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Draft Hanford Site Solid (Radioactive and Hazardous) Waste Program Environmental Impact Statement Richland, Washington

Volume I – Sections 1 through 7

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ABSTRACT:

The Draft Hanford Site Solid (Radioactive and Hazardous) Waste Program Environmental Impact Statement (HSW EIS) provides environmental and technical information concerning the U.S. Department of Energy (DOE) proposal to enhance waste management practices at the Hanford Site. DOE issued the Notice of Intent to prepare the EIS on October 27, 1997, and held public meetings during the scoping period that extended through January 30, 1998. The HSW EIS updates analyses of environmental consequences from previous documents and provides evaluations for activities that may be implemented as a result of DOE decisions on the Waste Management Programmatic Environmental Impact Statement (WM PEIS). Waste types considered in the HSW EIS include operational low-level radioactive waste (LLW), mixed low-level waste (MLLW), and post-1970 transuranic (TRU) waste. MLLW contains chemically hazardous components in addition to radionuclides. Alternatives for management of these wastes at the Hanford Site, including the alternative of No Action, are analyzed in detail. The LLW and MLLW alternatives are evaluated for a range of waste volumes, representing quantities of waste that could be managed at the Hanford Site as a result of the WM PEIS records of decision. A single maximum forecast volume is evaluated for TRU waste. The No Action Alternative considers continuation of ongoing waste management practices at the Hanford Site or ceasing operations when the limits of existing capabilities are reached. The No Action Alternative provides for indefinite storage of some waste types. The other alternatives evaluate enhanced waste management practices including treatment and ultimate disposal of most wastes. The environmental consequences of the alternatives are generally similar. The major differences occur with respect to the consequences of disposal versus indefinite storage and with respect to the range of waste volumes managed under the alternatives. The draft EIS is being issued for public review and comment, after which DOE will prepare the final EIS. Dates, times, and locations for public meetings will be announced in the *Federal Register* and local media. A record of decision will be published in the *Federal Register* no sooner than 30 days after distribution of the final EIS.

Summary

This Draft *Hanford Site Solid (Radioactive and Hazardous) Waste Program Environmental Impact Statement* (HSW EIS) provides environmental and technical information concerning the U.S. Department of Energy (DOE) proposal to enhance waste management practices at the Hanford Site near Richland, Washington (Figure S.1). The HSW EIS tiers from the *Final Waste Management Programmatic Environmental Impact Statement for Managing Treatment, Storage, and Disposal of Radioactive and Hazardous Waste* (WM PEIS, DOE 1997a) and addresses local decisions needed to implement the WM PEIS records of decision (RODs). It also updates previous environmental reviews prepared for waste management operations at the Hanford Site. The HSW EIS is being prepared in accordance with the National Environmental Policy Act (NEPA) of 1969, as amended (42 USC 4321 *et seq*.), the DOE implementing procedures for NEPA (10 CFR 1021), and the Council on Environmental Quality (CEQ) Regulations for Implementing the Procedural Provisions of NEPA (40 CFR 1500-1508).

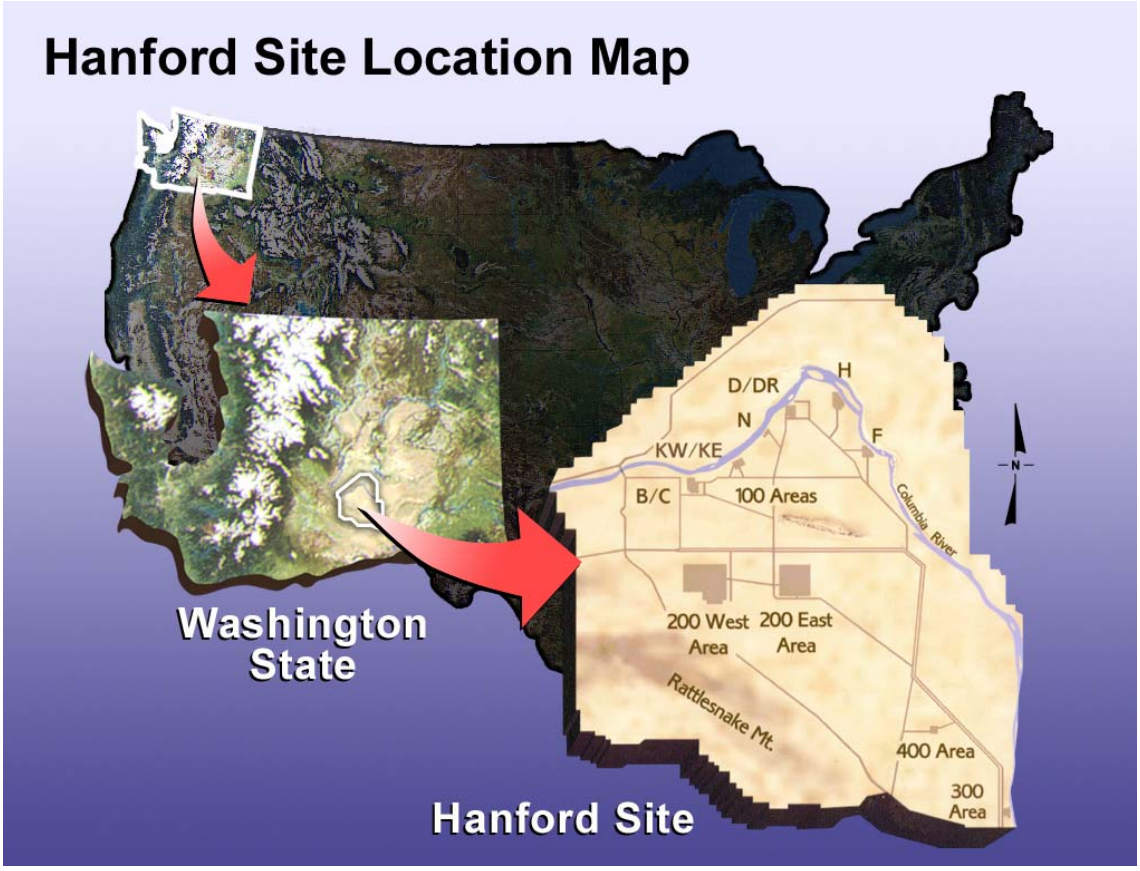

Figure S.1. Hanford Site Location Map

S.1 Introduction

DOE and its predecessors, the Manhattan Project, the U.S. Atomic Energy Commission (AEC), and the U.S. Energy Research and Development Administration (ERDA), have operated the Hanford Site since the 1940s. From the beginning through the 1980s, the primary mission at Hanford was to produce nuclear materials for national defense programs. Defense-materials production at Hanford has now ceased, and the Site's current activities include research, environmental restoration, and waste management. This HSW EIS describes the environmental consequences of alternatives for constructing, modifying, and operating facilities to manage low-level waste (LLW), mixed low-level waste (MLLW), and post-1970 transuranic (TRU) waste at Hanford.

Hanford solid waste program operations include three major functions of storage, treatment, and disposal. Waste from onsite and offsite generators is stored until it can be transferred to an appropriate treatment or disposal facility. DOE and other federal and state regulators monitor storage facilities to evaluate compliance with regulatory requirements. Treatment of these wastes may include volume reduction, destruction or neutralization of non-radioactive hazardous constituents, stabilization, and encapsulation. Disposal facilities at Hanford accept LLW and MLLW. After a previous NEPA analysis (DOE 1997b), DOE decided to dispose of TRU waste at the Waste Isolation Pilot Plant (WIPP) in New Mexico, a deep geologic repository that meets the requirements of 40 CFR 191 (63 FR 3623).

S.2 Purpose and Need

DOE needs to enhance and expand management of its current and anticipated volumes of solid LLW, MLLW, and post-1970 TRU waste at the Hanford Site and to make decisions that will enable the Site to provide storage, treatment, and disposal capabilities for these wastes.

S.3 Scoping

To determine the scope of the issues to be addressed in the EIS, DOE issued a notice of intent (NOI) to prepare the EIS (62 FR 55615). Comments and recommendations from interested parties on the range of actions, alternatives, and impacts that should be considered were requested. At the request of the State of Oregon, the initial public scoping period was subsequently extended (62 FR 65254). DOE held public scoping meetings during which DOE representatives presented an overview of the proposed actions and anticipated scope of the EIS. Four individuals provided oral comments at the public meetings, and eight individuals submitted written comments during the public scoping period. Many of the comments concerned the relationship of the HSW EIS to other DOE waste-management activities, including the WM PEIS (DOE 1997a) and the *Waste Isolation Pilot Plant Disposal Phase Final Supplemental Environmental Impact Statement* (DOE 1997b). Other comments concerned the need to understand the impacts of shipping offsite waste to Hanford; the use of commercial disposal facilities; and the need to address environmental, socioeconomic, and transportation impacts in the HSW EIS. DOE considered all of the comments received in its development of this draft HSW EIS.

DOE originally intended to evaluate the management of hazardous waste in the HSW EIS. However, DOE issued the final WM PEIS (DOE 1997a) and, based on that document, a ROD for the management of hazardous waste across the DOE complex (63 FR 41810). In its decision, DOE announced that it would continue the current practice of managing non-radioactive hazardous waste at commercial treatment and disposal facilities. Because no further decision is necessary regarding the management of non-radioactive hazardous waste at Hanford, this waste type was removed from the scope of the HSW EIS.

The environmental analyses in the HSW EIS were conducted through the year 2046, which represents the end of most waste management operations at the Site. Some activities that would occur after 2046, such as closure of the Low Level Burial Grounds (LLBGs), were also evaluated. This operational period was chosen for assessment, rather than the 20-year period evaluated in the WM PEIS (and as stated in the HSW EIS NOI), to provide a more complete evaluation of the consequences of waste management operations at Hanford. Certain environmental consequences, such as the long-term impacts of waste disposal on groundwater and the Columbia River, were evaluated for 10,000 years after the end of operations.

Other public comments and DOE programmatic decisions have resulted in restructuring the HSW EIS alternatives relative to those initially presented in the NOI. In the final WM PEIS (DOE 1997a), DOE selected a preferred alternative that provided for consolidated management of LLW and MLLW at a few major facilities across the DOE complex. The ROD for MLLW and LLW (65 FR 10061) identified Hanford Site and the Nevada Test Site as regional management facilities for these waste types. For management of post-1970 TRU waste, DOE decided that each site would prepare and certify waste generated at that site for ultimate disposal at WIPP (63 FR 3629).

Three sets of alternative actions are considered in the EIS for each waste type, consistent with the WM PEIS decisions. In very general terms, one set of activities represents continuation of current waste management practices without enhancements or implementation of many activities currently planned to meet legal or regulatory requirements. These activities comprise the No Action Alternatives, and they represent the baseline against which the proposed activities can be compared. The other alternatives represent the activities DOE might undertake to manage anticipated wastes consistent with the WM PEIS decisions.

Within each of the LLW and MLLW alternatives, a range of waste volumes was evaluated to reflect uncertainties in future waste receipts at the Hanford Site. In general, the lower bound volume for each waste type consists primarily of waste from Hanford Site generators, with a relatively small proportion of waste from other DOE sites. The upper bound volume includes additional offsite waste that Hanford could potentially receive as a result of the WM PEIS decisions to designate Hanford a regional disposal site for LLW and a regional treatment and disposal site for MLLW. For TRU waste, a single volume was evaluated corresponding to the maximum forecast receipts because substantial volumes of offsite TRU waste are not expected at Hanford.

S.4 Waste Types Analyzed

The types of waste managed by the solid waste program and evaluated in this draft HSW EIS include LLW, MLLW, and post-1970 TRU waste. Waste streams associated with each waste type are shown in Figure S.2. In the context of this document, a waste stream is defined as a collection of wastes with physical and chemical characteristics that will generally require the same management approach (that is, using the same storage, treatment, and disposal capabilities). Radioactive waste may also be classified as either contact-handled (CH) or remote-handled (RH).

Contact-Handled and Remote-Handled Waste

Contact-handled waste containers produce radiation dose rates less than or equal to 200 millirem/hr at the container surface. RH waste containers produce dose rates greater than 200 millirem/hr. CH containers can be safely handled by direct contact using appropriate health and safety measures. RH containers require special handling or shielding during waste management operations.

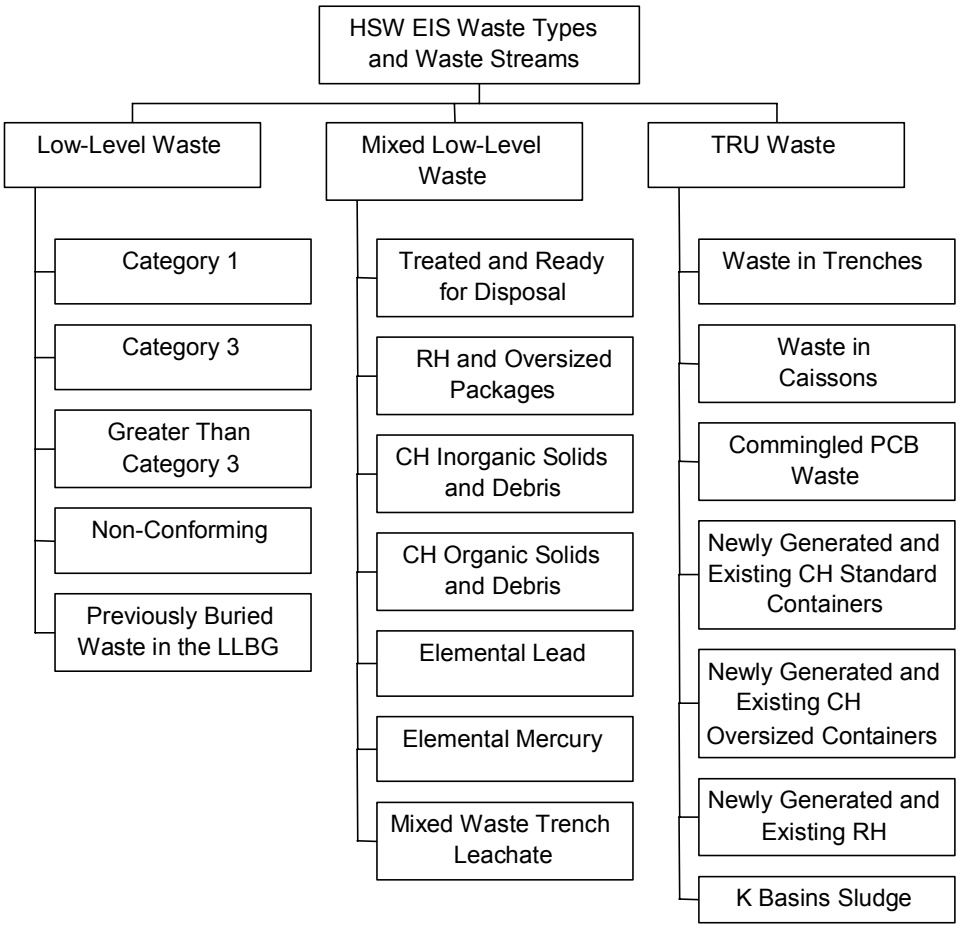

Figure S.2. Waste Types and Waste Streams Considered in this HSW EIS

Other programs at Hanford manage other types of materials, such as wastes from environmental restoration (site cleanup) activities, high-level radioactive waste, spent nuclear fuel, and wastes generated during building decontamination and decommissioning. These materials managed by other Hanford programs are not included within the scope of this EIS.

Low-Level Waste. LLW is waste that contains radioactive material and that does not fall under any other DOE classification of radioactive waste. DOE manages LLW and other radioactive waste under the authority of the Atomic Energy Act (AEA) of 1954 (42 USC 2011 *et seq*.). At Hanford, LLW is further divided into categories, depending on the type and quantity of radioactive material that it contains. Categories of LLW and other requirements for disposal of LLW at Hanford are described in the *Hanford Site Solid Waste Acceptance Criteria* (HSSWAC) established by the DOE Richland Operations office (DOE-RL) and the Hanford waste management contractor, Fluor Hanford, Inc. (FH 2001).

LLW at Hanford was generated during operation of analytical and research laboratories, reactors, chemical separation facilities, plutonium processing facilities, and waste management facilities. LLW typically consists of personal protective equipment, plastic sheeting, gloves, and other operating and laboratory wastes. Ongoing operations at Hanford continue to generate LLW. In addition, several other DOE sites currently send LLW to Hanford.

At present, most LLW is sent directly to the LLBGs for burial. A fraction of the waste is sent to the Waste Receiving and Processing Facility (WRAP) for characterization and verification before burial in the LLBGs. Waste that does not meet the HSSWAC is stored until it can be treated to permit final disposal.

Waste Definitions

Low-level waste is defined as radioactive waste, including accelerator-produced waste, that is not high-level waste, spent nuclear fuel, transuranic waste, or byproduct material (as defined under the Atomic Energy Act).

Mixed low-level waste is LLW that contains both radionuclides subject to the Atomic Energy Act of 1954, and a hazardous component subject to the Resource Conservation and Recovery Act.

Transuranic waste is defined as waste, other than high-level radioactive waste, that contains radionuclides with atomic numbers greater than that of uranium (92) and half-lives greater than 20 years, in concentrations greater than 100 nanocuries per gram of waste.

Mixed Low-Level Waste. MLLW is LLW that also contains non-radioactive hazardous constituents as defined by the Resource Conservation and Recovery Act (RCRA) of 1976 (42 USC 6901 *et seq*.) and applicable state regulations. The hazardous components of MLLW are so identified either because they contain specific listed materials; were generated during specific processes; or exhibit properties such as toxicity, corrosivity, ignitability, or reactivity that could present a hazard to human health and the environment.

MLLW was generated during facility maintenance, deactivation activities, and laboratory operations. MLLW typically consists of sludges, ashes, resins, paint wastes, soils, and other debris. Ongoing operations continue to generate MLLW. Until 1987, MLLW was managed in the same manner as LLW. Beginning in 1987, treatment of MLLW (generally immobilization, removal, or destruction of the hazardous components) was required before it could be sent to a RCRA-permitted land disposal facility.

At Hanford, MLLW is stored at the Central Waste Complex (CWC) or the T Plant Complex awaiting treatment or disposal. DOE currently characterizes and treats limited quantities of MLLW at WRAP and the T Plant Complex. Onsite treatment capabilities include amalgamation of mercury, neutralization of alkaline and acid waste, solidification of liquids, and macroencapsulation. DOE also has contracts with a commercial treatment facility to provide stabilization of inorganic solids, macroencapsulation of debris waste, and thermal treatment of some MLLW. MLLW that has been treated is currently disposed of in RCRA-permitted trenches in the 200 West Area. The MLLW trenches are constructed with a low permeability liner and a system for collecting any water that drains through the waste (referred to as leachate).

Post-1970 Transuranic Waste. TRU waste was produced during reactor operations, fuel reprocessing, and nuclear weapons production. Some TRU waste also resulted from development, production, and utilization of mixed oxide fuels at Hanford. Plutonium is the most common TRU element in waste from DOE facilities. Waste that contains a sufficiently high concentration of TRU radionuclides to meet the regulatory definition of TRU waste must be disposed of in a facility that meets U.S. Environmental Protection Agency (EPA) requirements (40 CFR 191). TRU waste must be characterized, packaged, and certified at Hanford as meeting the WIPP waste acceptance criteria before it can be shipped to that facility for disposal.

TRU waste was not defined as a separate waste type until 1970 and was managed in the same manner as LLW before that time. From 1970 through 1984, Hanford waste suspected of containing TRU radionuclides was retrievably stored in the LLBGs in trenches or in caissons (underground structures intended for storage of some higher activity waste). This waste is referred to as suspect TRU waste because only some of the stored waste contains TRU radionuclides at concentrations specified in the definition. DOE is determining whether suspect TRU waste should be retrieved and processed as TRU waste, or whether it can remain disposed of in the LLBGs. Since 1985, TRU waste has generally been stored in surface facilities, such as CWC or the T Plant Complex, until it can be processed and certified for disposal at WIPP.

Under current plans, newly generated and retrievably stored TRU waste would be sent to WRAP for processing and certification. At the present time, no commercial facilities are available for processing TRU waste. TRU waste that cannot be processed and certified onsite would be stored until treatment becomes available. DOE currently plans to dispose of certified TRU waste at WIPP.

S.5 Solid Waste Management Activities and Facilities

The waste management activities and facilities included within the scope of the draft HSW EIS are described briefly in the following sections. Hanford solid waste program activities include storage, treatment, and disposal of LLW and MLLW, as well as storage and processing of post-1970 TRU waste. Figure S.3 provides an overview of ongoing activities. Existing and proposed waste management facilities considered in this HSW EIS alternatives are also described.

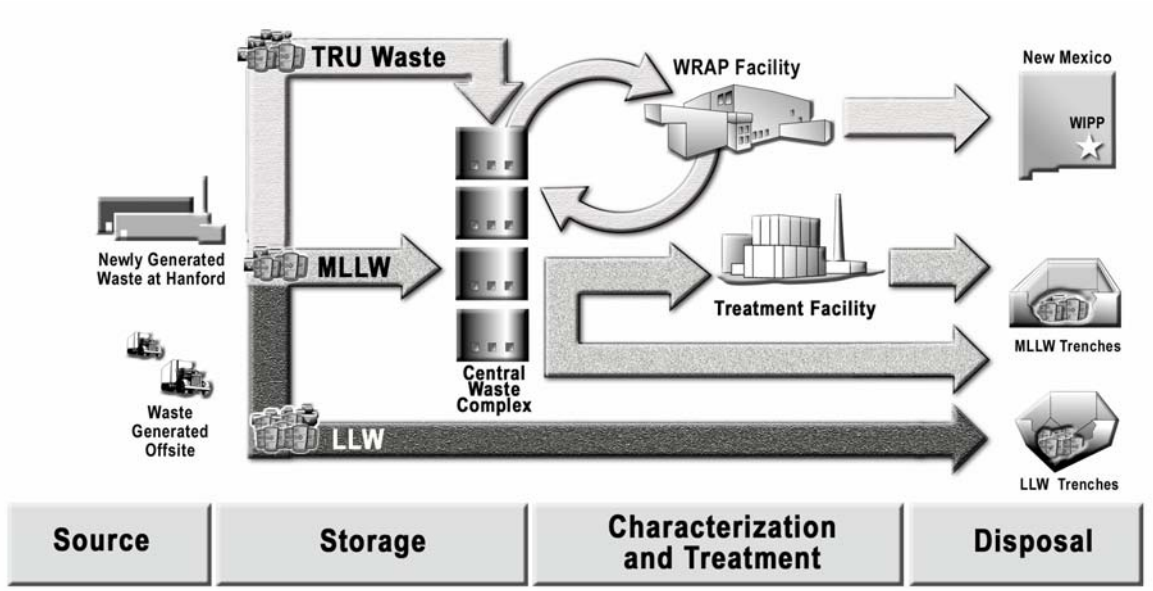

Figure S.3. Overview of Current Hanford Solid Waste Program

S.5.1 Solid Waste Storage

Waste is generally stored while awaiting treatment or disposal. The specific storage methods used depend on the chemical and physical characteristics of the waste as well as the type and concentration of radionuclides in the waste.

Storage Facilities

Existing Facilities
Central Waste Complex
LLBGs
- Trenches
- Caissons

T Plant Complex
WRAP

New/Modified Facilities
Additional CWC Buildings

At Hanford, waste is stored at either aboveground facilities or belowground. The primary Hanford waste storage facility is the CWC, a group of enclosed metal buildings on concrete pads that are used to store various types of waste awaiting verification, treatment, or disposal. Some waste is also stored outdoors on concrete pads if the outer containers are corrosion-resistant and suitable for such storage. The LLBGs consist of a series of below-grade trenches intended for ultimate disposal of LLW. In some cases, waste has been stored in LLBG trenches or in caissons for later retrieval and disposition, as described in the following sections. The T Plant Complex and WRAP also have some waste storage capabilities.

LLW is typically not stored for an extended period at Hanford. In most cases, a small fraction of each incoming shipment is stored until it can be inspected and verified that it meets the HSSWAC. The remainder is sent directly to the LLBGs for disposal. Trenches in the LLBGs are then backfilled with soil and maintained to prevent the spread of radioactive contamination.

Because the Hanford Site currently does not have facilities to treat all types of MLLW, untreated waste must be stored until it can be treated in compliance with RCRA and state regulations. Short-term

storage for MLLW is provided at many generator facilities throughout the Hanford Site for up to 90 days, the maximum allowed in a non-permitted storage facility. Storage of MLLW for longer than 90 days requires a RCRA-permitted storage facility that is engineered to prevent release of the wastes to the environment. Structures at CWC are constructed to meet these requirements, and they provide interim storage for MLLW until it can be treated. A small quantity of MLLW that has been prepared for disposal may also be stored in the LLBG in RCRA-permitted MLLW trenches.

From 1970 to 1988, drums and boxes of TRU waste were placed in storage in LLBG trenches. Small containers of RH TRU waste were also placed within four cement-lined caissons. The caissons are thick-walled concrete structures located in the LLBGs and intended to provide containment and shielding for the waste. Most TRU waste generated after 1988 is stored at CWC until it can be repackaged, as needed, and certified for shipment to WIPP.

Most alternatives evaluated in this HSW EIS would not involve construction of new storage facilities. However, some alternatives would require additional storage for wastes that could not be prepared for final disposal, in which case the CWC would be expanded as necessary.

S.5.2 Solid Waste Treatment

Waste treatment processes are used to change the physical, chemical, or biological characteristics of waste, to reduce its volume, or to make it safer for disposal. Treatment is not required for most LLW but may consist of volume reduction or other activities needed to stabilize the waste.

