry, retrievable storage; 13 lead-lined, concrete-filled 208 liter drums, soil covered; 22 concrete casks (1.66 m x 1.66 m x 1.22 m or 1.92 m high), soil covered; 39 EBR II casks (1.5 m high x 0.4 m diameter), soil covered; 1 Zircaloy Hull Container (152 cm long x 76 cm diameter)	Large additional capacity	By truck
308 Building Annex: Neutron Radiography Facility	Built in late 1970's water storage pool; 2.8 m diameter x 6 m deep	Small additional capacity	Truck shipments 4.5 MT crane

324 Building: B and D Cells	Dry storage in air; B Cell: 6.7 m x 7.6 m x 9.3 m high (SNF uses <10% of floor space). D Cell: 4 x 6.4 m x 5.2 m high (small part for fuel), thick concrete walls and floors with steel liners	Small additional capacity	Truck shipments only B Cell - 2.7 and 5.4 MT cranes; Airlock - 27 MT crane
325 Building: A and B Cells in 325 Radiochemical Facility; 325 Shielded Analytical Laboratory	Dry storage in air 325A - 1.8 m x 2.1 m x 4.6 m high (typical cell) 325B - 1.7 m x 1.7 m floor area (typical cell)	Small additional capacity	Truck shipments only 325A - 27 MT crane 325B - 2.7 MT crane
327 Building: A - F and I Cells; Upper and Lower SERF; Dry Storage vault; EBR II cask; Large Basin	Dry storage in air, except for water in large basin; variety of cell sizes, but storage only for fuel research	Small additional capacity	No direct rail Truck shipments 13.5 and 18 MT cranes

a. If 105-KE Basin fuel is consolidated with 105-KW Basin fuel, 105-KE Basin would be shut down. The storage capacity of 105-KW Basin would be increased by replacing all the storage racks to allow multitiered stacking of fuel storage canisters and by making minor facility modifications.

Table 3-3. Assumed changes to existing Hanford facilities in the No Action Alternative.

Facility	Facility changes
105-KE Basin	Fuel and sludge to be containerized; plans to upgrade safety and security systems
105-KW Basin	Fuel is already containerized; plans to upgrade safety and security systems
T Plant	None
PUREX Plant	Fuel to be moved to alternative location (assumed to be 105-K Basins for this alternative)
Plutonium Finishing Plant	None
Fast Flux Test Facility	None: Procure 10 dry storage casks by 8/95 (Bergsman 1995). Casks to weigh 50 T with storage cavity 3.8 m high x 0.56 m diameter (Bergsman 1994)
200 Area LL Waste Burial Grounds	None
308 Building Annex	None
324 Building	None
325 Building	None
327 Building	None

3.1.1.3 Description of New Facilities. No new buildings were analyzed

for the Hanford Site under the No Action Alternative. The only activities that were analyzed are those described for containerizing the N Reactor fuel and procuring casks for storage of FFTF fuel. The casks would be stored above ground on an existing concrete pad at the FFTF (Bergsman 1995). Major changes in rail, electrical, water, or other utilities are not expected under this alternative.

3.1.2 Decentralization Alternative

In the Decentralization Storage Alternative, as in the No Action Alternative, the current spent fuel inventory would continue to remain close to the point of generation or defueling. There are some existing storage sites that may receive or ship spent fuels, such as naval spent fuel, under one of several options under the Decentralization Alternative, but these options do not impact Hanford (DOE 1993a). No SNF would be shipped offsite or received from other storage locations outside of Hanford, but local transport might take place to support safety requirements and research and development. The Decentralization Alternative differs from the No Action Alternative in that significant facility development and upgrades are assumed, and spent fuel characterization, research and development, and possibly stabilization would occur. Summaries of the anticipated activities (Subsection 3.1.2.1) and facility requirements (Subsections 3.1.2.2 and 3.1.2.3) are provided below.

3.1.2.1 Anticipated Activities. The Decentralization Alternative would

include the three activities (fuel characterization, fuel and sludge containerization, and cask procurement for FFTF fuel) mentioned above in Subsection 3.1.1 for the No Action Alternative as well as the following general activities:

- Characterization of defense production fuels (N Reactor and single-pass reactor) to determine the feasibility of dry storage
- Evaluation of dry storage for other fuels (Shippingport Core II, FFTF, miscellaneous)
- Research and development on N Reactor fuel stabilization
- Construction and utilization of wet and/or dry storage facilities as well as a stabilization facility to support storage.

Only the defense fuels are being considered for wet storage, but dry storage in casks or vaults could be used for all or part of Hanford's spent fuel inventory under various options (Bergsman 1995). There are four basic options considered for storage of the spent fuels at Hanford under the Decentralization Alternative. Options W and X include both wet and dry storage: wet storage for defense fuels and dry storage for all other spent fuels in either a vault or casks. Options Y and Z involve only dry storage, again either in a vault or casks, but these options include one of three stabilization options for the metallic defense fuels.

The three potential processes considered for stabilizing the defense fuels in conjunction with Options Y and Z are shear/leach/calcine (P), shear/leach/solvent extraction (Q), and drying and passivation (D). Process P consists of shearing the fuel into a continuous dissolver and dissolving it in a nitric acid solution. Eventually, the processed material (without any radionuclide removal) is calcined, pressed into a ceramic waste form, and sealed in metal canisters.

Process Q uses solvent extraction by which metallic defense fuels are dissolved, separating uranium and plutonium and a liquid high-level waste stream that would most likely be vitrified for disposal in a geologic repository. In Process Q it is assumed that the process would be carried out on the Hanford Site. In commenting on the draft EIS, British Nuclear Fuels Limited (BNFL) proposed such processing be carried out in their facilities overseas. A discussion of the proposed sub-option is provided in Attachment B. Except for the additional impacts associated with transporting SNF from the Hanford Site to a West Coast shipping port, transoceanic shipment, transport of the SNF overland to BNFL facilities, and return shipment of resource materials (uranium-trioxide and plutonium-dioxide) and vitrified high-level waste, environmental impacts would be similar to those determined for Process Q.

Process D consists of drying and passivating the spent fuel and then canning it for storage. The relationships between the storage and stabilizing options are shown in Table 3-4.

Option W involves moving the N Reactor fuel from the existing basin storage into a new basin to be built by the year 2001. Simultaneously, a modular dry vault would be built for storage of the rest of the spent fuel at Hanford. Option X considers the use of casks for dry storage instead of the vault, but still requires moving the N Reactor fuel to a new basin. The casks would be placed on concrete pads outside of any buildings and would include two types of cask designs: concrete modules holding a storage cask, and upright concrete casks designed specifically for the FFTF fuel. Option Y would result in all of the non-defense spent fuel at Hanford being placed in a large vault facility. The defense fuel would require processing in a new facility by one of three options (P, Q, or D) prior to canning and placement in storage. The defense fuels processed using Option P or Option D would be stored in the vault; however, Option Q would result in several products that would be stored or processed further as high-level waste (Bergsman 1995). The final option, Option Z, is similar to Option Y except that casks would be used instead of a dry storage vault for all of the nondefense spent fuels. The defense fuels are handled as in Option Y. Additional details are provided by Bergsman (1995).

Table 3-4. Options under the Decentralization Alternative for Hanford.

Storage option	Stabilization option	Description	Facility requirements
W	None	Wet storage of defense fuels Dry storage of other fuels	New basin New vault
X	None	Wet storage of defense fuels Dry storage of other fuels	New basin New casks
Y	P, Q, or D	Dry storage of all fuel; stabilize defense fuels prior to storage	New vault; new processing facility [calcining (P), solvent extraction (Q), or drying and passivation (D)]
Z	P, Q, or D	Dry storage of all fuel; stabilize defense fuels prior to storage	New dry storage casks; new processing facility [calcining (P), solvent extraction (Q), or drying and passivation (D)]

3.1.2.2 Description of Existing Facilities and Impacts from the

Decentralization Alternative. The description of the existing facilities used to store SNF at Hanford was provided in Subsection 3.1.1.2. The Decentralization Alternative would impact the facilities beyond that already mentioned for the No Action Alternative to the extent that fuel would be removed from several of them: the Shippingport fuel would be removed from T Plant to a designated interim storage location on site; FFTF fuel would continue to be removed from the sodium-cooled storage facilities and placed in dry storage casks; and fuel in the 200-W burial grounds might be relocated onsite.

As shown in Table 3-2, there is very little excess capacity in any of the facilities in which fuel is currently stored. The storage basins, in addition to being old, were built for temporary holding, for a matter of months only; hence, bringing them up to standards for prolonged storage would be fraught with problems and would not be cost-effective. Except for the burial grounds, the locations in which SNF is currently held in air were not intended for prolonged storage either, having been built for temporary holding for research and development or pre-processing. The FFTF storage facilities are all dependent on maintaining sodium in the liquid state as coolant and storage medium, which is not cost-effective for 40 years of storage for nonbeneficial use. Hence, the existing facilities are not considered for use in the 40 year storage scenario.

3.1.2.3 Description of New Facilities. A minimum of two new facilities

are required, regardless of which option is chosen for storing spent fuel under the Decentralization Alternative. Both Options W and X require a new basin and either a new vault or a new cask storage facility. Descriptions of these potential new facilities are provided in Table 3-5. A proposed site consisting of about 260 hectares (one-quarter section) for construction of all new facilities is located as shown in Figure 4-1. The cask facility would cover about twice as much land area as a vault facility and would involve modular systems placed outside on concrete pads. While the basin requirement is dropped for Options Y and Z, a process facility is needed for the metallic defense fuels in addition to the new dry storage facility. The specifics of this facility vary depending on whether they involve shear/leach/calcining (process P), shear/leach/solvent extraction (process Q), or drying and passivation (process D). For process Q, it is assumed that a vitrification plant and storage facilities will be available for the processed spent fuel that would then consist of three products. The vitrification plant and storage for high-level wastes are part of the overall plan for Hanford.

The potential processing facilities that will result from this alternative will require increased utilities, compared with the new dry storage facilities that are not expected to have major utility requirements. A rail system for receiving spent fuel at the various facilities may be required and could be tied into the existing system. Water requirements are expected to be insignificant. Estimates of the power requirements for processes P, Q, and D are 10 megawatts, 18 megawatts, and 3 megawatts, respectively. While the existing excess electrical capacity of 21 megawatts would be sufficient for one of these facilities, other potential uses of the existing electrical power capacity may require upgrading the existing power system (Bergsman 1995).

3.1.3 1992/1993 Planning Basis Alternative

The 1992/1993 Planning Basis Alternative defines those activities that were already scheduled at the various sites for the transportation, receipt, processing, and storage of SNF.

3.1.3.1 Description of Spent Fuel Inventory As in the previous two

alternatives, no new spent fuel would be received at Hanford under the 1992/1993 Planning Basis Alternative. However, the 101 spent fuel elements currently in the 308 Building from TRIGA reactors and the small amount of TRIGA fuel from Oregon State University currently in the 200-W Area burial grounds would be shipped to INEL.

Table 3-5. Description of required facilities under the Decentralization Alternati

New facility	Description	Capac
Water Basin (W, X)	Building: 110 m long x 42.7 m wide x 19.8 m high Land use: <8094 m2 (<2 acres) Water storage pool: rectangular, 520 m2, cast-in-place concrete Canisters: double barreled, each 0.23 m diameter x 0.74 m high Construction: 3 year duration, operation by 2001	2103 8000
Dry Storage Vault Facility (W)	Building: 39.6 m long x 48.8 m wide x 19.8 m high Land use: <4047 m2 (<1 acre) Modular vault: metal tubes vertically arrayed in cast-in-place concrete structure; inert cover gas; natural convection cooling. Canisters: short, 0.508 m diameter x 3.96 m (FFTF fuels); long, 0.559 m diameter x 4.57 m (other non-defense fuels) Construction: 3 year duration, operation by 2001	30 MT short long
Dry Storage Cask Facility (X)	Building: none, concrete pads Land use: <8094 m2 (<2 acres) Cask Systems: 1) FFTF casks, 2.29 m diameter x 4.57 m high, 45.4 MT each, 2) Concrete module with fuel cask; reference storage module is 2.96 m wide x 5.52 m deep x 4.57 m high Canisters: 0.508 m diameter x 3.96 m (FFTF cask); 1.68 m diameter x 4.88 m long, weighs 90.8 MT (storage module) Construction: 3 year duration, operation by 2001	30 MT cask/ canis (FFTF and 6 modul casks
Shear/Leach / Calcine Process or Z Facility (Y)	Building: multilevel, steel-reinforced, cast in place concrete; 110.3 m long x 55.2 m wide x 25.9 m high (15.8 m above grade); shielded main canyon is 6.1 m wide x 70.1 m long x 25.9 m high; Land Use: 6070 m2 (1.5 acres) Operation: 24 hours/day, 7 days/week for 4 years to stabilize defense fuels; 75% efficiency; 280 day/year Construction: 3 year duration, operation by 2001	2103 years 2.5 M
Dry Storage Vault Facility (Y)	Building: 100.6 m long x 88.4 m wide x 18.3 m high Land use: <8094 m2 (<2 acre) Modular vault: metal tubes vertically arrayed in cast-in-place concrete structure; inert storage atmosphere; natural convection cooling. Canisters: 0.559 m diameter x 4.11 m (defense fuels); short, 0.508 m diameter x 3.96 m (FFTF fuels); long, 0.559 m diameter x 4.57 m (other non-defense fuels) Construction: 3 year duration, operation by 2001	2133 ~1200 canis 60 sh 25 lo defen canis
Dry Storage Cask Facility (Z)	Same as Dry Cask Storage Facility described for Option X Land use: 20,234 m2 (5 acres) Canisters: add storage modules/casks for stabilized defense fuels; same storage	2133 60 ca canis (FFTF 230 m

	container dimensions as for Option X	casks (defe 6 mod casks non-d
Solvent Extraction Fuel Process Facility (Y or Z)	Building: multilevel, steel-reinforced, cast in place concrete; 26.5 m long x 77.7 m wide x 25.9 m high (15.8 m above grade); shielded main canyon is 6.1 m wide x 76.2 m long x 25.9 m high; Land Use: 6070 m2 (1.5 acres) Canisters: generates 2 kg/MTU of fuel processed, resulting in about 30 cans of glass for 2103 MTU of fuel Operation: 24 hours/day, 7 days/week for 4 years to stabilize defense fuels; 75% efficiency; 280 day/year Construction: 3 year duration, operation by 2001	2103 years 2.5 M
Fuel Drying and Passivation Facility (Y or Z)	Building: multilevel, steel-reinforced, cast in place concrete; 115.8 m long x 64.0 m wide x 25.9 m high (15.8 m above grade); shielded main canyon is 6.1 m wide x 54.9 m long x 25.9 m high; Land Use: 6070 m2 (1.5 acres) Operation: 24 hours/day, 7 days/week for 4 years to stabilize defense fuels; 75% efficiency; 280 day/year Construction: 3 year duration, operation by 2000	2103 years 2.5 M

a. Source: Bergsman (1995).

3.1.3.2 Anticipated Activities Most of the activities previously

discussed for the decentralization storage alternative were already planned prior to this review. It was expected that all newly generated SNF that was owned by the U.S. Government would be sent to either INEL or to SRS. No new spent fuel was expected to be shipped to Hanford other than possibly limited quantities of material for research or other scientific endeavors supporting the nuclear industry. Upgrades and replacements of existing storage capacity were already planned and would involve those facilities described in Subsection 3.1.2 for the Decentralization Alternative. Thus, the activities that would be conducted under the 1992/1993 Planning Basis are the same as for the Decentralization Alternative under the four options listed in Table 3-4, except for the additional activity of shipping TRIGA spent fuel to INEL.

3.1.3.3 Description of Existing Facilities and Changes Required by

Alternative The description provided in Subsection 3.1.1.2 on the existing facilities for storing SNF at Hanford also applies to this alternative. No additional changes to facilities are anticipated from the 1992/1993 Planning Basis except that the 308 Building and the 200W Area burial grounds would no longer contain TRIGA spent fuel.

3.1.3.4 Description of New Facilities. The facilities that would be

required under the 1992/1993 Planning Basis are the same as those shown previously in Table 3-5 for the Decentralization Alternative. The impact on existing utilities would be the same as for the Decentralization Alternative, namely from 3 to 18 megawatts of power for stabilization facilities and minimal other impacts.

3.1.4 Regionalization Alternative

This alternative provides for the redistribution of SNF to candidate sites based on similarity of fuel types (Option A) or on geographic location (Options B1, B2, and C), in order to optimize the storage of SNF owned by the U.S. Government.

The Regionalization Alternative as it applies to the Hanford Site consists of the following options:

- Option A (regionalized by fuel type) - Defense production SNF would remain at Hanford; other types of SNF would be sent to INEL.
- Option B1 (geographic regionalization) - All SNF west of the Mississippi River except Naval SNF would be sent to Hanford.
- Option B2 (geographic regionalization) - All SNF west of the Mississippi River and Naval SNF would be sent to Hanford.
- Option C (geographic regionalization) - All Hanford SNF would be sent to INEL or NTS.

Facilities and features of Regionalization Option A would be the same as those described for Hanford defense production fuel in the Decentralization Alternative. The facilities and features for all other Hanford SNF would be very similar to those described for that SNF in the Centralization Alternative minimum option.

Facilities and features of Regionalization Options B1 and B2 would be incremental to those described for the Decentralization Alternative and would include facilities and features similar to those described in the Centralization Alternative maximum option.

Facilities and features of Regionalization Option C would be equivalent to those described for the Centralization Alternative minimum option.

3.1.4.1 Description of Spent Fuel Inventory. The spent fuel inventory

that would be stabilized and/or stored for each of the Regionalization options is shown in Table 3-1.

3.1.4.2 Activities Required by Each Option.

Option A, Suboption X

- wet storage of N Reactor and single-pass reactor fuel
- shipment of other Hanford Site fuel to INEL
- use of existing facilities (FFTF and T Plant) and new wet pool facilities to load shipping casks.

For N Reactor and single-pass reactor fuel, this option is the same as the Decentralization Alternative; for all other Hanford Site fuel, this option is nearly the same as for the Centralization Alternative minimum option.

Option A, Suboption Y

- dry storage of all defense production fuel in a large vault facility
- transport of other Hanford Site fuel to INEL
- defense production fuel stabilized prior to storage
- use of existing facilities (FFTF and T Plant) and a stabilization facility to load shipping casks
- leakers, if any, unloaded in a special module at a stabilization facility.

For N Reactor and single-pass reactor fuel, this option is identical to the Decentralization Alternative; for other Hanford Site fuel, this option is nearly identical to the Centralization Alternative minimum option.

Option A, Suboption Z

- dry storage of all fuel in casks in a large facility
- defense production fuel stabilized prior to storage
- dry storage casks loaded at existing facilities (FFTF and T Plant)
- use of existing facilities (FFTF and T Plant) and a stabilization facility to load shipping casks
- leakers unloaded in a special module at a stabilization facility.

For N Reactor and single-pass reactor fuel, this option is identical to the Decentralization Alternative; for other Hanford Site fuel, this option is nearly identical to the Centralization Alternative minimum option.

Option B1

All fuel from offsite would be stored dry in casks in a large facility, although a very small amount might require wet storage for an interim period prior to dry storage. SNF received from other DOE locations would arrive stabilized and canned as necessary for storage. SNF received from universities and SNF of U.S. origin from foreign research locations would require canning prior to storage. The required receiving and canning would be done in a new facility because of the extended period over which the fuel would be received. A small amount of fuel would arrive after only limited time since reactor discharge, which would require temporary water storage until it aged sufficiently to be dry stored. That water storage would be included in the receiving and canning facility. Technology development would be conducted in a separate, nearby facility.

Option B2

The activities for this option would be the same as those for Option B1, except that additional storage would be required for Naval fuel.

Option C

Hanford fuel would be stabilized as necessary, loaded, and shipped offsite.

3.1.4.3 Existing Facilities. Upgrades, replacements, and additions to

the existing facilities would occur as required under the Decentralization Alternative.

3.1.4.4 New Facilities. Research and development and pilot programs

for characterization, stabilization, and other needs to support future decisions on the ultimate disposition of SNF would also occur. Refer to Table 3-6 for the potential facility requirements under the three storage and three stabilization options. A description of these options is given in Section 3.1.2.1, Anticipated Activities under the Decentralization Alternative. Options X, Y, and Z with their respective stabilization suboptions are the same as those for the Regionalization and Decentralization Alternatives (see **Table 3-4**). What is different is the specific assortment of fuel to be managed in each of the alternatives. The stabilization facilities required under the Regionalization Alternative are the same as those listed in Table 3-5.

Table 3-6. Description of required facilities under Regionalization Alternatives.

Alternatives	New Facility	Description
Regionalization A/ Suboption X RAX	Water basin	Building: 109.7 m long x 42.7 m wide x 12.2 high pre-cast concrete Land use: <8094 m2 (<2 acres) Water storage pool: rectangular, 520 m2, ca place concrete Canisters: double barreled, each 0.23 m dia x 0.74 m high Construction: 3-year deviation, operation starting in 2001
Regionalization A/ Suboption Y RAY	Shear/leach/calcine stabilization process	See Table 3-5
Regionalization A/ Suboption RAY	Large modular dry storage vault	Building: 94.5 m long x 88.4 m wide x 18.3 cast-in-place concrete, pre-cast concrete superstructure Land Use: ~8094 m2 (~2 acres) Canisters: 0.58 m diameter x 4.11 m high Construction: 3-year duration, operation to in 2001
Regionalization A\ Suboption RAZ	Shear/leach/calcine stabilization process	See Table 3-5
Regionalization A/ Suboption RAZ	Concrete storage module holding NUHOMsa casks	Building: 3.0 m wide x 5.5 m long x 4.6 m h Land Use: 16,187 m2 (4 acres) Casks: 1.7 m diameter x 4.9 m long Construction: 3 year duration, operation to in 2001

Table 3-6. (contd)

Alternatives	New Facility	Description

Note: Facilities required for Alternatives RB1 and RB2 are in addition to those re Decentralization

Regionalization B1, RB1	Incremental cask storage	Building: 121.9 m x 365.8 m Similar to but larger than that for Decentralization Option X
	Receiving and canning facility	Building: 53.3 long x 53.3 m wide x 16 foot thick cast-in-place concrete
	Technology development facility	Building: 53.3 m long x 30.5 m wide x pre-cast concrete Land use for all three RB1 facilities: (10 acres) Construction: Receiving/canning and te 1998-2001; for 90% of storage facility for remaining 10% storage 2010-2035; op period: 2000 through 2035
Regionalization B2, RB2	Prefabricated by storage cask facility	Building: 914.4 m x 121.9 m; similar t larger than Option X for Decentralizati
	Receiving and canning facility	Sames as for RB1
	Technology development facility Land use for all three RB2 facilities: 101,172 m2 (25 acres)	Same as for RB1

a. NUHOMs casks [Nutech Horizontal Modular Storage (from Pacific Nuclear)]

3.1.5 Centralization Alternative

Under the Centralization Alternative for SNF storage, all current and future SNF from DOE and the Naval Nuclear Propulsion Program would be sent to one DOE site or other location. The activities at each site would depend on whether the SNF was being received or shipped offsite. Sites not selected would close down their storage facilities once the fuel had been removed. The following information summarizes the expected impact at Hanford and provides insight into the characteristics of the SNF and facilities that would be involved in shipping these fuels to Hanford.

3.1.5.1 Description of Spent Nuclear Fuel Inventory The SNF inventory

that would exist at Hanford under this alternative would include that which is presently at Hanford (see Table 3-1), as well as any new fuel shipped to Hanford. If the minimum option occurs under the Centralization Alternative, then all of this spent fuel would be shipped offsite and there would no longer be a spent fuel inventory at Hanford, barring any required for research. If the maximum option occurs, the spent fuel at all of the other sites across the United States would eventually be transported to Hanford.

The locations from which spent fuel would be sent, in addition to SRS and INEL, include Argonne National Laboratories East and West, Babcock and Wilcox, Brookhaven National Laboratory, General Atomics, Los Alamos National Laboratory, Oak Ridge National Laboratory, Sandia National Laboratories, West Valley, and Fort St. Vrain. Naval spent nuclear fuel from shipyards and prototypes would be sent first to the equivalent of the Expended Core Facility, which would be relocated to Hanford. There the fuel would be examined by the Naval Nuclear Propulsion Program prior to being turned over to DOE for storage at Hanford. Foreign fuel that may be returned to the United States following irradiation or testing offsite would also be included in this inventory under the Centralization Alternative. Summaries of the spent fuel at each site are shown in Volume I, Attachments B, C, and D and Volume III of DOE (1993a). Additional information is in DOE (1992a) (Fort St. Vrain and Peach Bottom high-temperature gas-cooled reactor spent graphite fuel).

3.1.5.2 Anticipated Activities. If Hanford is chosen as the site for storing the entire spent fuel inventory, the upgrades, increases, and replacements of storage capacity would occur as required for the existing spent fuel as well as to accommodate the increased spent fuel inventory. If the Centralization Alternative is chosen and Hanford is not selected, the activities would include stabilization to ensure safe storage and transportation offsite.

All fuel received from offsite would be stored dry in casks in a large facility, although some may require wet storage for an interim period prior to dry storage. SNF received from other DOE sites will arrive stabilized and canned as necessary for storage. SNF received from universities and from foreign locations would require containerization prior to storage. Naval SNF would arrive uncontainerized, but would not require containerization. The required receiving and containerizing would be done in a new facility because of the large throughput involved and the extended period (40 years instead of 4) during which the fuel would be received. Some university and foreign fuel would require temporary wet storage. That water storage is included in the receiving and canning facility. Technology development would be conducted in a separate, nearby facility.

3.1.5.3 Description of New Facilities. The new facilities required for the alternative in which all U.S. DOE SNF would be stored at the Hanford Site are of the same type as, but larger than, those required for Regionalization Alternative Option B2:

- The Prefabricated Dry Storage Cask Facility for offsite SNF would be approximately 120 meters x 1200 meters.
- The Receiving and Canning Facility would be approximately 110 meters x 50 meters x 20 meters high.
- The Technology Development Facility would be approximately 50 meters x 40 meters x 20 meters high.
- The land required for these three facilities together would be approximately 14 hectares (35 acres).

3.2 Comparison of Alternatives

A summary of environmental impacts among the various alternatives is provided in **Table 3-7.** The alternatives are briefly described below to aid in interpreting the material presented.

The No Action Alternative identifies the minimum actions deemed necessary for continued safe and secure storage of SNF at the Hanford Site. Upgrade of the existing facilities would not occur other than as required to ensure safety and security.

The Decentralization Alternative includes additional facility upgrades over those considered in the No Action Alternative, specifically, new wet storage (for defense production fuel only) or dry storage facilities, fuel processing via shear/leach/calcination or shear/leach/solvent extraction, with research and development activities to support such processing.

The 1992/93 Planning Basis Alternative differs from the Decentralization Alternative only in that TRIGA fuel currently stored at the Hanford Site would be shipped offsite. The storage and stabilization options identified for the Decentralization Alternative are also assumed for the 1992/1993 Planning Basis Alternative.

The Regionalization Alternative as it applies to the Hanford Site consists of the following options:

- Option A (fuel type) - Defense production SNF would remain at Hanford; other types of fuel would be sent to INEL.
- Option B1 (geographic) - All SNF west of the Mississippi River, except Naval SNF would be sent to Hanford.
- Option B2 (geographic) - All SNF west of the Mississippi River and Naval SNF would be sent to Hanford.
- Option C (geographic) - All Hanford SNF would be sent to INEL or NTS.

Table 3-7. Summarized comparisons of the alternativesa.

Resource or Consequence	Alternatives				
	No Action	Decentralization	1992/1993 Planning Basis	Regionalization A	Re za
Traffic and transportation	No change in onsite traffic patterns. Total population dose would be less than one person-rem and no fatal cancers would be projected.	From 1 to 6 percent increase in onsite traffic depending on suboption selected. Total population dose would be less than 2 person-rem and no fatal cancers would be projected.		From 1 to 5% increase in onsite traffic depending on suboption selected. Total population dose less than 1 person-rem and no fatal cancers would be projected.	Es sa De za Al
Health &					

Safety (fatal cancers over 40 years of normal operations)					
Occupational	None (0.4)	None (0.04-0.1)	None (0.04-0.1)	None (0.04-0.1)	No 0.
Public (max)	None (5.2 x 10-4)	None (2.5 x 10-3)	None (2.5 x 10-3)	None (2.5 x 10-3)	No 10
Utilities and energy (megawatt-hrs/yr) electricalb	12,000	100-127,000	100-127,000	100-127,000	10
Materials and waste management					
LLW, m3/y	95	41-420	41-420	61-420	43
TRU waste, m3/y	0	0-50	0-50	0-50	0-
HLW, m3/y	0	0-57	0-57	0-57	0-
Mixed waste, m3/y	1	0.23-2.10	0.23-2.0	0.23-2.0	0.
Hazardous Waste, m3/y	2.3	1.1-2.8	1.1-2.8	1.1-2.8	1.

a. Hyphenated numbers indicate range of values depending on processing options sel
b. Minimum value represents requirements during the period after all fuel has been or has been shipped offsite. Maximum value represents requirements during the inte years) while SNF is being processed and prepared for storage or shipment offsite, a operation of the process facility and the existing facilities where SNF is currentl Action Alternative).
c. Spent filters and ion exchange resins are the only sources of TRU waste. Filte charged before they become TRU waste.

Table 3-7. (contd)

Resource or Consequence	Alternatives				
	No Action	Decentralization	1992/1993 Planning Basis	Regionalization A	Regionalization B1
Postulated Accidents					
Facilities					
Point estimate of fatal cancer risk - worst consequences accident - public	<3.7 x 10-3	4.9 x 10-4	4.9 x 10-4	4.9 x 10-4	5.7 x 10-
Workers	<1.4 x 10-7	5.6 x 10-7	5.6 x 10-7	5.6 x 10-7	6.6 x 10-
Transportation					
Numbers of fatal cancers	None (5.5 x 10-2)	1(0.7)	1(0.7)	None (6.8 x 10-2)	1(0.7)
Land use (area converted for SNF stabilization, packaging and/or storage)	No change	4 to 7 ha (11-18 acres)	4 to 7 ha (11-18 acres)	4 to 7 ha (11-18 acres)	15-17 ha (36-43 acres)
Socioeconomics	No change	798-6374	798-6374	618-4684	1716-7592

(worker-years over 10 years)					
Cultural Resources	No change	No effects expected	No effects expected	No effects expected	No effect expected
Aesthetic and scenic	No change	No effects expected	No effects expected	No effects expected	No effect expected
Geologic resources	No change	No effects expected	No effects expected	No effects expected	No effect expected
Air quality and related consequences (fatal cancers over 40 years normal operations)	No change	None	None	None	None
Water quality and related consequences	Maximum radio- logical and non- radiological carcinogenic risks less than one chance per billion	Maximum radiological and nonradiological carcin than 50 chances per billion			
Ecological resources (Habitat area destroyed)	No change	4 to 7 ha (11-18 acres)	4 to 7 ha (11-19 acres)	4 to 7 ha (11-18 acres)	15 to 17 (36-43 acres)
Noise	No change	No effects expected	No effects expected	No effects expected	No effect expected

Two options exist at the Hanford Site for the Centralization Alternative: 1) which all SNF on the Hanford Site would be shipped offsite, and 2) the maximum opti within the DOE complex would be shipped to the Hanford Site for management and stor dry storage of all fuel sent to the Hanford Site from offsite would be assumed. A the Decentralization suboptions would be assumed for stabilization of defense produ storage; fuel received from offsite would have been stabilized for dry storage prio

4. AFFECTED ENVIRONMENT

4.1 Overview

The Hanford Site is characterized by a shrub-steppe climate with large sagebrush dominating the vegetative plant community. Jack rabbits, mice, badgers, deer, elk, hawks, owls, and many other animals inhabit the Hanford Site. The nearby Columbia River supports one of the last remaining spawn- ing areas for Chinook salmon and hosts a variety of other aquatic life. The climate is dry with hot summers and usually mild winters. Severe weather is rare. With construction of dams along the Columbia River, flooding is nearly nonexistent.

The Hanford Site was a major contributor to national defense during World War II and the Cold War era. The site was selected because it was sparsely settled and the Columbia River provided an abundant supply of cold, clean water to cool the reactors. As a result of wastes generated by these national defense activities, there are presently more than 1500 waste management units and four major groundwater contamination plumes. These have been grouped into 78 operable units: 22 in the 100 Area (reactor area), 43 in the 200 Area (chemical processing and refining areas), 5 in the 300 Area (research and development area), and 4 in the 1100 Area (storage area). An additional four units are found in the 600 Area (the rest of the Hanford Site). Each of these operable units is following a schedule for clean-up established by the Hanford Federal Facility Agreement and Consent Order (Tri-Party Agreement), which involves the U.S. Department of Energy (DOE), the Washington Department of Ecology, and the EPA.

4.2 Land Use

A brief description of the existing land use on the Hanford Site and adjacent lands and a brief discussion devoted to the existing land use on the proposed project site area follow.

4.2.1 Land Use at the Hanford Site

The Hanford Site is used primarily by DOE. Public access is limited to travel on the two access roads as far as the Wye Barricade, on Highway 240, and on the Columbia River (see Figure 4-1). The site encompasses 1450 square kilometers (560 square miles), of which most is open vacant land with widely scattered facilities, old reactors, and processing plants (Figure 4-1). In the past, DOE has stated that it intends to maintain active institutional control of the Hanford Site in perpetuity (DOE 1989). In the future, DOE could release or declare excess portions of the Hanford Site not required for DOE activities. Alternatively, Congress could act to change the management or ownership of the Hanford Site. The DOE operational areas are described below:

Figure 4-1. Hanford Site showing proposed spent nuclear fuel facility location.

- The 100 Area [11 square kilometers (4.2 square miles)], which borders the right bank (south shore) of the Columbia River, is the site of eight retired plutonium production reactors and N Reactor, which is in shutdown deactivation status.

- The 200-West and 200-East Areas [16 square kilometers (6.2 square miles)] are located on a plateau about 8 and 11 kilometers (5 and 7 miles), respectively, from the Columbia River. These areas have been dedicated for some time to fuel reprocessing and waste processing management and disposal activities. The proposed project would be located between these areas.

- The 300 Area [1.5 square kilometers (0.6 square miles)], located just north of the city of Richland, is the site of nuclear research and development.

- The 400 Area [0.6 square kilometers (0.25 square miles)] is about 8 kilometers (5 miles) north of the 300 Area and is the site of the

Fast Flux Test Facility (FFTF) used in the testing of breeder reactor systems. Also included in this area is the Fuels and Material Examination Facility.

- The 600 Area comprises the remainder of the Hanford Site and includes the Arid Land Ecology Reserve (ALE) [310 square kilometers (120 square miles)], which has been set aside for ecological studies, and the following facilities and sites:
    - a commercial low-level radioactive waste disposal site [4 square kilometers (1.7 square miles)], part of which is leased by the State of Washington.
    - Washington Public Power Supply System nuclear power plants [4.4 square kilometers (1.7 square miles)].
    - a 2.6-square kilometer (1 square mile) parcel of land transferred to Washington State as a potential site for the disposal of nonradioactive hazardous wastes.
    - a wildlife refuge of about 130 square kilometers (50 square miles) under revocable use permit to the U.S. Fish and Wildlife Service.
    - an area of about 6 square kilometers (2.3 square miles) has been provided to site a National Science Foundation Laser Gravitational-Wave Interferometer Observatory west of the 400 Area. When completed, this facility will occupy about 0.6 square kilometers (0.2 square miles).
    - a recreational game management area of about 225 square kilometers (87 square miles) under revocable use permit to the Washington State Department of Game.
    - support facilities for the controlled access areas.

In addition, an area comprising 310 square kilometers (120 square miles) has been designated for use as the ALE by the U.S. Fish and Wildlife Service for a wildlife refuge and by the Washington State Department of Wildlife for a game management area (DOE 1986a). The entire Hanford Site has been designated a National Environmental Research Park.

The Columbia River adjacent to the Hanford Site is a major site for public use by boaters, water skiers, fishermen, and hunters of upland game birds and migratory waterfowl. Some land access along the shore and on certain islands is available for public use.

4.2.2 Land Use in the Vicinity of the Hanford Site

Land use adjacent to the Hanford Site to the southeast and generally along the Columbia River includes residential, commercial, and industrial development. The cities of Richland, Kennewick, and Pasco are located along the Columbia River and are the closest major urban land uses adjacent to the Hanford Site. These cities (known as the Tri-Cities) together support a population of approximately 96,000.

Irrigated orchards and produce crops, dry-land farming, and grazing are also important land uses adjacent to the Hanford Site. In 1985 wheat represented the largest single crop in terms of area planted in Benton and Franklin counties with 190 square kilometers (73 square miles). Corn, alfalfa, hay, barley, and grapes are other major crops in Benton and Franklin counties. In 1986 the Columbia Basin Project, a major irrigation project to the north of the Tri-Cities, produced gross crop returns of $343 million, representing 19 percent of all crops grown in Washington State. In 1986 the average gross crop value per irrigated acre was $664.00. The largest percentage of irrigated acres produced alfalfa hay, 29.4 percent of irrigated acres; wheat, 15.0 percent; and corn (feed grain), 9.4 percent. Other significant crops are potatoes, apples, dried beans, asparagus, and pea seed.

4.2.3 Potential Project Land Use

The potential project site (Centralization Alternative) is located between the 200-West and 200-East Areas. The land is currently vacant. The proposed project would consist of constructing an SNF facility on the site. This potential project would involve typical land uses that occur during construction phases and a more industrial/commercial land use after reaching the operational stage.

4.2.4 Native American Treaty Rights

In prehistoric and early historic times, the Hanford Reach of the Columbia River was populated by Native Americans of various tribal affiliations. The Wanapum and the Chamnapum bands of the Yakama[a] tribe lived along the Columbia River from south of Richland upstream to Vantage (Relander 1986; Spier 1936). Some of their descendants still live nearby at Priest Rapids Dam (the Wanapum Tribe); others have been incorporated into the Yakama and Umatilla reservations. Palus people, who lived on the lower Snake River, joined the Wanapum and Chamnapum to fish the Hanford Reach of the Columbia River, and some inhabited the river's east bank (Relander 1986; Trafzer and Scheuerman 1986). Walla Walla and Umatilla people also made periodic visits to fish in the area. These people retain traditional secular and religious ties to the region, and many, young and old alike, have knowledge of the ceremonies and lifeways of their aboriginal culture. The Washane, or Seven Drums religion, which has ancient roots and had its start on what is now the Hanford Site, is still practiced by many people on the Yakama, Umatilla, Warm Springs, and Nez Perce reservations. Native plant and animal foods, some of which can be found on the Hanford Site, are used in the ceremonies performed by sect members.

Native American Lands designated on the Hanford Site fall under the protective rights of the Treaty of 1855 and the National Historic Preservation Act; these will be addressed further in the Cultural Resources Section. Under the Treaties of 1855, lands now occupied by the Hanford Site and other southeastern Washington lands were ceded to the United States by the confederated tribes and bands of the Yakama Indian Nation, the Confederated Tribes of the Umatilla Indian Reservation, and the Nez Perce Tribe. Under these treaties, the Native American tribes obtained the right to perform certain activities on those lands, including the rights to hunt, to fish at all usual and accustomed places and to erect temporary buildings for curing fish, to gather roots and berries, and to pasture horses and cattle on open unclaimed lands. The Wanapum Tribe, although members never signed a treaty, claims similar rights on ceded lands along the Columbia River.

Tribal members have expressed an interest in renewing their use of these resources in accordance with the Treaty of 1855, and the DOE is assisting them in this effort. Certain landmarks, especially Rattlesnake Mountain, Gable Mountain, Gable Butte, Goose Egg Hill, and various sites along the Columbia

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a. The spelling Yakama rather than Yakima has been adopted by the Yakama Nation.

River, are sacred to them. The many cemeteries found along the river are also considered to be sacred.

4.3 Socioeconomics

Activity on the Hanford Site plays a dominant role in the socioeconomics of the Tri-Cities (Richland, Pasco, and Kennewick) and other parts of Benton and Franklin counties. The Tri-Cities serves as a market center for a much broader area of eastern Washington, including Adams, Columbia, Grant, Walla Walla, and Yakima counties. The Tri-Cities also serves parts of northeastern Oregon, including Morrow, Umatilla, and Wallowa counties. Socioeconomic impacts of changes at Hanford are mostly confined to the immediate Tri-Cities community and Benton and Franklin counties (Yakima County to a lesser extent). However, because of the significance of the wider agricultural region and surrounding communities in the Tri-Cities' economic base, this section briefly discusses the wider region as well. Detailed analyses of the socioeconomics are found in Scott et al. (1987) and Watson et al. (1984). Additionally, the impact of the proposed SNF facility might be altered by changes in socioeconomic resources in the surrounding counties of Adams, Columbia, Grant, Walla Walla, and Yakima in Washington state; and Morrow, Umatilla, and Wallowa counties in Oregon (these and Benton and Franklin counties comprise the designated region of influence; see Figure 4-2). This section describes the population, economic activity, housing, and public services and public finance of each county within the region of influence and the Tri-Cities. Because Benton and Franklin counties are expected to be most impacted from changes in Hanford Site activities, the information presented in this section concentrates on those counties, with less attention paid to the other areas within the defined region of influence.

Figure 4-2. Areas of Washington and Oregon where socioeconomic resources may be region of influence).

Table 4.3-1 summarizes the regional (Benton and Franklin counties) projections for employment, labor force, population, and Hanford Site employment by year for the years 1995-2004. Population projections were provided by the Washington State Office of Financial Management (1992a); employment projections were based on projections from the U.S. Department of Commerce (1992); labor force projections were based on an historical averag unemployment rate of 8.8%; and Hanford Site employment projections were provided by DOE. It is anticipated at the time of this writing that a down-turn in Hanford Site employment will occur. The extent of the down-turn is unknown.

4.3.1 Demographics

This subsection briefly summarizes pertinent demographic information for each of the counties within the region of influence. Data for Washington were provided by the U.S. Department of Commerce (1992) and the Washington State Office of Financial Management (1992a,b). Data for Oregon were provided by the U.S. Department of Commerce (1992) and the Center for Population Research and Census (1993). Table 4.3-2 summarizes the population figures from 1960 to 1992 for each of the affected counties.

During the period from 1980 to 1990, growth in the affected Washington counties has been less than that of the state, with growth in the counties ranging from -0.07 percent (Columbia County) to 1.22 percent (Grant County) per year. During this same period, annual growth for the state of Washington averaged 1.66 percent. Washington counties within the region of influence also tended to have a younger population, with median ages ranging from 28.7

years to 39.0 years, as compared to the state median age of 33.1 years. These counties also tended to have a larger average household size than the state average, ranging from 2.44 to 3.03 persons, while the state average household size was listed at 2.53 persons.

Table 4.3-3 summarizes population projections through 2005 for each of the counties within the region of influence. All of the Washington counties are expected to experience continued growth, although most have projected growth rates less than that of the state. Washington is projected to have an increase in population of 21.8 percent by 2005 (from 4,866,692 in 1990 to 5,925,888 in 2005) for an annual average increase of 1.45 percent. Growth in the Oregon counties within the region of influence occurred rapidly during the 1970s; however, since 1980 population growth has tapered off. The Oregon counties within the region of influence are also expected to experience continued

Table 4.3-1. Regional economic and demographic indicators.

Year:	1995	1996	1997	1998	1999	2000	2001	2
Regional Employment	81,000	81,780	82,570	83,360	84,170	84,900	85,320	8
Regional Labor Force	88,820	89,670	90,540	91,410	92,290	93,090	93,550	9
Regional Population	162,660	164,810	166,980	169,180	171,410	173,380	175,730	1 0
Site Employment	18,700	16,200	14,700	14,700	14,700	14,700	14,700	1

Table 4.3-2. Population figures by county in the designated region of influence.

County	1960	1970	1980	1990	1992	1990 Median Age	1990 Average Household Size
Adams	9,929	12,014	13,267	13,603	14,100	30.7	2.94
Benton	62,070	67,540	109,444	112,560	118,500	32.1	2.65
Columbia	4,569	4,439	4,057	4,024	4,000	39.0	2.44
Franklin	23,342	25,816	35,025	37,473	39,200	28.7	3.03
Grant	46,477	41,881	48,522	54,758	58,200	31.9	2.74
Walla Walla	42,195	42,176	47,435	48,439	50,500	33.5	2.50
Yakima	145,112	145,212	172,508	188,823	193,900	31.5	2.80
Morrow	4,871	4,465	7,519	7,625	8,092a	-b	-
Umatilla	44,352	44,923	58,861	59,249	60,150a	-	-
Wallowa	7,102	6,247	7,273	6,911	7,135a	-	-

a. 1991 estimate.
b. Dash indicates the information was not available.

Table 4.3-3. Population projections by county in the designated region of influence.

County	1995 Forecast	1990 - 1995 % Change	2000 Forecast	1995 - 2000 % Change	2005 Forecast	2000 - 2005 % Change
Adams	13,867	1.94	14,163	2.14	14,424	1.84
Benton	121,328	7.79	128,752	6.12	136,892	6.32
Columbia	4,025	0.03	4,037	0.30	4,074	0.90
Franklin	41,336	10.31	44,630	7.97	48,213	8.03
Grant	58,026	5.97	60,518	4.30	62,983	4.07
Walla Walla	49,047	1.26	49,910	1.76	50,891	1.97
Yakima	199,578	5.70	207,870	4.15	216,245	4.03
Morrow	8,095	6.16	8,596	6.19	9,157	6.53
Umatilla	62,658	5.75	66,056	5.42	69,506	5.22
Wallowa	7,065	2.23	7,253	2.66	7,496	3.35

growth, although all have projected growth rates less than that of the state. Oregon is projected to have an increase in population of 25.5 percent (from 2,842,321 in 1990 to 3,566,189 in 2005) by 2005 for an annual average increase of 1.70 percent.

Within Benton and Franklin counties, the 1992 estimates distributed the Tri-Cities population as follows: Richland, 33,550; Kennewick, 44,490; and Pasco, 20,840. The combined populations of Benton City, Prosser, and West Richland totaled 10,460 in 1992. The unincorporated population of Benton County was 30,000. In Franklin County, incorporated areas other than Pasco had a total population of 2,540. The unincorporated population of Franklin County was 15,820.

4.3.2 Economics

This subsection summarizes pertinent economic activity within the region of interest and the Tri-Cities, including information on the general economy, employment, income, and impact of the Hanford Site. Historically, the primary industries within the region of influence have been related to agriculture; a multitude of crops encompassing many fruits, vegetables, and grains, are grown each year. Nearly all of the counties in the region of influence are home to food processing industries. Other primary industries within the region of influence include those relating to the wood industry: lumber, wood, and paper products. The data source for the Washington counties was the 1993 Washington State Yearbook (Office of the Secretary of State 1993), and the data source for the Oregon counties data was the 1991-92 Oregon Blue Book (Office of the Secretary of State 1991). Table 4.3-4 summarizes the primary industries, total employment for 1990, and total payroll for 1990 for the region of influence.

4.3.2.1 Employment in the Region of Interest. This subsection provides information on the employment and payroll breakdown by sector for each county within the region of influence. The source for the Washington counties was Washington State Employment Security Office (1992). The source for the Oregon counties was Department of Human Resources (1990). Tables 4.3-5 and and 4.3-6 provide information on average employment and payroll for 1990, broken down by

Table 4.3-4. County economic summary.

County	Primary Industries	1990 Total Employment	1990 Total Payroll ($ Million)
Adams	Food processing, agriculture	6,142	87.2
Benton	Food processing, chemicals, metal products, nuclear products	50,216	1,200.0
Columbia	Agriculture, food processing, wood products	1,559	22.3
Franklin	Food processing, publishing, agriculture, metal fabrication	17,958	284.6
Grant	Food processing, agriculture	20,851	346.0
Walla Walla	Food processing, agriculture, wood and paper products, manufacturing	20,546	366.5
Yakima	Agriculture, food processing, wood products, manufacturing	82,706	1,300.0
Morrow	Agriculture, food processing, utilities, lumber, livestock, recreation	2,791	53.5

Umatilla	Agriculture, food processing, wood products, tourism, manufacturing, recreation	21,448	366.0
Wallowa	Agriculture, livestock, lumber, recreation	2,216	37.9

industry, for each of the counties within the region of influence. For the Washington counties, the average employment includes only persons covered by the Employment Security Act and federal employment covered by Title 5, USC 85. For the Oregon counties, average employment includes only employees of businesses covered by the Employment Division Law.

4.3.2.2 Employment in the Tri-Cities. Three major sectors have been the principal driving forces of the economy in the Tri-Cities since the early 1970s: (1) the DOE and its contractors, which operate the Hanford Site; (2) Washington Public Power Supply System in its construction and operation of nuclear power plants; and (3) agriculture, including a substantial food-processing industry. With the exception of a minor amount of agricultural commodities sold to local area consumers, the goods and services produced by these sectors are exported from the Tri-Cities. In addition to direct employment and payrolls, these major sectors also support a sizable number of jobs in the local economy through their procurement of equipment, supplies, and business services.

Table 4.3-5. Employment by industry in the region of influence, 1990 figures.

Industry	Adams	Benton	Columbia	Franklin	Grant	Morrow
Agriculture, Forestry, Fisheries	1,660	4,487	105	4,265	4,496	558
Mining	0	3	0	89	0	0
Construction	0	2,809	27	628	0	33
Manufacturing	1036	12,310	563	1,599	2,761	884
Transportation and Public Utilities	236	884	58	1,212	657	153
Wholesale Trade	581	932	57	1,279	1,156	70
Retail Trade	720	7,865	120	2,669	3,109	195
Finance, Insurance, Real Estate	120	1,342	24	358	432	50
Services	564	11,741	144	2,768	2,512	142
Government	1,132	7,843	461	3,091	4,618	697
Not Elsewhere Classified	93	0	0	0	1,110	8

Table 4.3-6. Payroll by industry in the region of influence, 1990 figures ($ milli

Industry	Adams	Benton	Columbia	Franklin	Grant	Walla Wa
Agriculture, Forestry, Fisheries	14.7	39.1	1.5	39.1	47.9	18.4
Mining	0	0.1	0	2.3	0	0
Construction	0	79.3	1.0	12.7	0	0
Manufacturing	19.6	443.9	7.3	28.4	59.7	94.0
Transportation and Public Utilities	3.9	21.2	1.2	25.1	14.4	14.1
Wholesale	10.7	19.2	1.1	26.3	21.4	15.6

Trade						
Retail Trade	7.1	89.0	1.0	31.5	30.3	36.1
Finance, Insurance, Real Estate	2.0	22.0	0.4	6.2	7.6	13.2
Services	6.3	286.4	1.2	42.2	28.0	66.6
Government	21.2	225.8	7.7	70.8	107.0	100.0
Not Elsewhere Classified	1.6	0	0	0	29.7	8.6

1) The DOE and its Contractors (Hanford). Hanford continued to dominate the local employment picture with almost one-quarter of the total nonagricultural jobs in Benton and Franklin counties in 1992 (16,100 of 67,300). Hanford's payroll has a widespread impact on the Tri-Cities economy and state economy in addition to providing direct employment. These effects are further described in Subsection 4.3.

2) Washington Public Power Supply System. Although activity related to nuclear power construction ceased with the completion of the WNP-2 reactor in 1983, the Washington Public Power Supply System continues to be a major employer in the Tri-Cities area. Headquarters personnel based in Richland oversee the operation of one generating facility and perform a variety of functions related to two mothballed nuclear plants and one standby generating facility. In 1992, the Washington Public Power Supply System headquarters employment was more than 1700 workers. Washington Public Power Supply System activities generated a payroll of approximately $80.4 million in the Tri-Cities during the year.

3) Agriculture. In 1990 agricultural activities in Benton and Franklin counties were responsible for approximately 12,900 jobs, or 17 percent of the area's total employment. According to the U.S. Department of Commerce's Regional Economic Information System, about 2200 people were classified as farm proprietors in 1990. Farm proprietors' income from this same source w estimated at $121 million in the same year.

Crop and livestock production in the bicounty area generated about 7600 wage and salary jobs in 1990, as represented by the employees covered by unemployment insurance. The presence of seasonal farm workers would increase the total number of farm workers. Apart from the difficulty of obtaining reliable information on the number of seasonal workers, however, is the question of how much of these earnings are actually spent in the local For this analysis, the assumption is that the impact of seasonal workers on the local economy is sufficiently small to be safely ignored.

The area's farms and ranches generate a sizable number of jobs in supporting activities, such as agricultural services (for example, application of pesticides and fertilizers or irrigation system development) and sales of farm supplies and equipment. These activities, often called agribusiness, are estimated to employ 900 people. Although formally classified as a manufacturing activity, food processing is a natural extension of the farm sector. More than 20 food processors in Benton and Franklin counties produce such items as potato products, canned fruits and vegetables, wine, and animal feed.

In addition to those three major employment sectors, three other components are readily identified as contributors to the economic base of the Tri-Cities economy. The first component, categorized as other major employers, includes five employers: (1) Siemens Nuclear Power Corporation in north Richland, (2) Sandvik Special Metals in Kennewick, (3) Boise-Cascade in Wallula, (4) Burlington Northern Railroad in Pasco, and (5) Iowa Beef Processors in Wallula. The second component is tourism. The Tri-Cities area has increased its convention business substantially in recent years, in addition to business generated by travel for recreation. The final component in the economic base relates to the local purchasing power generated from retired former employees. Government transfer payments in the form of pension benefits constitute a significant proportion of total spendable income in the local economy.

Retirees. Although the Benton and Franklin counties have a relatively young population (approximately 56 percent under the age of 35), 15,093 people over the age of 65 resided in Benton and Franklin counties in 1990. The por the total population that is 65 years and older is currently increasing at about the same rate as that being experienced by Washington State (3.0 percent and 3.1 percent, respectively). This segment of the population supports the local economy on the basis of income received from government transfer payments and pensions, private pension benefits, and prior individual savings.

Although information on private pensions and savings is not available, data are available regarding the magnitude of government transfer payments. The U.S. Department of Commerce's Regional Economic Information System has estimated transfer payments by various programs at the county level. A summary of estimated major government pension benefits received by the residents of Benton and Franklin counties in 1990 is shown in Table 4.3-7. About two-thirds of the Social Security payments go to retired workers; the remainder are for disability and other payments. The historical importance of government activity in the Tri-Cities area is reflected in the relative magnitude of the government employee pension benefits as compared to total payments.

Table 4.3-7. Government retirement payments in Benton and Franklin counties in 1990 ($ million).

Source	Benton County	Franklin County	Total
Social Security (including survivors and disability)	101.5	31.1	132.6
Railroad retirement	2.7	3.6	6.3
Federal civilian retirement	10.5	2.8	13.3
Veterans pension and military retirement	14.7	3.1	17.8
State and local employee retirement	22.3	5.5	27.8
Total	151.7	46.1	197.8

4.3.2.3 Income Sources. Three measures of income are presented in

Table 4.3-8: total personal income, per capita income, and median household **income.** Total personal income is comprised of all forms of income received by the populace, including wages, dividends, and other revenues. Per capita income is roughly equivalent to total personal income divided by the number of people residing in the area. Median household income is the point at which half of the households have an income greater than the median and half have less. The source for total personal income and per capita income was the U.S. Department of Commerce's Regional Economic Information System; while median income figures for Washington State were provided in Washington State Office of Financial Management (1992b), and by personal communication with the Bureau of Census Housing Division for Oregon.

In 1990 the total personal income for the Washington was $92.2 billion; of this, the counties within the region of influence comprised 8.0 percent. Per capita income for Washington State was $18,777; all Washington counties within the region of influence had per capita incomes less than that of the state. All Washington counties within the region of influence, with the exception of Benton, had median household incomes less than the state median of $32,725.

In 1990 the total personal income for Oregon was $49.2 billion; of this, the counties within the region of influence comprised 2.4 percent. Per capita income for Oregon State was $17,182; two of the three affected Oregon counties had per capita incomes greater than that of the state in 1990; however, only one of the three counties had a median household income greater than the state median of $27,250.

Table 4.3-8. Income measures by county, 1990 figures.

County	Total Personal Income ($ Million)	Per Capita Income ($)	Median Income ($)
Adams	231	16,897	25,750
Benton	1,960	17,332	33,800
Columbia	72	17,927	21,000
Franklin	553	14,734	26,300

Grant	854	15,511	23,625
Walla Walla	799	16,438	25,400
Yakima	2,920	15,374	24,525
Morrow	144	18,868	29,969
Umatilla	896	15,069	22,791
Wallowa	121	17,461	21300

4.3.2.4 Hanford Employment. In 1991 Hanford employment accounted directly for 24 percent of total nonagricultural employment in Benton and Franklin counties and slightly more than 0.6 percent of all statewide nonagricultural jobs. In 1991 Hanford Site operations directly accounted for an estimated 42 percent of the payroll dollars earned in the area.

Previous studies have revealed that each Hanford job supports about 1.2-additional jobs in the local service sector of Benton and Franklin counties (about 2.2 total jobs) and about 1.5 additional jobs in the state's service sector (about 2.5 total jobs) (Scott et al. 1987). Similarly, each dollar of Hanford income supports about 2.1 dollars of total local incomes and about 2.4 dollars of total statewide incomes. Based on these multipliers, Hanford directly or indirectly accounts for more than 40 percent of all jobs in Benton and Franklin counties.

Based on employee residence records as of December 1993, 93 percent of the direct employment of Hanford is comprised of residents of Benton and Franklin counties. Approximately 81 percent of the employment is comprised of residents who reside in one of the Tri-Cities. More than 42 percent of the employment is comprised of Richland residents, 30 percent of Kennewick residents, and 9 percent of Pasco residents. West Richland, Benton City, Prosser, and other areas in Benton and Franklin counties account for 12 percent of total employment. Table 4.3-9 contains the estimated percent of Hanford employees residing in each of the counties within the region of influence. The information available did not include the residences of DOE employees nor those of ICF Kaiser Hanford Company or the Bechtel Hanford Company. It was assumed that the distribution of these employees would be similar to the distribution of the other Hanford contractors.

Table 4.3-9. Hanford employee residences by county.

County	Percent of Employees in Residence
Adams	0.18%
Benton	84.16%
Columbia	0.01%
Franklin	9.07%
Grant	0.25%
Walla Walla	0.21%
Yakima	5.08%
Morrow	0.01%
Umatilla	0.01%

Hanford and contractors spent nearly $298 million, or 45.6 percent of total procurements of $653 million, initially through Washington firms in 1993. About 18 percent of Hanford orders were filled by Tri-Cities firms.

Hanford contractors paid a total of $10.9 million in state taxes on operations and purchases in fiscal year 1988 (the most recent year available). Estimates show that Hanford employees paid $27.0 million in state sales tax, use taxes, and other taxes and fees in fiscal year 1988. In addition, Hanford paid $0.9 million to local government in Benton, Franklin, and Yakima counties in local taxes and fees (Scott et al. 1989).

4.3.3 Emergency Services

This subsection contains information on the law enforcement, fire protection, and health services provided by each county within the region of influence. These figures are presented in Table 4.3-10, with more detailed information about the Tri-Cities area. Law enforcement figures were obtained from each county sheriff's office in December 1993. Data on fire protection and health care facilities were provided by the Office of the Secretary of State (1993).

Table 4.3-10. Emergency services within the region of influence.

County	Commissioned Officers - County Sheriff	Number of Fire Districts - Unincorporated	Number of Hospital
Adams	16 + Sheriff	7	2
Benton	40	6	3
Columbia	10 + Sheriff	3	1
Franklin	18 + Sheriff	4	1
Grant	35 + Sheriff	12	1
Walla Walla	16 + Sheriff	8	2
Yakima	63	12	3
Morrow	70	NA	NA
Umatilla	12	NA	NA
Wallowa	5	NA	NA

Police protection in Benton and Franklin counties is provided by the Benton and Franklin County sheriff's departments, local municipal police departments, and the Washington State Patrol Division headquartered in Kennewick. Table 4.3-11 shows the number of commissioned officers and patrol cars in each department in June 1992.

Table 4.3-11. Police personnel in the Tri-Cities in 1992.

Area	Commissioned Officers	Patrol Cars
Kennewick Municipal	58	32
Pasco Municipal	39	11
Richland Municipal	44	35
West Richland Municipal	7	9
County Sheriff, Benton County	43	50
County Sheriff, Franklin County	23	23

Source: Personal communication with each department office, January 1993.

The Kennewick, Richland, and Pasco municipal departments maintain the largest staffs of commissioned officers with 53, 44, and 38, respectively.

The Hanford Fire Department, composed of 126 firefighters, is trained to dispose of hazardous waste and to fight chemical fires. During the 24-hour duty period, five firefighters cover the 1100 Area, seven protect the 300 Area, seven watch the 200-East and 200-West Areas, six are responsible for the 100 Areas, and six cover the 400 Area, which includes the WPPSS area. To perform their responsibilities, each station has access to a Hazardous Material Response Vehicle that is equipped with chemical fire extinguishing equipment, an attack truck that carries foam and Purple-K dry chemical, a mobile air truck that provides air for gasmasks, and a transport tanker that supplies water to six brush-fire trucks. The Hanford Fire Patrol owns five ambulances and maintains contact with local hospitals.

Table 4.3-12 indicates the number of fire-fighting personnel, both paid and unpaid, on the staffs of fire districts in the Tri-Cities area.

The Tri-Cities area is served by three hospitals: Kadlec Hospital, Kennewick General, and Our Lady of Lourdes. In addition, the Carondelet Psychiatric Care Center is located in Richland. Kadlec Hospital, located in Richland, has 136 beds and functions at 39.5 percent

Table 4.3-12. Fire protection in the Tri-Cities in 1992a.

Station	Fire-Fighting Personnel	Volunteers	Total	Service Are
Kennewick	54	0	54	City of Ken
Pasco	30	0	30	City of Pas
Richland	50	0	50	City of Ric
BCRFDb 1	6	120	126	Kennewick A
BCRFD 2	1	31	32	Benton City
BCRFD 4	4	30	34	West Richla

a. Source: Personal communication with each department office, January 1993.

b. BCRFD = Benton County Rural Fire Department.

capacity. Their 5754 annual admissions represent more than 42 percent of the Tri-Cities market. Non-Medicare/Medicaid patients accounted for 86 percent, or 4982 of their annual admissions. An average stay of 3.8 days per admission was reported for 1991.

Kennewick General Hospital maintains a 45.5 percent occupancy rate of its 71 beds with 3619 annual admissions. Non-Medicare/Medicaid patients in 1991 represented 58 percent of its total admissions. An average stay of 3.5 days per admission was reported.

Our Lady of Lourdes Health Center, located in Pasco, reported an occupancy rate of 36.5 percent; however, a significant amount of outpatient care is performed there. The out patient income serves as a primary source of income for the center. In 1990 Our Lady of Lourdes had 3328 admissions, of which 52 percent were non-Medicare/Medicaid patients. The institution reported an average admission stay of 5.33 days.

4.3.4 Infrastructure

4.3.4.1 Housing. This section provides information on the total number

of housing units, the number of occupied housing units, and a breakdown of total housing units by type for each of the counties within the region of influence. Additionally, specific information on the housing market in the Tri-Cities is included. The data source for Washington counties was the Washington State Office of Financial Management (1992b). The data source for the Oregon counties was by personal communication with the Population Research Center at Portland State University. The data source for the Tri-Cities was by personal communication with the Washington State Office of Financial Management. Table 4.3-13 summarizes housing information by county for 1990 for the region of influence.

In 1993 nearly 94 percent of all housing (of 40,344 total units) in the Tri-Cities was occupied. Single-unit housing, which represents nearly 58 percent of the total units, had a 97 percent occupancy rate throughout the Tri-Cities. Multiple-unit housing, defined as housing with two or more uni had an occupancy rate of nearly 94 percent. Pasco had the lowest occupancy rate, 92 percent, in all categories of housing; followed by Kennewick, 95 percent, and Richland, 96 percent. Mobile homes, which represent 9 percent of the housing unit types, had

Table 4.3-13. Housing by county in 1990.

County	Total	Occupied	Vacancy Rate	Single Family
Adams	5,263	4,586	12.9%	3,324

Benton	44,877	42,227	5.9%	28,193
Columbia	2,046	1,582	22.7%	1,597
Franklin	13,664	12,196	10.7%	7,782
Grant	22,809	19,745	13.4%	13,692
Walla Walla	19,029	17,623	7.4%	13,071
Yakima	70,852	65,985	6.9%	49,356
Morrow	3,412	2,803	17.8%	1,828
Umatilla	24,333	22,020	9.5%	15,178
Wallowa	3,755	2,796	25.5%	2,935

the lowest occupancy rate, 90 percent. In 1989 mobile homes had the highest occupancy rate, 93 percent. Table 4.3-14 shows a detailed listing of total units and occupancy rate by type in the Tri-Cities.

4.3.4.2 Human Services. The Tri-Cities offer a broad range of social services. State human service offices in the Tri-Cities include the Job Services office of the Employment Security Department; Food Stamp offices; the Division of Developmental Disabilities; Financial and Medical Assistance; the Child Protective Service; emergency medical service; a senior companion program; and vocational rehabilitation.

Table 4.3-14. Total units and occupancy rates (1993 estimates)a.

City	All Units	Rate	Single Units	Rate	Multiple Units	Rate	Mobile Homes
Richland	14,388	96	9,921	98	3,827	95	640
Pasco	7,846	92	3,679	96	2,982	91	1,016
Kennewick	18,110	95	9,824	97	5,944	96	1,942
Tri-Cities	40,344	94	23,424	97	12,753	94	3,598

a. Source: Personal communication, Office of Financial Management, State of Washington, Forecast Division.

The Tri-Cities are also served by a large number of private agencies and voluntary human services organizations. The United Way, an umbrella fund-raising organization, incorporates 25 participating agencies offering more than 50 programs (United Way 1992).

4.3.4.3 Government. This subsection presents the county government revenues by source (Table 4.3-15) and expenditures by function (Table 4.3-16) for each of the counties within the region of influence. The data were taken from U.S. Department of Commerce (1990, 1993). All county data, with the exception of Benton and Yakima counties, are from 1986-87. Benton and Yakima county data are from 1990-91. These years were the most recent ones available.

4.3.4.4 Public Education. This subsection provides information on the

educational sectors of each of the counties. The source for school district information, secondary education, and enrollment data for the Washington counties was the Office of the Secretary of State (1993); student/teacher ratios were provided by personal communication with the school districts. Information on the Oregon counties was provided by personal communication with the individual counties. Table 4.3-17 summarizes information on the number of school districts, enrollment, and post-secondary institutions within the region of influence.

In the Tri-Cities area, Benton County primary and secondary education is served by six school districts with an enrollment of 24,876 students in 1992. The student/teacher ratio in the Finley School District is 20.2; in Kennewick, 24.0; in Kiona Benton-City, 25.0; in Prosser, 22.0 for elementary and 25.0 for secondary; and in Richland, 23.0. The Paterson School District had an enrollment of 54 students in 1992, therefore a student/teacher ratio was not sought. Currently, the Kennewick, Richland, and Kiona-Benton City school districts are operating at or near capacity; Kennewick is working to alleviate some of the overcrowded conditions by constructing one new middle school and two new elementary schools. In addition, plans are under way for the construction of a new high school, scheduled to open in 1997. Kiona-Benton City is in the process of building additions at elementary and middle schools. The county also has a post-secondary institution located in Richland, a branch campus of Washington State University, WSU Tri-Cities. Enrollment for spring 1992 was 981 students.

Franklin County primary and secondary education is served by four school districts with an enrollment of 8,756 students in 1992 and a student/teacher ratio of 7.0 in Kahlotus; 17.6 in

Table 4.3-15. Revenue sources by county FY 1986-87 ($ thousand).

			Intergovernmental revenue	
County	Total	Total	From federal government	From state government
Adams	6,690	6,690	736	2,844
Bentonb	24,079	24,079	43	7,879
Columbia	2,560	2,560	78	1,388
Franklin	6,279	6,279	361	109
Grant	17,525	17,525	670	7,661
Walla Walla	11,698	11,698	426	3,763
Yakimab	45,310	45,289	392	14,066
Morrow	5,901	5,901	104	1,045
Umatilla	9,594	9,594	204	4,971
Wallowa	6,215	6,215	60	2,180

a. Dash indicates that the information was not available.
b. FY 1990-91.

Table 4.3-16. Expenditures by county FY 1986-87 ($ thousand).

General Expenditures

Major Functions

Capi-

Police

County	Total	Total	tal Outlay	Education	Welfare	Hospitals	Health	Highways	protection	Corr tion
Adams	6431	6431	1007	13	-a	-	286	3591	475	297
Bentonb	22027	22027	890	9	-	-	3626	3190	1956	4129
Columbia	2647	2647	255	-	-	-	230	1106	265	13
Franklin	8230	8230	608	-	-	-	461	2883	855	811
Grant	17589	17589	3314	-	-	-	1403	6617	1443	1180
Walla Walla	11879	11879	432	4	-	-	1068	4624	1257	610
Yakimab	45967	45937	10059	-	187	-	989	9761	4188	7382
Morrow	6382	6382	411	216	349	1113	325	1860	270	98
Umatilla	10707	10707	188	1095	-	-	2562	2337	540	561
Wallowa	6139	6139	362	339	794	2070	143	1181	208	111

a. Dash indicates that the information was not available.
b. FY 1990-91.

Table 4.3-17. Educational services by county in 1992.

County	Number of School Districts	Enrollment (1992)	Post-Se Educati Institu
Adams	5	3,437	0
Benton	6	24,876	1
Columbia	2	750	0
Franklin	4	8,756	1
Grant	10	13,232	1
Walla Walla	7	8,324	3
Yakima	15	42,227	3
Morrow	1	2,008a	0
Umatilla	12	12,500a	1
Wallowa	3	1,408a	0

a. 1993 enrollment

North Franklin; and 18.1 in Pasco. The Star School District had an enrollment of 15 students in 1992; therefore, a student/teacher ratio was not sought. Currently, Pasco School District is operating at or near capacity; however, the district is in the process of remodeling an old high school. The county also has a post-secondary institution of learning in Pasco, Columbia Basin Community College. Enrollment for 1992 was 6424 students.

4.4 Cultural Resources

The Hanford Site is known to be rich in cultural resources. It contains numerous, well-preserved archaeological sites representing both the prehistoric and historical periods and is still thought of as a homeland by many Native American people. A total of 248 known sites are prehistoric, 202 are historic, and 14 sites contain both prehistoric and historic comp Management of Hanford's cultural resources follows the Hanford Cultural Resources Management Plan (Chatters 1989) and is conducted by the Hanford

Cultural Resources Laboratory of Pacific Northwest Laboratory (PNL). The Plan contains contingency guidelines for handling the discovery of previously unknown cultural resources encountered during construction activities.

Cultural resources are defined as any prehistoric or historic district, site, building, structure, or object considered to be important to a culture, subculture, or community for scientific, traditional, religious or any other reason. These are usually divided into three major categories: prehistoric and historic archaeological resources, architectural resources, and traditional cultural resources. Significant cultural resources are those that are eligible or potentially eligible to the National Register of Historic Places (36 CFR 60.4).

Consultation is required to identify traditional cultural properties that are important to maintaining the cultural heritage of Native American Tribes. Under the Treaties of 1855, lands ultimately occupied by the Hanford Site were ceded to the United States by the confederated tribes and bands of the Yakama Indian Nation, and Confederated Tribes of the Umatilla Indian Reservation. Under the treaty, the Native American Tribes acquired the rights to perform certain activities on open unclaimed lands, including the rights to hunt, fish, gather foods and medicines, and pasture livestock on these lands. By the time the Hanford Site was established, little open unclaimed land remained. The Wanapum Band and the Joseph Band of the Nez Perce Tribes never signed a treaty but have cultural ties to these lands.

The methodology for identifying, evaluating, and mitigating impacts to cultural resources is defined by federal laws and regulations including the National Historic Preservation Act (NHPA), the Archaeological Resource Protection Act (ARPA), the Native American Graves Protection and Repatriation Act (NAGPRA) and the American Native American Religious Freedom Act (AIRFA). A project affects a significant resource when it alters the property's characteristics, including relevant features of its environment or use, that qualify it as significant according to the National Register criteria. These effects may include those listed in 36 CFR 800.9. Impacts to traditional Native American properties can be determined only through consultation with the affected Native American groups.

4.4.1 Prehistoric Archaeological Resources

People have inhabited the Middle Columbia River region since the end of the glacial period. More than 10,000 years of prehistoric human activity in this largely arid environment have left extensive archaeological deposits along the river shores (Leonhardy and Rice 1970; Greengo 1982; Chatters 1989). Well-watered areas inland from the river show evidence of concentrated human activity (Chatters 1982, 1989; Daugherty 1952; Greene 1975; Leonhardy and Rice 1970; Rice 1980), and recent surveys indicate extensive, although dispersed, use of arid lowlands for hunting. Graves are common in various settings, and spirit quest monuments are still to be found on high, rocky summits of the mountains and buttes (Rice 1968a). Throughout most of the region, hydroelectric development, agricultural activities, and domestic and industrial construction have destroyed or covered the majority of these deposits. Amateur artifact collectors have had an immeasurable impact on what remains. Within the Hanford Site, from which the public is restricted, archaeological deposits found in the Hanford Reach of the Columbia River and on adjacent plateaus and mountains have been spared some of the disturbances that have befallen other sites. The Hanford Site is thus a de facto reserve of archaeological information of the kind and quality that has been lost elsewhere in the region.

Currently 248 prehistoric archaeological sites are recorded in the files of the Hanford Cultural Resources Laboratory. Of 48 sites included on the National Register of Historic Places (National Register), two are single sites, Hanford Island Site (45BN121) and Paris Site (45GR317), and the remainder are located in seven archaeological districts (Table - 4.4-1). In addition, a draft request for Determination of Eligibility has been pre for one traditional cultural property district (Gable Mountain/Gable Butte). Three other sites, Vernita Bridge (45BN90) and Tsulim (45BN412), and 45BN163, are considered eligible for the National Register. Archaeological sites include remains of numerous pithouse villages, various types of open campsites, and cemeteries along the river banks (Rice 1968a, 1980), spirit quest monuments (rock cairns), hunting camps, game drive complexes, and quarries in mountains and rocky bluffs (Rice 1968b), hunting/kill sites in lowland stabilized dunes, and small temporary camps near perennial sources of water located away from the river (Rice 1968b).

Many recorded sites were found during four archaeological reconnaissance projects conducted between 1926 and 1968 (Krieger 1928; Drucker 1948; Rice 1968a, 1968b). Systematic archaeological surveys conducted from the middle 1980s through 1993 are responsible for the remainder (e.g., Chatters 1989; Chatters and Cadoret 1990; Chatters and Gard 1992; Chatters et al. 1990, 1991, 1992, 1993). Little excavation has been conducted at any of the sites, and the Mid-Columbia Archaeological Society has done most of that work. They have conducted minor test excavations at several sites on the river banks and islands (Rice 1980) and a larger scale test at site 45BN157 (Den Beste and Den Beste 1976). The University of Idaho also excavated a portion of site 45BN179 (Rice 1980) and collaborated with the Mid-Columbia Archaeological Society on its other work. Test excavations have been conducted by the Hanford Cultural Resources Laboratory at the Wahluke (45GR306), Vernita Bridge (45BN90), and Tsulim (45BN412) sites and at 45BN446, 45BN423, 45BN163, 45BN432, and 45BN433; results support assessments of significance for those sites. Most of the archaeological survey and reconnaissance activity has concentrated on islands and on a strip of land less than 400 meters wide on either side of the river (Rice 1980), but this is changing because of a Hanford Cultural Resources Laboratory effort to inventory a 10 percent sample of the site by 1994. During his reconnaissance of the Hanford Site in 1968, Rice inspected portions of Gable Mountain, Gable Butte, Snively Canyon, Rattlesnake Mountain, and Rattlesnake Springs but gave little attention to other areas (Rice 1968b). He also inspected additional portions of Gable Mountain and part of Gable Butte in the late 1980s (Rice 1987). Other reconnaissance of the Basalt Waste Isolation Project Reference Repository Location (RRL) (Rice 1984) included a proposed land exchange in T22N, R27E, Section 33 (Rice 1981), and three narrow transportation and utility corridors (Ertec Northwest, Inc. 1982; Morgan 1981; Smith et al. 1977). The 100 Areas were surveyed in 1991 through 1993, revealing a large number of new archaeological sites (Chatters et al. 1992; Wright 1993). To date only about 6 percent of the Hanford Site has been surveyed. Cultural resource reviews are conducted when projects are proposed for areas that have not been previously reviewed; about 100 to 120 reviews were conducted annually through 1991; this figure rose to more than 400 reviews during 1993.

Table 4.4-1. Archaeological districts and historic properties on the Hanford Site listed on the National Register of Historic Places (with their archaeological

District/Property Name	Site(s) Included
Wooded Island A.D.	45BN107 through 45BN112, 45BN168
Savage Island A.D.	45BN116 through 45BN119, 45FR257 through 45FR262
Hanford Island Site	45BN121
Hanford North A.D.	45BN124 through 45BN134, 45BN178
Locke Island A.D.	45BN137 through 45BN140, 45BN176, 45GR302 through 45GR305
Ryegrass A.D.	45BN149 through 45BN157
Paris Site	45GR317
Rattlesnake Springs A.D.	45BN170, 45BN171
Snively Canyon A.D.	45BN172, 45BN173
100-B Reactor	NA[b]

a. A.D. indicates archaeological district (this table).
b. Not applicable.

4.4.2 Native American Cultural Resources

In prehistoric and early historic times, the Hanford Reach of the Columbia River was heavily populated by Native Americans of various tribal affiliations. The Wanapum and the Chamnapum band of the Yakama tribe dwelt along the Columbia River from south of Richland upstream to Vantage (Relander 1956; Spier 1936). Some of their descendants still live nearby at Priest Rapids, and others have been incorporated into the Yakama and Umatilla reservations. Palus people, who lived on the lower Snake River, joined the Wanapum and Chamnapum to fish the Hanford Reach of the Columbia River and some inhabited the river's east bank (Relander 1956; Trafzer and Scheuerman 1986). Walla Walla and Umatilla people also made periodic visits to fish in the area. These people retain traditional secular and religious ties to the region, and many, young and old alike, have knowledge of the ceremonies and lifeways of their aboriginal culture. The Washane, or Seven Drums religion, which has ancient roots and had its start on what is now the Hanford Site, is still practiced by many people on the Yakama, Umatilla, Warm Springs, and Nez Perce reservations. Native plant and animal foods, some of which can be found on the Hanford Site, are used in the ceremonies performed by sect members.

4.4.3 Historic Archaeological Resources

The first Euro-Americans who came to this region were Lewis and Clark, who traveled along the Columbia and Snake rivers during their 1803-1806 exploration of the Louisiana Territory. They were followed by fur trappers, who also passed through on their way to more productive lands upriver and downstream and across the Columbia Basin. It was not until the 1860s that merchants set up stores, a freight depot, and the White Bluffs Ferry on the Hanford Reach. Chinese miners began to work the gravel bars for gold. Cattle ranches opened in the 1880s and farmers soon followed. Several small, thriving towns, including Hanford, White Bluffs, and Ringold, grew up along the riverbanks in the early 20th century. Other ferries were established at Wahluke and Richmond. The towns and nearly all other structures were razed after the U.S. Government acquired the land for the Hanford Nuclear Reservation in the early 1940s (Chatters 1989; Ertec Northwest, Inc. 1981; Rice 1980).

Historic archaeological sites totaling 202 and 11 other historic localities have been recorded by the Hanford Cultural Resources Laboratory on the Hanford Site. Localities include the Allard Pumping Plant at Coyote Rapids, the Hanford Irrigation Ditch, the Hanford townsite, Wahluke Ferry, the White Bluffs townsite, the Richmond Ferry, Arrowsmith townsite, a cabin at East White Bluffs ferry landing, the White Bluffs road, the old Hanford High School, and the Cobblestone Warehouse at Riverland (Rice 1980). Archaeological sites including the East White Bluffs townsite and associated ferry landings and an assortment of trash scatters, homesteads, corrals, and dumps have been recorded by the Hanford Cultural Resources Laboratory since 1987. Ertec Northwest, Inc. was responsible for minor test excavations at some of the historic sites, including the Hanford townsite locality. In addition to the recorded sites, numerous unrecorded site areas of gold mine tailings along the river bank and the remains of homesteads, farm fields, ranches, and abandoned Army installations are scattered over the entire Hanford Site. Of these historic sites, one is included in the National Register as an historic site, and 56 are listed as archeological sites.

More recent locations are the defense reactors and associated materials processing facilities that now dominate the site. The first reactors (B, D, and F) were constructed in 1943 as part of the Manhattan Project. Plutonium for the first atomic explosion and the bomb that destroyed Nagasaki to end World War II was produced in the B Reactor. Additional reactors and processing facilities were constructed after World War II during the Cold War.

All reactor containment buildings still stand, although many ancillary structures have been removed. The B Reactor has been listed on the National Register of Historic Places. A historic context for Manhattan Project facilities has been created as part of a Multiple Property Document. Until a full evaluation of all Manhattan Project buildings and facilities has been completed, statements about National Register status cannot be made.

4.4.4 200 Areas

An archaeological survey has been conducted of all undeveloped portions of the 200-East Area, and a 50 percent random sample has been conducted of undeveloped portions of the 200-West Area. The old White Bluffs freight road (see Rice 1984) crosses diagonally through the 200-West Area. The road, formerly a Native American trail, has been in continuous use since antiquity and has played a role in Euro-American immigration, development, agriculture, and Hanford Site operations. The road has been found to be eligible for listing on the National Register of Historic Places. A 100-m easement has been created to protect the road from uncontrolled disturbance. Historic buildings that have not been evaluated for National Register eligibility occur in both the 200-East and 200-West Areas.

4.5 Aesthetic and Scenic Resources

The land in the vicinity of the Hanford Site is generally flat with little relief. Rattlesnake Mountain, rising to 1060 meters (3477 feet) above mean sea level, forms the western boundary of the site. Gable Mountain and Gable Butte are the highest land forms within the site. The view toward Rattlesnake Mountain is visually pleasing, especially in the springtime when wild-flowers are in bloom. Large rolling hills are located to the west and far north. Columbia River, flowing across the northern part of the site and forming the eastern boundary, is generally considered scenic, with its contrasting blue against a background of brown basaltic rocks and desert sagebrush. The White Bluffs, steep whitish-brown bluffs adjacent to the Columbia River and above the northern boundary of the river in this region, are a striking feature of the landscape.

The potential project site (under all alternatives except No Action) is characterized by large sagebrush, desert grasses, and shrubs. Immediate views to the east include the 200-East Area facilities, views in the distant area of reactors. Somewhat hidden by a slight rise in the land are stacks for facilities in 200-West Area to the west of the project site. To the south southwest are gravel borrow pit and radio and meteorological towers. This site is of low sensitivity in terms of aesthetic and scenic resources.

4.6 Geology

This section summarizes the geologic setting, including potential geologic hazards, at the Hanford Site. Physiography, structure, soils, and seismicity and volcanic hazards are briefly discussed. A more detailed discussion of these subjects can be found in Cushing (1992).

4.6.1 General Geology

The Hanford Site lies within the Columbia Intermontane physiographic province, bordered on the north and east by the Rocky Mountains and on the west by the Cascade Range. The dominant geologic characteristics of the Hanford Site have resulted from basaltic volcanism and ancient catastrophic flooding.

Fluvial and lacustrine processes associated with the ancestral Columbia River system, including the ancestral Snake and Yakima rivers, have been active since the late Miocene. Deposits of these rivers and lakes are represented by the Ringold Formation and indicate that deposition was almost continuous from about 10.5 million years before present until abo
3.9 million years before present (DOE 1988). At some time before 900,000 years ago, a major change in regional base level resulted in fluvial incision of as much as 150 meters (500 feet). The post-Ringold erosional surface was partially filled with locally derived alluvium and fluvial sediment before and possibly between periods of Pleistocene flooding. However, in most areas of the Columbia Basin subprovince, the record of Pleistocene fluvial activity was destroyed by cataclysmic flooding. Loess (buff-colored silt) occurs in sheets that mantle much of the upland areas of the Columbia Basin subprovince.

Quaternary(a) volcanism has been limited to the extreme western margin of the Columbia Basin subprovince and is associated with the Cascade Range Province. Airfall tephra(b) from at least three Cascade volcanoes has blanketed the central Columbia Plateau since the late Pleistocene. This tephra includes material from several eruptions of Mount St. Helens before the May 1980 eruption. Other volcanoes have erupted less frequently; two closely spaced eruptions from Glacier Peak about 11,200 years ago, and the eruption of - Mount Mazama about 6,600 years ago. Generally tephra layers have not exceeded more than a few centimeters in thickness, with the exception of the Mount Mazama eruption when as much as 10 centimeters (3.9 inches) of tephra fell over eastern Washington (DOE 1988).

4.6.1.1 Physiography. The Hanford Site, located within the Pasco Basin of the Columbia Plateau, is defined generally by a thick accumulation of basaltic lava flows that extend laterally from central Washington eastward into Idaho and southward into Oregon (Tallman et al. 1979).

The Hanford Site overlies the structural low point of the Pasco Basin near the confluence of the Yakima and Columbia rivers. The boundaries of the Pasco Basin are defined by anticlinal structures of basaltic rock. These structures are the Saddle Mountains to the north; the Umtanum Ridge, Yakima Ridge, and Rattlesnake Hills to the west; and the Rattlesnake Hills and a series of doubly plunging anticlines merging with the Horse Heaven Hills to the south. The terrain within the Pasco Basin is relatively flat. Its surface features were formed by catastrophic floods and have undergone little modification since, with the exception of more recently formed sand dunes (DOE 1986a).

The elevations of the alluvial plain that covers much of the site vary from 105 meters (345 feet) above mean sea level in the southeast corner to 245 meters (803 feet) in the northwest. The 200-Area plateau in the central part of the site varies in elevation from 190 to 245 meters (623 to 803 feet).

The major geologic units of the Hanford Site are (in ascending order): subbasalt rocks (inferred to be sedimentary and volcanoclastic rocks), the Columbia River Basalt Group with intercalated sediments of the Ellensburg formation, the Ringold formation, the Plio-Pleistocene unit, and the Hanford formation. Locally, sand and silt exist as surface material. A generalized

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a. Quaternary- A geologic period beginning approximately two million years ago and extending to the present.

b. Tephra- A collective term for all clastic materials ejected from a volcano and transported through air.

stratigraphic column is shown in Figure 4.3.

Knowledge of the subbasalt rocks is limited to studies of exposures along the margin of the Columbia Plateau and to a few deep boreholes drilled in the interior of the plateau (DOE 1988). No subbasalt rocks are exposed within the central interior of the Columbia Plateau, including the Pasco Basin. Interpretation of data from wells drilled in the 1980s by Shell Oil Company in the northwestern Columbia Plateau indicates that in the central part of the Columbia Plateau the Columbia River Basalt Group is underlain predominantly by Tertiary continental sediments (Campbell 1989).

The Hanford formation lies on the eroded surface of the Plio-Pleistocene unit, on the Ringold formation, or locally on the basalt bedrock. The Hanford formation consists of catastrophic flood sediments that were deposited when ice dams in western Montana and northern Idaho were breached and massive volumes of water spilled abruptly across eastern and central Washington. The floods scoured the land surface, locally eroding the Ringold formation, the basalts, and sedimentary interbeds, leaving a network of buried channels crossing the Pasco Basin (Tallman et al. 1979). Thick sequences of sediments were deposited by several episodes of flooding with the last major flood sequence dated at about 13,000 years before the present (Myers et al. 1979).

Figure 4-3. A generalized stratigraphic column of the major geologic units of th

4.6.1.2 Structure. The Columbia Plateau is tectonically a part of the

North American continental plate, and is separated from the Pacific and Juan de Fuca oceanic plates to the west by the Cascade Range, Puget-Willamette Lowland, and Coast Range geologic provinces. It is bounded on the north by the Okanogan Highlands, on the east by the Northern Rocky Mountains and Idaho Batholith, and on the south by the High Lava plains and Snake River The tectonic history of the Columbia Plateau has included the eruption of the continental flood basalts of the Columbia River Basalt Group during the period of about 17 to 6 million years before present, as well as volcanic activity in the Cascade Range to the west (DOE 1988).

Structurally, the Columbia Plateau can be divided into three informal subprovinces: the Palouse, Blue Mountains, and Yakima Fold Belt. All but the easternmost part of the Pasco Basin is within the Yakima Fold Belt structural subprovince (DOE 1988). The Yakima Fold Belt contains four major structural elements: the Yakima Folds, Cle Elum-Wallula disturbed zone, Hog Ranch-Naneum anticline, and northwest-trending wrench faults.

The Yakima Folds are a series of continuous, narrow, asymmetric anticlines that have wavelengths between about 5 and 30 kilometers (3 to 19 miles) and amplitudes commonly less than 1 kilometers (less than 0.6 miles). The anticlinal ridges are separated by broad synclines or basins. The Yakima Folds are believed to have developed under generally north-south compression, but the origin and timing of the deformation along the fold structures are no well known (DOE 1988). Thrust or high-angle reverse faults are often found along both limbs of the anticlines, with the strike of the fault planes parallel or subparallel to the axis of the anticlines. Very little direct field evidence indicates quaternary movement along these anticlinal ridges. One of three cases of suspected Quaternary faulting is along the central Gable Mountain fault in the Pasco Basin. This fault is on the Hanford Site. It was considered by the NRC to be presumed capable, but not demonstrated to be capable for licensing purposes of the WNP plant.

The Cle Elum-Wallula disturbed zone is the central part of a larger topographic alignment called the Olympic-Wallowa lineament that extends from the northwestern edge of the Olympic Mountains to the northern edge of the Wallowa Mountains in Oregon. The Cle Elum-Wallula disturbed zone is a narrow zone about 10 kilometers (6 miles) wide that transects the Yakima Fold Belt and has been divided informally into three structural domains: a broad zone of deflected or anomalous fold and fault trends extending south of Cle Elum, Washington to Rattlesnake Mountain; a narrow belt of aligned domes and doubly plunging anticlines (called The Rattles) extending from Rattlesnake Mountain to Wallula Gap; and the Wallula fault zone, extending from Wallula Gap to the Blue Mountains. Evidence for quaternary deformation has been reported for 14 localities in or directly associated with the Cle Elum-Wallula disturbed zone. However, no evidence has been reported northwest of the Finley Quarry location (DOE 1988), about 60 kilometers (36 miles) southeast of the approximate center of the Hanford Site.

The Hog Ranch-Naneum Ridge anticline is a broad structural arch that extends from southwest of Wenatchee, Washington to the Yakima Ridge. This feature defines part of the northwestern boundary of the Pasco Basin, but little is known about the structural geology of this portion of the feature, and the southern extent of the feature is not known.

Northwest-trending wrench (strike-slip) faults have been mapped west of 120yW longitude in the Columbia Plateau (DOE 1988). The mean strike direction of the dextral wrench faults is 320y, but northeast-trending sinistral wrench faults that strike 013y are less numerous. These structures are not known to exist in the central Columbia Plateau.

Most known faults within the Hanford area are associated with anticlinal fold axes, are thrust or reverse faults although normal faults do exist, and were probably formed concurrently with the folding (DOE 1988). Existing known faults within the Hanford area include wrench (strike-slip) faults as long as 3 kilometers (1.9 miles) on Gable Mountain and the Rattlesnake-Wallula alignment, which has been interpreted as a right-lateral strike-slip fault. The faults in Central Gable Mountain are considered NRC capable by the U.S. Nuclear Regulatory Commission criteria (10 CFR 100) in that they have slightly displaced the Hanford formation gravels, but their relatively short lengths give them low seismic potential. No seismicity has been observed on or near Gable Mountain. The Rattlesnake-Wallula alignment is interpreted as possibly being capable, in part because of lack of any distinct evidence to the contrary and because this structure continues along the northwest trend of faults that appear active at Wallula Gap, some 56 kilometers (35 miles) southeast of the central part of the Hanford Site (DOE 1988).

Strike-slip faults have not been observed crosscutting the Pasco Basin. Anticlinal ridges that bound the Pasco Basin have been mapped in detail, and except for some component of dextral movement on the Rattlesnake-Wallula alignment, no strike-slip faults similar to those in the western Yakima Fold Belt have been observed (DOE 1988). Wrench (strike-slip) faults have been observed along the ridges at boundaries between geometrically coherent segments of the structures, as in the Saddle Mountains, but these faults are confined to the individual structures and formed as different geometries developed in the fold. Similar type faults have been mapped on Gable Mountain and studied in detail. These features are also interpreted as wrench (stike-slip) faults that are a response to folding.

In general, for structures within the Hanford Site area, the greatest deformation occurs in the hinge area of the anticlinal ridges and decreases with distance from that area; that is, the greatest amount of tectonic jointing and faulting occurs in the hinge zone and decreases toward the gently dipping limbs. The faults usually exhibit low dips with small displacements, may be confined to the layer in which they occur, and die out to no recognizable displacement in short lateral distances (DOE 1988).

4.6.1.3 Soils. Hajek (1966) lists and describes 15 different soil types on

the Hanford Site. The soil types vary from sand to silty and sandy loam. Various classifications, including land use, are also given in Hajek (1966). The proposed SNF facility site does not contain prime or unique farmland.

Section 4.8.2.1 (Groundwater Hydrology) provides a full discussion on ranges of thickness of the various geological units/soil types across the Hanford Site (Figures 4-3 and 4-11). The surface Hanford Formation varies in thickness across the Hanford Site from approximately 15 to 100 meters (49 to 328 feet) thick (Figure 4-11). The Middle Ringold Formation varies from 10 to 100 meters (32 to 328 feet) thick. The Lower Ringold and Basal Ringold Formations only extend eastward from the western boundary of the Hanford Site approximately 11 kilometers (6.8 miles). The former is rather uniform in thickness at 20 meters (65 feet), while the latter demonstrates a maximum thickness of 40 meters (131 feet) at the far western boundary of the Hanford Site. Groundwater movement within these layers is also discussed in Section 4.8.2.1.

There is a rather thick vadose zone on the Hanford Site. However, conclusions drawn from studies conducted at several locations vary from no downward percolation of precipitation on the 200 Area Plateau, where soil texture is varied and layered with depth (all moisture penetrating the soil is removed by evaporation) to observations of downward water movement below the root zone in the 300 Area, where soils are coarse textured and where precipitation was above normal (DOE 1987).

4.6.2 Mineral Resources

Sand, gravel, and cobble deposits are ubiquitous components of the soils over the Columbia Basin in general and the Hanford Site in particular: therefore, any possible economic impact to these resources resulting from the siting of the proposed SNF facility or an access road would be considered negligible. However, because gravel pits occur near the proposed SNF facility site, from which the DOE has been extracting gravel for many uses on the Hanford Site, these deposits could have economic value.

4.6.3 Seismic and Volcanic Hazards

The following discussion briefly summarizes seismic and volcanic hazards on the Hanford Site. A more detailed discussion of seismic and volcanic hazards can be found in Cushing (1992).

4.6.3.1 Seismic Hazards. The historic record of earthquakes in the Pacific

Northwest dates from about 1840. The early part of this record is based on newspaper reports of structural damage and human perception of the shaking, as classified by the Modified Mercalli Intensity scale, and is probably incomplete because the region was sparsely populated. Seismograph networks did not start providing earthquake locations and magnitudes of earthquakes in the Pacific Northwest until about 1960. A comprehensive network of seismic stations that provides accurate locating information for most earthquakes larger than magnitude 2.5 was installed in eastern Washington in 1969. A summary of the seismicity of the Pacific Northwest, a detailed review of the seismicity in the Columbia Plateau region and the Hanford Site, and a description of the seismic networks used to collect the data are provided in DOE (1988).

Large earthquakes (magnitude greater than 7 on the Richter scale) in the Pacific Northwest have occurred in the vicinity of Puget Sound, Washington, and near the Rocky Mountains in eastern Idaho and western Montana. A large earthquake of uncertain location occurred in north-central Washington in 1872. This event had an estimated maximum ranging from VIII to IX and an estimated magnitude of approximately 7. The distribution of intensities suggests a location within a broad region between Lake Chelan, Washington and the British Columbia border. Figure 4-4 shows the known faults occurring in the region.

Figure 4.4. Map of the Columbia Basin region showing the known faults.

Seismicit per area and the historical magnitude of these events, is relatively low when compared to other regions of the Pacific Northwest, the Puget Sound area and western Montana/eastern Idaho. Figure 4-5 shows the locations of all earthquakes that occurred in the Columbia Plateau before 1969 with IV or larger and with a magnitude of 3 or larger. Figure 4-6 shows the locations of all earthquakes that occurred from 1969 to 1986 with magnitudes of 3 or greater. The largest known earthquake in the Columbia Plateau occurred in 1936 around Milton-Freewater, Oregon. This earthquake had a magnitude of 5.75 and a maximum of VII, and was followed by a number of aftershocks that indicate a northeast-trending fault plane. Other earthquakes with magnitudes of 5 or larger and/or intensities of VI are located along the boundaries of the Columbia Plateau in a cluster near Lake Chelan extending into the northern Cascade Range; in northern Idaho and Washington; and along the boundary between the western Columbia Plateau and the Cascade Range. Three VI earthquakes have occurred within the Columbia Plateau, including one in the Milton-Freewater region in 1921, one near Yakima, Washington in 1892, and one near Umatilla, Oregon in 1893.

In the central portion of the Columbia Plateau, the largest earthquakes near the Hanford Site are two that occurred in 1918 and 1973. These two earthquakes had magnitudes of 4.4 and an intensity of V and were located north of the Hanford Site. Earthquakes often occur in spatial and temporal clusters in the central Columbia Plateau, and are termed earthquake swarms. The region north and east of the Hanford Site is a region of concentrated earthquake swarm activity, but earthquake swarms have also occurred in several locations within the Hanford Site.

Earthquakes in a swarm tend to gradually increase and decay in frequency of events, and usually no one outstanding large event is present within the sequence. These earthquake swarms occur at shallow depths, with 75 percent of the events located at depths less than 4 kilometers (2.5 miles). Each earthquake swarm typically lasts several weeks to months, consists of several to 100 or more earthquakes, and is clustered in an area 5 to 10 kilometers (3 to 6 miles) in lateral dimension. Often, the longest dimension of the swarm area is elongated in an east-west direction. However, detailed locations of swarm earthquakes indicate that the events occur on fault planes of variable orientation, and not on a single, throughgoing fault plane.

Earthquakes in the central Columbia Plateau also occur to depths of about 30 kilometers (18 miles). These deeper earthquakes are less clustered and occur more often as single, isolated events. Based on seismic refraction surveys in the region, the shallow earthquake swarms are occurring in the Columbia River Basalts, and the deeper earthquakes are occurring in crustal layers below the basalts.

Figure 4-5. Historical seismicity of the Columbia Plateau and surrounding areas. Intensity of IV or larger with a magnitude of 3 or greater are shown (Rohay 1989).

Figure 4-6. Recent seismicity of the Columbia Plateau and surrounding areas as m Modified Mercalli Intensity of IV or larger with a magnitude of 3 or greater are shown (Rohay 1989).

The spatial pattern of seismicity in the central Columbia Plateau suggests an association of the shallow swarm activity with the east-west-oriented Saddle Mountains anticline. However, this association is complex, and the earthquakes do not delineate a throughgoing fault plane that would be consistent with the faulting observed on this structure.

Earthquake mechanisms in the central Columbia Plateau generally indicate reverse faulting on east-west planes, consistent with a north-south-directed maximum compressive stress and with the formation of the east-west-oriented anticlinal fold of the Yakima Fold Belt (Rohay 1987). However, earthquake focal mechanisms indicate faulting on a variety of fault plane orientations.

Earthquake focal mechanisms along the western margin of the Columbia Plateau also indicate north-south compression, but here the minimum compressive stress is oriented east-west, resulting in strike-slip faulting (Rohay 1987). Geologic studies indicate an increased component of strike-slip faulting in the western portion of the Yakima Fold Belt. Earthquake focal mechanisms in the Milton-Freewater region to the southeast indicate a different stress field, one with maximum compression directed east-west instead of north-south.

Estimates for the earthquake potential of structures and zones in the central Columbia Plateau have been developed during the licensing of nuclear power plants at the Hanford Site. In reviewing the operating license application for a Washington Public Power Supply System project, the Nuclear Regulatory Commission (NRC 1982) concluded that four earthquake sources should be considered for the purpose of seismic design: the Rattlesnake-Wallula alignment, Gable Mountain, a floating earthquake in the tectonic province, and a swarm area.

For the Rattlesnake-Wallula alignment, which passes along the southwest boundary of the Hanford Site, the estimated maximum magnitude is 6.5, and for Gable Mountain, an east- west structure that passes through the northern portion of the Hanford Site, the estimated maximum magnitude is 5.0. These estimates were based upon the inferred sense of slip, the fault length, or the fault area. The floating earthquake for the tectonic province was developed from the largest event located in the Columbia Plateau, the magnitude 5.75 Milton-Freewater earthquake. The maximum swarm earthquake for the purpose of seismic design was a magnitude 4.0 event. Figures 4-7 through 4-11 demonstrate the ranges of frequencies versus the acceleration across the Hanford Site (Geomatri Consultants, Inc. 1993).

The seismic design is based upon a Safe-Shutdown Earthquake of 0.25 gravity (g; acceleration). The potential earthquake risk associated with the Gable Mountain structure dominated the risks associated with other potential sources that were considered. For DOE site comparison purposes, a maximum horizontal ground surface acceleration of 0.17-0.20g at the Hanford Site is estimated to result from an earthquake that could occur once every 2,000 years (DOE 1994c). The seismic hazard information presented in this EIS is for general seismic hazard comparisons across DOE sites. Potential seismic hazards for existing and new facilities could be evaluated on a facility specific basis consistent with DOE orders and standards and site specific procedures.

4.6.3.2 Volcanic Hazards. Several major volcanoes are located in the

Cascade Range west of the Hanford Site. The nearest volcano, Mount Adams, is about 165 kilometers (102 miles) from the Hanford Site, and the most active is Mount St. Helens, approximately 220 kilometers (136 miles) west-southwest from Hanford.

A period of renewed volcanic activity at Mount St. Helens began in March 1980 and climaxed in a major eruption on May 18, 1980. This eruption resulted in about 1 millimeter (0.039 inches) of ash fall over a 9-hour period at the Hanford Site, which was near the southern edge of the ash dispersal plume. Smaller eruptions of steam and ash occurred through October 1980, but none of these deposited measurable amounts of ash at the site. Because of their close proximity, the volcanic mountains of the Cascades are the principal volcanic hazard at Hanford.

The major concern is how ash fall might affect the operation of communications equipment and electronic devices, as well as the movement of truck and automobile traffic in and out the project site area.

4.7 Air Resources

This section addresses the general air resources at the Hanford Site and surrounding region. Included in this section are discussions on climate and meteorology, ambient air quality, and atmospheric dispersion.

Figure 4-7. Computed mean and 5th to 95th percentile hazard curves for the 200-W acceleration and 5 percent-damped spectral acceleration at 0.3 and 2.0 seconds (Geomatrix Consultants, Inc. 1993).

Figure 4-8. Computed mean and 5th to 95th percentile hazard curves for the 200-E acceleration and five percent-damped spectral acceleration at 0.3 and 2.0 seconds (Geomatrix Consultants, Inc. 1993).

Figure 4-9. Computed mean and 5th to 95th percentile hazard curves for the 300 Area of the Hanford Site. Shown are results for peak horizontal

acceleration and five percent-damped spectral acceleration at 0.3 and 2.0 seconds (Geomatrix Consultants, Inc. 1993).

Figure 4-10. Computed mean and 5th to 95th percentile hazard curves for the 400 acceleration and five percent-damped spectral acceleration at 0.3 and 2.0 seconds (Geomatrix Consultants, Inc. 1993).

Figure 4-11. Computed mean and 5th to 95th percentile hazard curves for the 100- acceleration and five percent-damped spectral acceleration at 0.3 and 2.0 seconds (Geomatrix Consultants, Inc. 1993).

4.7.1 Climate and Meteorology

The climate of the Hanford Site, located in southcentral Washington State, can be classified as mid-latitude semiarid or mid-latitude desert, depending on the climatological classification scheme used. Summers are warm and dry with abundant sunshine. Large diurnal temperature variations result from intense solar heating during the day and radiational cooling at night. Daytime high temperatures in June, July, and August periodically exceed 38yC (100yF). Winters are cool with occasional precipitation. Outbreaks of cold air associated with modified arctic air masses can reach the area and cause temperatures to drop below -18yC (0yF). Overcast skies and fog occur periodically (Stone et al. 1983).

Topographic features have a significant impact on the climate of the Hanford Site. All air masses that reach the region undergo some modification resulting from their passage over the complex topography of the Pacific Northwest. The climate of the region is strongly influenced by the Pacific Ocean and the Cascade Range to the west. The relatively low annual average rainfall of 16.1 centimeters (6.3 inches) at the Hanford Meteorological Station is caused largely by the rain shadow created by the Cascade Range. These mountains limit much of the maritime influence of the Pacific Ocean, resulting in a more continental-type climate than would exist if the mountains were not present. Maritime influences are experienced in the region during the passage of frontal systems and as a result of movement through gaps in the Cascade Range (such as the Columbia River Gorge).

The Rocky Mountains to the east and the north also influence the climate of the region. These mountains play a key role in protecting the region from the more severe winter storms and the extremely low temperatures associated with the modified arctic air masses that move southward through Canada. Local and regional topographical features, such as the Yakima Ridge and the Rattlesnake Hills, also impact meteorological conditions across the Hanford Site (Glantz and Perrault 1991). In particular, these features have a significant impact on wind directions, wind speeds, and precipitation levels.

Climatological data are collected for the Hanford Site at the Hanford Meteorological Station. The station is located between the 200-West and 200-East Areas and is in close proximity to the proposed project site. Data have been collected at this location since 1945 and are summarized in Stone et al. (1983). Beginning in the early 1980s, data have also been collected at a series of automated monitoring sites located throughout the Hanford Site and the surrounding region (Glantz et al. 1990). This Hanford Meteorological Monitoring Network is described in detail in Glantz and Islam (1988).

4.7.1.1 Wind. Prevailing wind directions on the 200-Area plateau are from the northwest in all months of the year. Secondary maxima occur for southwesterly winds. Summaries of wind direction indicate that winds from the northwest quadrant occur most often during the winter and summer. During the spring and fall, the frequency of southwesterly winds increases with a corresponding decrease in northwest flow. Winds blowing from other directions (for instance, the northeast) display minimal variation from month to month. Monthly average wind speeds are lowest during the winter months, averaging 2.8 to 3.1 meters per second (6.2 to 6.8 miles per hour)-, and highest during the summer, averaging 3.9 to 4.4 meters per second (8.7 to 9.9 miles per hour). Summertime drainage winds are generally northwesterly and can frequently gust to 14 meters per second (31 miles per hour). A wind rose for the Hanford Site is shown in Figure 4-12.

4.7.1.2 Temperature and Humidity. Eight separate temperature measurements are made at the 122-meter (400-foot) tower at the Hanford Meteorological Station. As of May 1987, temperatures are also measured at the 2-meter (6.6-foot) level on the twenty-two 9.1-meter (30-foot) towers located on and around the Hanford Site. The three 61-meter (200-foot) towers have temperature-measuring instrumentation at the 2-, 9.8-, and 61-meter (6.6-, 32-, and 200-foot) levels. The temperature data from the 9.1- and 61-meter (30- and 200-foot) towers are telemetered to the Hanford Meteorological Station.

Diurnal and monthly averages and extremes of temperature, dew point, and humidity are contained in Stone et al. (1983). Ranges of daily maximum and minimum temperatures vary from normal maxima of 2yC (36yF) in early January to 35yC (95yF) in late July. On the average, 55 days during the summer months have maximum temperatures greater than or equal to 32yC (90yF), and 13 days have maxima greater than or equal to 38yC (100yF). From mid-November through mid-March, minimum temperatures average less than or equal to 0yC (32yF), with the minima in early January averaging -6yC (21yF). During the winter, on average, four days have minimum temperatures less than or equal to -18yC (0yF); however, only about one winter in two experiences such temperatures. The record maximum temperature is 46yC (115yF), and the record minimum temperature is -33yC (-27yF). For the period 1912 through 1980, the average monthly temperatures ranged from a low of -1.5yC (29yF) in January to a high of 24.7yC (77yF) in July. During the winter, the highest monthly average temperature at the Hanford Meteorological Station was 7yC (45yF), and the record lowest was -5.9yC (21yF), both occurring during February. During the summer, the record highest monthly average temperature was 27.9yC (82yF, in July), and the record lowest was 17.2yC (63yF, in June).

Figure 4-12. Wind rose for the Hanford Site using data collected from January 19 of the petals of the wind rose indicates the wind direction, and the petal length is representative of the percentage of time the wind was from that direction. Petal thickness represents measured wind-speed category. The velocity categories, from thinnest line (near the center of the rose) to thickest line (near the edge of the rose), are 0.4-1.3 meters per second (1-3 miles per hour), 1.8-3.1 meters per second (4-7 miles per hour), 3.6-5.4 meters per second (8-12 miles per hour), 5.8-8.0 meters per second (13-18 miles per hour), 8.5-10.7 meters per second (19-24 miles per hour), 11.2-13.9 meters per second (25-31 miles per hour), respectively.

Relative humidity/dew point temperature measurements are made at the Hanford Meteorological Station and at the three 61-meter (200-foot) tower locations. The annual average relative humidity at the Hanford Meteorological Station is 54 percent. It is highest during the winter months, averaging about 75 percent, and lowest during the summer, averaging

about 35 percent. Wet bulb temperatures greater than 24yC (75yF) had not been observed at the Hanford Meteorological Station before 1975; however, on July 8, 9, and 10 of that year, seven hourly observations indicated wet bulb temperatures greater than or equal to 24yC (75yF).
Fog reduces the visibility to 6 miles during an average of 42 days each year and to less than 0.25 mile during an average of 25 days per year.

4.7.1.3 Precipitation. The average annual precipitation at the Hanford

Meteorological Station is 16.1 centimeters (6.3 inches). Most of the precipitation occurs during the winter with nearly half of the annual amount occurring in the months of November through February. Days with greater then 1.3 centimeters (0.5 inches) precipitation occur less than 1 percent of the year. A rainfall intensity of at least 1.3 centimeters per hour (0.5 inches per hour) persisting for 1 hour has only a 10 percent probability of occurring in any given year. A rainfall intensity of at least 2.5 centimeters per hour (1 inch per hour) has only a 0.2 percent probability of occurring in any given year. Winter monthly average snowfall ranges from 0.8 centimeters (0.3 inches) in March to 13.5 centimeters (5.3 inches) in January. The record snowfall of 53 centimeters (21 inches) occurred in December 1992. During the months of December, January, and February, snowfall accounts for about 38 percent of all precipitation.

4.7.1.4 Severe Weather. A discussion of severe weather may include a

variety of meteorological events, including, but not limited to, severe winds, dust and blowing dust, hail, fog, glaze, ash falls, extreme temperatures, temperature inversions, and blowing and drifting snow. These are described in detail in Stone et al. (1983). For many facilities, estimates of severe winds are of particular concern. The Hanford Meteorological Station's climatological summary and the National Severe Storms Forecast Center's database list only 24 separate tornado occurrences within 160 kilometers (100 miles) of the Hanford Site from 1916 to 1992 (Cushing 1992). Only one of these tornadoes was observed within the boundaries of the Hanford Site (on its extreme western edge), and no damage resulted. The estimated probability of a tornado striking a point at Hanford is 9.6 x 10-6 per year (Cushing 1992). Because tornadoes are infrequent and generally small in the Pacific Northwest (and hurricanes do not reach this area), risks from severe winds are generally associated with thunderstorms or the passage of strong cold fronts. The greatest peak wind gust recorded at 15 meters (50 feet) above ground level at the Hanford Meteorology Station was 36 meters per second (80 miles per hour). Projections on the return periods for peak gusts exceeding a specified speed are given in Stone et al. (1983). Extrapolations based on 35 years of observations indicate a return period of about 200 years for a peak gust in excess of 40 meters per second (90 miles per hour) at 15 meters (50 feet) above ground level.

4.7.1.5 Atmospheric Stability. The transport and diffusion of airborne

pollutants is dependent on the horizontal and vertical distribution of temperature, moisture, and wind velocity in the atmosphere. Greater amounts of turbulence or mixing in an atmospheric layer lead to greater rates of diffusion. The highest rates of diffusion are found in thermally unstable layers, moderate rates of diffusion are found in neutral layers, and the lowest rates of diffusion are found in thermally stable layers. There are a number of methods for estimating the "stability" of the atmosphere. Using a method based on the vertical temperature gradient (NRC 1980) and measurements made at the Hanford Meteorology Station, thermally unstable conditions are estimated to occur an average of about 25% of the time, neutral conditions about 31% of the time, and thermally stable conditions about 44% of the time. Detailed information on Hanford's atmospheric stability and associated wind conditions are presented in Glantz et al. (1990).

4.7.2 Nonradiological Air Quality

National ambient air quality standards (NAAQS) have been set by the EPA as mandated in the 1970 Clean Air Act. Ambient air is that portion of the atmosphere, external to buildings, to which the general public has access. For DOE facilities, this is interpreted to mean the site boundary or other publicly accessible location, e.g., highways on the site. The standards define levels of air quality that are necessary, with an adequate margin of safety, to protect the public health (primary standards) and the public welfare (secondary standards). Standards exist for sulfur oxides (measured as sulfur dioxide), nitrogen dioxide, carbon monoxide, particles with an aerodynamic diameter less than or equal to 10 micrometers (PM10), lead, and ozone. The standards specify the maximum pollutant concentrations and frequencies of occurrence that are allowed for specific averaging periods (that is, the concentration of carbon monoxide when averaged over 1 h allowed to exceed 40 milligrams per cubic meter only once per year). The averaging periods vary from 1 hour to 1 year, depending on the pollutant.

In addition to ambient air quality standards, the EPA has established standards for the Prevention of Significant Deterioration (PSD) of air quality. The PSD standards differ from the NAAQS in that the NAAQS provide maximum allowable concentrations of pollutants, while PSDs provide maximum allowable increases in concentrations of pollutants for areas already in compliance with NAAQS. Prevention of Significant Deterioration standards are expressed as allowable increments in atmospheric concentrations of specific pollutants (nitrogen dioxide, sulfur dioxide, and PM10) (40 CFR 52.21, "Prevention of Significant Deterioration of Air Quality"). Different PSD standards exist for Class I areas (where degradation of ambient air quality is to be severely restricted), and Class II areas (where moderate degradation of air quality is allowed) (Wark and Warner 1981). The PSD standards are presented in Table 4.7-1. The nitrogen oxide emissions from the Plutonium and Uranium Recovery through EXtraction (PUREX) plant and the Uranium Oxide (UO3) plant are permitted by the EPA under the PSD program (Cushing 1992).

State and local governments have the authority to impose standards for ambient air quality that are stricter than the national standards. Washington State has established more stringent standards for sulfur dioxide. In addition, Washington has established standards for volatile organic compounds, arsenic, fluoride, total suspended particulates, and other pollutants that are not covered by national standards. The state standards for carbon monoxide and nitrogen dioxide are identical to the national standards. At the local level, the Benton-Franklin Counties Clean Air Authority has the authority to establish more stringent air standards, but has not done so. Table 4.7-2 summarizes Washington State standards, and background and ambient concentrations for Hanford.

4.7.2.1 Background Air Quality. The closest Class I areas to the

Hanford Site are Mount Rainier National Park, located approximately 160 kilometers (100 miles) west of the site; Goat Rocks Wilderness Area, located approximately 145 kilometers (90 miles) west of the site;

Table 4.7-1. Maximum allowable increases for prevention of significant deterioration of air qualitya.

Pollutant	Averaging Time	Class I	Class II
Particulate matterb (PM10)			
	annual	4	17
	24 hours	8	30
Sulfur dioxide			
	annual	2	20
	24 hours	5	91
	3 hours	25	512
Nitrogen dioxide			
	annual	2.5	25

a. Source: 40 CFR 52.21.

b. Particulate matter is defined as suspended particulates with an aerodynamic diameter less than 10 micrometers.

Table 4.7-2. Washington State ambient air quality standards applicable to Hanford, maximum background concentration, background as percent of standard, ambient baseli (1995), ambient baseline as percent of standard, and ambient baseline plus backgrou as percent of standard (standards and concentrations are in microgram per cubic meter).

Pollutant	Averaging Time	Washington State Standard	Maximum Background Concentration	Background as Percent of Standard
Sulfur dioxide	annual	52	0.5	1
	24 hour	260	6	2
	1 hour	1,018	49	5
	1 hour	655b	49	7
Particulate matter				
TSPc	annual	60	56	93
	24 hour	150	356	237
PM	annual	50d	26e	52
	24 hour	150	596e	397
Carbon monoxide	8 hour	10,000	6,500	65
	1 hour	40,000	11,800	30
Ozone	1 hour	235	not estimated	not estimated
Nitrogen dioxide	annual	100	36	36
Lead	annual	1.5	not estimated	not estimated

a. Source: Air Quality Impact Analysis in Support of the New Production Reactor Environmental Impact Statement.

b. The standard is not to be exceeded more than twice in any seven consecutive day

c. The TSP standards have been replaced by the PM10 standards, but the former are serving as interim standards.

d. Arithmetic mean of the quarterly arithmetic means for the four calendar quarter of the year.

e. Maximum concentrations were measured in 1992 at Columbia Center in Kennewick. This value includes background concentration and site concentrations.

Mount Adams Wilderness Area, located approximately 150 kilometers (95 miles) southwest of the site; and Alpine Lakes Wilderness Area, located approximately 175 kilometers (110 miles) northwest of the site.

Air quality in the Hanford region is well within the state and federal standards for criteria pollutants, except that short-term particulate concentrations occasionally exceed the 24-hour PM10 standard (Table 4.7-2). Concentrations of toxic chemicals, as listed in 40 CFR Part 60.01, are not available for the Hanford Site. Because the highest concentrations of airborne particulate material are generally a result of natural events, the area has not been designated non-attainment(a) with respect to the PM10 standard. However, the local clean air authority is currently completing discussions with EPA and the Department of Ecology regarding plans to conduct additional evaluations of potential sources and mitigation measures, if any, that might be implemented to reduce the short-term particulate loading.

Particulate concentrations can reach relatively high levels in eastern Washington because of exceptional natural events (dust storms, volcanic eruptions, and large brushfires) that occur in the region. Washington ambient air quality standards do not consider rural fugitive dust from exceptional natural events when estimating the maximum background concentrations of particulate in the area east of the Cascade Mountain crest. Similarly, the EPA also exempts the rural fugitive dust component of background concentrations when considering permit applications and enforcement of air quality standards (Cushing 1992).

4.7.2.2 Source Emissions. Emissions inventories for permitted pollution sources in Benton, Franklin, and Walla Walla counties are routinely compiled by the Tri-County Air Pollution Control Board. The annual emission rates for stationary sources within the Hanford Site boundaries were reported to the Washington State Department of Ecology by the U.S. Department of Energy and are provided in Table 4.7-3.

The EPA's ISC/ST model was used for baseline modeling of stationary sources projected to be in operation in 1995 (Hadley 1991). Projected baseline conditions (presented in Table 4.7-2) are estimated to be well below any current national or state standards (Hadley 1991).

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a. An attainment area is an area where measured concentrations of a pollutant are below the primary and secondary National Ambient Quality Standards (NAAQS).

Table 4.7-3. Emission rates (tons per year) for stationary emission sources within the Hanford Site for 1992a.

Source	Operation (hours per year)	TSP	PM10	Sulfur Dioxide	Nitrogen Oxides
300 Area Boiler #2	6384	9	8	110	22
300 Area Boiler #6	8760	4	3	48	10
200-East Boiler	8760	3	1	200	58
200-West Boiler	8760	4	1	260	75
200-East, 200-West Fugitive Coal	8760	107	54	0	0
300 Area Temporary Boiler	8760	9	8	120	24
Fugitive Emissions, 200-E	8760	1	0	0	0

a. Source: Cushing in preparation.

4.7.2.3 Nonradiological Air Quality Monitoring.

4.7.2.3.1 Onsite Monitoring-The most recent monitoring data

available were obtained in 1992. Details of the monitoring program are described in Woodruff and Hanf (1993). The only onsite air quality monitoring conducted during 1991 was for nitrogen oxides. These oxides were sampled at three locations on the Hanford Site with a bubbler assembly operated to collect 24-hour integrated samples. The highest annual average concentration was <0.006 parts per million by volume, well below the applicable federal and Washington State annual ambient standard of 0.05 parts per million by volume (Cushing 1992). Monitoring of total suspended solids was discontinued in early 1988 when the Basalt Waste Isolation Project, for which those measurements were required, was concluded. In 1992 sampling was done at Rattlesnake Springs (near the southwestern edge of the site) for polychlorinated biphenyls (PCBs) and volatile organic compounds. Levels of PCB concentrations were found to be <0.27 to <0.29 nanogram per cubic meter (Woodruff and Hanf 1993). These values are well below the EPA limit of 1 nanogram per cubic meter. The volatile organic compounds tested for were halogenated alkanes and alkenes, benzene, and alkylbenzenes. All volatile organic compound concentrations were well below the occupational maximum allowable concentrations of air contaminants.

4.7.2.3.2 Offsite Monitoring-During the past 10 years, carbon

monoxide, sulfur dioxide, and nitrogen dioxide have been monitored periodically in communities and commercial areas southeast of Hanford. These urban measurements are typically used to estimate the maximum background pollutant concentrations for the Hanford Site because of a lack of specific onsite monitoring. Because these measurements were made in the vicinity of local sources of pollution, they will overestimate maximum background concentrations for the Hanford Site or at the site boundaries.

The only offsite monitoring in the vicinity of the Hanford Site in 1990 was conducted by the Washington Department of Ecology for particulates (WDOE 1991). Total suspended particulate (TSP) monitoring at Tri-Cities locations was discontinued in early 1989. Monitoring at the remaining two locations, Sunnyside and Wallula, continued during 1990. The annual geometric means of measurements at Sunnyside and Wallula for 1990 were 71 micrograms per cubic meter and 80 micrograms per cubic meter, respectively; both of these values exceeded the Washington State annual standard of 60 micrograms per cubic meter. The Washington State 24-hour standard, 150 micrograms per cubic meter, was exceeded six times during the year at Sunnyside and seven times at Wallula (Cushing 1992).

Particulate matter (PM10) was also monitored at three locations: Columbia Center in Kennewick, Walla Walla Fire Station, and Wallula. During 1992, the 24-hour PM10 standard adopted by Washington State, 150 micrograms per cubic meter, was exceeded two times at the Columbia Center monitoring location. The maximum 24-hour concentration at Columbia Center was 596 micrograms per cubic meter. The maximum 24-hour concentration at the Walla Walla Fire Station was 67 micrograms per cubic meter. The maximum 24-hour concentration at Wallula was 124 micrograms per cubic meter. None of the sites exceeded the annual primary standard, 50 micrograms per cubic meter

(Cushing in preparation). As noted previously, the Benton-Franklin counties area has not been designated nonattainment with respect to PM10 standards because the particulate concentrations result from natural events.

4.7.2.4 Summary of Nonradiological Air Quality. The Hanford Site is

currently considered an attainment area for criteria pollutants. However, PM10 concentrations are high enough that the designation may change. There are no Class I areas close enough to the site to be affected by emissions at Hanford. Carbon monoxide concentrations are at 65 percent of the allowed concentration (for an eight-hour averaging time). Current PM10 concentrations are at 52 percent of the allowed ambient standard. Nitrogen dioxide concentrations are at 36 percent of the allowed values. All other pollutants, for which ambient air quality standards exist, are below 25 percent of the allowed values.

4.7.3 Radiological Air Quality

Radionuclide emissions to the atmosphere from the Hanford Site have been steadily decreasing over the last few years as site operations have changed emphasis from the historical mission of materials production and processing to energy and waste management research. During 1992, all operations at the Hanford Site released less than 100 Ci of radionuclides to the atmosphere, most of which consisted of tritium and noble gases (Woodruff and Hanf 1993). Of that total, fission and activation products accounted for less than 0.036 Ci, uranium isotopes accounted for less than 1 x 10-6 Ci, and transuranics contributed less than 0.005 Ci. These releases resulted in a dose to the maximally exposed offsite resident of less than 0.005 mrem, which is several orders of magnitude less than the current EPA standard of 10 mrem per year for DOE facilities.

Ambient air monitoring for radionuclides consisted of sampling at 42 onsite and offsite locations during 1992. Total concentrations of alpha- and beta-emitting radionuclides at the site perimeter were indistinguishable from those at distant locations that are unaffected by Hanford emissions. Concentrations of two specific radionuclides (tritium and iodine-129) were elevated relative to background; however, their contribution to the total airborne activity was small.

4.8 Water Resources

4.8.1 Surface Water

4.8.1.1 Surface Water Hydrology. The Pasco Basin occupies about

4900 square kilometers (1900 square miles) and is located centrally within the Columbia Basin. Elevations within the Pasco Basin are generally lower than other parts of the plateau, and surface drainage enters it from other basins. Within the Pasco Basin, the Columbia River is joined by three major tributaries: the Yakima River, the Snake River, and the Walla-

Walla River.

The Hanford Site occupies approximately one-third of the land area within the Pasco Basin. Primary surface-water features associated with the Hanford Site are the Columbia and Yakima rivers. Several surface ponds and ditches are present, and they are generally associated with fuel- and waste-processing activities. Several small spring-streams occur on the Arid Land Ecology site on the western side of the Hanford Site.

A network of dams and multipurpose water resources projects is located along the course of the Columbia River. The principal dams are shown in Figure 4-13. Storage behind Grand Coulee Dam, combined with storage upstream in Canada, totals 3.1 x 1010 cubic meters (1.1 x 1012 cubic feet) of usable storage to regulate the Columbia River for power, flood control, and irrigation of land within the Columbia Basin project.

Figure 4-13. Locations of major surface water resources and principal dams withi

Approximately two-thirds of the surface runoff, if there were any from Hanford, would drain directly into the Columbia River along the Hanford Reach, which extends from the upstream end of Lake Wallula to the Priest Rapids Dam. One-third of the surface runoff would drain into the Yakima River, which flows into the Columbia River below the Hanford Site. The flow has been inventoried and described in detail by the U.S. Army Corps of Engineers (DOE 1986a). Flow along this reach is controlled by the Priest Rapids Dam. Several drains and intakes are also present along this reach. These include irrigation outfalls from the Columbia Basin Irrigation Project and Hanford Site intakes for the onsite water export system.

Recorded flow rates of the Columbia River have ranged from 4500 to 18,000 cubic meters per second (~158,900 to 635,600 cubic feet per second) during the runoff in spring and early summer, to 1000 to 4500 cubic meters per second (35,300 to 158,900 cubic feet per second) during the low flow period of late summer and winter. The average annual Columbia River flow in the Hanford Reach, based on records from 65 years, is about 3400 cubic meters per second (120,100 cubic feet per second) (DOE 1988). A minimum flow of about 1020 cubic meters per second (35,000 cubic feet per second) is maintained along the Hanford Site. Normal river elevations within the site range from 120 meters (394 feet) above mean sea level where the river enters the Hanford Site near Vernita to 104 meters (341 feet) where it leaves the site near the 300-Area.

The Yakima River, near the southern portion of the Hanford Site, has a low annual flow compared to the Columbia River. For 57 years of record, the average annual flow of the Yakima River is about 104 cubic meters per second (3673 cubic feet per second) with monthly maximum and minimum flows of 490 cubic meters per second (17,305 cubic feet per second) and 4.6 cubic meters per second (162 cubic feet per second), respectively.

Cold Creek and its tributary, Dry Creek, are ephemeral streams within the Yakima River drainage system along the southern boundary of the Hanford Site. Both streams drain areas to the west of the Hanford Site and cross the southwestern part of the site toward the Yakima River.

Surface flow, when it occurs, infiltrates and disappears into the surface sediments in the western part of the Hanford Site (refer to subsection 4.6.1.3 for a discussion of soil types and moisture percolation). Rattlesnake Springs, located on the western part of the site, forms a small surface stream that flows for about 3 kilometers (1.8 miles) before disappearing into the ground. Approximately one-third of the Hanford Site is drained by the Yakima River system.

Total estimated precipitation over the Pasco Basin is about 9 x 106 cubic meters (318 x 106 cubic feet) annually, averaging less than 20 centimeters per year (~8 inches per year). Mean annual runoff from the basin is estimated to be less than 3.1 x 107 cubic meters per year (109 x 107 cubic feet per year), or approximately 3 percent of the total precipitation. The basin-wide runoff coefficient is zero for all practical purposes. The remaining precipitation is assumed to be lost through evapotranspiration, with a small component (perhaps less than 1 percent) recharging the groundwater system (DOE 1988).

Water use in the Pasco Basin is primarily from surface diversion with groundwater diversions accounting for less than 10 percent of the use. A listing of surface water diversions, volumes, types of usage, and the populations served is given in DOE (1988). Industrial and agricultural usage represent about 32 percent and 58 percent, respectively, and municipal use about 9 percent. The Hanford Site uses about 81 percent of the water withdrawn for industrial purposes. However, because of the N Reactor shutdown and considering the data in DOE (1988), these percentages now approximate 13 percent for industrial, 75 percent for agricultural, and 12 percent for municipal use, with the Hanford Site accounting for about 41 percent of the water withdrawn for industrial use.

Approximately 50 percent of the wells in the Pasco Basin are for domestic use and are generally shallow (less than 150 meters [500 feet]). Agricultural wells, used for irrigation and stock supply, make up the second-largest category of well use, about 24 percent for the Pasco Basin. Industrial users account for only about 3 percent of the wells (DOE 1988).

Most of the water used by the Hanford Site is withdrawn from the Columbia River. The principal users of groundwater within the Hanford Site are the Fast Test Flux Facility, with a 1988 use of 142,000 cubic meters (5.0 x 106 cubic feet) from two wells in the unconfined aquifer, and the PNL Observatory, with a water supply from a spring on the side of Rattlesnake Mountain.

Regional effects of water-use activities are apparent in some areas where the local water tables or potentiometric levels have declined because of withdrawals from wells. In other areas, water levels in the shallow aquifers have risen because of artificial recharge mechanisms, such as excessive application of imported irrigation water or impoundment of streams. Wastewater ponds on the Hanford Site have artificially recharged the unconfined aquifer below the 200-East and 200-West Areas. The increase in water table elevations was most rapid from 1950 to 1960, and apparently had nearly reached equilibrium between the unconfined aquifer and the recharge during 1970 to 1980 when only small increases in water table elevations occurred. Wastewater discharges from the 200-West Area were significantly reduced in 1984 (DOE 1988), with an accompanying decline in water table elevations.

4.8.1.2 Flood Plains. **Large Columbia River floods have occurred in the** past (DOE 1987), but the likelihood of recurrence of large-scale flooding has been reduced by the construction of several flood control/water storage dams upstream of the site. Major floods on the Columbia River are typically the result of rapid melting of the winter snowpack over a wide area augmented by above-normal precipitation. The maximum historical flood on record occurred June 7, 1894, with a peak discharge at the Hanford Site of 21,000 cubic meters per second (742,000 cubic feet per second). The flood plain associated with the 1894 flood is shown in Figure 4-14. The largest recent flood took place in 1948 with an observed peak discharge of 20,000 cubic meters per second (706,280 cubic feet per second) at the Hanford Site. The probability of flooding at the magnitude of the 1894 and 1948 floods has been greatly reduced because of upstream regulation by dams.

The Federal Emergency Management Agency has not prepared flood plain maps for the Hanford Reach of the Columbia River because that agency prepares maps only for developing areas (a criteria that specifically excludes the Hanford Reach).

Evaluation of flood potential is conducted in part through the concept of the probable maximum flood, determined from the upper limit of precipitation falling on a drainage area and other hydrologic factors, such as antecedent moisture conditions, snowmelt, and tributary conditions, that could result in maximum runoff. The probable maximum flood for the Columbia River below Priest Rapids Dam has been calculated to be 40,000 cubic meters per second (1.4 million cubic feet per second-) and is greater than the 500-year flood. The flood plain associated with the probable maximum flood is shown in Figure 4-15. This flood would inundate parts of the 100-Areas located adjacent to the Columbia River, but the central portion of the Hanford Site where the SNF facility would be located would remain unaffected (DOE 1986a).

Figure 4-14. Flood area during the 1894 flood. Figure 4-15. Flood area for th

Flood with both regulated and unregulated peak discharges given for the Columbia River below Priest Rapids Dam. Frequency curves for both natural (unregulated) and regulated peak discharges are also given for the same portion of the Columbia River. The regulated Standard Project Flood for this part of the river is given as 15,200 cubic meters per second (54,000 cubic feet per second) and the 100-year regulated flood as 12,400 cubic meters per second (440,000 cubic feet per second). No maps for the flooded areas are provided.

Potential dam failures on the Columbia River have been evaluated (DOE 1986a; ERDA 1976). Upstream failures could arise from a number of causes, with the magnitude of the resulting flood depending on the degree of breaching at the dam. The U.S. Army Corps of Engineers evaluated a number of scenarios on the effects of failures of Grand Coulee Dam, assuming flow conditions of the order of 11,000 cubic meters per second (400,000 cubic feet per second). For purposes of emergency planning, they hypothesized that 25 percent and 50 percent breaches, the instantaneous disappearance of 25 percent or 50 percent of the center section of the dam, would result from the detonation of nuclear explosives in sabotage or war. The discharge or floodwave resulting from such an instantaneous 50 percent breach at the outfall of the Grand Coulee Dam was determined to be 600,000 cubic meters per second (21 million cubic feet per second). In addition to the areas inundated by the probable maximum flood (see Figure 4-15), the remainder of the 100 Areas, the 300 Area, and nearly all of Richland, Washington, would be flooded (DOE 1986a; ERDA 1976). Determinations were not made for failures of dams upstream, for associated failures down of Grand Coulee, or for breaches greater than 50 percent of Grand Coulee for two principal reasons: the 50 percent scenario was believed to represent the largest realistically conceivable flow resulting from either a natural or human-induced breach (DOE 1986a); that is, it was hard to imagine that a structure as large as the Grand Coulee Dam would be 100 percent destroyed instantaneously. It was also assumed that such a scenario as the 50 percent breach would only occur as the result of direct explosive detonation, not because of a natural event such as an earthquake. Even a 50 percent breach under these conditions would indicate an emergency situation where other overriding major concerns might be present.

The possibility of a landslide resulting in river blockage and flooding along the Columbia River has also been examined for an area bordering the east side of the river upstream from the city of Richland (DOE 1986a). The possible landslide area considered was the 75-meter- (250-foot-) high bluff generally known as White Bluffs. Calculations were made for an 8 x 105 cubic meter (1 x 106 cubic yards) landslide volume with a concurrent flood flow of 17,000 cubic meters per second (600,000 cubic feet per second) (a 200-year flood) resulting in a flood wave crest elevation of 122 meter (400 foot) above mean sea level. Areas inundated upstream from such a landslide event would be similar to those shown in Figure 4-15.

A flood risk analysis of Cold Creek was conducted in 1980 as part of the characterization of a basaltic geologic repository for high-level radioactive waste. Such design work is usually done to the criteria Standard Project Flood or Probable Maximum Flood rather than the worst case or 100-year flood scenario. Therefore, in lieu of 100- and 500-year floodplain studies, a probable maximum flood evaluation was made for a reference repository location directly west of the 200-East Area and encompassing the 200-West Area (Skaggs and Walters 1981). Figure 4-16 shows the extent of this evaluation.

4.8.1.3 Surface Water Quality.

4.8.1.3.1 Water Quality of the Columbia River-The Department of

Ecology classifies the Columbia River as Class A (excellent) between Grand Coulee Dam and the mouth of the river near Astoria, Oregon (DOE 1986a). The Hanford Reach of the Columbia River is the last free-flowing portion of the river in the United States.

Pacific Northwest Laboratory conducts routine monitoring of the Columbia River for both radiological and nonradiological water quality parameters. A yearly summary of results has been published since 1973 (Woodruff and Hanf 1993). Numerous other water quality studies have been conducted on the Columbia River relative to the impact of the Hanford Site during the past 37 years. Currently, eight outfalls are covered by National Pollutant Discharge Elimination System (NPDES) permits at the Hanford Site: two at the 100-K Area, five at the 100-N Area, and one at the 300 Area. These discharge locations are monitored for various measures of water quality, including nonradioactive and radioactive pollutants. The dose from any radionuclide releases is estimated for the Annual Environmental Monitoring Report for the Hanford Site. In 1993, monitored liquid discharges resulted in a dose of 0.012 mrem to the downstream maximally exposed individuals (Dirkes et al. 1994). Permit applications have been submitted to E the 100 and 300 Areas. These new facilities include a treatment facility for process wastewater (1325-N), a filter backwash/ash sluicing wastewater disposal facility (315/384), and the 300 Area Treated Effluent Disposal Facility.

Figure 4-16. Extent of probable maximum flood in Cold Creek area.

Radiological monitoring shows low levels of radionuclides in samples of Columbia River water. Tritium, iodine-129, and uranium are found in somewhat higher concentrations downstream of the Hanford Site than upstream (Woodruff and Hanf 1993), but well below concentration guidelines established by DOE and EPA drinking-water standards (Table 4.8-1). Cobalt-60 and iodine-131 were not consistently found in measurable quantities during 1989 in samples of Columbia River water from Priest Rapids Dam, the 300-Area water intake, or the Richland city pumphouse (Woodruff and Hanf 1991). In 1989, the average annual strontium-90 concentrations were essentially the same at Priest Rapids Dam (upstream of the Hanford Site) and the Richland Pumphouse (Woodruff and Hanf 1991).

Nonradiological water quality parameters measured during 1989 were similar to those reported in previous years and were within Washington State Water Quality Standards (Woodruff and Hanf 1991). Under Federal Water Pollution Control Act Amendments of 1972 (as amended by the Clean Water Act of 1972) the NPDES can regulate permits issued to DOE-RL for discharges of nonradioactive effluents made to the Columbia River.

Table 4.8-1. Annual average concentrations of radionuclides in Columbia River water during 1992.

Radionuclides	Water concentrations (pCi/L)		
	Upstream concentration (Priest Rapids Dam)	Downstream concentration (Richland Pumphouse)	EDA drinking water standard
H-3	50	101	20,000
Sr-90	0.09	0.09	8.0
Uranium	0.42	0.51	NA
Tc-99	0.10	0.21	900
I-129	<2.3 x 10-5	<1.4 x 10-4	1

a. Data taken from Woodruff and Hanf (1993).

4.8.1.3.2 Water Quality of the Unconfined Aquifer-As part of the continuing environmental

monitoring program, groundwater monitoring reports have been issued since 1956 and Hanford Site Environmental Report, which is issued by calendar year.

The shallow, unconfined aquifer in the Pasco Basin and on the Hanford Site contains waters of a dilute (less than or approximate total dissolved solids) calcium bicarbonate chemical type. Other principal constit magnesium, and nitrate. Variability in chemical composition exists within the unco of natural variation in the composition of the aquifer material; in part because of practices north, east, and west of the Hanford Site; and, on the Hanford Site, in p disposal.

Graham et al. (1981) compared analyses of unconfined aquifer water samples tak Survey in the Pasco Basin, but off the Hanford Site, with samples taken by PNL and the years 1974 through 1979. In general, Hanford Site groundwater analyses showed constituents and temperatures than were reflected in the analyses of offsite sample

Elevated levels of some constituents in the Hanford groundwater result from re wastes from disposal facilities, primarily in the 100 Areas (formerly the site of p and 200 Areas (formerly the spent fuel reprocessing and defense materials productio such as tritium and nitrate, from the 200 Areas are present in a groundwater plume southeastern quadrant of the Hanford Site and enters the Columbia River along a bro Contaminants having lower mobility are generally confined to smaller localized plum disposal facilities and migrate more slowly toward the Columbia River (Dirkes et al radionuclides, such as strontium-90 and cesium-137, have reached the groundwater, p disposal cribs. Minor quantities of longer-lived radionuclides have also reached t groundwater monitoring well casing and through reverse well injection, a disposal p at Hanford in 1947 (Smith 1980).

Of the contaminants found in groundwater, several radionuclides and nonradioac in concentrations that exceeded EPA drinking water standards or DOE Derived Concent (Dirkes et al. 1994). These quantities are used as a relative measure of contamina exception, groundwater beneath the site is not used for human consumption or food p utilized for drinking at the FFTF visitor center contains above-background quantiti from the 200 Area plume; however, these levels are well below the EPA drinking wate opportunity for contaminated groundwater to migrate to locations where members of t directly for domestic purposes or irrigation. Groundwater in the unconfined aquife relatively isolated, and generally flows toward the north and east where it dischar Normal hydraulic gradients within the unconfined aquifer beneath the Hanford Site p groundwater toward populated areas near Richland, and recharge to the Columbia Rive County to the north and east prevents radionuclides in the Columbia River from migr river from Hanford.

Groundwater monitoring at the 100 Areas detected concentrations of cobalt-60, and uranium that were above the EPA drinking water standards. Tritium concentratio drinking water standard and the DOE DCG at one sample well in each of the 100-N and cobalt-60, technetium-99, iodine-129, cesium-137, uranium, and plutonium were occas concentrations that exceeded the EPA drinking water standard; tritium and strontium drinking water standard and the DOE DCG in some locations. Only uranium exceeded t in 300 Area wells, a result of liquid waste disposal at former fuel fabrication fac

Three nonradiological constituents - nitrate, chromium, and trichloroethylene water standards in both 100 and 200 Area groundwater. In addition to those constit exceeded EPA drinking water standards for cyanide, fluoride, carbon tetrachloride, trichloroethylene was found above the drinking water limits in the 300 Area.

The occurrence and consequences of leaks from waste storage tanks and of radio have been described elsewhere (ERDA 1975). These occurrences have not resulted, an radiation exposure to the public (ERDA 1975; DOE 1987). Leakage from the 105-KE fu groundwater contamination with several radionuclides, as noted previously. The mor the Columbia River via springs near the 100-K Area, although radionuclides in the s drinking water standard in 1993 (Dirkes et al. 1994).

Radioactive and nonradioactive effluents are discharged to the environment fro Company facilities in the 200 Area (Cooney et al. 1988). These effluents, in gener column. Cooling water represents by far the largest volume of potentially radioact Additional treatment systems for these effluents are being designed and installed p forth in the Hanford Federal Facility Agreement and Consent Order, which was jointl Washington Department of Ecology in May 1989. Under the provisions of the Comprehe Compensation and Liability Act, remedial investigations/feasibility studies will be operable units at Hanford.

Springs are common on basalt ridges surrounding the Pasco Basin. Geochemicall

calcium or sodium bicarbonate type with low dissolved solids (approximately 200 to
1986a). Compositionally these waters are similar to shallow local groundwaters (un
Saddle Mountains basalt). However, they are readily distinguishable from waters of
(Mabton interbed) and the Wanapum and Grande Ronde basalts, which are of sodium bic
bicarbonate (or sodium chloride sulfate) type. Currently, no evidence suggests the
tain any significant component of deeper groundwater.

4.8.1.3.3 Water Quality of the Confined Aquifer-Areal and stratigraphic changes in

groundwater chemistry characterize basalt groundwaters beneath the Hanford Site (Gr
1981). The
stratigraphic position of these changes is believed to delineate flow-system bounda
evolution taking place along groundwater flow paths. Using these data, some potent
also been located; however, the rate of mixing is unknown. According to Woodruff
contamination was observed in the groundwater of the confined aquifer on Rattlesnak
well in this aquifer contained 8,800 micrograms of nitrate per liter in 1992. The
erosional window in the confining basalt flow. In another well, tritium levels wer
picocuries per liter) in 1992. In the same well, elevated levels of iodine-129 (0.
observed in 1992.

4.8.2 Groundwater

4.8.2.1 Groundwater Hydrology. The regional geohydrologic setting of the Pasco Basin is based on the

stratigraphic framework consisting of numerous Miocene tholeiitic flood basalts of
group; relatively minor amounts of intercalated fluvial and volcanoclastic Ellensbu
fluvial, lacustrine, and glaciofluvial suprabasalt sediments. The vertical order o
surface downward is Hanford formation, Middle Ringold Formation, Lower Ringold Form
Formation, and bedrock, e.g., basalt. Figure 4-3 illustrates the stratigraphic lay
units underlying the Hanford Site, and Figure 4-17 shows the order of the geologica
formation varies in thickness across the Hanford Site from approximately 15 to 100
(Figure 4-17). The Middle Ringold Formation varies from 10 to 110 meters (33 to 36
and Basal Ringold Formations extend eastward from the western boundary of the site
(6.8 miles). The Lower Ringold Formation is rather uniform in thickness at 20 mete
Ringold Formation demonstrates a maximum thickness of 40 meters (131 feet) at the f
(interpolated from Woodruff and Hanf 1993). Lateral groundwater movement is known to occur within a shallow,
unconfined
confined-to-semiconfined aquifers consisting of basalt flow tops, flow bottom zones
(DOE 1988). These deeper aquifers are intercalated with aquitards consisting of ba
flow and leakage between geohydrologic units is inferred and estimated from water l
data but is not quantified, and direct measurements are not available (DOE 1988).

Figure 4-17. Geologic cross section of the Hanford Site (modified from Tallman e

The multiaquifer system within the Pasco Basin has been conceptualized as cons
units: (1) the Grande Ronde Basalt; (2) Wanapum Basalt; (3) Saddle Mountain Basalt
and Ringold Formation sediments. Geohydrologic units older than the Grande Ronde B
importance to the regional hydrologic dynamics and system.

The Grande Ronde Basalt is the most voluminous and widely spread formation wit
group and has a thickness of at least 2745 meters (9000 feet). The Grande Ronde Ba
composed of the Grande Ronde Basalt and minor intercalated sediments equivalent to
Formation (DOE 1988). More than 50 flows of Grande Ronde Basalt underlie the Pasco
the lower 2200 to 2500 meters of this geohydrologic unit. This unit is a confined-
is recharged along the margins of the Columbia Plateau where the unit is at or clos
face, and by
surface-water and groundwater inflow from lands adjoining the plateau. Vertical mo
is known to occur. Groundwater within the unit in the eastern Pasco Basin is belie

groundwater inflow from the east and northeast.

The Wanapum Basalt geohydrologic unit consists of basalt flows of the Wanapum
minor and discontinuous sedimentary interbeds of the Ellensburg Formation or equiva
Basin, the Wanapum Basalt consists of three members, each consisting of multiple fl
underlies the entire Pasco Basin and has a maximum thickness of 370 meters (1215 fe
Wanapum Basalt geohydrologic unit is confined to semiconfined. Recharge is believe
where the Wanapum Basalt is not overlain by great thicknesses of younger basalt, le
formations, and surface-water and groundwater inflow from lands adjoining the plate
from irrigation. Within the Pasco Basin, recharge occurs along the anticlinal ridg
recharge in the eastern basin being from groundwater inflow from the east and north
transfer and vertical leakage are also believed to contribute to the recharge.

The Saddle Mountains Basalt geohydrologic unit is composed of the youngest for
Basalt Group and several thick sedimentary beds of the Ellensburg Formation or equi
up to 25 percent of the unit. Within the Pasco Basin, the Saddle Mountains Basalt
one or more flows. This geohydrologic unit underlies most of the Pasco Basin, atta
290 meters (950 feet), but is absent along the northwest part of the basin and alon
Groundwater in the Saddle Mountains geohydrologic unit is confined to semiconfined,
believed to be local (DOE 1988).

The rock materials that overlie the basalts in the structural and topographic
Plateau generally consist of Miocene-Pliocene sediments, volcanics, Pleistocene sed
ments (including those from
catastrophic flooding), and Holocene sediments consisting mainly of alluvium and eo
suprabasalt geohydrologic unit (referred to as the Hanford/Ringold unit) consists p
Miocene-Pliocene Ringold Formation stream, lake, and alluvial materials, and the Pl
deposits informally called the Hanford formation. Groundwater within the suprabasa
generally unconfined, with recharge and discharge usually coincident with topograph
The Hanford/Ringold unit is essentially restricted to the Pasco Basin with principa
periphery of the basin from precipitation and ephemeral streams.

Little if any natural recharge occurs within the Hanford Site, but artificial
waste disposal activities (Woodruff and Hanf 1993). Recharge from irrigation occur
Columbia River and in the synclinal valleys west of the Hanford Site. Upward leaka
fers into the unconfined aquifer is believed to occur in the northern and eastern s
Groundwater discharge is primarily to the Columbia River.

Groundwater under the Hanford Site occurs under unconfined and confined condit
unconfined aquifer is contained within the glaciofluvial sands and gravels of the H
Ringold Formation. It is dominated by the middle member of the Ringold Formation,
with varying amounts of cementation. The bottom of the unconfined aquifer is the b
the clay zones of the Lower Ringold. A semiconfined aquifer occurs in areas where
lies between the basalt and the fine-grained Lower Ringold. The confined aquifers
interbeds and/or interflow zones that occur between dense basalt flows in the Colum
main water-bearing portions of the interflow zones occur within a network of interc
fractures of the flow tops or flow bottoms.