MLLW requires treatment to specific standards defined by RCRA and state regulations before it can be disposed of in a permitted facility. The Hanford Site has limited capability to treat MLLW, and DOE has contracted with a RCRA-permitted commercial facility to begin treating limited quantities of stored CH MLLW. The 200 Area Effluent Treatment Facility (ETF) treats Hanford Site liquid wastes, including leachate collected from the MLLW trenches. Hanford requires additional capabilities to treat MLLW that cannot be accepted by commercial facilities, such as oversized items or containers and RH MLLW.

TRU waste may also require processing before it can be sent for disposal. Processing may include activities such as repackaging, characterization, and certification that it meets the WIPP waste acceptance criteria. WRAP provides the capability to process and certify some CH TRU waste for shipment to WIPP. However, additional capabilities are needed at Hanford to process and certify RH TRU waste and oversized containers.

For the purposes of this EIS, treatment facilities include those used to treat MLLW to RCRA standards, as well as those where TRU waste is processed and certified for shipment to WIPP. DOE is currently using a combination of Hanford facilities and offsite facilities to treat MLLW and

Treatment And Processing Facilities

Existing Facilities
- WRAP
- T Plant Complex
- Effluent Treatment Facility
- Commercial Treatment Facilities
- Other DOE sites

New/Modified Facilities
- Modified T Plant Complex
- New M-91 Facility
- Pulse Driers
- Commercial Treatment Facilities

TRU waste. The primary existing Hanford treatment facilities for solid waste are WRAP and the T Plant Complex. Commercial facilities have provided treatment capabilities for limited quantities of CH MLLW under two existing contracts. DOE does not currently have facilities for treating most CH MLLW, RH MLLW, or RH TRU waste, nor for treating large containers of MLLW and TRU waste. The ETF provides treatment for leachate from the MLLW trenches.

Proposed new facilities are included in the HSW EIS to provide capabilities for waste treatment and processing that are not currently available at Hanford. Either facilities in the T Plant Complex would be modified, or a new treatment facility would be constructed, to treat some MLLW and TRU waste streams. Existing commercial treatment contracts could also be extended, or new contracts could be established, to treat MLLW. Pulse driers would be used to process leachate from the MLLW trenches after existing treatment facilities at the ETF cease operation.

S.5.3 Solid Waste Disposal

The final step in the waste management process is disposal. Some types of waste can be disposed of safely in existing facilities using conventional methods, such as shallow land burial. Other types of waste require facilities that provide long-term isolation, such as deep geologic disposal.

Disposal Facilities

Existing Facilities
LLBGs
- LLW Trenches
- MLLW Trenches

New/Modified Facilities
LLBGs
- Current Design LLW Trenches
- Enhanced Design LLW Trenches
- Current Design MLLW Trenches
- Enhanced Design MLLW Trench
- Melter Trench
- Closure Caps

Hanford disposes of most LLW in LLBGs that consist of a series of trenches. Six LLBGs are located in the 200 West Area, and two are in the 200 East Area. One LLBG in the 200 West Area contains two trenches that are permitted for disposal of MLLW that has been treated to comply with RCRA and state regulations. The MLLW trenches are constructed with a low permeability liner and a system for collecting water that drains through the waste disposal area. The collected liquids, referred to as leachate, are shipped to the ETF and converted to a solid form suitable for disposal.

After onsite characterization and packaging, DOE plans to send post-1970 TRU waste to the WIPP repository for disposal. Transportation of TRU waste and disposal at WIPP were previously evaluated by DOE (1997b).

In some of the HSW EIS alternatives, new disposal capacity would be constructed for LLW and MLLW. Trenches of a design similar to those currently employed for disposal of LLW and MLLW at Hanford are evaluated, in addition to trenches of enhanced (deeper and wider) design. Separate designs are evaluated for each waste type and for melters from the tank waste treatment facility. In most alternatives, the LLBGs would ultimately be closed by applying a cap consisting of soil, sand, gravel, and asphalt to reduce water infiltration and the potential for intrusion.

S.6 Description of Alternatives

This draft HSW EIS considers a range of reasonable alternatives for managing solid LLW, MLLW, and post-1970 TRU waste at the Hanford Site. An overview of the alternatives for each waste type is presented in the following sections and in Table S.1. In addition to evaluating alternatives for site-specific waste management activities, this draft HSW EIS evaluates a range of waste volumes for MLLW and LLW. Table S.2 shows the volumes of waste that could be managed at Hanford under each of the alternatives. In its final decision, DOE could choose to implement a combination of actions from any of the alternatives evaluated in this EIS.

S.6.1 LLW Alternatives

DOE proposes to manage LLW from Hanford generators and other DOE sites by using existing facilities for waste verification and by constructing additional disposal capacity. DOE needs to determine which treatment, storage, and disposal activities are required for properly managing onsite and offsite solid LLW that currently exists, or that may be received at Hanford in the future. Currently, most LLW is packaged, inspected to determine that it complies with the HSSWAC (FH 2001), and placed in the LLBGs. Limited quantities of waste that do not meet the HSSWAC are currently stored until the waste can be treated to comply with Hanford requirements. DOE needs to evaluate options for permanent disposal of LLW at Hanford, including expansion and possible reconfiguration of disposal facilities to accommodate anticipated waste receipts.

S.6.1.1 LLW Alternative 1 (Preferred Alternative)

As needed, LLW would be inspected and verified at WRAP, the T Plant Complex, or other suitable locations within the Hanford Site. Non-conforming waste would be treated to comply with the HSSWAC using existing onsite capabilities, or if onsite treatment capacity does not exist, it would be treated at an offsite commercial facility. DOE would construct new disposal capacity using a deeper, wider trench design relative to the trenches previously employed for disposal of LLW at Hanford. Disposal would take place within the boundaries of currently defined LLBGs, and the LLBGs would ultimately be closed by applying a cap to reduce water infiltration and the potential for intrusion. This alternative was evaluated for a range of waste volumes that could be managed at Hanford under the WM PEIS ROD for LLW.

S.6.1.2 LLLW Alternative 2

As needed, LLW would be inspected and verified at WRAP, the T Plant Complex, or other suitable locations within the Hanford Site. Non-conforming waste would be treated to comply with the HSSWAC using existing onsite capabilities, or at a new onsite treatment facility. DOE would construct new disposal capacity using a trench design previously employed for disposal of LLW at Hanford. Depending on the volume of waste received at Hanford, expansion of the LLBGs within the 200 Area boundaries may be required. The LLBGs would ultimately be closed by applying a cap to reduce water infiltration and the potential for intrusion. This alternative was evaluated for a range of waste volumes that could be managed at Hanford under the WM PEIS ROD for LLW.

Table S.1. Summary Comparison of Alternatives

	Alternative 1	Alternative 2	No Action
Low-Level Waste			
Storage	No indefinite storage needed.	No indefinite storage needed.	Wastes that cannot be treated to HSSWAC would remain in storage in CWC indefinitely.
Treatment	Non-conforming wastes treated commercially. Category 3 (Cat 3) and greater than category 3 (GTC3) LLW emplaced in high-integrity containers (HICs) or in-trench grouted.	Non-conforming wastes treated in a new M-91 Facility. Cat 3 and GTC3 wastes emplaced in HICs or in-trench grouted.	Non-conforming wastes not treated. Cat 3 and GTC3 wastes emplaced in HICs or in-trench grouted.
Disposal	Future LLW trenches would be of the enhanced design. Cap LLBGs at closure.	Future trenches would be of the current design. Cap LLBGs at closure.	Future trenches would be of the current design. No capping of trenches.
Mixed Low-Level Waste			
Storage	No indefinite storage needed.	No indefinite storage needed.	Untreated wastes, including RH wastes and wastes in excess of current disposal capacity, would be indefinitely stored in an expanded CWC.
Treatment	Commercial treatment used for most CH wastes. Modify the T Plant Complex to provide treatment for other MLLW.	Limited commercial treatment. Build new M-91 facility to provide treatment for all other MLLW.	Limited commercial treatment only. Most MLLW remains untreated.
Disposal	Use enhanced design MLLW trenches after filling current trenches. A melter trench would be provided for used vitrification melters. Trenches capped when filled.	Use current MLLW trench design for future trenches. A melter trench would be provided for used vitrification melters. Trenches capped when filled.	Use only existing trenches. Store additional wastes indefinitely. Existing trenches capped when filled.
Post-1970 Transuranic Waste			
Storage	Continued use of CWC and LLBGs. No indefinite storage needed.	Continued use of CWC and LLBGs. No indefinite storage needed.	RH and oversized containers would be stored indefinitely in an expanded CWC.
Processing	Process standard CH wastes in WRAP. Process RH and oversized containers in modified T Plant Complex.	Process standard CH wastes in WRAP. Process RH and oversized containers in new M-91 Facility.	Process standard CH wastes in WRAP. RH and oversized containers would not be processed.
Disposal	Ship all certified wastes to WIPP.	Ship all certified wastes to WIPP.	Ship all certified wastes to WIPP. Some wastes remain untreated.

Table S.2. Waste Volumes Considered in HSW EIS Alternatives

Waste Type	Lower Bound Volume m^3 (ft^3)	Upper Bound Volume m^3 (ft^3)
LLW	432,582 (15,270,000)	631,427 (22,290,000)
MLLW	65,344 (2,307,000)	205,678 (7,260,000)
Post-1970 TRU Waste	45,806 (1,617,000)	
Note: These volumes also include 283,067 m^3 (9,992,000 ft^3) of waste previously disposed of in the LLBGs. For TRU waste, a single waste volume is evaluated representing the maximum Hanford Site forecast.		

S.6.1.3 LLW No Action Alternative

As needed, LLW would be inspected and verified at WRAP, the T Plant Complex, or other suitable locations within the Hanford Site. Non-conforming waste would be treated to comply with the HSSWAC using existing onsite capabilities, or if onsite treatment capacity does not exist, it would be stored indefinitely at the CWC. DOE would construct new disposal capacity using a trench design previously employed for disposal of LLW at Hanford. Disposal would take place within the boundaries of currently defined LLBGs. The trenches would be backfilled to grade, but the LLBGs would not be capped. This alternative was evaluated for the lower bound LLW volume that could be managed at Hanford under the WM PEIS ROD for LLW.

S.6.2 MLLW Alternatives

DOE proposes to treat and dispose of MLLW received from Hanford generators and other DOE sites using existing, expanded, or new facilities. DOE needs to determine which treatment, storage, and disposal activities are required to properly manage onsite and offsite solid MLLW that currently exists, or which may be received at Hanford in the future. The Hanford Site currently has limited treatment capabilities to treat MLLW in compliance with the RCRA Land Disposal Restrictions (LDRs). As a result, most MLLW has been placed in interim storage awaiting final disposition. Existing MLLW disposal facilities at Hanford consist of two engineered trenches permitted under RCRA. The capacity of those trenches is insufficient to dispose of all MLLW that Hanford expects to receive in the future. Therefore, DOE needs to evaluate options for treating Hanford's MLLW in accordance with RCRA and Washington State requirements and for expanding Hanford's MLLW disposal capacity.

S.6.2.1 MLLW Alternative 1 (Preferred Alternative)

MLLW received for storage or treatment would be inspected and verified at WRAP, the T Plant Complex, or other suitable locations within the Hanford Site. However, most verification of treated MLLW is expected to take place at either the generator or treatment facility. DOE would establish contracts with a RCRA-permitted commercial facility (or facilities) to treat most of Hanford's CH MLLW using both thermal and non-thermal processes. For MLLW that cannot be treated by commercial facilities, such as RH or oversized items, DOE would develop new onsite treatment capacity by modifying existing facilities in the T Plant Complex. Limited treatment capabilities that currently exist at WRAP and the T Plant Complex would also continue to be used.

DOE would fill two existing MLLW trenches at Hanford and then construct new disposal units of a deeper and wider design. Disposal would take place within the boundaries of currently defined LLBGs, and the trenches would be closed by applying a RCRA-compliant cap. This alternative was evaluated for a range of waste volumes that could be managed at Hanford under the WM PEIS ROD for MLLW.

S.6.2.2 MLLW Alternative 2

As needed, MLLW received for storage or treatment would be inspected and verified at WRAP, the T Plant Complex, or other suitable locations within the Hanford Site. However, most verification of treated MLLW is expected to take place at either the generator or treatment facility. Under this alternative, DOE would limit commercial treatment of CH MLLW to quantities specified in existing contracts and develop new onsite capabilities to treat most CH MLLW, RH MLLW, and oversized items by constructing a new treatment facility. Limited treatment capabilities that currently exist at WRAP and the T Plant Complex would also continue to be used.

DOE would fill two existing MLLW trenches at Hanford and then construct new disposal trenches of a similar design. A separate trench would be constructed for disposal of melters from the tank waste treatment plant. Disposal would take place within the boundaries of currently defined LLBGs, and the trenches would be closed by applying a RCRA-compliant cap. This alternative was evaluated for a range of waste volumes that could be managed at Hanford under the WM PEIS ROD for MLLW.

S.6.2.3 MLLW No Action Alternative

As needed, MLLW received for storage or treatment would be inspected and verified at WRAP, the T Plant Complex, or other suitable locations within the Hanford Site. However, most verification of treated MLLW is expected to take place at either the generator or treatment facility. DOE would treat CH MLLW, up to minimum quantities specified in existing contracts, at a RCRA-permitted commercial facility. Limited treatment capabilities that currently exist at WRAP and the T Plant Complex would also continue to be used.

DOE would fill two existing MLLW trenches at Hanford, and the trenches would be closed by applying a RCRA-compliant cap. Waste in excess of existing treatment and disposal capacity would be stored indefinitely at the T Plant Complex or at the CWC, which would be expanded as necessary. This alternative was evaluated for the lower bound MLLW volume that could be managed at Hanford under the WM PEIS ROD for MLLW.

S.6.3 TRU Waste Alternatives

DOE proposes to expand Hanford Site capabilities for storage, processing, and certification of TRU waste for disposal at WIPP. DOE needs to determine which processing, certification, and storage activities are required to properly manage post-1970 TRU waste that currently exists, or which may be received at the Hanford Site in the future. Since 1970, DOE has retrievably stored TRU waste at the Hanford LLBGs in trenches and caissons, and in aboveground facilities. DOE previously decided to dispose of this inventory of TRU waste and future generated TRU waste at the WIPP. WRAP currently has the capability to process and certify some types of TRU waste for disposal at WIPP. To meet WIPP waste acceptance criteria for all types of TRU waste, additional processing and certification capabilities must be developed and implemented at the Hanford Site.

S.6.3.1 TRU Waste Alternative 1 (Preferred Alternative)

DOE would continue to store post-1970 TRU waste awaiting processing at CWC, the T Plant Complex, and the LLBGs (for waste previously placed into retrievable storage in trenches and caissons). CH TRU waste in standard containers (drums and standard waste boxes) would continue to be processed and certified at WRAP for disposal at WIPP. For TRU waste that could not be processed at WRAP (primarily oversized packages and RH waste), onsite capabilities for processing and certification would be developed by modifying existing facilities in the T Plant Complex. Future TRU waste receipts, waste stored in surface facilities, and post-1970 TRU waste that had been retrievably stored in the LLBG trenches and caissons would be processed and shipped to WIPP. This alternative was evaluated using the maximum TRU waste volume forecast for management at Hanford.

S.6.3.2 TRU Waste Alternative 2

DOE would continue to store post-1970 TRU waste awaiting processing at CWC, the T Plant Complex, and the LLBGs (for waste previously placed into retrievable storage in trenches and caissons). CH TRU waste in standard containers (drums and standard waste boxes) would continue to be processed and certified at WRAP for disposal at WIPP. For TRU waste that could not be processed at WRAP (primarily oversized packages and RH waste), onsite capabilities for processing and certification would be developed by constructing a new facility. Future TRU waste receipts, waste stored in surface facilities, and post-1970 TRU waste that had been retrievably stored in the LLBG trenches and caissons would be processed and shipped to WIPP. This alternative was evaluated using the maximum TRU waste volume forecast for management at Hanford.

S.6.3.3 TRU Waste No Action Alternative

DOE would continue to store post-1970 TRU waste awaiting processing at CWC, the T Plant Complex, and the LLBGs (for waste previously placed into retrievable storage in trenches and caissons). CH TRU waste in standard containers (drums and standard waste boxes) would continue to be processed and certified at WRAP for disposal at WIPP. For TRU waste that could not be processed at WRAP (oversized packages, RH waste, and some miscellaneous waste streams), no onsite processing capability would be available. To the extent possible, future TRU waste receipts, waste stored in surface facilities, and post-1970 TRU waste that had been retrievably stored in the LLBG trenches and caissons would be processed at WRAP and shipped to WIPP. Waste that could not be processed and certified for disposal at WIPP would be stored indefinitely at the T Plant Complex or at CWC, which would be expanded as necessary. This alternative was evaluated using the maximum TRU waste volume forecast for management at Hanford.

S.6.3.4 Preferred Alternative

Based on the results of the environmental consequences analyses, in addition to cost and other considerations, DOE has identified a preferred alternative for the HSW EIS. At this time, the DOE preferred alternative consists of LLW Alternative 1, MLLW Alternative 1, and post-1970 TRU waste Alternative 1, as described in the preceding sections. In general, these three alternatives provide the most cost-effective and environmentally preferable approach to waste management at Hanford for the range of waste volumes that might be managed at the Site as a result of WM PEIS decisions. However, DOE will consider all comments received during the public comment period for this draft EIS before preparing the final EIS and publishing a ROD regarding Hanford solid waste program operations.

S.7 Affected Environment

The DOE Hanford Site lies within the semiarid Pasco Basin of the Columbia Plateau in southeastern Washington State (Figure S.4). The Site occupies an area of about 1517 km^2 (586 mi^2) north of the confluence of the Yakima River with the Columbia River. The major portion of the Hanford Site is undisturbed and provides a buffer for the relatively small areas used for nuclear materials storage, waste storage, and waste disposal. Only about 6 percent of the land area on the Site has been disturbed and actively used.

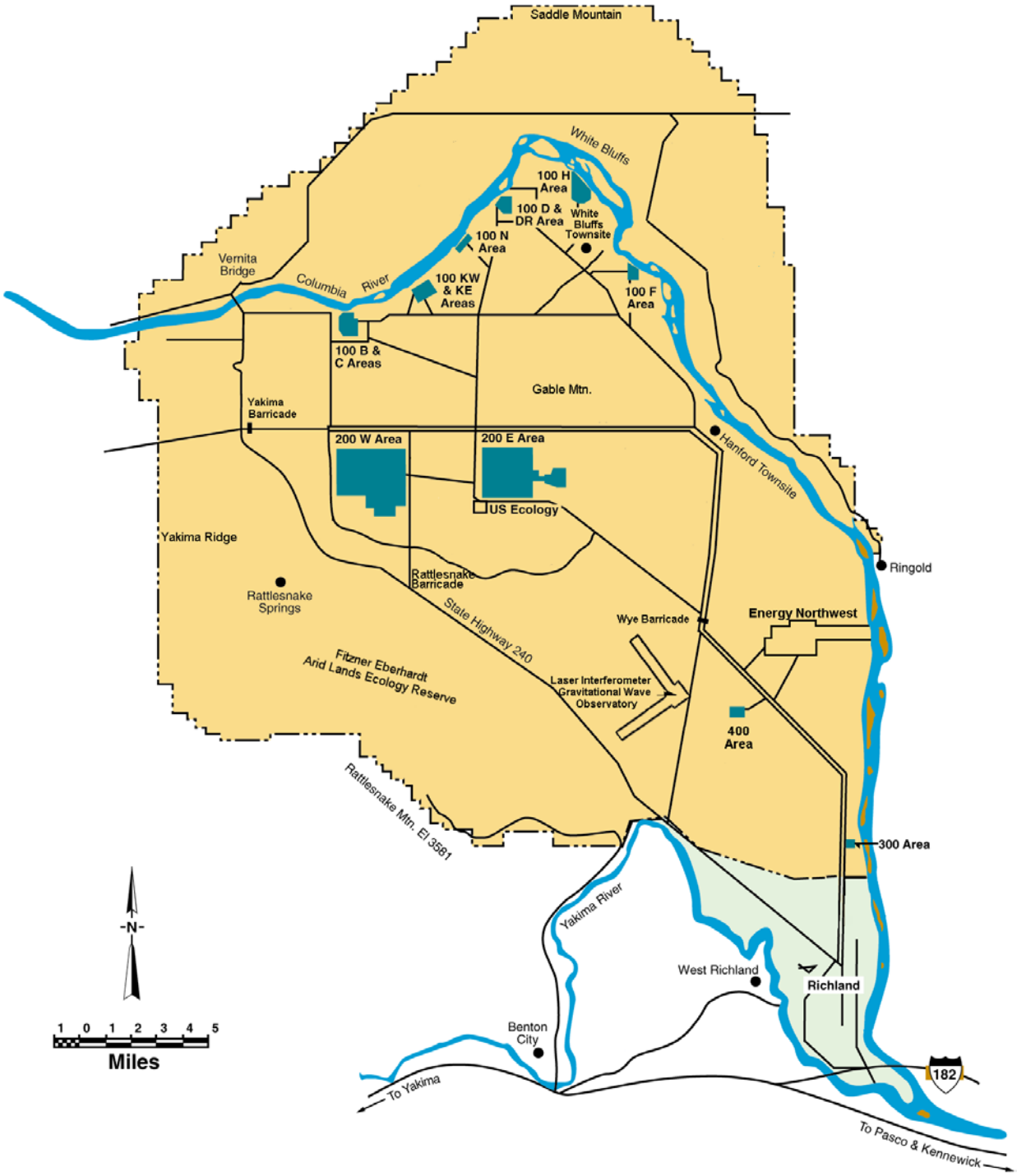

Figure S.4. U.S. Department of Energy – Hanford Site (after Neitzel 2001)

Most of the activities described and analyzed in the HSW EIS would occur within the existing boundaries of the Hanford Site 200 Areas. The 200 East and 200 West Areas occupy 51 km^2 (19.5 mi^2) in the 200 Area Plateau of the Hanford Site, about 8 to 11 km (5 to 7 mi) south of the Columbia River. Facilities located in the 200 Area Plateau were built to process irradiated fuel from the production reactors. The operation of these facilities resulted in the need for treatment, storage, and disposal facilities for radioactive and hazardous wastes. The WRAP, CWC, LLBGs, the MLLW trenches, TRU waste caissons and trenches, and the T Plant Complex are located in the 200 Areas. Unplanned releases of radioactive and non-radioactive waste have contaminated some parts of the 200 Areas. The Environmental Restoration Disposal Facility (ERDF) for Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA, 42 USC 9601) cleanup wastes is located in the 200 Area Plateau. Other federal agencies, such as the Department of the Navy, also use Hanford nuclear waste treatment, storage, or disposal facilities. Institutional controls are expected for CERCLA remediation areas in the 200 Area Plateau.

Archeological records show past Native American occupation and use of the Hanford area for hundreds of years. After Americans of European descent arrived, use of the area by indigenous peoples was curtailed, but not eliminated. In the Treaties of 1855, the Yakama Nation and the Confederated Tribes of the Umatilla Indian Reservation ceded land, including the present Hanford Site, to the United States.

Natural and cultural resource values at the Hanford Site include protection of the Columbia River, protection of the last remnant of mature sagebrush steppe in Washington State, protection of groundwater from further degradation, and restoration of groundwater quality to usable levels. The Hanford Site may also provide habitat for several federal or state threatened and endangered species, including the bald eagle, ferruginous hawk, and spring-run chinook salmon.

The Hanford Reach National Monument was created on June 9, 2000, to protect sensitive habitats and resources on the Hanford Site. The monument includes 79,253 ha (195,843 ac) of federally owned land making up a portion of the Hanford Site. The principal components of the monument are the Fitzner/ Eberhardt Arid Lands Ecology Reserve (ALE), the McGee Ranch and Riverlands area, the Saddle Mountain National Wildlife Refuge, land along the south and west sides of the Columbia River corridor, the federally owned islands within the portion of the Columbia River included in the monument, and the Hanford sand dune field. The components of the monument are managed by the U.S. Fish and Wildlife Service and by DOE, in consultation with the Department of the Interior. In June 2000, a wildfire burned approximately 80,000 ha (200,000 ac) of the Hanford Site and the surrounding area, including parts of the newly designated monument.

S.8 Environmental Consequences

The HSW EIS examines the potential consequences to environmental resources of implementing the alternatives through completion of most waste management operations. For some consequences, such as long-term effects of waste disposal on groundwater and the Columbia River, the evaluation period extends well beyond the end of the site operations. For most resources, little or no impact would occur as a result of implementing any of the alternatives. For some resources, differences in impacts among the

alternatives would exist. These differences are described in the following sections. Table S.3 provides a summary of the potential environmental consequences for selected resource areas under the three alternatives.

S.8.1 Land Use

Long-term commitment of land for waste disposal ranges from 146 ha (361 ac) of land within the 200 Areas under Alternative 1 (lower bound volume), to 178 ha (440 ac) under Alternative 2 (upper bound volume). In all cases, total land use for solid waste operations, including treatment and storage facilities, would represent less than 7 percent of the 200 Area Industrial-Exclusive zone. Land use described in the No Action Alternative includes land that would be needed for expansion of CWC to indefinitely store MLLW and TRU waste that could not be treated or disposed of, but it does not include land that would be needed at Hanford, or at another site, after 2046 to treat and dispose of those wastes. Under the other alternatives, CWC would not be expanded beyond its current footprint, although Alternative 2 would require additional land within the 200 Areas for constructing a new facility to treat MLLW and TRU waste.