4.8.2.2 Vadose Zone Hydrology. Sources of natural recharge to the unconfined aquifer are rainfall and

runoff from the higher bordering elevations, water infiltrating from small ephemera
along influent reaches of the Yakima and Columbia rivers. In order to define the m
zone, the movement of precipitation through the unsaturated (vadose) zone has been
the Hanford Site. Conclusions from these studies are varied depending on the locat
investigators conclude that no downward percolation of precipitation occurs on the
texture is varied and is layered with depth, and that all moisture penetrating the
Others have observed downward water movement below the root zone in tests conducted
are coarse textured and precipitation was above normal (DOE 1987).

From the recharge areas to the west, the groundwater flows downgradient to the
along the Columbia River. This general west-to-east flow pattern is interrupted l
mounds in the 200 Areas. From the 200 Areas, a component of groundwater also flows
Mountain and Gable Butte. These flow directions represent current conditions; the
responds to changes in natural and artificial recharge.

Local recharge to the shallow basalts is believed to result from infiltration
tation and runoff along the margins of the Pasco Basin. Regional recharge of the d
from interbasin groundwater movement originating northeast and northwest of the Pas
and Grande Ronde Basalts crop out extensively (DOE 1986a). Groundwater discharge f

overlying unconfined aquifer and the Columbia River. The discharge area(s) for the uncertain, but flow is believed to be generally southeastward with discharge specul Site (DOE 1986a).

4.8.3 Existing Radiological Conditions

This section relates to the hydrology of the Hanford Site in general and to th specifically because it is the location of the proposed SNF facility.

4.8.3.1 Hydrology of the Hanford Site. Groundwater quality on the Hanford Site has been affected by

defense-related activities to produce nuclear materials. Due to the arid nature of of the groundwater on the site is normally low. Artificial recharge has occurred i liquid waste associated with processing operations in the 100, 200, and 300 Areas t underlying discharge points. While most of the site does not have contaminated gro underlying the site do have elevated levels of both radiological and nonradiologica effluents discharged into the ground have carried with them certain radionuclides a the soil column at varying rates, eventually enter the groundwater, and form plumes 5.54 in DOE 1992a).

Groundwater monitoring is conducted on an annual basis on the Hanford Site as Water Environmental Surveillance Program and other monitoring programs to study the groundwater quality, and the concentration of certain constituents as regulated by Washington State. In 1992, several groundwater samples were taken from approximate percent were sampled at least quarterly or more frequently. The remainder were sam Figure 5.49 in DOE (1992a) illustrates the locations of these monitoring wells.

Results indicate that total alpha, total beta, tritium, cobalt-60, strontium-9 iodine-129, cesium-137, and uranium concentrations in wells in or near operating ar Standards (DWS) (see Tables C2 and C3 in Appendix C of DOE [1992a]). Concentration Area, tritium in the general 200 Area, strontium-90 in the 100-N and 200-East Areas Concentration Guides (DCGs) [see Table C6 in Appendix C of DOE (1992b)]. Tritium c migrate downgradient with the groundwater flow where it enters the Columbia River; discharged to the Columbia River from the 100 Areas in 1992 (Woodruff and Hanf 1993

Nitrate concentrations also exceeded DWS at various locations in the 100, 200, 600 Area locations. Elevated concentrations were also detected for chromium, cyani chloroform, and trichloroethylene in various sample wells in the 100 and 200 Areas. regarding groundwater quality on the Hanford Site, refer to DOE (1992b).

4.8.3.2 Hydrology of the 200 Areas. The unconfined aquifer beneath the Hanford Site is contained

within the Ringold Formation and the overlying Hanford formation. The unconfined a wastewater disposed to surface and subsurface disposal sites. The depth to groundw (180 to 310 feet) on the 200 Area Plateau. The bottom of the unconfined aquifer is in some areas, the clays of the Lower Ringold Member. The thickness of the unconfi ranges from less than 15 to 61 meters (50 to 200 feet). Beneath the unconfined aqu consisting of sedimentary interbeds or interflow zones that occur between dense bas

The sources of natural recharge to the unconfined aquifer are rainfall from ar of the Hanford Site and two ephemeral streams, Cold Creek and Dry Creek. From the groundwater flows downgradient and discharges into the Columbia River. This genera basalt outcrops and subcrops in the 200 Areas and by artificial recharge.

The unconfined aquifer beneath the 200 Areas receives artificial recharge from Cooling water disposed to ponds has formed groundwater mounds beneath two former an disposal sites: U Pond in the 200-West Area, B Pond east of the 200-East Area, and 200-East Area. The water table rose approximately 20 meters (65 feet) under U Pond B Pond compared with pre-Hanford conditions (Newcomb et al. 1972). However, U Pond been eliminated and, with no further recharge from them, the water levels will decl U Pond was deactivated in 1984 and Gable Mountain Pond was decommissioned and backf

B Pond increased after the elimination of Gable Mountain Pond.

The dry nature (for example, climate, waste form, and depth to water) of the l limited natural surface recharge available from precipitation minimize the probabil migration from these facilities.

Additional characterization and enhanced groundwater monitoring of the 200 Are conducted pursuant to requirements established under the Resources Conservation and this work will supply additional information on the 200 Areas.

4.8.4 Water Rights

The Hanford Site, situated along the Columbia River and near the Yakima River, traditionally concerned about water rights. Typical water uses in this region incl nuclear power plant, irrigation, and municipal and industrial uses. Cooling water River to cool the defense reactors at Hanford. The DOE continues to assert a feder right with respect to its existing Hanford operations. Current activities use wate River under the Department's federally reserved water right.

4.9 Ecological Resources

The Hanford Site is a relatively large, undisturbed area (1450 square kilomete shrub-steppe that contains numerous plant and animal species adapted to the region' site consists of mostly undeveloped land with widely spaced clusters of industrial western shoreline of the Columbia River and at several locations in the interior of buildings are interconnected by roads, railroads, and electrical transmission lines activities occupy about 6 percent of the total available land area, and their impac ing ecosystems is minimal. Most of the Hanford Site has not experienced tillage or Columbia River flows through the Hanford Site, and although the river flow is not d dams within the Hanford Site, the historical daily and seasonal water fluctuations upstream and downstream of the site (Rickard and Watson 1985). The Columbia River Hanford Site provide habitat for aquatic organisms. The Columbia River is also acc use and commercial navigation.

Topography of the proposed SNF facility site is level to gently sloping to the subject area is primarily Burbank loamy sand intergraded with Rupert sand. The lat stabilized sand dunes. Several used and unused unpaved roads cross the project are disturbance to the plant community. The subject area outside the disturbed area is sagebrush with an understory of cheatgrass, an alien weed species, and Sandberg's b are approximately 494 square kilometers (191 square miles) of this community on the bitterbrush/cheatgrass comprises the second largest plant community. Cover of big from 10-25 percent near Route 4 to 25-50 percent over the remainder of the site. C bluegrass is mostly uniform across the subject area at 25-50 percent and 10-20 perc

4.9.1 Terrestrial Resources

4.9.1.1 Vegetation. The Hanford Site, located in southeastern Washington, has been botanically char-

acterized as a shrub-steppe. Because of the site's aridity, the productivity of bo mals is relatively low compared with other natural communities. In the early 1800s nant plant in the area was big sagebrush with an understory of perennial bunchgrass bluegrass and bluebunch wheatgrass. With the advent of settlement that brought live raising, the natural vegetation mosaic was opened to a persistent invasion by alien Today cheatgrass is the dominant plant on fields that were cultivated 50 years ago. established on rangelands at elevations less than 244 meters (800 feet) (Rickard an

fires in the area are common; the most recent extensive fire in 1984 significantly
vegetation. The dryland areas of the Hanford Site were treeless in the years befor
for several decades before 1943, trees were planted and irrigated on most of the fa
When the farms were abandoned in 1943, some of the trees died but others have persi
Figure 4-18. Distribution of vegetation types on the Hanford Site. roots are dee
ing platforms for several species of
birds, including hawks, owls, ravens, magpies, and great blue herons, and as night
eagles (Rickard and Watson 1985). The vegetation mosaic of the Hanford Site curren
of plant communities:

1) thyme buckwheat/Sandberg's bluegrass
2) sagebrush/bluebunch wheatgrass
3) sagebrush/cheatgrass or sagebrush/Sandberg's bluegrass
4) sagebrush-bitterbrush/cheatgrass
5) greasewood/cheatgrass-saltgrass
6) winterfat/Sandberg's bluegrass
7) cheatgrass-tumble mustard
8) willow or riparian
9) spiny hopsage/Sandberg's bluegrass
10) sand dunes.

The dominant plant community on the proposed SNF site is sagebrush/Sandberg's
tumble mustard occurring in the southern portion of the site. A table listing comm
be found in Cushing (1992).

Almost 600 species of plants have been identified on the Hanford Site (Sacksch
dominant plants on the 200 Area Plateau are big sagebrush, rabbitbrush, cheatgrass,
cheatgrass providing half of the total plant cover. More than 100 species of plant
tified in the 200 Area Plateau. Cheatgrass and Russian thistle, annuals introduced
1800s, invade areas where the ground surface has been disturbed. Certain desert pl
depths approaching 10 meters (33 feet) (Napier 1982); however, root penetration to
demonstrated for plants in the 200 Areas. Rabbitbrush roots have been found at a d
the 200 Areas (Klepper et al. 1979). Mosses and lichens appear abundantly on the s
grow on the shrub stems. The important desert shrubs, big sagebrush and bitterbrus
provide less than 20 percent canopy cover. The important understory plants are gra
grass, Sandberg's bluegrass, Indian ricegrass, June grass, and needle-and-thread gr

As compared to other semiarid regions in North America, primary productivity i
number of vascular plant species is also low. This situation is attributed to the
(16 centimeters [~6 inches]), the low water-holding capacity of the rooting substra
summers and occasionally very cold winters.

Sagebrush and bitterbrush are easily killed by summer wildfires, but the grass
relatively resistant and usually recover in the first growing season after burning.
community to wind erosion. The severity of erosion depends on the severity and are
incinerate entire shrubs and damage grass crowns. Less intensive fires leave dead
herbs is prompt. The most recent and extensive wildfire occurred in the summer of

Bitterbrush shrubs provide browse for a resident herd of wild mule deer. Bitt
recolonize burned areas because invasion is by seeds. Bitterbrush does not sprout
relatively light.

Certain passerine birds (such as sage sparrow, sage thrasher, and loggerhead s
bitterbrush for nesting. These birds are not expected to nest in places devoid of
to avoid burned areas without shrubs. Birds that nest on the ground in areas witho
curlews, horned larks, Western meadowlarks, and burrowing owls.

An ecological inventory of the vegetation on the proposed SNF facility site re
vegetation types: burned and unburned sagebrush/cheatgrass. Two species predomina
grass and tarweed fiddleneck; the unburned vegetation comprised mainly cheatgrass a
one-day survey, approximately 43 species were identified.

4.9.1.2 Insects. More than 300 species of terrestrial and aquatic insects have been found on the Hanford

Site. Grasshoppers and darkling beetles are among the more conspicuous groups and,
are important in the food web of the local birds and mammals. Most species of dark
spring to fall period, although some species are present only during two or three m
Rickard 1977). Grasshoppers are evident during the late spring to fall. Both beet
to wide annual variations in abundance.

4.9.1.3 Reptiles and Amphibians. Among amphibians and reptiles, 12 species are known to occur on the

Hanford Site (Fitzner and Gray 1991). The occurrence of these species is infrequen pared with similar fauna of the southwestern United States. The side-blotched liza tile and can be found throughout the Hanford Site. Short-horned and sagebrush liza habitats. The most common snakes are the gopher snake, the yellow-bellied racer, a the Hanford Site. Striped whipsnakes and desert night snakes are rarely found, but recorded for the site. Toads and frogs are found near the permanent water bodies a Cushing (1992) contains a list of all the reptiles and amphibians occurring on the

4.9.1.4 Birds. Fitzner and Gray (1991) and Landeen et al. (1992) have presented data on birds observed

on the Hanford Site. The horned lark and western meadowlark are the most abundant shrub-steppe. A list of some of the more common birds present on the Hanford Site

4.9.1.4.1 Birds Inhabiting Terrestrial Habitats-The game birds inhabiting terrestrial

habitats at Hanford are the chukar, gray partridge, and mourning dove. The chukar and partridge are year-round residents, but mourning doves are migrants. Although a few doves overwinter in sou leave the area by the end of September. Mourning doves nest on the ground and in t Chukars are most numerous in the Rattlesnake Hills, Yakima Ridge, Umtanum Ridge, Sa Mountain areas of the Hanford Site. A few birds also inhabit the 200-Area Plateau. numerous as chukars, and their numbers also vary greatly from year to year. Sage g on the Hanford Site since the 1940s, and it is probable there are no grouse nests o nearest viable population is located on the U.S. Army's Yakima Training Center, loc the Hanford Site.

In recent years, the number of nesting ferruginous hawks has increased, at lea have accepted steel powerline towers as nesting sites. Only about 50 pairs are bel Washington. Other raptors that nest on the Hanford Site are the prairie falcon, no hawk, Swainson's hawk, and kestrel. Burrowing owls, great horned owls, barn owls, the site but in smaller numbers.

4.9.1.5 Mammals. Approximately 39 species of mammals have been identified on the Hanford Site (Fitzner

and Gray 1991), and a complete list can be found in Cushing (1992). The largest ve Hanford Site is the coyote, which ranges all across the site. Coyotes have been a Canada goose nests on Columbia River islands, especially islands upstream from the Bobcats and badgers also inhabit the Hanford Site in low numbers.

Black-tailed jackrabbits are common on the Hanford Site, mostly associated wit sagebrush. Cottontails are also common but appear to be more closely associated wi and equipment laydown areas associated with the onsite laboratory and industrial fa

Townsend's ground squirrels occur in colonies of various sizes scattered acros marmots are scarce. The most abundant mammal inhabiting the site is the Great Basi across the Columbia River plain and on the slopes of the surrounding ridges. Other mouse, harvest mouse, grasshopper mouse, montane vole, vagrant shrew, and Merriam's

The Hanford Site has seven species of bats that are known to be or are potenti mostly as fall or winter migrants. The pallid bat frequents deserted buildings and abundant of the various species. Other species include the hoary bat, silver-haire little brown bat, Yuma brown bat, and Pacific western big-eared bat.

A herd of Rocky Mountain elk is present on the ALE Reserve. It is believed th reserve from the Cascade Mountains in the early 1970s. This herd had grown from ap 119 animals in the spring of 1992. Elk frequently move off the ALE Reserve to priv and west, particularly during late spring, summer, and early fall. However, while they restrict their activities to the ALE Reserve. Lack of water and the high leve restrict the elk from using other areas of the Hanford Site. Despite the arid clim these elk appear to be very healthy; antler and body size for given age classes are this species (McCorquodale et al. 1989). In addition, reproductive output is also this species. Elk remain on the ALE Reserve because of the protection it provides

Mule deer are found throughout the Hanford Site, although areas of highest con Reserve and along the Columbia River. Deer populations on the Hanford Site appear herd is characterized by a large proportion of very old animals (Eberhardt et al. 1 Islands in the Hanford Reach of the Columbia River are used extensively as fawning et al. 1979) and thus are a very important habitat for this species. Hanford Site are killed by hunters on adjacent public and private lands (Eberhardt et al. 1984).

The ecological survey conducted on an area adjacent to the proposed SNF facili or sign) 12 bird, 7 mammal, and 3 reptile species.

4.9.2 Wetlands

Several habitats on the Hanford Site could be considered as wetlands. The lar tat is the riparian zone bordering the Columbia River. The extent of this zone var willows, grasses, various aquatic macrophytes, and other plants. The zone is exten seasonal water level fluctuations and daily variations related to power generation immediately upstream from the site.

Other extensive areas of wetlands can be found within the Saddle Mountain Nati Wahluke Wildlife Refuge Area. These two areas encompass all the lands extending fr Columbia River northward to the site boundary and east of the Columbia River down t habitat in these areas consists of fairly large ponds resulting from irrigation run sive stands of cattails (Typha sp.) and other emergent aquatic vegetation surroundi They are extensively used as resting sites by waterfowl.

Some wetlands habitat exists in the riparian zones of some of the larger sprin These areas are not extensive and usually amount to less than a hectare in size, al Rattlesnake Springs is probably about 2 kilometers (1.2 miles) in length and consis cattails, and other plants. No wetlands are on or in the vicinity of the proposed

4.9.3 Aquatic Resources

There are two types of natural aquatic habitats on the Hanford Site: one is t along the northern and eastern edges of the Hanford Site, and the other is provided seeps located mainly in the Rattlesnake Hills. Several artificial water bodies, bo formed as a result of wastewater disposal practices associated with the operation o facilities. These bodies of water are temporary and will vanish with cessation of they form established aquatic ecosystems (except West Pond) complete with represent and McShane 1980). West Pond is created by a rise in the water table in the 200 Ar thus, it is alkaline and has a greatly restricted complement of biota.

4.9.3.1 The Columbia River. The Columbia River is the dominant aquatic ecosystem on the Hanford Site

and supports a large, diverse community of plankton, benthic invertebrates, fish, a the fifth largest river in North America and has a total length of about 2000 kilom origin in British Columbia to its mouth at the Pacific Ocean. The Columbia has bee downstream from the Hanford Site, and the reach flowing through the area is the las reach of the Columbia River in the United States. Plankton populations in the Hanf enced by communities that develop in the reservoirs of upstream dams, particularly manipulation of water levels below by dam operations in downstream reservoirs. Phy populations at Hanford are largely transient, flowing from one reservoir to another does not allow characteristic endemic groups of phytoplankton and zooplankton to de tributaries enter the Columbia during its passage through the Hanford Site. Gray a of fish in the Hanford Reach of the Columbia River. Since 1977, the brown bullhead been collected, bringing the total number of fish species identified in the Hanford the chinook salmon, sockeye salmon, coho salmon, and steelhead trout use the river from upstream spawning areas and are of the greatest economic importance. Both the steelhead trout also spawn in the Hanford Reach. The relative contribution of uppe chinook salmon runs in the Columbia River increased from about 24 percent of the to percent to 60 percent of the total by 1988 (Dauble and Watson 1990). The destructi stream Columbia spawning grounds by dams has increased the relative importance of t (Watson 1970, 1973). Fish migrating from the Columbia River up the Snake River woul the Hanford area because the confluence of the two rivers lies downstream from the

4.9.3.2 Spring Streams. The small spring streams, such as Rattlesnake and Snively springs, contain

diverse biotic communities and are extremely productive (Cushing and Wolf 1984). D cress occur and are not lost until one of the major flash floods occurs. The aquat duction is fairly high as compared to that in mountain streams (Gaines 1987). The from site to site and is related to the proximity of colonizing insects and other f

4.9.4 Threatened, Endangered, and Sensitive Species

Threatened and endangered plants and animals identified on the Hanford Site, a government (50 CFR 17) and Washington (Washington Natural Heritage Program 1994), a plants or mammals on the federal list of endangered and threatened wildlife and pla known to occur on the Hanford Site. However, several species of both plants and an for formal listing by the federal government and Washington.

4.9.4.1 Plants. Four species of plants are included in the Washington listing. Columbia

milk-vetch (Astragalus columbianus Barneby) and Hoover's desert parsley (Lomatium t threatened, and Columbia yellowcress (Rorippa columbiae Suksd.) and northern wormwo borealis var. wormskioldii) are designated as endangered. Columbia milk-vetch occu the Columbia River in the vicinity of Priest Rapids Dam, Midway, and Vernita. It a Umtanum Ridge and in Cold Creek Valley near the present vineyards. Hoover's desert slopes in the vicinity of Priest Rapids Dam, Midway, and Vernita. Yellowcress occu water's edge along the Columbia River. Northern wormwood is known to occur near Be northern shoreline of the Columbia River across from the 100 Areas.

Table 4.9-1. Threatened (T) and endangered (E) species known or possibly occurring

Common name	Scientific name	Federal	State
Plants			
Columbia milk-vetch	Astragalus columbianus		T
Columbia yellowcress	Rorippa columbiae		E
Hoover's desert parsley	Lomatium tuberosum		T
Northern wormwood	Artemisia campestris borealis var. wormskioldii		E
Birds			
Aleutian Canada goose	Branta canadensis leucopareia	T	E
Peregrine falcon	Falco peregrinus	E	E
Bald eagle	Haliaeetus leucocephalus	T	T
White pelican	Pelecanus erythrorhychos		E
Sandhill crane	Grus canadensis		E
Ferruginous hawk	Buteo regalis		T
Mammals			
Pygmy rabbit	Brachylagus idahoensis		T
Insects			
Oregon silverspot butterfly	Speyerra zerene hippolyta	T	T

4.9.4.2 Animals. The federal government lists the Aleutian Canada goose (Branta canadensis

leucopareia) and the bald eagle (Haliaeetus leucocephalus) as threatened and the pe
peregrinus) as endangered. In addition to the peregrine falcon, Aleutian Canada go
lists the white pelican (Pelecanus erythrorhynchos) and sandhill crane (Grus canade
ferruginous hawk (Buteo regalis) as threatened. The peregrine falcon is a casual m
does not nest here. The Oregon silverspot butterfly (Speyerra zerene hippolyta) ha
threatened species by both the state and federal governments. The bald eagle is a
forages on dead salmon and waterfowl along the Columbia River; nesting attempts hav
but those have not been successful to date. does not nest on the Hanford Site. I
nesting sites by the ferruginous hawk on the Hanford Site has been noted. Washingt
Rules were issued in 1986 (WAC-232-12-292). These rules require DOE to prepare a m
disturbance; this has been done by Fitzner and Weiss (DOE/RL 1994). The Endangered
requires that Section 7 consultation be undertaken when any action is taken that ma
destroy, or adversely modify habitat of the bald eagle or other endangered species.

Table 4.9-2 lists the designated candidate species that are under consideratio
the threatened or endangered list. Table 4.9-3 lists the plant species that are of
Washington and are presently listed as sensitive or are in one of three monitor gro
Heritage Program 1994).

Sagebrush habitat is considered priority habitat by Washington because of its
state and its requirement as nesting/breeding habitat by loggerhead shrikes (federa
species), sage sparrows (state candidate), burrowing owls (state candidate), pygmy
and state threatened), sage thrashers (state candidate), western sage grouse (feder
sagebrush voles (state monitored). Although the last five species were not discove
of the proposed SNF site, the habitat should be considered potentially suitable for
western sage grouse have only rarely been seen on the Hanford Site, and then primar
Loggerhead shrikes have been seen frequently on the proposed SNF facility site and
sagebrush as nest sites (Poole 1992). Although this species begins migration at th
1992), one individual was observed during the present survey of the proposed SNF si
located. Ground squirrel burrows used by burrowing owls and owl pellets were obser
the proposed SNF site. Numerous sage sparrows were also observed on the proposed S
have been observed during this survey because they are primarily crepuscular and no
begun hibernation. However, this species is not known from lowland portions of the
known ferruginous hawk (federal candidate and state threatened species) nest is app
miles) northwest of the subject area. The subject area should be considered as com
foraging range of this species. No other species listed as endangered or threaten
listing by Washington or federal governments, or species listed as monitor species
observed on the proposed SNF site.

Table 4.9-2. Candidate species.

Common Name	Scientific Name	Federal	State
Mollusks			
Shortfaced lanx	Fisherola (=Lanx) nuttalli		X
Columbia pebble snail	Fluminicola (=Lithoglyphus) columbiana	X	X
Birds			
Common loon	Gavia immer		X
Swainson's hawk	Buteo swainsoni		X
Ferruginous hawk	Buteo regalis	X	
Western sage grouse	Centocrcus urophasianus phaios	X	X
Sage sparrow	Amphispiza belli		X
Burrowing owl	Athene cunicularia		X
Loggerhead shrike	Lanius ludovicianus	X	X
Northern goshawk	Accipter gentilis	X	
Harlequin duck	Histrionicus histrionicus	X	
Lewis' woodpecker	Melanerpes lewis		X
Long-billed curlew	Numenius americanus	X	
Sage thrasher	Oreoscoptes montanus		X
Flammulated owl	Otus fammeolus		X
Western bluebird	Sialia mexicana		X
Tricolored blackbird	Agelaius tricolor	X	
Golden eagle	Aquila chrysaetos		X

Black tern	Chlidonius niger	X	
Mammals			
Merriam's shrew	Sorex merriami		X
Pacific western big-eared bat	Plecotus townsendii townsendii	X	
Pygmy rabbit	Brachylagus idahoensis	X	
Insects			
Columbia River tiger beetle	Cinindela columbica		X
Plants			
Columbia milk-vetch	Astragalus columbianus	X	
Columbia yellowcress	Rorippa columbiae	X	
Hoover's desert parsley	Lomatium tuberosum	X	
Northern wormwood	Artemisia campetis borealis var. wormskioldii	X	

Table 4.9-3. Washington plant species of concern occurring on the Hanford Site.

Common Name	Scientific Name	Statusa
Dense sedge	Carex densa	S
Gray cryptantha	Cryptantha leucophaea	S
Bristly cyptantha	Cryptantha interrupta	S
Shining flatsedge	Cyperus rivularis	S
Piper's daisy	Erigeron piperianus	S
Southern mudwort	Limosella acaulis	S
False-pimpernel	Lindernia anagallidea	S
Dwarf desert primrose	Oenothera pygmaea	S
Desert dodder	Cuscuta denticulata	M1
Thompson's sandwort	Arenaria franklinii v. thompsonii	M2
Robinson's onion	Allium robinsonii	M3
Columbia River mugwort	Artemisia lindleyana	M3
Stalked-pod milkvetch	Astragalus sclerocarpus	M3
Medick milkvetch	Astragalus speirocarpus	M3
Crouching milkvetch	Astragalus succumbens	M3
Rosy balsamroot	Balsamorhiza rosea	M3
Palouse thistle	Cirsium brevifolium	M3
Smooth cliffbrake	Pellaea glabella	M3
Fuzzy beardtongue penstemon	Penstemon eriantherus	M3
Squill onion	Allium scillioides	M3

The following species may inhabit the Hanford Site, but have not been recently coll collections are questionable in terms of locations or identification.

Palouse milkvetch	Astragalus arrectus	S
Few-flowered blue-eyed Mary	Collinsia sparsiflora	S
Coyote tobacco	Nicotiana attenuata	S

a. Abbreviations: S, sensitive; taxa vulnerable or declining, and could become en without active management or removal of threats. M1, Monitor group 1; taxa for whi data to support listing as threatened, endangered, or sensitive. M2, Monitor group taxonomic questions. M3, Monitor group 3; taxa that are more abundant or less thre assumed.

4.9.5 Radionuclide Levels in Biological Resources

Samples of vegetation and wildlife are routinely collected as part of the site mental monitoring program and analyzed for various radionuclides. The following su levels reported in Woodruff and Hanf (1993).

A single sample of vegetation collected on the Hanford Site contained 0.015 pi gram dry weight and 0.0059 picocuries cesium-137 per gram dry weight. These values magnitude from those reported for the previous five years. Mean values of cesium-1 = 4) in 1992 were 0.02 picocuries per gram wet weight and were about an order of ma samples collected off of the Hanford Site the previous five years (n = 42). Mean v muscle (n = 12) were 0.09 picocuries per gram wet weight and exceed those collected five years (n = 27) by about threefold, and were an order of magnitude higher than Hanford Site. Values for strontium-90 in rabbit bone (n = 12) had a mean value of weight; mean values collected on the Hanford Site for the previous five years (n = wet weight, an order of magnitude higher. Mean strontium-90 concentrations in the collected off of the Hanford Site were 0.37 picocuries per gram wet weight. One sa deer in the 200-Areas contained 0.006 picocuries cesium-137 per gram wet weight, ne less than a similar sample collected off of the Hanford Site. Fish populations are Radionuclide levels of fish from the Hanford Reach are not significantly higher tha Because the confluence of the Snake and Columbia Rivers is downstream from the Hanf runs do not migrate through the Hanford reach.

4.10 Noise

Noise is technically defined as sound waves perceptible to the human ear. Sou frequency, measured in Hertz (Hz), and sound pressure expressed as decibels (dB). as the equivalent sound level (Leq), which normally refers to the equivalent contin intermittent sound, such as traffic noise. The Leq is expressed in A-weighted deci period of time and is a frequency-weighted measure of sound level related to human concept of equal loudness.

4.10.1 Hanford Site Sound Levels

Most industrial facilities on the Hanford Site are located far enough away fro dary that noise levels at the boundary are not measurable or are barely distinguish ground noise levels. Modeling of environmental noises has been performed for commer tors and State Highway 240 through the Hanford Site. These data are not concerned levels of noise and are not reviewed here. Two studies of environmental noise were as described in subsections 4.10.2 and 4.10.3. One study reported environmental no in 1981 during site characterization of the Skagit/Hanford Nuclear Power Plant Site was a series of site characterization studies performed in 1987 that included measu environmental noise levels at five places on the Hanford Site. Additionally, such and sampling have the potential for producing noise in the field apart from major p can be disruptive to wildlife and studies have been done to compile noise data in r

4.10.2 Skagit/Hanford Data

Preconstruction measurements of environmental noise were taken in June 1981 on 1982). Monitoring was conducted at 15 sites, showing point noise level reading ran corresponding values for more isolated areas ranged from 30 to 38.8 dBA. Measureme sites where the Washington Public Power Supply System was constructing nuclear powe dBA, reflecting operation of construction equipment. Measurements taken along the structures for WNP-2 were 47.7 and 52.1 dBA, compared to more remote river noise le three miles upstream of the intake structures). Community noise levels from point (3000 Area at Horn Rapids Road and Stevens Road [Route 240]) were 60.5 dBA, largely Richland is about 20 miles from the proposed site for SNF facilities.

4.10.3 Basalt Waste Isolation Project Data

Background noise levels were determined at five sites located within the Hanfo expressed as equivalent sound levels for 24 hours (Leq-24). The average noise leve dBA on the dates tested. Wind was identified as the primary contributor to backgro exceeding 12 mph significantly affecting noise levels. This study concluded that b undeveloped areas at Hanford can best be described as a mean Leq-24 of 24 to 36 dBA wind, which normally occur in the spring, would elevate background noise levels.

4.10.4 Noise Levels of Hanford Field Activities

In the interest of protecting Hanford workers and complying with Occupational Administration (OSHA) standards for noise in the workplace, the Hanford Environment monitored noise levels resulting from several routine operations performed in the f included well drilling, pile driving, compressor operations, and water wagon operat noise propagated in the field from outdoor activities ranged from 93.4 to 96 dBA.

4.10.5 Noise Related to the Spent Nuclear Fuel Facility

Ambient noise levels at the proposed project SNF site just west of the 200-Eas very low and would be expected to be less than 40 dBAs. The land is currently vaca transverses the site. A lightly used road borders the eastern side of the proposed generates moderate amounts of vehicular noise, but only for those personnel near th on the Hanford Site is centered primarily on the main arteries leading into the sit which connects with the Richland Bypass (Route 240) and eventually with Interstate 10, which also connects with Route 240 and leads into the 200 Areas in the site cen privately owned vehicles travel to and from the site each day using these roads. T owned vehicle movement occurs during the rush hours of 6 to 8 a.m. and 3:30 to 6 p. that 3,600 oncoming truck shipments, 445 oncoming rail shipments, and 837 intrasite on the Hanford Site. The movement of all this vehicular traffic generates noise al corridors. However, little, if any, population exists along these roadways because of work areas on the Hanford Site. Information on noise contours generated by peak community Leqs and dBAs is not available at this time.

4.10.6 Background Information

Studies at Hanford of noise propagation have been concerned primarily with occ Environmental noise levels have not been extensively evaluated due to the remotenes activities and their isolation from receptors that are covered by federal or state of 1972 and its subsequent amendments (Quiet Communities Act of 1978, 42 USC 4901-4 state to direct. The State of Washington has adopted RCW 70.107, which authorizes Ecology to implement rules consistent with federal noise control legislation. The compliance with state and federal noise regulations.

4.11 Traffic and Transportation

4.11.1 Regional Infrastructure

This section discusses the existing transportation environment at and around t and most material shipments are transported by road. Bulk materials or large items transportation is used only to move irradiated fuel, certain high-level radioactive materials (primarily coal). High-level and low-level wastes from spent fuel stabil waste management facilities by pipeline.

The regional transportation network in the Hanford vicinity includes the areas

Counties from which 93 percent of the commuter traffic associated with the site ori
that serve the area are I-82, I-182, and I-90 (Figure 4-19). Interstate-82 is 8 ki
south-southwest of the site. Interstate-182, a 24-kilometer (15-mile) long urban c
miles) south-southeast of the site, provides an east-west corridor linking I-82 to
Interstate-90 (not shown in Figure 4-19), located north of the site, is the major l
extends to the east coast; SR 224 (not shown in Figure 4-19), also south of the sit
Figure 4-19. Transportation routes in the Hanford vicinity. (10-mile) link betwe
primary link between Hanford and I-90. State Route 24 enters the site from the wes
northernmost portion of the site, and intersects SR 17 approximately 24 kilometers
boundary. State Route 17 is a north-south route that links I-90 to the Tri-Cities
continues south through the Tri-Cities. State Route 14 (not shown in Figure 4-19)
Washington, and provides ready access to I-84 (not shown in Figure 4-19) at several
Washington border.

General weight, width, and speed limits have been established for highways in
However, no unusual laws or restrictions that have been identified would significan
transportation.

Airline passenger and air freight service is provided at the Tri-Cities Airpor
Port of Pasco, at Pasco, Washington. The air terminal is located approximately 16
Hanford Site. Delta Airlines provides domestic Boeing-737 and 727 service to Salt
airline service is available for domestic and international travel. Two feeder air
United Express, a subsidiary of United Airlines, and Horizon Airlines, a subsidiary
service to Seattle, Portland, and several other regional cities. Federal Express s
airplane from Spokane to Pasco and Airborne Express serves the Tri-Cities with char
the Richland airport, Richland, Washington.

4.11.2 Hanford Site Infrastructure

Hanford's onsite road network consists of rural arterial routes (see Figure 4-
kilometers (65 of the 288 miles) of paved roads at Hanford are accessible to the pu
travel occurs along Route 4, with controlled access at the Yakima and Wye barricade
public route through the site. Public highways SR 24 and SR 243 also traverse the

The highway network is in excellent condition. A recently completed major hig
involved repavement and widening of the four-lane access route to the Wye Barricade
used extensively for transporting large
Figure 4-20. Transportation routes on the Hanford Site. equipment items, constru
programs are currently planned for segments of SR 17, SR 224, SR 240, and U.S. Rout

In 1988 about 32 percent of the work force at Hanford worked in offices in Ric
force was on the site. Approximately 80 percent of the work force resides in the T
percent), Kennewick (28 percent), and Pasco (7 percent). Approximately 1600 of the
transportation.

In 1988 nearly 12 million miles were logged by DOE vehicles at Hanford. In ad
privately owned vehicles were driven onsite each weekday and 560 were driven onsite
round-trip distance of 30 miles onsite for each of these vehicles, a total of about
annually by workers onsite.

The primary highways used by commuters are SR 24, SR 240, and I-182; 10, 90, a
use these routes, respectively (totals to more than 100 percent because some commut
With these commuting patterns, workers annually travel about 27 million miles offsi
shipment to Hanford compose about 5 percent of the vehicular traffic on and around
periods of moderate traffic congestion, some of which is expected to be alleviated

During 1988, 169 accidents were reported onsite, with 20 involving DOE vehicle
involved privately owned vehicles and included seven injury accidents and one fatal
offsite highway segments of concern, most accidents occurred along I-82. According
accidents involving trucks in 1987 in the Benton/
Franklin county study area resulted in 13 injuries and 3
fatalities.

Onsite rail transport is provided by a short-line railroad owned and operated
just south of the Yakima River with the Union Pacific line, which in turn interchan
and Burlington Northern railroads at Kennewick. AMTRAK passenger rail service is p
the Burlington Northern depot at Pasco. Approximately 145,000 rail miles were logg
primarily transporting coal to steam plants. Two noninjury rail accidents occurred

The Hanford Site infrequently uses the Port of Benton dock facilities on the C large shipments. Overland wheeled trailers are then used to transport those shipme accidents were reported in 1988.

4.12 Occupational and Public Health and Safety

This section summarizes the Hanford Site programs designed to protect the heal the public. It also describes existing radiological and nonradiological conditions perspective on worker and public exposures and potential health effects.

The section is based on existing documentation and generic descriptions. Refe orders, guidance documents, annual occupational exposure and environmental reports, documents. The parameters of greatest interest are the history of radiological rel doses, particularly those associated with the storage of SNF.

The DOE, the DOE-RL, and all Hanford Site contractors have established policie healthful workplace for all employees and visitors and to protect the environment a The DOE-RL manager has the overall responsibility for safety and health at the Hanf develops and enforces occupational and public health and safety programs that meet DOE orders, other federal agencies, and Washington State.

4.12.1 Occupational Health and Safety

Programs are in place at the Hanford Site to protect workers from radiological hazards. Radiological protection (health physics) programs are based on requiremen orders, and on guidance in radiological control manuals. Occupational nonradiologi are composed of industrial hygiene programs and occupational safety programs.

4.12.1.1 Radiological Health and Safety/Health Physics Program. In order to help ensure that

workers at DOE facilities are adequately protected from ionizing radiation, the DOE protection standards for occupational workers. These standards include radiation d dose from both external radiation and internally deposited radionuclides. The curr promulgated in 10 CFR Part 835, "Occupational Radiation Protection," which was ena includes limits on total effective dose equivalent to workers, dose to individual o the public (including minors and unborn children of workers) that may be incidental facilities.

Hanford contractors base their radiological protection programs, procedures, a CFR Part 835. This regulation establishes the criteria for radiation protection fo lists allowable doses, establishes a policy on keeping doses as low as reasonably a training requirements for radiation protection personnel and other workers. The DO DOE/EH-0256T, issued by DOE Headquarters, establishes practices for conducting radi all DOE sites. The DOE requires monitoring and reporting of radiation exposure rec certain visitors. Monitoring is required by 10 CFR Part 835 when the potential exi an annual effective dose equivalent above 100 millirem (1 millisievert), or an annu individual organ greater than 10 percent of DOE occupational exposure limits. Pers assigned a thermoluminescent dosimeter that is worn at all times during radiation w instrument measures the amount and type of external radiation dose the worker recei contractor personnel are processed by Pacific Northwest Laboratory. The centralize program reads, records, and summarizes results of dosimetry data as required. Reco are maintained, and reports of radiation dose are provided annually to each worker. provided to DOE and published periodically (Smith et al. 1992)

4.12.1.2 Radiation Doses to Workers. The reported cumulative doses to all Hanford Site workers and

visitors for all activities are given as a baseline for site operations.

In 1993, about 14,500 workers were monitored at the Hanford Site. Of those mo
as radiation workers, with an average annual dose equivalent of 0.02 rem per indivi
dose is well below the 10 CFR Part 835 dose limit of 5 rem per year and the DOE Adm
per year for occupational exposure.

For 1993, the estimated collective dose-equivalent was 200 person-rem for all
workers. Based on standard dose-to-health effects conversion factors (ICRP 1991),
expected to result among workers so exposed.

The worker radiation dose of most interest in this document is the cumulative
workers, which is described in the following subsection. The SNF management altern
document are similar to those current work activities associated with maintenance a
Hanford Site.

4.12.1.3 Radiation Dose to K-Basin Workers. On the Hanford Site the bulk of the SNF is stored in the

105-KE and 105-KW Basins, which are collectively referred to as the K-Basins. The
100-K Area of the Hanford Site. The basins are filled with recirculating water to
radiological shielding for personnel working in the facility. Westinghouse Hanford
Basins for DOE. Therefore the best measure of radiation dose from SNF is the dose
at the K Basins. The collective radiation dose to WHC K Basin workers over the 2-y
22 person-rem per year, or approximately 0.4 rem per year for each worker. An aver
to the K-Basin during 1991 and 1992, or approximately 29 workers per basin (Holloma

The nominal collective radiation dose per year of operation of each SNF basin
to be 11 person-rem. During the plutonium production mission, each reactor at the
nuclear fuel storage basin associated with its operation. This resulted in an esti
2000 person-rem, assuming 179 total operating reactor years plus six years of K-Bas
of the production reactors (Bergsman 1994). Therefore, operation of nuclear fuel s
approximately 2.4 percent of the total radiological dose received by all Hanford Si
1985, 86,100 rem (Gilbert et al. 1993). Based on standard dose-to-health effects c
the dose to SNF workers since Hanford start up would statistically relate to one fa

4.12.1.4 Worker Safety and Accidents. No incidents of overexposure to radiation have been reported to

DOE during 1990 and 1991 in association with SNF storage activities at the Hanford
as any exposure over regulatory limits established by the DOE (WHC 1990; Lansing et
period from 1991 through 1994, industrial-type accidents resulted in 98 lost workin
total of approximately 70,000 days worked.

4.12.1.5 Industrial Hygiene Program. Occupational nonradiological health and safety programs at

Hanford are composed of industrial hygiene and occupational safety programs. Indus
such subjects as toxic chemicals and physical agents, carcinogens, noise, biologica
and ergonomic factors. Occupational safety programs address such subjects as machi
rigging, electrical safety, building codes, welding safety, and compressed gas cyli

The governing document is DOE 5480.10, "Contractor Industrial Hygiene Program,
implementing procedure for DOE 5480.10 is RLIP 5480.10 "Industrial Hygiene Program,
establishes additional requirements and direction for implementation of an industri
and its contractors. In addition to the program requirements of DOE 5480.10, the R
addresses the following subject areas:

(1) Use of respiratory equipment
(2) Asbestos material
(3) Regulated carcinogen or suspect carcinogenic materials
(4) Sanitation
(5) Control of hazardous materials
(6) Filter testing
(7) Hearing conservation
(8) Indoor air quality

(9) Human factors
(10) Hazardous waste site safety/health management.

The responsibilities and authorities of the Occupational Medical Services Cont Hanford Environmental Health Foundation) of the Industrial Health Program are also These are 1) to provide technical industrial health support services, that is, air evaluate, recommend, and train workers in the use of respiratory devices, as reques contractors; 3) to provide an industrial health analytical laboratory; 4) to conduc 5) to support noise abatement and hearing conservation; and 6) to maintain permanen monitoring data. Hanford Environmental Health Foundation maintains centralized rec its contractors with the results of monitoring efforts.

The RL contractors are required to do the following:

- Conduct an effective program to educate employees on the potential health environment, the control measures, and the protection necessary to reduce acceptable levels.

- Inform employees of health hazards and the results from monitoring of har agents in the work environment, and document this action.

Records are maintained in accordance with DOE 1324.2, DOE 5483.1A, and DOE 548 are required to maintain records of employee toxic and physical agent exposure and data. Contractors of DOE-RL are also required to maintain Hanford Site material sa

The DOE requires that as low as reasonably achievable (ALARA) principles for r nonradiological hazardous materials be applied in the preparation of all health and such ALARA criteria are followed during the course of the work.

Training requirements consistent with 29 CFR 1910.120 for entry into sites pot hazardous material are specified by DOE (29 CFR OSHA 1991).

The DOE-RL requires that all work (including preliminary investigation activit manner that it conforms to applicable federal and state safety and health standards equipment meets all safety and operability standards and requirements.

4.12.2 Public Health and Safety

The DOE has the responsibility under the Atomic Energy Act to establish the ne members of the public from radiation exposures resulting from DOE activities. In a 12088, "Federal Compliance with Pollution Control Standards," requires all federal legislative acts and regulations relating to the prevention, control, and abatement The Hanford Site is also in compliance with EPA's National Emission Standards for H Radionuclides, 40 CFR 61, Subpart H. The EPA offsite air emissions limiting standa effective dose equivalent to the public. The National Primary Drinking Water Regul Water Act apply to the drinking water supplies at the Hanford Site. Several radion water standards (40 CFR 141, 142; 56 FR 33050-33127, 1991) For 1993, the Hanford S et al. 1994) relates that the facility is in compliance with these requirements.

4.12.2.1 Environmental Programs. DOE 5400.1, "General Environmental Protection Program,"

establishes the requirement for environmental protection programs. The Hanford Sit prepared annually pursuant to DOE 5400.1 to summarize environmental data that chara environmental management performance and regulatory compliance status. The most re status in 1993 of compliance with environmental regulations, describes programs at estimates of radiation dose to the public from Hanford activities, and presents inf and environmental surveillance, including groundwater monitoring (Dirkes et al. 19 programs were conducted at the Hanford Site to restore environmental quality, manag technology for cleanup activities, and study the environment.

4.12.2.2 Environmental Monitoring/Surveillance Information. Environmental monitoring at the

Hanford Site consists of effluent monitoring and environmental surveillance, includ Effluent monitoring is performed by the operators at the facility or at the point o Environmental surveillance consists of sampling and analyzing environmental media o detect and quantify potential contaminants and to assess their environmental and hu annual Hanford Site Environmental Reports (Dirkes et al. 1994) present a summary o Hanford Site. The Hanford Site operations contractor, Westinghouse Hanford Company annually on radioactive and nonradioactive materials released into the environment (WHC 1993a). Several federal and state laws and regulations require the reporting nonradioactive releases. The Hanford Site reports pursuant to the federal Clean Ai Clean Water Act.

4.12.2.3 Natural Cancer Incidence. The probability of an American contracting cancer in their

lifetime is 340 in 1000 (American Cancer Society 1993), and 20 percent of Americans estimated 526,000 cancer deaths in 1993. Table 4.12-1 shows the estimated 1993 can types of cancer for the United States and for Washington State. For the United Sta contracting cancer in 1993 is 4.9 in 1000, and 2.2 in 1000 of dying from that cance probability of contracting cancer in 1993 is 3.2 in 1000, and 1.4 in 1000 of dying

The expected survival period for cancer victims has increased as detection and improved. Currently, 40 percent of the victims of all forms of cancer survive for

4.12.2.4 Potential Radiation Doses. Potential radiation doses and exposures to members of the public

from releases of radionuclides to air and water at the Hanford Site are calculated Surface Environmental Surveillance Project at the Pacific Northwest Laboratory.

Table 4.12-1. Estimated 1993 cancer incidence and cancer deaths in the United Stat for different forms of cancer (American Cancer Society 1993).

Type of Cancer	United Statesa 1993 Estimated new cases	Estimated deaths	Washington Stateb 1 Estimated new cases
All types & sites	1,170,000	526,000	14,825
Female breast	182,000	46,000	3,300
Colon & rectum	152,000	57,000	2,400
Lung	170,000	149,000	3,100
Oral	29,800	7,700	500
Uterus	44,500	10,100	600
Prostate	165,000	35,000	3,300
Skin melanoma	32,000	6,800	600
Pancreas	27,700	25,000	475
Leukemia	29,300	18,600	550

a. Total population 250 million.
b. Total population 5 million.

4.12.2.4.1 Maximally Exposed Individual (MEI) Dose.

The MEI is defined in the Hanford Site Environmental Report as "an hypothetical person who lives at a location and has a l unlikely that other members of the public would receive higher radiation doses" (Di potential radiation doses to MEI have been published in annual Hanford Site Environ 1993, the total potential dose (via air and water pathways) to the MEI from Hanford 0.03 mrem (Dirkes et al. 1994). Estimates of the potential cumulative Effective Do from both air and water sources for the 28-year period 1994 through 1972 were recon Environmental Dose Reconstruction (HEDR) Project (TSP 1994).

The highest cumulative dose to an adult resident for the years 1944 through 19

with releases to the air was 1 rem; almost all of this dose was received during 194
to an adult resident for the years 1944 through 1971 from pathways associated with
rem; about one-half of this was received during the period from 1954 through 1964.
from both air and water releases was about 2.5 rem. For comparison, the dose recei
this 28-year period from natural background radiation was approximately 9 rem. Rad
public from Hanford releases after 1972 were vanishingly small.

The maximum cumulative dose to the thyroid of a small child for the years 1944
be 240 rad; the majority of this dose was received during 1945.

4.12.2.4.2 Population Dose - Estimates of the potential cumulative dose to the population

within 50 miles (80 km) of the Hanford Site for 1944 through 1972 were estimated fr
developed by the Hanford Environmental Dose Reconstruction (HEDR) project.
Pathways of exposure associated with
releases to the air dominated the population doses until after 1954 when their cont
The cumulative population dose during 1944 through 1972 was 100,000 person-rem; ess
received through air pathways in 1945. The cumulative population dose during 1944
water pathways was estimated to be about 6,000 person-rem; most of this dose was re
1954 and 1964.

The total potential radiation dose to the population within 50 miles (80 km) f
(Dirkes et al. 1994). By comparison, the total dose received in 1993 by this same
person-rem.

About 50 cancer deaths would be implied by the total public radiation dose fro
1944 using standard dose-to-health-effects conversion factors (ICRP 91). Essential
a result of radiation exposures received during 1945. For perspective, the populat
the Site would have experienced about 75,000 cancer deaths in 1993 from all causes.

4.13 Site Services

4.13.1 Water Consumption

The principal source of water in the Tri-Cities and the Hanford Site is the Co
water systems of Richland, Pasco, and Kennewick draw a large portion of the average
(11.38 billion gallons) used in 1991. Each city operates its own supply and treatm
supply system derives about 67 percent of its water from the Columbia River, approx
well field in North Richland, and the remaining from groundwater wells. The city o
was 2.1 x 107 cubic meters (5.65 billion gallons). This current usage represents a
maximum supply capacity. The city of Pasco system also draws from the Columbia Riv
estimate of consumption is 1.1 x 107 cubic meters (2.81 billion gallons). The Kenn
the Columbia River for its supply. These wells serve as the sole source of water b
provide approximately 62 percent of the total maximum supply of 2.8 x 107 cubic met
usage of those wells in 1991 was 1.1 x 107 cubic meters (2.92 billion gallons).

4.13.2 Electrical Consumption

Electricity is provided to the Tri-Cities by the Benton County Public Utility
Electrical Association, Franklin County Public Utility District, and City of Richla
All the power that these utilities provide in the local area is purchased from the
Administration, a federal power marketing agency. The average rate for residential
local utilities is approximately $0.0396 per kilowatt hour. Electrical power for t
wholesale from the Bonneville Power Administration. Energy requirements for the si
550 average megawatts.

Natural gas, provided by the Cascade Natural Gas Corporation, serves a small p 4800 residential customers in June 1992.

In the Pacific Northwest, hydropower, and to a lesser extent, coal and nuclear region's electrical generation system. Total generating capacity is about 40,270 m percent of the region's installed generating capacity is hydroelectric, which suppl of the electricity used by the region. Coal-fired generating capacity is 6,702 meg of the region's electrical generating capacity. Two commercial nuclear power plant Northwest, with a 2247-megawatt capacity of 6 percent of the region's generating ca account for about 3 percent of capacity.

The region's electrical power system, more than any other system in the nation On average, the region's hydropower system can produce 16,400 megawatts. Variable storage capabilities alter the system's output from 12,300 average megawatts under 20,000 average megawatts in record high water years. The Pacific Northwest system' power means that it is more constrained by the seasonal variations in peak demand t demand.

Throughout the 1980s, the Northwest had more electric power than it required a surplus. This surplus has been exhausted, however, and there is only approximately existing system to meet the current electricity needs. Hydropower improvement proj construction in the Northwest include about 150 megawatts of new capacity. The cos other resources are currently being studied (Northwest Power Planning Council 1986) current consumption of electricity, coal, propane, natural gas, and other utilities in Table 4.13-1.

4.13.3 Waste Water Disposal

The major incorporated areas of Benton and Franklin counties are served by mun systems, whereas the unincorporated areas are served by onsite septic systems. Ric system is designed to treat a total capacity of 27 million cubic meters per year (a 8.9 million gallons per day with a peak flow of 44 million gallons per day). In 1 average of 4.83 million gallons per day. The Kennewick system similarly has signif treatment capability of 12 million cubic meters per year (8.7 million gallons per d gallons per day. Pasco's waste-treatment system processes an average of 2.22 milli system could treat 4.25 million gallons per day or 16.2 liters per day.

4.14 Materials and Waste Management

This section discusses the management of materials and waste and presents both current status of the various waste types being generated and stored at the Hanford governing the management of these materials and wastes are discussed in Section 2.2

Table 4.13-1. Approximate consumption of utilities and energy on the Hanford Site

Energy	Consumption	
Electricity	340,000 megawatt-hours	
Coal	45,000 metric tons	(50,000 tons)
Fuel Oil	83,000 cubic meters	(22,000,000 gallons)
Natural Gas	680,000 cubic meters	(24,000,00 cubic feet)
LPG-propane	110 cubic meters	(29,000 gallons)
Gasoline	3,600 cubic meters	(950,000 gallons)
Diesel	1,700 cubic meters	(450,000 gallons)
Other Utilities		
Water	15,000,000 cubic meters	(4,000+ million gallons)
Power Demand	57 megawatts	

In order for Hanford programs to meet operational and mission requirements, ma or have been used onsite. Hazardous materials are not waste, but when no longer us of the potential for impacts to human health and the environment, hazardous materia Subsection 4.14.7.

Wastes at the Hanford Site are generated by both facility operations and envir activities. Facility operations include nuclear and non-nuclear research, material analysis, high-level waste stabilization, and nuclear fuel storage, manufacturing, general office work. They also include operation of all waste management facilitie disposal of Hanford wastes, as well as any waste shipped to Hanford for storage or restoration operations include remediation (identifying and arranging for the clean and decontamination and decommissioning of surplus facilities.

Wastes and materials handled at the Hanford Site are described in subsections wastes and materials have been classified as high-level waste (discussed in detail transuranic waste (discussed in detail in subsection 4.14.2), mixed low-level waste subsection 4.14.3), low-level waste (discussed in detail in subsection 4.14.4), haz detail in subsection 4.14.5), industrial solid waste (discussed in detail in subsec materials (discussed in detail in subsection 4.14.7). Table 4.14-1 shows expected year 2000, including the expected disposition.

The total amount of waste generated and disposed of at the Hanford Site has be through the efforts of the pollution prevention and waste minimization programs at Minimization (and Pollution Prevention) Program is an ambitious program aimed at so substitution, recycling, surplus chemical exchange, and waste treatment. The progr Executive Order 12780, DOE orders, RCRA, and EPA guidelines. All wastes on the Han radioactive, mixed, hazardous and non-hazardous regulated wastes are included in th Program.

Table 4.14-1. Baseline waste quantities as of the year 2000 at Hanforda.

Waste identification	Annual disposal volume from stabilization operations wastes (m3/yr)	Annual disposal volume from stabilization of stored wastes (m3/yr)	Total annual disposal volume from all waste stabilization (m3/yr)
High-level waste solidb	0	240	240c
Transuranic waste solide	0	170	170c
Low-level waste solidg	13,000	7,000	20,000
Mixed waste solidg	300	0	300
Hazardous waste liquid and solid	100	0	100
Other waste			
nonhazardous			
liquid	2,000,000	10,000,000	12,000,000
solid	38,000	0	38,000
sewage			
liquidh	210,000	0	210,000
solidi	4	0	4

a. Baseline values are projected from 1988 data.
b. Liquid high-level waste (HLW) is held in interim storage and then processed to
c. The baseline value is taken from 1988 data for planned future activities.
d. These wastes are targeted for disposal at a federal repository.
e. Liquids containing transuranics are processed as HLW.
f. These wastes are targeted for disposal at WIPP.
g. Solidified or absorbed-liquid-waste quantities are included in the solid waste
h. Liquid effluents from sewage treatment operations.
i. Solids from sewage treatment operations.

Reductions in the volumes of radioactive wastes generated have been achieved t intensive surveying, waste segregation, recycling, and use of administration and en examples of waste reduction follow:

- Waste minimization efforts have reduced the volume of waste water dischar the 300 Area by more than 5,600 cubic meters (>1.5 million gallons) per day. By the end of 1992, waste reduction efforts had reduced liquid waste by more than 22,000 cubi gallons) (Woodruff and Hanf 1993).

- In 1991, 440,645 kilograms (971,440 pounds) of ferrous metals, 49,323 kil of nonferrous metals, 275 cubic meters (9,076 cubic feet) of wood scrap, (299,993 pounds) of scrap paper were recycled. During 1992, approximatel

(400,000 pounds) of paper were recycled (Woodruff and Hanf 1993).

On-going projects include packaging reduction, waste minimization design, and
Databases are used at the Hanford Site to track and manage waste management in
have been screened to ensure that the information supplied is supported by official
public documents. Although the most reliable data available have been used to quan
volumes, past waste volumes are imprecise and may be subject to change as character
waste is undertaken and completed.

4.14.1 High-Level Waste

High-level radioactive waste is defined in the Nuclear Waste Policy Act of 198
highly radioactive material resulting from the reprocessing of SNF, including liqui
reprocessing and any solid material derived from such liquid waste that contains fi
concentrations; and (B) other highly radioactive material that the [Nuclear Regulat
with existing law, determines by rule requires permanent isolation."

High-level waste at Hanford was generated from the reprocessing of production
recovery of plutonium, uranium, and neptunium for defense and other national progra
irradiated targets. Radioactive waste generated on the Hanford Site from 1988 thro
2.

4.14.1.1 Historic Overview. Until recently, the primary mission of the Hanford Site was production of

special nuclear material for defense purposes. Since 1943, the Hanford Site has be
reactor fuel elements, operation of production reactors,

Table 4.14-2. Radioactive waste generated on the Hanford Site from 1988-1990 in ki
waste).

Calendar Year	Low-Level Waste	Transuranic Waste	High-Le
1988	3,800,000	21,900	0
1989	8,300,000	27,200	0
1990	3,600,000	24,500	0

Source: DOE 1991.

processing of irradiated fuel, separation and extraction of plutonium and uranium,
metal, and decontamination and decommissioning activities. Between 1943 and 1964,
built to store liquid radioactive wastes. No new wastes have been added to these t
liquid waste originally stored in the single-shell tanks has been transferred to so
double-shell tanks for safer storage (DOE 1993c).

High-level waste has been accumulating at Hanford since 1944. Most of these h
undergone one or more treatment steps (e.g., neutralization, precipitation, decanta
eventually require incorporation into a stable, solid medium (e.g., glass) for fina

Between 1956 and 1990, the Plutonium and Uranium Recovery through EXtraction (
irradiated reactor fuel to extract plutonium and uranium (DOE 1982). The wastes fr
in double-shell tanks after 1970, and are the second high-level waste stream (DOE 1

Cesium and Strontium Capsules: From 1968 to 1985, most of the high-heat emit
and cesium-137, plus their daughters) were extracted from the old tank waste, conve
fluoride and cesium chloride), placed in double-walled metal cylinders (capsules) a
inches) in length and 5 centimeters (2 inches) in diameter, which were stored in th
Storage Facility in water-filled pools (DOE 1993d).

4.14.1.2 Current Status. There are two high-level waste streams at Hanford: the single-shell tank

wastes and double-shell tank PUREX aging wastes. All wastes contained in double-sh
of high-level wastes, transuranic waste, and several low-level wastes, and are mana
level waste. The single-shell tank wastes make up 95 percent of the Hanford Site h
1993c).

There are currently 164,000 cubic meters (214,500 cubic yards) of wastes in th
are managed as high-level waste. The waste is multi-phased: most is sludge with in
the form of crystalline solids, and there are some supernatant liquids present in t
92,000 cubic meters (120,000 cubic yards) of PUREX wastes in the double-shell tanks

No known treatment is currently possible for these two waste streams, although
level wastes in the Hanford Waste Vitrification Plant, for which construction is sc
an operational start date in 2009 (DOE 1993c).

No high-level wastes are expected to be generated in 1995 from SNF management

Cesium and Strontium Capsules: The total number of cesium capsules produced i
1993, the number of known dismantled cesium capsules is 249; these have been put to
expected to be returned. The total number of remaining capsules requiring disposal
remaining capsules, 959 are in storage at Hanford, and 369 capsules have been lease
these capsules developed a small leak, and others have shown signs of bulging, so c
leased capsules back to the Hanford Site (DOE 1993d).

The total number of strontium capsules produced is 640. As of August 19, 1993
dismantled strontium capsules is 35; these have been put to beneficial use and are
total number of remaining capsules requiring disposal is 605. Of the 605, 601 are
been leased offsite for beneficial use.

Therefore, at present 1,328 cesium capsules (2.47 cubic meters - 3.23 cubic ya
capsules (1.08 cubic meters - 1.41 cubic yards) require storage. Nine-hundred and
605 strontium capsules are stored in pools of water in the Waste Encapsulation and
will be stored at Hanford until they can be transported to a proposed national repo

4.14.2 Transuranic Waste

Transuranic waste is defined in the Atomic Energy Act of 1954 (42 U.S.C. 2014[
contaminated with elements that have an atomic number greater than 92, including ne
and curium, and that are in concentrations greater than 10 nanocuries per gram, or
the Nuclear Regulatory Commission may prescribe to protect the public health and sa

Transuranic waste is primarily generated by research and development activitie
weapons manufacturing, environmental restoration, and decontamination and decommiss
waste exists in solid form (e.g., protective clothing, paper trash, rags, glass, mi
equipment). Some transuranic waste is in
liquid form (sludges) resulting from chemical processing for recovery of plutonium

4.14.2.1 Historic Overview. Prior to 1970 all DOE-generated transuranic waste was disposed of onsite

in shallow, unlined trenches. From 1970 to 1986, transuranic wastes were segregate
disposed in trenches designated for retrieval. Since 1986 all transuranic waste ha
retrievable storage pending shipment and final disposal in a permanent geologic rep

4.14.2.2 Current Status. Currently, all transuranic wastes are stored in above-grade storage

facilities in the Hanford Central Waste Complex and Transuranic Waste Storage and A
ship the stored transuranic waste to the Waste Isolation Pilot Plant near Carlsbad,
The inventory of transuranic wastes is given in Table 4.14-3.

4.14.3 Mixed Low-Level Waste

Mixed low-level waste is defined as mixtures of low-level radioactive material
physically) hazardous wastes. Typically, mixed low-level waste includes a

Table 4.14-3. Transuranic waste inventory through 1991a.

Disposition of TRU Waste	Mass of TRU Nuclides (kilograms)	Volume

		(cubic meters)
Buried Waste	346	109,000b
Retrievable Storage	480	10,200

a. Source: DOE 1992d, Figures 3.3-3.6.
b. This number includes soils contaminated with TRUs.

variety of contaminated materials, including air filters, cleaning materials, engin
residues, photographic materials, soils, building materials, and decommissioned pla

4.14.3.1 Historic Overview. Between 1987 and 1991, 16,745 cubic meters (21,902 cubic yards) of mixed

low-level waste were buried at the Hanford Site (between 1944 and 1986, no differen
level and low-level mixed wastes); all buried low-level wastes from that period are
subsection 4.14.4). Another 4,225 cubic meters (5,526 cubic yards) of mixed waste
storage in the Central Waste Complex, located in the 200-West Area (DOE 1993d).

The Hanford Site also receives defueled submarine reactor compartments, which
and lead. These compartments are managed as mixed waste. Several compartments are
in a trench in the 200-East Area (DOE 1993b).

4.14.3.2 Current Status. In 1992, 56,245 kilograms (124,000 pounds) of mixed low-level waste were

generated. The 78 mixed low-level waste streams at Hanford make up 85,000 cubic me
waste (101,314,863 kilograms - 223,361,010 pounds). Ninety-six percent of the tota
in the form of mostly aqueous liquid in the double-shell tanks. One stream (double
waste) accounts for 40,000 cubic meters (52,318 cubic yards) of the mixed low-level
the double-shell tank Double-Shell Slurry Feed, double-shell tank Complex Concentra
Double-Shell Slurry make up another 34,500 cubic meters (45,124 cubic yards). Thre
related to the 183-H Solar Evaporation Basin cleaning made up 2,500 cubic meters (3
These inorganic sludge/particulate wastes have been neutralized and treated for pac

It is expected that of all the mixed low-level wastes at Hanford, 49 percent c
technology is modified or verified. The remaining 51 percent is to be processed through the 242A-Evaporator (a
closed system in which distillates are passed through an ion-exchange system to rem

In 1992, eight defueled submarine reactor compartment disposal packages were r
94 of the 200-East Area Low-Level Waste Burial Grounds (Woodruff and Hanf 1993). T
Program will prepare an EIS for their proposal to bury additional reactor compartme
1993, there were a total of 35 submarine reactor compartments stored in Trench 94.

Mixed low-level wastes generated in 1995 from SNF management activities will t
cubic yards).

4.14.4 Low-Level Waste

Low-level radioactive waste is defined in the Nuclear Waste Policy Act of 1982
material that (A) is not high-level radioactive waste, spent nuclear fuel, transura
material...; and (B) the [Nuclear Regulatory Commission], consistent with existing
radioactive waste." By-product material is defined in the Atomic Energy Act of 195
any radioactive material (except special nuclear material) yielded in or made radio
radiation incident to the process of producing or utilizing special nuclear materia
wastes produced by the extraction or concentration of uranium or thorium from any o
source material content."

Commercial fuel low-level waste can be generated by fuel fabrication and react
waste also results from commercial operations by private organizations that are lic
materials. These include institutions engaged in research and various medical and
low-level waste is also generated by DOE environmental restoration activities. Oth
generated in future years by routine decommissioning and decontamination operations

4.14.4.1 Historic Overview. From 1944 to 1991, approximately 558,916 cubic meters (731,034 cubic

yards) of low-level waste was buried at Hanford (DOE 1993d). Between 1944 and 1986
between low-level and low-level mixed wastes - all data from that period are report
cubic meters (170 cubic yards) was placed into storage.

U.S. Ecology operates a licensed commercial low-level waste burial ground at H
leased to the State of Washington. Although physically located on the Hanford Site
the Hanford facility. The site area is 40 hectares (99 acres), of which 29.5 hect
usable, with 11.9 hectares (29.4 acres) used by the end of 1991. Through 1991 338,
yards) of low-level wastes had been disposed of at this site (DOE 1992d).

4.14.4.2 Current Status. Solid low-level waste currently is placed in unlined, near-surface trenches

at the 200-Area Low-Level Waste Burial Grounds. Onsite sources at the Hanford Site
meters of low-level waste in 1992. Table 4.14-4 lists quantities of radioactive ma
Site from offsite generators over 5 years. The site continues to receive low-level
for disposal. Major sources of this waste have been the Puget Sound Naval Shipyard
haven
National Laboratory in New York, and Lawrence Berkeley Laboratory in California. Ot
DOE facilities at nuclear power stations in Shippingport, Pennsylvania; Bechtel in
in Charleston, Rhode Island (DOE 1993d). The U.S. Ecology commercial low-level bur
operate.

Table 4.14-4. Offsite low-level waste receipts summary (from 1987 through 1991).

Year	Volume (m3)	Activity (curies)
1987	7,000	68,000
1988	5,000	107,000
1989	600	1,500
1990	5,500	240,000
1991	5,300	489,000

a. Source: Draft Environmental Restoration and Waste Management Fiscal Year 1993
Richland Field Office (DOE 1993d). (Does not include waste quantities received at
burial ground.)

In 1995, 174.5 cubic meters (228.3 cubic yards) of low-level wastes will be ge
activities. Of this amount, 167.2 cubic meters (218.7 cubic yards) are contact han
cubic yards) are remote handled.

4.14.5 Hazardous Waste

Hazardous waste is defined in the State of Washington Dangerous Waste Regulati
waste designated by 40 CFR Part 261 and regulated as hazardous wastes by the EPA.
designates wastes as either "dangerous waste" or "extremely hazardous waste." Haza
during normal facility operations and environmental restoration activities at the H

Mixed wastes are wastes that contain both hazardous waste (regulated under the
Recovery Act) and radioactive waste (regulated under the Atomic Energy Act). The f
material production and site restoration activities have generated or may generate

- fabrication of reactor fuel elements
- operation of the production reactors
- processing of irradiated fuel
- separation and extraction of plutonium and uranium
- preparation of plutonium metal
- environmental restoration (i.e., soil and groundwater cleanup)
- research and development support projects
- maintenance and operations support.

Table 4.14-5. Hazardous waste generated on the Hanford Site from 1988 through 1992

Calendar year	Hazardous waste (t)	Mixed waste (t)	Total (t)
1988	80,000	25,000	105,000
1989	66,000	9400	75,000
1990	780	12,000	13,000
1991	330	4600	4900
1992	620	3400	4000

Tank wastes constitute 99 percent of the mixed wastes at the Hanford Site. Th
233,689 cubic meters (305,654 cubic yards) of mixed wastes stored in these tanks:
cubic yards) of high-level waste, 3,935 cubic meters (5,147 cubic yards) of mixed t
cubic meters (110,917 cubic yards) of mixed low-level waste. These wastes consist
(2 high-level waste, 22 mixed transuranic waste, and 84 mixed low-level waste). Of
streams, 97 are still being generated. Additional environmental restoration waste
numbers and types remain to be determined (DOE 1993c).

The Resource Conservation and Recovery Act components of mixed waste at the Ha
following listed wastes: D002B (alkaline liquids, 22 streams), D006B (cadmium, 29 s
streams), D008B (lead, 30 streams), and F003 (nonchlorinated solvents, 30 streams).
the separations and extraction processes that were used to produce special nuclear

4.14.5.1 Historic Overview. In the past, hazardous waste generated at Hanford was either shipped offsite, recycled, or treated onsite. Hazardous waste was also disposed of onsite
burial grounds, or discharged to cribs or directly to the soil). For example, from
pipe-cleaning operation were discharged to the soil through two side-by-side cribs
Bluffs townsite. From 1955 through 1973, approximately 379-2,271 cubic meters (100
organic liquids, including carbon tetrachloride, were discharged to the soil in the
containing approximately 19 cubic meters (5,000 gallons) of organic solvent (primar
618-9 burial ground north of the 300 Area. Many of these disposal sites have been
remediated under CERCLA (DOE 1993d).

4.14.5.2 Current Status. As of March 15, 1993, the Hanford Site contained 64 interim status treatment, storage, or disposal units. Present plans are that final RCRA permits will be soug
status treatment, storage, or disposal units. Thirty-four units will be closed und
will be dispositioned through other regulatory options. Future circumstances may c
The treatment, storage, or disposal units within the Hanford facility include, but
systems, surface impoundments, container storage areas, waste piles, landfills, and
RCRA permits, such as research, development, and demonstration permits (for example
Treatment Facility), are also being pursued (DOE 1993d).

The principal present waste management practice for newly generated nonradioac
ship it offsite for treatment, recycling, recovery, and/or disposal. The Nonradioa
Facility (616 Building) and the 305-B Waste Storage Facility are the only active fa
hazardous waste (other than less than 90-day storage areas) (DOE 1992d, 1993d), oth
containing mixed and one containing nonradioactive waste) stored in the 222-S labor

Hazardous wastes generated in 1995 from SNF management activities will total 2
yards).

4.14.6 Industrial Solid Waste

Solid wastes are generated in all areas of the Hanford Site. Nondangerous sol
following nonradioactive, nonhazardous wastes:

(a) construction debris, office trash, cafeteria waste/garbage, empty contain materials, medical waste, inert materials, bulky items such as appliances solidified filter backwash and sludge from the treatment of river water, equipment and tools, air filters, uncontaminated used gloves and other cl chemical precipitates such as oxalates

(b) nonradioactive friable asbestos (regulated under the Clean Air Act)

(c) ash generated from powerhouses

(d) nonradioactive demolition debris from decommission projects.

4.14.6.1 Historic Overview. Both prior to and after establishment of the reservation, a number of

landfills have been used on the Hanford Site for solid waste disposal, including th Original Central, White Bluffs, East White Bluffs, Wahluke Slope and Hanford Townsi
The active Hanford Site Solid Waste Landfill, located in the 200-Area, began o Nondangerous wastes in category (a) above are buried in the solid waste section of located in the 200-Area. Nonradioactive friable asbestos is buried in designated a Landfill. The nonradioactive dangerous waste section of the landfill was closed to closed to asbestos in May 1988. Ash generated at powerhouses in the 200-East and 2 designated sites near those powerhouses. Demolition waste from 100-Area decommissi situ or in designated sites in the 100 Areas (Woodruff and Hanf 1993; WHC 1993b). the City of Richland landfill.

4.14.6.2 Current Status. In 1992, 22,213 cubic meters (29,054 cubic yards) of solid waste and 1,017

cubic meters (1,330 cubic yards) of asbestos were deposited in the solid waste sect Pit 10 was opened for disposal of inert material as defined in Washington Administr total of 11,389 cubic meters (14,986 cubic yards) were disposed of there. A summar at the Hanford Site from 1973 through 1992 is shown in Table 4.14-6. The landfill closure in 1997 (WHC 1993b). Quantities of solid waste disposed of at the City of available.

4.14.7 Hazardous Materials

A hazardous chemical is any chemical that poses a physical or health hazard [a 1900.1200(c)]. The Emergency Planning and Community Right-to-Know Act sets forth r and Tier 2) that provide the public with information on hazardous chemicals to enha chemical hazards and facilitate the development of state and local emergency respon

Table 4.14-6. 1973-1992: Historical annual volume of onsite buried solid sanitary

Waste Type	Volume (m3/year)							
	73-81	82	83	84	85	86	87	88
Construction Debrisa	4,149	5,819	9,494	10,378	10,789	14,254	14,316	12,
Metalsb	1,383	1,940	3,165	3,459	3,596	4,751	4,772	4,2
Paper	5,658	7,936	12,946	14,151	14,712	19,437	19,522	17,
Miscellaneousc	1,383	1,940	3,165	3,459	3,569	4,751	4,772	4,2
Total	12,573	17,635	28,770	31,447	32,694	43,193	43,382	38,

a. Construction Debris: Volume is calculated based on disposal volume (excluding debris 33 percent; Metals 11 percent, Paper 45 percent, Miscellaneous Waste 11
b. Metals: See note b above. Category consists of large bulky items such as appl
c. Miscellaneous: Category includes garbage, packaging, empty containers, medical

4.14.7.1 Historic Overview. Hazardous chemicals are used throughout the Hanford Site in facility and

environmental restoration operations. The types of chemicals in inventory onsite t
Hanford's mission involves mainly remediation and decontamination and decommissioning (as opposed to production
or processing). The amount of chemicals actually onsite changes from day to day, a
keep a real- time inventory of the quantity of chemicals onsite at any one time. A
chemicals used onsite that eventually become hazardous waste cannot be determined.

4.14.7.2 Current Status. The Hazardous Materials Inventory Database currently being used to generate

Tier 2 data indicates that approximately 1484 hazardous chemicals are reported in i
on the Hanford Site. These 1484 chemicals are contained in approximately 2926 diff
weights that range from less than 0.5 kilograms (one pound) to a maximum inventory
(78,614,420 pounds).