S.8.2 Transportation

The principal difference in environmental consequences between the alternatives would be a result of the waste volumes managed under each and the particular activities included. With the exception of MLLW Alternative 1, transportation analysis in the HSW EIS considers only shipment of waste within the Hanford Site. The WM PEIS evaluated the shipment of waste between DOE sites for several alternatives in which the Hanford Site would receive varying quantities of waste from offsite generators. Under MLLW Alternative 1, some MLLW would be shipped from Hanford to an offsite treatment facility and returned to Hanford for disposal. As a bounding case, a treatment facility in Oak Ridge, Tennessee, was assumed for purposes of the transportation analysis. Transportation of waste was determined to result in up to four fatalities.

S.8.3 Human Health

Health impacts were estimated from radionuclides and chemicals that could eventually leach from waste disposed at the Hanford Site and reach groundwater that in time would drain into the Columbia River. Under all of the alternatives, radioactive or hazardous chemical exposures to populations using Columbia River water downstream from the Hanford Site would be well below those from which any health effects would be expected. Airborne emissions from routine operations would likewise not result in additional latent cancer fatalities (LCFs) in the exposed population.

Neither occupational radiation exposure nor occupational injuries would be expected to result in fatalities among workers involved in the waste management operations, although some lost workday accidents would be expected based on Hanford Site labor statistics (Table S.3). The impacts of accidents vary greatly depending on the circumstances of the events analyzed. The highest consequence event involving waste management facilities considered in this EIS was a beyond design basis earthquake at CWC. That accident could result in up to 28 LCFs in the population within a 80 km (50 mi) radius, if the event occurred.

Table S.3. Summary Comparison of Impacts Among the Alternatives

Consequence Category	Alternative 1[a]	Alternative 2[a]	No Action Alternative
Land committed to disposal, ha	146-153	162-178	149
Potential habitat disturbance, ha[b]	76-86	107-133	86
Potential for impacts on Threatened and Endangered species	Negligible	Negligible	Negligible
Potential for impacts on cultural resources	Low	Low	Low
Socioeconomic impacts:			
Total labor, worker-years	15,600-16,300	15,800-16,600	20,600
Potential for impacts on Community	Low	Low	Low
Consumption of non-renewable resources:			
Diesel fuel, m^3	22,000-36,000	27,000-42,000	2400
Gasoline, m^3	170-280	290-410	80
Propane, m^3	16,000-16,000	19,000-22,000	1600
Maximum percentage of air quality limits	18 (SO_2)	18 (SO_2)	25 (PM_{10})
Maximum concentration of a nuclide as percentage of Drinking Water Standards:[c]			
Well 1-km from waste site (yr post-closure)	110 (1200)	110 (1200)	180 (1100)
Near river well	2.1 (1800)	3.5 (1800)	4.6 (1500)
Average in Columbia River water	0.0003	0.0005	0.0007
Health impacts (latent cancer fatalities [LCFs]) on public:			
Via air – routine radiological releases	None	None	None
Via air – routine chemical releases	None	None	None
Via groundwater, LCFs among Tri-Cities population over 10,000 years	None	None	None
Bounding Accident (Earthquake), LCFs in 80-km (50-mi) population	Up to 28 (all alternatives)		
Health impacts on workers:			
Industrial accidents, lost workdays	6100-6300	6200-6400	8000
Routine Operations, LCFs	None	None	None
Radiological accidents, individual probability of LCF if event occurs	1	1	1
Transportation of waste and materials:			
Crew – radiological – incident free, LCFs	1[d]	None	None
Public – radiological – incident free, LCFs	None	None	None
Public – non-radiological accident fatalities	1	None	None
Public – hydrocarbon emissions, LCFs	1 - 2	1	1

(a) Where a range of values is presented, they represent the consequences of managing the lower and upper bound waste volumes, respectively.
(b) Provided that habitat destroyed by the June 2000 range fire in the facility expansion area is re-established before facility expansion would be needed.
(c) Drinking Water Standards (DWSs) are not applicable at these locations, but are used as benchmarks for water quality impacts.
(d) Attributable principally to transport of some MLLW offsite for treatment and return for disposal.

S.8.4 Costs

Projected Costs (through year 2046)
Alternative 1: $3.0 to 3.3 billion
Alternative 2: $3.2 to 3.5 billion
No Action Alternative: $2.8 billion

The cost of implementing the HSW EIS alternatives ranges from $2.8 billion to $3.5 billion. The No Action Alternative corresponds to the lowest cost, but does not provide for final disposal of many waste streams that are ultimately disposed of in the other alternatives. Therefore, the No Action Alternative would entail deferred costs for eventual treatment and disposal of stored wastes that are not reflected in this estimate. Costs for Alternative 1 are marginally higher than for the No Action Alternative, and range from $3.0 to 3.3 billion, depending on the total volume of waste managed. However, this alternative would provide for eventual treatment and disposal of all waste streams evaluated in the HSW EIS. Alternative 2 would also provide for treatment and disposal of all waste streams, but involves a somewhat higher cost ($3.2 to 3.5 billion) because of additional facilities that would be constructed at Hanford.

S.8.5 Cumulative Impacts

Impacts for all resources considered in the HSW EIS are relatively small and would not be expected to contribute substantially to cumulative impacts of other activities at Hanford or in the surrounding region.

S.8.6 Mitigation

DOE has identified measures the agency could take to avoid or reduce environmental impacts that might occur as a result of the Hanford solid waste program. For example, to avoid loss of cultural resources, DOE would conduct cultural resource surveys before constructing solid waste management facilities. If any resources were discovered during construction, construction activities would be stopped until the find could be evaluated and its appropriate management determined. In addition, if mature sagebrush steppe habitat needs to be removed to construct a solid waste management facility, the habitat loss could be compensated by revegetating or protecting other parcels of land as agreed upon by DOE and regulatory agencies.

S.9 Public Involvement

DOE encourages public comments on this draft HSW EIS. Comments may be submitted at a public meeting (the time and place of such meetings will be announced in local media and in the Federal Register in advance) or by mail, fax, or email as noted below. DOE will consider all comments received during the designated comment period for this draft HSW EIS in the preparation of a final HSW EIS. Comments received after the end of the public comment period will be considered to the extent practicable. The final document will include responses to the comments received.

No sooner than 30 days following the issuance of the final HSW EIS, DOE will issue a ROD that announces the substance of the decision, describes the alternatives considered by the agency in reaching its decision, and specifies the alternative(s) that were considered to be environmentally preferable. DOE will also identify and discuss any additional factors that were used in making its decision. Finally, DOE will describe any mitigating actions proposed to avoid or minimize adverse environmental consequences from the alternative selected.

Following the issuance of the ROD, if required, DOE will prepare a Mitigation Action Plan that addresses the mitigation commitments made in its decision. The Mitigation Action Plan would explain how mitigation measures committed to in the decision are designed to mitigate adverse environmental impacts associated with the DOE course of action.

Comments on this draft HSW EIS may be submitted as follows:

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S.10 References

10 CFR 1021. "National Environmental Policy Act Implementing Procedures." *U.S. Code of Federal Regulation*s, as amended.

40 CFR 191. "Environmental Radiation Protection Standards for Management and Disposal of Spent Nuclear Fuel, High-level and Transuranic Radioactive Wastes." *U.S. Code of Federal Regulation*s.

40 CFR 1500-1508. Council on Environmental Quality, "Regulations for Implementing the Procedural Provisions of the National Environmental Policy Act." *U.S. Code of Federal Regulation*s, as amended.

42 USC 2011 *et seq*., Atomic Energy Act (AEA) of 1954.

42 USC 4321 *et seq*., National Environmental Policy Act (NEPA) of 1969, as amended.

42 USC 6901 *et seq*., Resource Conservation and Recovery Act (RCRA) of 1976.

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Acronyms/Abbreviations

ACPC	Accelerating Cleanup: Paths to Closure
ADT	annual average daily traffic
AEA	Atomic Energy Act
AEC	U.S. Atomic Energy Commission
ALARA	as low as reasonably achievable
ALE	Fitzner/Eberhardt Arid Lands Ecology (Reserve)
ANSI	American National Standards Institute
ARAR	applicable or relevant and appropriate requirement
ATG	Allied Technology Group, Inc.
AVS	analysis and visualization system
BCAA	Benton County Air Authority
BDAT	best demonstrated available technology
BHI	Bechtel Hanford, Inc.
BLS	Bureau of Labor Statistics
BNSF	Burlington Northern Santa Fe (railroad)
BPA	(U.S. Department of Energy) Bonneville Power Administration
BRMaP	Hanford Site Biological Resources Management Plan
BWIP	Basalt Waste Isolation Project
CAA	Clean Air Act
CAIRS	Computerized Accident/Incident Reporting System
Cat 1	Category 1 (low-level waste)
Cat 3	Category 3 (low-level waste)
CBC	Columbia Basin College
CEQ	Council on Environmental Quality
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFEST	Coupled Fluid, Energy, and Solute Transport
CFR	Code of Federal Regulations
CH	contact-handled
CNSS	Council of the National Seismic System
CO	carbon monoxide
CRCIA	Columbia River Comprehensive Impact Assessment
CWC	Central Waste Complex
D&D	decontamination and decommissioning
dB	decibel(s)
dBA	A-weighted decibel(s)
DCG	derived concentration guide
DEIS	Draft Environmental Impact Statement
D_l	longitudinal dispersivity

DOE	U.S. Department of Energy
DOE-RL	U.S. Department of Energy, Richland Operations Office
DOL	U.S. Department of Labor
DOT	U.S. Department of Transportation
D_t	transverse dispersivity
DWS	drinking water standard
EA	environmental assessment
ECAMP	Ecological Compliance Assessment Management Plan
ECEM	Ecological Contaminant Exposure Model
Ecology	Washington State Department of Ecology
EDE	effective dose equivalent
EDNA	environmental designation for noise abatement
EHQ	Environmental Hazard Quotient
EIS	environmental impact statement
EM	U.S. Department of Energy Office of Environmental Management
EMI	environmental management integration
EMSL	Environmental and Molecular Sciences Laboratory
ENCO	enterprise companies
EOC	Emergency Operations Center
EPA	U.S. Environmental Protection Agency
E/Q	dispersion facort(s)
ERDA	U.S. Energy Research and Development Administration
ER	environmental restoration
ERDF	Environmental Restoration Disposal Facility
ERPG	Emergency Response Planning Guideline
ERTC	Effluent Retention and Treatment Complex
ETF	200 Area Effluent Treatment Facility
FFTF	Fast Flux Test Facility
FH	Fluor Hanford, Inc.
FONSI	finding of no significant impact
FR	Federal Register
FRAMES	Framework for Risk Analysis in Multimedia Environmental Systems
FTE	full-time equivalent (or full-time employee)
FWS	U.S. Fish and Wildlife Service
FY	fiscal year
GIS	geographic information system
GOCO	government-owned contractor-operated
GTC3	greater than Category 3 (low-level waste)
HAMMER	Hazardous Materials Management and Emergency Response Facility (Volpentest Training and Education Center)

HCP EIS	Hanford Comprehensive Land-Use Plan Environmental Impact Statement
HCRC	Hanford Cultural Resources Case
HCRL	Hanford Cultural Resources Laboratory
HDW EIS	Disposal of Hanford Defense High-Level, Transuranic, and Tank Wastes Environmental Impact Statement
HEHF	Hanford Environmental Health Foundation
HEPA	high-efficiency particulate air
HIC	high-integrity container
HLW	high-level (radioactive) waste
HMS	Hanford Meteorological Station
HSRAM	Hanford Site Risk Assessment Methodology
HSSWAC	Hanford Site solid waste acceptance criteria
HSW EIS	Hanford Site Solid (Radioactive and Hazardous) Waste Program Environmental Impact Statement
HW	hazardous waste
HWMA	Washington State Hazardous Waste Management Act
HWMP	Hanford Waste Management Program
HWVP	Hanford Waste Vitrification Project
Hz	hertz
I&I	irreversible and irretrievable
ICRP	International Commission on Radiological Protection
IDLH	Immediately Dangerous to Life and Health
ILAW	immobilized low-activity waste
IPABS	Integrated Planning, Accountability and Budgeting System
ISCST3	Industrial Source Complex Short-Term Model, version 3
K_d	distribution coefficient
LCF	latent cancer fatality
LDR	Land Disposal Restriction
LERF	Liquid Effluent Retention Facility
LIGO	Laser Interferometer Gravitational Wave Observatory
LLBG	Low Level Burial Ground
LLW	low-level (radioactive) waste
LLWMA	low-level waste management area
LOEC	lowest observed effects concentration
LOEL	lowest observed effects level
LOS	level of service
LWC	lost workday case
LWD	lost workday
M&O	management and operations
MCL	maximum contaminant level

MEI	maximally exposed individual
MEPAS	Multimedia Environmental Pollutant Assessment System
MLLW	mixed low-level waste
MMEDE	Multimedia-Modeling Environmental Database Editor
MMI	Modified Mercalli Intensity
MTU	metric tons of uranium
NAAQS	National Ambient Air Quality Standards
National Register	National Register of Historic Places
NDA	non-destructive assay
NDE	non-destructive examination
ND	not detected
NE	no emissions
NEPA	National Environmental Policy Act
NESHAPs	National Emission Standards for Hazardous Air Pollutants
NHP	State of Washington Natural Heritage Program
NIOSH	National Institute for Occupational Safety and Health
NM	not measured
NMFS	National Marine Fisheries Service
NO_2	nitrogen dioxide
NOC	notice of construction
NOI	notice of intent
NO_x	nitrogen oxides
NPS	National Park Service
NRC	U.S. Nuclear Regulatory Commission
NS	no standard
NTS	Nevada Test Site
OCF	offsite commercial facility
OFM	Office of Financial Management
ORP	U.S. Department of Energy Office of River Protection
ORR	U.S. Department of Energy Oak Ridge Reservation
OSHA	U.S. Occupational Safety and Health Administration
PCB	polychlorinated biphenyl
PEIS	programmatic environmental impact statement
PEL	permissible exposure level
PFP	Plutonium Finishing Plant
PHMC	Project Hanford Management Contract
PM	particulate matter
PM_{10}	particulate matter with aerodynamic diameters 10 μm or smaller
PNNL	Pacific Northwest National Laboratory
ppm	parts per million
PSD	prevention of significant deterioration

Pu	plutonium
PUREX	Plutonium-Uranium Extraction Facility
R	roentgen
R&D	research and development
RCRA	Resource Conservation and Recovery Act
RCT	radiation control technologist
RCW	Revised Code of Washington
REIS	Regional Economic Information System
R_f	contaminant retardation factors
RfD	reference dose
RH	remote-handled
RIMS	Regional Input-Output Modeling System
ROD	record of decision
RPP	River Protection Project
SA	safety analysis
SAC	System Assessment Capability
SALDS	State-approved land disposal structure
SC	species of concern
SCAPA	Subcommittee on Consequence Assessment and Protective Actions
SEIS	supplemental environmental impact statement
SEPA	State Environmental Policy Act
SI	international system of units (metric system)
SIP	state implementation plan
SLD	shallow land disposal
SO_2	sulfur dioxide
SO_x	sulfur oxides
SR	State Route
SRS	U.S. Department of Energy Savannah River Site
STOMP	Subsurface Transport Over Multiple Phases
STP	site treatment plan
SWB	standard waste box
SWIFT	Site Wide Integrated Forecast Technical (report)
SWITS	Solid Waste Information and Tracking System
SWOC	Solid Waste Operations Complex
T&E	threatened and endangered
TCP	traditional cultural property
TD	temperature difference
TEDF	200 Area Treated Effluent Disposal Facility
TEEL	Temporary Emergency Exposure Limit
TI	Transportation Index
TLV	threshold limit value

TNC	The Nature Conservancy of Washington
TPA	Tri-Party Agreement (Hanford Federal Facility Agreement and Consent Order)
TRC	total recordable cases
TRIGA	Test Reactor and Isotope Production General Atomics
TRU	transuranic
TRUPACT-II	Transuranic Package Transporter-II
TRUSAF	Transuranic Storage and Assay Facility
TSCA	Toxic Substances Control Act
TSD	treatment, storage, and/or disposal
TSP	total suspended particulate
TWRS	Tank Waste Remediation System
UO_3	uranium trioxide
USC	United States Code
USGS	U.S. Geological Survey
UWGP	University of Washington Geophysics Program
VOC	volatile organic compounds
WAC	Washington Administrative Code
WDFW	Washington State Department of Fish and Wildlife
WDOH	Washington State Department of Health
WHC	Westinghouse Hanford Company
WIPP	Waste Isolation Pilot Plant
WM	waste management
WM PEIS	Waste Management Programmatic Environmental Impact Statement
WRAP	Waste Receiving and Processing Facility
WSU-TC	Washington State University – Tri-Cities Branch Campus

General Glossary of Terms

caisson At Hanford, an underground structure in which certain higher-activity radioactive wastes are placed.

candidate species Plants and animals with a status of concern, but about which more information is needed before they can be proposed for listing as **threatened species** or **endangered species**. A state **candidate species** is one that is being reviewed for possible listing as a state **endangered**, **threatened**, or sensitive species as specified by the Washington State Department of Fish and Wildlife. See also **endangered species**, **threatened species**, and **species of concern**.

capping As applied to radioactive and mixed-waste disposal facilities, the process of covering a burial ground with soil, rock, vegetation, or other materials as part of the facility closure process. The cap is designed to reduce migration of radioactive and hazardous materials in the waste by infiltration of water or by intrusion of humans, plants, or animals from the surface.

carcinogen Any substance that can cause or aggravate cancer.

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

Category 1 low-level waste Low-level radioactive waste containing radionuclide concentrations below the maximum limits defined for this waste type. These limits are site-specific, and they define the lowest activity category of low-level radioactive waste. Category 1 wastes typically do not require special packaging or treatment for disposal by shallow land burial.

Category 3 low-level waste Low-level radioactive waste containing radionuclide concentrations greater than those defined for **Category 1 waste**, but below the maximum limits defined for Category 3 waste. These limits are site-specific, and are established using the performance assessment for a particular disposal facility. Category 3 wastes typically require special packaging or treatment for disposal by shallow land burial.

characterization See **waste characterization**.

closure As applied to radioactive and hazardous waste disposal facilities, the process of site stabilization and placement of caps or other barriers to provide long-term confinement of the waste. Specific requirements for closure are defined by regulations for various types of waste management facilities.

contact-handled (CH) waste Packaged waste whose external surface dose rate does not exceed 200 mrem/hr and does not create a high radiation area (>100 mrem/hr at 30 cm), except that packages larger than 208 L (55 gal) could have a dose rate on normally nonaccessible surfaces that exceeds 200 mrem/hr as long as all accessible surfaces do not exceed 200 mrem/hr when in storage. See also **remote-handled waste.**

criteria pollutants Six pollutants (carbon monoxide, suspended particulates of specified sizes, sulfur dioxide, lead, nitrogen oxide, and ozone) known to be hazardous to human health or structures and for which the U.S. Environmental Protection Agency (EPA) sets National Ambient Air Quality Standards under the Clean Air Act (40 CFR 50).

cumulative impacts (effects) Impacts on the environment that result when the incremental impact of a proposed action is added to the impacts from other past, present, and reasonably foreseeable future actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time.

dangerous waste Solid waste designated in WAC 173-303-070 through 100 as dangerous or extremely hazardous waste, or mixed waste.

decommissioning Removal of a facility, or facilities, from service. May include actions taken to reduce the potential health and safety impacts of U.S. Department of Energy (DOE)-contaminated facilities, including activities to stabilize, reduce, or remove radioactive and hazardous materials, or to demolish the facilities.

decontamination The removal of radionuclides and hazardous materials from contaminated facilities, equipment, or soils by washing, heating, chemical or electrochemical action, mechanical cleaning, or other techniques.

disposal Discharge, deposit, injection, dumping, spilling, leaking, or placing of any solid waste or hazardous waste into or on any land or water so that such solid waste or hazardous waste or any constituent thereof may enter the environment or be emitted into the air or discharged into any waters, including groundwaters. Emplacement of waste in a manner that ensures protection of human health and the environment within prescribed limits for the foreseeable future with no intent of retrieval, and which requires deliberate action to regain access to the waste.

effluent Airborne and liquid wastes discharged from a DOE site or facility. This term does not include solid wastes, wastes for shipment offsite, wastes that are contained (for example, underground nuclear test debris) or stored (for example, in tanks) or wastes that are to remain onsite through treatment or disposal.

endangered species Plants or animals that are in danger of extinction throughout all or a significant portion of their ranges and have been listed as endangered by the U.S. Fish and Wildlife Service or the National Marine Fisheries Service, following the procedures set out in the Endangered Species Act and its implementing regulations (50 CFR 424). Washington State defines endangered species as any wildlife species native to the state of Washington that is seriously threatened with extinction throughout all or a significant portion of its range within the state (WAC 232-12-297). See also **candidate species** and **threatened species.**

generator Within the context of this document, generators refer to organizations within DOE or managed by DOE whose act or process produces low-level waste, mixed low-level waste, or transuranic waste.

graded approach A process by which the level of analysis, documentation, and actions necessary to comply with a requirement are commensurate with 1) the relative importance to safety, safeguards, and security; 2) the magnitude of any hazard involved; 3) the life cycle stage of a facility; 4) the programmatic mission of a facility; 5) the particular characteristics of a facility; and 6) any other relevant factor.

greater than Category 3 (GTC3) low-level waste Low-level radioactive waste that exceeds the maximum radionuclide concentrations as defined for Category 3 low-level waste. See also **Category 3 waste**.

Hanford Federal Facility Agreement And Consent Order See **Tri-Party Agreement**.

hazardous waste Waste that contains chemically hazardous constituents regulated under Subtitle C of the Resource Conservation and Recovery Act (RCRA), as amended (40 CFR 261) and regulated as a hazardous waste and/or mixed waste by the EPA. May also include solid waste designated by Washington State in WAC 173-303-070 through 100 as dangerous or extremely hazardous waste, or mixed waste. See also **mixed low-level waste**.

high-integrity container (HIC) A container that provides additional confinement for high-activity **low-level waste**, typically constructed of concrete or other durable material.

high-level (radioactive) waste (HLW) Defined by statute (the Nuclear Waste Policy Act) to mean the highly radioactive waste material resulting from the reprocessing of spent nuclear fuel, including liquid waste produced directly in reprocessing and any solid material derived from such liquid waste that contains fission products nuclides in sufficient concentrations; and other highly radioactive material that the U.S. Nuclear Regulatory Commission (NRC), consistent with existing law, determines by rule requires permanent isolation. The NRC has not defined sufficient concentrations of fission products or identified other highly radioactive material that requires permanent isolation. The NRC defines HLW to mean irradiated (spent) reactor fuel, as well as liquid waste resulting from the operation of the first-cycle solvent-extraction system, the concentrated wastes from subsequent extraction cycles in a facility for reprocessing irradiated reactor fuel, and solids to which such liquid wastes have been converted.

latent cancer fatality (LCF) A cancer death postulated to result from, and occurring some time after, exposure to ionizing radiation or other carcinogens.

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

low-level (radioactive) waste (LLW) Radioactive waste, including accelerator-produced waste, that is not **high-level waste**, spent nuclear fuel, **transuranic waste**, byproduct material (as defined in section 11e[2] of the Atomic Energy Act of 1954, as amended), or naturally occurring radioactive material.

macroencapsulation Treatment method applicable to debris wastes as defined by RCRA. Refers to application of surface coating materials, such as polymeric organics (e.g., resins and plastics) or of a jacket of inert material to reduce surface exposure to potential leaching media.

maximally exposed individual (MEI) The maximally exposed individual is a hypothetical person who has a lifestyle, and is in a location, such that that any other individual would be unlikely to receive a higher exposure to radiation or hazardous materials. The MEI may be a member of the public who resides or works near the Hanford Site, or who is temporarily at a publicly accessible location where the maximum dose from a short-term event would occur.

mixed low-level waste (MLLW) Consists of **low-level radioactive waste** that also contains a hazardous chemical component. See also **hazardous waste, dangerous waste**.

process In the context of this document, refers to any activity necessary to prepare waste for disposal. Processing waste may consist of repackaging, removal, or stabilization of non-conforming waste, or treatment of physically or chemically hazardous constituents in compliance with state or federal regulations.

radioactive waste In general, waste that is managed for its radioactive content. Waste material that contains source, special nuclear, or by-product material is subject to regulation as radioactive waste under the Atomic Energy Act. Also, waste material that contains accelerator-produced radioactive material or a high concentration of naturally occurring radioactive material may be considered radioactive waste.

release Any spilling, leaking, pumping, pouring, emitting, emptying, discharging, injecting, escaping, leaching, dumping, or otherwise disposing of substances into the environment. This includes abandoning/discarding any type of receptacle containing substances in an unenclosed containment structure, but does not include state or federally permitted emissions.

remedial action Activities conducted to reduce potential risks to people and/or harm to the environment from radioactive and/or hazardous substance contamination.

remote-handled (RH) waste Packaged radioactive waste for which the external dose rate exceeds that defined for **contact-handled waste** (generally 200 mrem/hr at the container surface). These wastes require handling using remotely controlled equipment, or placement in shielded containers, to reduce the potential for human exposures during routine waste management activities. See also **contact-handled waste**.

retrievably stored waste Waste stored in a configuration that is intended to permit retrieval at a future time.

site A geographic entity comprising leased or owned land, buildings, and other structures required to perform program activities.

species of concern Plants identified by the Washington Natural Heritage Program as sensitive (vulnerable or declining and could become endangered or threatened), Review 1 (more field work needed), and Review 2 (unresolved taxonomic problems). See also **endangered species** and **threatened species**.

storage The holding of waste for a temporary period, at the end of which the waste is treated, disposed, or stored elsewhere.

threatened species Any plants or animals that are likely to become **endangered species** within the foreseeable future throughout all or a significant portion of their ranges, and which have been listed as threatened by the U.S. Fish and Wildlife Service or the National Marine Fisheries Service following the procedures set out in the Endangered Species Act and its implementing regulations (50 CFR 424). Washington State defines threatened species as any wildlife species native to the state of Washington that is likely to become an endangered species within the foreseeable future throughout a significant portion of its range within the state (WAC 232-12-297). See also **candidate species** and **endangered species**.

Toxic Substances Control Act (TSCA) waste Any waste, including polychlorinated byphenyl commingled waste, regulated under the TSCA requirements codified in 40 CFR 761.

toxicological impact Impact on human health, due to exposure to, or intake of, chemical materials. These impacts are typically described in terms of damage to affected organs.

transuranic isotope Any element having an atomic number greater than 92 (the atomic number of uranium).

transuranic (TRU) waste Radioactive waste that is not classified as **high-level waste**, and which contains more than 100 nCi (3700 Bq) per gram of alpha-emitting **transuranic isotopes** with half-lives greater than 20 years.

Tri-Party Agreement (TPA) Informal title for the "Hanford Federal Facility Agreement and Consent Order," an agreement among the U.S. Department of Energy, the U.S. Environmental Protection Agency, and the Washington State Department of Ecology. The agreement establishes milestones to bring operating DOE facilities into compliance with the RCRA, and to coordinate cleanup of Hanford's inactive disposal sites under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA).

treatment The physical, chemical, or biological processing of dangerous waste to make such waste nondangerous or less dangerous, safer for transport, amenable for energy or material resource recovery, amenable for storage, or reduced in volume, with the exception of compacting, repackaging, and sorting as allowed under WAC 173-303-400(2) and 173-303-600(3).

vadose zone The soil layer between the ground surface and the top of the saturated zone.

waste characterization The identification of waste composition and properties, whether by review of process knowledge, or by nondestructive examination, nondestructive assay, or sampling and analysis, to determine appropriate storage, treatment, handling, transportation, and disposal requirements.

waste certification A process by which a waste generator certifies that a given waste or waste stream meets the waste acceptance criteria of the facility to which the generator intends to transfer waste for treatment, storage, or disposal.

waste container Any portable device in which a material is stored, transported, treated, disposed, or otherwise handled (WAC 173-303-040). A waste container may include any liner or shielding material that is intended to accompany the waste in disposal. At Hanford, waste containers typically consist of 55-gal (208-L) or 85-gal (320-L) drums, standard waste boxes for TRU waste. Other sizes and styles of containers may also be employed depending on the physical, radiological, and chemical characteristics of the waste.

waste disposal See **disposal**.

waste life cycle The life of a waste from generation through storage, treatment, transportation, and disposal. For waste that will be generated from a new project or activity, the life of the waste begins in the planning stage of the project or activity.

waste stream A waste or group of wastes from a process or a facility with similar physical, chemical, or radiological properties. In the context of this document, a waste stream is defined as a collection of wastes with physical and chemical characteristics that will generally require the same management approach (i.e., use of the same storage, treatment, and disposal capabilities).

waste type In the context of this document, three waste types managed by the solid waste program are defined: **low-level waste**, **mixed low-level waste**, and **transuranic waste.**

Watch List species One category of plant **species of concern** as identified by the Washington Natural Heritage Program. **Watch List species** consist of those that are more abundant and/or less threatened than previously assumed.

Glossary of Terms Related to Radioactivity, Radiation Dose, and Exposure

absorbed dose The energy absorbed by matter from ionizing radiation per unit mass of irradiated material at the place of interest in that material. The absorbed dose is expressed in units of rad (or gray) (1 rad = 0.01 gray).

becquerel (Bq) A unit of radioactivity equal to 1 disintegration per second. See also **curie**.

collective dose The sum of the **total effective dose equivalent** values for all individuals in a specified population. Collective dose is expressed in units of person-**rem** (or person-**sievert**).

committed dose equivalent The **dose equivalent** calculated to be received by a tissue or organ over a 50-year period after the intake of a radionuclide into the body. It does not include contributions from radiation sources external to the body. Committed dose equivalent is expressed in units of **rem** (or **sievert**).

committed effective dose equivalent The sum of the **committed dose equivalents** to various tissues in the body, each multiplied by the appropriate **weighting factor**. Committed effective dose equivalent is expressed in units of **rem** (or **sievert**).

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

dose equivalent The product of absorbed dose in rad (or gray) in tissue, a quality factor, and other modifying factors. Dose equivalent is expressed in units of **rem** (or **sievert**).

effective dose equivalent The summation of the products of the **dose equivalent** received by specified tissues of the body and the appropriate **weighting factor**. It includes the dose from radiation sources internal and external to the body. The effective dose equivalent is expressed in units of **rem** (or **sievert**).

external dose or exposure That portion of the **dose equivalent** received from radiation sources (i.e., "external sources") outside the body.

half-life (radiological) The time in which one-half of the atoms of a specific radionuclide decay into another nuclear form. Half-lives for different radionuclides range from fractions of a second to billions of years.

gray The SI (International System of Units) unit of absorbed dose. One gray (Gy) is equal to an absorbed dose of 1 joule/kg (1 Gy = 100 rads). (The joule in the SI unit of energy, abbreviated at J.) (See also **rad**.)

internal dose or exposure That portion of the **dose equivalent** received from radioactive material taken into the body (i.e., "internal sources").

quality factor The principal modifying factor used to calculate the **dose equivalent** from the **absorbed dose**; the **absorbed dose** (expressed in rad or gray) is multiplied by the appropriate quality factor. The quality factors to be used for determining **dose equivalent** in **rem** are shown in the following table:

Quality Factors[(a)]

Radiation type	Quality factor
X-rays, gamma rays, positrons, electrons (including tritium beta particles)	1
Neutrons, $\leq$ 10 keV	3
Neutrons, > 10 keV	10
Protons and singly-charged particles of unknown energy with rest mass greater than one atomic mass unit	10
Alpha particles and multiple-charged particles (and particles of unknown charge) of unknown energy	20

When spectral data are insufficient to identify the energy of the neutrons, a quality factor of 10 shall be used.

(ii) When spectral data are sufficient to identify the energy of the neutrons, the following mean quality factor values may be used:

Quality Factors for Neutrons

[Mean quality factors, Q (maximum value in a 30-cm dosimetry phantom), and values of neutron flux density that deliver in 40 hours, a maximum dose equivalent of 100 mrem (0.001 sievert).]

Neutron energy (MeV)	Mean quality factor	Neutron flux density (cm^2s^{-1})
2.5×10^{-8} thermal	2	680
1×10^{-7}	2	680
1×10^{-6}	2	560
1×10^{-5}	2	560
1×10^{-4}	2	580
1×10^{-3}	2	680
1×10^{-2}	2.5	700
1×10^{-1}	7.5	115
5×10^{-1}	11	27
1	11	19
2.5	9	20
5	8	16
7	7	17
10	6.5	17
14	7.5	12
20	8	11
40	7	10
60	5.5	11
1×10^{2}	4	14
2×10^{2}	3.5	13
3×10^{2}	3.5	11
4×10^{2}	3.5	10

(a) 10 CFR 835.

rad A unit of radiation absorbed dose (e.g., in body tissue). One rad is equal to an absorbed dose of 0.01 joule/kg (1 rad = 0.01 gray). (See also **gray**.)

rem The special unit of radiation **effective dose equivalent** (1 rem = 0.01 Sievert). See also **sievert**.

roentgen (R) The special unit of X- or gamma- radiation exposure. One roentgen equals 2.58 x 10^{-4} coulombs per kilogram of air.

sievert (Sv) The SI (International System of Units) unit of radiation effective dose equivalent (1 Sv = 100 rem). See also **rem**.

total effective dose equivalent (TEDE) The sum of the **effective dose equivalent** (for external exposures) and the **committed effective dose equivalent** (for internal exposures). Total effective dose equivalent is expressed in units of **rem** (or **sievert**).

weighting factor The fraction of the overall health risk, resulting from uniform, whole body irradiation, attributable to a specific tissue. The **dose equivalent** to each tissue is multiplied by the appropriate weighting factor to obtain the **effective dose equivalent** contribution from that tissue. The weighting factors are as follows:

Weighting Factors For Various Tissues[a]

Organs or tissues	Weighting factor
Gonads	0.25
Breasts	0.15
Red bone marrow	0.12
Lungs	0.12
Thyroid	0.03
Bone surfaces	0.03
Remainder[1]	0.30
Whole body[2]	1.00

(a) 10 CFR 835.

1 "Remainder" means the five other organs or tissues with the highest dose (e.g., liver, kidney, spleen, thymus, adrenal, pancreas, stomach, small intestine, and upper large intestine). The weighting factor for each remaining organ or tissue is 0.06.

2 For the case of uniform external irradiation of the whole body, a weighting factor equal to 1 may be used in determination of the effective dose equivalent.

Units of Measure

The principal units of measurement used in this Environmental Impact Statement (EIS) are SI units, an abbreviation for the International System of units, a metric system accepted by the International Organization of Standardization as the legal standard at a meeting in Elsinore, Denmark, in 1966. In this system, most units are made up of combinations of six basic units, of which length in meters, mass in kilograms, and time in seconds are of most importance in the EIS.

Numerical (Scientific or Exponential) Notation

Numbers that are very small or very large are often expressed in scientific or exponential notation as a matter of convenience. For example, the number 0.000034 may be expressed as 3.4×10^{-5} or 3.4E-05 and 65,000 may be expressed as 6.5×10^{4} or 6.5E+04. In the EIS, numerical values less than 0.001 or greater than 9999 are generally expressed in exponential notation.

Multiples or sub-multiples of the basic units are also used. A partial list of prefixes that denote multiples and sub-multiples follows, with the equivalent multiplier values expressed in scientific and exponential notation:

Name	Symbol	Value Multiplied by:		
atto	a	0.000000000000000001	or 1×10^{-18}	or 1E-18
femto	f	0.000000000000001	or 1×10^{-15}	or 1E-15
pico	p	0.000000000001	or 1×10^{-12}	or 1E-12
nano	n	0.000000001	or 1×10^{-9}	or 1E-09
micro	µ	0.000001	or 1×10^{-6}	or 1E-06
milli	m	0.001	or 1×10^{-3}	or 1E-03
centi	c	0.01	or 1×10^{-2}	or 1E-02
kilo	k	1,000	or 1×10^{3}	or 1E+03
mega	M	1,000,000	or 1×10^{6}	or 1E+06
giga	G	1,000,000,000	or 1×10^{9}	or 1E+09
tera	T	1,000,000,000,000	or 1×10^{12}	or 1E+12

The following symbols are occasionally used in conjunction with numerical expressions:

< less than

≤ less than or equal to

> greater than

≥ greater than or equal to

Basic Units and Conversion Table

Unit of Measure	English Unit	Symbol	Metric Unit	Symbol
Length	inches	in	centimeters	cm
	feet	ft	meters	m
	yards	yd	kilometers	km
	miles	mi		
Area	square feet	ft^2	square meters	m^2
	acres	ac	hectares	ha
	square miles	mi^2	square kilometers	km^2
Volume (dry)	cubic feet	ft^3	cubic meters	m^3
	cubic yards	yd^3		
Volume (liquid)	gallons	gal	liters	L
Mass	ounces	oz	grams	g
	pounds	lb	kilograms	kg
Concentration	parts per million	ppm	grams per liter	g/L
Radioactivity	curies	Ci	becquerels	Bq
Radiation Absorbed Dose	rad	rad	Gray	Gy
Radiation Effective Dose Equivalent	rem	rem	Sievert	Sv
Temperature	degrees Fahrenheit	°F	degrees Centigrade	°C

Base Unit	Multiply By	To Obtain	Base Unit	Multiply By	To Obtain
in	2.54	cm	cm	0.394	in
ft	0.305	m	m	3.28	ft
yd	0.914	m	m	1.09	yd
mi	1.61	km	km	0.621	mi
ft^2	0.093	m^2	m^2	10.76	ft^2
ac	0.405	ha	ha	2.47	ac
mi^2	2.59	km^2	km^2	0.386	mi^2
ft^3	0.028	m^3	m^3	35.3	ft^3
yd^3	0.765	m^3	m^3	1.31	yd^3
gal	3.77	L	L	0.265	gal
oz	28.349	g	g	0.035	oz
lb	0.454	kg	kg	2.205	lb
ppm	0.001	g/L	g/L	1000	ppm
Ci	3.7×10^{10}	Bq	Bq	2.7×10^{-11}	Ci
rad	0.01	Gy	Gy	100	rad
rem	0.01	Sv	Sv	100	rem
°F	(°F - 32) x 5/9	°C	°C	(°C x 9/5) + 32	°F

Radionuclide Nomenclature[a,b]

Symbol	Radionuclide	Half-Life	Symbol	Radionuclide	Half-Life
Ac-227*	actinium-227	22 y	Pu-240	plutonium-240	6563
Ag-110m	silver-110m	250 d	Pu-241	plutonium-241	14 yr
Am-241	americium-241	432 yr	Pu-242	plutonium-242	3.7×10^5 yr
Ba-137m	barium-137m	2.6 min	Pu-244	plutonium-244	8.1×10^7 yr
Be-7*	beryllium-7	53 d	Ra-224*	radium-224	3.7 d
Bi-212*	bismuth-212	61 min	Ra-226*	radium-226	1600 yr
Bi-214*	bismuth-214	20 min	Ra-228*	radium-228	5.8 yr
C-14*	carbon-14	5730 yr	Rb-87*	rubidium-87	4.8×10^{10} yr
Cd-113m*	cadmium-113m	15 y	Rh-106	rhodium-106	30 sec
Ce-144	cerium-144	285 d	Ru-106	ruthenium-106	374 d
Cl-36	chlorine-36	3.0×10^5 yr	Sb-125	antimony-125	2.8 yr
Cm-244	curium-244	18 yr	Sb-126m	antimony-126m	11 sec
Co-60	cobalt-60	5.3 yr	Se-75	selenium-75	120 d
Cs-137	cesium-137	30 yr	Se-79	selenium-79	6.5×10^5 yr
Eu-152	europium-152	14 yr	Sm-147*	samarium-147	1.1×10^{11} yr
Eu-154	europium-154	8.6 yr	Sm-151	samarium-151	90 yr
Eu-155	europium-155	4.8 yr	Sn-126	tin-126	1.0×10^5 yr
Fe-55	iron-55	2.7 yr	Sr-90	strontium-90	29 yr
H-3*	tritium	12 yr	Tc-99	technetium-99	2.1×10^5 yr
I -125	iodine-125	59 d	Th-228*	thorium-228	1.9 yr
I -129	iodine-129	1.6×10^7 yr	Th-229	thorium-229	7880 yr
K-40*	potassium-40	1.3×10^9 yr	Th-230*	thorium-230	7.5×10^4 yr
Mn-54	manganese-54	312 d	Th-232*	thorium-232	1.4×10^{10} yr
Mo-93	molybdenum-93	4000 yr	Th-234*	thorium-234	24 d
Nb-94	niobium-94	2.0×10^4 yr	U-232	uranium-232	69 yr
Ni-59	nickel-59	7.6×10^4 yr	U-233	uranium-233	1.6×10^5 yr
Ni-63	nickel-63	100 yr	U-234*	uranium-234	2.5×10^5 yr
Np-237	neptunium-237	2.1×10^6 yr	U-235*	uranium-235	7.0×10^8 yr
Pa-231*	protactinium-231	3.3×10^4 yr	U-236	uranium-236	2.3×10^7 yr
Pb-210*	lead-210	22 yr	U-238*	uranium-238	4.5×10^9 yr
Pb-212*	lead-212	11 hr	W-185	tungsten-185	75 d
Pd-107	palladium-107	6.5×10^6 yr	Y-90	yttrium-90	2.7 d
Pr-144	praseodymium-144	17 m	Zn-65	zinc-65	244 d
Pu-238	plutonium-238	88 yr	Zr-93	zirconium-93	1.5×10^6 yr
Pu-239	plutonium-239	2.4×10^4 yr	Zr-95	zirconium-95	64 d

(a) From *CRC Handbook of Chemistry and Physics*. 74th edition. ed. David R. Lide, CRC Press, Boca Raton, Florida 1993.

(b) Listing includes radionuclides evaluated in this document. Metastable isomers are indicated by the addition of an *m*. Short-lived decay products are not shown.

* Indicates radionuclides that occur in nature.

1.0 Introduction

This draft Hanford Site Solid (Radioactive and Hazardous) Waste Program Environmental Impact Statement (HSW EIS) provides environmental and technical information concerning the U.S. Department of Energy (DOE) proposal to enhance waste management practices at the Hanford Site in Washington State. The HSW EIS tiers from the Waste Management Programmatic EIS (WM PEIS, DOE 1997a) and addresses local decisions needed to implement the WM PEIS records of decision (RODs). It also updates previous environmental analyses prepared for waste management operations at the Hanford Site.

DOE and its predecessors, the Manhattan Project, the U.S. Atomic Energy Commission (AEC), and the U.S. Energy Research and Development Administration (ERDA), have operated the Hanford Site since the 1940s. From the beginning through the 1980s, the primary mission at Hanford was to produce nuclear materials for national defense programs. Defense materials production at Hanford has now ceased, and the Site's current activities include research, environmental restoration, and waste management.

This draft HSW EIS describes the environmental consequences of alternatives for constructing, modifying, and operating facilities to manage low-level (radioactive) waste (LLW), mixed low-level waste (MLLW), and post-1970 transuranic (TRU) waste at Hanford. In addition, the potential long-term consequences of waste disposal on groundwater and surface water are evaluated for a 10,000-year period (although DOE performance standards apply through the first 1000 years after disposal). The HSW EIS is being prepared in accordance with the National Environmental Policy Act (NEPA) of 1969, as amended (42 USC 4321 *et seq*.), the DOE implementing procedures for NEPA (10 CFR 1021), and the Council on Environmental Quality (CEQ) Regulations for Implementing the Procedural Provisions of NEPA (40 CFR 1500-1508).

1.1 Organization of the HSW EIS

The organization and content of this draft HSW EIS are described briefly as follows:

- **Section 1.0 – Introduction**: Provides an introduction, purpose and need for DOE action, a brief summary of Hanford Site radioactive and hazardous waste management operations, related documents, and the DOE process for making decisions via NEPA.

- **Section 2.0 – Background Information on Waste Streams and Waste Management Facilities**: Provides a description of Hanford solid waste program operations, waste types, waste streams, existing facilities, and proposed facilities.

- **Section 3.0 – Description and Comparison of Alternatives**: Describes alternative actions that could be taken to manage solid radioactive and hazardous waste at Hanford, including alternative management strategies for each waste type and the No Action Alternative. This section also provides a comparison of environmental impacts among the alternatives.

- **Section 4.0 – Affected Environment**: Discusses the human and physical environment that might be affected by radioactive and hazardous waste management operations at Hanford.

- **Section 5.0 – Environmental Consequences**: Identifies the potential impacts on the human and physical environment that might result from implementation of the alternatives for waste management at Hanford. This section also addresses environmental justice, cumulative impacts, irreversible and irretrievable commitment of resources, the relationship between short-term uses of the environment and the maintenance or enhancement of long-term productivity, and potential mitigation measures.

- **Section 6.0 – Regulatory Framework**: Identifies environmental regulations and permits that apply to waste management operations at Hanford.

- **Section 7.0 – List of Preparers and Contributors**: Identifies key persons who contributed to the preparation of the HSW EIS.

- **Index –** Provides an alphabetized list of key names, terms, and subjects in this EIS and the sections in which each item is mentioned.

- **Appendixes –** Provide additional information regarding specific sections of the EIS.

1.2 Overview of Hanford Site Operations and Waste Management Activities

The Hanford Site occupies approximately 1517 km^2 (586 mi^2), principally in Benton and Franklin counties of south central Washington State (Figure 1.1). The Columbia River flows through the northern and eastern parts of the Site, which extends about 46 km (25 mi) north from Richland, Washington.

Hanford Site missions have included producing and processing nuclear materials in support of United States defense, research, and biomedical programs. Operations associated with those programs utilized facilities for fabrication of nuclear reactor fuel, reactors for nuclear materials production, chemical separation plants, nuclear material processing facilities, research laboratories, and waste management facilities. Additional historical information regarding the Hanford Site is available on the Internet http://www.hanford.gov/.

Hanford Site activities generated a variety of wastes containing radionuclides and non-radioactive hazardous constituents. Such materials range from highly radioactive wastes that must be managed in specialized facilities to less radioactive waste that can be managed by more conventional means, such as shallow land disposal. When DOE established the Office of Environmental Management (EM) in 1989, it defined cleanup of DOE sites as a top priority and committed itself to addressing the challenges of waste management. EM is responsible for waste management activities at all DOE sites, including Hanford.

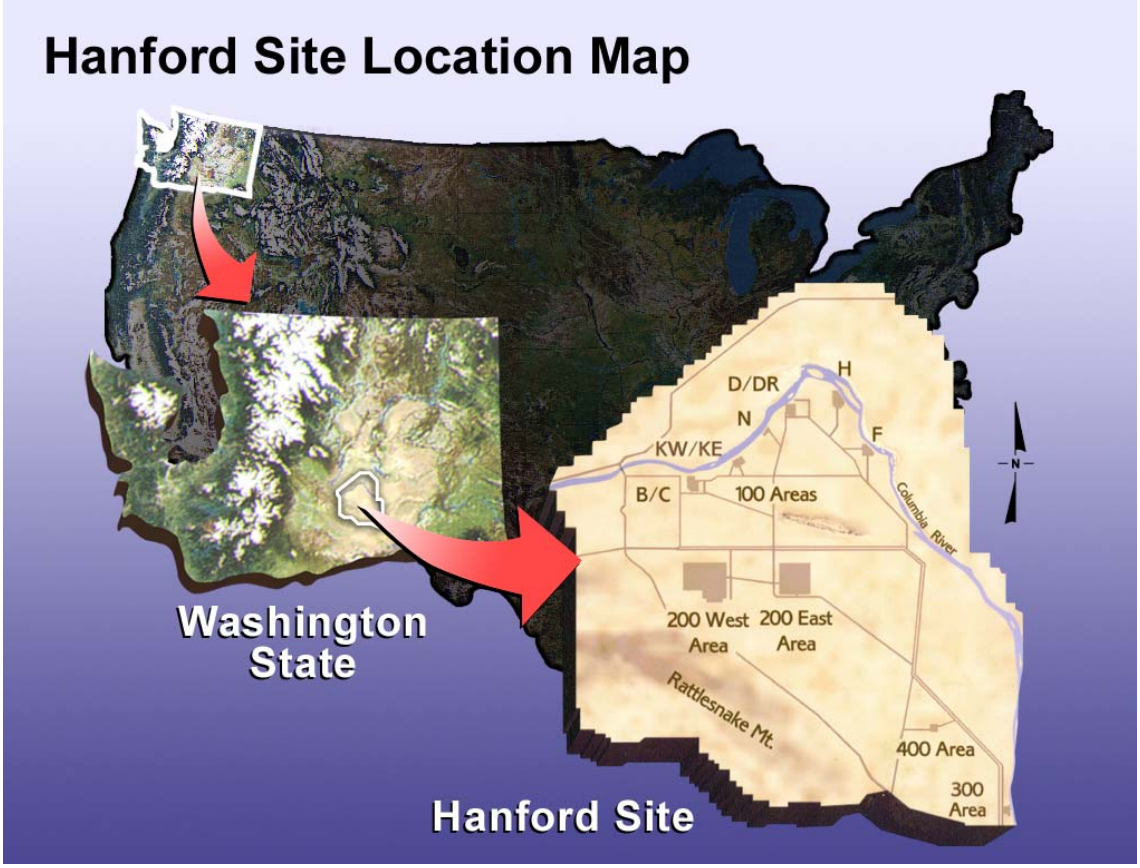

Figure 1.1. Hanford Site Location Map

This draft HSW EIS specifically addresses three waste types managed by the Hanford solid waste program: LLW, MLLW, and post-1970 TRU waste. The program's waste management operations include three major functions of storage, treatment, and disposal. Waste from onsite and offsite generators is stored until it can be transferred to an appropriate treatment or disposal facility. DOE and other federal and state regulators monitor storage facilities to evaluate compliance with regulatory requirements. Treatment of these wastes may include volume reduction, destruction or neutralization of non-radioactive hazardous constituents, stabilization, and encapsulation. Disposal facilities at Hanford can accept LLW and MLLW. Following a previous NEPA review (DOE 1997b), DOE decided to dispose of TRU waste at the Waste Isolation Pilot Plant (WIPP) in New Mexico, a deep geologic repository that meets the requirements of 40 CFR 191 (63 FR 3623).

1.3 Purpose and Need

DOE needs to enhance and expand management of its existing and anticipated volumes of solid LLW, MLLW, and post-1970 TRU waste at the Hanford Site and to make decisions that will enable the Site to provide storage, treatment, and disposal capabilities for these wastes.

1.4 Scope of the Draft HSW EIS

This draft HSW EIS addresses alternatives for managing most operational solid LLW, MLLW, and post-1970 TRU waste at Hanford and evaluates site-specific impacts associated with implementing RODs for the WM PEIS (DOE 1997a). The process for determining the scope of the draft HSW EIS, the types of waste managed by the solid waste program, waste management activities and facilities, and the alternatives evaluated in the draft HSW EIS are described in the following sections.