The DOE has prepared chemical inventory reports required by the Emergency Plan
Know Act since 1988 (for calendar year 1987). In 1992 the Emergency Planning and C
reporting threshold was exceeded for 53 hazardous chemicals.

5. ENVIRONMENTAL CONSEQUENCES

Descriptions of analyses for various potential environmental consequences as a result of implementing 1) No Action, 2) Decentralization, 3) 1992/1993 Planning Basis, 4) Regionalization, and 5) Centralization Alternatives for interim storage of SNF for the Hanford Site are presented in the following subsections. By and large these discussions are at the programmatic level because in many cases specific alternative treatments and locations, particularly for new facilities, have not been identified for the Hanford Site.

5.1 Overview

An overview of the various alternatives and a brief summary of potential environmental consequences of interest are provided in the following subsections. For purposes of this programmatic analysis, all new facilities were assumed to be constructed in a quarter section of land adjacent to the 200-East Area; commitment of that amount of land within the industrialized 200 Areas would be consistent with the site mission and would not represent a conflict on land use. Up to 15 percent of that area would be disturbed during construction of storage and support facilities where required. A survey of the area described revealed no threatened and endangered species or cultural resources. Routine operations under any of the alternatives would not add significantly to current occupational or near-zero public exposure to radiation. Although not quantified, no significant additions to current releases of criteria pollutants or other hazardous materials would be expected from implementing any of the alternatives. However, such implementation requires a small increase in Hanford's electrical power consumption; the largest increase would be less than 1.5 percent. The influx of workers would probably increase competition for desirable housing and strain teacher/student ratios in some local school districts, the extent of which (although small in any case) would depend on the option chosen.

5.1.1 No Action Alternative

The No Action Alternative identifies the minimum actions deemed necessary for continued safe and secure storage of SNF at the Hanford Site. Upgrade of the existing facilities would not occur other than as required to ensure safety and security. No receipt of fuels from offsite would occur. No research and development would take place; however, characterization of fuel would continue to establish a safety envelope for extended interim storage, fuel would be containerized at the 105-KE Basin, and the first 10 dry storage casks would be procured for FFTF fuel.

Results presented in the Hanford Site Environmental Report for 1992 (Woodruff and Hanf 1993) suggest that under normal conditions no significant environmental effects would be associated with the No Action Alternative. For example, the radiation dose to the maximally exposed individual in the Hanford environs from all Hanford sources was calculated to have been 0.02 mrem and the collective population dose was 0.8 person-rem during 1992. Continued storage of SNF contributed only a small portion of those doses. No health effects would be expected as a result of such small doses. For perspective, the Hanford Site doses for 1992 may be compared to annual individual doses of 300 mrem and an annual collective dose of about 100,000 person-rem from natural background radiation.

5.1.2 Decentralization Alternative

The Decentralization Alternative would consider additional facility upgrades over those considered in the No Action Alternative, specifically, new wet storage (for defense production fuel only) or dry storage facilities, fuel stabilization via shear/leach/calcination or shear/leach/ solvent extraction, with research and development activities to support SNF management.

Impacts from storage prior to implementation of new wet or dry storage or fuels stabilization would not differ from those indicated for the No Action Alternative. In the event new storage facilities are selected some impacts would be associated with construction of those facilities. A proposed site has been identified comprising one-quarter section of land adjacent to the 200-East Area where any new facilities associated with SNF storage or stabilization that might be necessary would be assumed to be built. The area has been surveyed both for threatened and endangered species and for the presence of cultural resources; none were found. However, one federal candidate species, the loggerhead shrike, and one state candidate species, the sage sparrow, were seen. Use of this area is consistent with the Hanford mission and would impact no threatened or endangered biota. Construction would take place on up to 15 percent of the selected site. Construction activities would result in dust generation and various amounts of pollutants released from diesel-fueled equipment; however, concentrations at points of public access are expected to be well below permissible levels. Impacts associated with SNF storage would be expected to be less than those in the No Action Alternative.

Research and development of technologies for SNF stabilization would be undertaken in existing hot cell facilities in the 300 Area. Although not examined in detail for this programmatic analysis, no important environmental consequences have resulted from work in these facilities and none would be anticipated for development activities related to fuel processing.

5.1.3 1992/1993 Planning Basis Alternative

The 1992/1993 Planning Basis Alternative differs from the Decentralization Alternative only in that TRIGA fuel currently stored at the Hanford Site would be shipped to INEL for storage. The storage and stabilization options identified for the Decentralization Alternative are also assumed for the 1992/93 Planning Basis Alternative and that discussion is not repeated here. The potential impacts of transportation of TRIGA fuel to INEL are covered in Appendix I.

5.1.4 Regionalization Alternative

The Regionalization Alternative as it applies to the Hanford Site contains the following options:

A) All SNF, except defense production SNF, would be sent to INEL.

B1) All SNF west of the Mississippi River, except Naval SNF would be sent to Hanford.

B2) All SNF west of the Mississippi River and Naval SNF would be sent to Hanford.

C) All Hanford SNF would be sent to INEL or Nevada Test Site (NTS).

Facilities and features of Regionalization A would be the same as those described for Hanford defense production fuel in the Decentralization Alternative. The facilities and features for all other Hanford SNF would be very similar to those described for that spent nuclear fuel in the Centralization Minimum Alternative.

Facilities and features of Regionalization B1 and B2 options would be incremental to those described for the Decentralization Alternative and would be similar, but not identical, to those described in the Centralization Maximum Alternative.

Facilities and features of Regionalization C would be equivalent to those described for the Centralization Minimum Alternative.

5.1.5 Centralization Alternative

Two options exist at the Hanford Site for the Centralization Alternative: 1) shipment of all fuel within the DOE complex to the Hanford Site for management and storage, and 2) shipment of all fuel off of the Hanford Site. In the former option, dry storage of all fuel sent to the Hanford Site from offsite would be assumed. A facility equivalent to the decentralization sub-options would be assumed for processing of SNF prior to storage; fuel received from offsite would have been stabilized for dry storage prior to receipt. The consequences of implementing this option would be larger than those of the Decentralization Alternative. In the option of transferring all Hanford fuel to another site, a fuel stabilization and packaging facility would need to be constructed to prepare existing fuel for shipment.

5.2 Land Use

Implications of implementing the alternatives for interim storage of SNF on land use at the Hanford Site are discussed in the following subsections.

5.2.1 No Action Alternative

No new SNF facilities would be built at the Hanford Site; thus, land use patterns would remain as described in Section 4.2 and have no impact on the existing environment. The Hanford Site would remain a federal facility dedicated to nuclear research and development and environmental cleanup. Other continuing activities would include waste management, commercial power production, ecological research, and wildlife management, as described i Section 4.2.

5.2.2 Decentralization Alternative

This alternative would require the construction of an SNF facility for fuel management and storage. Most SNF from the Hanford Site would be stored at that facility.

Historically, the Hanford Site has been used for nuclear materials production. The construction and operation of an SNF facility would be consistent with this historical use. Off-site land use would not be affected by construction and operations of an SNF facility, except to the extent that some undeveloped lands probably would be developed for worker housing. Such development would be subject to local land use and zoning controls, which vary by jurisdiction. No project facilities would be located offsite.

No direct or indirect effects would occur to wildlife refuges on the Hanford Site because SNF activities would not be close to these areas. Similarly, no direct or indirect effects would occur to the Columbia River. Although construction at the SNF site would disturb native vegetation (Section 5.9.1), on up to 7 hectares (18 acres) of the 65-hectare (160-acre) site, this would involve only a small part of similar natural habitat at Hanford. The use of Hanford as a National Environmental Research Park would not be significantly affected.

No impacts requiring mitigation would occur to land uses a result of construction or operation of an SNF facility at the Hanford Site.

5.2.3 1992/1993 Planning Basis Alternative

The 1992/1993 Planning Basis Alternative differs from the Decentralization Alternative only in that TRIGA fuel currently stored at the Hanford Site may be shipped to INEL for storage. Thus, land use would be essentially the same as in the Decentralization Alternative. Although construction at the SNF site would disturb native vegetation (Section 5.9.1), on up to 7 hectares (18 acres) of the 65-hectare (160-acre) site, this involve only a small part of similar natural habitat at Hanford. The use of Hanford as a National Environmental Research Park would not be significantly affected.

5.2.4 Regionalization Alternative

Construction of facilities in support of the Regionalization Alternative as it applies to the Hanford Site would result in the following disturbance of native vegetation and land use commitments:

A) From about 2 to 7 hectares (6 to 18 acres) when all SNF, except defense production SNF would be sent to INEL.

B1) From about 14 to 17 hectares (36 to 43 acres) when all SNF west of the Mississippi River, except Naval SNF would be sent to Hanford.

B2) From about 24 to 27 hectares (61 to 68 acres) when all SNF west of the Mississippi River and Naval SNF would be sent to Hanford.

C) From about 2 to 5 hectares (6 to 12 acres) when all Hanford SNF would be sent to INEL or NTS.

These areas involve only a small part of similar natural habitat at Hanford. The use of Hanford as a National Environmental Research Park would not be significantly affected.

5.2.5 Centralization Alternative

If Hanford is selected as the site for implementing the Centralization Alternative, the SNF facility and its support facilities (including a new Expended Core Facility) would be constructed. The impacts of such construction would be essentially the same as those presented for the Decentralization Alternative. Although construction at the SNF site would disturb native vegetation (Section 5.9.1) on up to 37 hectares (93 acres) of the 65-hectare (160-acre) site, this would involve only a small part of similar natural habitat at Hanford. In addition to the above total, new construction would also include construction of a new Expended Core Facility for fuel from the Naval Nuclear Propulsion Program. The use of Hanford as a National Environmental Research Park would not be significantly affected.

If Hanford is not selected as the site for centralization of SNF, an SNF stabilization and packaging facility would be built to prepare the fuel for transport offsite. This facility would have somewhat smaller construction requirements than would be required for storage of all DOE SNF at Hanford. The land use impacts would be similar to those described for the Regionalization option C.

5.2.6 Effects of Alternatives on Treaty or Other Reserved Rights of Indian

Tribes and Individuals

The Yakama Indian Nation and the Confederated Tribes of the Umatilla Indian Reservation acquired certain rights and privileges in the 1855 treaty. These rights and privileges are also claimed by the Wanapum Tribe. In Article III, of the 1855 treaty it states that "The exclusive right of taking fish in all streams, where running through or bordering said reservation, is further secured to said confederated tribes and bands of Indians, as also the right of taking fish at all usual and accustomed places, in common with citizens of the Territory, and of erecting temporary buildings for curing them; together with the privilege of hunting, gathering roots and berries, and pasturing their horses and cattle upon open unclaimed land.(a)"

Although access to the Hanford Site has been restricted, tribal members have expressed an interest in renewing their use of these resources in accordance with the Treaty of 1855, and the DOE is assisting them in this effort. In keeping with this effort, each of the alternatives would provide for the rights and privileges identified in the treaty:

- Taking Fish - The alternatives considered in this document would not reduce access to fishing locations on the Hanford Site.

- Hunting, Gathering Roots and Berries, and Pasturing Livestock - The No Action Alternative would not further reduce the areas potentially available for hunting, gathering roots and berries, or pasturing livestock. All existing fenced areas assigned for SNF storage and a suitable buffer zone would likely remain unavailable for these activities. All other alternatives would require the construction of new facilities. This would further reduce the land base available for hunting, gathering, and pasturing. This impact could be on the order of 18 acres.

5.3 Socioeconomics

The following section describes the socioeconomic impacts of the SNF project at the Hanford Site. For the analysis, a ten-county region of influence was identified. While the region of influence covers the counties of Adams, Benton, Columbia, Franklin, Grant, Walla Walla, and Yakima in the state of Washington; and Morrow, Umatilla, and Wallowa counties in the state of Oregon, the majority of the impacts would be confined to the Benton-Franklin County region and the Tri-Cities (Richland, Kennewick, and Pasco) (see Figure 4-2).

The socioeconomic impacts are classified in terms of direct and secondary effects. Changes in Hanford employment and expenditures are classified as direct effects, while changes that result from Hanford regional purchases, nonpayroll expenditures, and payroll spending by Hanford employees are classified as secondary effects. The total socioeconomic impact within the region is the sum of the direct and secondary effects.

Estimates of total employment impacts were calculated using the Regional Input-Output Modeling System developed for the Hanford region of influence by the U.S. Bureau of Economic Analysis. This assessment reports the changes in employment and earnings based on historic data, which indicate that 93 percent of Hanford employees reside in the Benton-Franklin county area. Table 4.3-1 in Section 4.3 presents the baseline projections from which comparisons can be made.

All employment comparisons are made relative to the regional employment projections and not current Hanford Site employment projections. While a down-turn in Hanford Site employment is anticipated, the extent of the down-turn is unknown. The effect of such a down-turn on the region's employment projection used in this analysis is expected to be minimal because the regional projection, released in 1992, assumed a more stable rate of growth than the actual "boom" experienced in recent years.

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a. These treaty rights and priviledges are subject to diverse interpretations. None of the lands contemplated for use for SNF processing and/or storage at Hanford were on "open unclaimed land" when the government established the Hanford Site.

5.3.1 No Action Alternative

Under the No Action Alternative, only the minimum actions required for continued safe and secure storage of SNF would occur. No new facilities would be constructed, and only minimal facility upgrades would take place. It is assumed that existing personnel would be utilized under this alternative, and therefore no incremental socioeconomic consequences are anticipated. Socioeconomic conditions would continue as described in Section 4.3.

5.3.2 Decentralization Alternative

Under the Decentralization Alternative, significant facility development and upgrades are permitted, with various suboptions defined for processing and storage of the SNF. The socioeconomic consequences related to implementing the decentralization alternatives are described in this subsection. The employment and population impacts related to construction and operation of the Decentralization Alternative suboptions are presented in Table 5.3-1. It was assumed that up to 300 current Hanford workers could be reassigned to operation activities (this number excludes current workers at the Fast Flux Test Facility because it was assumed that they would be reassigned to activities related to the Hanford Waste Vitrification Plant). Construction activities were assumed to require new workers coming into the area. Estimates of direct jobs were provided by Bergsman (1995). For construction activity, direct jobs were reported as number of jobs in the peak year and total person-years because it was assumed that construction activities would "ramp-up" to the peak year, and then "ramp-down," with the total number of jobs related to construction activity equaling the total person-years required, as reported in Bergsman (1995). Increases in activity levels could strain an already tight housing market and add to school-capacity concerns. However, because construction activities are short-term relative to the total project time frame, impacts from construction activities may be overstated.

5.3.2.1 Employment. All construction activity is assumed to peak in 1998. Construction activity for storage options W, X, Y, and Z occurs in the years 1997-2000; construction activity for processing suboptions P and Q occurs in the years 1998-2001. Increases in employment range from 221 (suboption X) to 1,094 (suboptions Y and P) and equate to between 0.3 and 1.3 percentage points over baseline regional employment projections (see **Table 4.3-1)**. All operations activity peaks in 2002, with incremental activity tapering off. Increases in employment range from 442 (suboptions Z and P) to 880 (suboptions Q and Small Vault) persons and equate to between 0.5 and 1.0 percentage points over baseline regional employment projections. Beyond 2004, operations activity will taper off as processing activities (suboptions P and Q) will occur only through 2005. Suboptions Y and Z each require only 50 workers beyond 2005 for operations activity. Because it is anticipated that up to 300 current workers could be reassigned, no incremental socioeconomic impacts are anticipated after 2005. This is also true with suboptions W and X because they are assumed to absorb between 200 and 210 current workers for the first two years of operation (2001-2002), with employment requirements falling to between 150 and 95

Table 5.3-1. Comparison of the socioeconomic impacts of spent nuclear fuel Decentr suboptions.

Decentralization Alternative	1995	1996	1997	1998	1999	2000	2001
Suboption W							
Direct Jobs	0	0	216	251	216	181	0
Secondary Jobs	0	0	240	280	240	200	0
Population Change	0	0	590	680	590	490	0
Suboption X							
Direct Jobs	0	0	200	221	200	178	0
Secondary Jobs	0	0	220	240	220	200	0
Population Change	0	0	540	600	540	490	0

Suboptions Y and P							
Direct Jobs	0	0	318	1,094	1,033	971	715
Secondary Jobs	0	0	350	1,200	1,130	1,070	780
Population Change	0	0	870	2,980	2,810	2,650	1,950
Suboptions Q and Small Vault							
Direct Jobs	0	0	62	947	934	920	872
Secondary Jobs	0	0	70	1,040	1,020	1,010	960
Population Change	0	0	170	2,580	2,540	2,510	2,380
Suboptions Z and P							
Direct Jobs	0	0	213	935	926	920	715
Secondary Jobs	0	0	230	1,030	1,020	1,010	780
Population Change	0	0	580	2,550	2,530	2,510	1,950
Suboptions Q and Cask							
Direct Jobs	0	0	45	917	917	917	872
Secondary Jobs	0	0	50	1,010	1,010	1,010	960
Population Change	0	0	120	2,500	2,500	2,500	2,380

workers in 2003 and 2004. For the remaining years (2005-2035), suboptions W and X each would require only 60 workers for operation activities.

5.3.2.2 Population. For construction-related activities, the

population is expected to peak in 1998, with increases in population ranging from 600 (suboption X) to 2,810 (suboptions Y and P) and equating to between 0.4 and 1.7 percentage points over baseline projections (see Table 4.3-1). All operations activity peaks in 2002, with incremental activity tapering off through 2007. Increases in population range from 1,310 (suboptions Z and P) to 2,610 (suboptions Q and Small Vault) persons and equate to between 0.7 and 1.5 percentage points over baseline projections for 2002.

5.3.3 1992/1993 Planning Basis Alternative

This alternative defines those activities that were already scheduled at the various sites for the transportation, receipt, processing, and storage of SNF. Under this alternative, no new spent fuel would be sent to the Hanford Site, but the TRIGA fuel would be shipped offsite. The upgrades of existing storage facilities, as defined in the Decentralization alternative, were already planned, so the impacts of the 1992/1993 Planning Basis Alternative are essentially the same as outlined in Subsection 5.3.2. Because of the shipment of TRIGA fuel, an additional two workers per year would be required over 3 years of operation; however, it was assumed that current personnel would be reassigned to fill these jobs; therefore, the incremental impacts would be the same as those presented in Table 5.3-1.

5.3.4 Regionalization Alternative

Under this alternative, SNF would be redistributed to candidate sites based on similarity of SNF types or region within the country. There are four possible cases: regionalization of SNF by fuel type (Regionalization A); regionalization in which all SNF currently stored in the western United States, or to be generated in the western United States, except Naval SNF would be sent to and stored at the Hanford Site (Regionalization B1); regionalization in which all SNF currently stored in the western United States, or to be generated in the western United States, and all Naval fuel would be sent to and stored at the Hanford Site (Regionalization B2); and regionalization in which all SNF currently located in the western United

States, or to be generated in the western United States, including all Hanford SNF, would be sent to and stored at another location (Regionalization C).

5.3.4.1 Regionalization A. In this case, all SNF currently located at

Hanford, except defense production fuel, would be sent to INEL. For the Hanford Site, the facility requirements for the N reactor and single-pass reactor fuel would be the same as those described in the Decentralization Alternative. Facilities for all other Hanford Site fuel would be similar to those described within the Centralization minimum alternative. The population and employment impacts related to Regionalization A are presented in Table 5.3-2.

5.3.4.1.1 Employment.

All construction activity is assumed to peak in 1998. Construction activity for suboptions RAX, RAY, and RAZ occurs in the years 1997-2000 and construction activity for suboption P occurs in the years 1998-2001. Increases in employment range from 176 (suboption RAX) to 1,065 (suboption RAY and P) and equate to between 0.2 and 1.3 percentage points over baseline projections of regional employment (see Table 4.3-1). All operations activity peaks in 2002, with incremental activity tapering off. Increases in employment range from 208 (suboption RAY and P) to 230 (suboption RAZ and P) persons and equate to between 0.2 and 0.3 percentage points over baseline projections. Beyond 2004, operations activity will taper off as processing activities (suboption P) will only occur through 2005. Suboptions RAY and RAZ each require only 50 workers beyond 2005 for operations activity. Because it is anticipated that up to 300 current workers could be reassigned, no incremental socioeconomic impacts are anticipated after 2005. This is also true with suboption RAX because it would require only 59 workers for operation activities after 2005.

5.3.4.1.2 Population.

For construction-related activities, the population is expected to peak in 1998, with increases in population ranging from 480 (suboption RAX) to 2,900 (suboption RAY and P) and equating to between 0.3 and 1.7 percentage points over baseline projections (see Table 4.3-1). All operations activity peaks in 2002, with incremental activity tapering off through 2006. Increases in population range from 620 (suboption RAX) to 680 (suboption RAY and P) persons and equate to between 0.3 and 0.4 percentage points over baseline projections for 2002.

Table 5.3-2. Comparison of socioeconomic impacts of spent nuclear fuel Regionaliza

Regionalization A Suboptions	1995	1996	1997	1998	1999	2000	2001
Suboption RAX							
Direct Jobs	0	0	90	176	176	176	0
Secondary Jobs	0	0	100	190	190	190	0
Population Change	0	0	250	480	480	480	0
Suboption RAY and P							
Direct Jobs	0	0	150	1,065	1,065	1,065	715
Secondary Jobs	0	0	160	1,170	1,170	1,170	780
Population Change	0	0	410	2,900	2,900	2,900	1,950
Suboption RAZ and P							
Direct Jobs	0	0	150	865	865	865	715
Secondary Jobs	0	0	160	950	950	950	780
Population Change	0	0	410	2,360	2,360	2,360	1,950

5.3.4.2 Regionalization B1. In this case, all SNF currently stored or

to be generated in the western United States, except Naval SNF, would be sent to and stored at the Hanford Site. Facility requirements for this case would be incremental to those described for the Decentralization Alternative. Additional facilities include a storage facility for offsite fuel, a receiving and canning facility, and a technology development facility (RB1). The population and employment impacts related to regionalization B1 are presented in Table 5.3-3.

5.3.4.2.1 Employment.

All construction activity is assumed to peak in 2000. Construction activity for suboptions W, X, Y, and Z occurs in the years 1997-2000; construction activity for suboptions P and Q occurs in the years 1998-2001; and construction of the additional facilities (suboption RB1) for receiving and canning and technology development occurs in the years 1998-2001, with 90% of the storage facility being constructed during the years 2000-2010 and the remaining 10% being constructed during the years 2010-2035. Increases in employment range from 398 (suboption X and RB1) to 1,191 (suboption Y and P and RB1) and equate to between 0.5 and 1.4 percentage points over baseline projections of regional employment (see Table 4.3-1). All operations activity peaks in 2002, with incremental activity tapering off. Increases in employment range from 73 (suboption X and RB1) to 1,050 (suboption Q and Small Vault and RB1) persons and equate to between 0.1 and 1.2 percentage points over baseline projections. Beyond 2004, operations activity will taper off as described in Section 5.3.2.2.1.

5.3.4.2.2 Population.

For construction-related activities, the population is expected to peak in 2000, with increases in population ranging from 1,090 (suboptions W and RB1 and X and RB1) to 3,250 (suboption Y and P and RB1) and equating to between 0.6 and 1.9 percentage points over baseline projections (see Table 4.3-1). All operations activity peaks in 2002, with incremental activity tapering off through 2006. Increases in population range from 200 (suboptions X and RB1) to 3,100 (suboptions Q, Small Vault, and RB1) persons and equate to between 0.1 and 1.7 percentage points over baseline projections for 2002.

5.3.4.3 Regionalization B2. In this case, all fuel currently stored or

to be generated in the western United States, including Naval fuel, would be sent to and stored at the Hanford Site. Facility requirements for this case would be essentially the same as those described in the Regionalization B1 case, as the only difference would be the presence of Naval fuel. The receiving and canning facility, offsite storage facility, and technology development facility are referred to as suboption RB2. Also required for this case is the Naval Nuclear Propulsion

Table 5.3-3. Comparison of socioeconomic impacts of spent nuclear fuel Regionaliza

Regionalization B1 Suboption	1995	1996	1997	1998	1999	2000	2001	2002

Suboptions W and RB1								
Direct Jobs	0	0	216	381	352	401	215	75
Secondary Jobs	0	0	240	420	390	440	240	80
Population Change	0	0	590	1,040	960	1,090	590	210
Suboptions X and RB1								
Direct Jobs	0	0	200	351	336	398	215	73
Secondary Jobs	0	0	220	390	370	440	240	80
Population Change	0	0	540	960	910	1,090	590	200
Suboptions Y, P, and RB1								
Direct Jobs	0	0	318	1,224	1,169	1,191	930	637
Secondary Jobs	0	0	350	1,340	1,280	1,310	1,020	800
Population Change	0	0	870	3,340	3,180	3,250	2,530	1,87
Suboptions Z, P, and RB1								
Direct Jobs	0	0	213	1,065	1,064	1,140	930	615
Secondary Jobs	0	0	230	1,170	1,170	1,250	1,020	770
Population Change	0	0	580	2,900	2,900	3,110	2,530	1,80
Suboptions Q, Small Vault, and RB1								
Direct Jobs	0	0	62	1,077	1,070	1,140	1,090	1,05
Secondary Jobs	0	0	70	1,180	1,170	1,250	1,190	1,33
Population Change	0	0	170	2,940	2,920	3,110	2,960	3,10
Suboptions Q, Cask, and RB1								
Direct Jobs	0	0	45	1,047	1,053	1,137	1,087	995
Secondary Jobs	0	0	50	1,150	1,150	1,250	1,190	1,26
Population Change	0	0	120	2,850	2,870	3,100	2,960	2,93

Program's Expended Core Facility (ECF). Discussion on the relocation of the ECF to the Hanford Site is provided in Appendix D to the INEL Spent Nuclear Fuel PEIS and is not included here. Population and employment impacts of the Regionalization B2 case are presented in Table 5.3-4.

5.3.4.3.1 Employment.

All construction activity is assumed to peak in 2000. Construction activity for suboptions W, X, Y, and Z occurs in the years 1997-2000; construction activity for suboptions P and Q occurs in the years 1998-2001; and construction of the additional facilities (suboption RB1) for receiving and canning and technology development occurs in the years 1998-2001, with 35% of the storage facility being constructed during the years 2000-2010 and the remaining 65% being constructed during the years 2010-2035. Increases in employment range from 488 (suboptions X and RB2) to 1,281 (suboptions Y, P, and RB2) and equate to between 0.6 and 1.5 percentage points over baseline projections of regional employment (see Table 4.3-1). All operations activity peaks in 2002, with incremental activity tapering off. Increases in employment range from 80 (suboptions X and RB2) to 1,085 (suboptions Q, Small Vault, and RB2) persons and equate to between 0.1 and 1.3 percentage points over baseline projections. Beyond 2004, operations activity will taper off as described in section 5.3.2.2.1.

5.3.4.3.2 Population.

For construction-related activities, the population is expected to peak in 2000, with increases in population ranging from 1,330 (suboptions X and RB2) to 3,490 (suboptions Y, P and RB2) and equating to between 0.8 and 2.0 percentage points over baseline projections (see Table 4.3-1). All operations activity peaks in 2002, with incremental activity tapering off through 2006. Increases in population range from 220 (suboption X and RB2) to 3,190 (suboptions Q, Small Vault, RB2) persons and equate to between 0.1 and 1.8 percentage points over baseline projections for 2002.

5.3.4.4 Regionalization C. In this case, all fuel currently stored or to be generated in the western United States, including all Hanford Site fuel, would be sent to and stored at INEL or NTS. Facility requirements for the Hanford Site in this case are identical to those described in the Centralization Minimum Alternative. Employment and population impacts of this case are provided in Table 5.3-5 and are discussed in Section 5.3.5.2.

Table 5.3-4. Comparison of socioeconomic impacts of spent nuclear fuel Regionaliza

Regionalization Alternative	1995	1996	1997	1998	1999	2000	2001	2002
Suboptions W and RB2								
Direct Jobs	0	0	216	451	446	491	310	107
Secondary Jobs	0	0	240	490	490	540	340	120
Population Change	0	0	590	1,230	1,220	1,340	850	300
Suboptions X and RB2								
Direct Jobs	0	0	200	421	430	488	310	80
Secondary Jobs	0	0	220	460	470	540	340	90
Population Change	0	0	540	1,150	1,170	1,330	850	220
Suboptions Y, P, and RB2								
Direct Jobs	0	0	318	1,294	1,263	1,281	1,025	669
Secondary Jobs	0	0	350	1,420	1,380	1,400	1,120	840
Population Change	0	0	870	3,530	3,440	3,490	2,790	1,960
Suboptions Z, P, and RB2								
Direct Jobs	0	0	213	1,135	1,158	1,230	1,025	647
Secondary Jobs	0	0	230	1,240	1,270	1,350	1,120	810
Population Change	0	0	580	3,090	3,150	3,350	2,790	1,900
Suboptions Q, Small Vault and RB2								
Direct Jobs	0	0	62	1,147	1,164	1,230	1,182	1,085
Secondary Jobs	0	0	70	1,260	1,280	1,350	1,300	1,370
Population Change	0	0	170	3,130	3,170	3,350	3,220	3,190
Suboptions Q, Cask, and RB2								
Direct Jobs	0	0	45	1,117	1,147	1,227	1,182	1,027
Secondary Jobs	0	0	50	1,230	1,260	1,350	1,300	1,300
Population Change	0	0	120	3,040	3,130	3,340	3,220	3,020

Table 5.3-5. Comparison of socioeconomic impacts of spent nuclear fuel Centralizat maximum case suboptions.

Centralization Alternative	1995	1996	1997	1998	1999	2000	2001	2002
Suboptions W and CM								
Direct Jobs	0	0	216	626	606	611	430	242
Secondary Jobs	0	0	240	690	660	670	470	280
Population Change	0	0	590	1,710	1,650	1,670	1,170	680
Suboptions X and CM								
Direct Jobs	0	0	200	596	590	608	430	164
Secondary Jobs	0	0	220	650	650	670	470	180
Population Change	0	0	540	1,620	1,610	1,660	1,170	450
Suboptions, Y, P, and CM								
Direct Jobs	0	0	318	1,469	1,423	1,401	1,145	804
Secondary Jobs	0	0	350	1,610	1,560	1,540	1,260	1,00
Population Change	0	0	870	4,000	3,880	3,820	3,120	2,35
Suboptions Z, P, and CM								
Direct Jobs	0	0	213	1,310	1,318	1,350	1,145	782
Secondary Jobs	0	0	230	1,440	1,440	1,480	1,260	970
Population Change	0	0	580	3,570	3,590	3,680	3,120	2,28

Suboptions Q, Small Vault, and CM								
Direct Jobs	0	0	62	1,322	1,324	1,350	1,302	1,22
Secondary Jobs	0	0	70	1,450	1,450	1,480	1,430	1,53
Population Change	0	0	170	3,600	3,610	3,680	3,550	3,58
Suboptions Q, Cask, and CM								
Direct Jobs	0	0	45	1,292	1,307	1,347	1,302	1,16
Secondary Jobs	0	0	50	1,420	1,430	1,480	1,430	1,46
Population Change	0	0	120	3,520	3,560	3,670	3,550	3,41

5.3.5 Centralization Alternative

Under this alternative, all current and future SNF would be stored at a centralized location. There are two possible options: the maximum option in which all fuel is stored at Hanford, and the minimum option in which all fuel at Hanford is shipped offsite. The socioeconomic consequences related to implementing the Centralization Alternative suboptions are described in this subsection. The employment and population impacts related to construction and operation of the maximum option are presented in Table 5.3-5. The population and employment impacts related to construction and operation of the option are presented in Table 5.3-6. It was assumed that up to 300 current Hanford workers could be reassigned to operation activities (this number excludes current workers at the Fast Flux Test Facility, as it was assumed that they would be reassigned to activities related to the Hanford Waste Vitrification Plant). Construction activities were assumed to require new workers coming into the area. Estimates of direct jobs were provided by Bergsman (1995). For construction activity, direct jobs were reported as number of jobs in the peak year and total person-years because it was assumed that construction activities would "ramp-up" to the peak year, and then "ramp-down," with the total number of jobs related to construction activity equaling the total person-years required as reported in Bergsman (1995). Although the housing market is currently uncertain and beginning to turn downward, increases in activity levels could strain the housing market and add to school-capacity concerns. However, because construction activities are short-term relative to the total project time frame, impacts from construction activities may be overstated.

5.3.5.1 Centralization - Maximum Option. Under the maximum option,

Hanford SNF would be stabilized and stored under one of the options outlined in the decentralization alternative, with larger storage facilities. A facility would also be built to receive SNF from other sites. Additionally, the ECF would be relocated from the INEL site. The impacts of the ECF to regional population and employment are presented in Appendix D of Volume 1 of this EIS and are not discussed here. Table 5.3-5 presents the employment and population impacts of the options under the maximum centralization option.

5.3.5.1.1 Employment.

All construction activity is assumed to peak in 2000. Construction activity for suboptions W, X, Y, and Z occurs in the years 1997-2000; construction activity for suboptions P and Q occurs in the years 1998-2001; and construction activity for the

Table 5.3-6. Comparison of socioeconomic impacts of spent nuclear fuel Centralizat minimum case suboptions.

Centralization Alternative	1995	1996	1997	1998	1999	2000	2001	2002
Suboption P								
Direct Jobs	0	0	0	715	715	715	715	360
Secondary Jobs	0	0	0	780	780	780	780	460
Population Change	0	0	0	1,950	1,950	1,950	1,950	1,07
Suboption Q								
Direct Jobs	0	0	0	872	872	872	872	786
Secondary Jobs	0	0	0	960	960	960	960	1,00
Population Change	0	0	0	2,380	2,380	2,380	2,380	2,33
Suboption D								
Direct Jobs	0	0	619	620	619	619	357	357
Secondary Jobs	0	0	680	680	680	680	460	460
Population Change	0	0	1,690	1,690	1,690	1,690	1,060	1,06

receiving and canning facility (suboption CM) occurs in the years 1998-2001, with 50% of the construction activity for the modular storage facility occurring during the years 2000-2010 and the other 50% occurring during the years 2010-2035. Increases in employment range from 608 (suboptions X and CM) to 1,401 (suboptions Y, P, and CM) and equate to between 0.7 and 1.7 percentage points over baseline projections of regional employment (see **Table 4.3-1)**. All operations activity peaks in 2002, with incremental activity tapering off. Increases in employment range from 164 (suboptions X and CM) to 1,220 (suboptions Q, Small Vault, and CM) persons and equate to between 0.2 and 1.4 percentage points over baseline projections. Beyond 2004, operations activity will taper off as processing activities (suboptions P and Q) will occur only through 2005. Operation of the receiving and canning facility will require 190 workers through 2011, falling to 150 workers through 2035. Suboptions Y and Z each require only 50 workers beyond 2005 for operations activity. Because it is anticipated that up to 300 current workers could be reassigned, no incremental socioeconomic impacts are anticipated after 2005. This is also true with suboptions W and X because each would require only 60 workers for operation activities.

5.3.5.1.2 Population.

For construction-related activities, the population is expected to peak in 2000, with increases in population ranging from 1,620 (suboptions X and CM) to 3,818 (suboptions Y, P, and CM) and equating to between 0.9 and 2.2 percentage points over baseline projections (see Table 4.3-1). All operations activity peaks in 2002, with incremental activity tapering off through 2007. Increases in population range from 450 (suboptions X and CM) to 3,580 (suboptions Q, Small Vault, and CM) persons and equate to between 0.3 and 2.0 percentage points over baseline projections for 2002.

5.3.5.2 Centralization. Minimum Option. Under the minimum option,

Hanford's SNF would be shipped offsite. Some stabilization of fuel would be required prior to shipment of N Reactor and single-pass reactor fuel. Three options were identified for the stabilization: a shear/leach/calcine facility (suboption P); a solvent extraction facility (suboption Q); or a drying and passivation facility (suboption D). Suboptions P and Q are the same processing facilities that were included in the Decentralization Alternative. Table 5.3-6 presents the employment and population impacts of the suboptions under the Centralization minimum option.

5.3.5.2.1 Employment.

All construction activity is assumed to peak **in 1998.** Construction activity for suboptions P and Q occurs in the years 1998-2001. Increases in employment range from 620 (suboption D) to 872 (suboption Q) and equate to between 0.7 and 1.0 percentage points over baseline projections (see Table 4.3-1). All operations activity peaks in 2002, with incremental activity ending after 2006 for suboptions P and Q, and after 2004 for suboption D. Increases in employment range from 357 (suboption D) to 786 (suboption Q) persons and equate to between 0.4 and 0.9 percentage points over baseline projections.

5.3.5.2.2 Population.

For construction-related activities, the population is expected to peak in 1998, with increases in population ranging from 1,690 (suboption D) to 2,380 (suboption Q) and equating to between 1.0 and 1.4 percentage points over baseline projections (see Table 4.3-1). All operations activity peaks in 2002, with incremental activity ending after 2006. Increases in population range from 1,060 (suboption D) to 2,330 (suboption Q) persons and equate to between 0.6 and 1.3 percentage points over baseline projections for 2002.

5.4 Cultural Resources

The potential impacts of SNF management activities on cultural resources were assessed by 1) identifying project activities that could directly or indirectly affect significant resources; 2) identifying the known or expected significant resources in areas of potential impact; and 3) determining whether a project activity would have no effect, no adverse effect, or an adverse effect on significant resources (36 CFR 800.9). Direct impacts are considered to be those associated with ground disturbance or activities that would destroy or]modify an architectural structure. Indirect impacts are considered to be those resulting from improved visitor access, changes in land status, or other actions that limit scientific investigation of the resources.

Possible measures that would be worked out in consultation with the Washington State Historic Preservation Officer (SHPO), Advisory Council for Historic Preservation, and area tribes may include avoidance or data recovery.

5.4.1 No Action Alternative

The No Action Alternative would not involve upgrade or expansion of existing facilities, other than those that may be required to ensure safety and security. Specific actions considered in the No Action Alternative include continued storage at the following facilities:

- 105-KE and 105-KW Basins
  y T Plant
- FFTF
- 308 Building
- 324 Building
- 325 Building
- 327 Building
- Low-Level Burial Grounds.

With the exception of FFTF, these are existing Manhattan Project and/or

Cold War facilities currently under evaluation for National Register of Historic Places (NRHP) eligibility.

No new facilities would be required; however, the following facility modifications would be considered:

- Upgrade water supply and distribution system to 100-K Area.
- Upgrade seismic adequacy of K Basins.
- Upgrade fire protection systems for the K Basins.
- Safeguards and security upgrades to the K Basins.

Upgrade of the water supply and distribution system has the potential to adversely affect prehistoric archaeological sites in the vicinity of the 100-K Area. Several archaeological sites (45BN115, 45BN152, 45BN423, 45BN434, 45BN464, 45BN424, and H3-10) have been identified in this area (Chatters et al. 1992). These sites are being evaluated for their National Register eligibility. A careful review of the detailed project plans is necessary prior to initiation of this work. If the upgrade results in ground disturbance, as in the replacement and/or addition of new water lines, then these actions could directly affect the archaeological sites. However, proper design of the upgrade system could allow for avoidance of these prehistoric sites. If avoidance is not possible, some sort of data recovery or other measures may be developed in conjunction with affected Native American Tribes and the SHPO. The remaining facility modifications are not likely to affect the historical or architectural value of the Manhattan Project and/or Cold War facilities.

Some indirect effects might result from the continued operation of SNF storage facilities by Hanford workers in the culturally sensitive 100-K Area, if unauthorized artifact collection would contribute to the degradation of nearby archaeological sites. These effects could be mitigated through a worker education program, which would use posters to inform workers of applicable laws, briefing sessions for all persons expected to work along the corridor, and penalties for disturbing an archaeological site. The briefing sessions would stress the importance of cultural resources and specifics of the laws and regulations that exist for site protection.

Direct or indirect impacts are not anticipated to any known traditional cultural resources that are significant to members of the Yakama Indian Nation, the Confederated Tribes of the Umatilla Indian Reservation, or the Wanapum Band. This conclusion is based on the proposed locations of facilities relative to sacred and culturally important areas identified through ethnohistorical research and interviews with elders of bands that formerly used the Hanford Site (Chatters 1989).

5.4.2 Decentralization Alternative

This alternative would involve additional facility upgrades beyond those described for the No Action Alternative, including the construction of new storage facilities and/or a processing facility. Several suboptions have been proposed that would require construction of new facilities. Table 5.4-1 lists the various suboptions and their facility requirements.

Table 5.4-1. Facility requirements of Decentralization suboptions and estimations of area disturbed, [hectares (acres)].

Sub-options	Process option	New pool	New dry vault	New dry casks	New process facility	New land disturbed
W	None	2.4 (6)	2.4 (6)			4.9 (12)
X	None	2.4 (6)		2 (5)		4.5 (11)
Y	P		4.9 (12)		2.4 (6)	7.3 (18)
	Q		2.4 (6)		4.9 (12)	7.3 (18)
	D		4.9 (12)		2.4 (6)	7.3 (18)
Z	P			4.9 (12)	2.4 (6)	7.3 (18)
	Q			2 (5)	4.9 (12)	6.9 (17)

D	4.9 (12)	2.4 (6)	7.3 (18)

All suboptions would require the temporary use of 105-KE and 105-KW basins for packaging of fuel prior to relocation to a new wet storage facility, or stabilization for dry storage. These are existing Manhattan Project and/or Cold War facilities (currently under evaluation for National Register eligibility). Modifications to these existing facilities are considered to be comparable to those identified in the No Action Alternative.

Actions during the upgrade of the water supply and distribution system for the 100-K Area that disturb ground have the potential to adversely affect prehistoric archaeological sites in the vicinity of the 100-K Area (45BN115, 45BN152, 45BN423, 45BN434, 45BN464, 45BN424, and H3-10). A review of specific upgrade actions is required to determine these effects prior to initiation of these actions. Design of the upgrade system should incorporate avoidance of these prehistoric sites. If avoidance is not possible, some sort of data recovery or other measures may be developed in conjunction with affected Native American Tribes, the SHPO, and the Advisory Council.

An indirect effect of continued operation and maintenance of these facilities is the potential for Hanford workers to conduct unauthorized artifact collection activities. This effect could be mitigated through a worker education program, which would use posters to inform workers of applicable laws, briefing sessions for all persons expected to work along the corridor, and penalties for disturbing an archaeological site. The briefing sessions would stress the importance of cultural resources and specifics of the laws and regulations that exist for site protection.

All of the suboptions would require the construction of new facilities. Wet storage pool and dry storage vault facilities would be cast-in-place concrete structures. The dry cask storage facility would consist of modular storage casks on a concrete pad. The stabilization facilities would be multilevel steel-reinforced, cast-in-place concrete structures. The total land area disturbed by the construction of these facilities is estimated to range from 11 to 18 acres.

All new facilities would be located on a 160-acre site just west of 200-East Area (Figure 4-1). The construction of these facilities is not expected to directly affect any archaeological resources. The proposed project area has been surveyed for cultural resources (HCRC 94-600-001), and no prehistoric or historic archaeological properties were found. Consultation with the State Historic Preservation Office and affected Native American Tribes is still in progress. No indirect effects would be anticipated either because no archaeological sites are known to occur within approximately 4 kilometers of the location proposed for the SNF storage facilities. The SNF facilities would be constructed in an industrialized area and would not alter the feeling or association of the Manhattan Project and/or Cold War facilities located nearby.

Text describing impacts to areas of known traditional or religious significance to specific Native American Tribes for the No Action Alternative in Subsection 5.4.1 also applies to the Decentralization Alternative.

5.4.3 1992/1993 Planning Basis Alternative

This alternative involves continued SNF onsite transportation, receipt, processing, and storage at the Hanford Site. However, the TRIGA fuel currently stored at Hanford would be shipped to INEL. The impacts to cultural resources caused by storage of this fuel at INEL are covered in Volume 1, Appendix B (INEL Spent Nuclear Fuel Management Program). The storage and stabilization facility options for Hanford under this alternative are assumed to be consistent with those of the Decentralization Alternative. Refer to Subsection 5.4.2 for a discussion of the cultural resource impacts.

5.4.4 Regionalization Alternative

All new facilities would be constructed on the 65 hectare (163-acre) site west of 200-East Area (Figure 4.1). Construction of these facilities is not expected to have a direct effect on any significant archaeologic resources. The proposed project area has been surveyed for cultural resources (HCRC 94-600-017), and no prehistoric or historic archaeological properties were found. Two isolated artifacts, one historic and one prehistoric in origin, were recorded during the inventory. Because of their isolated status, neither of the artifacts is considered significant. No indirect effects are anticipated because no known archaeological sites are present within approximately 4 kilometers (2 1/2 miles) of the location proposed for the SNF storage facilities. Because the site for the new SNF facilities is in an industrialized area, construction of these facilities would not alter the feeling or association of the Manhattan Project and/or Cold War facilities located nearby.

Although no cultural resource impacts are expected, the potential for discovery during construction is proportional to the amount of land that would be disturbed. For the various options of the Regionalization Alternative, those areas would amount to the following amounts of land:

A) From about 2 to 7 hectares (6 to 18 acres) when all SNF, except defense production SNF, would be sent to INEL

B1) From about 14 to 17 hectares (36 to 43 acres) when all SNF west of the Mississippi River, with the exception of Naval SNF, would be sent to Hanford

B2) From about 24 to 27 hectares (61 to 68 acres) when all SNF west of the Mississippi River and Naval SNF would be sent to Hanford

C) About 2 to 5 hectares (6 to 12 acres) when all Hanford SNF would be sent to INEL or NTS.

In any event, the maximum option would require a processing facility (equivalent to Decentralization process options P, Q, or D) with a specialty fuel processing area; an inspection and packaging facility; an SNF storage complex (similar to, but larger than that for the Decentralization options W, X, Y, or Z); and a new Expended Core Facility. The existing 105-KE and 105-KW basins would be used to package fuel for wet transport to the processing facility. These are existing Manhattan Project and/or Cold War facilities that are currently under evaluation for National Register eligibility. Modifications to these facilities are considered to be similar to those depicted for the No Action and Decentralization alternatives (refer to Subsections 5.4.1 and 5.4.2). Ground-disturbing upgrades to the 100-K Area water supply and distribution system are considered to have potentially adverse effects on prehistoric archaeological sites 45BN115, 45BN152, 45BN423, 45BN434, 45BN424, H3-10, and/or 45BN464 located in this vicinity. A review of the specific upgrade plans is required to determine the effects before beginning these activities. Design of the upgraded water supply system should incorporate avoidance of the prehistoric sites. If avoidance is not possible, then some data recovery or other measures would be developed in conjunction with the affected Native American Tribes, the SHPO, and the Advisory Council. Text describing potential unauthorized artifact collection and possible mitigation measures for the Decentralization Alternative in Subsection 5.4.2 also applies to the Regionalization Alternative.

Text describing impacts to areas of known traditional or religious significance to specific Native American Tribes for the No Action Alternative in Subsection 5.4.1 also applies to the Regionalization Alternative.

5.4.5 Centralization Alternative

This alternative consists of two scenarios: shipment of all SNF off of the Hanford Site (minimum option), and storage of all SNF at the Hanford Site (maximum option). For the minimum option, a new fuel stabilization and packaging (canning) facility would be constructed.

The maximum option would require a processing facility (equivalent to Decentralization process options P, Q, or D) with a specialty fuel processing area; an inspection and packaging facility; an SNF storage complex (similar to the decentralization options W, X, Y, or Z); and a new Expended Core Facility. The existing 105-KE and 105-KW Basins would be used to package defense production fuel for wet transport to the processing facility. These are existing Manhattan Project and/or Cold War facilities that are currently under evaluation for National Register eligibility. Modifications to these facilities are considered to be similar to those depicted for the No Action and Decentralization Alternatives (refer to Subsections 5.4.1 and 5.4.2). Ground-disturbing upgrades to the 100-K Area water supply and distribution system are considered to have potentially adverse effects on prehistoric archaeological sites 45BN115, 45BN152, 45BN423, 45BN434, 45BN424, H3-10, and/or 45BN464 located in this vicinity. A review of the specific upgrade plans is required to determine the effects before beginning these activities. Design of the upgraded water supply system should incorporate avoidance of the prehistoric sites. If avoidance is not possible, then some data recovery or other measures would be developed in conjunction with the affected Native American Tribes, the SHPO, and the Advisory Council. Text describing potential unauthorized artifact collection and possible mitigation measures for the Decentralization Alternative in Subsection 5.4.2 also applies to the Centralization Alternative.

All new facilities would be constructed on the 160-acre site west of 200-East Area (Figure 4.1). The construction of these facilities is not expected to have a direct effect on any archaeologic resources. The proposed project area has been surveyed for cultural resources (HCRC 94-600-001), and no prehistoric or historic archaeological properties were found. No indirect effects are anticipated because no known archaeological sites are present within approximately 4 kilometers of the location proposed for the SNF storage facilities. The site for the new SNF facilities is in an industrialized area, thus construction of these facilities would not alter the feeling or association of the Manhattan Project and/or Cold War facilities located nearby.

Text describing impacts to areas of known traditional or religious significance to specific Native American Tribes for the No Action Alternative in Subsection 5.4.1 also applies to the Centralization Alternative.

5.5 Aesthetic and Scenic Resources

Implications of implementing the alternatives for interim storage of SNF on aesthetic and scenic resources at the Hanford Site are discussed in the following subsections.

5.5.1 No Action Alternative

Impacts from this alternative would have no effect on the aesthetic and scenic resources.

5.5.2 Decentralization Alternative

This alternative would require the construction of an SNF facility at Hanford, where most SNF from the Hanford Site would be stored.

Changes caused by construction and operation of an SNF facility would be consistent with the existing overall visual environment of the Hanford Site. Topographic features obstruct the SNF site from view from populated areas. The site could be seen from the farmland bluffs that overlook the Columbia River on the east. However, these lands are on private property not readily accessible to the public. Landowners would likely grant access permission only during the hunting season, if at all. No impacts requiring mitigation would occur to the aesthetics or to the visual environment as a result of construction or operation of an SNF facility at the Hanford Sit

5.5.3 1992/1993 Planning Basis Alternative

Activities in this alternative are sufficiently similar to those of the Decentralization Alternative that they are not repeated here.

5.5.4 Regionalization Alternative

This alternative (see Section 5.1.4 for details) would require the construction of a variety of SNF facilities depending on the option chosen. The facilities would range from a packaging/stabilization facility if all fuel were to be removed from Hanford (option C) to storage facilities for all SNF west of the Mississippi River (option B2). However, changes caused by construction and operation of these facilities would be consistent with the existing overall visual environment of the Hanford Site. Topographic features obstruct the SNF site from view from populated areas. The site could be seen from the farmland bluffs to the east of the site that overlook the Columbia River. However, these lands are on private property that is not readily accessible to the public. Landowners would likely grant access permission only during the hunting season, if at all.

No impacts requiring mitigation would occur to the aesthetics or to the visual environment as a result of construction or operation of an SNF facility at the Hanford Site.

5.5.5 Centralization Alternative

If Hanford is selected as the site for centralization of SNF, then the SNF facility and its support facilities would be constructed here.

Changes caused by construction and operation of an SNF facility would be substantially larger in the Centralization Maximum Alternative. However, they would be consistent with the existing overall visual environment of the Hanford Site. Topographic features obstruct the SNF site from view from populated areas. The site could be seen from the farmland bluffs that overlook the Columbia River on the east. However, these lands are on private property not readily accessible to the public. Landowners would likely grant access permission only during the hunting season, if at all.

No impacts requiring mitigation would occur to the aesthetics or to the visual environment as a result of construction or operation of an SNF facility at the Hanford Site. If Hanford is not selected as the site for centralization of SNF, only an SNF packaging/ processing facility for shipment of fuel would be constructed and there would be even less potential for impact to the aesthetic and scenic resources.

5.6 Geologic Resources

No postulated impacts to the geologic resources of the Hanford Site have been identified under any of the alternatives. Thus, geologic resources would remain as described under Section 4.6.

5.7 Air Quality and Related Consequences

The consequences of the five alternatives on ambient air quality at the Hanford Site are presented in this section. In the case of radiological emissions, the consequences are compared among the alternatives and to current Hanford Site operations. For nonradiological emissions, projected ambient concentration at key receptor locations are compared with current concentrations at the Hanford Site. Development of the specific analysis for each alternative is discussed in subsequent subsections.

The consequences of radiological emissions were evaluated using the GENII computer code package (Napier et al. 1988). The radiological consequences of airborne emissions during normal operation have been estimated for the SNF storage alternatives considered in this document. Three separate analyses were performed for each facility included in a particular alternative using the GENII computer code. The receptors evaluated in these cases were at the location of maximum exposure representing a potential onsite worker outside of the SNF facility, the maximally exposed offsite resident, and the collective population within 80 kilometers. Standard parameters for radiological dose calculations at the Hanford Site were used for these estimates (Schreckhise et al. 1993). The maximum impact of each alternative on offsite receptors and workers was obtained by summing the consequences associated with the individual facilities, although these receptors may be physically at very different locations. The health consequences in terms of cancer fatalities were calculated using recommendations of the International Commission on Radiological Protection in its Publication 60 (ICRP 1991) - 4E-04 fatal cancers/rem for workers and 5E-04 fatal cancers/rem for the general population. Risk conversion factors were applied to both individual and collective doses, although they are based on population averages for individuals with varying degrees of sensitivity. The individual risk estimates therefore represent the risk to a hypothetical individual, which would be somewhat lower than the risk to more sensitive members of the population.

None of the alternatives would result in a dose to the maximally exposed offsite resident that exceeds 1 percent of the current EPA standard of 10 millirem/year. The consequences of the No Action Alternative are caused by emissions from existing facilities where spent fuel is stored. These facilities contribute a relatively small fraction of the total dose from airborne emissions at all Hanford Site operations (less than half and likely much less). The No Action Alternative represents the baseline for SNF operations at Hanford. The consequences of the Decentralization, Regionalization, and Centralization Alternatives vary depending on which storage and processing options are considered. Options including processing of defense reactor fuel result in the highest doses, which are at most an order of magnitude greater than those in the No Action Alternative. The consequences of options involving only containerization of defense reactor fuel followed by wet storage, and dry storage of all other fuel, in a new facility are approximately an order of magnitude lower than those in the No Action Alternative.

The potential nonradiological air quality pollutants of concern for this assessment include all pollutants for which there exist federal, state, or local standards. This includes both the standard set of criteria pollutants (e.g., nitrogen dioxide, oxides of sulfur, respirable particles) and toxic pollutants.

For criteria pollutants, concentration levels are regulated by the provisions of the Clean Air Act; Washington State standards for these criteria pollutants are at least as stringent as the federal standards. In the State of Washington, the Department of Ecology has the responsibility for promulgating and enforcing air quality standards for the protection of public health. The regulation that governs the control of toxic air pollutants (WAC 1990a,b) requires the owners of new or modified air emission sources to apply for approval before construction. Owners of sources emitting toxic air pollutants must demonstrate that they will employ the best available control technology for emissions control with reasonable environmental, energy, and economic impacts.

Construction of new facilities can also negatively impact air quality through the emission of fugitive dusts. To model this aspect, the EPA's Fugitive Dust Model (FDM) was selected. This model is especially designed to compute the air quality impacts from fugitive dust emissions, such as those associated with facility construction sites (Winges 1992). The FDM uses steady-state Gaussian plume algorithms and a gradient-transfer deposition algorithm to compute air quality impacts. Emissions for each source must be apportioned into a series of particle-size classes; each of which is assigned a representative deposition velocity. The model can operate using either joint frequency distributions or hourly meteorological data to represent atmospheric conditions. The model can handle up to 200 sources and 500 receptors per model run. The user may define a variety of point, line, area, and volume sources.

The Industrial Source Complex (ISC2) models were selected to estimate routine nonradiological air quality impacts. There are two ISC2 models: the ISC2 short-term model (ISCST2) and the ISC2 long-term model (ISCLT2). The two ISC2 models use steady-state Gaussian plume algorithms to estimate pollutant concentrations from a wide variety of sources associated with industrial complexes (EPA 1992). The models are appropriate for flat or rolling terrain, modeling domains with a radius of less than 50 kilometers, and urban or rural environments. The ISC2 models have been approved by the EPA for specific regulatory applications and are designed for use on personal computers. Input requirements for the ISC2 model include a variety of information that defines the source configuration and pollutant emission parameters. The user may define a variety of point, line, area, and volume sources. The ISCST2 model uses hourly meteorological data and joint frequency distribution data to compute straightline plume transport. Plume rise, stack-tip downwash, and building wake can be computed. The ISC2 models compute a variety of short- and long-term averaged products at user-specified receptor locations and receptor rings. The ISC2 models also treat deposition processes and allow the exponential decay of pollutants.

5.7.1 No Action Alternative

Facilities included in the No Action Alternative consist of those where SNF is currently stored at the Hanford Site. Minimal repackaging, stabilization, and relocation of fuel would be undertaken to ensure continued safe storage prior to ultimate disposition. The majority of spent fuel at Hanford is located at the 100-K Area wet storage basins. In addition, smaller quantities of fuel are stored at other onsite facilities. These include T Plant and a low-level waste burial ground in the 200-West Area; the Fast Flux Test Facility in the 400 Area; and the 308, 324, 325, and 327 buildings in the 300 Area. Releases for the No Action Alternative are based on operations for these facilities during 1992 (Bergsman 1995). These emissions were assumed to represent operations at existing SNF storage facilities over the EIS evaluation period, although they are subject to change with individual facility missions and operating status. It should also be noted that some existing facilities support a variety of other programs in energy research and waste management in addition to laboratory and hot cell examination of fuel materials. The historical releases from these multi-purpose facilities may reflect other activities in addition to spent fuel storage. The past operating emissions, therefore, represent an upper bound estimate for the fuel storage activities. The No Action Alternative also represents the baseline of maximum expected impacts for future spent fuel storage activities.

5.7.1.1 Radiological. Radiological air emissions for normal operation of existing fuel storage facilities in the No Action Alternative are listed in Tables 5.7-1 through 5.7-3 (DOE/RL 1993). The sealed fuel canisters temporarily stored at the 200-West Area burial ground are assumed to release negligible quantities of radionuclides in this analysis, although actual emissions from the stored fuel have not been quantified.

The consequences of air emissions from existing facilities utilized in the No Action Alternative are summarized in Table 5.7-4 and include a maximum annual dose of 1E-5 rem to a potential onsite worker with a 5E-9 probability of fatal cancer. The maximum dose to an offsite resident is estimated as 3E-6 rem/year, and the corresponding probability of fatal cancer is 1E-9. The dose estimate for an onsite worker or an offsite individual represents the sum of doses to separate maximally exposed individuals for each of the facilities included in the alternative. Because these facilities are in different areas of the Hanford Site, the respective maximally exposed workers and offsite residents are at different locations. The actual dose to a single worker or

Table 5.7-1. Annual atmospheric releases for normal operation - wet storage basins at 100-KE Area and 100-KW Area.

Radionuclide	100-KE Area Release (Ci/yr)	100-KW Area Release (Ci/yr)
Cobalt-60	1.3E-06	1.4E-06
Strontium-90	1.6E-04	9.9E-07
Ruthenium-106	1.3E-05	6.2E-06
Antimony-125	1.1E-05	NA[a]
Cesium-137	2.3E-04	2.7E-05
Europium-154	NA	4.9E-06
Plutonium-238	1.3E-06	3.0E-08
Plutonium-241	3.9E-05	NA
Americium-241	5.1E-06	NA
Plutonium-239	8.5E-06	1.8E-07
Tritium	(b)	(b)

a. NA indicates not available.

b. Although tritium emissions are not routinely monitored at these facilities, the releases from both basins were recently estimated as 1-2 Ci/year. These emissions could account for up to 25% of the total dose from these facilities to the maximally exposed offsite resident. However, the contribution from the 100 area tritium emissions would not change the estimated dose from all Hanford emissions to the site's maximally exposed offsite resident.

Table 5.7-2. Annual atmospheric releases for normal operation - fuel storage at 300 Area 308, 324, 325, and 327 buildings.

Radionuclide	308 Building Release (Ci/yr)	324 Building Release (Ci/yr)	325 Building Release (Ci/yr)	327 Buildin Release (Ci/yr)
Tritium	NA[a]	9.6E+00	2.5E+01	NA
Total beta[b]	1.1E-07	6.4E-07	2.4E-06	9.3E-07
Total alpha[c]	3.0E-08	3.9E-07	8.5E-07	1.1E-07

a. NA indicates not available.

b. Total beta emissions were assumed to be strontium-90 for modeling

purposes.
c. Total alpha emissions were assumed to be plutonium-239 for modeling purposes.

Table 5.7-3. Annual atmospheric releases for normal operation - fuel storage at 200 West Area T Plant and 400 Area FFTF.

Radionuclide	200-West Area T Plant Release (Ci/yr)	400 Area FFTF Release (Ci/yr)
Argon-41	NAa	8.5E+00b
Total beta/strontium-90	1.2E-05	6.7E-06c
Cesium-137	1.3E-05	NA
Americium-241	2.0E-06	NA
Total alpha/plutonium-239	2.2E-05	1.1E-06d

a. NA indicates not available.
b. Releases of Ar-41 occurred during reactor operation in 1992. The reactor was subsequently shut down, and releases of short-lived activation products are not anticipated from future fuel storage activities.
c. Total beta emissions were assumed to be strontium-90 for modeling purposes.
d. Total alpha emissions were assumed to be plutonium-239 for modeling purposes.

offsite resident from all facilities combined would therefore be less than the sum of the individual facility receptor doses reported in Table 5.7-4. The peak collective dose to the population within 80 kilometers (50 miles) is 3E-2 person-rem per year, which is predicted to result in less than one fatal cancer (6 x 10-4) over 40 years of storage.

5.7.1.2 Nonradiological Consequences. The No Action Alternative

involves no new construction so there would not be an increase in particulate emissions. The facilities currently used in storing the SNF do not have any nonradiological releases, so there would be no increase in concentrations of these pollutants.

5.7.2 Decentralization Alternative

The Decentralization Alternative permits construction of new facilities where these represent an improvement over current storage practices. Relocation of fuel could be undertaken as part of this alternative to meet programmatic needs; however, no fuel would be shipped to, or received from, offsite locations. It is assumed for purposes of this analysis that new facilities would be constructed under this alternative, and that they would be located in a dedicated SNF management complex adjacent to the 200-East Area.

Table 5.7-4. Radiological consequences of airborne emissions during normal operati Alternative for spent nuclear fuel storage at Hanford.

		Onsite worker		Offsite resident
Area	Facility	Peak annual dose (EDE) (rem/yr)	Probability of fatal cancer	Peak annual dose (EDE) (rem/yr)
100 KE	Wet Basin	9.3E-06		2.0E-07
100 KW	Wet Basin	1.2E-07		3.3E-09
300	308 Bldg	3.3E-09		2.1E-09
300	324 Bldg	1.4E-08		2.9E-07
300	325 Bldg	1.2E-07		1.9E-06

300	327 Bldg	1.7E-09		2.4E-09
200 W	Burial Ground	0.0E+00		0.0E+00
200 W	T Plant	1.3E-07		3.3E-08
400	Fast Flux Test Facility	1.9E-06		1.9E-07
Total from All Facilities		1.2E-05	4.6E-09	2.6E-06

The Decentralization Alternative at Hanford includes two basic options, each with several suboptions depending on the types of storage and processing facilities included. The first major option includes a combination of wet storage of defense production fuel and dry storage of all other fuel in either a small vault facility (suboption W) or in casks (suboption X). The second major option provides for dry storage of all fuel, which would require processing of defense fuel prior to dry storage. If a shear/leach/calcine process is used (suboption P), the calcine product and all other fuel would be consolidated in a single large vault facility (suboption Y) or in casks (suboption Z). If a solvent extraction process is chosen for the defense fuel (suboption Q), the oxide products could be stored in either new or existing facilities that would have lower space and shielding requirements than for the calcine product. A high-level liquid waste stream would also be produced and transferred to underground storage tanks. All fuel other than the processed defense fuel would be stored in a small vault facility or in casks as in suboptions W and X.

5.7.2.1 Radiological. Estimated radiological air emissions for normal

operations of new facilities in the Decentralization Alternative are listed in Tables 5.7-5 through 5.7-7. The dry storage facilities are assumed to have no radiological emissions under normal operating conditions because all fuel is contained in sealed decontaminated canisters and storage casks. Therefore, there is no mechanism for routine release of radionuclides from dry storage facilities over the time period covered in this document.

The consequences of air emissions from individual facilities in the Decentralization Alternative are summarized in Table 5.7-8 and include a maximum annual dose of 2E-9 rem to a

Table 5.7-5. Estimated annual atmospheric releases for normal operation - new wet storage at 200-East Area.

Radionuclide	Release (Ci/yr)
Cobalt-60	1.4E-05
Strontium-90	1.1E-06
Ruthenium-106	6.2E-06
Cesium-137	2.3E-05
Europium-154	4.9E-06
Plutonium-238	1.1E-08
Plutonium-239	6.7E-08

Table 5.7-6. Estimated annual atmospheric releases for normal operation - shear/leach/calcine fuel process at 200-East Area.

Radionuclide	Release (Ci/yr)
Tritium	7.0E+02
Carbon-14	6.5E+00
Krypton-85	2.7E+05
Strontium-90	4.8E-07
Ruthenium-106	4.3E-09
Antimony-125	1.0E-08
Tellurium-125M	2.5E-09
Iodine-129	5.0E-03
Cesium-134	1.0E-08
Cesium-137	6.0E-07

Cerium-144	2.3E-09
Promethium-147	1.6E-07
Samarium-151	7.4E-09
Europium-154	7.2E-09
Americium-242	2.4E-12
Curium-242	6.1E-12
Plutonium-238	3.2E-09
Plutonium-241	3.8E-07
Americium-241	7.8E-09
Plutonium-239/240	0.00000002

potential onsite worker (8E-13) probability of fatal cancer) for the option including a combination of wet and dry spent fuel storage facilities. The dose to an offsite resident at the highest exposure location is estimated as 6E-10 rem/year, and the corresponding probability of fatal cancer is 3E-13. The peak collective dose to the population within 80 kilometers is 2E-5 person-rem per year, which is predicted to result in less than one (4 x 10-7) fatal cancer over 40 years of storage.

Table 5.7-7. Estimated annual atmospheric releases for normal operation - spent nuclear fuel solvent extraction fuel process at 200-East Area.

Radionuclide	Release (Ci/yr)
Tritium	7.0E+02
Carbon-14	6.5E+00
Krypton-85	2.7E+05
Strontium-90	2.4E-02
Ruthenium-106	5.1E-04
Antimony-125	4.6E-04
Tellurium-125M	2.4E-04
Iodine-129	1.9E-02
Cesium-134	5.1E-04
Cesium-137	3.0E-02
Cesium-144	1.2E-04
Promethium-147	8.1E-03
Samarium-151	7.4E-09
Europium-154	4.2E-04
Europium-155	1.7E-04
Americium-242	2.4E-12
Curium-242	6.1E-12
Plutonium-238	1.6E-03
Plutonium-241	1.9E-02
Americium-241	4.4E-03
Plutonium-239/240	0.008

Table 5.7-8. Radiological consequences of airborne emissions during normal operati Decentralization Alternative for spent nuclear fuel storage at Hanford.

Area	Facility	Onsite worker Peak annual dose (EDE) (rem/yr)	Probability of fatal cancer	Offsite resident Peak annual dose (EDE) (rem/yr)
Combination Wet + Dry Storage Option				
200 E	New Wet Storage	2.0E-09	8.0E-13	5.7E-10
200 E	New Dry Storage	0.0E+00	0.0E+00	0.0E+00
Dry Storage Only Option with Defense Fuel Processing				
200 E	New Dry Storage	0.0E+00	0.0E+00	0.0E+00
200 E	New Fuel Calcine	4.1E-06	1.7E-09	7.0E-06
200E	New Solvent Extraction	2.7E-05	1.1E-08	2.1E-05

For the all dry storage option, processing defense fuel is required in the Decentralization Alternative (suboptions P and Q), and additional emissions would result from these activities if they were conducted. The dose to the onsite worker from air emissions would be 4E-6 rem per year for a shear/leach/calcine process or 3E-5 rem per year for a solvent extraction process (2E-9 or 1E-8 probability of fatal cancer, respectively) in addition to tho from the dry storage facility. The corresponding consequences for the offsite resident would be 7E-6 rem per year (4E-9 probability of fatal cancer) for the shear/leach/calcine facility and 2E-5 rem per year (1E-8 probability of fatal cancer) for the solvent extraction facility. The collective dose to the offsite population from the respective fuel processing facilities is estimated at 0.3 to 1 person-rem per year, resulting in less than one expected fatal cancer (<0.02) over 40 years of storage.

5.7.2.2 Nonradiological Consequences. Fugitive dust emissions from new

construction activities, toxic chemical emissions, and nitrogen oxide emissions from fuel processing would contribute to the non-radiological emissions in the Decentralization Alternative.

5.7.2.2.1 Fugitive Dust.

Three different construction options are under consideration in this alternative: 1) construction of wet and dry storage facilities, 2) construction of dry storage and the shear/leach/calcine facility, and 3) construction of a dry storage and a solvent extraction facility. In options 1 and 2, approximately 12 acres would be disturbed for the construction of the storage facilities; in option 3, 6 acres would be disturbed for the dry storage facility. An additional 6 acres would be disturbed for the shear/leach/calcine facility or 12 acres for the solvent extraction facility. In total up to 12 acres would be disturbed in the first option and 18 acres in the second and third options (Bergsman 1995).

Details of the construction process are not available for the alternatives, but a standard default value of 1.2 tons/acre/month of particles can be assumed to be generated during new construction (EPA 1977). Most of the particles produced by construction activities are large and settle a short distance from the source (Seinfeld 1986). A conservative estimate is that approximately 30 percent of the mass released would be particles small enough to be transported away from the construction site (EPA 1988).

Experience with construction activities at Hanford indicates that fugitive dust concentrations at the nearest point of public access and at the site boundaries would be less than Washington State PM10 limits for both annual and 24-hour averages. Standard control techniques (such as applying water to the disturbed ground) could be used to limit the PM10 emissions at the construction site and resulting airborne concentrations. Although extensive construction activities have the potential to contribute to short-term airborne particulate concentrations if they coincide with high wind events, such effects would generally be obvious only in the immediate area and could be mitigated by dust control measures over both the short and long term. In any case, such activities would be temporary and would not adversely affect regional air quality on a continuing basis. Construction activities would also result in increased emissions of pollutants from diesel- and gasoline-powered construction equipment. However, the increase in ambient levels of pollutants would be minimal because of the relatively low levels of emission and large distances to the nearest points of public access and the site boundary.

5.7.2.2.2 Nitrogen Oxides.

Nitrogen oxide emissions during facility operation are approximately the same for both the shear/leach/calcine facility and the solvent extraction facility. It is assumed that all nitrogen oxide emissions are in the form of nitrogen dioxide. Annual concentrations at the nearest point of public access, 7.5 kilometers (6.4 miles) southwest of the release site, are estimated to be 0.1 micrograms per cubic meter. This concentration is 0.1 percent of the allowed Washington State standard and 0.4 percent of the Prevention of Significant Deterioration (PSD) standard.

Nitrogen oxide concentrations were also calculated for onsite locations. The maximum annual concentration estimated by the model is 1.2 micrograms per cubic meter, which occurs 500 meters (0.3 miles) south of the processing facility. The maximum ground level concentration is some distance from the processing facility because the emissions are from an elevated stack rather than at ground level. For example, at a distance of 100 meters (0.06 miles) from the base of the facility, the greatest estimated nitrogen oxide annual concentration is only 1.8 x 10-5 micrograms per cubic meter.

5.7.2.2.3 Toxic Chemical Emissions.

Information about routine toxic chemical emissions from either the shear/leach/calcine facility or the solvent extraction facility is unavailable. However control techniques would be used to ensure that concentrations of toxics in the atmosphere comply with the DOE abatement policy and local permitting requirements.

5.7.3 1992/1993 Planning Basis Alternative

The 1992/1993 Planning Basis Alternative is assumed to be similar to the Decentralization Alternative discussed in the previous section, including construction of wet or dry storage facilities adjacent to the 200-East Area and process facilities for defense production fuel if it is to be stored dry. The only change to the Hanford Site fuel inventory would involve shipment of a relatively small quantity of TRIGA fuel to an offsite location. This would not substantially alter the scope of planned spent fuel storage activities, and the 1992/1993 Planning Basis Alternative assumes emissions for new facilities are the same as those in the Decentralization Alternative.

5.7.3.1 Radiological Consequences. The consequences for this

alternative are assumed to be the same as those for the Decentralization Alternative. Refer to Table 5.7-8 for the list of facilities included in this option and their consequences.

5.7.3.2 Nonradiological Consequences. The consequences for this

alternative are considered to be the same as those for the Decentralization Alternative.

5.7.4 Regionalization Alternative

The Regionalization Alternative at Hanford includes three options, depending on the quantity of SNF shipped to, or from, the site. Option A provides for regional storage of SNF by type, and would entail shipping all fuel at Hanford except defense production fuel to another location. In this case, defense fuel would either be stored wet at a new pool facility, or it would be processed for dry storage using suboptions similar to those described in the Decentralization Alternative.

An additional option in the Regionalization Alternative describes importing SNF to Hanford from other sites based on their geographic distribution. In the first option, designated Option B1, all fuel at locations west of the Mississippi River except Naval SNF would be stored at Hanford. In the second option, designated Option B2, all SNF at locations west of the Mississippi River and Naval SNF would be stored at Hanford. All imported fuel would ultimately be placed into a new dry storage facility, the size of which would be determined by the quantity of imported fuel to be stored. In addition, a receiving and canning facility would be built to repackage any fuel as needed, and to provide temporary wet storage for fuels that could not be immediately placed into dry storage. This option would also include a technology development facility for fuel characterization and research related to SNF management. SNF currently at Hanford would be stored according to the options described in the Decentralization Alternative. Option B2 would include a separate facility to examine and characterize Naval SNF, as described in Appendix D to Volume 1 of this EIS.

The third Regionalization option (designated Option C) would relocate all SNF at the Hanford Site to another western U.S. location. The only new facility that would be required for this option is a processing and packaging facility to stabilize and repackage defense fuel and to place other fuel into canisters as needed for shipping offsite. Prior to preparation for offsite shipment, SNF would continue to be managed at existing facilities, as for the No Action Alternative. All new facilities considered in the Regionalization Alternative options would be constructed in a dedicated SNF management complex adjacent to the 200-East Area, as for the Decentralization Alternative.

5.7.4.1 Radiological Consequences. Emissions from new facilities in

Regionalization Alternative A would be the same as those described for the Decentralization Alternative in Table 5.7-8. Although this option does not include the dry storage capacity for fuel other than defense production fuel, dry storage facilities add nothing to the normal operating emissions; therefore, the emissions and consequences from this alternative would be quantitatively the same as those previously described for the Decentralization Alternative.

Emissions from the new facilities in the Regionalization Alternative B and C options are expected to be bounded by those in the Centralization maximum and minimum options, respectively, as described in Section 5.7.5.

5.7.4.2 Nonradiological Consequences. Because of the similarity of

operations, consequences for the Regionalization Alternative are considered to be the same as those for the Decentralization Alternative.

5.7.5 Centralization Alternative

The Centralization Alternative at Hanford includes two options: a maximum option in which all SNF for which DOE is responsible would be stored at Hanford, and a minimum option in which all SNF currently at Hanford would be shipped to another site. The maximum option is similar to that described in the Regionalization Option B2, except that the size of the receiving and canning and dry storage facilities would be increased as necessary to accommodate the larger quantity of imported fuel. The minimum option is identical to that described for the Regionalization Alternative, Option C. All new facilities considered in the Centralization Alternative options would be constructed in a dedicated SNF management complex adjacent to the 200-East Area.

5.7.5.1 Radiological. For the Centralization maximum option at

Hanford, emissions from the wet storage and processing facilities would be identical to those described in the Decentralization Alternative (refer to Tables 5.7-5 through 5.7-7). Minimal emissions from the large dry storage facility are assumed in this case (see Table 5.7-9) because some of the imported fuel could be stored without canning, and the assumption of zero emissions could not be justified as in the Decentralization Alternative. The consequences of emissions from a relocated Expended Core Facility (ECF) are described in Appendix D to Volume 1 of this EIS and are not included here. It should be noted that the assumptions used in Appendix D calculations for the ECF at Hanford may differ from those used to estimate the consequences of emissions from other Hanford facilities.

The consequences of air emissions from individual facilities in the Centralization Alternative maximum option are summarized in Table 5.7-10 and include a maximum annual dose of 9E-9 rem to a potential worker (4E-12 probability of fatal cancer) for a combination of wet and dry spent fuel storage facilities. The dose to an offsite resident at the highest exposure location is estimated as 2E-9 rem/year, and the corresponding probability of fatal cancer is 8E-13. The peak collective dose to the population within 80 kilometers is 7E-5 person-rem per year, which is predicted to result in less than one (4 x 10-8) fatal cancer.

Table 5.7-9. Estimated annual atmospheric releases for normal operation - new dry storage at 200-East Area (maximum option).

Radionuclide	200-East Area Release (Ci/yr)
Cobalt-60	2.8E-08
Strontium-90	9.1E-07
Yttrium-90	9.1E-07
Cesium-137	1.2E-07
Plutonium-239	2.8E-07

Table 5.7-10. Radiological consequences of airborne emissions during normal operat Alternative for spent nuclear fuel storage at Hanford.

Area	Facility	Onsite worker Peak annual dose (EDE) (rem/yr)	Probability of fatal cancer	Offsite resident Peak annual dose (EDE) (rem/yr)
Combination Wet + Dry Storage Option				
200 E	New Wet Storage	2.0E-09	8.0E-13	5.7E-10
200 E	New Dry Storage	7.0E-09	3.0E-12	1.0E-09
Dry Storage Only Option with Defense Fuel Processing				
200 E	New Dry Storage	7.0E-09	3.0E-12	1.0E-09
200 E	New Fuel Calcine	4.1E-06	1.7E-09	7.0E-06
200E	New Solvent Extraction	2.7E-05	1.1E-08	2.1E-05
Relocation of Expended Core Facilitya				

a. Data for the expended core facility (ECF) are presented in Appendix D to Volume Assumptions used in Appendix D calculations for the ECF at Hanford may differ from the doses consequences of emission from other Hanford facilities.

Processing of defense fuel is required prior to dry storage in the maximum option, and additional air emissions would result from those activities if defense fuel is stored dry rather than wet. The dose to the worker would increase by 4E-6 rem/year for a shear/ leach/ calcine process or 3E-5 rem/year for a solvent extraction process (2E-9 or 1E-8 probability of fatal cancer, respectively). The corresponding added consequences for the offsite resident would be 7E-6 rem/year (4E-9 probability of fatal cancer) for the shear/leach/calcine facility and 2E-5 rem/year (1E-8 probability of fatal cancer) for the solvent extraction facility. The collective dose to the offsite population from the respective fuel processing facilities is estimated at 0.3 to 1 person-rem per year, resulting in less than one (5 x 10-4) fatal cancer.

In the Centralization Alternative minimum option, the consequences of existing facilities utilized for interim fuel storage prior to shipment offsite are the same as in the No Action Alternative. Consequences for defense fuel processing prior to shipment are described under the centralization maximum alternative and are equivalent to those from the shear/leach/calcine facility. Refer to Tables 5.7-4 and 5.7-10 for the consequences of facilities included in this option.

5.7.5.2 Nonradiological. **Because of the similarity of operations** leading to nonradiological impacts on air quality, consequences for the Centralization Alternative are considered to be the same as those for the Decentralization Alternative with the addition of emissions from the naval fuels Expended Core Facility. Analysis of nonradiological releases from the Expended Core Facility can be found in Volume 1, Appendix D.

5.8 Water Quality and Related Consequences

This section evaluates the potential impacts to groundwater and surface water resources from the construction and operation of SNF storage and associated support facilities at the Hanford Site. Potential impacts to groundwater and surface water, water use, and water quality from the potential release of contaminants into, and migration through, hydrologic water-based environments are evaluated. The potential significance of these impacts is evaluated with respect to environmental contaminant levels from potential releases of contaminants into the environment and the health impacts of these contaminant levels. Contaminant waste streams include radionuclide and chemical carcinogens and noncarcinogenic chemicals.

The Multimedia Environmental Pollutant Assessment System (MEPAS), a computer model, was utilized to simulate the release, migration, fate, exposure, and risk to surrounding receptors of wastes that are discharged into the environment from the operation of SNF facilities. The MEPAS model is a fully integrated, physics-based, PC-platform, intermedia transport- and risk computation code that is used to assess health impacts from actual and potential releases of both hazardous chemicals and radioactive materials. The MEPAS model is designed for site-specific assessments using readily available information. It follows EPA risk-assessment guidance in evaluating 1) the release of contaminants into the environment; 2) their movement through and transfer between various environmental media [i.e., subsurface (vadose and saturated zones), surface water, overland (surface soil), and atmospheric]; 3) exposure to surrounding receptors via inhalation, ingestion, dermal contact, and external dose; and 4) risk to carcinogens and hazard to noncarcinogens. The MEPAS model follows ICRP/NCRP and EPA guidelines, where the user is allowed to choose the appropriate guidelines.

5.8.1 No Action Alternative

The only release directly to the surface water in the No Action Alternative was associated with the 105-KE and 105-KW basins. The 105-KE and 105-KW basins were combined as one release and represented by a "single liquid release point to the Columbia River" (Bergsman 1995). The annual liquid discharge is assumed to be 1.4E+06 cubic meters per year (3.7E+08 gallons year), with a total activity of approximately 0.4 Ci: 0.26 Ci tritium, 0.066 Ci cobalt-60, 0.01 Ci cesium-137, 0.0010 Ci strontium-90, and 9.2E-06 Ci plutonium-239 (Bergsman 1995). All of the constituents in this assessment are radionuclides. The release is assumed to continue at this level over the period of 18 years from 1997 through 2015. Operational liquid effluents from the K Basins are discharged to the Columbia River via the monitored and regulated National Pollutant Discharge Elimination System (NPDES) permitted 1908-KE outfall. Contaminant migration is from the point-source discharge point to the Columbia River, and in the Columbia River to receptors downstream. The flow discharge in the Columbia River is assumed to be under low-flow conditions of 1,000 cubic meters per second (36,000 cubic feet per second) (Whelan et al. 1987), which represents the most conservative case for maximizing surface water concentrations. As a conservative assumption, the removal of water from the Columbia River is assumed to be 100 meters (328 feet) downstream of the point of entry of the contaminant into the river. The assessment addressed recreational activities (e.g., boating, swimming, and fishing) in the Columbia River and use of the water as a drinking water supply and for bathing, irrigation, etc. The risk of fatal cancer in this scenario considering all pathways was found to be less than one chance in a billion. For more information, refer to Whelan et al. (1994).

Intermittent leakage of water from the K Basins is monitored via onsite groundwater sampling. Although radionuclide concentrations in some of the 100-K area monitoring wells exceed EPA drinking water standards, this condition does not constitute a risk to the public because the groundwater is not used directly for human consumption or food production. Analyses of water from the K area springs, where groundwater enters the Columbia River, indicate that radionuclide levels are below the EPA drinking water standards. Dilution of this seepage in the river flow would further reduce the risk to the downstream population, as indicated by the fact that radionuclide concentrations in the Columbia River at the Richland pump house are orders of magnitude below the drinking water standard (Dirkes et al 1994).

5.8.2 Decentralization Alternative

The Spent Nuclear Fuel Wet Transfer and Storage scenario was documented. The source term represents the maximum potential water releases that would be expected if a secondary containment failure and/or piping leak occurred and went undetected for one month at a state-of-the-art wet storage fuel/transfer facility utilizing water treatment technology now available. Releases resulting from such a failure should not be thought of as operational or planned releases. However, for the purposes of a nonzero release source-term, this scenario addresses those situations where an unexpected release may occur. The source-term information was derived from data related to the operation of the Flourinel and Storage Facility (FAST) at INEL's Chemical Processing Plant (ICPP 666) and is considered to be extremely conservative, given the state-of-the-art engineering practices, monitoring, leak-detection equipment, and surveillance procedures likely to be used at any new SNF facility, such as FAST.

Any new facility would be built using state-of-the-art technologies, including leak detection and water-balance monitoring equipment. This equipment, along with the uncertainties associated with evaporation monitoring, will have a minimum detection sensitivity. It is possible that the new SNF facility could experience a failure that would result in a leak that is below the sensitivity of the detection system. Based on the size of the facility and the current monitoring programs at similar facilities, 5 gallons per day has been established as a conservative value to account for potential undetected leakage from the facility. The nonzero release source term would then exceed what could be expected for a new SNF wet storage or transfer facility. Factors contributing to the conservatism in volume estimates are the design criteria, which state that the new facility will contain leak-detection systems (Hale 1994) and will have a lower surface area [i.e., 2000 square meters (6600 square feet)] available for leakage as compared to FAST [i.e., 3830 square meters (12,560 square feet)] (Hale 1994). For the purposes of this assessment, the entire release is assumed as a point source, which is the most conservative assumption. The concentration data associated with the release were contained in or derived from January 6, 1986 to February 14, 1994 weekly water quality reports for FAST and are considered to be reasonable nonzero release source terms at the 95% confidence level. Although surveillance at the FAST facility occurs daily with radiological surveys occurring weekly, the aqueous release assumes that the liner and/or piping leaks and secondary containment failure go undetected for one month.

The specific radionuclide activities in the release solution are assumed as follows: 280 pCi/L strontium-90, 3360 pCi/L cobalt-60, 160 pCi/L cobalt-57[a], 93 pCi/L cesium-137, and 100 pCi/L antimony-125. All of the constituents in this assessment are radionuclides. Contaminant migration is through the vadose zone through the saturated zone to the Columbia River, and in the Columbia River to receptors downstream. The flow discharge in the Columbia River is assumed to be under low-flow conditions 1000 m3 per second (36,000 cubic feet per second) (Whelan et al. 1987), which represents the most conservative case for maximizing surface water concentrations. As a conservative assumption, the removal of water from the Columbia River is assumed to be 100 meters (328 feet) downstream of the contaminant influent point to the river. The assessment addresses recreational activities (e.g., boating, swimming and fishing) in the Columbia River and use of the water as a drinking-water supply and for bathing, irrigation etc. The risk of fatal cancers considering all pathways was found to be significantly less than one chance in a trillion. For more information, refer to Whelan et al. (1994).

The Decentralization Alternative also includes an operational release scenario to the Hanford 200 Area Treated Effluent Disposal Facility (TEDF). Liquid effluents would be added to the TEDF, which receives liquid effluent from many facilities in the 200 Area. The "Discharge Target" allowable concentrations in the TEDF are presented in Bergsman (1995). Only 380 liters (100 gallons) per day will be discharged to the TEDF basin from this operation, although other facilities unrelated to SNF storage will also be discharging to the basin. For a ponded situation, the maximum outflow from the basin is equal to the transmission rate (i.e., saturated hydraulic conductivity under a unit hydraulic gradient) of the soil immediately below the basin, which is 24 cubic meters per day (6260 gallons per day). To maximize the flow velocity through the vadose zone and the mass flux of contaminant leaving the basin (i.e., concentration x area x flow velocity), the assessment assumes that this facility leaks into the vadose zone over a 4-year period with the infiltration rate limited by the transmissi soil. The discharge from the pond is assumed to last for 4 years from 2002 through 2006.

Based on the movement of the second tritium plume from the Plutonium and Uranium Recovery through Extraction cribs in the 200 Area to Well 699-24-33, a distance of 6 kilometers (4 miles) in a 5-year period (1983 to 1988), the average pore-water velocity (i.e., specific discharge divided by the effective

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a. Cobalt-57 is substituted in the analysis for cobalt-58 because the MEPAS database contains only cobalt-57.

porosity) in the saturated zone was 3.3 meters per day (10.8 feet per day) (Schramke et al. 1994). Davis et al. (1993) performed a more recent analysis and determined the pore-water velocity as 0.02 meters per day (0.08 feet per day) just below the TEDF site, although this is not necessarily indicative of the velocity as the water moves toward the river. Both velocities were initially used in assessing the migration of contamination from the basin to determine the most conservative result with respect to risk. In the final analysis, the highest pore-water velocity of 3.3 meters per day (10.8 feet per day) was used because 1) it is consistent with other assessments at the installation, 2) the contaminants reached the river and receptors earlier, and 3) the resulting exposure analysis provided the more conservative estimate of risk over the 7000-year assessment time frame.

Radionuclides, chemical carcinogens, and noncarcinogens are contained in the waste stream. The concentrations in the TEDF were represented by the discharge target allowable concentrations. Contaminant migration is from the ponded water, through the vadose zone, through the saturated zone to the Columbia River, and in the Columbia River to receptors downstream. The flow discharge in the Columbia River is assumed to be under low-flow conditions of 1000 cubic meters per second (36,000 cubic feet per second) (Whelan et al. 1987), which represents the most conservative case for maximizing surface water concentrations. As a conservative assumption, the removal of water from the Columbia River is assumed to be 100 meters (328 feet) downstream of the point of entry of the contaminant into the river. The assessment addressed recreational activities (e.g., boating, swimming, and fishing) in the Columbia River and use of the water as a drinking-water supply and for bathing, irrigation, etc.

The maximum radionuclide and chemical carcinogenic risks were found to be less than 50 chances in a billion for all of the constituents through all of the exposure routes. Likewise, noncarcinogenic chemical individual doses were found to be below their respective reference doses, except chromium VI, which had a dose about 50 percent higher than the reference dose. Chromium VI had an assigned distribution coefficient (i.e., Kd) of zero (Serne and Wood 1990), which represents the most mobile condition in the vadose zone. For more information, refer to Whelan et al. (1994).

5.8.3 1992/1993 Planning Basis Alternative

Scenarios and consequences relating to water quality would be the same as for the Decentralization Alternative. For more information, refer to Whelan et al. (1994).

5.8.4 Regionalization Alternative

Scenarios and consequences relating to water quality in the Regionalization options would be the same as for water quality aspects in the Decentralization Alternative. For more information, refer to Whelan et al. (1994).

5.8.5 Centralization Alternative

Scenarios and consequences relating to water quality would be the same as for the Decentralization Alternative. For more information, refer to Whelan et al. (1994).

5.9 Ecological Resources

Implications of implementing the alternatives for interim storage of SNF on terrestrial resources, wetlands, aquatic ecosystems, and threatened and endangered species at the Hanford Site are discussed in the following subsections.

5.9.1 No Action Alternative

Implications of implementing the No Action Alternative for interim storage of SNF on terrestrial resources, wetlands, aquatic resources, and threatened and endangered species at the Hanford Site are discussed in the following subsections.

5.9.1.1 Terrestrial Resources. No new SNF facilities would be

constructed at Hanford and there would be no impacts to the terrestrial resources of the Hanford Site beyond those resulting from natural processes of succession and the impacts of ongoing Hanford operations. They would remain as described under Section 4.9.1.

5.9.1.2 Wetlands. No new SNF facility would be constructed; therefore,

no changes to wetlands on the Hanford Site would be expected beyond those changes resulting from natural processes and the impacts of ongoing Hanford operations (see Section 4.9.3).

5.9.1.3 Aquatic Resources. No new SNF facility would be constructed

and the fact that there are no surface water facilities on the SNF facility site indicates that there would be no impacts on the aquatic resources of the Hanford Site other than those changes resulting from natural processes and the impacts of ongoing Hanford operations and they would remain as described in Section 4.9.3.

5.9.1.4 Threatened and Endangered Species. No new SNF facilities would

be constructed and operated at Hanford. Thus, populations of species listed as endangered or threatened, or candidates for such listing by the federal and Washington State governments, or species listed as monitor species by the Washington State government would not be impacted (either directly by displacement or indirectly by habitat alteration) beyond effects resulting from ongoing Hanford operations and natural processes.

5.9.1.5 Radioecology. Releases of radionuclides to the environment are

expected to be on the order of those released in the recent past by site operations (Woodruff and Hanf 1993), and thus will not be accumulated into terrestrial or aquatic ecosystems in concentrations that could cause measurable impacts.

5.9.2 Decentralization Alternative

Implications of implementing the Decentralization Alternative for interim storage of SNF on terrestrial resources, wetlands, aquatic resources, and threatened and endangered species at the Hanford Site are discussed in the following subsections.

5.9.2.1 Terrestrial Resources. This alternative would require the construction of an SNF facility for fuel management and storage. Most spent fuel from the Hanford Site would be stored here.

Construction of an SNF facility at Hanford would disturb up to 9 hectares (24 acres) on the 65 hectare (160 acres) site, representing about 0.01 percent of the total area of the Hanford Site. Approximately 9 hectares (24 acres) would be occupied by facilities, access roads, or rights-of-way and therefore, would remain developed for the life of the project. The remaining land would be revegetated with native grasses and shrubs upon completion of construction.

Vegetation within construction areas would be destroyed during land-clearing activities. Plant species that are dominant on the Hanford SNF site, and thus would be most affected, include big sagebrush, cheatgrass, and Sandberg's bluegrass. Total area destroyed would amount to about less than 1 percent of this community on the Hanford Site. Although the plant communities to be disturbed are well-represented on the Hanford Site, they are relatively uncommon regionally because of the widespread conversion of shrub-steppe habitats to agriculture. Disturbed areas are generally recolonized by cheatgrass, a nonnative species, at the expense of native plants. Mitigation of these impacts could include minimizing the area of disturbance and revegetating with native species, including shrubs, and establishing a 2:1 acreage replacement habitat in concert with a habitat enhancement plan presently being developed for the Hanford Site in general. Adverse impacts to vegetation on Hanford are expected to be limited to the project area and vicinity and are not expected to affect the viability of any plant populations on the Hanford Site.

Construction of an SNF facility and support facilities would have some adverse affect on animal populations. Less mobile animals such as invertebrates, reptiles, and small mammals within the project area would be destroyed during land-clearing activities. Larger mammals and birds in construction and adjacent areas would be disturbed by construction activities and would move to adjacent suitable habitat, and these individual animals might not survive and reproduce. Project facilities would displace about 9 hectares (up to 24 acres) of animal habitat for the life of an SNF facility. Revegetated areas (e.g., construction laydown areas and buried pipeline routes) would be reinvaded by animal species from surrounding, undisturbed habitats. The adverse impacts of construction are expected to be limited to the project area and vicinity and should not affect the viability of any animal populations on the Hanford Site because similar suitable habitat would remain abundant on the site.

Very small quantities of radionuclides would be released to the atmosphere during SNF facility operations. No organisms studied to date are reported to be more sensitive than man to radiation (NRC-8). Therefore, as concluded for humans, the effects of these releases on terrestrial organisms are expected to be minor.

These impacts to the vegetation and animal communities could be mitigated by minimizing the amount of land disturbed during construction, employing soil erosion control measures during construction activities, and revegetating disturbed areas with native species. These measures would limit the amount of direct and indirect disturbance to the construction area and surrounding habitats and would speed the recovery process for disturbed lands.

Operational impacts to terrestrial biotic resources would include exposure of plants and animals to small amounts of radionuclides released during operation of the SNF facility. The levels of radionuclide exposure would be below those levels that produce adverse effects.

5.9.2.2 Wetlands. No wetlands occur on or near the SNF facility site,

so no impacts from the construction and operation of the facility to wetlands would occur. Wetlands resources on the Hanford Site would remain as described in Section 4.9.2. No mitigation efforts would be required because no wetlands would be affected.

5.9.2.3 Aquatic Resources. No aquatic habitats occur on the SNF site;

thus, no impacts to aquatic resources are expected from the construction and operation of the SNF facility. No mitigation efforts would be required because no impacts are anticipated to aquatic resources.

5.9.2.4 Threatened and Endangered Species. Construction and operation

of the SNF facility would remove approximately 9 hectares (24 acres) of relatively pristine big sagebrush/ cheatgrass-Sandberg's bluegrass habitat. This sagebrush habitat is considered priority habitat by the State of Washington because of its relative scarcity in the state and its use as nesting/ breeding habitat by loggerhead shrikes, sage sparrows, sage thrashers, burrowing owls, pygmy rabbits, and sagebrush voles. Bald Eagles, peregrine falcons, and Oregon silverspot butterflies do not inhabit the potential proposed site.

Loggerhead shrikes, listed as a federal candidate (Category 2) and state candidate species, forage on the proposed SNF site and are relatively common on Hanford. This species is sagebrush-dependent, as it is known to select primarily tall big sagebrush as nest sites. Construction of the SNF facility would remove big sagebrush habitat which would preclude loggerhead shrikes from nesting there. SNF site development would also be expected to reduce the value of the site as foraging habitat for shrikes known to nest in adjacent areas.

Sage sparrows and sage thrashers, both state candidate species, occur in mature sagebrush/ bunchgrass habitat at Hanford. Sage thrashers were not observed on the SNF site, and are extremely rare on the Hanford Site. These species are known to nest primarily in sagebrush. Construction of the SNF facility would preclude both of these species nesting there and reduce the site's suitability as foraging habitat for these species.

SNF construction is not expected to substantially decrease the Hanford population of loggerhead shrike, sage sparrow, or sage thrashers because similar sagebrush habitat is still relatively common on the Hanford Site. However, the cumulative effects of constructing the SNF facility, in addition to future developments that further reduce sagebrush habitat (causing further fragmentation of nesting habitat), could negatively affect the long-term viability of populations of these species on the Hanford Site.

Burrowing owls, a state candidate species, are relatively common on the Hanford Site and nest in abandoned ground squirrel burrows on the proposed SNF site. SNF construction would remove sagebrush and disturb soil, displacing ground squirrels and thus reducing the suitability of the area for nesting by burrowing owls. Construction would also displace small mammals, which constitute a portion of the prey base for this species. Construction for an SNF facility would, however, not be expected to negatively impact the viability of the population of burrowing owls on Hanford, as their use of ground squirrel burrows as nests is not limited to burrows in big sagebrush habitat.

Pygmy rabbits, a federal candidate (Category 2) and state threatened species, are known to utilize tall clumps of big sagebrush habitat throughout most of their range. However, this species has not recently been observed on the Hanford Site. Construction of the SNF facility would therefore reduce the potential for recolonization by this species by removing habitat suitable for its use.

Sagebrush voles, a state monitor species, are common on the Hanford Site and select burrow sites near sagebrush; however, this species is common only at higher elevations around the Hanford Site. Construction of the SNF facility would remove sagebrush habitat, precluding sagebrush voles from utilizing the site. However, construction would not affect the overall viability of sagebrush vole populations on the Hanford Site because the majority of the population is found on the Fitzner/Eberhardt Arid Lands Ecology Preserve.

The closest known nests of ferruginous hawks, a federal candidate (Category 2) and state threatened species, and Swainson's hawk, a state candidate, are 8.5 km (5 mi) and 6.2 km (3.7 mi), respectively, from the proposed SNF site. The SNF site comprises a portion of the foraging range of these hawks. Construction of the SNF facility is not expected to disrupt the nesting activities of these species. However, construction would displace small mammal populations and thus reduce the prey for these birds. The cumulative effects of constructing the SNF facility, in addition to future reductions in sagebrush habitat (causing further fragmentation of foraging habitat), could negatively affect the long-term viability of populations of these two species on Hanford.

5.9.2.5 Radioecology. Releases of radionuclides to the environment are

expected to be below those currently released by site operations (Woodruff and Hanf 1993), and thus will not be accumulated into terrestrial or aquatic ecosystems in concentrations that could cause measurable impacts.

5.9.3 1992/1993 Planning Basis Alternative

The 1992/1993 Planning Basis Alternative differs from the Decentralization Alternative only in that TRIGA fuel currently stored at the Hanford Site would be shipped to INEL for storage. (It is possible that the TRIGA fuel may be transferred to third parties for beneficial use prior to the planned time of shipment to INEL.) Thus, impacts on terrestrial resources, wetlands, aquatic resources, threatened and endangered species, and radioecology at the Hanford Site would be essentially the same as described for the Decentralization Alternative.

5.9.4 Regionalization Alternative

All new facilities would be constructed on the 65 hectare (163-acre) site west of 200-East Area (Figure 4.1). Although impacts on terrestrial resources are expected to be minimal, the impacts that would occur would be roughly proportional to the amount of land that would be disturbed during construction. For the various options of the Regionalization Alternative, those areas would amount to the following amounts of land:

A) From about 2 to 7 hectares (5 to 18 acres) when all SNF except defense production SNF would be sent to INEL.

B1) From about 15 to 17 hectares (38 to 43 acres) when all SNF west of the Mississippi River except Naval SNF would be sent to Hanford.

B2) From about 25 to 28 hectares (63 to 70 acres) when all SNF west of the Mississippi River and Naval SNF would be sent to Hanford.

C) From about 2 to 5 hectares (5 to 12 acres) when all Hanford SNF would be sent to INEL or NTS.

While the largest area cited above (28 hectares) is about three times the size of the area to be disturbed in the Decentralization Alternative, it is still a very small fraction of similar habitat on the Hanford Site. By and large the discussion on flora and fauna presented in Section 5.9.2 applies to the Regionalization Alternative, bearing in mind that the area involved would be more or less depending on the option chosen.

5.9.5 Centralization Alternative

If Hanford is selected as the site for the Centralization Alternative, an SNF facility, as substantially described in the Decentralization Alternative, would be constructed at Hanford. Although the facility would store about 25 weight percent more SNF than would be stored under the Decentralization Alternative and the number of casks would increase the required space, the ecological impacts would be essentially the same as those described in Section 5.9.2.

If Hanford is not selected as the site for the Centralization Alternative, an SNF packaging facility would be built to prepare the fuel for shipment offsite. While that facility would not be as extensive as the SNF facility, the ecological impacts would not likely be importantly different from those described in Section 5.9.3 for the Decentralization Alternative.

5.10 Noise

Implications of implementing the alternatives for interim storage of SNF on noise levels at the Hanford are discussed in the following subsections.

5.10.1 No Action Alternative

Under this alternative, new SNF facilities would not be constructed, and the noise associated with SNF facility construction and operation activities would not occur. Because no major changes in existing noise-emitting sources are expected at Hanford during the projected SNF facility construction period, the ambient noise levels at Hanford would be expected to remain essentially the same for the no-action alternative as during the baseline period.

5.10.2 Decentralization Alternative

This alternative would require the construction and operation of an SNF facility for fuel management and storage. Most spent fuel from the Hanford Site would be stored here. The results of a detailed analysis of the potential noise impacts from constructing and operating a new production reactor (project since cancelled) and its support facilities at Hanford have been published. The analysis indicates that noise from constructing a facility the size of a production reactor, and from operational facilities, equipment, and machines, would not cause ambient noise levels to exceed the limits set by the Washington State noise control regulations or EPA guidelines. The latter are set to protect the public from the effect of broadband environmental noise and to protect the public against hearing loss. The results also indicate that increases in noise levels from constructing and operating a facility the size of a production reactor and its support facilities, including increased traffic along the major roadways, would result in little or no increase in the annoyance level experienced by communities or individuals.

No significant noise impacts from activities associated with SNF facility construction and operation are expected at sensitive receptor locations outside the Hanford boundary or at residences along the major highways leading to the proposed SNF site at Hanford.

5.10.3 1992/1993 Planning Basis Alternative

The 1992/1993 Planning Basis Alternative differs from the Decentralization Alternative only in that TRIGA fuel currently stored at the Hanford Site would be shipped to INEL for storage. (It is possible that the TRIGA fuel may be transferred to third parties for beneficial use prior to the planned time of shipment to INEL.) Thus, impacts would be essentially the same as described for the Decentralization Alternative.

5.10.4 Regionalization Alternative

All new facilities would be constructed on the 65 hectare (163-acre) site west of 200-East Area (Figure 4.1). Although noise is not expected to be a factor in evaluating the alternatives, the amount and duration of noise associated with construction would be roughly proportional to the amount of land that would be disturbed during construction. For the various options of the Regionalization Alternative, those areas would amount to the following amounts of land:

A) From about 2 to 7 hectares (5 to 18 acres) when all SNF except defense production SNF would be sent to INEL.

B1) From about 15 to 17 hectares (38 to 43 acres) when all SNF west of the Mississippi River except Naval SNF would be sent to Hanford.

B2) From about 25 to 28 hectares (63 to 70 acres) when all SNF west of the Mississippi River and Naval SNF would be sent to Hanford.

C) From About 2 to 5 hectares (5 to 13 acres) when all Hanford SNF would be sent to INEL or NTS.

Although not likely to be heard offsite, the duration of noise that is generated would range from about a quarter to three times that described for the Decentralization Alternative depending on the Regionalization option chosen.

5.10.5 Centralization Alternative

If Hanford is selected as the site for centralization of SNF, new SNF facilities would be constructed at Hanford. Although somewhat larger than for the Decentralization Alternative, the impacts from noise would be the same as those described in Subsection 5.10.2.

5.11 Traffic and Transportation

The implications of implementing the alternatives for interim storage of SNF on traffic and incident-free onsite transportation of SNF and materials supporting SNF storage at the Hanford are discussed in the following subsections. The impacts of offsite transportation of SNF are discussed in Appendix I.

5.11.1 No Action Alternative

Implications of implementing the No Action Alternative for interim storage of SNF on traffic and incident-free onsite transportation of SNF and materials supporting SNF storage are discussed in the following subsections.

5.11.1.1 Traffic. Under the No Action Alternative, the number of

workers would stay the same as under present conditions; therefore, there would be no change in traffic patterns. At present, there are periods of moderate traffic congestion, some of which is expected to be alleviated by a new road to the 200 areas.

5.11.1.2 Transportation. The RISKIND (Yuan et al. 1993) and RADTRAN 4

(Neuhauser and Kanipe 1992) computer codes were applied to calculate the radiation doses to transport workers and the public that are estimated to result from incident-free onsite transportation of SNF. RISKIND was also used to calculate the consequences of bounding transportation accidents. All of the onsite SNF shipments were assumed to emit radiation that would result in a dose rate at the regulatory limit (i.e., 0.01 rem per hour at 2 meters (6 feet) from the external surface of the shipments). This assumption contributes to the conservatism of the analysis because the shipment dose rates cannot be larger than this value but frequently will be substantially smaller. All shipments were assumed to be made by truck. A detailed description of the approach and other important shipment-related parameters are discussed in Volume 2, Chapter 5, and Appendix I. Hanford-specific information and input parameters are presented in this section.

The doses per incident-free shipment of each type of SNF were calculated using RISKIND and RADTRAN 4. The potential receptors considered are the transportation crew of two, on-link (on the road) and off-link (persons near the roadway) populations. Guards and/or inspectors may also be exposed to the shipments. Guards and inspectors may be exposed when they prepare a shipment to leave its origin facility or prepare to receive a shipment that has arrived at a destination facility. Guards and inspectors may also be exposed while the shipment is enroute between facilities. Guard and inspector doses at origin and destination facilities are included in the doses calculated in Section 5.13. Most onsite shipments originate in the 200 and 100 Areas and will not travel through a guarded checkpoint. The guard/inspector doses for these shipments are zero. Only the miscellaneous fuel shipments originating in the 300 Area and the FFTF shipments originating in the 400 Area will travel past a guarded checkpoint (see Wye Barricade in Section 4.11). Doses to the guards at the Wye Barricade were calculated assuming they were exposed briefly at a distance of 5 meters, (16 feet) from the shipment, as described in Volume 2, Chapter 5. The computer code RISKIND was used to calculate maximum and individual doses; RADTRAN 4 was used to calculate collective population doses.

Five general classes of SNF were considered in this analysis. These include N Reactor fuel, FFTF fuel, single-pass reactor (SPR) fuel, PWR Core-II fuel, and miscellaneous fuel. A sixth type of fuel, fuel wastes in EBR-II metal casks, was assumed to have similar shipping characteristics to miscellaneous fuels. Some of the key shipment characteristics for these fuels are presented in Table 5.11-1, including the SNF material forms, quantities, shipment capacities, and numbers of shipments. Radionuclide inventories for the various types of fuel shipments are provided in Table 5.11-2. The radionuclide inventories were derived from the irradiated fuel inventories and characteristics provided by Bergsman (1994, 1995) and the shipment characteristics listed in Table 5.11-2.

The population densities of the different areas of the Hanford Site across which shipments must travel will influence the transportation impacts. Doses to persons along the highways (i.e., off-link doses) will be received only by Hanford Site workers for onsite shipments.

Table 5.11-1. Spent nuclear fuel shipment characteristics.

Fuel Type	Material Form	Quantity, Assemblies	Shipment Capacit Assemblies/shipme
N Reactor	Uranium metal clad with Zircalloy-2	Short: 66,300 Long: 63,700	Short: 128 Long: 96
FFTF	Mixed uranium-plutonium oxide in stainless steel tubes	317	4
Single-pass reactor	Uranium metal enclosed in aluminum jackets	1,100	900
PWR Core-II	Natural uranium oxide clad in zirconium alloy	72	1
Fuel wastes in EBR-II metal casks	Plutonium-uranium compounds sealed in stainless steel canisters	24 casks	1 cask per shipme
Miscellaneous	Various uranium compounds from research and development programs	77	4

a. This column provides the number of onsite shipments projected to occur in the D 1992/1993 Planning Basis, Regionalization, and Centralization Alternatives. For th Alternative, one shipment of N Reactor fuel currently at PUREX and all of the misce assumed to be transported onsite.

Table 5.11-2. Radionuclide inventories for shipments of each type of spent nuclear fuel on the Hanford Site (Ci/shipment). ,b

Radio-nuclide	FFTF	N Reactor	PWR Core-II fuel	Single-pass reactor
H-3	2.1E+02	3.9E+03	1.6E+02	3.9E+03
Mn-54	7.0E+02	0.0E+00	0.0E+00	0.0E+00
Fe-55	6.9E+02	1.1E+03	6.1E+03	1.1E+03
Co-60	7.3E+02	7.9E+02	4.2E+03	7.9E+02
Ni-63	6.0E+01	0.0E+00	2.7E+03	0.0E+00
Kr-85	1.8E+03	7.5E+04	1.6E+03	7.5E+04
Sr-90	1.3E+04	8.7E+05	1.8E+04	8.7E+05
Y-90	1.3E+04	8.7E+05	1.8E+04	8.7E+05
Ru-106	1.8E+04	7.1E+03	2.9E+02	7.1E+03
Rh-106	1.8E+04	7.1E+03	2.9E+02	7.1E+03
Sb-125	3.7E+03	1.6E+04	1.1E+03	1.6E+04
Te-125m	9.1E+02	4.3E+03	2.6E+02	4.3E+03
Cs-134	5.2E+03	1.9E+04	1.6E+03	1.9E+04
Cs-137	3.6E+04	1.1E+06	3.6E+04	1.1E+06
Ba-137m	3.4E+04	1.0E+06	3.4E+04	1.0E+06
Ce-144	6.3E+03	4.1E+03	0.0E+00	4.1E+03
Pr-144	6.3E+03	4.1E+03	0.0E+00	4.1E+03
Pr-144m	7.6E+01	0.0E+00	0.0E+00	0.0E+00
Pm-147	2.8E+04	2.9E+05	4.5E+03	2.9E+05
Sm-151	1.4E+03	1.3E+04	1.9E+02	1.3E+04
Eu-154	1.0E+03	1.3E+03	2.1E+03	1.3E+03
Eu-155	3.2E+03	4.8E+03	7.6E+02	4.8E+03
U-233	0.0E+00	0.0E+00	0.0E+00	0.0E+00
U-234	0.0E+00	1.5E+00	0.0E+00	1.5E+00
U-235	2.0E-04	6.7E-02	0.0E+00	6.7E-02
U-238	2.7E-02	1.0E+00	0.0E+00	1.0E+00
Np-237	4.6E-02	3.5E-02	0.0E+00	3.5E-02
Pu-238	6.6E+02	0.0E+00	1.1E+03	0.0E+00
Pu-239	1.4E+03	1.8E+02	2.8E+02	1.8E+02
Pu-240	1.5E+03	4.5E+01	3.7E+02	4.5E+01
Pu-241	6.3E+04	1.7E+03	6.8E+04	1.7E+03
Pu-242	5.2E-01	3.0E-03	0.0E+00	3.0E-03
Am-241	8.0E+02	3.1E+01	1.6E+03	3.1E+01
Cm-243	4.6E+01	0.0E+00	0.0E+00	0.0E+00
Cm-244	8.8E+01	0.0E+00	7.9E+02	0.0E+00

a. Radionuclide inventory data were derived from information in Bergsman (1994) and WHC (1993c).

b. For radionuclides that are indicated to have 0.0 Ci per shipment, the quantities of fission and activation are less than 5 Ci/assembly and less than 10 g/assembly for actinides. Radionuclides not listed on the table are also less than these quantities.

c. Fuel inventories for EBR-II casks are assumed to be applicable to miscellaneous fuels. The SNF in EBR-II casks and miscellaneous SNF consist primarily of irradiated light-water reactor fuels.

The population densities for each work area on the site, used for occupational dose calculations, are listed in Table 5.11-3. The off-link doses are included in the occupational dose results.

For the calculation of doses to persons traveling on the highways (i.e., on-link doses), two-lane highways were assumed and the number of persons per vehicle was assumed to be 2.0. No vehicle stops were included in the calculations because the shipments are not long enough to warrant intermediate stops for food and rest. One-way traffic densities were based on traffic counts provided in DOE (1989). Because average traffic densities were not available in that document and there are no administrative restrictions on time of day when SNF transport could occur, the peak count on a given route segment (vehicles per day) was used to calculate the traffic density for that route. The traffic densities used for the five types of SNF and shipping distances for the various fuel types are provided below.

- FFTF Fuel - 640 vehicles per hour; 28 kilometers one-way shipping distance

- N Reactor Fuel - 170 vehicles per hour; 16 kilometers one-way shipping distance
- PWR Core II Fuel - 180 vehicles per hour; 5 kilometers one-way shipping distance
- Single-pass Reactor Fuel - 100 vehicles per hour; 16 kilometers one-way shipping distance
- EBR-II/300 Area Miscellaneous Fuel - 640 vehicles per hour; 37 kilometers one-way shipping distance.

Table 5.11-3. Population densities for work areas at Hanford.

Work Area	Worker Population	Land Area, km2	Worker Density, per km2
100 B and C	4	1.7	3
100 D and DR	4	1.5	3
100 H	4	0.7	6
100 K	124	0.9	140
100 N	360	1.0	360
200 West	1968	9.5	210
200 East	2923	9.0	330
300	2487	1.5	1700
400	638	2.1	300
600	514	1450	0.35
WPPSS	1125	4.4	260

The computer code RISKIND was used to calculate the doses to Maximally-Exposed Individual (MEI) members of the public as discussed in Volume 2, Chapter 5. Two exposure scenarios were modeled, including a "tailgater" and a "bystander." The dose received by a tailgater was calculated by assuming that an individual precedes or follows an SNF shipment for the entire duration of a shipment. The exposure distance was assumed to be 48.8 meters (160 feet). The dose calculated in Volume 2, Chapter 5, was based on a 37 kilometers (23 miles) shipping distance, which is also the same as the longest shipping distance anticipated for SNF shipments at Hanford (300 Area to the 200 Area). Therefore, the public MEI dose amounts to 0.015 millirem per tailgating incident.

The dose to a "bystander" was calculated in Volume 2, Chapter 5, to be 0.0014 millirem. This dose was calculated assuming a shipment passes by an individual at an average speed of 56 kilometers per hour (35 miles per hour) at a distance of 1 meter (3 feet) from the shipment. This individual was postulated to be standing on the side of the road as an SNF shipment passes by and was assumed to be exposed only one time.

The dose to the maximally-exposed worker from incident-free transportation will be received by the truck crew. The dose to the truck crew was calculated using the maximum allowable dose rate in the truck cab (2 millirem per hour) for all shipments. It was assumed that the maximum-exposed worker will accompany all of the spent fuel shipments, even though the dose will most likely be apportioned over a larger number of workers. The total dose received by this individual was calculated by multiplying the maximum dose rate by the total shipping time. The total shipping time for the various alternatives was determined by dividing their total shipping distances by the average speed, 56 kilometers per hour (35 miles/hour).

The results of the analysis of the No Action Alternative are presented in Table 5.11-4. As shown, two shipment campaigns occur in this alternative; 1) shipment of N Reactor fuels at PUREX to the 105-K basins for storage and 2) shipment of miscellaneous SNF in the 300 Area to the 200 Area to be placed in dry storage. The total radiological impacts from incident-free transportation in this alternative are dominated by the shipments of miscellaneous fuels from the 300 Area to the 200 Area. This is primarily because there are approximately 24 shipments of miscellaneous fuels, and the N Reactor fuel at PUREX will make up only a fraction of a shipment.

Table 5.11-4. Impacts of incident-free transportation for the No Action Alternative.

Impactsb	General Populationc	Occupational
Total Dose (person-rem)	7.8E-02	1.2E-01
Cancer Fatalities	3.9E-05	4.7E-05

a. The N Reactor fuel currently at PUREX is the only N Reactor fuel transported in this alternative. The impacts of transporting this fuel were calculated by adjusting the impacts of transporting all N Reactor fuel (0.3 MTHM at PUREX/2096 MTHM total N Reactor fuel).

b. Total detriment, which includes latent cancer fatalities, nonfatal cancers, and genetic effects in subsequent generations, can be calculated by multiplying the total dose to the general population by 7.3E-04 effects per person-rem and the total occupational dose by 5.6E-04 effects per person-rem.

c. Rural population density.

The doses to the maximally-exposed workers and members of the public are summarized below:

- The dose to a tailgater was calculated to be 0.015 millirem.
- The dose to a bystander was calculated to be 0.0014 millirem.
- The dose to a truck crewman that accompanies all of the spent fuel shipments in the No Action Alternative was calculated to be about 46 millirem.

The RISKIND computer code was used to calculate the radiological consequences of accidental releases of radioactive material during transportation. Consequences of severe, reasonably foreseeable accidents were calculated to workers and the offsite population. Workers were placed at a distance that maximizes the dose from a potential release. Hanford-specific population density data (see Beck et al. 1991) were used to assess the integrated doses to the offsite public, as described in Volume 2, Chapter 5.

As discussed in Appendix I, maximum radiological impacts were calculated for a severe, reasonably foreseeable accident. For this assessment, the consequences were assessed to populations and individuals assuming the most severe accident scenario with a probability greater than 1E-07. The methods and data described in Appendix I were used to calculate the accident probabilities of the various shipments in the No Action Alternative. Hanford-specific numbers of shipments and shipping distances were used in the calculations. Accident rate information from Saricks and Kvitek (1991) for urban areas in the State of Washington were used in the calculations. The results of these calculations indicate that the probabilities of the severe accident defined in Appendix I for the irradiated fuels transported in the No Action Alternative are less than the 1E-07 criteria. The most likely severe accident scenario was determined to be one involving shipments of miscellaneous fuels from the 300 Area. The probability of such an accident was calculated to be about 1E-09. As shown in Table 5.11-5, this is also the highest-consequence accident scenario for the No Action Alternative.

The impacts of potential severe transportation accidents for the No Action Alternative are shown in Table 5.11-5. The maximum exposed individual and public collective doses are shown in Table 5.11-5 for shipments of miscellaneous SNF in the 300 Area to dry storage in the 200 Area. This was determined to be the most severe reasonably foreseeable onsite transportation accident scenario for the No Action Alternative, even though its probability is significantly smaller than 1E-07, as discussed above. As shown, consequence estimates are presented for two atmospheric dispersion conditions; 1) neutral (Pasquill stability class D, wind speed = 4 meters per second) and 2) stable (Pasquill stability class F , wind speed = 1 meters per second).16

Table 5.11-5. Impacts of accidents during transportation for the No Action Alternative.

Dose Consequence	Cancer Fatalities

Exposure Group	Stability Category		Stability Category	
	D	F	D	F
Offsite Populationb	1.4E+01 person-rem	1.1E+02 person-rem	6.8E-03	5.5E-
Maximum Exposed Individual	5.0E-01 rem	1.7E+00 rem	2.0E-04	6.7E-

a. The maximum-consequence onsite transportation accident for the No Action Alternative is one involving a shipment of miscellaneous fuels currently located in the 300 Area. This is also the most likely accident scenario, but its probability is below the 1E-07 criteria for a maximum reasonably foreseeable accident.

b. Rural population density.

Nonradiological impacts consist of fatalities that may result from traffic accidents as well as health effects from pollutants emitted from vehicles involved in onsite shipments of spent nuclear fuel. These risks are unrelated to the radioactive nature of the materials being transported. Nonradiological impacts from accidents were calculated using unit risk factors derived by Saricks and Kvitek (1991) that convey the estimated number of fatalities per unit distance traveled. The total nonradiological impacts are calculated by multiplying the total shipping distance traveled by onsite shipments by the appropriate unit risk factors.

The total nonradiological transportation impacts for the No Action Alternative were calculated to be less than one (1.9E-05) fatality.

5.11.2 Decentralization Alternative

Implications of implementing the Decentralization Alternative for interim storage of SNF on traffic and incident-free onsite transportation of SNF and materials supporting SNF storage are discussed in the following subsections.

5.11.2.1 Traffic. Under the Decentralization Alternative, the number

of construction workers would range from about 220 to 870. During operations, the number of workers would range from about 1100 to 1300, depending on the option selected. This would add from 1 to 6 percent to the present workforce and to additional commuting traffic on the Hanford Site, assuming that the proportion of workers that take the bus to work or drive their own vehicles remains essentially constant.

5.11.2.2 Transportation. The same approaches and basic assumptions and

data described in Section 5.11.1.2 for the No Action Alternative were used to assess the impacts of onsite transportation for the Decentralization Alternative. The key differences between the alternatives are the numbers of shipments and destinations. More SNF is transported in this alternative than in the No Action Alternative. In this alternative, all N Reactor SNF in the 105-K Basins is to be transported to the 200 Area for processing and/or storage, depending upon the particular suboption selected. The FFTF fuel is to be transported from the 400 Area to the 200 Area for storage. The PWR Core-II, single- pass reactor fuels, and 300 Area miscellaneous fuels are also to be transported to a new facility in the 200 Area for storage.

Table 5.11-6 presents the incident-free transportation impacts for the Decentralization Alternative. As shown in Table 5.11-6, the truck crews are the largest exposure group. The total doses were found to be dominated by the exposures received during transportation of N Reactor fuel. This is because there are significantly more truck shipments of N Reactor fuel in this alternative than shipments of other types of fuel.

The doses to the maximally-exposed workers and members of the public are summarized below:

- The dose to a tailgater was calculated to be 0.015 millirem.
- The dose to a bystander was calculated to be 0.0014 millirem.
- The dose to a truck crewman that accompanies all of the spent fuel shipments in the Decentralization Alternative was calculated to be about 800 millirem.

The worker MEI dose is higher than that calculated for the No Action Alternative because there are many more onsite spent fuel shipments in the Decentralization Alternative.

Table 5.11-7 presents the impacts of potential severe transportation accidents for the Decentralization Alternative. The maximum exposed individual and public collective doses are shown in Table 5.11-7 for two accident scenarios: the highest probability and highest consquence. As explained in the table footnotes, the probabilities of both scenarios are less than MEI 1E-07 criteria discussed in Appendix I. As shown, consequence estimates are presented for

Table 5.11-6. Impacts of incident-free transportation for the Decentralization Alternative.

Impacts[a]	General Population[b]	Occupational
Total Dose (person-rem)	4.3E-01	1.7E+00
Cancer Fatalities	2.2E-04	6.8E-04

a. Total detriment, which includes latent cancer fatalities, non-fatal cancers, and genetic effects in subsequent generations, can be calculated by multiplying the total dose to the general population by 7.3E-04 effects per person-rem and the total occupational dose by 5.6E-04 effects per person-rem.

b. Rural population density.

Table 5.11-7. Impacts of accidents during transportation for the Decentralization Alternative.

		Dose Consequence		Cancer Fatalities
Accident Scenario	Exposure Group	Stability Category		Stability Category
		D	F	D
Highest Probability[a]	Offsite Population b	1.7E+01 Person-rem	1.4E+02 Person-rem	8.6E-03
	Maximum Exposed Individual	7.2E-01 Rem	2.4E+00 Rem	2.9E-04
Highest Consequence[c]	Offsite Population	1.7E+02 Person-rem	1.3E+03 Person-rem	8.4E-02
	Maximum Exposed	5.4E+00 Rem	1.8E+01 Rem	2.2E-03

Individual

a. The highest-probability accident is one involving a shipment of N Reactor fuel. The probability of this accident scenario was calculated to be approximately 5E-8 over the entire N-Reactor fuel shipping campaign.
b. Rural population density.
c. The highest-consequence accident scenario was determined to be one involving shipments of FFTF fuel. However, the probability of the accident scenario analyzed here is approximately 6E-09, which is below the 1E-07 probability criteria for a reasonably foreseeable accident.
two atmospheric dispersion conditions; 1) neutral (Pasquill stability class D, wind speed = 4 meters per second) and 2) stable (Pasquill stability class F , wind speed = 1 meters per second). This table is different from Table 5.11-5 (No Action Alternative) because of the additional fuel types transported in the Decentralization Alternative.

The total nonradiological transportation impacts for the Decentralization Alternative were calculated to be 6.6E-04 fatalities. The nonradiological transportation impacts of this alternative are significantly higher than the impacts of the No Action Alternative because the numbers of shipments, and thus total shipment mileage, is significantly higher.

5.11.3 1992/1993 Planning Basis Alternative

Implications of implementing the 1992/1993 Planning Basis Alternative for interim storage of SNF on traffic and incident-free onsite transportation of SNF and materials supporting SNF storage are discussed in the following subsections.

5.11.3.1 Traffic. Because the only difference between the

Decentralization Alternative and the 1992/1993 Planning Basis Alternative is the shipment of the small amount of TRIGA fuel offsite, traffic patterns would not be significantly different from those described for the Decentralization Alternative.

5.11.3.2 Transportation. The impacts of onsite transportation for the

1992/1993 Planning Basis Alternative are substantially the same as the impacts of the Decentralization Alternative (see Section 5.11.2). The only difference between these two alternatives is the disposition of the TRIGA fuel in the 308 Building. The quantity and number of TRIGA fuel shipments is small relative to the other fuel types so the disposition of the TRIGA fuels will have a negligible impact on the results presented in Tables 5.11-3 and 5.11-4.

5.11.4 Regionalization Alternative

Implications of implementing the Regionalization Alternative for interim storage of SNF on traffic and incident-free onsite transportation of SNF and materials supporting SNF storage are presented in this section. The onsite transportation requirements for the four Regionalization Alternative options are as follows:

- Option A - Defense production fuel will be shipped from the 105-K basins and Plutonium and Uranium Recovery through Extraction to a new facility in the 200 Area for storage. All other fuel will be shipped offsite; the transportation impacts of offsite shipments are addressed in Appendix I.

- Option B1 - All SNF located or to be generated west of the Mississippi River will be sent to Hanford for storage, except for Naval SNF. Shipments of SNF from offsite locations are addressed in Appendix I. The onsite SNF will be transported from its current locations to the 200 Area for storage. In terms of onsite transportation impacts, this option is essentially the same as the Decentralization Alternative (see Section 5.11.2).
  - Option B2 - The same as Option B1 except that Naval SNF will also be transported to Hanford. This alternative would result in the same onsite transportation impacts as Option B1.

- Option C - All Hanford SNF will be transported offsite to a facility at INEL or NTS. Offsite transportation impacts are addressed in Appendix I.

5.11.4.1 Traffic. Under the Regionalization Option A, the number of

construction workers would range from about 180 to 1200, depending on the option selected. During operations, the number of workers would range from about 280 to 320, depending on the suboption selected. This would add from less than 1 to about 5 percent to the present workforce and to additional commuting traffic on the Hanford Site, assuming that the proportion of workers that take the bus to work or drive their own vehicles remains essentially constant. Assuming that all of the N Reactor fuel shipments travel 16 kilometers (10 miles) one way (approximate distance from the 100 Areas to the 200 Area), a total of about 40,000 vehicle-kilometers are needed for the N Reactor fuel shipments in this option. It was stated in Section 4.11 that in 1988 DOE vehicles logged over 19,000,000 vehicle-kilometers (12,000,000 vehicle-miles) at Hanford. The increase in vehicle mileage resulting from the Regionalization Option A, assuming that all the Hanford SNF shipments will be made in one year, is less than 1 percent above the 1988 base DOE-vehicle mileage.

For the Regionalization options B1 and B2, the impacts on traffic would be essentially the same as those described for the Decentralization Alternative (see Section 5.11.2.1).

The Regionalization Option C involves offsite shipments of Hanford fuel. The number of Hanford workers would stay approximately the same as the No Action Alternative. The impacts on traffic are predominantly related to the additional vehicles on the highways that are carrying Hanford fuels to INEL or NTS. Assuming that all of the onsite Hanford fuel shipments travel 48 kilometers (30 miles) one way (approximate distance from the 100 Areas to the 300 Area), a total of about 130,000 vehicle-miles are needed for the onsite segments of these shipments. It was stated in Section 4.11 that in 1988 DOE vehicles logged over 12,000,000 miles at Hanford. The increase in vehicle mileage resulting from Regionalization Option C, assuming that all the Hanford fuel shipments will be made in one year, is about 1 percent above the 1988 base DOE-vehicle mileage.

5.11.4.2 Transportation. In Regionalization Option A, all N Reactor

SNF in the 105-K basins and at PUREX would be transported to the 200 Area for processing and/or storage, depending on the particular suboption selected. The FFTF, PWR Core-II, single-pass reactor fuels, and 300 Area miscellaneous fuels are to be transported to INEL. Offsite transportation impacts are addressed in Appendix I. Onsite transportation impacts for this option, therefore, would consist of the impacts of transporting N Reactor fuel from the 105-K basins and PUREX to the 200 Area.

The transportation impacts of this option were calculated by determining the impacts of transporting N Reactor fuel on a per-shipment basis and then multiplying the total number of shipments. The methods and input data described in Section 5.11.1 were used to calculate the per-shipment impacts. The results of the transportation impact calculations for the Regionalization Option A are as follows:

- Incident-free transportation impacts: Public exposures - 2.4E-01 person-rem (9.6E-05 LCFs); Worker exposures - 1.4E+00 person-rem (5.6E-04 LCFs).
- Impacts of transportation accidents: Public, Pasquill Stability Class D - 1.7E+01 person-rem (8.6E-03 LCFs); Public - Pasquill Stability Class F - 1.4E+02 person-rem (6.8E-02 LCFs). Maximum exposed individual, Pasquill Stability Class D - 7.2E-01 rem (2.9E-04 LCFs); Maximum exposed individual Pasquill Stability Class F - 2.9E+00 rem (9.6E-04 LCFs). See the "highest probability" accident in Table 5.11-7.
- Nonradiological impacts: 5.6E-04 fatalities.

The incident-free doses to the maximally-exposed workers and members of the public are summarized below:

- The dose to a tailgater was calculated to be 0.015 millirem.
- The dose to a bystander was calculated to be 0.0014 millirem.
- The dose to a truck crewman who accompanies all of the SNF shipments in Regionalization Option A was calculated to be about 680 millirem.

The worker MEI dose is higher than that calculated for the No Action Alternative because there are many more onsite spent fuel shipments in the Regionalization Option A. The worker MEI dose is lower than that calculated for the Decentralization Alternative because only N Reactor fuel is shipped onsite in Regionalization Option A, and all fuel types are shipped onsite in the Decentralization Alternative.

In Regionalization options B1 and B2, all Hanford SNF would be shipped onsite from its current locations to the 200 Area. Traffic and transportation impacts for both Regionalization options B1 and B2 would be essentially the same as those calculated for the Decentralization Alternative.

In Regionalization Option C, all of the Hanford Site SNF would be shipped to and stored at either INEL or NTS. Because all of the shipments of Hanford SNF would be considered to be offsite shipments, the impacts are addressed in Appendix I. For Hanford, this option is identical to the Centralization Alternative, minimum option.

5.11.5 Centralization Alternative

Implications of implementing the Centralization Alternative for interim storage of SNF on traffic and incident-free onsite transportation of SNF and materials supporting SNF storage are discussed in the following subsections.

5.11.5.1 Traffic. Traffic patterns would be essentially the same as

for the Decentralization Alternative if Hanford were selected to receive all DOE SNF. The patterns would last for up to twice as long because of the additional fuel to be brought to the reprocessing/ stabilization and storage facility (although there is only 25 weight percent more fuel to be shipped, it would likely require smaller quantities per shipment because of its higher heat load). If all Hanford fuel were to be shipped offsite, traffic patterns would not be significantly different from those of the No Action Alternative.

5.11.5.2 Transportation. The Centralization Alternative results in the

same onsite transportation impacts as the Decentralization Alternative. In the Decentralization Alternative, all Hanford Site SNF will be transported to the 200 Areas for further processing and/or storage, depending on the specific option. In the Centralization Alternative, all Hanford Site SNF is transported to either a stabilization/packaging facility in the 200 Area for preparation for offsite shipment or to the Central Storage Facility to be located in the 200 Area. All of these cases requires onsite shipment of Hanford SNF from their current locations to a 200 Area facility. Therefore, the onsite transportation impacts for the Centralization Alternative are the same as those for the Decentralization Alternative (see Section 5.11.2).

5.12 Occupational and Public Health and Safety

Implications of implementing the alternatives for interim storage of SNF on worker and public health and safety at the Hanford Site are discussed in the following subsections. By and large this material consists of summary material extracted from Section 5.7, "Air Quality and Related Consequences;" 5.8, "Water Quality and Related Consequences;" 5.11, "Traffic and Transportation;" and 5.15, "Accidents."

5.12.1 No Action Alternative

Radiological and nonradiological consequences relating to occupational and public health and safety for the No Action Alternative are presented in the following subsections.

5.12.1.1 Radiological Consequences. The consequences of air emissions

from routine operations of existing facilities utilized in the No Action Alternative include a maximum annual dose of 1E-5 rem to a potential onsite worker with a 5E-9 probability of fatal cancer. The collective annual dose to workers in spent fuel storage facilities is 24 person-rem per year (Bergsman 1995), which would require about 60 years of such operation to accumulate a collective worker dose from which one fatal cancer might be inferred.

The dose to an offsite resident at the highest exposure location is estimated as 3E-6 rem/year, and the corresponding probability of fatal cancer is 1E-9.

The peak collective dose to the population within 80 kilometers (50 miles) is 3E-2 person-rem per year, which is predicted to result in less than one fatal cancer (about 36,000 years of such operation would be required to reach a dose from which one fatal cancer might be inferred).

5.12.2 Decentralization Alternative

Radiological and nonradiological consequences relating to occupational and public health and safety for the Decentralization Alternative are presented in the following subsections.

5.12.2.1 Radiological Consequences. The consequences of air emissions from individ-

ual facilities in the Decentralization Alternative are summarized in Table 5.7-8 an include a maximum annual dose of 2E-9 rem to a potential onsite worker (8E-13 probability of fatal cancer) for any combination of wet or dry spent fuel storage facilities. The dose to an offsite resident at the highest exposure location is estimated as 6E-10 rem per year, and the corresponding probability of fatal cancer is 3E-13. The peak collective dose to the population within 80 km is 2E-5 person-rem per year, which is predicted to result in less than one fatal cancer. The collective annual dose to workers at SNF facilities for a combination of wet and dry storage facilities is 2 person-rem per year for maintenance and operations. Loading the new facilities would require an additional 17-18 person-rem depending on the form of dry storage. For dry storage only, the dose from initial loading would be 7-12 person-rem, and there would be no dose from normal operations (Bergsman 1995).

For dry storage of defense fuel, stabilization prior to dry storage is included in the routine operations of the Decentralization Alternative, and additional emissions would result from these activities. The dose to the onsite worker from air emissions would increase by 4E-6 rem/year for a shear/leach/calcine process or 3E-5 rem/year for a solvent extraction process (2E-9 or 1E-8 probability of fatal cancer, respectively). Collective worker dose at fuel stabilization facilities would range from 44 person-rem per year at a shear/ leach/ calcine facility to 78 person-rem per year at a solvent extraction facility over the 4 years in which these facilities are expected to operate (Bergsman 1995). The dose to an individual worker in the facility is assumed to be limited by administrative controls to no more than 0.5 rem per year.

The consequences from stabilization for the offsite resident would be 7E-6 rem per year (4E-9 prob- ability of fatal cancer) for the shear/leach/ calcine facility and 2E-5 rem per year (1E-8 probability of fatal cancer) for the solvent extraction facility. The collective dose to the offsite population from the respective fuel stabilization facilities is estimated at 0.3 to 1 person-rem per year, resulting in less than one fatal cancer (would require from about 1000 to 3700 years of such exposure to reach a dose from which one fatal cancer might be inferred).

5.12.3 1992/1993 Planning Basis Alternative

Because the activities are similar, radiological consequences of routine operations for the 1992/1993 Planning Basis Alternative are considered to be the same as those for the Decentralization Alternative.

5.12.4 Regionalization Alternative

Radiological and nonradiological consequences relating to occupational and public health and safety for the Regionalization Alternative are presented in the following subsections.

5.12.4.1 Radiological Consequences. Because of the similarity of

activities, the radiological consequences of routine operations for the Regionalization Alternative Option A are considered to be the same as those for the Decentralization Alternative. The consequences to the public of options B and C are the same as described in the following section for the Centralization Maximum and Minimum options, respectively. Consequences to onsite workers would differ based on the processing and storage options for onsite fuel as in the decentralization alternative, as well as on the quantity of imported fuel to be received and placed into dry storage under each option. The consequences over the 40-year storage period range from 98 to 320 person-rem for option A, 700-920 person-rem for options B1 and B2, and 190-320 person-rem for option C. No fatal cancers would be expected as a result of implementing any of these options.

5.12.5 Centralization Alternative

Radiological and nonradiological consequences relating to occupational and public health and safety for the Centralization Alternative are presented in the following subsections.

5.12.5.1. Radiological consequences of air emissions from routine

operations in the Centralization Alternative include a maximum annual dose of 9E-9 rem to a potential onsite worker (4E-12 probability of fatal cancer) for any combination of wet or dry spent fuel storage facilities.
The collective
annual dose to SNF facility workers for a combination of wet and dry storage facilities is 2 person-rem per year for maintenance and operations. Loading the new facilities would require an additional 19-22 person-rem depending on the form of dry storage. For dry storage only, the dose from initial loading would be 9-12 person-rem, and there would be no dose from normal operations (Bergsman 1995). Shear/leach/calcine and solvent extraction activities would add 44 or 78 person-rem per year, respectively, and the receiving, canning, and technology development facilities would entail an additional 20 person-rem per year.

The dose from air emissions to an offsite resident at the highest exposure location is estimated as 2E-9 rem per year, and the corresponding probability of fatal cancer is 8E-13. The peak collective dose to the population within 80 kilometers (50 miles) is 7E-5 person-rem per year, which is predicted to result in less than one fatal cancer. These estimates do not include relocation of the expended core facility to Hanford, which is discussed in Appendix D to Volume 1 of this EIS. Assumptions used in the Appendix D calculations for consequences of locating an expended core facility at Hanford may differ from those used for other Hanford facilities.

5.13 Site Services

Implications of implementing the alternatives for interim storage of SNF on site services at the Hanford Site are discussed in the following subsections.

5.13.1 No Action Alternative

Implementing the No Action Alternative would require no significant additional consumption of material or energy; however, about 12,000 megawatt-hours per year are currently used for SNF management activities.

5.13.2 Decentralization Alternative

Incremental requirements for materials and energy in construction associated with the Decentralization Alternative are shown in Table 5.13-1. Annual consumption of energy during operations is similar to that used during construction for the water storage options (W and X), the total would be a small fraction of the present consumption rate. Annual consumption of energy during operations in the options where defense production fuel is stabilized is significantly greater; however it is still within the capacity of existing facilities.

Table 5-13-1. Materials and energy required for Decentralization suboptions.

Item	Option		
	W	X	Y
Concrete, thousand cubic meters/(cubic yards)	13 (17)	15 (20)	17 (23)
Carbon steel, thousand tonnes (tons)	2.4 (2.7)	2.8 (3.1)	3.3 (3.6)
Stainless steel, thousand tonnes (tons)	0.1 (0.1)	0.1 (0.1)	0
Copper, thousand tonnes (tons)	0	0	0
Lumber, thousand cubic meters (board feet)	1.2 (500)	1.4 (570)	1.6 (650)
Asphalt, sand, and crushed rock, thousand cubic meters (thousand cubic yards)	0.6 (0.8)	0.7 (0.9)	0.8 (1.1)
Electricity			
Construction (MW-hrs)	2500	2900	3500
Operations (MW-hrs/yr)	1600	1600	100
Diesel fuel, thousand cubic meters (thousand gallons)	0.5 (130)	0.6 (150)	0.7 (175)
Gasoline, thousand cubic meters (thousand gallons)	0.5 (130)	0.6 (150)	0.7 (175)
Construction Cost ($ Million)	265	280	350

a. Assumes operation of the process facility (28,000 or 115,000 MW-hrs/yr) concurrently with those facilities where SNF is currently stored (12,000 MW-hrs/yr, as in the No Action Alternative) for an interim period less than 4 years.

In the Decentralization Alternative, an extension of existing utilities to the project site area would likely be necessary. This would include water mains, electrical power lines, sewage facilities, telephone lines, etc. All of these utilities are available in the adjacent 200-East Area. In addition, an existing rail line might need to be upgraded for increased traffic, and construction of new spurs going to various proposed new facilities would likely be required. The project would be served by an 8-inch water main capable of delivering 7600 liters per minute (2000 gallons per minute). Facilities would be designed to preclude discharge of water except for sanitary waste.

5.13.3 1992/1993 Planning Basis Alternative

Energy requirements in the 1992/1993 Planning Basis Alternative would be essentially the same as those cited above for the Decentralization Alternative.

5.13.4 Regionalization Alternative

Material and energy requirements in the Regionalization Option A would be slightly less than those cited above for the Decentralization Alternative. Material and energy requirements in the Regionalization options would be similar to those cited above for the Decentralization Alternative, although the construction requirements would occur over most of the interim storage period. Incremental requirements for materials and energy in construction associated with the Regionalization options are shown in Tables 5.13-2 and

5.13-3. For the Regionalization options that involve fuel from other

locations being stored at the Hanford Site, the requirements shown are for fuel received from other locations and are in addition to those shown in **Table 5.13-1 for fuel already at the Hanford Site.** For the Regionalization option that has no fuel stored at the Hanford Site, the requirements shown are the total incremental requirements.

5.13.5 Centralization Alternative

Similar to the Decentralization Alternative, annual consumption of energy during operations is similar to that used during construction for the water storage options (W and X), and the total would be a small fraction of the present consumption rate. Annual consumption of energy during operations in the options where defense production fuel is stabilized is significantly greater; however it is still within the capacity of existing facilities. Materials and energy requirements for construction in the Centralization Alternatives are shown in Table 5.13-4. Similar to the Regionalization options, the Centralization Alternative that involves fuel from other locations being stored at the Hanford Site shows the requirements associated with storing the fuel received from other locations and are in addition to those shown for fuel already at the Hanford Site in Table 5.13-1. For the Centralization option that has no fuel stored at the Hanford Site, the requirements shown are the total incremental requirements.

In the Centralization Alternative where all SNF is brought to the Hanford Site, an extension of existing utilities to the project site area would be necessary. This would include water mains, electrical power lines, sewage facilities, telephone lines, etc. All of these utilities

Table 5-13-2. Materials and energy required for Regionalization A suboptions.

Item	Option		
	W	X	Y
Concrete, thousand cubic meters/(cubic yards)	9 (12)	9 (12)	16 (21)
Carbon steel, thousand tonnes (tons)	1.7 (1.9)	1.7 (1.9)	3.0 (3.4)
Stainless steel, thousand tonnes (tons)	0.1 (0.1)	0.1 (0.1)	0
Copper, thousand tonnes (tons)	0	0	0
Lumber, thousand cubic meters (board feet)	0.8 (350)	0.8 (350)	1.4 (600)
Asphalt, sand, and crushed rock, thousand cubic meters (thousand cubic yards)	0.5 (0.6)	0.5 (0.6)	0.8 (1.0)
Electricity			
Construction (MW-hrs)	1800	1800	3200
Operations (MW-hrs/yr)	1600	1600	100
Diesel fuel, thousands cubic meters (thousand gallons)	0.4 (100)	0.4 (100)	0.6 (160)
Gasoline, thousand cubic meters (thousand gallons)	0.4 (100)	0.4 (100)	0.6 (160)
Construction Cost ($ Million)	200	200	340

a. Assumes operation of the process facility (28,000 or 115,000 MW-Hrs/yr) concurrently with those facilities where SNF is currently stored (12,000 MW-Hrs/yr, as in the No Action Alternative) for an interim period less than 4 years.

Table 5-13-3. Materials and energy required for construction of Regionalization B and C options.

Item	Option		
	SNF Stored at the Hanford Site Without Naval SNF	SNF Stored at the Hanford Site With Naval SNF	No SNF Store at the Hanfo Site
Concrete, thousand cubic meters/(cubic yards)	54 (70)	115 (150)	18 (23)
Carbon steel, thousand tonnes (tons)	8.2 (9)	19.1 (21)	3.1 (3.4)
Stainless steel thousand tonnes (tons)	0.1 (0.1)	0.1 (0.1)	0.4 (.5)
Copper, thousand tonnes (tons)	0	0	0.05 (0.05)
Lumber, thousand cubic	4.8 (2000)	10 (4200)	1.6 (660)

meters (board feet)			
Asphalt, sand, and crushed rock, thousand cubic meters (thousand cubic yards)	2.5 (3.3)	5.4 (7.1)	0.8 (1.1)
Electricity			
Construction (MW-hrs)	16,000	30,000	3400
Operations (MW-hrs/yr)a	100-127,000	100-127,000	0-20,000
Diesel fuel, thousand cubic meters (thousand gallons)	1.9 (500)	4.2 (1100)	0.6 (170)
Gasoline, thousand cubic meters (thousand gallons)	1.9 (500)	4.2 (1100)	0.6 (170)
Construction Cost ($ Million)	765	1465	560

a. Minimum value represents requirements during the period after all fuel has been placed into dry storage, or has been shipped offsite. Maximum value represents requirements during the interim period (less than 4 years) while SNF is being processed and prepared for storage or shipment offsite, assuming concurrent operation of the process facility and the existing facilities where SNF is currently stored (as in the No Action Alternative).

are available in the adjacent 200-East Area. In addition, an existing rail line might need to be upgraded for increased traffic and the construction of new spurs to various proposed new facilities would likely be required.

The following section describes the material requirements for operation of facilities in each SNF alternative and the corresponding quantities of waste generated by these activities. Table 5.14-1 lists the breakdown by alternative and suboption of the various types of waste generated by SNF management facilities.

Table 5-13-4. Materials and energy requirements for construction of Centralization options.

Item	No Fuel Stored at the Hanford Site	All Offsite Fuel Stored at the Hanford Site
Concrete, thousand cubic meters (cubic yards)	18 (23)	150 (200)
Carbon Steel, thousand tonnes (tons)	3.1 (3.4)	25 (27.5)
Stainless Steel, thousand tonnes (tons)	0.4 (0.5)	0.1 (0.1)
Copper, thousand tonnes (tons)	0.045 (0.05)	0
Lumber, thousand cubic meters (board feet)	1.6 (660)	13 (5600)
Asphalt, Sand, and Crushed Rock (thousand cubic meters (thousand cubic yards)	0.8 (1.1)	7.2 (9.5)
Electricity		
Construction (MW-hrs)	3400	40,000
Operations (MW-hrs/yr)a	0-20,000	100-127,000
Diesel fuel, thousand cubic meters (thousand gallons)	0.6 (170)	5.7 (1500)
Gasoline, thousand cubic meters (thousand gallons)	0.6 (170)	5.7 (1500)
Construction Cost ($ Million)	560	1950

a. Minimum value represents requirements during the period after all fuel has been placed into dry storage, or has been shipped offsite. Maximum value represents requirements during the interim period (less than 4 years) while SNF is being processed and prepared for storage or shipment offsite, assuming concurrent operation of the process facility and the existing facilities where SNF is currently stored (as in the No Action Alternative).

5.14 Materials and Waste Management

5.14.1 No Action Alternative

The No Action Alternative involves only fuel storage at existing facilities, and material requirements for the current configuration are minimal. The exception is make-up water for the 105-K fuel storage basins, which amounts to 2.8 million cubic meters per year.

The quantity of waste generated in the No Action Alternative is also relatively small because the only planned modifications to existing facilities are safety and security upgrades to the 105-K basins. About 530 cubic meters of low-level waste would result from containerization of SNF in 105-KE Basin, and small quantities of radioactive and mixed waste are generated at the 325 Building.

Table 5.14-1. Waste generation for spent nuclear fuel management alternatives.

Waste Type	No Action	Decentralization		
		W	X	Y
Construction Waste (m3, total)	0	1500	1700	170
High-Level Radioactive Waste (m3/y)	0	0	0	0
Transuranic Waste (m3/y)	0	0	0	0
Low-Level Radioactive Waste (m3/y)c	95	41	50	0
Mixed Waste (Low-Level Radioactive and Hazardous, (m3/y)	0.96	0.23	0.23	0
Non-radioactive Hazardous Waste (m3/y)	2.3	1.1	1.1	0

a. These quantities are associated with new facilities that would be required for to Hanford from other sites. They represent incremental increases over those for f required to manage SNF currently at Hanford, which are discussed in the No-Action a Alternatives.

b. A new ECF is not included in these totals; requirements for this facility are d Appendix D.

c. Annual totals do not include containerization of defense production reactor SNF 105-K basins. This activity is expected to generate 530 cubic meters of low-level period of approximately 2 years.