1.4.1 Scoping Process and Development of this Draft HSW EIS Alternatives

The scope of an EIS consists of the range of actions, alternatives, and impacts to be considered in the environmental assessment (40 CFR 1508.25). Scoping is a public process used by DOE to help identify significant issues related to a proposed action. As part of that process, DOE invited comments and recommendations from interested parties on the scope of this draft EIS.

The notice of intent (NOI) to prepare the HSW EIS was published in the October 27, 1997 *Federal Register* (62 FR 55615), in accordance with 40 CFR 1501.7, 40 CFR 1508.22, and 10 CFR 1021.311. The NOI announced the schedule for the public scoping process and summarized the alternatives and environmental consequences to be considered in the EIS.

- **Public Comment Period –** Originally scheduled from October 27, 1997 through December 11, 1997, the comment period was extended by DOE through January 30, 1998 in response to a request from the State of Oregon. The Notice of Extension appeared in the December 11, 1997 *Federal Register* (62 FR 65254).

- **Public Scoping Meetings –** Two scoping meetings were held in Richland, Washington, on November 12, 1997, followed by a meeting in Pendleton, Oregon, on November 13, 1997. Each meeting began with a short presentation by a DOE official on the EIS process, the overall waste management program at the Hanford Site, and an overview of DOE proposed actions and scope of the HSW EIS. A question-and-answer session was held prior to the official comment period at each meeting. Commenters, representing themselves or various organizations, were heard on a first-come, first-served basis and were encouraged to provide written versions of their oral comments for the record. Oral comments were recorded by a court reporter and are part of the official scoping meeting record. Printed information and displays were available, and opportunities were provided at each meeting for informal discussion about the DOE proposed action and the scope and content of the HSW EIS.

- **Scoping Results –** Both oral and written comments were received at the public scoping meetings. Written comments were also accepted by conventional and electronic mail. All written and oral comments were given equal consideration in preparing the draft HSW EIS. Commenters provided comments on several common topics: coordination with other EISs and DOE activities, alternatives and activities to analyze, waste types and volumes to analyze, environmental consequences, and public involvement and government agency consultation. A summary of the comments and DOE's

disposition of those comments is presented in Appendix A. As discussed in the following items, the structure of the draft HSW EIS evolved as a result of the scoping comments and publication of the WM PEIS RODs.

- **Operational Period –** The NOI indicated the EIS would identify impacts for the same 20-year operational period as evaluated in the WM PEIS. A number of comments indicated the EIS should provide a complete analysis of the operational and long-term consequences of managing waste at Hanford. The current planning basis for Hanford Site solid waste management operations extends through the year 2046 (DOE-RL 2001). Therefore, DOE determined that analyzing activities through this period provided a more comprehensive life-cycle analysis of proposed activities, some of which would occur after the end of the 20-year analysis discussed in the NOI. The analyses also include certain activities that may occur after 2046, such as eventual closure of the Low Level Burial Grounds (LLBGs). That approach facilitates a more complete evaluation of long-term consequences, including the potential for migration of waste components to groundwater and surface water. Decommissioning, surveillance, and maintenance activities that occur after closure of the waste management facilities are not included within the scope of the HSW EIS.

  A letter of intent was recently signed by DOE, the U.S. Environmental Protection Agency (EPA) and Washington State officials to accelerate environmental restoration activities at the Hanford Site. Although the solid waste program does not directly manage environmental restoration waste, the schedule for cleanup activities at Hanford may affect solid waste program receipts of operational waste generated during cleanup. In that case, the schedule for waste receipts from onsite generators, such as equipment from tank waste retrieval and treatment, might differ from the assumptions used in the HSW EIS analyses. However, the details of an accelerated cleanup schedule are not sufficiently developed to permit incorporating them into the analyses for this document. It is expected the types and quantities of waste assumed for analysis in this document would bound those projected for an accelerated cleanup schedule.

- **Alternatives –** The HSW EIS NOI identified four alternatives for analysis. Public comments received during the scoping process encouraged DOE to focus on Hanford wastes and to understand the impacts from management of those wastes separately from the impacts of accepting additional offsite waste. The structure of the alternatives as proposed in the NOI did not lend itself to conducting such an analysis. As a result of those comments and subsequent publication of the WM PEIS RODs for management of LLW, MLLW, and TRU waste, DOE revised the alternatives evaluated in the draft HSW EIS. The draft HSW EIS now considers alternatives by waste type, consistent with DOE decisions following publication of the WM PEIS (63 FR 3629, 63 FR 41810, 64 FR 46661, and 65 FR 10061). In those decisions regarding DOE-wide waste management, several roles were identified for the Hanford Site:

  - disposal of LLW and MLLW from Hanford generators and other DOE sites
  - treatment of MLLW from Hanford generators and other DOE sites
  - processing and certification of TRU waste for disposal at WIPP.

The alternatives for each waste type are described in Section 3.0, Description and Comparison of Alternatives, and the WM PEIS is discussed further in Section 1.5.3, Related NEPA Documents.

- **Waste Volumes –** Within the alternatives for LLW and MLLW, a range of waste volumes was evaluated to reflect the uncertainties in future waste receipts at the Hanford Site. In general, the lower bound volume for each waste type consists primarily of waste from Hanford Site generators, with a relatively small proportion of waste from other DOE sites. The upper bound volume includes additional offsite waste that Hanford could potentially receive as a result of the WM PEIS decisions to designate Hanford as a regional disposal site for LLW and a regional treatment and disposal site for MLLW. For TRU waste, a single volume was evaluated corresponding to the maximum forecast receipts because Hanford is not expected to receive substantial quantities of TRU waste from offsite generators. The bases for waste volumes evaluated in the draft HSW EIS are described further in Section 3.4 and Appendix C.

- **Management of Post-1970 TRU Waste –** The HSW EIS NOI indicated that alternatives for retrieval of TRU waste stored in the Hanford Site LLBGs after 1970 would be evaluated in the EIS, although DOE had previously analyzed that activity in the Hanford Defense Waste EIS (HDW EIS, DOE 1987). DOE recently prepared an environmental assessment (EA) for recovery of about 3000 m^3 of suspect TRU waste, primarily in drums, from the 200 West Area LLBGs (DOE 2002). DOE decided to defer analysis of further retrieval activities until additional experience is available from other DOE facilities and from the proposed initial project at Hanford as described in the EA. Additional NEPA documentation would be prepared as necessary for retrieval of the remaining TRU waste when subsequent projects are planned. However, the draft HSW EIS evaluates post-retrieval processing, certification, and shipment to WIPP for all retrievably stored TRU waste in the LLBGs in the same manner as for other newly generated TRU waste.

1.4.2 Waste Types Evaluated in the Draft HSW EIS

The types of waste managed by the solid waste program and evaluated in the draft HSW EIS are described in the following sections. Descriptions of the specific waste streams within each waste type and their management alternatives at Hanford are presented in Section 2.0 and Section 3.0, respectively.

1.4.2.1 Low-Level Waste

LLW is waste that contains radioactive material and which does not fall under any other DOE classification of radioactive waste. DOE manages LLW and other radioactive waste under the authority of the Atomic Energy Act (AEA) of 1954 (42 USC 2011 *et seq*.). LLW may be further divided into categories, depending on the type and quantity of radioactive material that it contains, as defined in the *Hanford Site Solid Waste Acceptance Criteria* (HSSWAC) (FH 2001).

Low-Level Waste (LLW)
Low-level radioactive waste is radioactive waste that is not high-level radioactive waste, spent nuclear fuel, transuranic waste, byproduct material (as defined in section 11e.(2) of the Atomic Energy Act of 1954, as amended), or naturally occurring radioactive material.

LLW and other radioactive wastes are also classified as either contact-handled (CH) or remote-handled (RH), depending on radiation dose rates as measured in contact with the container surface. LLW streams managed at Hanford are described in Section 2.1.1.

> ***Contact-Handled (CH) and Remote-Handled (RH) Waste***
> Contact-handled waste containers produce radiation dose rates less than or equal to 200 millirem/hour at the container surface. RH waste containers produce dose rates greater than 200 millirem/hour. CH containers can be safely handled by direct contact using appropriate health and safety measures. RH containers require special handling or shielding during waste management operations.

1.4.2.2 Mixed Low-Level Waste

MLLW is LLW that also contains non-radioactive hazardous constituents as defined by the Resource Conservation and Recovery Act (RCRA) of 1976 (42 USC 6901 *et seq*.) and applicable state regulations. Federal regulations implementing the RCRA appear in 40 CFR 260-280. EPA has delegated implementation authority for RCRA to some states, including the State of Washington, which has promulgated implementing regulations in the Washington Administrative Code (WAC). Additional discussion of regulations for managing radioactive and hazardous wastes at Hanford is provided in Section 6.0.

The hazardous components of MLLW are so identified either because they contain specific listed materials; were generated during specific processes; or exhibit properties such as toxicity, corrosivity, ignitability, or reactivity that could present a hazard to human health and the environment. Until 1987, MLLW was managed in the same manner as LLW. Beginning in 1987, treatment of MLLW (generally immobilization, removal, or destruction of the hazardous components) was required before it could be sent to a RCRA-permitted land disposal facility. At Hanford, MLLW was segregated and placed in storage until it could be treated for disposal. MLLW streams managed at Hanford are described in Section 2.1.2.

> ***Mixed Low-Level Waste (MLLW)***
> Mixed low-level waste is LLW that contains both radionuclides subject to the Atomic Energy Act of 1954, as amended, and a hazardous component subject to the Resource Conservation and Recovery Act.

1.4.2.3 Post-1970 TRU Waste

TRU waste is produced during reactor operations, fuel reprocessing, and nuclear weapons production. Some TRU waste also resulted from development, production, and utilization of mixed oxide fuels at Hanford. Plutonium is the most common TRU element in waste from DOE facilities. Waste that contains a sufficiently high concentration of TRU radionuclides to meet

> ***Transuranic (TRU) Waste***
> Transuranic waste is radioactive waste containing more than 100 nanocuries (3700 becquerels) of alpha-emitting transuranic isotopes per gram of waste, with half-lives greater than 20 years. High-level radioactive waste and certain other wastes designated by DOE, EPA, and the Nuclear Regulatory Commission (NRC) are excluded from the definition of TRU waste.

the regulatory definition of TRU waste must be disposed of in a facility that meets EPA requirements in 40 CFR 191. TRU waste must be characterized, packaged, and certified at Hanford as meeting the WIPP waste acceptance criteria before it can be shipped to that facility for disposal.

TRU waste was not defined as a separate waste type until 1970 and was managed in the same manner as LLW before that time. From 1970 through 1988, waste suspected of containing TRU radionuclides was retrievably stored in the Hanford LLBGs. This waste is referred to as suspect TRU waste because only part of the stored waste contains TRU radionuclides at concentrations specified in the definition. DOE is determining whether suspect TRU waste should be retrieved and processed as TRU waste, or whether it can remain disposed of in the LLBGs. Since 1988, TRU waste has generally been stored in surface facilities until it can be processed and certified for disposal at WIPP. TRU waste managed by the Hanford solid waste program is described in Section 2.1.3.

1.4.3 Waste Types Not Specifically Evaluated in the HSW EIS

Management of some radioactive and other hazardous materials at Hanford is outside the scope of the draft HSW EIS. These materials include high-level (radioactive) waste (HLW), most liquid waste, spent nuclear fuel, naval reactor compartments, commercial LLW at the U.S. Ecology site near the 200 Areas, non-radioactive hazardous solid waste, and other solid waste. Most wastes from environmental restoration activities conducted under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA, 42 USC 9601 *et seq*.) are also outside the scope of this EIS, although some waste generated during CERCLA cleanup activities may eventually be transferred to the solid waste program for management (as discussed in Section 1.5.1.2). Each of these materials has physical or regulatory management requirements that differ from those that apply to wastes typically managed under the solid waste program. The impacts from managing these other wastes and materials are included in this HSW EIS (Section 5.14), to the extent that they have been evaluated and information is available. Related activities and analyses for many of the wastes are discussed in Section 1.5.

Although non-radioactive solid hazardous waste was listed in the NOI as a waste stream that would be evaluated in the draft HSW EIS, it has since been removed from the HSW EIS scope. Shortly before publication of the NOI, DOE published the final WM PEIS (DOE 1997a), and thereafter issued a ROD for management of non-wastewater hazardous waste across the DOE complex (63 FR 41810). In that decision, DOE announced that its facilities would continue to manage hazardous waste at commercial treatment and disposal facilities. Because no further decision or evaluation is necessary regarding management of Hanford's non-radioactive hazardous waste at this time, it is not included within the scope of the draft HSW EIS.

Likewise, decontamination of equipment and materials was listed in the NOI as an activity that would be included in the draft HSW EIS, but it has since been removed from the scope. At the time the NOI was prepared, this activity was expected to expand substantially in scope compared to the level of ongoing operations. At present, the level of decontamination activity has decreased, and substantial expansion beyond historic levels is not anticipated. Therefore, no further decision is necessary and

decontamination operations have been removed from the scope of this draft EIS. LLW, MLLW, and TRU waste that may be generated as a result of decontamination activities are included in the waste volumes evaluated in this EIS.

1.4.4 Hanford Waste Management Activities Evaluated in the Draft HSW EIS

The waste management activities and facilities included within the scope of the draft HSW EIS are described briefly in the following sections. Hanford solid waste program activities include storage, treatment, and disposal of LLW, MLLW, and post-1970 TRU waste. Figure 1.2 provides an overview of ongoing activities. Existing and proposed waste management facilities considered in the HSW EIS alternatives are described in Section 2.2.

1.4.4.1 Solid Waste Storage

Waste is generally stored while awaiting treatment or disposal. The specific storage methods used depend on the chemical and physical characteristics of the waste as well as the type and concentration of radionuclides in the waste.

At Hanford, waste is stored at either aboveground facilities or belowground. The Central Waste Complex (CWC) is a group of enclosed metal buildings on concrete pads that are used to store various types of waste awaiting verification, treatment, or disposal (Section 2.2.1). Some waste is also stored outdoors on concrete pads if the outer containers are corrosion-resistant and suitable for such storage. The LLBGs consist of a series of below grade trenches intended for ultimate disposal of LLW. In some cases, waste has been stored in these trenches for later retrieval and disposition, as described in the following sections. The T Plant Complex also has some waste storage capabilities.

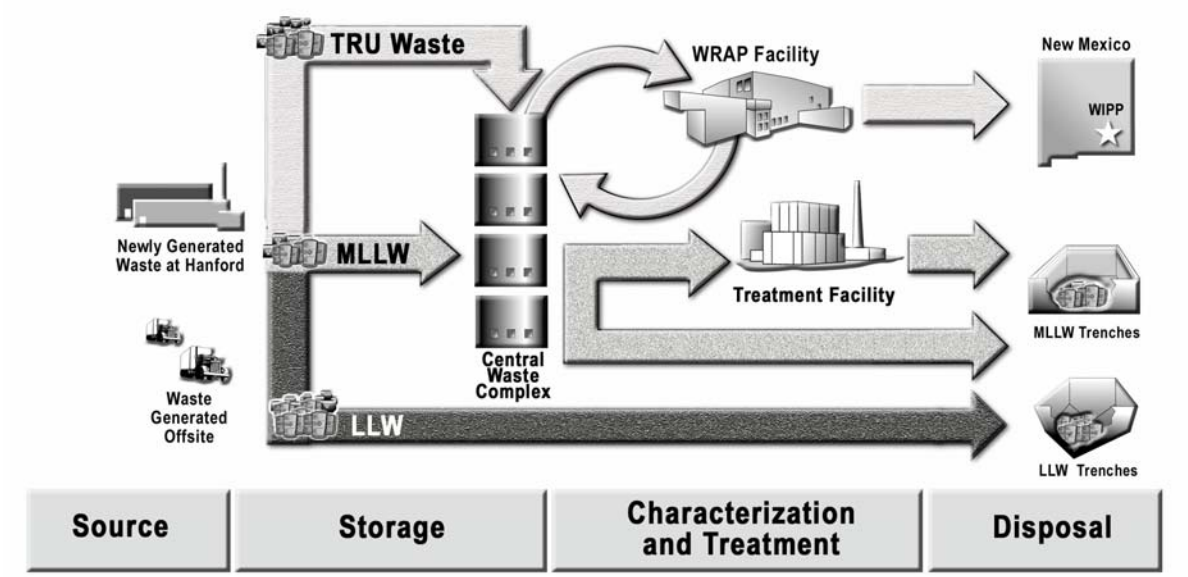

Figure 1.2. Overview of Current Hanford Solid Waste Program

LLW is typically not stored for an extended period at Hanford. In most cases, a small fraction of each incoming shipment is stored until it can be inspected and verified that it meets the HSSWAC. The remainder is sent directly to the LLBGs for disposal. Trenches in the LLBGs are then backfilled with soil and maintained to prevent the spread of radioactive contamination.

Because the Hanford Site currently does not have facilities to treat all types of MLLW, untreated waste must be stored until it can be treated in compliance with RCRA and state regulations. Short-term storage for mixed waste is provided at many generator facilities throughout the Hanford Site for up to 90 days, the maximum allowed in a non-permitted storage facility. Storage of mixed waste for longer than 90 days requires a RCRA-permitted storage facility that is engineered to prevent release of the wastes to the environment. Structures at CWC are constructed to meet these requirements, and they provide interim storage for MLLW until it can be treated. A small quantity of MLLW that has been prepared for disposal may also be stored in the LLBG in RCRA-permitted MLLW trenches.

From 1970 to 1988, drums and boxes of TRU waste were placed in storage in LLBG trenches. Small containers of RH TRU waste were also placed within four cement-lined caissons. The caissons are thick-walled concrete structures located in the LLBGs and intended to provide containment and shielding for the waste. Most TRU waste generated after 1988 is stored at CWC until it can be repackaged, as needed, and certified for shipment to WIPP.

1.4.4.2 Solid Waste Treatment

Waste treatment processes are used to change the physical, chemical, or biological characteristics of waste, to reduce its volume, or to make it safer for disposal. Treatment is not required for most LLW but may consist of volume reduction or other activities needed to stabilize the waste.

MLLW requires treatment to specific standards defined by RCRA and state regulations before it can be disposed of in a permitted facility. The Hanford Site has limited capability to treat MLLW, and DOE has contracted with a RCRA-permitted commercial facility to begin treating limited quantities of stored CH MLLW. The 200 Area Effluent Treatment Facility (ETF) treats Hanford Site liquid wastes and leachate collected from the MLLW trenches. Hanford requires additional capabilities to treat MLLW that cannot be accepted by commercial facilities, such as oversized items or containers and RH MLLW.

TRU waste may also require processing before it can be sent for disposal. Processing may include activities such as repackaging, characterization, and certification that it meets the WIPP waste acceptance criteria. Waste Receiving and Processing Facility (WRAP) provides the capability to process and certify some CH TRU waste for shipment to WIPP. However, additional capabilities are needed at Hanford to process and certify RH TRU waste and oversized containers.

1.4.4.3 Solid Waste Disposal

The final step in the waste management process is disposal. Some types of waste can be disposed of safely in existing facilities using conventional methods such as shallow land burial. Other types of waste require facilities that provide long-term isolation, such as deep geologic disposal.

Hanford disposes of most LLW in LLBGs that consist of a series of trenches. Six LLBGs are located in the 200 West Area, and two are in the 200 East Area. One LLBG in the 200 West Area contains two trenches that are permitted for disposal of MLLW that has been treated to comply with RCRA and state regulations. The MLLW trenches are constructed with a low permeability liner and a system for collecting water that drains through the waste disposal area. The collected liquids, referred to as leachate, are shipped to the ETF and converted to a solid form suitable for disposal. Section 2.2.3 describes these facilities, and Appendix D provides diagrams showing the 200 West Area LLBGs, the 200 East Area LLBGs, and specific trench locations.

Following onsite characterization and packaging, DOE plans to send post-1970 TRU waste to the WIPP repository for disposal. Transportation of TRU waste and disposal at WIPP were previously evaluated by DOE (1997b).

1.4.5 Alternatives Evaluated in the Draft HSW EIS

This draft HSW EIS considers a range of reasonable alternatives for management of solid LLW, MLLW, and post-1970 TRU waste at the Hanford Site. An overview of the alternatives for each waste type is presented in the following sections. In addition to evaluating alternatives for site-specific waste management activities, this draft HSW EIS evaluates a range of waste volumes for MLLW and LLW. In its final decision, DOE could choose to implement a combination of actions from any of the alternatives evaluated in this EIS.

1.4.5.1 LLW Alternatives

DOE proposes to manage LLW from Hanford generators and other DOE sites using existing facilities for waste verification and by constructing additional disposal capacity. DOE needs to determine which treatment, storage, and disposal activities are required for properly managing onsite and offsite solid LLW that currently exists or that may be received at Hanford in the future. Currently, most LLW is packaged, inspected to determine that it complies with the HSSWAC (FH 2001), and placed in the LLBGs. Limited quantities of waste that do not meet the HSSWAC are currently stored until the waste can be treated to comply with Hanford requirements. DOE needs to evaluate options for permanent disposal of LLW at Hanford, including expansion and possible reconfiguration of disposal facilities to accommodate anticipated waste receipts.

LLW Alternative 1 (Preferred Alternative). As needed, LLW would be inspected and verified at WRAP, the T Plant Complex, or other suitable locations within the Hanford Site. Non-conforming waste would be treated to comply with the HSSWAC using existing onsite capabilities, or if treatment capacity does not exist at Hanford, it would be treated at an offsite commercial facility. DOE would construct new disposal capacity using a deeper, wider trench design relative to the trenches previously employed for disposal of LLW at Hanford. Disposal would take place within the boundaries of currently defined LLBGs, and the LLBGs would ultimately be closed by applying a cap to reduce water infiltration and the potential for intrusion. This alternative was evaluated for a range of waste volumes (about 433,000 to 631,000 m^3 [584,550 to 851,850 yd^3]) that could be managed at Hanford under the WM PEIS ROD for LLW.

LLW Alternative 2. As needed, LLW would be inspected and verified at WRAP, the T Plant Complex, or other suitable locations within the Hanford Site. Non-conforming waste would be treated to comply with the HSSWAC using existing onsite capabilities or at a new onsite treatment facility. DOE would construct new disposal capacity using a trench design similar to that previously employed for disposal of LLW at Hanford. Depending on the volume of waste received at Hanford, expansion of the LLBGs within the 200 Area boundaries may be required. The LLBGs would ultimately be closed by applying a cap to reduce water infiltration and the potential for intrusion. This alternative was evaluated for a range of waste volumes (about 433,000 to 631,000 m^3 [584,550 to 851,850 yd^3]) that could be managed at Hanford under the WM PEIS ROD for LLW.

LLW No Action Alternative. As needed, LLW would be inspected and verified at WRAP, the T Plant Complex, or other suitable locations within the Hanford Site. Non-conforming waste would be treated to comply with the HSSWAC using existing onsite capabilities, or if treatment capacity does not exist at Hanford, it would be stored indefinitely at the CWC. DOE would construct new disposal capacity using a trench design similar to that previously employed for disposal of LLW at Hanford. Disposal would take place within the boundaries of currently defined LLBGs. The trenches would be backfilled to grade, but the LLBGs would not be capped. This alternative was evaluated for a single lower bound LLW volume (433,000 m^3 [584,550 yd^3]) that could be managed at Hanford under the WM PEIS ROD for LLW.

1.4.5.2 MLLW Alternatives

DOE proposes to treat and dispose of MLLW received from Hanford generators and other DOE sites using existing, expanded, or new facilities. DOE needs to determine which treatment, storage, and disposal activities are required to properly manage onsite and offsite solid MLLW that currently exists or that may be received at Hanford in the future. The Hanford Site currently has limited treatment capabilities to treat MLLW in compliance with the RCRA land disposal restrictions (LDRs). As a result, most MLLW has been placed in interim storage awaiting final disposition. Existing MLLW disposal facilities at Hanford consist of two engineered trenches permitted under RCRA. The capacity of those trenches is insufficient to dispose of all MLLW that Hanford expects to receive in the future. Therefore, DOE needs to evaluate options for treating Hanford's MLLW in accordance with RCRA and state requirements, as well as for expanding Hanford's MLLW disposal capacity.

MLLW Alternative 1 (Preferred Alternative). MLLW received for storage or treatment would be inspected and verified at WRAP, the T Plant Complex, or other suitable locations within the Hanford Site. However, most verification of treated MLLW is expected to take place at either the generator or treatment facility. DOE would establish contracts with a RCRA-permitted commercial facility (or facilities) to treat most of Hanford's CH MLLW using both thermal and non-thermal processes. For MLLW that cannot be treated by commercial facilities, such as RH or oversized items, DOE would develop new onsite treatment capacity by modifying existing facilities in the T Plant Complex. Limited treatment capabilities that currently exist at WRAP and the T Plant Complex would also continue to be used.

DOE would dispose of MLLW in two existing trenches at Hanford and then construct new disposal units of a deeper and wider design. A separate trench would be constructed for disposal of melters from

the tank waste treatment plant. Disposal would take place within the boundaries of currently defined LLBGs, and the trenches would be closed by applying a RCRA-compliant cap. This alternative was evaluated for a range of waste volumes (65,000 to 206,000 m^3 [87,750 to 278,100 yd^3]) that could be managed at Hanford under the WM PEIS ROD for MLLW.