Table 5.14-1. (contd)

Waste Type	Regionalization			
	AX	AY	AZ	AP
Construction Waste (m3, total)	900	1600	2100	
High-Level Radioactive Waste (m3/y)	0	0	0	
Transuranic	0	0	0	

Waste (m3/y)			
Low-Level Radioactive Waste (m3/y)[c]	61	0	0
Mixed Waste (Low-Level Radioactive and Hazardous, (m3/y)	0.23	0	0
Non-radioactive Hazardous Waste (m3/y)	1.1	0	0

a. These quantities are associated with new facilities that would be required for to Hanford from other sites. They represent incremental increases over those for f required to manage SNF currently at Hanford, which are discussed in the No-Action a Alternatives.

b. A new ECF is not included in these totals; requirements for this facility are d Appendix D of this document.

c. Annual totals do not include containerization of defense production reactor SNF 105-K basins. This activity is expected to generate 530 cubic meters of low-level period of approximately 2 years.

5.14.2 Decentralization Alternative

Material requirements for the Decentralization Alternative depend on the suboption chosen. The suboptions involving wet storage of production reactor fuel (suboptions W and X) require make-up water for the storage basin at approximately 2300 cubic meters per year. Material requirements for dry storage of fuel (suboptions Y and Z) are minimal, and consist of decontamination chemicals in small quantities. Those suboptions including processing of production reactor fuel (suboptions P and Q, which would be combined with either Y or Z) require relatively large quantities of nitric acid (2000 - 4000 cubic meters per year) and other process chemicals in smaller quantities.

Construction waste generated for each of the suboptions depends on the size and number of facilities required. Dry storage of all fuel, including processing of production reactor fuel, would result in the largest quantity of construction waste, which is assumed to be nonradioactive, nonhazardous solids. Radioactive and hazardous waste from operations is also greater for the dry storage suboption with processing. Wet storage of production reactor fuel and dry storage of other onsite fuel results in the smallest quantity of both construction and operational hazardous waste.

5.14.3 1992/1993 Planning Basis Alternative

This alternative would be essentially the same as the Decentralization Alternative at Hanford.

5.14.4 Regionalization Alternative

Regionalization Alternative Option A would be essentially the same as the Decentralization Alternative at Hanford in terms of operational material requirements and waste generation because these originate largely from the storage pool or process facilities, depending on the suboption selected. The quantity of construction waste would be smaller because the dry storage capacity for nondefense production fuel would not be needed.

The Regionalization Alternative B options would require materials in similar quantities to the Decentralization Alternative, but would generate construction and operational wastes in greater quantities because of additional facilities that would be necessary to receive, package, and store imported SNF. Note that the waste quantities reported in Table 5.14-1 represent incremental increases for SNF facilities above those listed for the Decentralization Alternative.

The Regionalization Alternative Option C involves only stabilization of defense production fuel and packaging of all Hanford SNF for shipment offsite. It is identical to the Centralization Alternative minimum option as described in Section 5.14.5.

5.14.5 Centralization Alternative

The Centralization Alternative minimum option for offsite shipment of Hanford fuel requires construction of a stabilization and canning facility, which would produce annual quantities of construction and operational wastes similar to those for onsite combined wet and dry storage (suboptions W and X) in the Decentralization Alternative. However, these wastes would only be generated for the time required to stabilize and package fuel for offsite shipment (approximately 4 years).

Centralization at Hanford (maximum option) would include the same suboptions as Decentralization for SNF currently at Hanford, and the material requirements and waste generation would be identical. For SNF imported from other sites, additional dry storage capacity would be needed, and new additional facilities to package and examine the fuel would be constructed. The estimates in Table 5.14-1 for Centralization at Hanford represent incremental increases for these additional facilities above those in the Decentralization Alternative. They do not incorporate the additional requirements of the Expended Core Facility, which are discussed in Volume 1, Appendix D of this document. Operational material requirements for the incremental dry storage capacity would be minimal, as would be the quantities of waste generated. Construction of the new facilities would generate nonhazardous solid waste in quantities greater than any of the other options, but operation of the additional facilities would produce relatively small quantities of radioactive and hazardous waste.

5.15 Facility Accidents

Implications of facility accidents associated with implementing the alternatives for SNF storage at Hanford are discussed in the following section. The method used to screen and select accidents for analysis is described, as are the procedures for evaluating the consequences of selected accidents, and the results of the analysis. Additional detail concerning specific accidents and parameters used in the analysis is provided in Attachment A, Facility Accidents.

5.15.1 Historical Accidents Involving SNF at Hanford

There are no known instances at Hanford where storage, handling, or processing of SNF has resulted in an accident that involved a significant release of radioactive or other hazardous materials to the environment or that resulted in detrimental exposure of workers or members of the public to hazardous materials.

5.15.2 Emergency Preparedness Planning at Hanford

Although the safety record for operations at Hanford and other DOE facilities is generally good, DOE-RL and all Hanford Site contractors have established Emergency Response Plans to prepare for and mitigate the consequences of potential emergencies on the Hanford Site (DOE 1992c). These plans were prepared in accordance with DOE Orders and other federal, state, and local regulations. The plans describe actions that will be taken to evaluate the severity of a potential emergency and the steps necessary to notify and coordinate the activities of other agencies having emergency response functions in the surrounding communities. They also specify levels at which the hazard to workers and the public are of sufficient concern that protective action should be taken. The Site holds regularly scheduled exercises to ensure that individuals with responsibilities in emergency planning are properly trained in the procedures that have been implemented to mitigate the consequences of potential accidents and other events.

5.15.3 Accident Screening and Selection for the EIS Analysis

The alternatives for SNF storage considered in this EIS necessitate evaluation of accidents at a variety of different types of facilities. In the No Action Alternative, the facilities consist of those where SNF is currently stored on the Hanford Site, or those where SNF will be stored at the time of the record of decision. All facilities considered in the No Action Alternative currently exist at the Hanford Site, and no construction of new facilities is assumed. For many of these facilities, storage of SNF is incidental to other activities that take place in the buildings. For the other alternatives (Decentralization, Regionalization, 1992/1993 Planning Basis, and Centralization), construction of new facilities dedicated solely to SNF management is assumed.

Accidents evaluated for existing facilities at Hanford consisted of maximum reasonably foreseeable accidents described in such previously published analyses as safety or NEPA documentation. The source documents for specific accidents evaluated in this section are referenced in the detailed accident descriptions in Attachment A. In the case of new facilities, hypothetical accidents were based on operation of similar facilities at Hanford or other sites. Depending on the time at which the source document was prepared, the number and types of accidents considered for each facility would be somewhat variable. However, the screening process used in the relatively recent analyses considers a wide scope of accident initiators and scenarios, including industrial accidents (fires, explosions, overpressurization, loss of containment or confinement), criticality, operator error or injury, external hazards (surface vehicle or aircraft impact), waste management, natural phenomena (seismic events, wind, floods, volcanic activity), interactions with activities at adjacent facilities (construction, maintenance, operations), and common cause events (power failure). Older safety documents generally address these issues as well, although perhaps not with the same rigor as newer analyses. Transportation accidents are considered in a separate section of this appendix and are not discussed here.

Acts of terrorism are accounted for indirectly in the present analysis because the potential consequences of terrorist activities are used to determine security requirements for a given facility. Security measures are implemented to mitigate the impact, or reduce the probability, of high consequence events. Therefore, reasonably foreseeable scenarios for terrorist activities would entail risks that are similar to those for the types of accident initiators generally considered in the source documents that provide the basis for this analysis.

For the purposes of this EIS, accidents are ideally grouped into three categories based on their estimated frequencies as follows: abnormal events (frequency >10-3 per year), design basis accidents (frequencies <10-3 to 10-6 per year), and beyond design basis accidents (frequency <10-6 to 10-7 per year). Because the accident categories commonly used for development of safety documents encompass different probability ranges, the estimated frequencies (or frequency ranges) for Hanford facility accidents are reported as indicated in the source document without regard to the accident frequency categories established for use in the EIS. For accidents where only a range rather than a point estimate of frequency is available, the frequency of the accident is reported as being less than the highest frequency that defines the range. In alternatives that consider SNF imported from other sites (such as other DOE facilities or U.S. and foreign research reactors), frequencies for specific accidents have been adjusted to account for increased fuel handling at receiving, canning, and storage facilities.

Accident frequencies as reported in safety documents (Safety Analysis Reports and related analyses) typically represent the overall probability of the accident, including the probability of the initiating event combined with the frequency of any contributing events required for an environmental release to occur. The contributing events may include equipment or barrier failures, or failures of other mitigating systems designed to prevent accidental releases. In general, the safety documents do not evaluate the consequences of events with expected frequencies of <10-6 per year because such accidents are not considered reasonably foreseeable; therefore, accidents in the beyond design basis category are generally not evaluated for this analysis. Evaluation of aircraft traffic at the Richland and Pasco, Washington airports determined that impacts of commercial or military aircraft were less than 1x10-7 for a facility in the Hanford 300 Area, which is at highest risk because of its location (PNL 1992a). Therefore, aircraft accidents are not considered further in this analysis as initiators for accidents at Hanford SNF management facilities.

As noted previously, the safety documents for SNF facilities generally considered a broad range of accidents; however, only the consequences of the maximum reasonably foreseeable accidents for each facility in a given alternative were evaluated for this document. Of the existing facilities assessed in the No Action Alternative, most are multipurpose facilities with diverse missions such as research or process development. These facilities typically contain relatively small quantities of SNF relative to the 105-K basins, where the bulk of Hanford's existing SNF is stored. The accidents evaluated in the source documents for multipurpose facilities may therefore reflect activities other than SNF storage or handling. The risks for such accidents are reported in this EIS for completeness, although in some cases, neither the frequency nor the consequences associated with the accident depend on the presence of SNF in the facility.

5.15.4 Method for Accident Consequence Analysis

In the No Action Alternative, accident consequence analyses utilized release estimates as presented in the source document for a given existing facility. For new facilities, release estimates were based on historical operation of similar facilities at Hanford. These estimates were also assumed to represent typical accidental releases in alternatives that consider storage of fuel from offsite locations, such as other DOE facilities or U.S. and foreign research reactors. Accidents evaluated for the research reactor fuels indicate that releases for such specialized fuels would be comparable to those included in this analysis (DOE 1993b; Hale and Reutzel 1993). The assumptions used to determine radionuclide releases are included in Attachment A.

Because most source documents (other than the more recent Safety

Analysis Reports) do not evaluate hazardous materials other than radionuclides, a different approach was used for accidents involving nonradioactive materials. The hazardous material inventories for each facility were used to estimate releases based on the physical state of each compound as described in Attachment A. Specific initiators and accident scenarios were generally not postulated for nonradioactive materials; therefore, frequencies were not estimated for hazardous chemical accidents.

The downwind concentrations for materials released in accidents were then calculated at receptor locations as defined for the EIS. The receptors included a worker who is onsite but outside the facility where the accident takes place, a member of the public who is temporarily at the nearest access location (such as a road that crosses the site or at the site boundary), and the maximally exposed offsite resident. Collective dose to the population within 80 kilometers (50 miles) was also calculated for radionuclide releases. Individual dispersion calculations were performed using 95 percent atmospheric conditions (those resulting in air concentrations that would not be exceeded more than 5 percent of the time). Dose to the population was calculated using both 50 percent and 95 percent atmospheric dispersion parameters. Dispersion calculations were performed using the GENII computer code (Napier et al. 1988) for radionuclide releases and the EPIcode (Homann 1988) for nonradioactive compounds.

The radiation dose to each receptor evaluated for the EIS was recalculated for the specific conditions and release location as appropriate to each alternative using the GENII computer code. Doses were calculated as the effective dose equivalent using standard assumptions for the Hanford Site as summarized in Schreckhise et al. (1993). Health effects were also estimated as probability of fatal cancer based on recommendations of the International Commission on Radiological Protection in its Publication 60 (ICRP 1991). The accident doses were recalculated for this analysis using a consistent, reasonably conservative set of methods and assumptions and to include the complete set of receptors that are to be evaluated in the EIS. This was necessary because the methods used in the source documents were not necessarily consistent and in some cases were outdated. For this reason, the doses developed for this analysis may differ from those reported in the source documents that describe the accidents; however, they should be viewed as a screening analysis for the purposes of the EIS and are not intended to replace or invalidate the previous results.

Individual doses were based on exposure of the receptor during the entire release, except where the release time was sufficiently long that such an assumption is unrealistic. For releases that were expected to last more than a few hours, the exposure duration for onsite workers and members of the public at accessible onsite locations was limited to 2 hours, corresponding to the maximum time required to evacuate the Hanford Site in the event of an accident. Offsite residents were assumed to be exposed during the entire release, regardless of the accident duration. Exposure via inhalation and external pathways (groundshine and submersion in the plume) were considered for workers and the nearest public access receptors; ingestion of contaminated food was evaluated only for offsite residents. Because protective action guidelines specify mitigative actions to prevent consumption of contaminated food, the ingestion dose to offsite individuals and populations is reported separately from the other exposure routes. Reduced exposure to the plume or to contaminated ground surface as a result of early evacuation of offsite populations is not assumed for the purposes of this analysis, although such actions would also be mandated if the projected dose from an accident exceeded the protective action guidelines. Because the circumstances and consequences postulated for workers at the scene of an accident are so speculative, they serve no useful purpose in the decision-making process. As a consequence, discussion of impacts on "close-in" workers are not brought forward into the text of this Appendix. Consequences in terms of the "close-in" workers for one scenario in each accident may be found in Attachment A.

5.15.5 Radiological Accident Analysis

5.15.5.1 No Action Alternative. The No Action Alternative consists of

fuel storage at existing Hanford facilities, including the 100-K wet storage basins; T Plant, and a low-level burial ground in the 200-West Area; the 308, 324, 325, and 327 buildings in the 300 Area; and the Fast Flux Test Facility (FFTF) in the 400 Area. Of these facilities, only the 100-K storage basins and the FFTF fuel storage facility are primarily devoted to SNF storage; the others are all multipurpose facilities that house a variety of activities in addition to storing relatively small quantities of SNF. The consequences and risks of accidents associated with these facilities are described in Tables 5.15-1 through 5.15-5.

The maximum reasonably foreseeable accident for multipurpose facilities is an earthquake scenario at the 324 Building, which releases non-SNF related radioactive material that has accumulated in a hot cell (Table 5.15-1 through **Table 5.15-5).** The contributions of other activities at the facility, including SNF storage, are estimated to be relatively minor. The maximum reasonably foreseeable accident directly involving SNF management is a fire at a fuel storage facility adjacent to FFTF. Several of the accident scenarios evaluated for this alternative involve initiators that could affect more than one facility (e.g., earthquakes); however, the combined consequences of releases from potentially affected facilities have not been evaluated for a common receptor.

5.15.5.2 Decentralization Alternative. The Decentralization

Alternative involves several options for construction of new facilities at Hanford. One option includes a combination of new wet storage for defense production reactor fuel currently stored at the 105-K basins and new dry storage for fuel that is currently at other locations. Alternative options are included for processing of production reactor fuel prior to dry storage. The consequences of accidents at the new facilities are based on previously evaluated accidents for similar installations, adapted for the conditions and location of these facilities as assumed in this EIS.

The maximum reasonably foreseeable accident for the new facilities is a severe cask impact followed by a fire at a dry storage facility (Tables 5.15-1 through 5.15-5). The risk from a cask drop while loading fuel at a wet storage facility is similar for most receptors, although this scenario is conservative for a new facility as discussed in Attachment A.

5.15.5.3 1992/1993 Planning Basis Alternative. Accidents and

consequences would be essentially the same as for the Decentralization Alternative.

5.15.5.4 Regionalization Alternative. The consequences of the

regionalization alternatives are similar to those of other action alternatives because they only differ in the quantity of imported fuel placed into dry storage at the site. The types of facilities and activities involved are generally the same as those considered for the decentralization and centralization alternatives. Point estimates of risk for some accidents differ from those of corresponding

Table 5.15-1. Radiological accidents, individual worker probability of latent canc

Accident Description	Attribute	No Action	Decentralization
SNF facilities:			
Wet storage fuel cask drop	Consequences	1.4E-03	3.5E-04
	Annual Frequency	<1E-04	<1E-04
	Point Estimate of Risk	<1.4E-07	<3.5E-08
FFTF liquid metal fire in fuel storage	Consequences	2.4E-07	NA
	Annual Frequency	<1E-04	NA
	Point Estimate of Risk	<2.9E-11	NA
Multi-Purpose Facilities:			
324 Building Seismic evente	Consequences	(b)	NA
	Annual Frequency	4E-04	NA
	Point Estimate of Risk	(b)	NA
325 Building Seismic event	Consequences	1.0E-01	NA
	Annual Frequency	2E-04	NA
	Point Estimate of Risk	2.0E-05	NA
308 Building Fuel transfer accident	Consequences	5.2E-06	NA
	Annual Frequency	<1E-02	NA
	Point Estimate of Risk	<5.2E-08	NA

Table 5.15-1. (contd)

Accident Description	Attribute	No Action	Decentralization
New dry storage - cask impact & fire	Consequences	NAa	9.4E-02
	Annual Frequency	NA	6E-06
	Point Estimate of Risk	NA	5.6E-07
New SNF process - U metal fire	Consequences	NA	8.3E-08
	Annual Frequency	NA	<1.0E-04
	Point Estimate of Risk	NA	<8.3E-12
New ECF	Consequences	NA	NA
	Annual	NA	NA

	Frequency		
	Point Estimate of Risk	NA	NA

a. NA = Not applicable.
b. The dose from this scenario (1.1E + 03) rem is sufficiently high that applicati inappropriate.
c. See Appendix D for consequences of accidents at this facility.
d. Dash indicates that the information was not available.
e. The consequences associated with this accident are a result of existing contami neither its likelihood nor its severity depend on the presence of spent nuclear fue of spent nuclear fuel to releases from the accident is assumed to be negligible com

Table 5.15-2. Radiological accidents, general population - 80 km latent cancer fat

Accident Description	Attribute	No Action	Decentralization	1992/ Plann Basis
SNF Facilities:				
Wet Storage Fuel Cask Drop	Consequences	6.9E+00	3.0E+00	3.0E+
	Annual Frequency	<1.0E-04	<1.0E-04	<1.0E
	Point Estimate of Risk	<6.9E-04	<3.0E-04	<3.0E
FFTF Liquid Metal Fire in Fuel Storage	Consequences	3.2E+01	NA	NA
	Annual Frequency	<1.0E-04	NA	NA
	Point Estimate of Risk	<3.2E-03	NA	NA
Multipurpose Facilities:				
324 Building Seismic Evente	Consequences	9.7E+02	NA	NA
	Annual Frequency	4E-04	NA	NA
	Point Estimate of Risk	3.9E-01	NA	NA
325 Building Seismic Event	Consequences	2.0E+00	NA	NA
	Annual Frequency	2E-04	NA	NA
	Point Estimate of Risk	4.0E-04	NA	NA
308 Building Fuel Transfer Accident	Consequences	NEb	NA	NA
	Annual Frequency	<1.0E-02	NA	NA
	Point Estimate of Risk	-	NA	NA

Table 5.15-2. (contd)

Accident Description	Attribute	No Action	Decentralization	1992/ Plann Basis
New dry storage - cask impact & fire	Consequences	NA	8.1E+01	8.1E+
	Annual Frequency	NA	6E-06	6E-06
	Point Estimate of Risk	NA	4.9E-04	4.9E-
New SNF process - U metal fire	Consequences	NA	6.4E-02	6.4E-
	Annual Frequency	NA	<1.0E-04	<1.0E
	Point Estimate of Risk	NA	<6.4E-06	<6.4E
New ECF	Consequences	NA	NA	NA
	Annual Frequency	NA	NA	NA
	Point Estimate of Risk	NA	NA	NA

a. NA = Not applicable.
b. NE = Collective dose not evaluated for this scenario.
c. Dash indicates that the information was not available.
d. See Appendix D for consequences.
e. The consequences associated with this accident are a result of existing contami cells, and neither its likelihood nor its severity depend on the presence of SNF at contribution of SNF to releases from the accident is assumed to be negligible compa

Table 5.15-3. Radiological accidents, general population - 80 km latent cancer fat

Accident Description	Attribute	No Action	Decentralization	19921 Plann Basis
SNF Facilities:				
Wet storage - fuel cask drop	Consequences	4.0E-01	1.9E-01	1.9E-
	Annual Frequency	<1.0E-04	<1.0E-04	<1.0E
	Point Estimate of Risk	<4.0E-05	<1.9E-05	<1.9E
FFTF liquid metal fire in fuel storage	Consequences	3.8E+00	NA	NA
	Annual Frequency	<1.0E-04	NA	NA
	Point Estimate of Risk	<3.8E-04	NA	NA
Multipurpose	Facilities:			
324 Building Seismic Evente	Consequences	1.0E+02	NA	NA
	Annual Frequency	4E-04	NA	NA
	Point Estimate of Risk	4.0E-02	NA	NA

325 Building Seismic Event	Consequences	2.3E-01	NA	NA
	Annual Frequency	2E-04	NA	NA
	Point Estimate of Risk	4.6E-05	NA	NA
308 Building fuel transfer accident	Consequences	NEb	NA	NA
	Annual Frequency	<1.0E-02	NA	NA
	Point Estimate of Risk	-	NA	NA

Table 5.15-3. (contd)

Accident Description	Attribute	No Action	Decentralization	1992/ Plann Basis
New dry storage - cask impact & fire	Consequences	NA	4.0	4.0
	Annual Frequency	NA	6E-06	6E-06
	Point Estimate of Risk	NA	2.4E-05	2.4E-
New SNF process - U metal fire	Consequences	NA	4.6E-03	4.6E-
	Annual Frequency	NA	<1.0E-04	<1.0E
	Point Estimate of Risk	NA	<4.6E-07	<4.6E
New ECF	Consequences	NA	NA	NA
	Annual Frequency	NA	NA	NA
	Point Estimate of Risk	NA	NA	NA

a. NA = Not applicable.
b. NE = Collective dose not evaluated for this scenario.
c. Dash indicates that the information was not available.
d. See Appendix D for consequences of accidents at this facility.
e. The consequences associated with this accident are a result of existing contami
cells, and neither its likelihood nor its severity depend on the presence of SNF at
contribution of SNF to releases from the accident is assumed to be negligible compa

Table 5.15-4. Radiological accidents, nearest public access - individual probabili

Accident Description	Attribute	No Action	Decentralization	1992/ Plann Basis
SNF Facilities:				
Wet storage fuel cask drop	Consequences	1.3E-03	3.1E-05	3.1E-
	Annual Frequency	<1E-04	<1E-04	<1E-0
	Point Estimate of Risk	<1.3E-07	<3.1E-09	<3.1E
FFTF liquid	Consequences	1.2E-07	NA	NA

metal fire in fuel storage				
	Annual Frequency	<1E-04	NA	NA
	Point Estimate of Risk	<1.2E-11	NA	NA
Multipurpose facilities:				
324 Building Seismic Eventd	Consequences	1.9E-01	NA	NA
	Annual Frequency	4E-04	NA	NA
	Point Estimate of Risk	7.6E-05	NA	NA
325 Building seismic event	Consequences	6.3E-03	NA	NA
	Annual Frequency	2E-04	NA	NA
	Point Estimate of Risk	1.3E-06	NA	NA
308 Building fuel transfer accident	Consequences	4.3E-07	NA	NA
	Annual Frequency	<1E-02	NA	NA
	Point Estimate of Risk	<4.3E-09	NA	NA

Table 5.15-4. (contd)

Accident Description	Attribute	No Action	Decentralization	1992/ Plann Basis
New dry storage - cask impact and fire	Consequences	NA	3.8E-05	3.8E-
	Annual Frequency	NA	6E-06	6E-06
	Point Estimate of Risk	NA	2.3E-10	2.3E-
New SNF process - U metal fire	Consequences	NA	2.2E-08	2.2E-
	Annual Frequency	NA	<1.0E-04	<1.0E
	Point Estimate of Risk	NA	<2.2E-12	<2.2E
New ECF	Consequences	NA	NA	NA
	Annual Frequency	NA	NA	NA
	Point	NA	NA	NA

Estimate of
Risk

a. NA = Not applicable.
b. See Appendix D for consequences of accidents at this facility.
c. The consequences associated with this accident are a result of existing contami cells, and neither its likelihood nor its severity depend on the presence of SNF at contribution of SNF to releases from the accident is assumed to be negligible compa

Table 5.15-5. Maximum exposed offsite individual - probability of latent cancer fa

Accident Description	Attribute	No Action	Decentralization	1992/ Plann Basis
SNF Facilities:				
Wet storage fuel cask drop	Consequences	2.5E-04a	1.8E-04	1.8E-
	Annual Frequency	<1E-04	<1E-04	<1E-0
	Point Estimate of Risk	<2.5E-08	<1.8E-08	<1.8E
FFTF liquid metal Fire in fuel storage	Consequences	2.5E-04a	NA	NA
	Annual Frequency	<1E-04	NA	NA
	Point Estimate of Risk	2.5E-08	NA	NA
Multipurpose	Facilities:			
324 Building Seismic Eventd	Consequences	2.5E-04a	NA	NA
	Annual Frequency	4E-04	NA	NA
	Point Estimate of Risk	1.0E-07	NA	NA
325 Building Seismic Event	Consequences	2.5E-04a	NA	NA
	Annual Frequency	2E-04	NA	NA
	Point Estimate of Risk	5.0E-08	NA	NA
308 Building fuel transfer accident	Consequences	4.3E-08	NA	NA
	Annual Frequency	<1E-02	NA	NA
	Point Estimate of Risk	4.3E-10	NA	NA

Table 5.15-5. (contd)

Accident Description	Attribute	No Action	Decentralization	1992/ Plann Basis
New dry	Consequences	NA	2.5E-04	2.5E-

storage - cask impact & fire				
	Annual Frequency	NA	6E-06	6E-06
	Point Estimate of Risk	NA	1.5E-09	1.5E-
New SNF process - U metal fire	Consequences	NA	3.4E-06	3.4E-
	Annual Frequency	NA	<1.0E-04	<1.0E
	Point Estimate of Risk	NA	<3.4E-10	<3.4E
New ECF	Consequences	NA	NA	NA
	Annual Frequency	NA	NA	NA
	Point Estimate of Risk	NA	NA	NA

a. The offsite dose from this accident is assumed to be limited to 0.5 rem by appl guidelines. Potential dose without protective action is 1.4 rem for 105-K Basin Ca seismic event, 16 rem for 325 Building seismic event, and 5 rem for FFTF liquid met

b. NA = Not applicable.

c. See Appendix D for consequences of accidents at this facility.

d. The consequences associated with this accident are a result of existing contami cells, and neither its likelihood nor its severity depend on the presence of SNF at contribution of SNF to releases from the accident is assumed to be negligible compa accidents in the other alternatives because the frequencies were adjusted to account for the quantity of fuel handled in each option (See Tables 5.15-1 through 5.15-5). Under subalternatives A and B, the types of accidents and their consequences would be the same as those for the decentralization alternative. However, the frequencies (and therefore the risks), would differ in some cases because of the volume of imported fuel that would be placed into dry storage. For subalternative C, all fuel currently at Hanford would be transported to another site, and the risks would be identical to those in the centralization minimum alternative.

5.15.5.5 Centralization Alternative. The Centralization Alternative

consists of two options at Hanford: a minimum option in which all DOE spent fuel at Hanford is transported offsite to another location for interim storage, and a maximum option that would result in storage of all DOE spent fuel at Hanford. Accident scenarios for the minimum option would include those discussed under the No Action Alternative prior to shipment of the fuel offsite. In addition, defense reactor fuel would be processed and repackaged in a new facility prior to shipment. The risks associated with this new facility are expected to be similar to the processing facility discussed under the Decentralization Alternative. The cask impact accident at a dry storage facility has been included in this option to account for handling of fuel prior to shipment from Hanford.

The maximum option contains suboptions for wet or dry fuel storage with processing similar to those for the Decentralization Alternative, and the consequences are expected to be essentially the same as those described previously. The frequency of the cask impact at a dry storage facility has been increased to account for additional fuel that would be handled at Hanford under this option. The only other installation that would be included in this option is the Expended Core Facility (ECF), which would be relocated from INEL. The consequences of accidents at this facility are discussed in Volume

1, Appendix D of this EIS, and are not described here. Note that the accident analysis for the ECF in Appendix D incorporates different assumptions than those used for other Hanford facilities in this section, and the two sets of results are not directly comparable. The consequences of ECF accidents at Hanford using assumptions consistent with those in this section would be higher than those reported in Appendix D.

5.15.6 Secondary Impacts of Radiological Accidents

Secondary impacts of radiological accidents have been evaluated qualitatively for this analysis. Accidents that resulted in doses to the maximally exposed offsite resident of less than 100 millirem were considered to have little or no secondary impact because the levels of environmental contamination in these cases would be relatively small. Accidents that exce this level may have secondary impacts with severity depending on the expected levels of environmental contamination. Although the levels of environmental contamination were not assessed quantitatively for this analysis, the offsite individual dose provides a measure of the air concentration and radionuclide deposition at the receptor location and can be used as a semi-quantitative estimate of the level of environmental contamination from a given accident. The estimated secondary consequences of maximum reasonably foreseeable SNF facility accidents are presented in Table 5.15-6.

5.15.7 Nonradiological Accident Analysis

For purposes of the EIS, a worst case accident scenario was developed for each existing and planned facility. The details of the nonradiological accident scenario are presented in Attachment A, and the information is summarized in this section. The accident assumes that a chemical spill occurs within a building and is followed by an environmental release from the normal exhaust system. It is assumed that the building remains intact but containment measures fail, allowing releases occur through the ventilation system. It is assumed that all, or a portion of, the entire inventory of toxic chemicals stored in each building is spilled. The environmental releases are modeled, and the hypothetical concentrations at three receptor locations are compared to toxicological limits.

Several chemical inventory and chemical emissions lists are provided by alternative and facility (Bergsman 1995). Effects to onsite workers, the nearest point of public access, and the public at the nearest offsite residence were estimated using the computer model EPIcode (DOE 1993b). Results from the EPIcode model were compared to available Emergency Response Planning Guideline (ERPG) values, Immediately Dangerous to Life and Health (IDLH) values, and Threshold Limit Values/Time Weighted Averages (TLV/TWA). In the absence of these values, toxicological data for similar health endpoints, from the Registry of Toxic Effects for Chemical Substances (RTEC) are used.

The results of the accident scenario for each alternative are presented in **Table 5.15-8.** As a general statement, in the event of an accident, the existing 105-KE and 105-KW facilities and the proposed new wet storage facility present the predominant risk for chemical exposure.

Under the No Action Alternative there is a potential for irreversible health effects to occur in the 308, 324, 325 A and B buildings, while nitric acid is a potential odor and irritation problem from both of the proposed fuel stabilization alternatives.

5.15.7.1 No Action Alternative. A baseline of chemicals kept in spent

nuclear storage facilities was developed from chemical inventories for these facilities compiled to comply with the Emergency Planning and Community Right-To-Know Act (EPCRA). The existing storage facilities include 105-KE, 105-KW, PUREX (202A), T-Plant (221T), 2736-ZB Building, 200-West low-level burial grounds, FFTF 403 Building, 308 Building, 324 Building, 325 A&B Building, and 327 Building. The Emergency Planning and Community Right-To-Know Act (EPCRA) lists used are from 1992.

Because most facilities have various missions, the need to have a supply of chemicals at these facilities may not be related to the storage of SNFs. However for purposes of the EIS, the assumption is made that the existing inventories represents the anticipated amounts and types of chemicals which may be needed in the future.

The results of the accident scenario under conditions of the No Action Alternative are presented in Table 5.15-7.

5.15.7.2 Decentralization Alternative. The Decentralization Alternative involves construction of several new facilities at Hanford, including new dry storage for spent fuel, or a combination of new wet and dry storage. Options are also included for several types of fuel processing prior to storage. The consequences of new facilities are based on previously evaluated accidents for similar installations, adapted for the conditions and locations of these facilities as assumed in this EIS.

The baseline chemical inventory for the proposed facilities is primarily derived from the facility costs section in the engineering design data (Bergsman 1995). However, the wet storage facility uses the 105-KE Basin as a surrogate for a baseline chemical inventory because the facility cost section lists only two chemicals, sodium hydroxide and sulfuric acid.

Table 5.15-6. Assessment of secondary impacts of accidents for the No-Action Alter

	Environmental or Social Factor			
Accident Description	Biotic Resources	Water Resources	Economic Impacts	National Defense
Accidents with frequencies y10-3 per year				
308 Building (fuel handling accident)	a	a	a	a
Accidents with frequencies <10-3 per year				
324 Building (seismic event)	Potential local effects on individuals of some species	Potential temporary closure of Hanford Reach of Columbia River to boat traffic, restriction of water use locally (Richland, Pasco)	Possible loss of crops, cost incurred for clean-up	None anticipated
325 Building (seismic event)	b	b	b	b
FFTF fuel	b	b	b	b

storage (liquid metal fire)				
105-K wet storage (cask drop)	b	b	b	b
200-W burial ground (cask impact & fire)	b	b	b	b
327 Building (hot cell fire)	b	b	b	b
T-plant (fuel damage)	a	a	a	a

a. Consequences of this accident would be limited to very local onsite impact only
b. Consequences of this accident would be similar in nature to those of the 324 bu
storage facility (worst case) accidents; however they would be less severe because
would be lower by at least two orders of magnitude.

The results of the accident scenario under conditions of the Decentralization Alternative are presented in Table 5.15-8.

5.15.7.3 1992/93 Planning Basis Alternative. Accidents and consequences

would be essentially the same as for the Decentralization Alternative.

5.15.7.4 Regionalization Alternative. Except for Regionalization Option

C, which would be essentially the same as the Centralization Alternative minimum case, accidents and consequences for options A, B1, and B2 would be essentially the same as for the Decentralization Alternative. The quantity of nondefense fuels placed into dry storage would not affect the potential for releases of hazardous chemicals because no such materials are present in the dry storage facilities.

5.15.7.5 Centralization Onsite Alternative. The Centralization Onsite

Alternative consists of consolidating all spent fuel at the Hanford site. Options are available for wet or dry fuel storage with processing similar to those for the Decentralization Alternative. The consequences are expected to be essentially the same as those described for the first 5 years of the No Action Alternative, and then they are the same as those described for the Decentralization Alternative.

The results of the accident scenario under conditions of the No Action and Decentralization Alternatives are presented in Table 5.15-8.

5.15.7.6 Centralization Offsite Alternative. The Centralization Offsite

Alternative consists of transporting all DOE SNF at Hanford offsite to another location for interim storage. Fuel would be stabilized prior to shipment in a fuel drying and passivation facility. Therefore the impacts from this alternative are the same as those for the No Action Alternative for the first 5 years, and then they are the same as those described for the fuel drying and passivation facility.

The results of the accident scenario under conditions of the No Action Alternative and the fuel drying and passivation facility are presented in Table 5.15-8.

Table 5.15-7. Assessment of secondary impacts of accidents for the Decentralizatio Basis, Regionalization, and Centralization Alternatives.

	Environmental or Social Factor			
Accident Description	Biotic Resources	Water Resources	Economic Impacts	National Defense
New dry storage (cask impact with fire)	Minimal local effects	Possible temporary restriction of use of Columbia River for recreation	Clean-up costs locally, potential loss of crops	None anticipated
New process facility (U metal fire)	a	a	a	a
New wet storage (cask drop)	b	b	b	b

a. Consequences of this accident would be limited to very local onsite impact only

b. Consequences of this accident would be similar in nature to those of the 324 bu storage facility (worst case) accidents; however they would be less severe because would be lower by at least two orders of magnitude.

5.15.8 Construction and Occupational Accidents

Table 5.15-9 shows the predicted number of injuries, illnesses, and fatalities among workers from construction activities and operations activities for each alternative. Injury, illness, and fatality counts for construction workers are presented separately because of the relatively more hazardous nature of construction work.

Decentralization suboptions P and Q represent the highest predicted construction and occupational accident count of any of the alternatives. The higher number of accidents is attributable to increased construction and fuel processing required by these alternatives. The Centralization Onsite Alternative has accident counts similar to those for suboptions P and Q. The lowest accident counts are for the No Action Alternative and the Centralization Offsite Alternative. All other alternative are similar in their predicted accident counts.

5.16 Cumulative Impacts Including Past and Reasonably Foreseeable

Actions

Cumulative impacts associated with implementing the alternatives for interim storage of SNF at the Hanford Site together with impacts from past and reasonably foreseeable future actions are described in the following subsections.

5.16.1 No Action Alternative

Cumulative impacts associated with implementation of the No Action Alternative are described in the following subsections.

5.16.1.1 Land Use. The Hanford Site consists of about 1450 square kilometers (360,000 acres), of which about 87 square kilometers (22,000 acres) have been disturbed. Implementation of the No Action Alternative would not change that land use. Construction of the Environmental Restoration Disposal Facility will require disturbance of approximately 4.1 square kilometers (1.020 acres) of land. However, restoration of existing disturbed sites will compensate for this loss.

Table 5.15-8. Nonradiological exposure to public and workers to chemicals in spent locations released during an accident.

Alternative/ Facility/ Chemical	Worker Exposure mg/m3	Exposure at Nearest Public Access mg/m3	Exposu Neares Reside
No Action			
105-KE			
chlorine	4.30	4.30	0.13
PCB	23.00	23.00	0.66
sodium hydroxide	140.00	140.00	0.40
sulfuric acid	220.00	220.00	6.40
105-KW			
chlorine	4.30	4.30	0.13
ethylene glycol	2.40	2.40	0.07
kerosene	15.00	0.86	0.43
polyacrylamide	4.20	0.24	0.12
sodium hydroxide	140.00	140.00	0.40
sulfuric acid	220.00	220.00	6.40
PUREX (202A)			
cadmium nitrate tetrahydrate	0.03	0.03	0.02
diesel fuel	1.80	1.70	1.10
mercury	7.20E-04	6.90E-04	4.30E-
methanol	2.10E-04	2.00E-04	1.30E-
PCB	0.00	0.00	0.00
sodium hydroxide	0.03	0.03	0.01
sodium nitrite	0.04	0.04	0.03
T-Plant (221T)			
potassium permanganate	0.01	0.00	0.00
sodium	0.10	0.01	0.00
sodium hydroxide	0.02	0.01	0.00
sodium nitrite	0.05	0.00	0.00
FFTF (403 Building)			
sodium	67.00	24.00	0.83
sodium potassium alloy	5.40	2.70	0.39
308 Building			
acetone	0.03	0.02	0.01
ethylene glycol	70.00	57.00	37.00
x-ray film (Ag)	88.00	0.77	0.36

Table 5.15-8 (contd)

Alternative/	Worker	Exposure at	Exposu

Facility/ Chemical	Exposure mg/m3	Nearest Public Access mg/m3	Neares Reside
324 Bldg			
alkyl dimethyl benzyl ammonium	29.00	1.90	0.24
bis-tri-n-butyltin oxide	38.00	2.40	0.31
poly oedmi ethylene dichloride	82.00	5.20	0.68
325 Building			
mercury	3.20	0.20	0.03
poly oedmi ethylene dichloride	21.00	1.30	0.17
zinc	0.04	0.00	0.00
327 Building			
poly oedmi ethylene dichloride	0.05	0.01	0.04
Decentralization Suboption W			
Wet Storage Facility			
chlorine	0.75	0.10	0.04
PCB	3.90	0.54	0.20
sodium hydroxide	36.00	1.10	0.06
sulfuric acid	39.00	5.30	2.00
Vault Dry Storage Facility			
no chemicals of concern			
Decentralization Suboption X			
Wet Storage Facility			
chlorine	0.75	0.10	0.04
PCB	3.90	0.54	0.20
sodium hydroxide	36.00	1.10	0.06
sulfuric acid	39.00	5.30	2.00
Casks Dry Storage Facility			
no chemicals of concern			
Decentralization Suboption Y			
Vault Dry Storage Facility			
no chemicals of concern			
Shear\Leach\Calcine Stabilization Facility			
diesel fuel	0.42	0.40	0.26
nitric acid	21.00	20.00	13.00
sodium hydroxide	0.86	0.73	0.20
sodium nitrite	0.11	0.10	0.06
sulfuric acid	0.53	0.51	0.32

Table 5.15-8 (contd)

Alternative/ Facility/ Chemical	Worker Exposure mg/m3	Exposure at Nearest Public Access mg/m3	Exposu Neares Reside
Decentralization Suboption Z			
Casks Dry Storage Facility			
no chemicals of concern			

Shear\Leach\Calcine Stabilization Facility			
diesel fuel	0.42	0.40	0.26
nitric acid	21.00	20.00	13.00
sodium hydroxide	0.86	0.73	0.20
sodium nitrite	0.11	0.10	0.06
sulfuric acid	0.53	0.51	0.32
Decentralization Suboption P			
105-KE			
chlorine	4.30	4.30	0.13
PCB	23.00	23.00	0.66
sodium hydroxide	140.00	140.00	0.40
sulfuric acid	220.00	220.00	6.40
105-KW			
chlorine	4.30	4.30	0.13
ethylene glycol	2.40	2.40	0.07
kerosene	15.00	0.86	0.43
polyacrylamide	4.20	0.24	0.12
sodium hydroxide	140.00	140.00	0.40
sulfuric acid	220.00	220.00	6.40
Shear\Leach\Calcine Stabilization Facility			
diesel fuel	0.42	0.40	0.26
nitric acid	21.00	20.00	13.00
sodium hydroxide	0.86	0.73	0.20
sodium nitrite	0.11	0.10	0.06
sulfuric acid	0.53	0.51	0.32
Decentralization Suboption Q			
105-KE			
chlorine	4.30	4.30	0.13
PCB	23.00	23.00	0.66
sodium hydroxide	140.00	140.00	0.40
sulfuric acid	220.00	220.00	6.40

Table 5.15-8 (contd)

Alternative/ Facility/ Chemical	Worker Exposure mg/m3	Exposure at Nearest Public Access mg/m3	Exposu Neares Reside
105-KW			
chlorine	4.30	4.30	0.13
ethylene glycol	2.40	2.40	0.07
kerosene	15.00	0.86	0.43
polyacrylamide	4.20	0.24	0.12
sodium hydroxide	140.00	140.00	0.40
sulfuric acid	220.00	220.00	6.40
Solvent Extraction Fuel Stabilization Facility			
cadmium nitrate tetrahydrate	0.03	0.03	0.02
diesel fuel	0.42	0.40	0.26
hydrazine	0.02	0.02	0.01
kerosene	0.84	0.81	0.51
nitric acid	21.00	20.00	13.00
potassium permanganate	0.00	0.00	0.00
sodium hydroxide	0.86	0.73	0.20
sodium nitrite	0.11	0.10	0.06
sulfuric acid	0.53	0.51	0.32
1992/1993 Planning Basis same as Decentralization			

Regionalization same as Decentralization			
Centralization Onsite same as No Action for first 5 years, then same as Decentralization			
Centralization Offsite same as No Action for first 5 years, then same as fuel drying and passivation facility			
Fuel Drying and Passivation Facility			
diesel fuel	0.42	0.40	0.26

Table 5.15-8 (contd)

Alternative/ Facility/ Chemical	Worker Exposure mg/m3	Exposure at Nearest Public Access mg/m3	Exposu Neares Reside
sodium hydroxide	0.09	0.07	0.02
sodium nitrite	0.11	0.10	0.06
sulfuric acid	0.53	0.51	0.32

a. Emergency Response Planning Guideline (ERPG) value 1 (irritation or odor), or T Values/Time Weighted Averages (TLV/TWA), or value for a similar toxicological end p data in the Registry of Toxic Effects for Chemical Substances (RTEC).
b. ERPG 2 (irreversible health effects), or 0.1 of Immediately Dangerous to Life a value for a similar toxicological end point from toxicological data in RTEC.
c. ERPG 3 (death), IDLH, or value for a similar toxicological end point from toxic
d. Bold italic type indicates that the toxicological limit was exceeded at one or

Table 5.15-9. Estimated injuries, illnesses, and fatalities of workers expected during construction and operation of facilities in each alternative (cumulative totals through 2035).

Alternative	Construction Workersa		Operations Workersa	
	Injury & illness (persons)	Fatalities (persons)	Injury & illness (persons)	Fatalitie (persons)
No Actionb	0	0	231	0
Decentralization				
Suboption W	54	0	83	0
Suboption X	49	0	84	0
Suboption Yc	79	0	69	0
Suboption Zc	48	0	69	0
Suboption Pc	183	0	84	0
Suboption Qc	223	0	139	0
1992/3 Planning Basis	same as Decentralization			
Regionalization				
Suboption AX	38	0	82	0
Suboption AYc	74	0	69	0
Suboption AZc	37	0	69	0
Suboption B1d	99	0	109	0
Suboption B2d	211	0	136	0
Suboptions C	same as Centralization offsite			
Centralization Onsited	285	0	205	0
Centralization Offsite	154	0	84	0

a. Facility construction and operation estimates are based on DOE and DOE contractor accident rates (See Volume 2, Part B, Table F-4-7 of this EIS).

b. Worker year estimates from Bergsman (1995).
c. Dry storage suboptions (Y or Z) would be paired with either of two processing options
(P or Q).
d. These estimates represent incremental increases for fuel imported from offsite locations only; estimates for storage (and stabilization where required) of onsite fuel woule be the same as in the Decentralization Alternative.

5.16.1.2 Air Quality. Air quality limits (WAC 173-470-030,-100) at the

Hanford Site boundary are not expected to be approached as a result of implementing the No Action Alternative or from reasonably foreseeable additions to the Hanford Site, e.g., construction and operation of a Laser Interferometer Gravitational-Wave Observatory or from decommissioning of unused facilities or site restoration activities.

5.16.1.3 Waste Management. Under the No Action Alternative, there

would be a continuing generation of about 100 cubic meters of low-level wastes per year from incidental activities and about 530 cubic meters during containerization of SNF and sludge in the 100-K Area basins. All presently anticipated activities on the Hanford Site would result in approximately 20,000 cubic meters of low-level waste per year. Thus, at a maximum, the total quantity of low-level waste from SNF activities would account for about 5 percent of the annual quantity of low-level waste generated at the Hanford Site.

5.16.1.4 Socioeconomics. Under the No Action Alternative, the SNF

workforce would remain the same, about 60 workers. The Hanford Site workforce is expected to drop from about 18,700 in 1995 to 14,700 in 1997 and to remain approximately at 14,700 through 2004. The regional workforce is expected to range from 81,000, to 86,000 in that same period.

5.16.1.5 Occupational and Public Health. The cumulative population

dose since plant startup was estimated to be about 100,000 person-rem (estimated to one significant figure; Section 4.12.2.4.2). The number of inferred fatal cancers since plant startup would amount to about 50 (essentially all of which would be attributed to dose received in the 1945-52 time frame). In the 50 years since plant startup, the population of interest (assuming a constant population of 380,000 and an individual dose of about 0.3 rem/year) would have received about 5,000,000 person-rem from naturally occurring radiation sources (natural background) which would relate to about 2,500 latent cancer fatalities. In the same 50 years about 27,000 cancer fatalities from all causes would have been expected in that population.

If the Hanford sitewide contribution to public dose from all exposure pathways is considered (0.8 person-rem per year from DOE facilities and 0.7 person-rem per year from Washington Public Power Supply System reactor operation for 40 years), it is estimated that the cumulative collective dose would be approximately 60 person-rem. No latent fatal cancers would be expected from such a dose. Over 40 years of interim storage of SNF, the population of interest would have received 4,000,000 person-rem from natural background radiation. That dose would relate to 2,000 latent cancer fatalities. In the same 40 years, about 21,000 cancer fatalities from all causes would be expected among the population in the region of interest (380,000 population).

Air quality limits [(40 CFR 61 Subpart H), 10 millirem per year at the Hanford Site boundary] are not expected to be approached as a result of implementing the No Action Alternative or from reasonably foreseeable additions to the Hanford Site, e.g., construction and operation of a Laser Interferometer Gravitational-Wave Observatory or from decommissioning of unused facilities or site restoration activities.

Cumulative spent fuel worker dose from plant startup to date was estimated at about 2,000 person-rem (Section 4.12.1.2), from which one fatal cancer might be inferred. In the near term the annual increments to cumulative worker dose would be expected to be about 24 person-rem. No latent fatal cancers would be expected from 40 years of the No Action Alternative (960 person-rem).

The cumulative worker dose since start up of activities at the Hanford Site is about 90,000 person-rem, to which would be added about 210 person-rem/yr for a total cumulative worker dose of about 100,000 person-rem through the next 40 years. Thus for 90 years of Hanford operations, about 50 latent cancer fatalities (LCFs) might be inferred (4 LCFs inferred from 1995 onward). In those 90 years about 4,500 LCFs would be inferred from natural background radiation and 48,000 LCFs from all causes would be expected.

Although the worker dose assocated with all future site restoration activities is expected to be small in comparison with cumulative worker dose to date, it is too speculative to quantify at this time.

5.16.2 Decentralization Alternative

Cumulative impacts associated with implementation of the Decentralization Alternative are described in the following subsections.

5.16.2.1 Land Use. The Hanford Site consists of about 1450 square

kilometers (360,000 acres), of which about 87 square kilometers (22,000 acres) have been disturbed. Implementation of the Decentralization Alternative would disturb an additional area of up to 0.6 square kilometers (160 acres) for a total of about 88 square kilometers (22,000 acres). The amount of land actually occupied by new facilities would range from about 4 ha (11 acres) to about 7 hectares (18 acres). Construction of the Environmental Restoration Disposal Facility will require disturbance of approximately 4.1 square kilometers (1.020 acres) of land. However, restoration of existing disturbed sites will compensate for this loss.

5.16.2.2 Air Quality. Air quality limits (WAC 173-470-030,-100) at the

Hanford Site boundary are not expected to be approached as a result of implementing any of the options in the Decentralization Alternative or from reasonably foreseeable additions to the Hanford Site, e.g., construction and operation of a Laser Interferometer Gravitational-Wave Observatory or from decommissioning of unused facilities or restoration activities.

5.16.2.3 Waste Management. In the near term under the Decentralization

Alternative, there would be about 530 cubic meters of low-level waste generated during 2 years of repackaging and containerization of SNF and sludge in the 100-K Basins. Thereafter low-level waste generation would range from 41 to 420 cubic meters per year for about 4 years depending on suboption selected. All presently anticipated activities on the Hanford Site would result in approximately 20,000 cubic meters of low-level waste per year. Thus, at a maximum, the total low-level waste from SNF activities would account for about 8 percent of the annual quantity of low-level waste generated at the Hanford Site.

High-level waste that might be generated in the Decentralization Alternative would not add significantly to the more than 250,000 cubic meters of waste at Hanford currently handled as high-level waste.

5.16.2.4 Socioeconomics. Under the Decentralization Alternative, the

SNF workforce would increase from 80 to about 740. The Hanford Site workforce is expected to drop from 18,700 in 1995 to 14,700 in 1997 and remain at approximately 14,700 through 2004. The regional workforce is expected to range from 81,000, to 86,000 in that same period. The maximum change with respect to the regional workforce would be an increase of about 0.9 percent.

5.16.2.5 Occupational and Public Health. The cumulative population

dose since plant startup was estimated to be about 100,000 person-rem (estimated to one significant figure; Section 4.12.2.4.2). The number of inferred fatal cancers since plant startup would amount to about 50 (essentially all of which would be attributed to dose received in the 1945-52 time frame). In the 50 years since plant startup, the population of interest (assuming a constant population of 380,000 and an individual dose of about 0.3 rem/year) would have received about 5,000,000 person-rem from naturally occurring radiation sources (natural background), which would relate to 2,500 latent cancer fatalities. In the same 50 years about 27,000 cancer fatalities from all causes would have been expected in the region of interest.

If the Hanford sitewide contribution to public dose from all exposure pathways is considered (0.8 person-rem per year from DOE facilities and 0.7 person-rem per year from Washington Public Power Supply System reactor operation for 40 years), it is estimated that the cumulative collective dose would be approximately 60 person-rem. Additional collective population dose from implementation of the Decentralization Alternative would range from 1 to 4 person-rem over 40 years (dose from 4 years of processing would dominate). Thus, in total, the collective population dose from man-made sources would remain approximately 60 person-rem. No latent fatal cancers would be expected from such a dose. Over 40 years of interim storage of SNF, the population of interest would have received 4,000,000 person-rem from naturally occurring radiation sources (natural background). That dose would relate to 2,000 latent cancer fatalities. In the same 40 years, about 21,000 cancer fatalities from all causes would be expected among the population in the region of interest (380,000 population).

Air quality limits [(40 CFR 61 Subpart H), 10 millirem per year at the Hanford Site boundary] are not expected to be approached as a result of implementing the Decentralization Alternative or from reasonably foreseeable additions to the Hanford Site, e.g., construction and operation of a Laser Interferometer Gravitational-Wave Observatory or decommissioning of unused facilities, or site restoration activities.

Cumulative spent fuel worker dose from plant startup to date was estimated at about 2,000 person-rem (Section 4.12.1.2), from which one latent fatal cancer might be inferred. Collective worker dose from SNF activities would amount to about 80 person-rem for maintenance and operations, 18 person-rem for loading storage facilities, and 180 to 320 person-rem depending on processing option selected. Thus, the total collective 40-year worker dose from SNF activities would be from about 300 to 420 person-rem. Within the accuracy of the estimates, cumulative worker dose in the Decentralization Alternative would not add significantly to the cumulative Hanford Site worker dose over 90 years as described for the No Action Alternative.

5.16.3 1992/1993 Planning Basis Alternative

Because of the similarity of activities, cumulative impacts of the 1992/1993 Planning Basis Alternative would be essentially the same as those described for the Decentralization Alternative.

5.16.4 Regionalization Alternative (Options A, B1, B2, and C)

Cumulative impacts for implementation of the four Regionalization Subalternatives are described in the following subsections.

5.16.4.1 Regionalization Option A . Cumulative impacts associated with

implementation of the Regionalization Option A where Hanford's defense SNF is stored at the Hanford Site and other SNF is shipped offsite for storage are described in the following subsections.

5.16.4.1.1 Land Use.

The Hanford Site consists of about 1450 square kilometers (360,000 acres) of which about 87 square kilometers (22,000 acres) have been disturbed. Implementation of Regionalization Option A would disturb an additional area of up to 0.6 square kilometers (160 acres), for a total of about 88 square kilometers (22,000 acres). The amount of land actually occupied by new facilities would range from about 2 hectares (6 acres) to about 7 hectares (18 acres). Construction of the Environmental Restoration Disposal Facility will require disturbance of approximately 4.1 square kilometers (1.020 acres) of land. However, restoration of existing disturbed sites will compensate for this loss.

5.16.4.1.2 Air Quality.

Air quality limits (WAC 173-470-030,-100) at the Hanford Site boundary are not expected to be approached as a result of implementing any of the options in the Regionalization A Alternative or from reasonably foreseeable additions to the Hanford Site, e.g., construction and operation of a Laser Interferometer Gravitational-Wave Observatory or from decommissioning of unused facilities or restoration activities.

5.16.4.1.3 Waste Management.

In the near term under Regionalization Option A, there would be about 530 cubic meters of low-level waste generated during containerization of SNF and sludge in the 100-K basins. Thereafter, low-level waste generation would range from 61 to 420 cubic meters per year for about 4 years depending on option selected.. All presently anticipated activities on the Hanford Site would result in approximately 20,000 cubic meters of low-level waste per year. Thus, at a maximum, the total low-level waste from SNF activities would account for about 8 percent of the annual Hanford generation of low-level waste.

High-level waste that might be generated in Regionalization A would not add significantly to the more than 250,000 cubic meters of waste at Hanford currently handled as high-level waste.

5.16.4.1.4 Socioeconomics.

Under Regionalization Option A, the SNF workforce would increase by 60 to about 470. The Hanford Site workforce is expected to drop from about 18,700 in 1995 to about 14,700 in 1997 and to remain at approximately 14,700 through 2004. The regional workforce is expected to range from 81,000, to 86,000 in that same period. The maximum change with respect to the regional workforce would be an increase of about 0.6 percent.

5.16.4.1.5 Occupational and Public Health.

The cumulative population dose since plant startup was estimated to be about 100,000 person-rem (estimated to one significant figure; Section 4.12.2.4.2). The number of inferred fatal cancers since plant startup would amount to about 50 (essentially all of which would be attributed to exposures in the 1945-52 time frame). In the 50 years since plant startup the population of interest (assuming a constant population of 380,000 and an individual dose of about 0.3 rem/year) would have received about 5,000,000 person-rem from naturally occurring radiation sources (natural background), which would relate to 2,500 latent cancer fatalities. In the same 50 years about 27,000 cancer fatalities from all causes would have been expected in the region of interest.

If the Hanford sitewide contribution to public dose from all exposure pathways is considered (0.8 person-rem per year from DOE facilities and 0.7 person-rem per year from Washington Public Power Supply System reactor operation for 40 years), it is estimated that the cumulative collective dose would be approximately 60 person-rem. Additional collective population dose from implementation of Regionalization Option A would range from 1 to 4 person-rem over 40 years (dose from 4 years of processing would dominate). Thus, in total, the collective population dose from man-made sources would be about 60 person-rem. No latent fatal cancers would be expected from such a dose. Over 40 years of interim storage of SNF, the population of interest would have received 4,000,000 person-rem from naturally occurring radiation sources (natural background). That dose would relate to 2,000 latent cancer fatalities. In the same 40 years, about 21,000 cancer fatalities from all causes would be expected among the population in the region of interest (380,000 population).

Air quality limits ([40 CFR 61 Subpart H], 10 millirem per year at the Site boundary) are not expected to be approached as a result of implementing the Regionalization Alternative or from reasonably foreseeable additions to the Hanford Site, e.g., construction and operation of a Laser Interferometer

Gravitational-Wave Observatory, or decommissioning of unused facilities, or site restoration activities.

Cumulative spent fuel worker dose from plant startup to date was estimated at about 2,000 person-rem (Section 4.12.1.2), from which one latent fatal cancer might be inferred. Collective worker dose from SNF activities would amount to about 80 person-rem for maintenance and operations, 18 person-rem for loading storage facilities, and 180 to 320 person-rem depending on processing option selected. Thus the total collective 40-year worker dose would be from about 300 to 420 person-rem. Within the accuracy of the estimates, cumulative worker dose in Regionalization A would not add significantly to the cumulative Hanford Site work dose over 90 years as described for the No Action Alternative.

5.16.4.2 Regionalization Option B1. Cumulative impacts associated with

the implementation of Regionalization Option B1, where all SNF west of the Mississippi River, except for Naval SNF, is transported to Hanford are described in the following subsections.

5.16.4.2.1 Land Use.

The Hanford Site consists of about 1450 square kilometers (360,000 acres), of which about 87 square kilometers (22,000 acres) have been disturbed. Implementation of Regionalization Option B1 would disturb an additional area of upto 0.6 square kilometers (160 acres), for a total of about 88 square kilometers (22,000 acres). The amount of land actually occupied by new facilities would range from about 15 hectares (36 acres) to about 28 hectares (68 acres). Construction of the Environmental Restoration Disposal Facility will require disturbance of approximately 4.1 square kilometers (1.020 acres) of land. However, restoration of existing disturbed sites will compensate for this loss.

5.16.4.2.2 Air Quality.

Air quality limits (WAC 173-470-030,-100) at the Hanford Site boundary are not expected to be approached as a result of implementing any of the options in Regionalization Option B1 or from reasonably foreseeable additions to the Hanford Site, e.g., construction and operation of a Laser Interferometer Gravitational-Wave Observatory or from decommissioning of unused facilities or restoration activities.

5.16.4.2.3 Waste Management.

In the near term under Regionalization Option B1, there would be about 530 cubic meters of low-level waste generated during repackaging and containerization of SNF and sludge in 100-K Basins. Thereafter low-level waste generation would range from 61 to 420 cubic meters per year for about 4 years depending on the suboption selected. All presently anticipated processing activities on the Hanford Site would result in approximately 20,000 cubic meters of low-level waste per year. Thus, the total quantity of low-level waste from SNF activities would account for about 8 percent of the annual quantity of low-level waste generated at the Hanford Site.

High-level waste that might be generated in Regionalization B1 would not add significantly to the more than 250,000 cubic meters of waste at Hanford currently handled as high-level waste.

5.16.4.2.4 Socioeconomics.

Under Regionalization Option B1, the SNF workforce would increase by about 170 to about 800. The Hanford Site workforce is expected to drop from 18,700 in 1995 to 14,700 in 1997 and remain around 14,700 through 2004. The regional workforce is expected to range from 81,000, to 86,000 in that same period. The maximum change with respect to the regional workforce would be an increase of about 1 percent.

5.16.4.2.5 Occupational and Public Health.

The cumulative population dose since plant startup was estimated to be about 100,000 person-rem (estimated to one significant figure; Section 4.12.2.4.2). The number of inferred fatal cancers since plant startup would amount to about 50 (essentially all of which would be attributed to exposures in the 1945-52 time frame). In the 50 years since plant startup, the population of interest (assuming a constant population of 380,000) would have received about 5,000,000 person-rem from naturally occurring radiation sources (natural background), which would relate to 2,500 latent cancer fatalities. In the same time, about 27,000 cancer fatalities from all causes would have been expected in the region of interest.

If the Hanford sitewide contribution to public dose from all exposure pathways is considered (0.8 person-rem per year from DOE facilities and 0.7 person-rem per year from Washington Public Power Supply System reactor operation for 40 years), it is estimated that the cumulative collective dose would be approximately 60 person-rem. Additional collective population dose from implementation of Regionalization Option B1 would range from 1 to 4 person-rem over 40 years (dose from 4 years of processing would dominate). Thus, in total, the collective population dose from man-made sources would remain approximately 60 person-rem. No latent fatal cancers would be expected from such a dose. Over 40 years of interim storage of SNF, the population of interest would have received 4,000,000 person-rem from naturally occurring radiation sources (natural background). That dose would relate to 2,000 latent cancer fatalities. In the same 40 years, about 21,000 cancer fatalities from all causes would be expected among the population in the region of interest (380,000 population).

Air quality limits [(40 CFR 61 Subpart H), 10 millirem per year at the Hanford Site boundary] are not expected to be approached as a result of implementing Regionalization Option B1 or from reasonably foreseeable additions to the Hanford Site, e.g., construction and operation of a Laser Interferometer Gravitational-Wave Observatory or from decommissioning of unused facilities or site restoration activities.

Cumulative spent fuel worker dose from plant startup to date was estimated at about 2,000 person-rem (Section 4.12.1.2), from which one latent fatal cancer might be inferred. Collective worker dose from SNF activities would amount to about 80 person-rem for maintenance and operations, 18 person-rem for loading storage facilities, and 180 to 320 person-rem depending on processing option selected. Thus the total collective 40-year worker dose would be from about 300 to 420 person-rem. Within the accuracy of the estimates, cumulative worker dose in Regionalization B1 would not add significantly to the cumulative Hanford Site worker dose over 90 years as described for the No Action Alternative.

5.16.4.3 Regionalization Option B2. Cumulative impacts associated

with the implementation of Regionalization Option B2, where all SNF west of the Mississippi River and Naval SNF, are transported to Hanford are described in the following subsections.

5.16.4.3.1 Land Use.

The Hanford Site consists of about 1450 square kilometers (360,000 acres) of which about 87 square kilometers (22,000 acres) have been disturbed. Implementation of Regionalization Option B2 would disturb an additional area of up to 0.6 square kilometers (160 acres), for a total of about 88 square kilometers (22,000 acres). The amount of land actually occupied by new facilities would range from about 21 hectares (52 acres) to about 30 hectares (74 acres). Construction of the Environmental Restoration Disposal Facility will require disturbance of approximately 4.1 square kilometers (1.020 acres) of land. However, restoration of existing disturbed sites will compensate for this loss.

5.16.4.3.2 Air Quality.

Air quality limits (WAC 173-470-030,-100) at the Hanford Site boundary are not expected to be approached as a result of implementing any of the suboptions in Regionalization Option B1 or from reasonably foreseeable additions to the Hanford Site, e.g., construction and operation of a Laser Interferometer Gravitational-Wave Observatory, or from decommissioning of unused facilities or restoration activities.

5.16.4.3.3 Waste Management.

In the near term under Regionalization Option B2, there would be about 530 cubic meters of low-level waste generated during repackaging and containerization of SNF and sludge in the 100-K Basins. Thereafter, low-level waste generation would range from 61 to 420 cubic meters per year. All presently anticipated activities on the Hanford Site would result in approximately 20,000 cubic meters of low-level waste per year. Thus, at a maximum, the total quantity of low-level waste from SNF activities would account for about 4 percent of the annual quantity of low-level waste generated at the Hanford Site.

High-level waste that might be generated in Regionalization B2 would not add significantly to the more than 250,000 cubic meters of waste at Hanford currently handled as high-level waste.

5.16.4.3.4 Socioeconomics.

Under Regionalization Option B2, the SNF workforce would increase by about 170 to about 800. The Hanford Site workforce is expected to drop from 18,700 in 1995 to 14,700 in 1997 and remain around 14,700 through 2004. The regional workforce is expected to range from 81,000, to 86,000 in that same period. The maximum change with respect to the regional workforce would be an increase of about 1 percent.

5.16.4.3.5 Occupational and Public Health.

The cumulative population dose since plant startup was estimated to be about 100,000 person-rem (estimated to one significant figure; Section 4.12.2.4.2). The number of inferred fatal cancers since plant startup would amount to about 100 (essentially all of which would be attributed to exposures in the 1945-52 time frame). In the 50 years since plant startup, the population of interest (assuming a constant population of 380,000) would have received about 5,000,000 person-rem from naturally occurring radiation sources (natural background) which would relate to 2,500 latent cancer fatalities. In the same time about 27,000 cancer fatalities from all causes would have been expected in the region of interest.

If the Hanford Site contribution from all exposure pathways to public dose is added (0.8 person-rem per year from DOE facilities and 0.7 person-rem per year from Washington Public Power Supply System reactor operation for 40 years), it is estimated that the cumulative collective dose would be approximately 60 person-rem. Additional collective population dose from implementation of Regionalization Option B2 would range from 1 to 4 person-rem over 40 years (dose from 4 years of processing would dominate). Thus, in total, the collective population dose from man-made sources would remain approximately 60 person-rem. No latent fatal cancers would be expected from such a dose. Over 40 years of interim storage of SNF, the population of interest would have received 4,000,000 person-rem from naturally occurring radiation sources (natural background). That dose would relate to 2,000 latent cancer fatalities. In the same 40 years, about 21,000 cancer fatalities from all causes would be expected among the population in the region of interest (380,000 population).

Air quality limits [(40 CFR 61 Subpart H), 10 millirem per year at the Site boundary] are not expected to be approached as a result of implementing Regionalization Option B2 or from reasonably foreseeable additions to the Hanford Site, e.g., construction and operation of a Laser Interferometer Gravitational-Wave Observatory, or decommissioning of unused facilities or site restoration activities.

Cumulative spent fuel worker dose from plant startup to date was estimated at about 2,000 person-rem (Section 4.12.1.2), from which one latent fatal cancer might be inferred. Collective worker dose from SNF activities would amount to about 80 person-rem for maintenance and operations, 18 person-rem for loading storage facilities, and 180 to 320 person-rem depending on the processing suboption selected. Thus the total collective 40-year worker dose would be from about 300 to 420 person-rem. Within the accuracy of the estimates, cumulative worker dose in Regionalization B2 would not add significantly to the cumulative Hanford Site worker dose over 90 years as described for the No Action Alternative.

5.16.4.4 Regionalization C Option. Cumulative impacts in this option,

where all Hanford SNF is sent to INEL or NTS, would be essentially the same as those described for the Centralization Alternative, minimum option.

5.16.5 Centralization Alternative

Cumulative impacts associated with implementation of one or the other of two options under the Centralization Alternative are described in the following subsections.

5.16.5.1 Centralization Alternative Maximum Option. Cumulative impacts

associated with implementation of the Centralization Alternative maximum option, where all SNF is sent to the Hanford Site, are described in the following subsections.

5.16.5.1.1 Land Use.

The Hanford Site consists of about 1450 square kilometers (360,000 acres), of which about 87 square kilometers (22,000 acres) have been disturbed. Implementation of the Centralization Alternative maximum option would disturb up to an additional area of about 0.6 square kilometers (160 acres) for a total of about 88 square kilometers (22,000 acres). The amount of land actually occupied by new facilities would range from about 35 hectares (86 acres) to about 38 hectares (93 acres). Construction of the Environmental Restoration Disposal Facility will require disturbance of approximately 4.1 square kilometers (1.020 acres) of land. However, restoration of existing disturbed sites will compensate for this loss.

5.16.5.1.2 Air Quality.

Air quality limits (WAC 173-470-030,-100) at the Hanford Site boundary are not expected to be approached as a result of implementing any of the suboptions in the Centralization Alternative maximum option or from reasonably foreseeable additions to the Hanford Site, e.g., construction and operation of a Laser Interferometer Gravitational-Wave Observatory, or from decommissioning unused facilities or restoration activities.

5.16.5.1.3 Waste Management.

In the near term under the Centralization Alternative maximum option, there would be about 532 cubic meters of low-level waste generated during repackaging and containerization of SNF and sludge in the 100-K Basins. Thereafter, low-level waste generation would amount to about 140 cubic meters per year. All presently anticipated activities on the Hanford Site would result in approximately 20,000 cubic meters of low-level waste per year. Thus, at a maximum, SNF activities would account for about 1 percent of the total.

High-level waste that might be generated in the Centralization maximum option would not add significantly to the more than 250,000 cubic meters of waste at Hanford currently handled as high-level waste.

5.16.5.1.4 Socioeconomics.

Under the Centralization Alternative maximum option, the SNF workforce would increase by about 290 to about 900. The Hanford Site workforce is expected to drop from 18,700 in 1995 to 14,700 in 1997 and remain around 14,700 through 2004. The regional workforce is expected to range from 81,000, to 86,000 in that same period. The maximum change with respect to the regional workforce would be an increase of about 1 percent.

5.16.5.1.5 Occupational and Public Health.

The cumulative population dose since plant startup was estimated to be about 100,000 person-rem (estimated to one significant figure; Section 4.12.2.4.2). The number of inferred fatal cancers since plant startup would amount to about 50 (essentially all of which would be attributed to exposures in the 1945-52 time frame). In the 50 years since plant startup, the population of interest (assuming a constant population of 380,000) would have received 5,000,000 person-rem from naturally occurring radiation sources (natural background), which would relate to 2,500 latent cancer fatalities. In the same time about 27,000 cancer fatalities from all causes would have been expected in the region of interest .

If the Hanford sitewide contribution to public dose from all exposure pathways is considered (0.8 person-rem per year from DOE facilities and 0.7 person-rem per year from Washington Public Power Supply System reactor operation for 40 years), it is estimated that the cumulative collective dose would be approximately 60 person-rem. Additional collective population dose from implementation of the Centralization Alternative maximum option would range from 1 to 4 person-rem over 40 years (dose from 4 years of processing would dominate). Thus, in total, the collective population dose from man-made sources would remain approximately 60 person-rem. No latent fatal cancers would be expected from such a dose. Over 40 years of interim storage of SNF, the population of interest would have received 4,000,000 person-rem from naturally occurring radiation sources (natural background). That dose would relate to 2,000 latent cancer fatalities. In the same 40 years, about 21,000 cancer fatalities from all causes would be expected among the population in the region of interest (380,000 population).

Air quality limits [(40 CFR 61 Subpart H), 10 millirem per year at the Hanford Site boundary] are not expected to be approached as a result of implementing the Centralization Alternative maximum option or from reasonably foreseeable additions to the Hanford Site, e.g., construction and operation of a Laser Interferometer Gravitational-Wave Observatory, or decommissioning of unused facilities or site restoration activities.

Cumulative spent fuel worker dose from plant startup to date was estimated at about 2,000 person-rem (Section 4.12.1.2), from which one latent fatal cancer might be inferred. Collective worker dose from SNF activities in the Centralization Alternative maximum option would amount to about 80 person-rem for maintenance and operations, 18 person-rem for loading storage facilities, and 180 to 320 person-rem depending on processing suboption selected.

Within the accuracy of the estimates, cumulative worker dose in the Centralization maximum option would not add significantly to the cumulative Hanford Site worker dose over 90 years as described for the No Action Alternative.

5.16.5.2 Centralization Alternative Minimum Option. Cumulative impacts

associated with implementation of the Centralization Alternative minimum option, where all SNF on the Hanford Site is shipped offsite for storage, are described in the following subsections.

5.16.5.2.1 Land Use.

The Hanford Site consists of about 1450 square kilometers (360,000 acres) of which about 87 square kilometers (22,000 acres) have been disturbed. Implementation of the Centralization Alternative minimum option would disturb up to an additional area of about 0.6 square kilometers (160 acres) for a total of about 88 square kilometers (22,000 acres). The amount of land actually occupied by new facilities would range from about 2 hectares (6 acres) to about 15 hectares (12 acres). Construction of the Environmental Restoration Disposal Facility will require disturbance of approximately 4.1 square kilometers (1.020 acres) of land. However, restoration of existing disturbed sites will compensate for this loss.

5.16.5.2.2 Air Quality.

Air quality limits (WAC 173-470-030,-100) at the Hanford Site boundary are not expected to be approached as a result of implementing the any of the suboptions in the Centralization Alternative minimum option or from reasonably foreseeable additions to the Hanford Site, e.g., construction and operation of a Laser Interferometer Gravitational-Wave Observatory, or from decommissioning unused facilities or restoration activities.

5.16.5.2.3 Waste Management.

In the near term under the Centralization Alternative minimum option, there would be about 532 cubic meters of low-level waste generated during repackaging and containerization of SNF and sludge in the 100-K Basins. Thereafter, low-level waste generation would range from 110 to 490 cubic meters per year. All presently anticipated activities on the Hanford Site would result in approximately 21,000 cubic meters of solid waste per year. Thus, at a maximum, SNF activities would account for about 2 percent of the annual generation of low-level waste at the Hanf

High-level waste that might be generated in the Centralization mininim option would not add significantly to the more than 250,000 cubic meters of waste at Hanford currently handled as high-level waste.

5.16.5.2.4 Socioeconomics.

Under the Centralization Alternative minimum option, the SNF workforce would increase by about 390 to about 590. The Hanford Site workforce is expected to remain at about 18,000 from 1995 through 2004. The regional workforce is expected to range from 81,000, to 86,000 in that same period. The maximum change with respect to the regional workforce would be an increase of about 0.7 percent.

5.16.5.2.5 Occupational and Public Health.

The cumulative population dose since plant startup was estimated to be about 200,000 person-rem (estimated to one significant figure; Section 4.12.2.4.2). The number of inferred fatal cancers since plant startup would amount to about 50 (essentially all of which would be attributed to exposures in the 1945-52 time frame). In the 50 years since plant startup, the population of interest (assuming a constant population of 380,000) would have received 5,000,000 person-rem from naturally occurring radiation sources (natural background), which would relate to 2,500 latent cancer fatalities. In the same time about 24,000 cancer fatalities from all causes would have been expected in the region of interest.

Cumulative spent fuel worker dose from plant startup to date was estimated at about 2,000 person-rem (Section 4.12.1.2), from which one latent fatal cancer might be inferred. Collective worker dose from SNF activities in the Centralization Alternative minimum option would amount to about 80 person-rem for maintenance and operations, 18 person-rem for loading storage facilities, and 180 to 320 person-rem depending on processing suboption selected. Thus the total collective 40-year worker dose would be from about 300 to 420 person-rem.

Within the accuracy of the estimates, cumulative worker dose in the Centralization minimum option would not add significantly to the cumulative Hanford Site worker dose over 90 years as described for the No Action Alternative.

5.17 Adverse Environmental Impacts that Cannot be Avoided

Unavoidable adverse impacts that might arise as a result of implementing the alternatives for interim storage of SNF at the Hanford Site are discussed in the following subsections.

5.17.1 No Action Alternative

Adverse impacts associated with the No Action Alternative would derive from the expense and radiation exposure associated with maintaining facilities that are near or at the end of their design life and the possible future degradation of fuel and facilities, thus increasing the potential for releases of materials to the environment.

5.17.2 Decentralization Alternative

Adverse impacts associated with the Decentralization Alternative would derive principally from construction activities needed for new facilities. There would be displacement of some animals from the construction site and the destruction of plant life within the site up to 9 hectares (24 acres). Criteria pollutants, radionuclides, and hazardous chemicals would also be released in up to permitted quantities during processing preparations. Traffic congestion and noise are expected to increase by a few percent during the construction of major facilities. Competition for adequate housing would increase in the already tight market, and capacities at some of the local school would be moderately strained with approximately 0.5 to 1.5 percent additional students, depending on which processing and/or storage option were chosen.

5.17.3 1992/1993 Planning Basis Alternative

Adverse impacts associated with the 1992/1993 Planning Basis Alternative would be essentially the same as those for the Decentralization Alternative. If transport of any amount of SNF were considered an adverse impact, that impact would occur in this alternative if the small amount of TRIGA fuel at Hanford were transported to INEL.

5.17.4 Regionalization Alternative

Unavoidable adverse environmental impacts for the Regionalization Alternative range from those of the Centralization (Minimum) Alternative for Regionalization C where all Hanford SNF is shipped offsite to essentially those of the Centralization (Maximum) Alternative for Regionalization B2 where all SNF west of the Mississippi River including Naval SNF is shipped to Hanford.

5.17.5 Centralization Alternative

In the option where Hanford receives all DOE SNF, adverse impacts would be somewhat larger than those associated with implementing the Decentralization Alternative because about 25 weight percent more fuel than already exists on the Hanford Site would need to be stored; however, higher heat loads on that fuel might nearly triple the capacity needed for storage. Transport of that 25 weight percent of SNF to the Hanford Site also likely would be viewed as an adverse impact.

In the option where Hanford ships all of its fuel to another site, adverse impacts would be associated with construction and operation of a fuel packaging facility. The impacts, however, would be expected to be substantially less than those noted for the Decentralization Alternative. Transporting a relatively large amount of SNF offsite to another DOE facility also likely would be considered an adverse impact.

5.18 Relationship Between Short-Term Uses of the Environment and

the Maintenance and Enhancement of Long-Term Productivity

SNF storage is contemplated for up to 40 years pending decisions on ultimate disposition. SNF is essentially uranium-238 with varying amounts of uranium-235 and small amounts of plutonium contaminated by small masses of fission products (but high activity). Because of this composition, a decision could be made at the end of the planned storage period to either continue storage until the energy resource value of the SNF warrants processing for power-reactor fuel or to determine that the fuel will never have any resource value and will be disposed of. If the decision is to continue to store the SNF, that option could be seen as the best use of land at the Hanford Site in terms of long-term productivity. This conclusion would apply to all of the alternatives except for the Regionalization C Alternative and the Centralization Alternative with storage at other than Hanford.

If the decision is to dispose of the SNF or if the non-Hanford centralization option for storage is selected, the land on the Hanford Site would become available for other uses. Because of the potential for, or perception of, contamination, use of the land for agriculture might not be appropriate. Moreover, the land occupied (or that would be occupied) by SNF facilities was of marginal utility for farming before it was obtained for the Hanford Site, and it remains so. However, other uses, such as for wildlife refuges, might be appropriate long-term uses of land vacated by SNF facilities after decommissioning is completed.

5.19 Irreversible and Irretrievable Commitment of Resources

This section addresses the irretrievable commitment of resources that would likely be used to implement the proposed project or its alternatives. An irretrievable resource is a natural or physical resource that is irreplaceably lost and cannot be replenished.

Implementation of the proposed project would result in the irretrievable use of fossil fuels in construction activities and in the transport of raw materials to the project site. In addition, there would be an irretrievable use of electricity and fossil fuel in the SNF operations. Briefly summarized below are discussions of irretrievable and irreversible resource impacts for each alternative.

5.19.1 No Action Alternative

The irreversible and irretrievable commitment of resources for the No Action Alternative would include an additional increment of energy, materials, and manpower to maintain safe and secure facilities. A new SNF facility would not be built, and Hanford SNF would continue to be managed in the current mode.

If the No Action Alternative were implemented, the following facilities would likely be used at the Hanford Site to maintain continued safe and secure storage of SNF: the 105-KE and KW Basins, FFTF, T-Plant, and the 308, 324, 325, and 327 buildings. Excluding energy and materials expended during construction of minor facilities to maintain safety and security, the operational staff is estimated at 215 personnel, and electrical power consumption is estimated to be 12,000 megawatt hours per year. This alternative represents less than a 2 percent increase in existing personnel at the Hanford Site and a negligible increase in the total amount of electrical energy currently used at the Hanford Site.

5.19.2 Decentralization Alternative

The irreversible and irretrievable commitment of resources for the Decentralization Alternative would include an additional increment of energy, materials, and personnel. Existing Hanford Site SNF would be safely stored for a 40-year period, with some limited SNF shipments. To accommodate this mission, existing facilities would require upgrading and new storage systems would need to be constructed. Various options have been proposed on which facilities to build and how to upgrade existing ones, but it has not been determined exactly which kind of facilities would need to be built. A representative set of values is presented in Table 5.19-1, which roughly indicates the material, personnel, and energy commitments. Depending on the option chosen, the alternative could require less than a 1.5 percent increase or up to a 33 percent increase (but only for 4 years) in the total amount of electrical energy currently used at the Hanford Site.

In addition to energy increases, additional water resources would be required for this alternative, but are not expected to be an excessive amount, compared to the more than 15 million cubic meters (4 billion gallons) of water used each year on the Hanford Site for all processes.

Table 5.19-1. Irretrievable commitment of materials in the Decentralization Alternative suboptions.

Item	Suboption

	W	X	Y	Z
Concrete, thousand cubic meters/(cubic yards)	13 (17)	15 (20)	17 (23)	24 (32)
Lumber, thousand cubic meters (board feet)	1.2 (500)	1.4 (570)	1.6 (650)	2.2 (930)
Electricity				
Construction (MW--hrs)	2500	2900	3500	4800
Operations (MW-hrs/yr)	1600	1600	100	100
Diesel fuel, cubic meters (thousand gallons)	500 (130)	570 (150)	660 (175)	900 (240)
Gasoline, cubic meters (thousand gallons)	500 (130)	570 (150)	660 (175)	900 (240)

a. Assumes operation of the process facility (28,000 or 115,000 MW-Hrs/yr) concurrently with those facilities where SNF is currently stored (12,000 MW-Hrs/yr, as in the No Action Alternative) for an interim period less than 4 years.

5.19.3 1992/1993 Planning Basis Alternative

The irreversible and irretrievable commitment of resources for the 1992/1993 Planning Basis Alternative would be very similar to those for the Decentralization Alternative. The materials, personnel, and energy estimates are assumed to approximate those stated in the Decentralization Alternative.

5.19.4 Regionalization Alternative

The Regionalization Alternative as it applies to the Hanford Site contains the following options:

- Option A - All SNF except defense production SNF would be sent to INEL.
- Option B1 - All SNF west of the Mississippi River except Naval SNF would be sent to Hanford.
- Option B2 - All SNF west of the Mississippi River and Naval SNF would be sent to Hanford.
- Option C - All Hanford SNF would be sent to INEL or NTS.

With the exception of Option C, which for Hanford is equivalent to the Centralization Alternative minimum option, the irretrievable and irreversible commitment of material resources are provided in Tables 5.19-2 through 5.19-4.

5.19.5 Centralization Alternative

The Centralization Alternative has two major options: either all Hanford SNF would be shipped offsite to another DOE facility where all SNF would be centralized (minimum option), or the Hanford Site would become the centralized location for all DOE SNF to be temporarily

Table 5.19-2. Irretrievable commitment of material resources in the Regionalization A suboptions.

Item	Suboption			
	W	X	Y	Z
Concrete, thousand cubic meters/(cubic yards)	9 (12)	9 (12)	16 (21)	19 (25)
Lumber, thousand cubic meters (board feet)	0.8 (350)	0.8 (350)	1.4 (600)	1.7 (700)
Electricity				
Construction (MW-hrs)	1800	1800	3200	3800
Operations (MW-hrs/yr)	1600	1600	100	100
Diesel fuel, cubic meters (thousand gallons)	380 (100)	380 (100)	610 (160)	720 (190)
Gasoline, cubic meters (thousand gallons)	380 (100)	380 (100)	610 (160)	720 (190)

a. Assumes operation of the process facility (28,000 or 115,000 MW-Hrs/yr) concurrently with those facilities where SNF is currently stored (12,000 MW-Hrs/yr, as in the No Action Alternative) for an interim period less than 4 years.

Table 5.19-3. Irretrievable commitment of material resources in the Regionalization B1 option.
(In addition to those listed for the Decentralization Alternative)

Concrete, thousand cubic meters/(cubic yards)	54 (70)
Lumber, thousand cubic meters (board feet)	5 (2,000)
Electricity, megawatt hours per year	3.000
Diesel fuel, cubic meters (thousand gallons)	1,900 (500)
Gasoline, cubic meters (thousand gallons)	1,900 (500)

Table 5.19-4. Irretrievable commitment of material resources in the Regionalization B2 option.
(In addition to those listed for the Decentralization Alternative)

Concrete, thousand cubic meters/(cubic yards)	120 (150)
Lumber, thousand cubic meters (board feet)	10 (4,200)
Electricity, megawatt hours per year	3,000
Diesel fuel, cubic meters (thousand gallons)	4,400 (1,200)
Gasoline, cubic meters (thousand gallons)	4,400 (1,200)

stored (maximum option). The increases in energy, materials, and personnel for both options are shown in Table 5.19-5. If all the SNF were shipped to the Hanford Site, then the impacts would be similar, although somewhat larger, than those of the Regionalization B options. If all the SNF were shipped offsite, then the impacts would be identical to the similar Regionalization B options. If all SNF were shipped offsite, construction and operation of a fuel packaging facility would be necessary before shipments could be made to an offsite facility.

5.20 Potential Mitigation Measures

This section summarizes possible mitigation measures that might be considered to avoid or reduce impacts to the environment as a result of Hanford Site operations in support of SNF management. These measures would be reviewed and revised as appropriate, depending on the specific actions to be taken at a facility, the level of impact, and other pertinent factors.

Table 5.19-5. Irretrievable commitment of materials in the Centralization options.

Item	No Fuel Stored at the Hanford Site	All Offsite Fuel Stored at the Hanford Site
Concrete, thousand cubic meters (cubic yards)	18 (23)	150 (200)
Lumber, thousand cubic meters (board feet)	1.6 (660)	13 (5600)
Electricity, megawatt hours per year	0-20,000	100-127,000
Diesel fuel, cubic meters (thousand gallons)	640 (170)	5700 (1500)
Gasoline, cubic meters (thousand gallons)	640 (170)	5700 (1500)

Possible mitigation measures are generally the same for all alternatives and are summarized by resource category below. No impacts on land use and aesthetic and scenic resources were identified; therefore, mitigation measures would not be necessary.

5.20.1 Pollution Prevention/Waste Minimization

The U.S. Department of Energy is responding to Executive Order 12856 and associated DOE orders and guidelines by reducing the use of toxic chemicals; improving emergency planning, response, and accident notification; and encouraging the development and use of clean technologies and the testing of innovative pollution prevention technologies. Program components include waste minimization, source reduction and recycling, and procurement practices that preferentially procure products made from recycled materials. The pollution prevention program at the Hanford Site is formalized in a Hanford Site Waste Minimization and Pollution Prevention Awareness Program Plan.

The SNF program activities would be conducted in accordance with this plan and implementation of the pollution prevention and waste minimization plans would minimize the generation of waste during SNF management activities.

5.20.2 Socioeconomics

The level of predicted employment for SNF activities at the Hanford Site is not large enough in comparison with present Hanford, local, or regional employment to produce a boom-bust impact on the economy.

5.20.3 Cultural (Archaeological, Historical, and Cultural) Resources

To avoid loss of cultural resources during construction of SNF facilities on the Hanford Site a cultural resources survey of the area of interest would be conducted by PNL Cultural Resources staff. Assuming no such resources were found, construction would proceed. If, however, during construction (earth moving) any cultural resource is discovered, construction activities would be halted and the PNL Cultural resources staff called upon to evaluate and determine the appropriate disposition of the find.

To avoid loss of cultural resources during operation, such as unauthorized artifact collection, workers could be educated through programs and briefing sessions to inform them of applicable laws and regulations for site protection. These educational programs would stress the importance of preserving cultural resources and specifics of the laws and regulations for site protection. The exact location of cultural resources are not identified by the PNL Cultural Resources group; therefore, any such artifact collection would be in an area discovered by the worker(s).

5.20.4 Geology

Soil loss would be controlled during construction using standard dust suppression techniques on disturbed soil and by stockpiling with cover where necessary. Following construction, soil loss would be controlled by revegetation and relandscaping of disturbed areas. Any soil that might become contaminated as a result of SNF management activities could be remediated using methods appropriate to the type and extent of contamination.

5.20.5 Air Resources

To avoid impacts associated with emissions of fugitive dust during construction activities, exposed soils would be treated using standard dust suppression techniques. New facility sources of pollutant emissions to the atmosphere would be designed using best available technology to reduce emissions to as low as reasonably achievable.

5.20.6 Water Resources

The impacts to surface and groundwater sources could be minimized through recycling of water, where feasible, and with clean-up of excess process water before release to ground or surface water.

5.20.7 Ecology

To avoid impacts to endangered, candidate, or state-identified sensitive species, pre-construction surveys would be completed to determine the presence of these species or their habitat. Within six months of ground breaking, DOE would again consult with the U.S. Fish and Wildlife Service to determine current species listings and perform a biological survey of the proposed SNF site. The presently proposed site at Hanford has been surveyed and no currently listed species were found. While not endangered, stands of Big Sagebrush habitat are diminishing generally and Hanford would expect to implement its habitat replacement program to provide areas on at least a 2 to 1 basis to mitigate habitat loss. In addition, areas disturbed would, as appropriate, be seeded with native plant species.

5.20.8 Noise

Generation of construction and operations noise would be reduced, as practicable, by using equipment that complies with EPA noise guidelines (40 CFR Parts 201-211). Construction workers and other personnel working in environments exceeding EPA-recommended guidelines during SNF storage construction or operation would be provided with earmuffs or earplugs approved by the Occupational Safety and Health Administration (29 CFR Part 1910). Because of the remote location of the Hanford SNF activities, there would be no noise impacts with respect to the public for which mitigation would be necessary.

5.20.9 Traffic and Transportation

At sites with increasing traffic concerns, DOE could encourage use of high-occupancy vehicles (such as vans or buses), implementing carpooling and ride-sharing programs, and staggering workhours to reduce peak traffic.

5.20.10 Occupational and Public Health and Safety

Although no radiological impacts on workers or the public were evident from the evaluation of routine SNF activities at Hanford, further improvement in controls to protect both workers and the general public is a continuing activity. The as low as reasonably achievable (ALARA) principle would be used for controlling radiation exposure and exposure to hazardous/toxic substances. Hanford would continue to refine its current emergency planning, emergency preparedness, and emergency response programs in place to protect both workers and the public.

5.20.11 Site Utilities and Support Services

No mitigation measures beyond those identified for ground disturbance activities associated with bringing power and water to the SNF site would appear necessary. In those cases use of standard dust suppression techniques and revegetation of disturbed areas would mitigate ground disturbance impacts.

5.20.12 Accidents

The Hanford Site maintains an emergency response center and has emergency action plans and equipment to respond to accidents and other emergencies. These plans include training of workers, local emergency response agencies (such as fire departments) and the public communication systems and protocols, readiness drills, and mutual aid agreements. The plans would be updated to include consideration of new SNF facilities and activities. Design of new facilities to current seismic and other facility protection standards would reduce the potential for accidents, and implementation of emergency response plans would substantially mitigate the potential for impacts in the event of an accident.

6. LIST OF PREPARERS

Rosanne L. Aaberg, dose calculations. B.S. (Chemical Engineering) University of Was Seventeen years of experience in dose calculations, and EIS preparation.
John C. Abbott, affected environment and environmental impacts. BA. (Geography) Sou Texas State University, M.S. (Conservation of Natural Resources) University of Texa Antonio. Over seventeen years of experience in the preparation of NEPA documents, e risk assessment evaluations, regulatory compliance activities, and other program ov activities.
John M. Alvis, Jr., facility descriptions. B.S. (Nuclear Engineering) and M.S. (Nuc Engineering) Texas A&M University. Six years of experience in reviewing safety anal licensing submittals, and contributing to the development of safety policies and gu Assisted in the technical review of licensee documents for NRC.
Larry K. Berg, meteorology. B.S. (Meteorology) Pennsylvania State University. One y experience in analyzing air quality and air resource parameters.
Frances M. Berting, fuel inventories. BA. (Physics) Oberlin College, MA. (Physics) College, Ph.D. (Materials Science) University of Virginia. Characterization of high gas-cooled reactor spent fuel, characterization of N Reactor spent fuel, and experi destructive and destructive examination of irradiated fuel elements. Prepared NRC a reports on fuel performance at commercial power plants and a report on commercial s reracking.
Charles A. Brandt, ecological characterization. B.S. (Zoology) Oregon State Univers (Zoology) Duke University. Over ten years of experience as a terrestrial ecologist ecological restoration, ecological risk and impact assessment, and conservation bio Extensive experience in preparation and analysis of NEPA-related documentation.
Mitchel E. Cunningham, spent nuclear fuel management. B.S. (Nuclear Engineering) an (Nuclear Engineering) Oregon State University. Several years of experience in such the behavior of spent fuel during both inert and air dry storage, investigating in-gas release, and the development of integrated computer codes for predicting nuclea behavior.

Colbert E. Cushing, deputy project manager, ecological resources. B.S. (Fisheries M and M.S. (Limnology) Colorado State University, Ph.D. (Limnology) University of Saskatchewan. Thirty-four years of experience in freshwater ecological research in radioecology, and over twenty years of experience in EIS preparation. Teach univers in stream ecology and writing journal articles.

Phillip M. Daling, transportation impacts. B.S. (Physical Metallurgy) Washington St University. Related experience includes performing transportation impact calculatio various EIS and environmental assessments and in support of environmental documenta over ten years.

James F. Donaghue, materials and waste management. B.S. (Civil Engineering) Univers Arkansas, J.D. Golden Gate School of Law. Nine years of experience in environmental compliance activities. Reviewed EISs and prepared portions of EISs and environmenta assessments for Air Force construction projects. Involved in the analysis of altern writing for the DOE Environmental Restoration Programmatic EIS.

Elizabeth A. Flores, materials and waste management. B.S. University of Connecticut (Environmental Studies) Yale University. Twelve years of experience in environmenta protection and waste management. Assistant Director for Connecticut Department of Environmental Protection for RCRA program.

Stephen Gajewski, regulatory framework and requirements. BA. (English) and BA. (Psychology) Gonzaga University. J.D. University of Washington. Over fourteen years experience in geotechnical operations planning, land management and environmental r compliance, including quality assurance on commercial power reactors, onshore and o and gas exploration, industrial hygiene program development and training, and envir strategic planning.
Clifford S. Glantz, non-radiological air quality impacts. B.S. (Physics and Atmosph State University of New York at Albany, M.S. (Atmospheric Sciences) University of W Twelve years of experience in the analysis of non-radiological air quality impacts.

Richard J. Guenther, alternatives and facilities descriptions. B.S. (Engineering Ph (Nuclear Engineering), and Ph.D. (Nuclear Engineering) Oregon State University. Ove years of experience testing and evaluating nuclear fuels to determine their charact performance under reactor operating conditions, wet and dry interim storage, and lo storage in a monitored retrievable or geologic storage environment.

George V. Last, cultural resources and land use. B.S. (Geology) Washington State Un Eighteen years of experience in geological research and cultural resources studies. experience in preparation and review of NEPA-related documents.

John P. McDonald, water quality and related consequences. A. .S. (Computer Science A.S. (Arts and Science) Columbia Basin College, B.S. (Geology) Eastern Washington U Four years of experience in conceptual model development of groundwater flow system collection of hydraulic head data, and determination of groundwater flow rate and d hydraulic testing to determine aquifer properties, testing and maintenance of the w portion of a multiple environmental media computer model, and application of numeri analytic computer models to environmental problems

Emmett Moore, project manager. B.S. (Chemistry) Washington State University, Ph.D. Chemistry) University of Minnesota. Twenty years of experience in environmental reg participation in and management of the preparation of environmental permits and documentation (NEPA). University professor of physics, chemistry, and environmental

Iral C. Nelson, deputy project manager, environmental consequences. B.S. (Mathemati University of Oregon, MA. (Physics) University of Oregon, diplomate, American Board Health Physics. Thirty-eight years of experience in various aspects of health physi protection) and twenty years of experience in conducting NEPA reviews and preparing documentation.

Ronald C. Phillips, geology and water resources. B.S. (Biology) Wheaton College, M. (Botany) Florida State University, Ph.D. (Botany) University of Washington. Wetland ecologist including delineation and mitigation of freshwater wetlands. Several year experience in the preparation and review of categorical exclusion documents, review environmental assessments, and preparation of biological assessments.

Kathleen Rhoads, air quality and accident analysis. B.S. (Microbiology) and M.S. (R Sciences) University of Washington. Nineteen years of experience in the analysis of assessment variables, estimation of radiation does following routine or accidental radionuclides to the environment, and evaluation of health effects from energy prod

Chikashi Sato, water quality and related consequences. B.S. (Chemical Engineering) National College of Technology, M.S. (Environmental Health Engineering) University Ph.D. (Environmental Engineering) University of Iowa. Thirteen years of experience university teaching, application of the Multimedia Environmental Pollutant Assessme (MEPAS), and performance of fate and transport analysis at waste sites.

Dillard B. Shipler, Introduction and review. B.S. (Mathematics and Science) Souther College, M.S. (Physics) University of Wisconsin-Milwaukee, other studies at Univers Oregon, Oregon State University, Reed College, University of Nevada, and University Washington. More than thirty years of experience in the planning and management of programs on regulatory compliance, radiological protection, environmental impact as radiological waste management, and environmental safety and health protection.

Donna J. Stucky, socioeconomics. BA. (Economics) Pacific Lutheran University, M.S. (Agricultural Economics) Purdue University. Two years of experience in the compilat economic data relating to eastern Washington State.

Betty Tegner, editor. BA. (English) University of Washington, MA. (English) Califor Polytechnical State University. Previous experience in journalism and university te Five years of experience in technical editing.
Gene Whelan, water quality and related consequences. B.S. (Civil Engineering) Penns State University, M.S. (Mechanics and Hydraulics) University of Iowa, Ph.D. (Civil Environmental Engineering) Utah State University. Seventeen years of experience in multimedia contaminant environmental exposure assessments.

Mona K. Wright, cultural resources and land use. BA. (Anthropology) Eastern Oregon

College, MA. (Anthropology) Washington State University. Fifteen years experience i
resource management, Federal regulations including the National Historic Preservati
NEPA, Executive Order 11593, the Archaeological Resources Protection Act of 1979, a
Native American Grave Protection and Repatriation Act, and historic and prehistoric
identification and recording.

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8. ACRONYMS AND ABBREVIATIONS

ALARA	as low as reasonably achievable
ANL	Argonne National Laboratory
ARMF	advanced reactivity measurement facility
ATM	approved testing materials
ATRC	advanced test reactor canal
BWR	boiling water reactor
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
CFRMF	coupled fast reactivity measurement facility
DCG	Derived Concentration Guides
DFA	driver fuel assemblies
DOE	U.S. Department of Energy
EA	environmental assessment
ECF	Expended Core Facility
EIS	environmental impact statement
EPA	Environmental Protection Agency
EPCRA	Community Right-to-Know-Act
ERPG	Emergency Response Planning Guideline
ER&WM	environmental restoration and waste management
FAST	Flourinel and Storage Facility at INEL
FECF	fuel element cutting facility
FFTF	Fast Flux Test Facility
FSF	fuel storage facility
FSF	Underwater Fuel Storage Facility (located at INEL)
HLW	high-level waste
IDF	Inspection dose factor
IDLF	Immediately Dangerous to Life and Health Values
IDS	interim decay storage
IDLH	Immediately Dangerous to Life and Health Values
IEM	interim examination and maintenance
INEL	Idaho National Engineering Laboratory
IVS	in-vessel storage
ILCF	latent cancer fatalities
LLW	low-level waste
MEPAS	Multimedia Environmental Pollutant Assessment System
MT	metric tons
MTHM	metric tons of heavy metal
MTR	materials test reactor
MTU	metric tons of uranium
NEPA	National Environmental Policy Act

NPDES	National Pollutant Discharge Elimination System
NRF	Naval Reactors Facility
NRHP	National Register of Historic Places
NTS	Nevada Test Site
ORNL	Oak Ridge National Laboratory
OSHA	Occupational Safety and Health Administration
PBF Canal	power burst facility canal
PEIS	programmatic environmental impact statement
PFP	Plutonium Finishing Plant
PSD	Prevention of Significant Deterioration
PUREX	Plutonium and Uranium Recoverv thrnii~ PYt~~~~
PWR	pressurized water reactor
RH-TRU	remote-handled transuranic material
RTEC	Registry of toxic effects for chemical substances
SBA	standard blanket assemblies
SHPO	Washington State Historic Preservation Officer
SNF	spent nuclear fuel
SPR	single-pass reactor
SRS	Savannah River Site
SS	single-shell tank
TDFA	test driver fuel assemblies
TEDF	Treated Effluent Disposal Facility
TFA	test fuel assemblies
TLV/TWA	Threshold Limit Values/Time Weighted Averages
TRIGA	Training, research, and isotope reactors built by General Atomic
WAC	Washington Administrative Code
WIPP	Waste Isolation Pilot Plant

ATTACHMENT A

FACILITY ACCIDENTS

Methods used to evaluate facility accidents associated with implementing the for SNF storage at Hanford are discussed in this attachment. The selection of radio accidents for the analysis was based on information available in previously publish National Environmental Policy Act documents, as described in Section 5. 15. Analyze of nonradiological hazardous materials were based on actual or expected inventories management facilities using conservative release assumptions. Industrial constructi operational accidents are also evaluated based on the person-years needed to build SNF facilities.

A.1 Radiological Accidents

The GENII computer code (Napier et a!. 1988) was used to perform calculations each facility to estimate the consequences of radionuclide releases to the atmosphe workers, members of the public at accessible locations on or near the site, individ the site boundary, and the population within 80 km of the release location. Dose ca used standard assumptions for the Hanford Site (Schreckhise et a!. 1993), and healt were estimated using recommendations of the International Commission on Radiologica Protection in its Publication 60 (ICRP 1991). The risks of cancer and other long-te health effects as estimated by ICRP (1991) are based on populations exposed to rela doses of radiation at high dose rates. For estimating risk to populations where the are below 20 rad, the ICRP recommended a low-dose reduction factor equal to 2. In t analysis, where accidents would yield individual dose estimates greater than 20 rad risk factors are used without the low dose correction to obtain the potential healt

Individual doses were estimated based on exposure of the receptor during the release, except where the release was sufficiently tong that it could be divided in and long-term components. In that case, onsite workers and members of the public at onsite locations were assumed to remain in the path of the plume for the duration o term component. The exposure duration for onsite individuals was assumed to be two corresponding to the maximum time required to evacuate the Hanford Site in the even accident, and no ingestion pathways were considered. Offsite individuals were assum exposed during the entire release, regardless of the accident duration. Because pro guidelines specify mitigative actions to prevent consumption of contaminated food, offsite individuals and populations was estimated both with and without the food in pathways. Reduced exposure to the plume or to contaminated ground surface as a resu early evacuation of offsite populations was not considered for the purposes of this although such action would certainly be taken in the event of a severe accident at

Individual dose calculations were performed using atmospheric dispersion param that represented 95 percent conditions (i.e., the air concentrations used would not more than S percent of the time). In the case of collective dose, the area surround source was divided into 16 directions and 10 sectors by distance, and the dose was only the direction resulting in maximum collective exposure. Dose to the population calculated using both 50 percent and 95 percent atmospheric dispersion parameters.

A.1.1 No Action Alternative

The No Action Alternative consists of fuel storage at existing Hanford facilit the 100-K Area wet storage basins; T Plant and a low-level burial ground in the 200 the 308, 324, 325, and 327 buildings in the 300 Area; and the Fast Flux Test Facili 400 Area. Maximum reasonably foreseeable accidents determined by Previously publish analyses were used for this evaluation, and the impacts of these accidents were ree using a consistent set of parameters for the spectrum of receptors required for thi

A.1.1.1 105-KE and 105-KW Basin Wet Storage. Airborne releases from the fuel

storage pool are bounded by a postulated accident for the 105-ICE and 105-KW Basins accident, a cask is dropped and overturned in the fuel transfer area, with broken f spilling out of the cask, within the pool building, but away from the pool. The sce that the shipping cask ruptures, exposing all of the broken fuel elements in three 42 fuel elements each containing 22.5 kilograms (50 pounds) of fuel. The probabilit accident is estimated as 10(-4) to 10(-6) per year. The analysis assumes 1O-year-ol (12 percent of plutonium content is Plutonium.240). The source term is calculated b multiplying the inventory at risk by the release fraction. The calculation of the r assumes the fuel heats but does not melt. Also, site evacuation is assumed, giving time for calculation of the onsite release factor. The offsite release factor was c an eight-hour release time. The calculated release quantity was 61 grams (0.14 poun onsite exposure and 244 grams (0.54 pounds) for offsite exposure, resulting in the releases listed in Table A-1. Recalculation of the doses for this analysis yields t

Table A-2.

A cask drop involving broken fuel elements falling out of the cask would most observed by the workers, who would also be alerted by area radiation alarms and the monitor in attendance of a change in radiation intensity. The assumed 12 workers wo be in Special Work Permit protective clothing, but typically would not be wearing r protection. The worke radiation (by increasing their distance from the source), for which their clothing protection. Once at a distance, they would move upwind of the postulated airborne r before beginning decontamination procedures. Assuming the workers evacuate within 1 minutes, their dose would range from about 70 to 140 rem. Using risk factors cite the maximum probability of an individual contracting a fatal cancer from a dose of would amount to about 0.06. The collective worker dose for such a scenario would am about 1800 person-rem for which one fatal cancer would be inferred. It should be no however, the risk factors used are not generally intended to be applied to large ac such acute doses might produce minor near term adverse health effects.

Table A-1. Estimated radionuclide releases for a dropped fuel casket accident in

Table A-2. Consequences of 105-KE Basin cask drop accident.

Recent preliminary analyses, based on updated information on the ability of the Basins to withstand natural forces indicate that seismic-induced damage at the 105- could, under some circumstances, result in radiation exposure to the public and wor than that indicated in this EIS. The underlying concern is whether the fuel in its condition could become uncovered by loss of the basin water thereby resulting in la of radionuclides to the atmosphere; in the present analysis the fuel is assumed to covered. A scenario in which the fuel would remain exposed to the air and allowed t not considered a reasonably foreseeable accident for the time period covered by thi

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a. cute doses of this magnitude are in the lower end of the range of doses that mi symptoms of acute radiation syndrome in humans.

A.1.1.2 Liquid Release Scenario for 105-KE or 105-KW Basin. Accidental liquid

releases from the 105-K Basins are bounded by seismic events or other mechanical di the basin or its water supply system. The most probable scenario is a break in an 8 supply line that overfills the storage pool causing water to overflow onto the surr (Bergsman 1995). The flow is assumed to continue for 8 hours before the supply is s resulting in release of 2300 cubic meters (600,000 gallons) of water and 60% of the inventory m the pool water. The inventory released from the 105-ICE Basin is assume Ci tritium, 0.029 Ci cobalt-60, 9.2 Ci strontium-90, 0.042 Ci cesium-134, 12 Ci ces 137/barium-137m, 0.0098 Ci plutonium-238, and 0.056 Ci plutonium-239.

The corresponding radionuclide inventory m the 105-KW Basin overflow pond is sumed to be as follows: 0.48 Ci tritium, 0.0013 Ci cobalt-60, 0.0031 Ci cesium-134, cesium-137, 1.1 Ci strontium-90, 5.9E-06 Ci plutonium-238, and 3.lE-05 Ci plutonium overflow is assumed to leach through the subsurface environment to the Columbia Riv Because the transmission rate of the soil is estimated as 570 centimeters per day [DOE's Programmatic Environmental Impact Statement (PEIS) (Schramke 1993)], a leachi rate of 26.3 centimeters per day (10 inches per day) will not result in a ponded si therefore, the entire 2300 cubic meters (600,000 gal) of overflow will leach into t eight-hour period. Contaminants are assumed to travel through the vadose zone, thro saturated zone to the Columbia River and in the Columbia River to receptors downstr flow discharge in the Columbia River is assumed to be under low-flow conditions of meters per second (36,000 cubic feet per second) (Whelan et al. 1987), which repres most conservative case for maximizing surface water concentrations. As a conservati assumption, the removal of water from the Columbia River is assumed to be 100 meter (328 feet) downstream of the point of entry of the contaminant into the river. The addressed recreational activities (e.g., boating, swimming, fishing) in the Columbi of the water as a drinking-water supply and for bathing, irrigation, etc. The colle fatal cancer from the spill at the 105-KW Basin was estimated as approximately 1.1 cancers for the maxiinum pathway and radionuclide (ingestion of plutonium-239 in fi years. The cumulative risk from all radionuclides and pathways amounted to approxim 10(-13) fatal cancers. The corresponding risks from a spill at the 105-KE Basin wer cancers for the maximum nuclide and pathway (also from ingestion of plutonium-239 i and about 6 x 10.10 fatal cancers for all radionuclides and pathways (Whelan et al.

The overflow scenario described in the previous paragraph has been extrapolat include a larger release because of recent concerns about the effects of a seismic enough to breach joints in the basin. A crack in the basin would potentially releas basin water and perhaps some of the sludge to the subsurface environment, where it available for leaching to groundwater and transport to the Columbia River. Because overflow scenario assumes release of over half of the basin water, the risk to a do individual from release of all the basin water would be less that twice that estima overflow scenario. Radionuclides in the sludge would be much less mobile and would groundwater slowly, providing time for remediation and mitigation measures as neces if significant quantities of sludge remained in the subsurface soil for an extended clean up, the risk to the downstream individuals and population would not likely be higher than that estimated for the overflow scenario.

This accident would not likely present any hazard to workers at the basin because scenario is liquid to ground to groundwater and on to the Columbia River and does n a source of exposure to the close-in workers.

A.1.1.3 308 Building. The maximum reasonably foreseeable accident for airborne

releases related to fuel storage at the 308 Euilding is dropping a transfer basket fuel from the reactor core to the storage pool (WHC 1990). It was conservatively es 13 fuel elements would have their cladding damaged, resulting in the release of 100 the krypton-85 to the environment in S minutes. The probability of this accident is 10(-2) to 10(-4) per year. In the Original Safety Analysis Report, the resulting do 0.013 rem to the worker, 8.6 x 10(-4) rem to the onsite individual, and 8.6 x 10(-5 boundary. Collective dose to the population was not reported in the SAR. The indivi correspond to a probability of fatal cancer of 5.2E-06 per year for the worker, 4.3 for the onsite member of the public, and 4.3E-08 per year at the site boundary.

This information is provided in more detail in WHC (1990), which, however, does detail the total quantity of krypton-85 released in any of its accident scenarios. quantities for krypton-85 were not available, the consequences of this accident wer evaluated for this analysis. Note that the SAR worker evaluation is for an individu facility who is assumed to evacuate within S minutes. This is a somewhat different those for the other worker consequences presented for the Hanford Site, which assum remains outside the facility at the point of maximum air concentration for a period 2 hours.

A transfer basket drop that results in damage to 13 fuel elements would most observed by the workers, who would also be alerted by area radiation alarms and the monitor in attendance of a change in radiation intensity. The assumed 12 workers wo be in Special Work Permit protective clothing, but typically would not be wearing r protection. The workers would immediately evacuate the area to reduce their exposur radiation (by increasing their distance from the source), for which their clothing protection. Once at a distance, they would move upwind of the postulated airborne r before beginning decontamination procedures. It was estimated (WHC 1990) that the w would receive a dose of 13 millirem. The collective worker dose would amount to abo 0.2 person-rem, and no latent cancer fatalities would be predicted for these worker

A.1.1.4 324 Building. The greatest potential safety concern at the 324 Building comes

from a safety assessment of the current levels of potentially highly mobile radioac B-Cell (PNL 1992a). The potential failure of the 324 Building exhaust ventilation s 0.1 g seismic event, along with shaking of highly mobile holdup material in the 324 cells, could cause a total release of 610 Ci of cesium- 137 and 310 Ci of strontium 12 hours. Of this total, approximately 55 percent (340 Ci of cesium-137 and 170 Ci strontium-90) would be released in the first two hours. The probability of the init event is 4 x 10A per year, and the other events leading to the release are assumed analysis to occur with certainty. The consequences of this accident are presented i In comparison to this accident, other potential releases from the building are judg insignificant, or they have been determined to be less probable because of radioact containment or handling frequency. The consequences associated with this accident a of existing contamination in the 324 Building hot cells, and neither its likelihood depend on the presence of spent fuel in the facility. The actual contribution of sp releases from the accident is assumed to be negligible compared with that of other

A seismic event that causes the failure of the 324 Building exhaust ventilati releases significant quantities of non-spent nuclear fuel-related radioactive mater building could occur at any time, whether or not there were workers in the building

Table A-3. Consequences of a seismic event at the 324 Building.

quake of sufficie workers in the building. In all likelihood, area radiation alarms would also sound. 50 workers would immediately evacuate the building and move to a position upwind of building. Although speculative, the workers might receive as much as 25 rem before completely safe zone. If that were the case, they would probably be restricted from radiation worker pending results of reading their dosimeters and completion of a me evaluation. The maximum probability of an individual contracting a fatal cancer fro dose would amount to about 0.02. The postulated collective dose would amount to abo 1300 person-rem, from which one latent cancer fatality might be inferred. Based onl estimated initiating earthquake frequency, the chances of these consequences occurr about 1 in 5,000 per year.

A.1.1.5 325 Building. A severe earthquake, without subsequent fire, is the maximum

reasonably foreseeable accident for the 325 Building (PNL 1992b). It is postulated earthquake would cause windows to break but not cause general or local structural c Doors may be jammed open after building evacuation, leaving additional openings for releases. Building power or ventilation could be lost. Further damage would be caus boxes and the contents of shelves and cabinets. The expected effects are considered most severe that could result from a 0.135 g horizontal acceleration, corresponding 2 x 10(-4)per year seismic event for which protection is required by DOE design cri structure.

Radionuclide releases associated with this accident are listed in Table A-4. noted that the environmental releases associated with the earthquake scenario are f sources in the 325 Building; fuel storage activities account for only a small fract Because these releases consist of a variety of chemical forms, the dose factors use tion of the consequences represented the maximum dose for all radionuclides in the release. The consequences of this accident are presented in Table A-5.

An earthquake that results in openings for unfiltered releases from the 325 B releasing significant quantities of non-spent nuclear fuel-related radioactive mate occur at any time, whether or not there were workers in the building. An earthquake sufficient intensity to cause damage to the ventilation system and possibly glove b windows would surely be noticed by any workers in the building. Whether area radiat monitors alarmed or not, the assumed 50 workers would immediately evacuate the buil once outside, would move to a position upwind of the building. Although speculative workers might receive as much as 3 rem before reaching a completely safe zone. The probability of latent fatal cancer for such a dose would be 0.001. The postulated c would amount to about 150 person-rem, from which no latent cancer fatalities would

A.1.1.6 327 Building. The postulated maximum reasonably foreseeable accident for

fuel storage at the 327 Building consists of mechanical damage to fuel pins and sub involving reactive fuel within a hot cell (WHC 1987). Because of the variety of act can occur in the hot cells, specific details of the accident were not postulated. T damage would breach the pin cladding and immediately release the gaseous fission pr the fuel-cladding gap. The subsequent fire would cause complete reaction of reactiv

Table A-4. Radionuclide releases for the 325 Building earthquake scenario.

Ta HEPA and activated charcoal filtration. The frequency of this accident is estimated 10(-6) per year. The hot cell inventory and the fraction of the inventory released Table A-6.

The previous analysis evaluated the most extreme case for damaged material con the maximum allowable limits of fission products that had not been vented to releas gases. In this case, fuel materials involved are assumed to be nonreactive in water

contain a maximum fission product inventory of 6.5 x 106 Ci including 2500 Ci of ha
Radionuclide releases from the fuel into the basin water and thence into the air ab
are based on U.S. Nuclear Regulatory Commission Regulatory Guide 1.25, which addres
accidents involving spent fuel in a storage pool. The consequences of the accident
for this document are listed in Table A-7.
Table A-6. Assumed inventories and release fractions for a 327 Building hot cell
and releases of radioactive material to the intact filtered ventilation system and
atmosphere. There would be no added source of radiation exposure to the close-in wo
the hot cell.

A.7.1.7 200-West Area Low-Levei Waste Btirial Grounds. The only accident

postulated to have any significant radiological releases in the Burial Ground safet
report is briefly described as a vehicle impact on one or more EBR II casks followe
(Saito 1992). Two vehicle impact scenarios were discussed in the document:

1. Severe impact or collision followed by a short-duration fire caused by a vehi accident in the trench.
2. Extremely severe impact or collision followed by a long duration fire.

The consequences of the latter accident were evaluated for fuels containing m
inventories of either fission product or transuranic radionuclides. The probability
accident is estimated to be 9.8 x 10-6 per year. The consequences of the less sever
Table A-8. Radionuclide releases for spent nuclear fuel storage at 200-West Buria
would be approximately an order of magnitude lower. The radionuclide releases for a
scenario 2 are shown in Table A-8; the accident consequences as re-evaluated for th
are presented in Table A-9. The maximum fission product inventory fuel yielded the
consequences for offsite receptors where the ingestion pathway was considered. The
transuranic inventory was associated with higher consequences for the inhalation an
exposure pathways.

The severe impact or collision followed by fire as postulated here might have
fatal nonradiological consequences to drivers and passengers of the vehicles involv
assumed that two drivers and two passengers are involved, These individuals would e
Table A-9. Consequences of the cask impact accident and fire at 200-West Burial G
or passengers would be able to evacuate the area to a safe distance from radiologic
consequences, the worst case is assumed, that the four individuals perish in this a
principally from trauma caused by the collision and fire. The likelihood of these c
occurring are estimated at 1 chance in 100,000 per year.

A.1.1.8 T Plant. The maximum scenario for fuel storage at T Plant is a dropped fuel

assembly inside the building (Jackson and Hanson 1978). The probability associated
accident is estimated to be 2.8 x 10(-3) per year. The release estimates assume dam
fraction of the wafers in the dropped fuel module containing 4-year-cooled Shipping
Core II fuel (a conservative assumption because the fuel has now been cooled for ap
20 years). Other release assumptions include the following:

- 10% of nonvolatile radionuclides in broken fuel are released to the bu
- 0.1% of the released particulate matenal is resuspended in the buildin
- All of the volatile krypton-85 is released to the building atmosphere
- Building filtration removed 98.6 percent of the particulate materials effluent exiting the stack.

Release estimates for this scenario are presented in Table A-10 and the consequence
release are listed in Table A-11.

Because workers evacuate the canyon area when fuel assemblies are being moved
from the casks or pool, there would be no opportunity for impacts on workers from a
fuel assembly in fuel storage at T Plant.
Table A-10. Releases for damaged assembly of Shippingport Core II fuel with 4-yea
Table A-11. Consequences of fuel assembly damage at T Plant. A.1.1.9 Fast Flux Te
storage of irradiated FFTF fuel in the Fuel Storage Facility (FSF) is a liquid meta
1989). The accident scenario is a spill of 11,793 kg of liquid sodium and subsequen
spill is initiated by either an internal event or a seismic event that causes a bre

between the FSF and heat exchangers. The liquid sodium is assumed to ignite spontan and burn, releasing aerosols to the atmosphere. The probability of this accident is be 10(-4) to 10(-6) per year.

The radionuclide release is from cesium that has been leached from the fuel i sodium. It is assumed for this accident that 0.1 percent of the elements are breach the sodium contains 0.9 uCi cesium- 134 per gram of sodium and 5 uCi cesium-137 per sodium. It is assumed that 35 percent of the sodium and cesium aerosols generated i are released to the atmosphere. The total activity released is estimated as 3.7 Ci and 25 Ci cesium-137. The consequences of the accident as estimated are listed in T Onsite individuals (workers and members of the public at onsite access locations) w to be exposed during 0.4 percent of the total release, because the spilled sodium w over 20 days to burn completely, and onsite individuals were assumed to be evacuate 2 hours.

Table A-12. Consequences of liquid metal fire at the Fast Flux Test Facility. An and heat exchangers could occur whether workers were present or not. The event woul be noticed by any workers in the building. In all likelihood, area radiation alarms sound. The assumed 50 workers would immediately evacuate the building and, once out would move to a position upwind of the building. Because this is an accident that i slow release of material to the atmosphere, it is speculated that dose to the close would not exceed 0.1 rem from this accident. The postulated collective dose would a about 5 person-rem, from which no latent cancer fatalities would be expected.

A.1.2 Decentralization Alternative

The Decentralization Alternative involves construction of several new facilit Hanford, including new dry storage for spent fuel or a combination of new wet and d Options are also included for several types of fuel processing prior to storage. Th quences of new facilities are based on previously evaluated accidents for similar i adapted for the conditions and location of these facilities as assumed in this anal

A.1.2.1 New Wet Storage. This accident scenario is the same as that described for a

dropped fuel container at the 100-K Basins. The releases are assumed to be the same accident previously described (see Table A-1), but the evaluation was repeated for location of the new facility adjacent to the 200-East Area. The accident frequency No Action Alternative is also assumed for this alternative because the quantity of in either case would be the same. The consequences of this accident for a new facil shown in Table A- 13.

A maximum reasonably foreseeable liquid release scenario has been postulated new pool storage facility for wet storage of nuclear fuels. The leak is based on a water-supply pipe breaking inside of the pool building and releasing 7600 liters pe (2000 gallons per minute). The flow is not shut off for 8 hours, resulting in 3600 (960,000 gal) being added to the pool. Because the pool cannot handle this amount o there is an overflow of 2300 cubic meters (600,000 gal) in this 8-hour period. Beca missidn rate of the soil is estimated as 570 centimeters per day (220 inches per da DOE's Programmatic Environmental Impact Statement (PEIS) (Schramke 1993)], a leachi rate of 26.3 centimeters per day (10 inches per day) will not result in ponding; th entire volume of overflow will leach into the soil over an 8-hour period. The basin does contain 61 percent of the basin-water radionuclide inventory, which is estimat The specific radionuclide inventory in the overflow pond is assumed to be as follow tritium, 0.0013 Ci cobalt-60,'0.031 Ci cesium-134, 0.22 Ci cesium-137, 1.1 Ci stron 5.9E-06 Ci plutonium-238, and 3.1E-05 Ci plutonium-239. All of the constituents in assessment are radionuclides. Contaminant migration is through the vadose zone, thr saturated zone to the Columbia River, and in the Columbia River to receptors downst The flow discharge in the Columbia River is assumed to be under low-flow conditions 1000 cubic meters per second (36,000 cubic feet per second) (Whelan et al. 1987), w represents the most conservative case for maximizing surface water concentrations. conservative assumption, the removal of water from the Columbia River is assumed to 100 meters (328 feet) downstream of the point of entry of the contaminant into the assessment addressed recreational activities (e.g., boating, swimming, fishing) in River and use of the water as a drinking-water supply and for bathing, irrigation, overall risk of fatal cancer from this accident was found to be less than 10 chance (Whelan et al. 1994).

Table A-13. Consequences of cask drop accident at new wet storage facility adjace

A cask drop involving broken fuel elements falling out of the cask at a new w facility would be tile same as discussed in Section A. 1. 1. 1. No prompt radiation cancer fatalities would be~redictcd for workers in this scenario.

The accident scenario at the 105-ICE and 105-KW Basins and its results descri the No Action Alternative would also be applicable under the Decentralization Alter to transport of fuel to a new storage facility.

A.1.2.2 New Dry Storage - Small Vault or Cask Facility. The maximum reasonably

foreseeable accident for the dry storage facility is assumed to be the same as that previously evaluated accident involving transport of FFTF fuel (DOE 1986b). This ac used as a surrogate for a dry storage facility accident involving an impact by eith or external initiator that results in a fire. The release associated with this acci at 5.4E + 02 Ci, based on the hypothetical scenario of six FFTF fuel assemblies irr 150 MWD/Kg being subjected to a severe impact followed by a fire. The fuel pins rup impact or on heating in the fire, which burns for an hour before being extinguished probability of such an accident resulting in b~ach of the transport cask is estimat 9 x 10(-7)or lower for 100 onsite shipments of FFw fuel. The estimated frequency fo accident in tile Decentralization Alternative has been adjusted to 6 x 10(-6) per y quantity of fuel that would be handled in loading the dry storage facility. Volatil and noble gases are released to the atmosphere. The estimated radionuclide releases in Table A-14, and the radiological consequences are presented in Table A-15.

Table A-14. Estimated radionuclide releases for cask impact accident and fire at

Table A-15. Consequences of cask impact accident with fire at new dry storage fac

facility would surely be noticed by nearby workers. In all likelihood, area radiati also sound. The assumed 12 workers would immediately evacuate the area and, once at distance, would move to a position upwind of the building. Evacuation time to that would be measured in minutes. The dose to close-in workers is speculated to be abou The maximum probability of latent fatal cancer from such a dose would be 0.001. The postulated collective dose would amount to about 36 person-rem, from which no laten fatalities would be expected.

A.1.2.3 New Fuel Stabilization Facility. The maximum reasonably foreseeable

radiological accident for fuel processing (either calcine or solvent extraction) is fire in a storage vessel (DOE 1986b; Bergsman 1995). The frequency of this accident estimated at 10A to 10~ per year. Releases for the accident from a new facility adj 200-East Area are listed in Table A-16. The total release assumes that fuel burns f of 20 hours; therefore, doses to onsite receptors were calculated on the basis that exposed for 2 hours (or 10 percent of the total release, assuming a constant releas duration of the fire). The consequences of the accident are listed in Table A-17.

This accident involves a uranium fire in a storage vessel with releases of rad material to the atmosphere. There would be no added source of radiation exposure of close-in worker in the processing facility.

A.1.3 1992/1993 Planning Basis Alternative

Accidents and consequences would be essentially the same as those for the D zation Alternative.

A.1.4 Regionalization Alternative

Accidents and consequences would be essentially the same as for the Decentral Alternative. The accident frequencies for a cask impact and fire at handling and st facilities were adjusted to account for the quantity of imported or exported fuel h of the suboptions at a receiving and canning facility or in loading storage facilit

Table A-16. Estimated airborne radionuclide release from shear/leach/ calcine sta vessel).

Table A-17. Consequences of uranium metal fire at fuel stabilization facility.

Regionalization A (all fuel except defense fuel would be shipped offsite) the frequ assumed to be the same as in Decentralization (6E-06 per year). The frequency in Regionalization B (Western fuel comes to Hanford) is slightly higher (7E-06) becaus additional fuel that would be handled. The Regionalization Alternative is assigned frequency (5E-06) when all SNF is shipped offsite.

A.1.5 Centralization Alternative

The Centralization Alternative consists of two options at Hanford - a minimum which all DOE spent fuel at Hanford is transported offsite to another location for storage, and a maximum alternative that would result in storage of all DOE spent fu Hanford. Accident scenarios for the minimum option would include those discussed un No Action Alternative prior to shipment of the fuel offsite. In addition, N reactor would be stabilized prior to shipment in a facility simflar to the shear/leach/calc discussed under the Decentralization Alternative. The uranium metal fire accident d under that alternative is assumed to be the maximum reasonably foreseeable accident stabilization facility in this case as well. The estimated frequency for the cask i storage or canning and shipping facilities has been adjusted to 5 x 10(-6) per year quantity of fuel that would be handled in the centralization minimum alternative.

The maximum option contains suboptions for wet or dry fuel storage with proce similar to those for the Decentralization Alternative, and the consequences are exp essentially the same as those described previously. The estimated frequency for the and fire at a receiving and canning or dry storage facility has been adjusted to 8 based on the quantity of imported fuel that would be handled in the Centralization maximum option. The only additional installation that would be included in this opt Expended Core Facility (ECF), which would be relocated from the INEL. The consequen accidents at this facility are discussed in Volume 1, Appendix D of this document. noted that the accident evaluation for the ECF at Hanford in Appendix D uses assump are different from those used for the Hanford accidents in this attachment and ther risks associated with the ECF at Hanford cannot be compared directly with those for Hanford facilities presented here. The consequences of the ECF accidents using Hanf assumptions would be higher than those presented in Appendix D.

A.2 Nonradiological Accidents

For purposes of the analysis, a worst-case accident scenario was developed fo existing and planned facility. The details of the nonradiological accident scenario in this section. The scenario involves a chemical spili within a building, followed environmental release from the normal exhaust system. It is assumed that the buildi intact but containment measures fail, allowing release to occur through the ventila It is assumed that all, or a portion of, the entire inventory of toxic chemicals st building is released. The environmental releases are modeled and the hypothetical concentrations at three receptor locations are compared to toxicological limits.

A.2.1 Chemical Lists

Chemical inventory and chemical emissions lists have been developed provided alternative and facility (Bergsman 1995). These chemical lists are of three basic t type is a "worst-case chemical inventory," prepared to comply with the Emergency Pl Community Right-To-Know Act reporting requirement. For facilities that store SNF, t which ones are of particular interest. The second type, presented in the Facility C a general statement listing proposed process chemicals. The third type of list is a proposed liquid effluents and airborne emissions, presented in the Facility Dischar Effluent and emissions data are not presented for every option.

A.2.2 Baseline Chemical Inventory Based on Existing Facilities

A baseline inventory of chemicals kept in SNF facilities was developed from c Inventories for these facilities that were compiled to comply with the Emergency Pl Community Right-To-Know Act. The existing storage facilities are 105-ICE Basin, 105 Basin, PUREX (202A), T Plant (22 IT), 2736-ZB Building, 200W low-level burial groun Fuel Test Facility (FFTF) (403 Building), 308 Building, 324 Building, 325 A&B Build 327 Building. The Emergency Planning and Community Right-To-Know Act lists used are 1992.

Because most facilities have various missions, the need for an inventory of c these facilities may not be related to the storage of SNF. The assumption is made t existing inventories represent the amounts and types of chemicals that may be neede future.

Table A-15 lists chemicals by facility, the regulated reportable quantity (RQ of an environmental release, the maximum quantity stored, its physical state (gas, the reference where the chemical is listed, the hypothetical release fraction (1 fo liquids, and 0.01 for solids), the calculated total hypothetical chemical release, probable use.

In the table, a solid frame around a number indicates that a stored quantity reportable quantity for that chemical; a double-lined frame indicates that a conser hypothetical accidental release would exceed the reportable quantity. A total of se chemicals fail in the latter category and have the highest probability to be releas These seventeen chemicals are the ones that would demand the highest attention in a emergency plan.

Because a reportable quantity has itt been defined for every chemical, the in toxicity of each chemical was also considered in assessing its importance. The rele used in the accidental spill scenario are conservative, higher than those reported by as much as three orders of magnitude (Hickey et al. 1991).

A.2.3 Proposed Facilities

Table A-19 is primarily derived from the Facility Costs section of the engine data (Bergsman 1995). However, the 105-KE Basin is used as a surrogate for a baseli chemical inventory for the wet storage facility because the Facility Cost section l hydroxide and suffuric acid.

Table A-19 lists chemicals by facility, the regulated reportable quantity (RQ of an environmental release, the maximum quantity stored, its physical state (gas, the reference where the chemical is listed, the hypothetical release fraction (1 fo liquids, and 0.01 for solids), the calculated total hypothetical chemical release, probable use. In the table, a solid frame around a number indicates that a stored q exceeds the reportable quantity for that chemical; a double-lined frame indicates t conservative hypothetical accidental release would exceed the reportable quantity. chemicals fall in the latter category and have the highest probability to be releas These six chemicals are the ones that would demand the highest attention in an emer

A.2.4 Atmospheric Modeling

Effects to onsite workers, the nearest point of pubic access, and the public offsite residence were estimated using the computer model EPlcode (DOE 1993b). EPic uses a straight line Gaussian plume model and characteristics of an individual chem estimate downwind concentrations independent of direction. The 95 percent meteorolo parameters were used to determine the wind speeds and stability class used for the In each case, stability class F was used. Wind speeds of 0.89 meters per second (2. hour) were used for calculating effects to an onsite worker, the nearest point of p and at the nearest offsite residence. Other criteria used in the model simulations in DOE (1993a).

Table A-18. Baseline Chemical Inventory for Existing Facilities in SNF Storage Lo

Table A-18. Page 2 Table A-18. Page 3 Table A-18. Page 4 Table A-18. Page 5

Results from the EPlcode model were compared to available Emergency Response Planning Guideline (ERPG) values, Immediately Dangerous to Life and Health (IDLH) v and Threshold Limit Values/Time-Weighted Averages. In the absence of these values, toxicological data for similar health endpoints, obtained from the Registry of Toxi Chemical Substances (RTEC), are used.

Emergency Response Planning Guidelines are estimates of airborne concentratio thresholds above which one can reasonably anticipate observing adverse effects (DOE Emergency Response Planning Guideline values are specific for a substance and are d three general severity levels: ERPG.1, ERPG-2, and ERPG-3. ERPG-1 values result in unacceptable likelihood that one would experience mild transient adverse health eff perception of a clearly defined objectionable odor (DOE 1993b). ERPG-2 values resul unacceptable likelihood that one would experience or develop irreversible or other health effects or symptoms that could impair one's ability to take protective actio 1993b). ERPG-3 values result in an unacceptable likelihood that one would experienc threatening health effects (DOE 1993b).

For many chemicals, ERPG levels are not defined. In these instances, Threshol Value/Time-Weight Average (TLV/TWA) values are substituted for ERPG-1 values. Ten percent of Immediately Dangerous to Life or Health (IDLH) values are substituted fo values, and IDLH values are substituted for ERPG-3 values (DOE 1993b).

Data from RTEC were used for eight chemicals. Acute toxicity data were utiliz generate exposure limits to approximate the ERPG endpoints--irritation/odor, irreve health effects, and death.

All references for Attachment A are included
in Chapter 7 of this Appendix

ATTACHMENT B

EVALUATION OF OPTION FOR FOREIGN PROCESSING OF SPENT
NUCLEAR FUEL CURRENTLY LOCATED AT THE HANFORD SITE

B.1 Description of Foreign Processing Alternative

This option was considered in response to a public comment requesting that forei
spent nuclear fuel (SNF) from the Hanford Site be addressed as a reasonable alterna
and storage. Under this alternative, the SNF currently stored in basins at the 100
would be packaged for shipment to an overseas facility where it would be processed.
stored at the 100-K Basins was considered in this analysis because it represents a
homogenous material that would require stabilization in order to be suitable for 40
quantities of other types of fuel currently stored at Hanford either would not requ
sufficiently different characteristics that they could not be stabilized efficientl
facility.

This analysis assumes that high-level waste (HLW) arising from the process would
interim storage, although it could potentially be stored overseas until a domestic
which to permanently dispose of it. Similarly, uranium and plutonium resulting fro
to be returned to Hanford for interim storage; however, these materials could also
decision is made on their disposition by the U.S. Department of Energy (DOE).

The following analysis was undertaken despite substantial uncertainties concerni
distance transport of SNF in its current condition from the Hanford Site. Approxim
currently stored underwater at the 100-K West Basin in sealed, vented containers, a
100-K East Basin in containers that are open to water. Efforts to characterize the
the SNF are just getting underway, and those studies may reduce the uncertainties a
transport of this SNF.

The SNF shipment would be required to meet national and international regula
the cask seal in the event of internal pressure build-up, acceptable gas concentrat
allowable quantities of dispersible radionuclides. Because the defense production
during handling and discharge from the reactors, and because it was not designed fo
storage, a substantial fraction of the fuel elements have degraded during the time
(ranging from 7 to more than 20 years). The Hanford SNF in its present condition m
because of the quantity of dispersible radionuclides in damaged and corroding SNF,
and possible buildup of gases within the shipping container that might result from
in the wet overpack.

If the Hanford fuel were not able to meet the transportation requirements, the o
alternative would necessitate additional expense and risk to stabilize the fuel or
smaller quantities than assumed for the present analysis, perhaps to the extent tha
impractical altogether. The overland transport evaluation presented in Volume 1, A
that Hanford SNF was in a stabilized form prior to shipment, as described in this a
uncertainties surrounding the feasibility of long-distance transport of Hanford SNF
to be consistent with the overland transport analysis in Appendix I, the SNF for ov
presumed to be stabilized prior to shipment or is limited to elements that are suff
requirements of the transportation regulations could be met using a wet overpack sh
quantities assumed in the overseas transport analysis include the total mass of SNF
K Basins, although some of the SNF is known to exist as corrosion products and slud
for shipment without prior treatment to convert them into a less dispersible form.

B.2 Methods and Assumptions

The following sections describe the methods used to evaluate potential consequen processing option. The analysis focuses on the activities associated with transpor Kingdom (U.K.) for processing and return of the waste and products to the U.S. The activities at Hanford to prepare the SNF for shipment, as well as those associated of the SNF within the U.K., to the extent that information was available. Informat facility located in the U.K. was used as the basis for this evaluation (BNFL 1994). facilities as a representative case would not preclude processing of SNF from Hanfo installation.

B.2.1 Shipping Scenarios

Potential shipping scenarios are described in this option for transporting irrad Hanford Site to the U.K., and the return of separated plutonium, uranium, and HLW t stabilization and packaging, as necessary, of the SNF currently stored in the 100-K Site. From the 100 Area, the SNF would be loaded for onsite or offsite transport a Offsite transport would take place via either barge, truck, or rail to a port desig particular hazard" in accordance with 33 CFR 126, where the shipment would be loade transport. The overseas segment of the shipment was assumed to utilize purpose-bui employed by the representative processing facility in the U.K. for shipping SNF (BN likely be necessary if Hanford SNF were to be shipped without prior stabilization b would presumably not have either the equipment or expertise required for long-dista in a wet overpack. If the SNF were stabilized before shipment, a variety of commer options might be available (see DOE 1995 for a discussion of those options).

After processing of the SNF, the products and wastes were assumed to be returned storage via the same U.S. seaport at which the initial shipments exited the country addressed in the analysis for the return shipments are plutonium, uranium, and HLW. separated plutonium and uranium would be converted to oxide forms and shipped to th ship similar to that used for transporting the irradiated fuel. Other transport op for these materials, including use of military or commercial ships or aircraft. Hi be processed to a stable form (borosilicate glass encased in stainless steel canist section provides descriptions of the shipping scenarios, transportation and packagi characteristics of the shipments, transportation routes, and port facilities that w

B.2.1.1 Port Selection. Ports evaluated for the foreign processing option were chosen to minimize either

the overland or ocean segments of the shipments and to provide a reasonable range o modes between the Hanford Site and the port (i.e., barge, truck, or rail). For the two potential West Coast U.S. ports (Seattle/Tacoma, Washington, and Portland, Oreg Coast port (Norfolk, Virginia) were evaluated for the overland transportation analy along the routes to these ports are representative of those in the vicinity of many addition, the port of Newark, New Jersey, was included in the port accident analysi of an accident in a location with a very high surrounding population.

B.2.1.2 Overseas Transport. The routing for overseas transport from West Coast U.S. ports would include

transit via the Columbia River or Puget Sound to the Pacific Ocean, a southerly rou around Cape Horn in South America, and then north to the U.K. The route around the maximizes the distance that a shipment might be required to travel, and therefore, risks associated with the ocean transport segment. However, a route via the Panama

West Coast shipments because it avoids potential risk associated with the added dis conditions that might be encountered during transport around the cape. Transport vi be directly across the Atlantic Ocean to the U.K. The total distance for ocean tra approximately 7,000 nautical miles via the Panama Canal or 17,000 nautical miles vi Coast is approximately 3000 nautical miles.

B.2.1.3 Overland Transport Scenarios. Overland transport between the Hanford Site and overseas shipping

ports was evaluated for three different scenarios, as described in the following se

B.2.1.3.1 Barge to Portland, Transoceanic Shipment to the U.K. This scenario begins with cask

loading operations at the Hanford Site 100-K Area Basins. The shipping casks would for truck transport to the Port of Benton barge slip near the 300 Area of the Hanfo barge slip, the shipping casks would be transloaded onto the barge via crane and th barge. After a full load of casks was secured, the barge would depart for the Port down the Columbia River through routinely navigated shipping channels. At the Port casks would be lifted off the barge and placed aboard a ship for the overseas segme casks would then be secured, and the ship would depart for the U.K. After processi were assumed to return via Portland, where the material would be transloaded onto a Hanford for interim storage. Shipments of uranium and plutonium oxide would be ret

B.2.1.3.2 Truck/Rail to the Port of Seattle, Transoceanic Shipment to the U.K. The first leg of

this scenario is different from the barge-to-Portland scenario in that the shipping K Basins and shipped directly to the Port of Seattle, Washington, for transloading The overland leg would consist of either truck or rail shipments. It was assumed t transported per truck shipment or two casks per rail shipment. After arrival at t casks would be transloaded onto the ocean-going vessel and when a shipload of casks sail through Puget Sound and the Strait of Juan de Fuca to the Pacific Ocean, trave Canal or Cape Horn, and then north to the U.K. After processing, the uranium, plut be returned to the U.S. by ship via Seattle and finally to Hanford by truck or rail

B.2.1.3.3 Truck/Rail to the Port of Norfolk, Virginia, Transoceanic Shipment to

the U.K. This scenario would be similar to the truck/rail to Seattle scenario exce port would be Norfolk, Virginia. Similar to the Port of Seattle scenario, the ship ocean-going vessel and shipped to the U.K. This shipping scenario maximizes the ov minimizes the ocean travel distance. As with the other two shipping scenarios, the oxide, and uranium oxide materials were assumed to be returned to Hanford via Norfo

B.2.2 Shipping System Descriptions

This section presents descriptions of the shipping cask and truck, rail, and bar used in the three potential shipping scenarios. The information presented focuses eters important to the impact calculations, namely the cargo capacities and radionu The shipping cask assumed to be used for the SNF shipments from Hanford to the U routinely used for commercial SNF transport (BNFL 1994). The cask could transport fuel (with a smaller capacity for damaged fuel). The loaded cask weight is about 4 one cask could be transported per highway shipment and two per rail shipment. The were assumed to be 24 casks each. A total of 17 transoceanic shipments would be re caskloads that would be necessary to ship all Hanford SNF. The actual number of sh the number of casks available, or on procurement of a sufficient number of new cask shipment of Hanford SNF on a reasonable schedule.

The radionuclide inventories for the SNF shipments were determined using the inf fuel inventories presented in Bergsman (1994). The resulting radionuclide inventor shipments (truck, rail, and barge/ship) are presented in Table B-1.

The return shipments of HLW and plutonium and uranium oxide were assumed to be s for overseas shipment of Hanford SNF. For the barge to Portland option, these mate returned to the U.S. by ship to the Port of Portland, where HLW shipping casks woul and uranium and plutonium onto trucks for transport to Hanford. Similarly for the would be transported by ships to the ports of Norfolk or Seattle, transloaded onto and transported to Hanford.

The number of shipments of solidified HLW was estimated using assumed shipping c estimated that a total of 500 containers of vitrified HLW, each weighing about 500 processing the N Reactor SNF (BNFL 1994). The U.K. processing facility has designe for vitrified HLW that would be capable of carrying 21 HLW containers per shipment. would be required to return the HLW to the U.S. This material was assumed to be tr in one shipment and then transloaded onto a rail car for the overland shipment segm to be transported by regular truck service). The actual number of shipments requir HLW casks available or on procurement of a sufficient number of new casks to provid of HLW on a reasonable schedule.

The radionuclide inventories for the solidified HLW shipments are presented in T were calculated by dividing the total quantity of each radionuclide shipped to the plutonium) by the number of HLW casks (24) to be returned to the U.S.

Table B-1. Facility and transport mode radionuclide inventory developmenta

Radionuclide	Curies/ MTU	Grams/ MTU	Total Curies in SNF	Curies/Shipmentb		
				Truck	Rail	Bar
Shipments				408	204	17
Duration				5 years	5 years	5 y
H3	4.59E+01		9.64E+04	2.36E+02	4.73E+02	5.6
Fe-55	1.22E+01		2.56E+04	6.28E+01	1.26E+02	1.5
Co-60	8.78E+00		1.84E+04	4.52E+01	9.04E+01	1.0
Kr-85	8.07E+02		1.69E+06	4.15E+03	8.31E+03	9.9
Sr-90	9.32E+03		1.96E+07	4.80E+04	9.59E+04	1.1
Y-90	9.32E+03		1.96E+07	4.80E+04	9.59E+04	1.1
Ru-106	8.52E+01		1.79E+05	4.39E+02	8.77E+02	1.0
Rh-106	8.52E+01		1.79E+05	4.39E+02	8.77E+02	1.0
Sb-125	2.02E+02		4.24E+05	1.04E+03	2.08E+03	2.5
Te-125	4.94E+01		1.04E+05	2.54E+02	5.09E+02	6.1
Cs-134	3.01E+02		6.32E+05	1.55E+03	3.10E+03	3.7
Cs-137	1.20E+04		2.52E+07	6.18E+04	1.24E+05	1.4
Ba-137m	1.14E+04		2.39E+07	5.87E+04	1.17E+05	1.4
Ce-144	3.97E+01		8.34E+04	2.04E+02	4.09E+02	4.9
Pr-144	3.97E+01		8.34E+04	2.04E+02	4.09E+02	4.9
Pr-144m	4.77E-01		1.00E+03	2.46E+00	4.91E+00	5.8
Pm-147	2.72E+03		5.71E+06	1.40E+04	2.80E+04	3.3

Table B-1. (contd)

Radionuclide	Curies/ MTU	Grams/ MTU	Total Curies in SNF	Curies/Shipmentb		
				Truck	Rail	Bar
Shipments				408	204	17
Duration				5 years	5 years	5 y
Sm-151	1.10E+02		2.31E+05	5.66E+02	1.13E+03	1.3
Eu-154	2.17E+02		4.56E+05	1.12E+03	2.23E+03	2.6
Eu-155	5.14E+01		1.08E+05	2.65E+02	5.29E+02	6.3
U-234	4.34E-01	6.94E+01	9.11E+02	2.23E+00	4.47E+00	5.3

U-235	1.60E-02	7.39E+03	3.35E+01	8.22E-02		1.64E-01	1.9
U-236	7.63E-02	1.18E+03	1.60E+02	3.93E-01		7.86E-01	9.4
U-238	3.31E-01	9.84E+05	6.94E+02	1.70E+00		3.40E+00	4.0
Np-237	4.75E-02		9.98E+01	2.45E-01		4.89E-01	5.8
Pu-238	1.22E+02		2.56E+05	6.28E+02		1.26E+03	1.5
Pu-239	1.36E+02	2.20E+03	2.86E+05	7.02E+02		1.40E+03	1.6
Pu-240	9.94E+01	4.38E+02	2.09E+05	5.12E+02		1.02E+03	1.2
Pu-241	8.71E+03	8.46E+01	1.83E+07	4.49E+04		8.97E+04	1.0
Pu-242	6.45E-02	1.64E+01	1.35E+02	3.32E-01		6.63E-01	7.9
Am-241	1.84E+02		3.86E+05	9.47E+02		1.89E+03	2.2
Cm-244	2.62E+01		5.50E+04	1.35E+02		2.70E+02	3.2

a. Radionuclide inventory taken from Bergsman (1994) and represents 10-year cooled Pu-240 constitutes 16% of total plutonium.

b. Curies/shipment inventories assume 1 cask per truck shipment, 2 truck casks per casks per barge shipment.

c. Curies/cask inventories are based on one cask per truck and/or rail shipment.

d. HLW - Solidified high level waste; inventory assumes 100% removal of plutonium level waste to be shipped only by barge (24 casks per barge) or rail (1 cask per r

e. Plutonium and uranium oxide inventories assume 100% removal, and the number of adjusted to reflect conversion from metal to oxide. Plutonium and uranium oxide to and truck only.

The number of shipments of uranium and plutonium oxide were estimated using stan for uranium and plutonium. The estimated quantities to be shipped include 2,360 to and 6.5 tons of plutonium oxide generated from processing the K Basin SNF. For thi the plutonium oxide would be transported by truck in a Type B package with a capaci results in a total of 186 caskloads of plutonium oxide. The vehicle for transport o Safe-Secure Trailer/Armored Tractor specifically designed for shipment of special n U.S. The uranium oxide was assumed to be transported by truck in shipping systems 10,000 kg/shipment. This would require a total of 236 caskloads of uranium oxide. for overland segments was assumed. One sea shipment of uranium oxide and one of pl required.

The radionuclide inventories for the plutonium oxide and uranium oxide shipments The inventories were determined by dividing the total quantities of uranium and plu U.K. by the respective numbers of caskloads presented above.