MLLW Alternative 2. As needed, MLLW received for storage or treatment would be inspected and verified at WRAP, the T Plant Complex, or other suitable locations within the Hanford Site. However, most verification of treated MLLW is expected to take place at either the generator or treatment facility. Under this alternative, DOE would limit commercial treatment of CH MLLW to quantities specified in existing contracts and develop new onsite capabilities to treat most CH MLLW, RH MLLW, and oversized items by constructing a new treatment facility. Limited treatment capabilities that currently exist at WRAP and the T Plant Complex would also continue to be used.

DOE would dispose of MLLW in two existing trenches at Hanford and then construct new disposal trenches of a similar design. A separate trench would be constructed for disposal of melters from the tank waste treatment plant. Disposal would take place within the boundaries of currently defined LLBGs, and the trenches would be closed by applying a RCRA-compliant cap. This alternative was evaluated for a range of waste volumes (65,000 to 206,000 m^3 [87,750 to 278,100 yd^3]) that could be managed at Hanford under the WM PEIS ROD for MLLW.

MLLW No Action Alternative. As needed, MLLW received for storage or treatment would be inspected and verified at WRAP, the T Plant Complex, or other suitable locations within the Hanford Site. However, most verification of treated MLLW is expected to take place at either the generator or treatment facility. DOE would treat CH MLLW, up to minimum quantities specified in existing contracts, at a RCRA-permitted commercial facility. Limited treatment capabilities that currently exist at WRAP and the T Plant Complex would also continue to be used.

DOE would dispose of MLLW in two existing trenches at Hanford, and the trenches would be closed by applying a RCRA-compliant cap. Waste in excess of existing treatment and disposal capacity would be stored indefinitely at the T Plant Complex or at the CWC, which would be expanded as necessary. This alternative was evaluated for a single lower bound MLLW volume (65,000 m^3 [87,750 yd^3]) that could be managed at Hanford under the WM PEIS ROD for MLLW.

1.4.5.3 Post-1970 TRU Waste Alternatives

DOE proposes to expand Hanford Site capabilities to store, process, and certify post-1970 TRU waste for disposal at WIPP. DOE needs to determine which storage, processing, and certification activities are required to properly manage post-1970 TRU waste that currently exists, or that may be received at the Hanford Site in the future. Since 1970, DOE has retrievably stored TRU waste at the Hanford LLBGs in trenches and caissons, and in surface facilities. DOE previously decided to dispose of this inventory of post-1970 TRU waste and future generated TRU waste at the WIPP. The WRAP at Hanford currently has the capability to process and certify some types of TRU waste for disposal at WIPP. In order to meet WIPP waste acceptance criteria for all types of TRU waste, additional processing and certification capabilities must be developed and implemented at the Hanford Site.

TRU Waste Alternative 1 (Preferred Alternative). DOE would continue to store post-1970 TRU waste awaiting processing at CWC, the T Plant Complex, and the LLBGs (for waste previously placed into retrievable storage in trenches and caissons). CH TRU waste in standard containers (drums and standard waste boxes) would be processed and certified at WRAP for disposal at WIPP. For TRU waste that could not be processed at WRAP (primarily oversized packages and RH waste), onsite capabilities for processing and certification would be developed by modifying existing facilities in the T Plant Complex. Future TRU waste receipts, waste stored in surface facilities, and post-1970 TRU waste that had been retrievably stored in the LLBG trenches and caissons would be processed and shipped to WIPP. This alternative was evaluated using the maximum TRU waste volume (46,000 m^3) forecast for management at Hanford.

TRU Waste Alternative 2. DOE would continue to store post-1970 TRU waste awaiting processing at CWC, the T Plant Complex, and the LLBGs (for waste previously placed into retrievable storage in trenches and caissons). CH TRU waste in standard containers (drums and standard waste boxes) would be processed and certified at WRAP for disposal at WIPP. For TRU waste that could not be processed at WRAP (primarily oversized packages and RH waste), onsite capabilities for processing and certification would be developed by constructing a new facility. Future TRU waste receipts, waste stored in surface facilities, and post-1970 TRU waste that had been retrievably stored in the LLBG trenches and caissons would be processed and shipped to WIPP. This alternative was evaluated using the maximum TRU waste volume (46,000 m^3 [62,100yd^3]) forecast for management at Hanford.

TRU Waste No Action Alternative. DOE would continue to store post-1970 TRU waste awaiting processing at CWC, the T Plant Complex, and the LLBGs (for waste previously placed into retrievable storage in trenches and caissons). CH TRU waste in standard containers (drums and standard waste boxes) would be processed and certified at WRAP for disposal at WIPP. For TRU waste that could not be processed at WRAP (oversized packages, RH waste, and some miscellaneous waste streams), no onsite processing capability would be available. To the extent possible, future TRU waste receipts, waste stored in surface facilities, and post-1970 TRU waste that had been retrievably stored in the LLBG trenches and caissons would be processed at WRAP and shipped to WIPP. Waste that could not be processed and certified for disposal at WIPP would be stored indefinitely at the T Plant Complex or at CWC, which would be expanded as necessary. This alternative was evaluated using the maximum TRU waste volume (46,000 m^3 [62,100yd^3]) forecast for management at Hanford.

1.5 Relationship of the HSW EIS to Other Hanford and DOE Programmatic Actions and NEPA Documents

A number of other DOE programmatic and Hanford actions are related to this draft HSW EIS. The relationships of these actions and associated NEPA documents to this EIS are described in the following sections.

1.5.1 Hanford Site Programs and Decisions

Hanford Site activities and programs that affect decisions regarding waste management include the Hanford Federal Facility Agreement and Consent Order (referred to as the Tri-Party Agreement, or TPA), RCRA and CERCLA activities, and the Groundwater/Vadose Zone Program.

1.5.1.1 Tri-Party Agreement

Beginning in 1986, DOE, EPA, and the Washington State Department of Ecology (Ecology) began to examine how best to bring the Hanford Site into compliance with RCRA, CERCLA, and applicable state hazardous waste regulations. The regulatory agencies and DOE agreed to develop one compliance agreement that set milestones for cleaning up past disposal sites under CERCLA and bringing operating facilities into compliance with RCRA. Negotiations concluded in late 1988, and the TPA was signed by the three participating agencies on January 15, 1989 (Ecology *et al*. 1989). The parties to this agreement have established milestones to bring DOE operating facilities into compliance with RCRA and to coordinate the cleanup of past Hanford disposal sites under CERCLA. Milestones established under the TPA influence some activities proposed for management of MLLW and post-1970 TRU waste in this draft HSW EIS. In particular, the M-91 series of milestones establish target dates for development of capacity to treat and dispose of Hanford's MLLW and TRU waste for which capabilities do not exist. The TPA is discussed further in Section 6.2.

1.5.1.2 RCRA Requirements and CERCLA Remediation Activities

Regulatory jurisdiction over hazardous substances and waste is generally implemented through two statutes, RCRA and CERCLA, as well as related state regulations. RCRA establishes regulatory standards for the generation, transportation, storage, treatment, and disposal of hazardous waste (including the hazardous components of MLLW). RCRA standards primarily cover ongoing waste management at active facilities; however, substantive elements also may serve as applicable or relevant and appropriate requirements during CERCLA cleanups.

CERCLA established a program to ensure the government or responsible parties clean up sites contaminated by hazardous substances. CERCLA primarily regulates cleanup of inactive waste sites and facilities. CERCLA requires remediation of sites where a release, or a threat of release, of hazardous substances has occurred. The CERCLA process for evaluating remediation alternatives includes comparing each alternative against nine criteria, including overall protection of human health and the environment, long-term effectiveness, and short-term effectiveness. These criteria address many of the elements that would be addressed in a NEPA review. Long-term effectiveness considers the magnitude of the residual risk (risk to human health or the environment from untreated waste or treatment residuals remaining at the conclusion of remediation activities). It also considers the adequacy and reliability of controls needed to manage untreated wastes or treatment residuals. Short-term effectiveness evaluates impacts occurring during remediation, such as risks to the community (for example, from air emissions), risks to workers, and risks to the environment.

Beginning in 1944 and continuing for nearly 50 years, facilities in the Hanford Site 200 Areas were used to separate and purify uranium and plutonium from irradiated nuclear fuel that was produced by reactors in the Hanford 100 Areas. Past operations resulted in waste sites that are now being managed under CERCLA, largely consisting of places that were used to dispose of wastewater (ponds, cribs, french drains, and ditches), and solid waste (inactive burial grounds).

The CERCLA sites in the 200 Areas, including burial grounds closed before 1970, are the last sites scheduled for a major characterization effort. DOE has undertaken a project that includes characterization to assess the nature and extent of soil contamination and to select appropriate remedial actions. Decisions regarding remediation would be made on an operable-unit basis as characterization is completed. The framework for the characterization and remediation of 200 Area CERCLA sites is defined in the *200 Areas RI/FS Implementation Plan*, DOE/RL-98-28 (DOE-RL 1999).

Hazardous waste, LLW, and MLLW generated by CERCLA remediation activities at Hanford are disposed of at the Environmental Restoration Disposal Facility (ERDF). ERDF is a large waste disposal facility located near the 200 West Area and is not part of the solid waste program LLBGs. Waste disposed of at the ERDF consists primarily of LLW and MLLW from Hanford Site cleanup programs. In some cases, CERCLA actions would generate waste, such as TRU waste, that could not be disposed of at ERDF. That waste would subsequently be transferred to the solid waste program for any required processing and certification before shipping it to WIPP.

1.5.1.3 Groundwater/Vadose Zone Program

DOE and a team of contractors have developed, and are implementing, a sitewide program that integrates all assessment and remediation activities that address key groundwater, vadose zone, and related Columbia River issues. This effort is coordinated by the Groundwater/Vadose Zone Program to support cleanup and closure decisions for the Hanford Site and protection of the Columbia River. As available, information developed under that program was used to evaluate long-term impacts of LLW and MLLW disposal in this draft HSW EIS. Additional information can be found at http://www.bhi-erc.com/projects/vadose/.

1.5.2 Interim Actions During Preparation of the Draft HSW EIS

During the preparation of this draft HSW EIS, DOE determined that several actions within or related to the scope of the EIS met the criteria for permissible interim actions under 40 CFR 1506.1. These actions are described in the following documents:

- **Offsite Thermal Treatment of Low-Level Mixed Waste (DOE/EA-1135 May 1999)**

  This EA analyzed the use of Allied Technology Group, Inc. (ATG), a commercial treatment facility in Richland, Washington to thermally treat a portion of MLLW stored at the Hanford Site (DOE 1999). DOE considered the use of ATG for treatment of a limited quantity of MLLW from Hanford as a demonstration project. This EA analyzed impacts of transporting the MLLW from Hanford to ATG, treatment of the waste in the ATG facility, and transportation of the treated waste

back to Hanford for disposal. Construction and operation of the ATG treatment facility was evaluated in a State Environmental Policy Act (SEPA) EIS (City of Richland 1998). Based on analyses in the EA, DOE determined the proposed action was not a major federal action significantly affecting the quality of the human environment and issued a finding of no significant impact (FONSI) on May 6, 1999.

- **Non-Thermal Treatment of Hanford Site Low-Level Mixed Waste (DOE/EA-1189 September 1998)**

The EA considered the use of a commercial treatment facility to stabilize or encapsulate a portion of Hanford MLLW to allow disposal of the waste (DOE 1998). Regulatory requirements for treatment of MLLW to allow land disposal vary depending upon the nature of the waste. Wastes considered in this EA consisted of those that did not require thermal treatment. The ATG facility was also considered for thermal treatment of a portion of the Hanford MLLW (DOE 1999a). Construction and operation of the ATG treatment facility was evaluated in a SEPA EIS (City of Richland 1998). Based on analyses in the EA, DOE determined the proposed action was not a major federal action significantly affecting the quality of the human environment and issued a FONSI on September 29, 1998.

- **Trench 33 Widening in 218-W-5 Low-Level Burial Ground (DOE/EA-1203 July 1997)**

In this EA, DOE proposed to widen and operate the existing and unused disposal Trench 33 within the 218-W-5 LLBG in the 200 West Area for disposal of LLW (DOE 1997c). The existing V-type LLW trenches were designed before 1976 and were analyzed in a previous Environmental Statement (ERDA 1975). The widening of Trench 33 increased the disposal capacity and allowed for disposal of both boxed and large packages of Category (Cat) 1 LLW that would not efficiently fit in the standard trench configuration. The proposed action provided for more cost-effective land use and increased the capacity of the LLBG without increasing the footprint. Based on analyses in the EA, DOE determined the proposed action was not a major federal action significantly affecting the quality of the human environment and issued a FONSI on July 28, 1997.

- **Widening Trench 36 of the 218-E-12B Low-Level Burial Ground (DOE/EA-1276 February 1999)**

This EA was prepared to assess potential environmental impacts associated with the proposed action to widen and operate the existing and unused Trench 36 in the 218-E-12B LLBG for disposal of bulk LLW (DOE 1999b). The existing V-type LLW trenches were designed before 1976 and were analyzed in a previous Environmental Statement (ERDA 1975). DOE determined the trench design was inefficient for disposal of bulk waste. The V-type trenches are narrow at the bottom and are generally less than about 5 m (16 ft) deep. DOE determined that widening the trenches would more efficiently utilize LLBG space. Given trenches of equivalent depth, the wider trenches allow more waste to be placed per square foot of surface area. This pattern not only saves trench construction costs but also decreases closure cover size and cost for disposal of a given volume of waste. Based

on analyses in the EA, DOE determined the proposed action was not a major federal action significantly affecting the quality of the human environment and issued a FONSI on February 11, 1999.

- **K Basins Sludge Storage at 221-T Building, Hanford Site, Richland, Washington (DOE/EA-1369 June 2001)**

  This EA was prepared to assess potential environmental impacts associated with modification of the 221-T Building (part of the T Plant Complex) to receive and store sludge from the 100 K Area fuel storage basins at the Hanford Site (DOE 2001a). The proposed action included modification of the pool cell and other shielded cells within the facility to store the sludge. The sludge would ultimately be designated as RH TRU waste and transferred to the solid waste program for storage, processing at an onsite facility, and shipment to WIPP for disposal. Based on analyses in the EA, DOE determined the proposed action was not a major federal action significantly affecting the quality of the human environment and issued a FONSI on June 20, 2001.

- **(Draft) Environmental Assessment for Trench Construction and Operation in the 281-E-12B and 218-W-5 Low-Level Burial Grounds, Hanford Site, Richland, Washington (DOE/EA-1373 February 2001)**

  This EA was prepared to assess potential environmental impacts associated with the proposed action to construct four new LLW disposal trenches in the Hanford Site 200 East and 200 West Areas (DOE 2001b). Additional trench capacity was determined to be necessary over the short-term for operational efficiency in disposing of different physical types of LLW at Hanford. Comments on the draft EA are being considered.

1.5.3 Related NEPA Documents

This section briefly describes a number of NEPA documents related to the HSW EIS. They offer background material for understanding the HSW EIS and its purpose.

- **Final Environmental Statement, Waste Management Operations, Hanford Reservation, Richland, Washington (ERDA-1538 December 1975)**

  The U.S. Energy Research and Development Administration (ERDA) prepared an Environmental Statement for use in planning and decision making to ensure that future waste management practices would minimize adverse environmental consequences (ERDA 1975). Treatment and disposal of waste generated by nuclear defense production, research and development, and other activities at the Hanford Site were addressed. This document was written for the Waste Management Operations Program at the Hanford Site. Because this document predated the CEQ NEPA regulations, a formal ROD was not issued. To some extent, Hanford waste management programs still rely upon the analyses conducted in ERDA-1538. The HSW EIS provides an updated analysis and revisits potential alternatives for Hanford Site solid waste program operations.

- **Disposal of Decommissioned Defueled Naval Submarine Reactor Plants EIS (U.S. Department of the Navy 1984)**

  This EIS considered the disposal of defueled naval submarine reactor compartments in the Hanford LLBGs. The EIS was prepared by the U.S. Department of the Navy and was adopted by DOE (Navy 1984). The EIS analyzed preparation of the reactor compartments at the Puget Sound Naval Shipyard, transportation to Hanford, and disposal in the 200 Areas. The ROD was published in the Federal Register on December 6, 1984 (49 FR 47649).

- **Disposal of Hanford Defense High-Level, Transuranic and Tank Wastes, Hanford Site, Richland, Washington (DOE/EIS-0113 December 1987)**

  In 1987, DOE prepared the HDW EIS to examine potential impacts from preparing TRU and tank waste stored at the Hanford Site since 1943, as well as future wastes, for disposal (DOE 1987). Most LLW and wastes associated with decommissioning of existing surplus or retired Hanford Site facilities were not considered in the HDW EIS. In the 1988 ROD (53 FR 12449), DOE decided to dispose of or store double-shell tank waste and cesium and strontium capsules. Retrievably stored TRU waste in the 200 Area LLBGs would be retrieved and disposed of with other newly generated TRU waste. A decision was also made to retrieve buried pre-1970 suspect TRU-contaminated waste from the 618-11 site. As part of that decision, DOE decided to construct and operate a facility for vitrification of HLW, facilities for grout stabilization and disposal of the low activity fraction from processing tank waste, and the WRAP for processing, certification, and shipment of TRU waste. Subsequent to preparation of the HDW EIS, the TPA was established to implement many of the actions discussed in the ROD. The agreement also ensures compliance with RCRA and CERCLA requirements. The HSW EIS provides an updated analysis for some Hanford solid waste program operations previously evaluated in the HDW EIS.

- **Environmental Assessment – Hanford Environmental Compliance Project, Hanford Site, Richland Washington (DOE/EA-0383 March 1992)**

  This EA included an evaluation for construction and operation of the ETF in the Hanford Site 200 East Area (DOE 1992). This facility would receive leachate collected from the MLLW trenches (in addition to other liquid waste generated at Hanford). The EA also evaluated construction of additional facilities at the CWC. Based on analyses in the EA, DOE determined the proposed action was not a major federal action significantly affecting the quality of the human environment and issued a FONSI on March 11, 1992.

- **Solid Waste Retrieval Complex, Enhanced Radioactive and Mixed Waste Storage Facility, Infrastructure Upgrades, and Central Waste Complex (DOE/EA-0981 September 1995)**

  In this EA, DOE proposed to construct and operate the Solid Waste Retrieval Complex and the Enhanced Radioactive Mixed Waste Storage Facility, to expand the CWC, and to upgrade the associated Hanford infrastructure (DOE 1995). These facilities were to be located in the 200 West Area to support the Solid Waste Operations Complex (SWOC) operation. The proposed action was

to address retrieval of TRU waste, storage capacity for retrieved and newly generated TRU waste, and upgrading the infrastructure network in the 200 West Area to enhance operational efficiencies and reduce the cost of operating the existing SWOC. Actions evaluated in the EA included:

- construction and operation of the Retrieval Complex and the Enhanced Radioactive Mixed Waste Storage Facility
- expansion of the CWC
- upgrading associated infrastructure (that is, utilities and roads) in the 200 West Area to support the SWOC
- retrieval of post-1970 TRU waste in the LLBGs and the construction, operation, and maintenance of a complex of facilities to be used for the retrieval
- construction of a RCRA-permitted storage facility for great than Category 3 (GTC3) waste, retrieved TRU waste and newly generated TRU waste awaiting processing in the WRAP, and for processed waste awaiting shipment to WIPP
- construction of two pre-engineered metal solid waste management support buildings.

In addition, the proposed action included a mitigation strategy to address lost shrub-steppe habitat. Based on analyses in the EA, DOE determined the proposed action was not a major federal action significantly affecting the quality of the human environment and issued a FONSI on September 28, 1995. This draft HSW EIS considers post-retrieval processing, certification, and shipment to WIPP for retrievably stored post-1970 TRU waste in the LLBGs.

- **Management of Spent Nuclear Fuel from the K Basins at the Hanford Site, Richland, Washington (DOE/EIS-0245 January 1996)**

This EIS evaluated alternatives for treatment and interim storage of irradiated fuels from the Hanford production reactors (DOE 1996). After the reprocessing of production reactor fuels for weapons material at Hanford was suspended, a substantial quantity of unprocessed irradiated fuel remained in the fuel storage basins at the 100-K Area. As a result of the EIS analysis, DOE decided to stabilize the stored fuel using a cold vacuum drying process, package the fuel into storage canisters, and place the canisters into storage in the 200 East Area at Hanford. The EIS also addressed cleaning out the 100-K Area fuel storage basins following removal of the fuel. The EIS evaluated storage of the retrieved sludge in underground tanks for eventual treatment with other Hanford tank wastes, or alternatively, grouting and disposal of the sludge fractions that would meet the HSSWAC. This draft HSW EIS evaluates storage and treatment of the sludge by the solid waste program, an alternative not considered in the K Basin EIS. The treated sludge ultimately would be disposed of at WIPP with other Hanford TRU waste. A ROD was issued in the Federal Register on March 15, 1996 (61 FR 10736).

- **Disposal of Decommissioned, Defueled Cruiser, Ohio Class, and Los Angeles Class Naval Reactor Plants (DOE/EIS-0259 April 1996)**

This EIS considered the disposal of certain defueled Naval Reactor plants in the Hanford LLBG. The EIS was prepared by the U.S. Department of the Navy (1996). The EIS analyzed preparation of the

reactor compartments at the Puget Sound Naval Shipyard, transportation to Hanford, and disposal in the 218-E-12B burial ground in the Hanford 200 East Area. DOE participated as a cooperating agency in the development of the EIS on this federal action and has adopted the EIS. The ROD was issued in the Federal Register on August 9, 1996 (61 FR 41596).

- **Tank Waste Remediation System EIS (DOE/EIS-0189 August 1996)**

In the *Tank Waste Remediation System Environmental Impact Statement* (TWRS EIS*)*, DOE examined the management and disposal of the contents of 177 HLW tanks, as well as cesium and strontium capsules (DOE and Ecology 1996). These items account for nearly 97 percent of the radionuclide inventory at Hanford (282 million curies). In the ROD, DOE decided to retrieve, separate, vitrify, and dispose of the tank waste (62 FR 8693). The low activity waste fraction from the separation process would be retrievably stored onsite. The HLW would be disposed of at a geologic repository. A decision on disposition of cesium and strontium capsules was deferred. This HSW EIS does not address HLW management and disposal. However, the tank waste remediation program is expected to be a major generator of LLW and MLLW sent to the solid waste program for disposal in the Hanford LLBGs.

- **Waste Management Programmatic EIS (DOE/EIS-0200 May 1997)**

The WM PEIS is a DOE complex-wide study examining the environmental impacts of managing more than 2,000,000 m^3 (2,700,000 yd^3) of radioactive wastes from past, present, and future DOE activities (DOE 1997a). The DOE goal in preparing the WM PEIS was to develop a nationwide strategy to treat, store, and dispose of the wastes in a safe, responsible, and efficient manner that minimizes the impacts to workers and the public. Wastes analyzed in the WM PEIS result primarily from nuclear weapons production and related activities. They include MLLW, LLW, TRU waste, HLW, and hazardous waste. The study provides information on the impacts of various alternatives that DOE used to decide at which sites to consolidate or decentralize treatment, storage, and disposal activities for each waste type. However, the specific location of new facilities at selected sites will not be decided until completion of sitewide or project-specific NEPA reviews for the activities.

Management of CERCLA waste generated by DOE environmental restoration activities was reviewed, but not analyzed, in the WM PEIS. The Natural Resources Defense Council and other non-governmental groups filed a lawsuit in 1997 to require DOE to prepare a programmatic EIS for its environmental restoration program. The lawsuit was settled in 1998 when DOE and the other parties agreed to develop tools that would enhance public understanding of DOE site cleanup. Under the terms of the settlement, DOE agreed to complete three major items:

1. develop and deploy a Central Internet Database with information on waste, materials, facilities, and contaminated media
2. conduct a study on long-term stewardship
3. establish a $6.25 million fund for technical and scientific reviews by citizen and tribal organizations.

The Final WM PEIS was issued in May 1997, and decisions for each waste type analyzed in the WM PEIS have since been issued. The TRU waste treatment and storage ROD (63 FR 3629) announced that TRU waste at DOE sites would be treated and stored at the generator site prior to disposal at WIPP. The WM PEIS analyzed potential impacts associated with Hanford's receipt of TRU waste from other sites for treatment and storage prior to disposal at WIPP. However, the ROD for TRU waste did not provide for transfer of TRU waste to Hanford.

The hazardous waste treatment ROD (63 FR 41810) announced a DOE decision to continue to use commercial facilities for the treatment of non-wastewater hazardous waste generated at DOE sites. The HLW storage ROD determined that HLW should be stored at the generator sites pending disposal in a geologic repository (64 FR 46661).

The ROD for MLLW and LLW was issued on February 25, 2000 (65 FR 10061). Under this decision, DOE will continue to rely on sites that have existing capacity to treat or dispose of LLW and MLLW. Hanford and the Nevada Test Site (NTS) were identified in the ROD to receive LLW and MLLW from other DOE sites that do not have capabilities to dispose of their wastes. The Idaho National Engineering and Environmental Laboratory, Los Alamos National Laboratory, the Oak Ridge Reservation (ORR), and the Savannah River Site (SRS) would continue to dispose of LLW generated at those sites, as well as waste generated by the naval nuclear propulsion program. DOE also identified Hanford, the Idaho National Engineering and Environmental Laboratory, ORR, and SRS as regional MLLW treatment facilities that could accept waste from other sites for treatment. Those decisions generally represent a continuation of ongoing treatment and disposal activities at the identified sites. The final disposition of particular waste streams would be based on matching waste characteristics to waste acceptance criteria at each disposal site. Following publication of these decisions, ORR (DOE 2001c) and SRS (DOE 2001d) prepared NEPA analyses for shipment of LLW and MLLW to other DOE sites, potentially including Hanford.