B.2.3 Transportation Route Information

The overland transportation routes assumed for this analysis are described in th descriptive information includes the shipping distances and population density data using the HIGHWAY (Johnson et al. 1993a) and INTERLINE (Johnson et al. 1993b) compu shipments, respectively, and are used to calculate transportation impacts. These d each transport segment described in Section B.2.2. No population data are presente because once at sea, the exposed population becomes essentially zero.

Hanford to Seattle, Washington: The truck and rail shipping distances from Hanford be 277 km (172 miles) and 716 km (445 miles), respectively. The large difference i the fact that the rail route is not a direct link to Seattle, but travels from Hanf then to Seattle. For the highway route, the shipment travels through 88.1% rural a density 4.5 persons/km2), 10% in suburban areas (359 persons/km2) and 1.9% in urban sons/km2). The rail route travels through 74.1% rural areas (9.8 persons/km2), 19% (415.5 persons/km2), and 6.9% in urban areas (2226 persons/km2).

Hanford to Norfolk, Virginia: The truck and rail shipping distances from Hanford t 4585 km (2849 miles) and 4984 km (3097 miles), respectively. For the highway route 84.5% rural areas (7.3 persons/km2), 13.4% in suburban areas (365 persons/km2) and (2299 persons/km2). The rail route travels through 83% rural areas (7.8 persons/km (360.4 persons/km2), and 2.4% in urban areas (2149 persons/km2).

Hanford to Portland, Oregon: The only option evaluated for using the Port of Portl Portland, where it would be transloaded onto the ship. The distance and population shipment was approximated using INTERLINE (Johnson et al. 1993b), which evaluates p the rail lines closely follow the Columbia River in which the barge would be operat data for a barge shipment would be similar to that for a rail shipment. The rail d conservative than actual barge data because the rail lines pass closer to the city would a barge.

B.2.4 Description of Methods Used to Estimate Consequences

This section describes the methods used to estimate consequences of normal and a individuals or populations to radioactive materials. The RADTRAN 4 (Neuhauser and et al. 1993) computer codes were used to calculate the transportation impacts, and (Napier et al. 1988) was used to estimate the consequences of port accidents. The software (Grove Engineering 1988) was used to determine approximate external dose r as input to the transportation consequences. Nonradiological impacts from both inc accidents were also evaluated.

The output from computer codes, as total effective dose equivalent (TEDE or dose was then used to express the consequences in terms of potential latent cancer fatal of the International Commission on Radiological Protection (ICRP 1991) for low dose exposures were used to convert dose as TEDE to LCF. The conversion factor applied LCF/rem TEDE, and that for the general population was 5 x 10-4 LCF/rem TEDE. The g have a higher rate of cancer induction for a given radiation dose than healthy adul workers because of the presence of more sensitive individuals (e.g., children) in t

The estimated LCF for potential accidents was multiplied by the expected acciden shipment, or for the entire duration of the foreign processing operation, to provid consistent with those reported in the remainder of this EIS. Incident-free transpo operations were assumed to occur (i.e., they have a frequency of 1.0); therefore, t with normal operations would be identical to the predicted number of latent cancer the operation.

Nonradiological incident-free and accident impacts were also evaluated. Nonradi impacts consist of fatalities from pollutants emitted from the vehicles. Nonradiol the fatalities resulting from potential vehicular accidents involving the shipments categories of impacts are related to the radiological characteristics of the cargo. nonradiological impacts were derived by multiplying the unit risk factors (fataliti total shipping distances for all of the shipments in each shipping option. Nonradi incident-free transport were taken from Rao et al. (1982), and for vehicular accide Kvitek (1994).

B.2.4.1 RADTRAN 4 Description. The RADTRAN 4 computer code (Neuhauser and Kanipe 1992) was used to

perform the analyses of the radiological impacts of routine transport, the integrat accidents during transport of irradiated N-Reactor SNF to the U.K., and the return oxide, and uranium oxide from the U.K. to Hanford. RADTRAN was developed by Sandia calculate the risks associated with the transportation of radioactive materials. T SNL in 1977 in association with the preparation of NUREG-0170, Final Environmental Transportation of Radioactive Material by Air and Other Modes (NRC 1977). The code expanded and is currently maintained by SNL under contract with DOE. RADTRAN 4 is (Madsen et al. 1986) and RADTRAN 2 (Taylor and Daniel 1982, Madsen et al. 1983) com

The RADTRAN 4 computer code is organized into the following seven models (Neuhau

- material model
- transportation model
- population distribution model
- health effects model
- accident severity and package release model
- meteorological dispersion model
- economic model.

The code uses the first three models to calculate the potential population dose fro transportation and the first six models to calculate the risk to the population fro scenarios. The economic model is not used in this study.

B.2.4.1.1 Material Model. The material model defines the source as either a point source or as a line

source. For exposure distances less than twice the package dimension, the source i
to be a line source. For all other cases, the source is modeled as a point source
in all directions.

The material model also contains a library of 59 isotopes each of which has 11 d
eters that are used in the calculation of dose. The user can add isotopes not in t
by creating a data table in the input file consisting of eleven parameters.

B.2.4.1.2 Transportation Model. The transportation model allows the user to input descrip-

tions of the transportation route. A transportation route may be divided into link
the journey with information for each link on population density, mode of travel (e
truck or ship), accident rate, vehicle speed, road type, vehicle density, and link
the transportation route also can be described by aggregate route data for rural, u
For this analysis, the aggregate route method was used for each potential origin-de
The origin-destination combinations addressed in this analysis were discussed in Se

B.2.4.1.3 Health Effects Model. The health effects model in RADTRAN 4 is outdated and is replaced by

hand calculations. The health effects are determined by multiplying the population
RADTRAN 4 by a conversion factor.

B.2.4.1.4 Accident Severity and Package Release Model. Accident analysis in RADTRAN 4 is performed

using the accident severity and package release model. The user can define up to 2
population densities (urban, suburban, and rural), each increasing in magnitude. E
SNF containers that are related to fire, puncture, crush, and immersion environment
(NRC 1977). Various other studies also have been performed for small packages (Cla
packages (Dennis et al. 1978) that also can be used to generate severity categories
further defined by allowing the user to input release fractions and aerosol and res
severity category. These fractions are also a function of the physical-chemical pr
transported.

B.2.4.1.5 Meteorological Dispersion Model. RADTRAN 4 allows the user to choose two different

methods for modeling the atmospheric transport of radionuclides after a potential a
either Pasquill atmospheric-stability category data or averaged time-integrated con
analysis, the dispersion of radionuclides after a potential accident is modeled by
concentration values in downwind areas compiled from national averages by SNL.

B.2.4.1.6 Incident-Free Transport. The models described above are used by RADTRAN 4 to determine

dose from incident-free transportation or risk from potential accidents. The publi
by RADTRAN 4 for incident-free transportation are dependent on the type of material
transportation index (TI) of the package or packages. The TI is defined in 49 CFR
package dose rate in millirem per hour at a distance of 1 m from the external surfa
consequences are also dependent on the size of the package, which as indicated in t
will determine whether the package is modeled as a point source or line source for

B.2.4.1.7 Analysis of Potential Accidents. The accident analysis performed in RADTRAN 4 calculates

population doses for each accident severity category using six exposure pathway mod inhalation, resuspension, groundshine, cloudshine, ingestion, and direct exposure. assumes that any contaminated area is either mitigated or public access controlled pathway equals zero. The consequences calculated for each severity category are mu frequencies for accidents in each category and summed to give a total point estimat accident. The parameters used to calculate the frequencies and consequences of tra presented in Section B.2.4.2.

B.2.4.2 RADTRAN 4 Input Parameters. RADTRAN 4 input parameters for calculating routine population

doses include route information (shipping distances, population densities, and frac rural, suburban, and urban areas), numbers of shipments, dose rate, and parameters population exposure characteristics. The route information and numbers of shipment Section B.1.2 and will not be repeated here. The remaining exposure parameters are

RADTRAN 4 uses the dose rate at 1 m (referred to as the TI) in calculating dose t All of the SNF and HLW shipments in this analysis were assumed to be at the regulat which is 10 mrem per hour at a distance of 2 m from the cask surface. This would b (or a dose rate of 13 mrem/hr at 1 m from the surface). Although it is likely that will have significantly smaller TI values, the use of the regulatory maximum value cannot be exceeded.

Because shipments of plutonium oxide and uranium oxide would have much smaller do HLW, preliminary shielding calculations were performed to derive more realistic val MICROSHIELD (Grove Engineering 1988) was used to perform these calculations. Both modeled as cylindrical sources with cylindrical shields. The parameters used in th shown below:

- Plutonium oxide: The plutonium source was assumed to be 12.7 cm in diameter a Shielding was assumed to be provided by a 1-cm thick steel shield and an 8-cm hydrogenous material. The source inventory was the same as that shown in Tabl

- Uranium oxide: The uranium source was modeled as a single large container alt will most likely be composed of several smaller containers. The source dimens be 114 cm in diameter and 370 cm in length. The source was assumed to be surr steel cylinder and a 3-cm thick shield of solid hydrogenous material. The sou shown in Table B-1.

The dose rate at 1 m from the surface of the plutonium oxide shipment was calcula Because this was increased by a factor of five to provide a bounding estimate, the shipments was set to 0.1 mrem/hr. The dose rate for the uranium oxide shipments wa 0.0049 mrem/hr. This was also increased by a factor of five to 0.025 mrem/hr for c

Table B-2 is a list of input parameters that are used by RADTRAN 4 in the calcula incident-free transportation. Many of the parameters are default values in the RAD default values are identified and their sources are provided in footnotes to the ta

The potential receptors include workers and the general public. Worker doses in truck, rail, or barge crew and package handlers aboard the barge. Although RADTRAN persons who handle packages during intermediate stops, the routine doses to this gr personnel who inspect the shipping containers aboard the barge. The equations used assume that a five-person team spends approximately 0.5 hr per handling operation (or per inspect casks). Although not exact, this is believed to be a reasonable approximation.

Table B-2. Input parameters for analysis of incident-free impactsa

Parameter	Rail	Barge
Dose rate 1 m from vehicle/package (mrem/h)b	13.1	13.1
Length of package (m)	3.0	3.0
Exclusive use	No	Yes
Velocity in rural population zone (km/h)c	64.4	16.09

Velocity in suburban population zone (km/h)b	40.3	8.06
Velocity in urban population zone (km/h)c	24.2	3.20
Number of crewmen	5	2
Distance from source to crew (m)	152	45.70
Stop time per km (h/km)c	0.033	0.01
Persons exposed while stoppedc	100	50
Average exposure distance while stopped (m)c	20.0	50.0
Number of people per vehicle on linkc	3	0
Traffic count passing a specific point-rural zone,one-wayc	1.0	0
Traffic count passing a specific point-suburban zone,one-wayc	5.0	0
Traffic count passing a specific point-urban zone,one-wayc	5.0	0

a. Values shown are shipment-specific unless otherwise noted.
b. These values were used for SNF and HLW shipments. See text for the derivation oxide (0.1 mrem/hr) and uranium oxide shipments (0.025 mrem/hr).
c. Default values from RADTRAN (Neuhauser and Kanipe 1992 and Madsen et al. 1983).

Public doses include doses to persons on the highway or railway (this category i shipments as indicated in the RADTRAN documentation), doses to persons who reside n river, and doses at stops (for barge transport, this was assumed to include stops a For all three shipping modes, the doses to passengers were assumed to be 0.0 becaus traveling with the shipments. In addition, there were assumed to be no intermediat shipments, and the doses to in-transit storage personnel were set equal to 0.0.

Information needed to characterize the potential routes between Hanford and the distances, population densities in rural, suburban, and urban areas along the route shipping distance that travel through rural, suburban, and urban areas. These data Section B.2.3.

B.2.4.3 RISKIND Description. RISKIND (Yuan et al. 1993) was used to calculate doses to the maximum

individual and the public for both rail and truck transportation accidents. RISKIN model incident-free and accident conditions during transportation of SNF. The code model accidental releases based on data contained in the NRC modal study (Fischer e designed to calculate the dose to individuals or groups of individuals for each of identified in the modal study and provide probability-weighted dose risk, acute fat genetic effect values. The probability-weighted dose risk values are calculated by dose for each severity category times the fraction of accidents within each severit calculated by multiplying probability-weighted dose risk values by appropriate conv analysis, point estimates of risk for latent cancer fatalities were estimated as de

The code is comprised of subroutines or models used to calculate radiological ex specific receptor locations. The information used to calculate these exposures can values contained in RISKIND or using receptor-specific data, supplied by the user. performed based on the receptor location, exposure conditions (i.e., inhalation and meteorological conditions.

RISKIND can be used to model all environmental exposure pathways based on the du is, for acute or short-term exposures, RISKIND can calculate exposures from initial shipping-cask shielding. For chronic or long-term exposures, RISKIND calculates ex and ingestion from the food-chain pathways.

A radiological source inventory is contained internal to RISKIND that is based o and burnup rates. An analyst can input other radiological source inventories to ca exposures. The radiological source inventory for this analysis is shown in Table B

To calculate doses to the receptor, cask accident responses for both truck and r have been incorporated into RISKIND. This information is based on the NRC modal st discussed earlier, all shipments will be performed using Type B shipping containers to use RISKIND to calculate the dose to the maximally exposed individual for all wa

B.3 Radiological Dose to Workers

The following sections describe expected radiological consequences to workers du portation and processing of N-Reactor SNF from Hanford.

B.3.1 Worker Dose from Pre-Shipment Activities at Hanford

Packaging of the K-Basin SNF for temporary wet storage was estimated to result i mately 140 person-rem (5.5 x 10-2 LCF) over a period of about 2 years. The activit include repacking fuel assemblies in both K-East and K-West Basins and disposing of The consequences of preparing the fuel for overseas shipment were assumed to be sim evaluation. If stabilization of the fuel prior to shipment were necessary, an addi accumulated by onsite workers over a 4-year period, resulting in 7.0 x 10-2 LCF (se appendix). Consequences of air emissions from the storage or stabilization facilit much lower than those from direct exposure of workers in these facilities (see Sect

The consequences of accidents at the wet storage facility or the stabilization f Section 5.15 of this appendix. Air emissions from a fuel handling accident at the at the stabilization facility would result in a point estimate of risk to the nearb <8.3 x 10-12 LCF per year of operation, respectively. The estimated frequency for and 1 x 10-4 per year. Operations at the K Basins to package SNF for shipment woul the stabilization facility would require 4 years to process all of the K Basin SNF. that might be directly involved in such accidents is highly speculative, and is add ment A-Facility Accidents.

B.3.2 Worker Doses from Transportation to U.S. Ports

This section discusses the results of the worker impact calculations for truck, and from the U.K. These doses were calculated using the RADTRAN 4 computer code (N RADTRAN 4 program uses a combination of meteorological, demographic, health physics and material factors to analyze risks associated with both normal transport (incide selected accident scenarios. The RADTRAN 4 computer code description for both rout presented in Section B.2.4.

The results of the incident-free transportation impact calculations are presente radiological impacts are presented in terms of the population dose (person-rem) rec the projected health effects calculated to occur in the exposed population. As sho calculated to result from any of the five transportation options considered in this

As shown in Table B-3, the transportation option to U.S. ports that results in t doses is that involving barge shipments to the Port of Portland. This option is cl shipping by rail to the Port of Seattle. The option involving truck transport to t lowest option. The option of shipping by rail to the Port of Norfolk is next, foll truck to the Port of Norfolk. This result is intuitively obvious because the shipp from Hanford to Norfolk than to the other ports.

Table B-3. Results of incident-free transportation impact calculations for workers

Option and material	Radiation doses, person-rem	Latent cancer fatalities
Barge to Portland		
SNF	3.0E+00	1.2E-03
HLW	1.8E-01	7.0E-05
Pu	7.7E-02	3.1E-05
U	5.3E-02	2.1E-05
TOTAL	3.3E+00	1.3E-03
Truck to Seattle		
SNF	6.0E+00	2.4E-03

HLW (Rail)	3.8E-01	1.5E-04
Pu (Truck)	4.5E-02	1.8E-05
U (Truck)	3.4E-02	1.3E-05
TOTAL	6.5E+00	2.6E-03
Rail to Seattle		
SNF	3.2E+00	1.3E-03
HLW (Rail)	3.8E-01	1.5E-04
Pu (Truck)	4.5E-02	1.8E-05
U (Truck)	3.4E-02	1.3E-05
TOTAL	3.7E+00	1.5E-03
Truck to Norfolk		
SNF	1.0E+02	4.2E-02
HLW (Rail)	1.5E+00	5.9E-04
Pu (Truck)	7.7E-01	3.1E-04
U (Truck)	5.8E-01	2.3E-04
TOTAL	1.1E+02	4.3E-02
Rail to Norfolk		
SNF	1.3E+01	5.0E-03
HLW (Rail)	1.5E+00	5.9E-04
Pu (Truck)	7.7E-01	3.1E-04
U (Truck)	5.8E-01	2.3E-04
TOTAL	1.5E+01	6.1E-03

In general, the shipments of N Reactor SNF to the U.K. would produce the highest
This is attributed primarily to the higher number of N Reactor SNF shipments than t
can be seen that rail shipments generally result in lower worker doses than truck s
exposure distances between the source and crew are much longer for rail shipments t
Similarly, the crew doses for rail and barge shipments are approximately comparable

Maximum individual doses to workers from incident-free transport were calculated
code, consistent with the approach described in Volume 1, Appendix I. The maximall
shipments were found to be the truck drivers (two-person crew), who were assumed to
hour per year. The maximally exposed worker for rail shipments was a transportatio
spent a time- and distance-weighted average of 0.16 hours inspecting, classifying,
assumed to be present for all of the radioactive shipments.

The maximum incident-free exposure calculations for workers were performed for e
results are 1.46 person-rem for the barge to Portland option, 2.0 person-rem for th
by truck, 1.03 person-rem for the option of shipping to Seattle by rail, 35.3 perso
to Norfolk by truck, and 17.9 person-rem for the option of shipping to Norfolk by r

B.3.3 Worker Dose from Port Activities

The following sections describe expected radiological consequences to workers fr
transport of SNF to the U.K. The consequences for return of HLW, uranium, and plut
to, or lower than, those for initial shipment of SNF to the U.K. because of the sma
required for return to the U.S. Radiological consequences of normal transport of u
small compared with those for SNF and HLW.

B.3.3.1 Consequences of Normal Port Activities. Consequences to workers during handling and loading

activities in ports are based on commercial experience during the last three quarte
workers handled two shipments consisting of 16 loaded casks, and 1 shipment consist
collective dose to the 30 workers involved was 0.024 person-rem, with the maximum i
Assuming that handling of the empty casks did not contribute measurably to that tot
dose from handling a single loaded cask is estimated to be on the order of 0.001 re
worker and 0.0015 person-rem total to all workers. The consequences for loading an
shipment from the U.S. to the U.K. would therefore be approximately 1.2 person-rem
expected 5-year campaign. Accounting for an additional two handling activities per
at the U.K. process facility would roughly double that estimate, resulting in a col
and a potential for 9.8 x 10-4 LCF for all shipments. The maximum dose to an indiv
worker were involved in handling all 408 casks at one point in the shipping sequenc

0.4 rem over 5 years.

B.3.3.2 Consequences of Accidents During Port Activities. The consequences of accidents during port

transit were estimated based on the highest activity N Reactor SNF (Bergsman 1994). content of a single shipping cask is based on a loading of 5 MTU (see inventory for Representative ports on the West and East Coasts of the U.S. (Seattle-Tacoma, Washi Norfolk, Virginia; and Newark, New Jersey) were used for this analysis, based on re suitability for handling of SNF shipments. Newark was included in this part of the relatively large surrounding population (adjacent to New York City), whereas the po Portland, and Norfolk are located in somewhat smaller population centers. In a pre consequences of in-port accidents were shown to be proportional to the surrounding

The consequences (as radiation dose to individuals and populations and correspon range of accident severities leading to airborne release of radioactive material, c categories and radionuclide release fractions used for the overland transportation I, Table I-28). The overall accident frequency associated with each accident categ conditional probability for that severity category, multiplied by the overall frequ accident would occur (as estimated by DOE 1994, Table E-8). The consequences (as L were multiplied by the corresponding frequency with which an accident in that categ point estimate of risk for each accident category. The total risk per shipment was risks over all accident severity categories. The frequencies for airborne release atmospheric dispersion (stable) conditions (those that would not be exceeded more t assumed to be 10% of those evaluated using 50% (neutral) dispersion conditions, whi typical or expected conditions. The risk to U.S. ports for shipping all Hanford SN per shipment times 17 shipments. The risk to U.K. ports is assumed to be comparabl

The port accident analyses assume that the contents of a single cask were involv probability that multiple casks could be breached in the event of an accident is sm cask, and the consequences would be proportional to the number of casks involved. the special purpose ships, with eight segregated holds each containing at most thre involve more than three casks is not considered to be reasonably foreseeable.

The consequences to an individual at a distance of 100 m, assumed to be a port w applicable exposure pathways including inhalation, external dose from submersion in exposure from radionuclides deposited on the ground for a period of 2 hours. The p accident at the Port of Portland are estimated to be 6.1 x 10-11 to 1.0 x 10-09 LCF respectively. The corresponding point estimates of risk for Seattle/Tacoma (based Tacoma airport and the population within 50 miles of the Port of Tacoma) ranged fro The point estimates of risk to workers at East Coast ports were similar - ranging f at Norfolk and 5.3 x 10-11 to 9.0 x 10-10 LCF at Newark.

The maximum reasonably foreseeable accident was a category 6 accident, which has port transit, and which was evaluated for stable atmospheric conditions resulting i x 10-7 for all 17 SNF shipments. The dose to the port worker was estimated to be 1 at Newark, and 2.1 rem at Portland and Norfolk. The corresponding probability of L point estimates of risk, from 1.5 x 10-9 to 1.8 x 10-9 LCF.

B.3.4 Worker Dose from Ocean Transport to the United Kingdom

The following sections describe radiological consequences to workers from normal accidents during overseas shipments of SNF from the Hanford Site to the U.K.

B.3.4.1 Consequences of Normal Ocean Transit. The primary impact of routine (incident-free) marine

transport of SNF is potential radiological exposure to crew members of the ships us of the general public and marine life would not receive any measurable dose from th marine transport of the casks. While at sea, the crew dose would be limited to tho the ship's hold during transit and receive external radiation in the vicinity of th times, the crew would be shielded from the casks by the decking and other structure

entries and inspections would be a function of the transit time from the port of lo
loading.

External radiation from an intact shipping package must be less than specified l
exposure of the handling personnel and general public. These limits are establishe
of interest is a 10 mrem/hr dose rate at any point 2 m from the outer surfaces of t
applies to exclusive-use shipments, i.e., a shipment in which no other cargo is loa
transportation casks, not that the ship is an exclusive-use vessel, although this w
the commercial special purpose ships assumed for this analysis.

It is anticipated that the external dose rates at the outside of the transport c
the regulatory limits. It was estimated that the N Reactor SNF considered in this
design envelope of the internationally licensed casks routinely used by the U.K. fa
1994). However, estimates of dose during normal transportation have been made assu
regulatory limits, using analyses performed for transport of foreign research react
These analyses may be used to develop an upper bound of the doses anticipated to be
transport of the N Reactor SNF. Actual doses would be expected to be lower than th

B.3.4.1.1 Bounding Dose Calculations. Calculations performed to estimate bounding radiation doses

during routine cask inspections aboard ship (DOE 1995) provided information from wh
(IDF) could be determined of 6 x 10-5 rem y minute-1 y cask-1 y day-1 y person-1, b
Because the ship crews are highly trained and the ships are designed for SNF transp
inspection of each of the eight holds on the ship (each containing three casks) wou
15 minutes, or an average of 5 minutes per cask for the total 24 casks. The total
2 hours. If an inspection crew were assumed to consist of two members of the ship'
daily inspection would be

6 x 10-5 (IDF) x 5 minutes x 24 casks = 0.007 rem y person-1 y da

Assuming a travel time from an eastern U.S. port of 10 days, the estimated maxim
of a two-person inspection crew would be 0.07 rem. This value would not exceed the
of the general public. The transit time for a shipment originating on the West Coa
five times longer, resulting in a dose per shipment of 0.35 rem. This value would
a member of the general public. However, because the ship's crews are trained and
presumed that they would be considered radiation workers. Although it is not clear
exposure of the ship's crew would fall under the jurisdiction of the U.K. or U.S. r
these standards are identical for both countries (5 rem per year, with an administr
year). Therefore, the maximum possible dose received by individual workers during
within the limits of the U.S. and U.K. radiation protection standards for workers.

Complete transport of the SNF to the U.K. for processing would require 17 shipme
collective dose to crew members responsible for conducting inspections on the trans
transport from the U.S. East Coast would be

(0.007 rem y person-1 y day-1) x 2 persons x (10 days y trip-1) x 17 tri

Based on this bounding estimate of the collective dose to the ship's crew for tr
upper limit of approximately 0.001 LCF would be expected among the ship's crew from
from the SNF transport casks. If all shipments originated at a western U.S. port,
to 12 person-rem with a corresponding consequence of 0.005 LCF.

The above analysis does not consider the return of the processed SNF products an
U.S. It was projected that the number of shipments containing these products would
shipments. However, as a bounding estimate the same number of return shipments and
at the regulatory limit, might be assumed. Under those circumstances, an upper lim
among the ships' crews from exposure to the external radiation during all shipments

B.3.4.1.2 Commercial Fuel Transport Experience. Information on radiation doses to ships' crews

during transport of commercial fuel, gathered from actual crew dosimeters, supports
actual doses to the crew would be lower than the calculated bounding doses. The av
voyage was 0.001 rem, with a maximum individual dose of 0.022 mrem. The collective
voyage was about 0.038 person-rem. On that basis, the crew's collective dose for 1
0.65 person-rem. A comparison of bounding dose estimates and commercial transport
Table B-4. Based on these results, less than 0.0003 LCF would be expected among sh

Table B-4. Comparison of bounding and typical ship crew's doses.

	Bounding Dose Calculations	Commercial Fuel Transpo Experience
Individual dose, rem	0.07 - 0.35	0.001 typical 0.022 maximum
Collective dose, person-rem		
- 17 SNF shipments	2.4 - 12	0.65
- < 17 round trips	< 24	< 1.3

from radiation exposure during SNF transport, and approximately 0.0005 LCF would be exposure during transport of SNF and the subsequent return of processing products a

B.3.4.2 Consequences of Accidents During Ocean Transit. The consequences of accidents during ocean

transit would likely be similar to those of port workers who are near the scene of Section B.3.3.2). Individuals in the immediate vicinity of the impact would probab an accident severe enough to cause release of radioactive materials from a SNF ship cask. Effects on the ocean environment would not be expected to be discernable bec in the event of an airborne release.

B.3.5 Worker Dose from Return of Processing Products to the United States

Return of HLW to the U.S. is assumed to result in cumulative worker doses that a the initial SNF shipments to the U.K. However, the distribution of dose among indi because of the different configuration and radionuclide content of the HLW canister B.2.4.2, the dose rates associated with plutonium and uranium shipments are substan maximum that was assumed for the SNF and HLW shipments.

B.4 Consequences to Members of the Public

The following sections describe expected consequences to the public from various transporting N Reactor SNF to the U.K.

B.4.1 Public Impacts from Pre-Shipment Activities at Hanford

Activities at Hanford prior to preparation of N Reactor SNF for shipment would r consequences to the public, as discussed in Section 5.7 of this appendix. The remo basins was estimated to result in offsite consequences comparable to those observed the fuel, or approximately 2 x 10-5 to 3 x 10-4 (1 x 10-11 to 1.5 x 10-10 probabili exposed offsite individual (DOE 1992).

The risk from accidents involving handling of N-Reactor SNF at the 100-K Basins Section 5.15 of this appendix. The consequences to the maximally exposed offsite i 2.5 x 10-4 LCF, with an associated point estimate of risk equal to <2.5 x 10-8 fata accident frequency <1 x 10-4 per year). The consequences to the population within as 0.4 LCF for 50% (neutral) atmospheric dispersion conditions and 6.9 LCF for 95% (conditions that would not be exceeded more than 50% or 5% of the time, respectivel estimates of risk amounted to <4.0 x 10-5 and <6.9 x 10-4 LCF per year, respectivel

B.4.2 Public Impacts from Transportation Activities

This section presents the analysis of the public incident-free radiological expo risks, and nonradiological impacts from transporting radioactive materials to and f public exposed to radiation include persons on the highway, railroad, or waterway w residing near these transport links, and persons at intermediate stops along the ro and stops at rail classification yards). The RADTRAN 4 computer code was used to p A description of RADTRAN 4 was presented in Section B.2.4. The following sections incident-free exposure calculations, description of the accident-analysis input par accident risk impact calculations, and the evaluation of nonradiological impacts.

B.4.2.1 Results of Incident-Free Transportation Impact Calculations. The results of the public dose

calculations, developed using the RADTRAN 4 computer code and the input parameters presented in Table B-5.

Table B-5. Results of public incident-free exposure calculations.

Option and material	Radiation doses, person-rem	Latent Cancer Fat
Barge to Portland		
SNF	3.4E-01	1.7E-04
HLW	6.7E-03	3.4E-06
Pu	3.7E-02	1.9E-05
U	2.9E-02	1.4E-05
TOTAL	4.1E-01	2.1E-04
Truck to Seattle		
SNF	1.5E+01	7.6E-03
HLW (rail)	1.9E-01	9.6E-05
Pu (truck)	2.5E-02	1.2E-05
U (truck)	1.9E-02	9.3E-06
TOTAL	1.5E+01	7.7E-03
Rail to Seattle		
SNF	1.6E+00	8.1E-04
HLW (rail)	1.9E-01	9.6E-05
Pu (truck)	2.5E-02	1.2E-05
U (truck)	1.9E-02	9.3E-06
TOTAL	1.9E+00	9.3E-04
Truck to Norfolk		
SNF	2.5E+02	1.3E-01
HLW (rail)	7.0E-01	3.5E-04
Pu (truck)	4.1E-01	2.1E-04
U (truck)	3.1E-01	1.6E-04
TOTAL	2.5E+02	1.3E-01
Rail to Norfolk		
SNF	5.9E+00	3.0E-03
HLW (rail)	7.0E-01	3.5E-04
Pu (truck)	4.1E-01	2.1E-04
U (truck)	3.1E-01	1.6E-04
TOTAL	7.3E+00	3.7E-03

From a domestic transportation perspective, the lowest-impact option is one that from Hanford to the Port of Seattle. This option is followed closely by the option the Port of Portland by barge. The third lowest domestic transportation option is Seattle by truck. The highest impact options are those involving shipments from Ha Obviously, the lowest impact domestic transportation option would be that involving distances (i.e., Hanford to Seattle or Portland). Some of the impacts of the long would be offset by subsequent reductions in the lengths of the ocean shipment segme rankings of the options presented in Table B-5 do not necessarily represent the ran ocean segments of the shipments were included. However, public routine doses are n voyages because the separation distance between the ship and the nearest exposed po in extremely low radiation dose rates.

The results in Table B-5 demonstrate that barge shipments of SNF (and HLW) would doses than truck or rail shipments. This is attributed primarily to the lower traf relative to railroads and highways, generally greater separation distances between to the separation distances between highways/ railroads and the public, as well as capacities of barges relative to truck and rail shipments (resulting in fewer shipm

Table B-5 also demonstrates that rail shipments would produce lower public routi truck shipments. This can be seen by comparing the SNF shipment impacts for truck rem) and rail shipments to Seattle (1.6 person-rem). Even though the rail shipping is much longer than the truck route (277 km and 716 km), the total public routine d shipments, this is attributed to lower traffic volumes, larger separation distances capacity for rail shipments.

Maximum individual doses to members of the public from incident-free transport w RISKIND computer code, which is consistent with the approach described in Volume 1, shipments, three potential exposure scenarios were evaluated by RISKIND, as describ The maximally exposed members of the public from incident-free truck transport were potential exposure scenarios (see Volume 1, Appendix I).

The maximum incident-free exposure calculations for members of the public were p option. The results are 0.28 person-rem for the barge to Portland option, 0.20 per shipping to Seattle by truck, 0.28 person-rem for the option of shipping to Seattle the option of shipping to Norfolk by truck, and 0.28 person-rem for the option of s

B.4.2.2 Assessment of Public Impacts from Transportation Accidents. **Radiological accident impacts**

are presented in this section as integrated population risks (i.e., accident freque consequences integrated over the entire shipping campaign), as well as the conseque foreseeable accident. Population risk calculations were performed using the RADTRA and Kanipe 1992). The consequences of the maximum reasonably foreseeable accident RISKIND computer code (Yuan et al. 1993). Separate sections are provided for the i (i.e., RADTRAN 4) calculations and the maximum reasonably foreseeable accident cons calculations.

B.4.2.2.1 Integrated Population Risk Assessment. **For this analysis, risk is defined as the product**

of the frequency of occurrence of an accident involving a shipment and the conseque Consequences are expressed in terms of the radiological dose and LCF from a release the shipping cask or the exposure of persons to radiation that could result from da frequency of an accident that involves radioactive materials is expressed in terms accidents per unit distance integrated over the total distance traveled. The respo accident environment and the probability of release or loss of shielding, is relate accident.

The frequencies of occurrence of transportation accidents that would release sig radioactive material are relatively small because the shipping casks are designed t transportation accident conditions (i.e., the shipping casks for all the materials assumed to meet the Type B packaging requirements specified in 49 CFR 174 and 10 CF railways are difficult to totally eliminate. However, because the shipping casks a certain accident environments, including mechanical and thermal stress, only a rela accidents involve conditions that are severe enough to result in a release of radio

Should an accident involving a shipment occur, a release of radioactive material were to fail. A failure would most likely be a small gap in a seal or small split the radioactive material to reach the environment, it would have to pass through th the failed seal. Materials released to the environment would be dispersed and dilu fraction would be deposited on the ground (i.e., drop out of the contaminated plume Emergency response crews arriving on the scene would evacuate and secure the area t accident scene. The released material would then be cleaned up using standard deco

excavation and removal of contaminated soil. Monitoring of the area would be perfo
areas and to guide cleanup crews in their choice of protective clothing and equipme
and filtered masks). Access to the area would be restricted by federal and/or stat
until it had been decontaminated to safe levels.

The RADTRAN 4 computer code was used to calculate the radiological risk of trans
radioactive material shipments. The RADTRAN 4 methodology was summarized previousl
to the discussions presented by RADTRAN III (Madsen et al. 1986) and RADTRAN 4: Vol
(Neuhauser and Kanipe 1992).

There are five major categories of input data needed to calculate potential acci
impacts using the RADTRAN 4 computer code. These are: 1) accident frequency, 2) r
3) atmospheric dispersion parameters, 4) population distribution parameters, and 5)
models. Accident frequency and release quantities are discussed below, the remaini
discussed in previous sections.

Accident Frequency. The frequency of a severe accident is calculated by multiplyin
(accidents per truck-km or per rail-km) by the conditional probability that an acci
and/or thermal conditions that are severe enough to result in container failure and
radioactive material. Overall accident rates per kilometer of truck or rail travel
Kvitek (1994). State-specific accident rates were used in this study. For the Por
composite weighted-average accident rate was developed using the state-specific acc
Kvitek (1994), and travel fractions through each state that were derived from the H

For this analysis, six shipment-specific severity categories were defined, with
severe and the higher categories (2-6) representing increasingly severe conditions.
probabilities of encountering accident conditions in each severity category were ta
Regulatory Commission (NRC) document (Fischer et al. 1987). Those conditional prob
on reviews of accident records and statistics compiled by various state and federal
probability for a given severity category is defined as the fraction of accidents t
severity category if an accident were to occur. The conditional probabilities for
determined using a binning process described in Volume 1, Appendix I of this EIS.
rates and conditional probabilities used in this analysis are discussed below. [Th
for barge accidents were taken directly from Pippen et al. (1995)].

As discussed above, severity category levels were defined to model the response
accidents. Severity category 1 was defined as encompassing all accidents that are
envelope that would not be severe enough to result in failure of the shipping cask
release). The higher categories (2-6) were defined to include more severe accident
release of radioactive material. The derivation of the severity category schemes a
of accidents in each severity category are discussed below for each shipping cask o
presents the conditional probabilities of the various severity categories that were

Release Fractions. Release fractions (array RFRAC in RADTRAN 4) are used to determ
active material released to the environment as a result of an accident. The quanti
of the severity of the accident (i.e., thermal and mechanical conditions produced i
of the shipping container to these conditions, and the physical and chemical proper
shipped. The basis for the release fractions used in this analysis are discussed b
Table B-7.

Release fractions for N Reactor fuel shipments were taken from Volume 1, Appendi
release fractions for metallic fuels was used (Table I-28). All of the released ma
respirable form for this assessment. Release fractions for damaged N Reactor SNF w
undamaged fuel. This is because it was assumed that some form of stabilization wou
damaged SNF. Stabilization was assumed to provide a level of containment for damag
in an overpack container, to replace the containment boundary that was provided by
cladding. Stabilization was also assumed to include some form of treatment to mini
pyrophoric reaction involving the metallic uranium and to prevent the accumulation
of hydrogen gas that may be generated by the fuel elements.

Table B-6. Accident severity categories and conditional probabilities.

Mode	Conditional probability by severity category					
	1	2	3	4	5	6
Trucka	9.943E-01	4.03E-05	3.82E-03	1.55E-05	1.80E-03	9.84E-06
Raila	9.940E-01	2.02E-03	2.72E-03	6.14E-04	8.55E-04	1.25E-04
Bargeb	9.53E-01	2.02E-03	4.02E-02	6.41E-04	4.01E-03	1.34E-04
Shipc	6.03E-01	3.95E-01	2.0E-03	4.0E-04	4.0E-04	4.0E-04

a. Source: Fischer et al. (1987) and Volume 1, Appendix I, Figure I-2.
b. Source: Pippen et al. (1995).

c. Source: DOE (1994).

Table B-7. Release fractions used for assessment of accident impacts.

	Release fraction by severity category					
Material	1	2	3	4	5	6
SNFa						
Gases	0.0	9.9E-03	3.3E-02	3.9E-01	3.3E-01	6.3E-01
Cesium	0.0	3.0E-08	1.0E-07	1.0E-06	1.0E-06	1.0E-05
Ruthenium	0.0	4.1E-09	1.4E-08	2.4E-07	1.4E-07	2.4E-06
Particles	0.0	3.0E-10	1.0E-09	1.0E-08	1.0E-08	1.0E-07
HLWa	HLW release fractions are the same as those for SNF					
Pu oxide						
Particles	0.0	1.0E-06	1.0E-05	1.0E-04	1.0E-03	1.0E-02
U oxide						
Particles	0.0	1.0E-06	1.0E-05	1.0E-04	1.0E-03	1.0E-02

a. These release fractions were applied to truck and rail shipments of SNF and HLW barge shipments were multiplied by 1/24, 1/12, 1/6, 1/3, and 1 for severity categor respectively, to reflect the number of shipping casks that are damaged in each cate

A different, but related, set of release fractions were used for barge shipments relationship deals with the potential involvement of multiple shipping casks in a b It is overly conservative to assume that all 24 shipping casks would fail in minor lower severity categories, the accident conditions are not severe enough to damage In fact, in the lowest severity category that results in a release, only the shippi of the collision would be affected. Consequently, the release fraction for severit multiplied by 1/24 to reflect the assumption that only one of the total of 24 shipp would be damaged. Category 3 release fractions were multiplied by 1/12 to reflect two shipping casks out of 24 would be damaged in the accident. The release fractio categories 4, 5, and 6 were multiplied by 1/6, 1/3, and 1 to reflect the assumption 24 casks would be damaged, respectively.

Release fractions for HLW shipments were assumed to be the same as those for SNF ments. The difference is that the strength and durability of the vitrified HLW for that not all of the materials released are in respirable or dispersable form. RADT "immobilized" radionuclides were used to model the dispersable and respirable fract material. This means that the fraction of released material that is in dispersable respirable fraction is 5.0E-02 (Neuhauser and Kanipe 1992). The HLW release fracti were adjusted similarly to those for SNF to account for the fraction of casks that in the six severity categories.

For plutonium and uranium oxide shipments, no data were readily available. There fractions presented in Table B-7 are representative approximations. It was assumed released from the plutonium and uranium shipment accidents is in dispersable form a respirable form, based on recommendations made by Neuhauser and Kanipe (1992) for s materials.

B.4.2.2.2 Consequences of Maximum Reasonably Foreseeable Accidents. The dose to the maximum

individual and the collective population dose from the maximum reasonably foreseeab calculated for each type of shipment, i.e., SNF, solidified HLW, and plutonium and quantity and radiological constituents of each waste form are discussed in Chapter The computer code RISKIND (Yuan et al. 1993) was used to calculate the dose to the population.

RISKIND Input Parameters. This analysis evaluates the consequences of accidents in shipments. A separate assessment was not performed for barge shipments to Portland between the rail and barge routing data (see Section B.2.3). The radiological inve oped in Table B-1 have been used to calculate the dose to the maximum individual an were calculated for each of the NRC modal study severity categories, assuming the m 100 m from the point of release and neutral weather conditions (i.e., Atmospheric S wind speed). To determine the maximum individual dose for each of the material typ of the NRC modal study categories (20) were binned into the accident severity categ results of the RISKIND calculations for each severity category are presented in Tab

An accident frequency (accidents per year) and probable accident location by pop suburban, and urban) were developed for each campaign, based on the type of materia transportation routing information, and state-specific transportation accident data campaign is defined as the total number of shipments required to transport all of t origin to the destination.

For each of the transportation modes, existing transportation model computer cod 1993a; population data revised in 1994) and INTERLINE (Johnson 1993b; population da to develop the route-specific information required for the accident analyses.

The information required to calculate the accident frequencies included the tota campaign, the campaign duration, the total shipping distance, population zone-speci and the conditional probabilities shown in Table B-6. The population zone-specific calculated using the state-specific accident data (accidents per kilometer) for eac contained in Saricks and Kvitek (1994) and the distance traveled in each of the pop adjusted accident rates are shown in Table B-9. The values in this table were used foreseeable accident scenario.

Table B-8. RISKIND calculated doses summarized by severity categorya.

Severity Categoryb	Truck			Rail	
	Spent Nuclear Fuel (rem)	Pu Oxide (rem)	U Oxide (rem) c	Spent Nuclear Fuel (rem)	Solidified H (rem)
1e	2.36E-05	2.36E-05	2.36E-05	2.36E-05	2.36E-05
2	8.59E-03	3.91E-04	2.36E-05	1.30E-01	1.26E-01
3	5.01E-02	1.25E-03	2.36E-05	8.53E-01	8.39E-01
4	9.39E-02	1.23E-02	2.36E-05	2.96E-01	1.26E-01
5	1.18E-01	1.23E-02	2.36E-05	9.80E-01	8.39E-01
6	2.60E-01	1.23E-01	2.36E-05	1.27E+00	8.39E-01

a. Maximum individual doses are in BOLD. (These doses were estimated in the event they were not multiplied by the corresponding accident frequencies).

b. Severity categories are defined in Table B-6.

c. Only external doses were calculated.

d. The quantity of HLW released has been adjusted because of the immobilized form adjustment, 1.0E-06, was taken from RADTRAN 4 (Neuhauser and Kanipe 1992).

e. Although, no material would be released, an external dose is calculated as a re shielding caused by an accident impact.

The calculated maximum individual doses were cross referenced with the accident the maximum individual doses for reasonably foreseeable accidents (i.e., the accide 1 x 10-7/year) have been reported.

The population dose from the maximum reasonably foreseeable accident is also pro based on the same assumptions used to calculate the dose to the maximally exposed i accident (or population zone) is the same as the accident location used to calculat The population densities for each of the impacted population zones were developed u and INTERLINE (Johnson 1993b).

Table B-9. Summary of route-specific accident rates.

Total distance (km)	Distance per zone (km)			Travel fraction			Population zo (1.0E-07/km)	
	Rural	Suburban	Urban	Rural	Suburban	Urban	Rural	Suburb
Norfolk to Hanford - Truck								
4311.43	3640.28	619.48	51.67	0.84	0.14	0.01	2.508	3.369
Portland to Hanford -Truck								
416.82	353.25	50.21	13.36	0.85	0.12	0.03	2.279	2.802
Seattle to Hanford - Truck								
276.80	243.80	27.70	5.30	0.88	0.10	0.02	2.500	2.055
Norfolk to Hanford - Rail								
4984.78	4140.40	723.60	120.78	0.83	0.15	0.02	0.524	0.678
Portland to Hanford -Rail								
430.50	366.32	4921	14.97	0.86	0.11	0.03	0.361	0.298
Seattle to Hanford - Rail								
715.8	530.5	136.4	48.9	0.74	0.19	0.07	0.349	0.349

B.4.2.3 Results of Transportation Accident Impact Calculations. The results of the integrated population risk assessment are presented in Table B-10. The lowest impact option i from Hanford to the Port of Seattle by rail. The Port of Seattle by truck option i order by the rail option to Norfolk, truck to Norfolk, and then barge to Portland. options are dominated by the SNF shipments to the U.K. and plutonium oxide return s because the quantities and forms of these materials are more vulnerable to accident higher radiotoxicities than vitrified HLW and uranium oxide. Shipments of vitrifie present the lowest impacts of all the materials because of the reasons given plus t material relative to the other materials.

Shipments by barge are shown in Table B-10 to result in relatively higher accide rail or truck. This is because the inventories of radioactive materials transporte potential accident releases, are at least an order of magnitude greater than for tr Because the accident rates for the three modes are comparable, this results in a hi accident risk for barge than the other modes. This higher per-shipment risk more t attributable to fewer barge shipments so, overall, barge accident risks appear to be higher than truck or rail comparing the magnitudes of the accident risks in Table B-8 to the public routine e seen that the accident risks are lower than the routine public exposures. Conseque transportation accident risk impacts are insignificant contributors to the total im options.

Table B-10. Results of transportation accident risk assessmenta.

Option and material	Accident impacts, person-rem	Latent cancer fatalities
Barge to Portland		
SNF	1.8E-02	9.0E-06
HLW	1.5E-08	7.5E-12
Pu	9.3E-03	4.7E-06
U	2.7E-06	1.4E-09
TOTAL	2.7E-02	1.4E-05
Truck to Seattle		
SNF	9.3E-05	4.7E-08
HLW (Rail)	1.6E-10	8.0E-14
Pu (Truck)	3.6E-03	1.8E-06
U (Truck)	1.1E-06	5.5E-10
TOTAL	3.7E-03	1.9E-06
Rail to Seattle		
SNF	6.3E-05	3.2E-08
HLW (Rail)	1.6E-10	8.0E-14
Pu (Truck)	3.6E-03	1.8E-06
U (Truck)	1.1E-06	5.5E-10
TOTAL	3.7E-03	1.8E-06
Truck to Norfolk		
SNF	2.1E-03	1.1E-06
HLW (Rail)	9.3E-10	4.7E-13
Pu (Truck)	8.3E-02	4.1E-05
U (Truck)	2.4E-05	1.2E-08
TOTAL	8.5E-02	4.2E-05
Rail to Norfolk		
SNF	7.4E-04	3.7E-07
HLW (Rail)	9.3E-10	4.7E-13
Pu (Truck)	8.3E-02	4.1E-05
U (Truck)	2.4E-05	1.2E-08
TOTAL	8.3E-02	4.2E-05

a. Reported values are point estimates of risk; i.e., the accident frequency multi that would be expected if an accident occurred.

The results of the maximum reasonably foreseeable accident consequence assessmen through B-14. The results in these tables were generated using the RISKIND compute paragraphs discuss the results of the maximally exposed individual consequence asse This is followed by a discussion of the results of the collective dose calculations N Reactor SNF. As discussed in Section 2.0, SNF will be loaded into shipping casks by barge, truck, or rail to ocean ports for shipment to the U.K. Two shipping mode routes were evaluated. The radiological source inventory used in the analysis was fractions used here were taken from Volume 1, Appendix I of this EIS (see Table B-7 evaluation are shown in Table B-11.

As can be seen in Table B-11, for reasonably foreseeable events (i.e., the accid 1.0E-07/year), the dose received by the maximally exposed individual from a rail ac 1.27E+00 rem depending on the location of the individual and transportation route. 4.90E-04 to 6.35E-04. The accident frequency also varies based on the transportati from 1.27E-07 to 1.91E-06/year. Table B-11 also presents the dose received by the from a truck accident. The dose to the maximally exposed individual ranges from 1. depending on the location of the individual and transportation route. The accident the transportation route and accident location from 1.23E-07 to 1.02E-05/year. The 5.90E-05 to 1.30E-04.

Collective doses to the public were also calculated for each of the transport mo (see Table B-11). For this analysis, it was assumed that the accident occurred in determined in the maximum individual dose calculations. The population dose from a 3.18E+00 to 3.27E+02 person-rem depending on the accident location, population dens The doses to population from a truck accident range from 1.37E-01 to 9.44E+02 perso from 1.59E-03 to 0.170 for rail and 6.85E-05 to 4.72E-1 for truck.

Table B-11. Calculated maximum individual and population radiological doses and la based on accident location and frequency of SNF shipments.

Transportation Route	Mode	No. of shipmentsa	Accident frequency (per year)b	Accident location: population zonec	Maximum in TEDEd (rem
Hanford, Washington to Portland, Oregon	Truck	408	1.23E-07	Urban	2.60E-01
Hanford, Washington to Seattle, Washington			1.02E-05	Rural	1.18E-01
Hanford, Washington to Norfolk, Virginia			1.43-06	Urban	2.60E-01
Hanford, Washington to Portland, Oregon	Rail	204	3.46E-07	Rural	9.80E-01
Hanford, Washington to Seattle, Washington			1.27E-07	Urban	1.27E+00
Hanford, Washington to Norfolk, Virginia			1.91E-06	Urban	1.27E+00

a. Assumes one truck cask per truck shipment and two truck casks per rail shipment
b. Accident frequency based on the number of shipments, campaign duration, one-way conditional probability.
c. Accident location is based on population zone where the maximum individual dose
d. TEDE - 50-year total effective dose equivalent.
e. LCF - Latent cancer fatalities. Calculated on dose (rem) to maximum individual 5.0E-04 LCF/rem

Table B-12. Calculated maximum individual and population radiological doses and la based on accident location and frequency for plutonium oxide shipments.

Transportation Route	Mode	No. of Ship.	Accident Frequency (per year)b	Accident Location: Population Zonec	Maximum TEDEd (rem)

Portland, Oregon to Hanford, Washington	Truck	186	1.22E-07	Urban	1.23E-01
Seattle, Washington to Hanford, Washington			1.01E-05	Rural	1.23E-02
Norfolk, Virginia to Hanford, Washington			1.42E-06	Urban	1.23E-01

a. Assumes one cask per truck shipment.
b. Accident frequency based on the number of shipments, campaign duration, one-way conditional probability.
c. Accident location is based on population zone where maximum individual dose occ
d. TEDE - 50 year Total Effective Dose Equivalent.
e. LCFs - Latent cancer fatalities. Calculated based on dose (rem) to maximum ind i.e., 5.0E-04 LCFs/rem

Plutonium Oxide. The separated plutonium oxide was assumed to be returned to its p
This material was assumed to be transported to a U.S. port (Seattle, Portland, or N
offloaded to a Safe-Secure Trailer/Armored Tractor for subsequent highway shipment
shipment).

The results of this analysis are provided in Table B-12. The dose, to the maxim
the maximum reasonable foreseeable accident, ranges from 1.23E-02 to 1.23E-01 rem,
the individual and transportation route. The potential LCF ranges from 5.90E-06 to
ranges from 1.22E-07 to 1.01E-05/year depending on the transportation route and acc

The potential population doses from the maximum reasonably foreseeable accident
are shown in Table B-12. Assuming that the accident occurs in the same location or
determined for the maximally exposed individual, the population dose ranges from 3.
The potential LCF range from 1.73E-06 to 9.40E-03.

Uranium Oxide. As with plutonium oxide, uranium oxide resulting from SNF processin
Hanford. This material was assumed to be transported by ship to a port facility wh
truck for subsequent highway transport to Hanford. As with the plutonium oxide, on
evaluated. The calculated dose received by the maximum individual from a truck acc
Table B-13). The potential LCF are 1.18E-08. The accident frequency ranges from 1
depending on the transportation route and accident location.

The potential collective dose ranges from 3.65E-06 to 1.98E-03 person-rem depend
transportation route. The potential LCF range from 1.83E-09 to 9.90E-07 and also d
and transportation route.

Solidified High-Level Waste. Following separation of all plutonium and uranium fro
resulting HLW was assumed to be vitrified and poured into canisters. These caniste
rail shipping casks by ship to a U.S. port facility and offloaded to rail cars at t
accidents were evaluated for shipments of HLW. The radiological source inventory u
in Table B-1 and the release fractions were shown in Table B-7. Because the waste
solidified in glass logs was considered to be "immobilized" material, the fraction
also dispersable and the fraction that is also respirable were adjusted, as discuss
Table B-13. Calculated maximum individual and population radiological doses and la
based on accident location and frequency for uranium oxide shipments.

Transportation route	Mode	No. of ship- mentsa	Accident frequency (per year)b	Accident location: population zonec	Maximum TEDEd (rem)
Portland, Oregon to Hanford, Washington	Truck	236	1.23E-07	Urban	2.36E-05
Seattle, Washington to Hanford, Washington			1.01E-05	Rural	2.36E-05
Norfolk, Virginia to Hanford, Washington			1.43E-06	Urban	2.36E-05

a. Assumes one cask per truck shipment.
b. Accident frequency based on the number of shipments, campaign duration, one-way conditional probability.
c. Accident location is based on the population zone where maximum individual dose

d. TEDE - 50-year total effective dose equivalent.
e. LCF - Latent cancer fatalities. Calculated on dose (rem) to maximum individual 5.0E-04 LCF/rem.

The calculated dose to the maximally exposed individual and population are shown in Table B-14. The dose to the maximally exposed individual was 8.39E-01 rem and the potential latent cancer fatalities would be 4.20E-04. The accident frequency varies by route and ranges from 1.25E-07 to 1.88E-06/year.

The population doses are also shown in Table B-14. The collective dose ranges from 3.48E+00 to 1.42E+03 person-rem. The potential latent cancer fatalities range from 1.74E-03 to 0.710.

B.4.2.4 Assessment of Nonradiological Impacts. Nonradiological accident impacts

consist of fatalities that may result from traffic accidents involving the shipments to and from the offshore processing facility. Nonradiological incident-free impacts are those resulting pollutants emitted from the vehicles. These impacts are not related to the radioactive nature of the materials being transported. In fact, the number of estimated injuries and fatalities would be the same even if the cargo were not radioactive materials. This section uses unit risk factors to estimate the nonradiological impacts associated with the five shipping scenarios considered in this evaluation.

The potential for accidents involving shipments of materials to and from an offshore processing facility is assumed to be comparable to that of general truck, rail, and barge transport in the U.S. Nonradiological accident unit risk factors were taken from Saricks and Kvitek (1994) to calculate nonradiological accident impacts. These risk factors, in units of fatalities-per-km of travel in rural and urban population zones, were multiplied by the total distance traveled in each zone by all of the shipments and then summed to calculate the expected number of nonradiological fatalities. The unit risk factor for travel in suburban zones was represented by the average of the rural and urban unit risk factors given by Saricks and Kvitek (1994).

Impacts to the public from non-radiological causes are also evaluated. This includes fatalities resulting from pollutants emitted from the vehicles during normal transportation. Based on the information contained in Rao et al. (1982), the types of pollutants that are present and can impact the public are sulfur oxides (SOx), particulates, nitrogen oxides (NOx), carbon monoxide (CO), hydrocarbons (HC), and photochemical oxidants (Ox). Of these pollutants, Rao et al. (1982) determined that the majority of the health effects are from SOx and the particulates. Unit risk

Table B-14. Calculated maximum individual and population radiological doses and la based on accident location and frequency for solidified high level waste shipments

Transportation Route	Mode	No. of ship-ments. a	Accident frequency (per year)b	Accident location: population zonec	Maximum i TEDEd (rem)
Portland, Oregon to Hanford, Washington	Rail	24	3.39E-07	Rural	8.39E-01
Seattle, Washington to Hanford, Washington			1.25E-07	Urban	8.39E-01
Norfolk, Virginia to Hanford, Washington			1.88E-06	Urban	8.39E-01

a. Assumes one cask per rail shipment.
b. Accident frequency based on the number of shipments, campaign duration, one-way conditional probability.
c. Accident location is based on population zone where maximum individual dose occ

d. TEDE - 50-year total effective dose equivalent.
e. LCF - Latent cancer fatalities. Calculated on dose (rem) to the maximum indivi
i.e., 5.0E-04 LCF/rem.

factors (fatalities per kilometer) for both truck and rail shipments were developed by Rao et al. (1982) for travel in urban population zones (1.0E-07/km and 1.3E-07/km truck and rail respectively). These unit risk factors were combined with the total shipping distance in urban population zones to calculate the nonradiological incident-free impacts to the public.

The results of the nonradiological accident and incident-free impact calculations for the five potential shipping scenarios are presented in Table B.15. The values reported in the table represent the sum of the impacts from all of the shipments and include the impacts from shipments carrying cargo as well as those from empty return shipments.

B.4.3 Dose to the Public from Port Activities

Normal port activities during transport of N Reactor SNF are not expected to have any consequences for members of the public other than port workers, as discussed in Section 3.3.

The consequences of accidents during port transit were estimated using the same assumptions described for worker consequences in Section 3.3.2. Collective point estimates of risk to the population within 50 miles (80 km) of each location was estimated for an accident at the dock and on the approach to the port. The point estimate of risk to an individual at 1600 m (1 mile) was also estimated for applicable exposure pathways as described in Attachment A of this appendix. Consequences for populations and individuals are reported, both with and without the risk from ingestion of locally grown foods because protective action guidelines would require mitigative actions if the projected dose exceeded specified levels. Individual consequences assume 95% atmospheric dispersion, whereas consequences to populations are estimated for both 50% and 95% atmospheric dispersion.

Table B.15. Nonradiological transportation impacts of offshore processing scenarios

Shipping scenario	Accident impacts, fatalities	Incident-free impacts, fatalities
Barge to Portland	1.1E-02	2.1E-03
Seattle by Truck	8.9E-03	1.2E-03
Seattle by Rail	1.2E-02	3.4E-03
Norfolk by Truck	1.3E-01	1.6E-02
Norfolk by Rail	1.2E-01	1.5E-02

The consequences of port accidents were estimated in a manner similar to that used for overland transportation impacts. The contents of one shipping cask were assumed to be involved in an accident (see Table B-1), with radionuclide releases according to the release fractions reported in Table B-7. The dose and resulting LCF were calculated for each of the six accident severity categories. The point estimates of risk included the consequences as LCF for accidents of each severity category multiplied by the frequency with which an accident of that severity would occur. The accident frequencies for each severity category were assumed to be the overall accident rate per port transit (3.2 x 10-4) multiplied by the conditional probability for accidents in each severity category listed in Table B-6 (DOE 1994). The total accident risk for an individual or population was then estimated as the sum of risks for all accident severity categories. Risks for accidents evaluated at 95% (stable) atmospheric dispersion were assumed to be 10% lower than those at 50% (neutral) dispersion.

The results for accidents at the four representative ports are shown in Table B-16, with estimated risks for individual residents and populations within 80 km (50 miles). Point estimates of risk for the individual resident ranged from 6.2 x 10-13 to 1.3 x 10-11 LCF if no locally grown food were considered; results for all exposure pathways including ingestion were 3.5 x 10-11 to 7.8 x 10-10 LCF.

Collective point estimates of risk to the population within 50 miles of Portland, Oregon were 5.2 x 10-9 to 4.9 x 10-6 LCF assuming 50% atmospheric dispersion conditions and 1.0 x 10-8 to 8.3 x 10-6 LCF for 95% atmospheric dispersion. Corresponding results for the population in the vicinity of Newark are 2.3 x 10-8 to 4.9 x 10-5 LCF assuming 50% atmospheric dispersion and 1.5 x 10-8 to 8.4 x 10-5 LCF for 95% atmospheric dispersion. Consequences for the collective populations of Seattle-Tacoma and Norfolk fell between the estimates for the other two ports.

The maximum reasonably foreseeable accident was a category 6 accident, which has a frequency of 1.3 x 10-7 per port transit, and which was evaluated for either neutral or stable atmospheric conditions resulting in a cumulative frequency of 2.2 x 10-6 or 2.2 x 10-7, respectively for 17 SNF shipments. Dose and risk estimates for the maximum reasonably foreseeable accident are presented in Table B-17. The dose to the resident member of the public ranged from an estimated 0.02 to somewhat over 1 rem for all ports, depending on whether locally grown food was considered as an exposure pathway. The corresponding probability of LCF ranged from 9.0 x 10-6 to 6.5 x 10-4 and point estimates of risk, from 2.0 x 10-12 to 1.4 x 10-10 LCF. The collective

Table B-16. Point estimate of riska of latent cancer fatalities from port accident

Port location	Portland, Oregon		Seattle-Tacoma, Washington	
Exposure Pathways	All pathways	Inhalation + external	All pathways	Inhalation + external
Individual at 1600 m - 95% (stable) atmospheric conditions				
1 Shipment	4.6E-11	7.9E-13	3.5E-11	6.2E-13
17 Shipments	7.8E-10	1.3E-11	6.0E-10	1.0E-11
Population within 80 km (50 miles) of dock - 50% (neutral) atmospheric conditions				
1 Shipment	2.9E-07	6.6E-09	1.9E-07	4.3E-09
17 Shipments	4.9E-06	1.1E-07	3.2E-06	7.2E-08
Population within 80 km (50 miles) of harbor approach - 50% (neutral) atmospheric c				
1 Shipment	2.4E-07	5.2E-09	6.0E-08	1.4E-09
17 Shipments	4.0E-06	8.9E-08	1.0E-06	2.3E-08
Population within 80 km (50 miles) of dock - 95% (stable) atmospheric conditions				
1 Shipment	4.5E-07	1.0E-08	2.3E-07	5.1E-09
17 Shipments	7.6E-06	1.8E-07	3.9E-06	8.8E-08
Population within 80 km (50 Miles) of Harbor Approach - 95% (stable) Atmospheric Co				
1 Shipment	4.9E-07	1.0E-08	1.2E-07	2.8E-09
17 Shipments	8.3E-06	1.7E-07	2.0E-06	4.7E-08

a. Point estimate of risk is defined as the consequences to the receptor or popula accident of a given severity category (assuming the accident occurs), multiplied by shipment with which an accident of that severity would occur. The risks for accide categories are then summed to obtain the total risk per shipment. consequences to the populations within 80 km (50 mi) of the ports ranged from 2.0 x 10-3 to 380 LCF assuming the accident occurs, depending on the location of the accident (port or harbor approach) and the exposure pathways considered. The corresponding point estimates of risk for latent fatal cancers amounted to 4.4 x 10-9 to 8.2 x 10-5.

B.4.4 Dose to the Public from Ocean Transport to the United Kingdom

This analysis expects no dose to members of the public resulting from incident-free ocean transport of N Reactor SNF to the U.K. The ships carrying the fuel are owned and operated by the commercial vendor, and its shipboard crews are assumed to be classified as radiation workers for the purposes of this analysis.

The effects of losing a cask at sea are estimated to be comparable to those evaluated for shipment of foreign research reactor SNF to the U.S. (DOE 1994), based on similar shipping inventories of long-lived radionuclides per cask. The maximum dose to an individual for a cask lost in coastal waters was expected to be 11 mrem/year if the cask were left in place until all its contents dispersed. The corresponding consequences to marine biota were 0.24 mrad/year for fish, 0.32 mrad/year for crustaceans, and 13 mrad/year for mollusks. The consequences resulting from loss of a cask in the deep ocean would be many orders of magnitude lower than estimates for coastal waters.

The probability of accident on the open ocean was estimated to be 4.6 x 10-5 per shipment for an average duration voyage of about 20 days in transporting SNF from foreign research reactors to the U.S. (DOE 1995). The frequency of accidents for overseas shipment of SNF and process materials via special-purpose ships would likely be within a factor of two or three of this estimate. However, that frequency applies to commercial freight shipping experience, and it is possible that the use of special-purpose ships could result in a different accident rate. Using the commercial freight accident rate given above, the probability of an accident on the open ocean involving transport of SNF (17 ocean shipments), HLW (1 shipment), uranium oxide (1 shipment), and plutonium oxide (1 shipment) was calculated to be about 9.2E-04, integrated over all the shipments.

Table B-17. Consequences and risk to the public surrounding port facilities from m foreseeable accidents involving SNF shipments at or near the ports.

Port Location	Portland, Oregon		Tacoma, Washington	
	All pathways	Inhalation + external	All pathways	Inha + Ex
Resident at 1600 m				
Dose (rem)	1.3E+00	2.3E-02	9.9E-01	1.8E
LCF	6.5E-04	1.2E-05	5.0E-04	9.0E
LCF risk	1.4E-10	2.5E-12	1.1E-10	2.0E
Population within 80 km (50 mi) of dock - 50% (neutral) atmospheric dispersion				
Dose (person-rem)	8.7E+02	1.9E+01	5.5E+02	1.2E
LCF	4.4E-01	9.7E-03	2.8E-01	6.0E
LCF risk	9.5E-07	2.1E-08	6.0E-07	1.3E
Population within 80 km (50 mi) of harbor approach - 50% (neutral) atmospheric disp				
Dose (person-rem)	6.9E+02	1.5E+01	1.8E+02	4.0E

LCF	3.5E-01	7.5E-03	9.0E-02	2.0E
LCF risk	7.5E-07	1.6E-08	2.0E-07	4.4E
Population within 80 km (50 mi) of dock - 95% (stable) atmospheric dispersion				
Dose (person-rem)	1.3E+04	2.9E+02	6.9E+03	1.5E
LCF	6.5E+00	1.4E-01	3.5E+00	7.5E
LCF risk	1.4E-06	3.1E-08	7.5E-07	1.6E
Population within 80 km (50 mi) of harbor approach - 95% (stable) atmospheric dispe				
Dose (person-rem)	1.4E+04	3.1E+02	3.6E+03	7.8E
LCF	7.0E+00	1.6E-01	1.8E+00	3.9E
LCF risk	1.5E-06	3.4E-08	3.9E-07	8.5E

B.5 Legal and Policy Considerations

B.5.1 Policy Considerations

For a general discussion of the policy considerations associated with DOE's manag
see Section 2 of Volume 1. Several policy considerations bear on the evaluation of international
shipment and processing of SNF.

The primary consideration in international shipment of nuclear materials is conce
unauthorized diversion of such materials to foreign weapons programs (nuclear proli
concern is mitigated, but not eliminated, because SNF is not directly useable in si
weapons. Stringent safeguards exist for overseas transportation of nuclear materia
enriched uranium has been transported overseas for research purposes, and SNF from
reactors has been returned to the U.S. for disposition. Although such return shipm
occurred routinely since 1988, DOE is considering resumption of such shipments in s
efforts to remove highly enriched uranium SNF from international commerce. Two suc
were completed on an urgent relief basis in 1994, and additional shipments may resu
completion of an evaluation by DOE (1995).

DOE (1993) has evaluated the safety and policy issues associated with overseas tr
and concluded that such shipments could be made safely and securely within the cont
and international regulations for transport of radioactive materials (including spe
The report (DOE 1993) addresses risks to the public and the environment, emergency
safeguards, and the regulatory framework within which such shipments could be made.

The overseas transportation of SNF and eventual return of vitrified wastes and en
contemplated in this alternative would be managed in accordance with well defined a
demonstrated practices. However, a decision to implement the overseas transportati
processing option will require close examination of various policy and internationa
address plutonium stockpiling and the exchange of nuclear materials.

Other major policy considerations are the comparative risk of overseas shipment a
versus strictly domestic transportation and management of SNF and the involvement o
population and environment in the foreign processing alternative. A decision to im
BNFL option would be likely to generate controversy over the perception of transfer
environmental problems overseas. Transportation risks are addressed in Sections B.
attachment.

The representative facility used for this analysis (British Nuclear Fuels facilit
Sellafield, U.K.) began in the 1940s with the same primary mission as Hanford. Thi
facility processes large volumes of SNF from several foreign countries. Round trip

management of SNF and waste products would therefore be undertaken within a demonst
regulatory, technical, and physical infrastructure.

B.5.2 Applicable Laws, Regulations, and Other Requirements

B.5.2.1 General. This discussion is limited to regulatory considerations associated with the

round trip domestic and overseas transportation of SNF and other hazardous and radi
materials. For a discussion of general laws and regulation governing the managemen
Section 2.2 of this appendix. State and local requirements will not be discussed h
shipments of SNF under consideration would be in interstate or foreign commerce and
provisions would govern. Internal DOE Orders also are not discussed.

The significant international and federal laws and regulations that apply to the
hazardous and radioactive materials include the following laws:

- International Convention on the Safety of Life at Sea of 1960 (as amended)
- Atomic Energy Act (42 U.S.C. 2011 et seq.)
- Hazardous Transportation Materials Act (49 U.S.C. 1801 et seq.)
- Resource Conservation and Recovery Act, as amended by the Hazardous and Solid Amendments (42 U.S.C. 26901 et seq.)
- Executive Order 12898 (Environmental Justice)
- Executive Order 12114 (Environmental Effects Abroad of Major Federal Actions).

B.5.2.2 Domestic Packaging and Transportation. Transportation of hazardous and radioactive

materials, substances, and wastes are governed by the regulations of the U.S. Depar
Transportation (DOT) (49 CFR 171-178, 383-397), the U.S. Nuclear Regulatory Commiss
(10 CFR 71), and the U.S. Environmental Protection Agency (EPA) (40 CFR 262, 265).

United States DOT regulations contain requirements for identifying a material as
radioactive. These regulations interface with NRC and EPA regulations for identify
the DOT regulations govern hazard communication via placarding, labeling, reporting
requirements (see especially 10 CFR 71.5, in which DOT regulations are applied to s
radioactive materials by NRC regulations).

Nuclear Regulatory Commission regulations address packaging design and certificat
ments. Certification is based on safety analysis report data on the packaging desi
hypothetical accident conditions.

General overland carriage is governed by specific regulations dealing with packag
tion, escorts, and communication. There are specific provisions for truck and for
by truck, the carrier must use interstate highways or state-designated preferred ro
of Transportation regulations found in 49 CFR 397.101 establish routing and driver
requirements for highway carriers of packages containing "highway-route-controlled
radioactive materials. Spent nuclear fuel shipments constitute such controlled shi
carriage by rail car, each shipment by the railroad must comply with 49 CFR 174 Sub
"Detailed Requirements for Radioactive Materials."

B.5.2.3 Overseas Transportation. To the extent feasible, the NRC and DOT conform their

regulations to the model regulations of the International Atomic Energy Agency. Th
international regulations are also incorporated into the International Maritime Dan

Code, which was developed to supplement the International Convention on the Safety to which the U.S. is a signatory. Transportation risk in the global commons must b accordance with Executive Order 12114 (Environmental Effects Abroad of Major Federa

Transportation of dangerous cargoes through the Panama Canal is governed by the Maritime Dangerous Goods Code (IMDG) and is addressed in 35 U.S.C. 113. General pr passage through the Panama Canal are found at 35 U.S.C. 101-135. General regulatio navigation, including the applicability of the International Regulations for the Pr Collisions at Sea (1972), are found throughout Title 33 of the CFRs.

Relevant regulations applying to transport of SNF by vessel are found in 10 CFR P (NRC) and 49 CFR Part 176 (DOT). These regulations address prenotification to the Guard for inspection, and provide specifications for packaging, labelling, and othe tion for shipment. A Certification of Competent Authority must be obtained in comp International Atomic Energy Agency requirements. Specific provisions are made for including package surface temperature limitations, spacing, and total aggregate vol of freight containers.

B.6 Environmental Justice

For analytical purposes, three modes of transportation were selected for evaluati rail to a port on Puget Sound (such as Tacoma, Washington); 2) barge to a Columbia the vicinity of Portland, Oregon; or 3) rail or truck across the country to an East Coast port of reference was assumed to be Norfolk, Virginia (Hampton Roads). These are considered to provide a reasonable range of ports and transportation options fo

The DOE draft Environmental Impact Statement on the Proposed Nuclear Weapons Nonproliferation Policy Concerning Foreign Research Reactor (FRR) Spent Nuclear Fue 0218D) provides information on the numbers and spatial locations of minority and lo populations surrounding the ports of interest identified above and the Hanford Site FRR EIS (see Section A.2) utilized somewhat different analytical methodologies for justice purposes than those utilized in this document, some data may vary. The rea variations are explained in Section L-3.5 of Appendix L of this document. Utilizin data entirely from the FRR EIS for the purposes of this attachment, allows for comp sites of interest under consistent definitions and assumptions because the ports id not demographically evaluated in Appendix L of this EIS. The reader is referred to EIS for maps locating the spatial distribution of minority and low income populatio

Table B-18 lists information on selected populations of interest for regions sur Hanford loading facility and ports. Regions surrounding each port are areas that l within a 16-km (10-mile) radius of the port. Eighty kilometers (50 miles) is used Population characteristics shown in the table were extracted from detailed, block-g population data of the 1990 census. A block group usually includes 250 to 550 hous

Because the impacts as a result of transportation and facility operations are sma foreseen accidents present no significant risk, no reasonably foreseeable adverse i identified to the surrounding population. Therefore, no disproportionately high an would be expected for any particular segment of the population, including minority populations.

Table B-18. Characterization of populations residing near candidate facilities (Ha candidate ports of embarkationa).

Facility	Total population within 16 km of facility	Total minority populati within 16 km of facilit		Households within 16 km of facility	Low income households within 16 km of facil	
	Number	Number	Percent	Number	Number	Percent

Hanford, Washingtonc	383,934	95,042	24.8	136,496	57,667	42.2
Tacoma, Washington	511,575	85,341	16.7	198,458	83,101	41.9
Portland, Oreg	356,064	54,704	15.4	146,047	66,186	45.3
Norfolk, Virgi	681,864	300,179	44.0	206,464	90,723	43.9

a. Data based on draft FRR EIS (DOE/EIS-0218D).
b. Hispanic origin individuals can be of any race.
c. In the case of the Hanford loading facility, a radius of 80 km rather than 16 k the nearby population.

B.7 Cost

The cost estimate for the foreign processing option, as provided by the represent includes the full service of transporting the SNF from the Hanford Site to the U.K. processing the material into recovered uranium and plutonium and HLW, packaging the appropriately for return to the U.S., storing the packaged materials pending shipme transporting the materials back to the U.S. (BNFL 1994). The proposal provides onl cost ($1.3 - $2 billion), with no breakdown of those costs into the principal cost there is no detailed estimate of costs for the individual parts of the full service estimate does not include costs incurred at Hanford to package and stabilize the fu prior to shipment, or to manage degraded fuel and sludge that may not be suitable f shipment.

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