Analyses of alternatives in the HSW EIS are consistent with, and tier from, DOE complex-wide policies and practices that have been described in the WM PEIS ROD for each waste type. This draft HSW EIS alternatives include the impacts from managing a range of LLW and MLLW volumes to reflect the potential waste receipts from offsite sources.

- **Relocation and Storage of Isotopic Heat Sources (DOE/EA-1211 June 1997)**

In this EA, DOE proposed construction and operation of a storage site at the CWC in the 200 West Area of the Hanford Site for storage, pending future disposal decisions, of isotopic heat sources that were previously stored in the 324 Building (DOE 1997d). The material includes 34 isotopic sources: 30 sealed isotopic heat sources manufactured in the 324 Building as part of a bilateral agreement between the Federal Republic of Germany and DOE; two production demonstration canisters; and two instrumented canisters. The agreement was for developing processes for the treatment and immobilization of HLW. Subsequently, the need for the sources was eliminated and Germany and DOE entered into another agreement for the storage and disposition of the materials. Based on analyses in the EA, DOE determined the proposed action was not a major federal action significantly affecting the quality of the human environment and issued a FONSI on June 6, 1997.

- **Waste Isolation Pilot Plant Disposal Phase Final Supplemental EIS (DOE/EIS-0026-S-2 September 1997)**

  DOE prepared the *Waste Isolation Pilot Plant Disposal Phase Final Supplemental EIS* to consider disposal of TRU waste at the WIPP (DOE 1997b). The supplement evaluated transportation methods, the disposal inventory, and the level of treatment required for disposal or storage (repackaging to meet planning basis WIPP waste acceptance criteria, thermal treatment, or treatment by shred and grout). The Hanford Site was considered for treatment of TRU waste by any of the three methods, and for storage of TRU waste (either without disposal at WIPP or pending disposal). The ROD was issued on January 23, 1998 to dispose of Hanford and other sites' TRU waste at WIPP (63 FR 3623), after treatment to meet WIPP waste acceptance criteria. The HSW EIS evaluates the impact of processing Hanford's TRU waste for ultimate disposal at WIPP.

- **Final Hanford Comprehensive Land-Use Plan EIS (DOE/EIS-0222F September 1999)**

  DOE prepared a *Final Hanford Comprehensive Land-Use Plan EIS* (HCP EIS, formerly named *Hanford Remedial Action Environmental Impact Statement and Comprehensive Land-Use Plan*) to evaluate the potential environmental impacts associated with implementing a comprehensive land-use plan for the Hanford Site for at least the next 50 years (DOE 1999c). Working with federal, state, and local agencies and tribal governments, DOE evaluated six land use alternatives. In the ROD for the HCP EIS, DOE decided to designate the 200 Areas for Industrial-Exclusive use (64 FR 61615). Radioactive and hazardous waste treatment, storage, and disposal activities, as described in this draft HSW EIS, are consistent with the Industrial-Exclusive land use selected for the 200 Areas in the HCP EIS.

- **Environmental Assessment – Disposition of Surplus Hanford Site Uranium, Hanford Site, Richland, Washington. (DOE/EA-1319 June 2000)**

  An EA was prepared to assess environmental impacts associated with the disposition of surplus Hanford Site uranium. DOE identified about 1900 metric tons of uranium (MTU) on the Hanford Site as surplus (DOE 2000). DOE decided to relocate approximately 900 MTU of potentially saleable uranium materials to DOE's Portsmouth site near Portsmouth, Ohio, for future beneficial use. The remaining materials consisted of approximately 140 MTU that were subsequently disposed of onsite, and approximately 825 MTU, which would be consolidated and stored in the 200 Areas pending final decisions on its disposition. The materials designated for onsite management may ultimately be transferred to the solid waste program for disposal in the Hanford Site LLBGs. Based on analyses in the EA, DOE determined the proposed action was not a major federal action significantly affecting the quality of the human environment and issued a FONSI on June 15, 2000.

- **Environmental Assessment – Use of Existing Borrow Areas, Hanford Site, Richland, Washington. (DOE/EA-1403 October 2001)**

  This EA evaluated potential environmental consequences of operating existing borrow areas at the Hanford Site to provide soil, sand, gravel, and rock for construction projects, site maintenance

activities, and closure of solid waste burial sites (DOE 2001e). Although the total quantities of material necessary for final closure of the 200 Area LLBGs were not included in this EA, the locations evaluated include likely sources for these materials in the foreseeable future. Based on analyses in the EA, DOE determined the proposed action was not a major federal action significantly affecting the quality of the human environment and issued a FONSI on October 10, 2001.

- **Environmental Assessment – Transuranic Waste Retrieval from the 218-W-4B and 218-W-4C Low-Level Burial Grounds, Hanford Site, Richland, Washington. (DOE/EA-1405 March 2002)**

  This EA was prepared to evaluate alternatives for retrieval of some suspect TRU waste retrievably stored in the LLBG trenches (DOE 2002). The activity would involve recovery of up to 15,200 208-L (55-gal) drums and a small number of miscellaneous other containers of post-1970 suspect TRU waste buried in the 200 West Area LLBGs. The contents of each container would be evaluated and containers determined not to be TRU waste would remain in the LLBGs. Drums that contain TRU waste would ultimately be processed and certified at the WRAP and shipped to WIPP for disposal. Based on analyses in the EA, DOE determined the proposed action was not a major federal action significantly affecting the quality of the human environment and issued a FONSI on March 22, 2002.

1.5.4 Related State Environmental Policy Act Documents

This section describes non-DOE documents for facilities that may be used as part of the overall solid waste program for management of Hanford Site LLW and MLLW.

- **Draft Environmental Impact Statement. Commercial Low-Level Radioactive Waste Disposal Site, Richland, Washington, Washington State Department of Health (WDOH) and Washington State Department of Ecology (August 2000).**

  WDOH and Ecology (2000) evaluated potential environmental consequences of operating a commercial LLW disposal facility located near the Hanford Site 200 Areas. The EIS evaluated renewal of the facility's operating license, establishing an upper limit on disposal rate for some types of LLW, and approval of the site stabilization and closure plan. The Hanford Site could dispose of some LLW at commercial facilities if there were cost or environmental benefits to utilizing non-DOE disposal capacity. The final SEPA EIS had not been issued at the time of publication of this draft HSW EIS.

- **Environmental Impact Statement for Treatment of Low-Level Mixed Waste, City of Richland. (February 1998)**

  The City of Richland, Washington published a SEPA EIS (City of Richland 1998) for operation of a MLLW treatment facility by ATG. The EIS analyzed impacts of construction and operation of the facility in Richland for treatment of MLLW from federal and private customers, including Hanford and potentially other DOE sites. The consequences of treating limited quantities of Hanford MLLW at this facility were also evaluated separately (DOE 1998, 1999a).

1.6 Public Involvement Process and Record of Decision

This draft HSW EIS has been distributed for review and comment to the general public, members of Congress, appropriate federal agencies, interested governmental organizations, and affected state, tribal, and local governments. In addition to soliciting written comments, DOE will schedule public hearings to receive oral and written comments on this draft HSW EIS. These public hearings will be announced in the *Federal Register* and by other means.

After considering the comments received on this draft HSW EIS, DOE will revise the document as needed. DOE will consider all comments received during the public comment period on the draft EIS and will consider to the extent practicable those comments received after the public comment period ends. A final EIS or an addendum to this draft EIS will be issued depending on the extent and scope of revisions. The final EIS will receive a distribution similar to that of this draft EIS.

Following completion of the final EIS, but no sooner than 30 days after the notice of availability of the final EIS is published in the *Federal Register*, DOE will publish any ROD(s) in the *Federal Register*. In addition to the environmental consequences described in this draft EIS, DOE may evaluate other issues such as cost, programmatic considerations, and national needs in making its decision(s).

If mitigation measures, monitoring, or other conditions are adopted as part of the DOE decision, they will be summarized in the ROD, as applicable, and a mitigation action plan will be prepared. The ROD and mitigation action plan, if needed, will be placed in the DOE reading room in Washington, D.C., and in the DOE-RL Public Reading Room at Washington State University, Tri-Cities Campus. They will also be available to interested parties upon request.

1.7 References

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40 CFR 1500-1508. 2001. "Council on Environmental Quality Environmental Policy Act." U.S. Code of Federal Regulations. Online at: http://www.access.gpo.gov.

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42 USC 6901 *et seq*., Resource Conservation and Recovery Act (RCRA) of 1976. Online at: http://www4.law.cornell.edu.

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62 FR 55615. 1997. "Notice of Intent to Prepare a Hanford Site Solid (Radioactive and Hazardous) Waste Program Environmental Impact Statement, Richland, Washington," *Federal Register* (October 27, 1997).

62 FR 65254. 1997. "Hanford Site Solid (Radioactive and Hazardous) Waste Program Environmental Impact Statement Richland, Washington; Public Scoping Period Extension," *Federal Register* (December 11, 1997).

63 FR 3623. 1998. "Record of Decision for the Department of Energy's Waste Isolation Pilot Plant Disposal Phase," *Federal Register* (January 23, 1998).

63 FR 3629. 1998. "Record of Decision for the Department of Energy's Waste Management Program: Treatment and Storage of Transuranic Waste," *Federal Register* (January 23, 1998).

63 FR 41810. 1998. "Record of Decision for the Department of Energy's Waste Management Program: Treatment of Non-wastewater Hazardous Waste," *Federal Register* (August 5, 1998).

64 FR 46661. 1999. "Record of Decision for the Department of Energy's Waste Management Program: Storage of High-Level Radioactive Waste," *Federal Register* (August 26, 1999).

64 FR 61615. 1999. "Record of Decision: Hanford Comprehensive Land-Use Plan Environmental Impact Statement (HCP EIS)." *Federal Register*. (November 12, 1999).

65 FR 10061. 2000. "Record of Decision for the Department of Energy's Waste Management Program: Treatment and Disposal of Low-Level Waste and Mixed Low-Level Waste; Amendment of the Record of Decision for the Nevada Test Site." *Federal Register* (February 25, 2000).

City of Richland. 1998. *Environmental Impact Statement for Treatment of Low-Level Mixed Waste*. Prepared by Jacobs Engineering Group, Inc. for the Allied Technology Group Mixed Waste Facility. Richland, Washington.

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2.0 Background Information on Waste Streams and Waste Management Facilities

This section describes the following:

- the three waste types, low-level waste (LLW), mixed low-level waste (MLLW), and transuranic (TRU) waste
- the specific waste streams within the three waste types
- the waste management facilities that are currently being used
- the new or modified facilities that may be needed in the future for Hanford waste management activities.

Additional information on Hanford waste streams and facilities is contained in Appendixes B and C and the Fluor Hanford, Inc. document (2002).

2.1 Solid Waste Types and Waste Streams

Historically solid LLW was disposed of in shallow land disposal units. In 1970, a U.S. Department of Energy (DOE) predecessor agency, the U.S. Atomic Energy Commission (AEC), determined that waste containing TRU radionuclides would be managed separately from LLW and stored until an appropriate disposal facility was available (AEC 1970). Beginning at that time, the suspect TRU waste was placed into retrievable storage (hence it is sometimes called “retrievably stored”).

In 1987, DOE directed that radioactive waste containing chemically hazardous components, as identified under the Resource Conservation and Recovery Act (RCRA), be separated and managed separately from LLW (10 CFR 962.3). This waste, referred to as MLLW, is placed into aboveground storage facilities at Hanford until it can be treated and disposed of.

Each of the three waste types has been further divided into waste streams for analysis in this Hanford Solid (Radioactive and Hazardous) Waste Program Environmental Impact Statement (HSW EIS). For the purposes of this EIS, a waste stream is defined as waste with physical and chemical characteristics that would generally require the same management approach (i.e., using the same storage, treatment, and disposal capabilities). The waste types and waste streams considered within this EIS are shown in Figure 2.1. Brief descriptions of the waste streams are contained in subsequent sections. Information on the volume of waste associated with each stream is contained in Section 3.4.

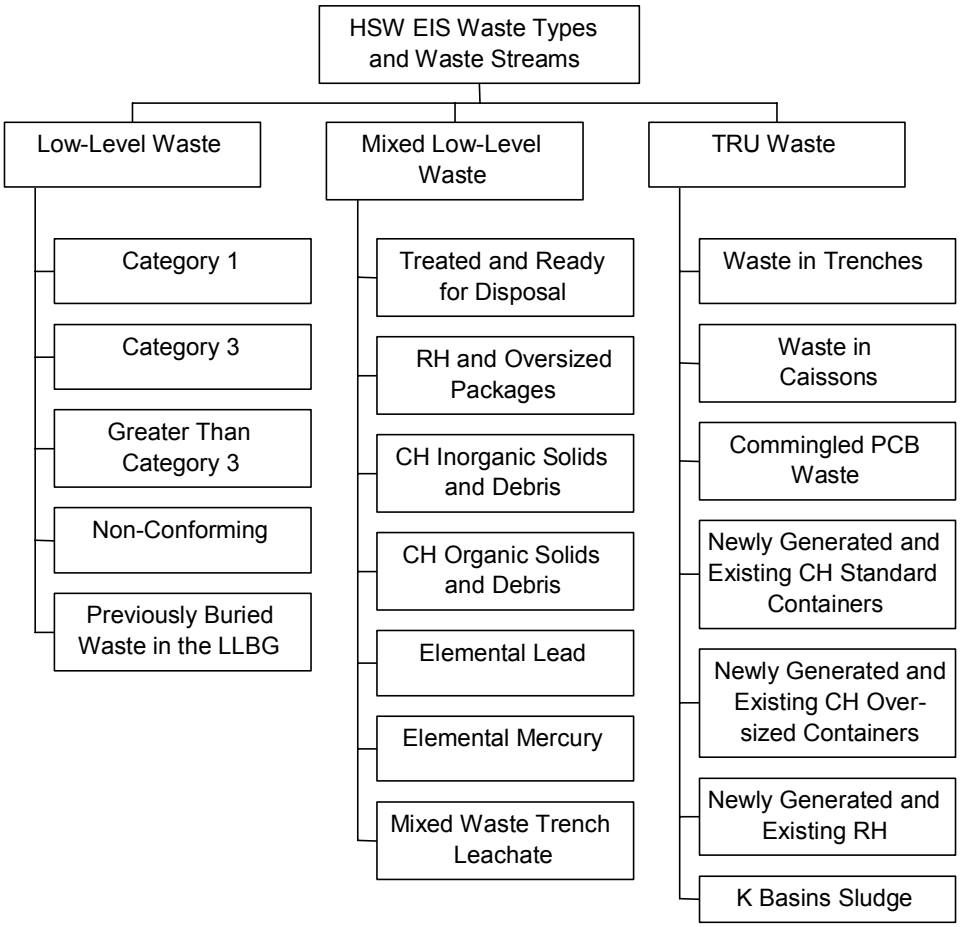

Figure 2.1. Waste Types and Waste Streams Considered in the HSW EIS

Radioactive waste is identified as contact-handled (CH) or remote-handled (RH). CH waste has a dose rate less than 200 millirem/hr as measured with the detector in contact with the container and can usually be handled without shielding. The RH waste classification applies to containers with a contact dose rate greater than 200 millirem/hr. RH waste requires the use of additional shielding in special facilities to protect workers.

2.1.1 LLW Streams

Low-level waste may be generated during the handling of radioactive materials, which results in the contamination of items and materials. Because many different activities are conducted using different types of radioactive materials and levels of radioactivity, there is a wide variation in the chemical and physical characteristics of waste and levels of contamination. Most of the LLW currently in the Low Level Burial Grounds (LLBGs) was generated by analytical laboratories, reactors, separation facilities, plutonium processing facilities, and waste management activities. At Hanford, solid LLW includes protective clothing, plastic sheeting, gloves, paper, wood, analytical waste, contaminated equipment, contaminated soil, nuclear reactor hardware, nuclear fuel hardware, and spent deionizer resin from

purification of water in radioactive material storage basins. In the foreseeable future, analytical laboratories, research operations, facility deactivation projects, waste management activities, and other onsite and offsite activities would likely continue to generate LLW.

Typical containers used for burial of LLW include 208-L (55-gal) metal drums and boxes nominally 1.2 m by 1.2 m by 2.4 m (4 ft by 4 ft by 8 ft) in size. Other boxes are made in various sizes to accommodate specific waste items. Cardboard, wood, and fiber-reinforced plastic boxes have also been used. Large items or equipment may be wrapped in plastic. However, some bulk waste (that is, soil or rubble) is disposed of without containers.

Both onsite and offsite generators of LLW are required to meet specific criteria for their wastes to be accepted for disposal at Hanford. Those requirements are defined in the *Hanford Site Solid Waste Acceptance Criteria* (HSSWAC) (FH 2001). To verify that generators conform with the HSSWAC, a random sample of incoming CH waste is periodically selected for verification at the Waste Receiving and Processing Facility (WRAP), the T Plant Complex, or other appropriate location. Verification of RH waste is typically conducted at the generating facility. Discovery of non-conforming waste can result in rejection of the waste for disposal or the need for removal or treatment of prohibited items. Most LLW is only stored for short periods of time awaiting verification or disposal.

The HSSWAC also define LLW categories summarized below by radionuclide activity level. The categories are based on site-specific performance assessments that were conducted in conformance with DOE Manual 435.1-1 (DOE 2001a). The HSSWAC should be consulted for technical details defining Category 1 (Cat 1), Category 3 (Cat 3), and greater than Category 3 (GTC3) wastes.

The U.S. Nuclear Regulatory Commission (NRC) in Code of Federal Regulations 10 CFR 61.55 defines four classes of LLW (A, B, C, and greater than Class C). However, the radionuclide concentrations specified for each NRC class are not necessarily the same as those defined in the HSSWAC for LLW categories.

2.1.1.1 Low-Level Waste – Category 1

Cat 1 LLW represents the largest volume of waste expected at the Hanford Site. It has the lowest concentrations of radioactivity and can be directly placed into the LLBG trenches without treatment and in some cases without additional packaging. Cat 1 LLW can be either CH or RH waste.

2.1.1.2 Low-Level Waste – Category 3

In the original development of the waste categories, Category 2 LLW was defined. However, this category resulted in a small volume of waste and the previous Category 2 material is now managed as Cat 3 LLW. Cat 3 LLW is defined as having radionuclide concentrations greater than limits specified in the HSSWAC for Cat 1 LLW, but lower than maximum concentration limits defined for Cat 3 LLW. Cat 3 LLW is similar to Cat 1 LLW except that it has higher concentrations of certain radionuclides, and requires greater confinement for burial in the LLBGs (FH 2001). Cat 3 LLW may also be CH or RH waste. Greater confinement in the LLBGs has typically been provided either by packaging the wastes in

high-integrity containers (HICs) or by creating a monolithic waste form in the trench prior to burial (Section 2.2.3). Typical sources of the Cat 3 LLW are operation or cleanout of hot cells and canyon facilities, removal of HLW storage tank equipment, examination of irradiated reactor fuel assembly components, and other operations that handle higher activity items.

2.1.1.3 Low-Level Waste – Greater Than Category 3

GTC3 LLW exceeds the radionuclide concentration limits for Cat 3 LLW. GTC3 LLW requires a specific enumeration to demonstrate that requirements of the LLBG performance assessment would be met before it can be disposed of at Hanford. GTC3 LLW can generally be disposed of in the same manner as Cat 3 LLW in HICs or by in-trench grouting. The sources of GTC3 LLW are similar to Cat 3 LLW. However, very small volumes of this waste stream are expected in the future.

2.1.1.4 Low-Level Waste – Non-Conforming

Non-conforming LLW is waste that does not meet the current HSSWAC for burial and cannot readily be treated to meet those requirements. For example, the major non-conforming waste characteristic is waste that exceeds one percent free liquid. Non-conforming waste needs to be processed so it conforms with the HSSWAC.

2.1.1.5 Previously Buried Waste in the Low-Level Burial Grounds

This waste stream includes the waste that was placed in the LLBGs after 1962, but excludes the retrievably stored TRU wastes. The previously buried waste is included in this EIS to allow an evaluation of LLBG performance for both previously buried and forecast future waste, as well as to assess the long-term risks to the public. Previously buried waste is also included in the operational impacts of LLBG closure.

2.1.2 Mixed Low-Level Waste Streams

MLLW contains non-radioactive hazardous materials as well as radionuclides as defined in Section 1.4.4.2. Regulatory information for mixed wastes can be found in Sections 6.3 and 6.4. In addition to waste subject to RCRA requirements, Hanford has some LLW containing polychlorinated biphenyls (PCBs), which are regulated under the Toxic Substances Control Act (TSCA) of 1976 (15 USC 2601 *et seq*.). TSCA wastes are managed similar to mixed wastes and are included in MLLW inventories and projections. In addition, wastes that are not considered hazardous by the U.S. Environmental Protection Agency (EPA) may be managed as MLLW because they are considered toxic, persistent, or corrosive by state regulations. MLLW was generated by activities similar to those that created LLW, and the two types of waste were managed in the same manner until 1987. Beginning in 1987 DOE managed MLLW at Hanford by placing it into storage at RCRA-permitted facilities until the waste could be treated and disposed of. This required the expansion of the Central Waste Complex (CWC) to provide sufficient capacity to store Hanford's MLLW (DOE 1995).

Hanford's MLLW was generated from operations, maintenance, and cleanout of reactors, chemical separation facilities, high-level waste (HLW) tanks, and laboratories. It consists of materials such as sludges, ashes, resins, paint waste, soils, lead shielding, and contaminated equipment. Hazardous components may include lead and other heavy metals, solvents, paints, oils, other hazardous organic materials, or components that exhibit characteristics of ignitability, corrosivity, toxicity, or reactivity as defined by the RCRA regulations.

Extended storage of MLLW is restricted to specially engineered facilities, such as the CWC, permitted under RCRA and the Washington Hazardous Waste Management Act. However, non-permitted facilities may accumulate newly generated MLLW for periods up to 90 days before transferring them to a permitted storage or treatment facility (WAC 173-303-200). RCRA compliant treatment (generally immobilization or destruction of the hazardous component) is required before most of the MLLW can be sent to a RCRA permitted land disposal facility. In some cases, MLLW will already be treated and RCRA compliant when it is received and can be sent directly to the disposal facility. In other cases, the waste will require treatment prior to disposal. The current approach to treatment of MLLW at Hanford uses a combination of onsite and commercial treatment facilities. The Hanford Site currently has limited capacity for MLLW treatment at the WRAP and the T Plant Complex. Two contracts were placed with a commercial vendor to begin treating limited quantities of CH MLLW in the year 2000 (DOE 1998, 1999). The contracts were intended to serve as a technical demonstration for future commercial treatment of the majority of Hanford's MLLW. After the waste has been treated and meets the RCRA requirements, it can be disposed of in a RCRA-compliant disposal facility. Hanford currently has two MLLW disposal trenches located in the 200 West Area that are operating under RCRA permits. To minimize settling of the cover and caps on the burial ground, waste packages are required to be 90 percent full when they are received.

2.1.2.1 Mixed Low-Level Waste – Treated and Ready to Dispose

This waste stream consists of MLLW that has been treated to meet the RCRA and state requirements for land disposal. The River Protection Project (RPP) is expected to be the primary Hanford generator MLLW. The RPP waste consists of long-length equipment (see Figure 2.2) from HLW tank retrieval operations, which would be macroencapsulated, and glass melters removed from the tank waste treatment plant. Most MLLW received from offsite generators is expected to arrive RCRA compliant and ready for disposal. Both onsite and offsite MLLW would be required to meet the HSSWAC.

2.1.2.2 Mixed Low-Level Waste – RH and Oversized Packages

Existing and forecast quantities of RH MLLW cannot currently be treated within the existing MLLW treatment contracts or at onsite facilities. This waste has physical and chemical characteristics similar to other MLLW, but requires a shielded facility and special equipment for remote handling that does not exist at Hanford. In the future some oversized packages of CH waste may also be received for which there is no treatment facility. This waste would remain in storage until treatment facilities are available.

Figure 2.2. Long Length Equipment Being Removed from a Tank

2.1.2.3 MLLW – CH Inorganic Solids and Debris

> ***Non-Thermal Treatments*** such as stabilization and macroencapsulation are used to immobilize radionuclides and other hazardous inorganic components using cement or thermoplastics either as a jacket of material around the waste or as a matrix incorporating the waste.

Inorganic solid waste may include substances such as sludges, paints, and dried inorganic chemicals. Debris waste must meet RCRA criteria (WAC 173-303-040). Inorganic debris wastes often contain metal, ceramic, and concrete items and may result from removal of failed or obsolete equipment or from disposal of items used during process operations. They may also result from cleanout or decommissioning of inactive facilities. These wastes generally require treatment by stabilization, immobilization, or macroencapsulation before disposal.

2.1.2.4 MLLW – CH Organic Solids and Debris

> ***Thermal Treatments***
> are used to destroy organic constituents within the waste that can be either hazardous or non-hazardous. Thermal treatment use, high temperatures and can include processes such as arc plasmas, incinerators, or vitrification.

Organic solid waste may include substances such as resins, organic absorbents, and activated carbon. Organic debris wastes meet the requirements for debris wastes (WAC 173-303-040) and have a greater than 10 percent organic/carbonaceous content. Typical wastes include paper, wood, plastic, or inorganic debris contaminated with organic constituents that require treatment for their organic content. These wastes are included as organic/carbonaceous waste in WAC 173-303-140, which requires that they be thermally treated if capacity is available. There are no existing or planned Hanford facilities with thermal treatment capability for solid waste. Until thermal treatment is available within 1610 km (1000 mi), DOE has been authorized by Washington State Department of Ecology (Ecology) to treat organic debris waste by macroencapsulation.

2.1.2.5 MLLW – Elemental Lead

Lead metal has been used at Hanford and other DOE sites for radiation shielding and in applications where its high density is of benefit. Most of the lead waste has surface contamination and some of the lead is radioactive from neutron activation. Lead waste must be treated as mixed waste by macroencapsulation, or other approved technology, before disposal.

2.1.2.6 MLLW – Elemental Mercury

> ***Thermal Desorption***
> heats the waste to temperatures sufficient to vaporize mercury which is subsequently condensed in a separate vessel.
>
> ***Amalgamation***
> Solidification of mercury by mixing it with sulfur to form a solid with low mercury vapor pressure.

Elemental mercury is a contaminant for several different types of waste. Waste can contain liquid mercury from various items (that is, light bulbs, switches, thermometers, and chemical process equipment). Mercury can be removed from bulk waste by thermal desorption and then solidified by amalgamation. Limited amalgamation treatment capacity for mercury waste is available at existing Hanford facilities, but additional capability for treatment of the remaining waste is needed.

2.1.2.7 MLLW – Mixed Waste Trench Leachate

This waste stream is generated from operation of the MLLW trenches. It is mostly rainwater or melted snow that is trapped by the collection systems in the MLLW trenches. It is a liquid waste and is managed differently from the other wastes discussed in this EIS. The liquid waste is currently removed from the lined trenches and trucked to the Effluent Treatment Facility (ETF) where it is treated along with other liquid mixed wastes. Solid waste resulting from the treatment is included in the solid waste streams discussed in previous sections.

2.1.3 Post-1970 TRU Waste Streams

TRU waste is material that has been contaminated with elements that have a higher atomic number than uranium (transuranics). The production of TRU materials, primarily plutonium, was the primary defense mission of the Hanford Site. Most of the Hanford TRU waste was produced in plutonium handling facilities for management of weapons materials or from research on plutonium fuels.

Prior to 1970, TRU waste had not been designated as a separate waste type. In 1970 the AEC determined that waste containing transuranics might be associated with increased hazards and should be disposed of in facilities that provide a greater level of confinement than the type of shallow land burial typically used for disposal of LLW.

The definition of TRU waste is based on the concentration of alpha-emitting TRU isotopes with a half-life of greater than 20 years. Initially, the AEC set a minimum concentration level of TRU at 10 nanocuries per gram of waste. At that time field instrumentation was not available to measure concentrations at that level. Therefore, any waste associated with the handling of plutonium was considered to be suspect TRU waste and was placed in retrievable storage. The definition of TRU waste was changed to 100 nanocuries/gram in 1984. Therefore, some of the suspect TRU waste placed into retrievable storage before 1984 can be managed as LLW once it is determined that the concentration of transuranics is below 100 nanocuries/gram. An evaluation of the CH waste placed into retrievable storage estimated that 50 percent of the drums currently managed as TRU waste would be reclassified as LLW (Anderson *et al*. 1990).

After 1970, TRU waste was stored in several different ways at Hanford. TRU waste was initially placed into retrievable storage in the LLBGs, either with or without a soil cover. After 1985 most TRU waste was no longer placed in trenches, but was stored in an existing facility near the T Plant Complex that had been retrofitted for TRU waste storage. This building was known as the Transuranic Storage and Assay Facility (TRUSAF). Waste storage in that facility was discontinued in 1998 and its inventory, along with all newly generated TRU waste, is now stored in the CWC.

TRU waste disposal began in 1999 with the opening of DOE's Waste Isolation Pilot Plant (WIPP) in New Mexico. The Hanford Site began shipping waste to WIPP in July 2000. Wastes to be shipped to WIPP must be certified to meet the WIPP Waste Acceptance Criteria (DOE-WIPP 1999). WRAP was designed and built at Hanford to perform certification of some TRU waste for disposal at WIPP, along with several other functions. Currently, CH TRU drums are being removed from CWC, certified at the WRAP, and shipped to WIPP. TRU waste drums are placed in shipping casks known as Transuranic Package Transporter-II (TRUPACT-II) and are transported by special trucks to the WIPP (see http://www.emnrd.state.nm.us/wipp/trubig.htm for description).

In the future some TRU waste may be shipped by rail. The consequences of transportation and disposal of TRU waste at WIPP were evaluated in the WIPP Supplemental Environmental Impact Statement (SEIS) II (DOE 1997a) and the Waste Management Programmatic Environmental Impact Statement (WM PEIS) (DOE 1997b) and, therefore, are not included within the scope of this EIS.

Some TRU waste also contains hazardous components (mixed TRU waste) and would be managed under RCRA or TSCA. All TRU waste is managed in the same manner, and mixed TRU waste has not been identified as a separate waste type in this EIS. Mixed TRU waste is acceptable at WIPP. DOE's hazardous waste permit for WIPP, issued by the State of New Mexico Environment Department, authorizes the disposal of CH mixed TRU waste.

2.1.3.1 TRU Waste – Waste from Trenches

From 1970 to 1985 the primary method for storage of TRU wastes involved placing drums or boxes of waste on asphalt pads and covering the drums with wood, plastic, and a layer of soil (see Section 2.2.1.2). The post-1970 TRU waste placed in trenches was expected to remain there for less than 20 years. Corrosion of the packaging has continued since they were buried and preliminary inspection of some older containers has confirmed deterioration in their condition. However, observations and monitoring of the area around the drums within the trenches has not detected the release of any alpha emitters, such as plutonium.

DOE previously decided to retrieve this TRU waste (DOE 1987; 53 FR 12449) for disposal at WIPP. Because it was previously evaluated, retrieval of the waste is not evaluated in this EIS. The CH drums can be processed, repackaged, and certified at WRAP. However, neither the Hanford Site, other DOE sites, nor commercial facilities have the capability to process, certify, and ship oversized boxes or RH wastes to WIPP. Processing of these wastes would require development of new capabilities.

2.1.3.2 TRU Waste – Waste from Caissons

Beginning in 1970 through 1988 higher activity TRU waste was placed in four caissons for retrievable storage. The TRU waste caissons are located in burial ground 218-W-4B as shown in Appendix D. Most of the waste in the TRU caissons originated from laboratory activities in hot cells in the 300 Area facilities. About 5500 containers were sent to these caissons. Of those, about 97 percent were 4.5-L (1-gal) cans containing residue from the examination of nuclear fuels and irradiated structural materials. Some of the individual containers had measured radiation levels in excess of 1500 R/hr at the time of placement. Other wastes included small-scale process equipment used for radionuclide separations operations. For additional information about the caissons see Section 2.2.1.3.

DOE previously decided to retrieve this waste (DOE 1987; 53 FR 12449) for disposal at WIPP. The retrieval of this waste is not evaluated in this EIS; however, the processing of this waste is evaluated.

2.1.3.3 TRU Waste– Commingled PCB Waste

A small amount of TRU waste has sufficient concentrations of PCBs to make it subject to TSCA requirements. The majority of the material is debris commingled with a small amount of PCBs, although some drums contain liquids with higher PCB content. Sludge from the K Basins is also TSCA regulated due to its PCB content, but is discussed separately in Section 2.1.3.7. At this time TSCA regulations require treatment of PCB wastes by incineration or other approved technology (40 CFR 761.60). TRU waste commingled with PCBs has not yet been approved for disposal at WIPP. However, DOE is

preparing a permit application to allow disposal of this waste at WIPP. If WIPP is granted a permit to dispose of PCB-commingled waste, treatment may not be necessary for the debris materials. Liquid waste containing PCBs may still require thermal treatment or an approved alternative treatment before it could be accepted at WIPP. No capabilities currently exist on the Hanford Site to treat PCB waste. The wastes are expected to remain in storage until a treatment facility is available or until WIPP can accept such materials.

2.1.3.4 TRU Waste – Newly Generated and Existing CH Standard Containers

This waste stream includes CH TRU waste in standard containers stored in the CWC and future TRU waste that would be received in standard containers. This waste stream also includes the CH TRU waste that will be retrieved from the 618-10 and 618-11 burial grounds. The retrieved waste will be placed into standard containers including 208-L (55-gal) and 322-L (85-gal) drums and standard waste boxes (SWBs). The SWB is a metal box 181 cm (71 in) long, 94 cm (37 in) high, and 138 cm (54.5 in) wide that has been designed as a Type A shipping container for use in the TRUPACT-II shipping container. The waste would be inspected and certified at WRAP and would ultimately be shipped to the WIPP for disposal.

2.1.3.5 TRU Waste – Newly Generated and Existing CH Non-Standard Containers

This TRU waste is contained in non-standard boxes or containers that are not compatible with a TRUPACT-II shipping container and that cannot be handled within WRAP. Much of this waste is old equipment or gloveboxes that were removed from processing and laboratory facilities. Processing of this waste would likely include size reduction and repackaging. The Hanford Site does not currently have a facility where these wastes can be prepared for shipment to WIPP.

2.1.3.6 TRU Waste – Newly Generated and Existing RH Containers

This TRU waste stream consist of existing and newly generated RH TRU waste, including a small quantity of waste that may be generated during retrieval from the 618-10 and 618-11 burial grounds. Existing RH TRU waste is shielded for storage in the CWC (see Section 2.2.1.1). The Hanford Site does not currently have a facility where RH TRU waste can be prepared for shipment to WIPP, nor are the WIPP waste acceptance criteria or shipping system in place. For analysis in this EIS, it is assumed that RH TRU waste would ultimately be accepted at WIPP.

2.1.3.7 TRU Waste – K Basin Sludge

This sludge is a combination of corrosion debris from stored fuel elements and their containers, dust, and other materials that have accumulated in the 100 Area K Basins over many years of use. Because of the plutonium, fission product and activation product concentrations in the sludges, they have been determined to be RH TRU waste. In addition, the sludge is TSCA regulated due to PCBs. DOE plans to containerize the waste as it is removed from the basins and then transport it to the T Plant Complex for storage (DOE 2001b) until a facility is available to treat the waste and prepare it for shipment to WIPP.

2.2 Hanford Waste Storage, Treatment, and Disposal Facilities, and Transportation Capabilities

This section provides a brief description of existing and proposed facilities for the management of Hanford solid waste. The facilities provide storage, treatment, or disposal functions and are grouped by their primary function in the following discussion. (See FH 2002 for additional details on specific facilities.) Text describing new facilities, or those that would be substantially modified under the alternatives described in Section 3.0 is presented in text boxes to distinguish those facilities from existing facilities. This section also briefly discusses the transportation of waste onsite.

2.2.1 Storage Facilities

Storage Facilities

Existing Facilities
- Central Waste Complex
- LLBGs
  - Trenches
  - Caissons
- T Plant Complex
- WRAP

New/Modified Facilities
- Additional CWC Buildings

The primary storage facility for solid radioactive and mixed waste at Hanford is the CWC. Storage also exists at WRAP, the T Plant Complex, and the LLBGs. The T Plant Complex, described in Section 2.2.2.4 as a treatment facility, would be used to store sludge from the K Basins, and potentially other RH waste, as space is available. Trenches in the LLBGs have been used for retrievable storage of TRU wastes and other materials. Additional details on the CWC, and trenches and caissons in the LLBGs are described in the following sections.

2.2.1.1 Central Waste Complex

The CWC is a series of handling areas, storage buildings, and storage modules that have been built in several phases for the receipt, inspection, storage, and limited treatment (that is, absorption and solidification of free liquids, neutralization of corrosive materials, and stabilization and encapsulation in solid waste matrixes) of wastes and materials awaiting verification, treatment, or disposal. The primary waste types of interest to the HSW EIS, with respect to storage, are MLLW and TRU waste, because most LLW is sent directly to burial. An aerial view of the CWC is shown in Figure 2.3. The Solid Waste Inventory Tracking System lists CWC inventory at the end of 2001 as a total of about 9200 m^3 (325,000 ft^3), comprised mainly of MLLW 7350 m^3 (260,000 ft^3) and TRU waste 1560 m^3 (55,000 ft^3) (FH 2002). Its capacity is estimated to be 16,700 m^3 (589,000 ft^3). Most MLLW and TRU waste received since 1987 is now stored in the CWC, including TRU waste relocated from other facilities at Hanford. The CWC could be expanded as needed for future receipts of waste that require storage, including any retrievably stored waste removed from the LLBGs.

The CWC waste is segregated by content to assure compatibility of the contents of the various storage containers (for example, acidic and basic materials are stored separately). In addition to MLLW and TRU waste, some non-conforming LLW and GTC3 LLW may also be stored in CWC. All waste containers must be CH to be accepted at CWC. Some RH waste is stored at CWC by shielding it to CH levels. Most of the waste is packaged in 208-L (55-gal) drums; however, other package sizes can also be stored.

Figure 2.3. Aerial View of the Central Waste Complex

Typically, four drums are banded onto a pallet to allow easy handling by forklifts and stacked up to three layers high. Aisles are provided to gain access to the drums for required routine visual inspections. The packages have identifying numbers (bar codes) for tracking their location and contents. Waste remains within the CWC until it is shipped to other facilities for processing or disposal.

New/Modified Storage Facility: Additional CWC Buildings

Additional storage buildings would be constructed at CWC as part of the No Action Alternative. The new buildings would be similar to the larger existing buildings. Each new building would be about 37 m (120 ft) wide by 55 m (180 ft) long by 6.1 m (20 ft) high to the eaves, and would hold about 4,600 208-L (55-gal) drums. The interior floors would be sloped with raised perimeter curbing to contain and direct spilled liquids to collection sumps. The floors would be sealed with impervious epoxy resins to reduce impacts of any liquid spills.

2.2.1.2 Retrievable Storage of Suspect TRU Waste in LLBG Trenches

Beginning in 1970, suspect TRU waste, primarily CH but also some RH waste, was placed in retrievable storage at the Hanford Site in specific trenches in Burial Grounds 218-W-3A, 218-W-4B, 218-W-4C, and 218-E-12B. From 1972 to 1973, drums of TRU waste were placed in a concrete V-trench (218-W-4B) with a metal cover. After 1974, drums and boxes were stored in trenches on either asphalt pads or plywood and covered with wood sheathing, tarps, and plastic. A layer of at least 1.2 m (4 ft) of earth was placed over the tarp cover. After 1985 most TRU waste was sent to an aboveground storage facility. However small amounts of waste have occasionally been added to the trench inventory. A small

volume of this waste was never covered with dirt and has recently been removed from the trenches and placed in the CWC. About 14,600 m^3 (516,000 ft^3) of suspect TRU waste remain in the trenches (FH 2002).

2.2.1.3 Retrievable Storage of TRU Waste in LLBG Caissons

The TRU waste caissons, designed to store RH waste, are reinforced cylindrical steel and concrete vaults 2.4 m (8 ft) in diameter and 3 m (10 ft) high. Four caissons have received TRU waste. The caissons were buried in Trench 14 of Burial Ground 218-W-4B. The caissons have an offset connecting chute between the caisson and the soil surface to reduce radiation dose to workers as the waste was deposited.

Gases from the caissons are passively filtered through high-efficiency particulate air (HEPA) filters. Caisson configuration is illustrated in Figure 2.4. Waste containers similar to 3.8-L and 18.9-L (1- and 5-gal) paint cans were dropped into the loading chute from a shielded shipment cask. Each caisson has been limited to a total plutonium-239 inventory equivalent of 5 kg (11 lb). Radiation levels in the caissons have been measured at 1,500 to 10,000 R/hr (FH 2002).

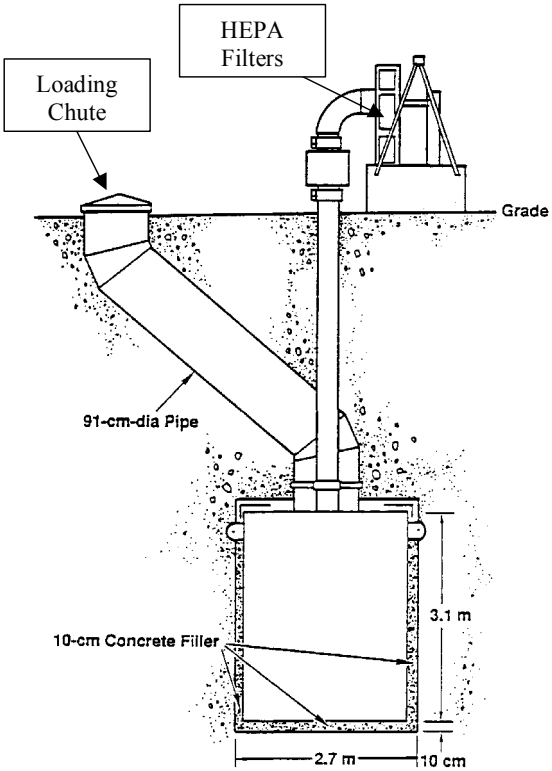

Figure 2.4. Schematic Drawing of RH TRU Caisson

2.2.2 Treatment and Processing Facilities

Treatment and processing facilities include those used to treat MLLW to RCRA standards, as well as those where post-1970 TRU waste is processed and certified for shipment to WIPP. DOE is currently using a combination of Hanford facilities and offsite facilities to treat MLLW and TRU waste. Commercial facilities have provided treatment capabilities for limited quantities of CH MLLW under two existing contracts. DOE does not currently have facilities for treatment of most CH MLLW, treatment of RH MLLW or TRU waste, nor for large containers of MLLW and TRU waste. The ETF provides treatment for leachate from the MLLW trenches.

Treatment And Processing Facilities

Existing Facilities
- WRAP
- T Plant Complex
- ETF
- Commercial Treatment Facilities
- Other DOE sites

New/Modified Facilities
- Modified T Plant Complex
- New M-91 Facility
- Pulse Driers
- Commercial Treatment Facilities

2.2.2.1 Waste Receiving and Processing Facility

WRAP began operation in 1998 on the Hanford Site for management of TRU waste, MLLW, and LLW. The major function of WRAP is the inspection, repackaging, and certification of CH TRU waste to prepare it for transport and disposal at WIPP. The facility is also used to verify that incoming LLW meets HSSWAC, and to characterize MLLW for quality assurance purposes. A picture of WRAP is shown in Figure 2.5.

Figure 2.5. Waste Receiving and Processing Facility

WRAP can accept CH drums and standard waste boxes. Handling of drums and boxes can be performed manually or by use of automated guided vehicles. WRAP provides the capability for non-destructive examination (NDE) and non-destructive assay (NDA) of incoming waste. The NDE is an X-ray process used to identify the physical contents of the waste containers in supporting waste characterization (see Figure 2.6). The NDA is a neutron or gamma energy assay system used to determine radionuclide content and distribution in waste packages.

Figure 2.6. X-Ray Image of Transuranic Waste Drum Contents

A layout for the 4806 m^2 (51,700 ft^3) facility is shown in Figure 2.7. The layout illustrates the major functions of shipping and receiving, examination, and repackaging within WRAP. Many operations at the facility, such as handling, opening, and processing waste packages, are conducted in gloveboxes or using automated equipment to minimize worker exposure to radioactive and hazardous materials. Certified CH TRU waste drums and standard waste boxes are loaded into TRUPACT-II shipping containers for transport from the facility to WIPP. Figure 2.8 shows the loading of a TRUPACT-II container in the WRAP.

WRAP also has limited treatment capabilities for TRU waste and MLLW by deactivation, solidification or absorption of liquids, neutralization of corrosives, amalgamation of mercury, microencapsulation, macroencapsulation, volume reduction by super compaction, stabilization of reactive waste, and repackaging waste as needed.

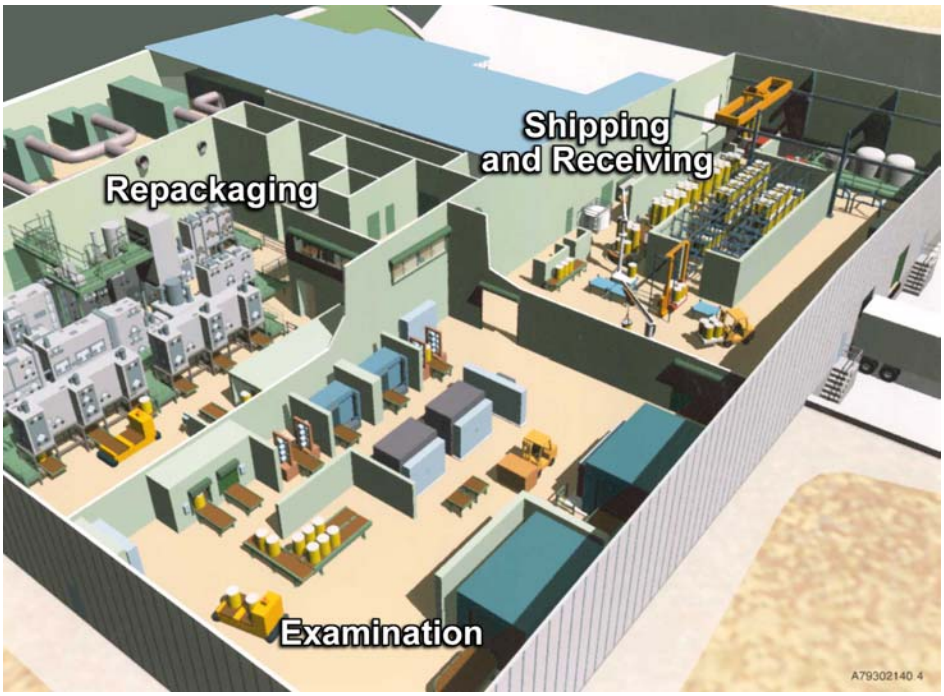

Figure 2.7. Layout for the Waste Receiving and Processing Facility

Figure 2.8. Transuranic Package Transporter-II Being Loaded in the Waste Receiving and Processing Facility

2.2.2.2 Commercial Treatment

Commercial treatment services have been used to treat some Hanford MLLW streams. These treatment capabilities consist of both non-thermal and thermal processes. Two contracts were placed with Allied Technology Group, Inc. (ATG) for thermal and non-thermal treatment of Hanford MLLW in a demonstration project beginning in 2000.

The non-thermal treatment contract provided for treatment of at least 1,600 m^3 (56,500 ft^3) of MLLW. The MLLW will largely consist of debris waste and will be treated principally by stabilization and macroencapsulation. Waste being macroencapsulated at ATG is shown in Figure 2.9. ATG also has some capability for physical extraction, neutralization, chemical oxidation, chemical reduction, microencapsulation, and deactivation. ATG also has pretreatment capability for size reduction, drying, and sorting. The stabilization processes can be either cement or polymer based. Additional details on ATG processes can be found in DOE (1998).

Beginning in 2001 the thermal treatment contract provides for processing a minimum of 600 m^3 (21,200 ft^3) and a maximum of 3,585 m^3 (126,600 ft^3) MLLW over a 5-year period. ATG plans to use a high-temperature process to convert most organic contaminants to carbon dioxide and water (DOE 1999). The solid residuals from this process would be returned to Hanford for disposal. The contract provides treatment for CH MLLW that requires thermal treatment either as the required technology-based standard or as the best-demonstrated available technology for concentration-based land disposal restrictions (LDRs). A total of 125 m^3 (4,400 ft^3) MLLW has been shipped to the contractor for thermal treatment.

Figure 2.9. Macroencapsulation of Mixed Low-Level Waste Debris at Allied Technology Group Commercial Treatment Facilities

New/Modified Treatment Facility: Commercial Treatment Facilities

Under MLLW Alternative 1 existing treatment contracts would be modified or new contracts would be put in place. All CH MLLW in standard size containers would be processed through commercial treatment contracts. In LLW Alternative 1 non-conforming LLW would also be treated through commercial treatment contacts.

2.2.2.3 Leachate Treatment

MLLW disposal facilities are required to incorporate a leachate collection system (WAC 173-303). The collection system retains rain and snowmelt that may contact waste because of the potential to leach hazardous constituents from the waste. The leachate from onsite mixed waste trenches is collected and either sent to the 200 East Area Liquid Effluent Retention Facility (LERF) prior to treatment in the ETF or sent directly to ETF. Leachate is currently transported from the MLLW trenches in the 200 West Area by tanker truck. The ETF treats liquid waste using pH adjustment, filtration, ultraviolet light, and peroxide destruction of organic materials, reverse osmosis, and ion exchange.

The ETF has an approved Part B Permit. The leachate to be treated at ETF is required to meet ETF waste acceptance criteria. If the leachate does not meet these requirements, an alternative treatment is required. The volume of leachate is expected to depend on the exposed surface area of the trenches.

New/Modified Treatment Facility: ETF Replacement Capability

The ETF is scheduled to shut down at the end of 2025. After this time, pulse driers would be used for leachate treatment. The pulse driers treat leachate by evaporation, leaving behind solids as secondary waste. These secondary wastes would be treated, as necessary, and disposed of in MLLW trenches as part of MLLW Alternative 1 and MLLW Alternative 2. Depending on the amount of trench space available, these secondary wastes may be stored in CWC as part of the No Action Alternative.

2.2.2.4 T Plant Complex

The T Plant Complex consists of a number of buildings, as shown in Figure 2.10. The T Plant canyon and tunnel (221-T Building) are used for handling and processing of materials that require remote handling. Spent commercial reactor fuel and other RH wastes are being stored in the T Plant canyon. Dry decontamination, inspection, segregation, verification, and repacking of RH and large items are also performed in the canyon. Current plans are to use the water-filled basin and refurbished process cells at T Plant to provide storage for the K Basin sludge (DOE 2001b). The sludge is expected to remain in the T Plant canyon until a treatment facility is available.

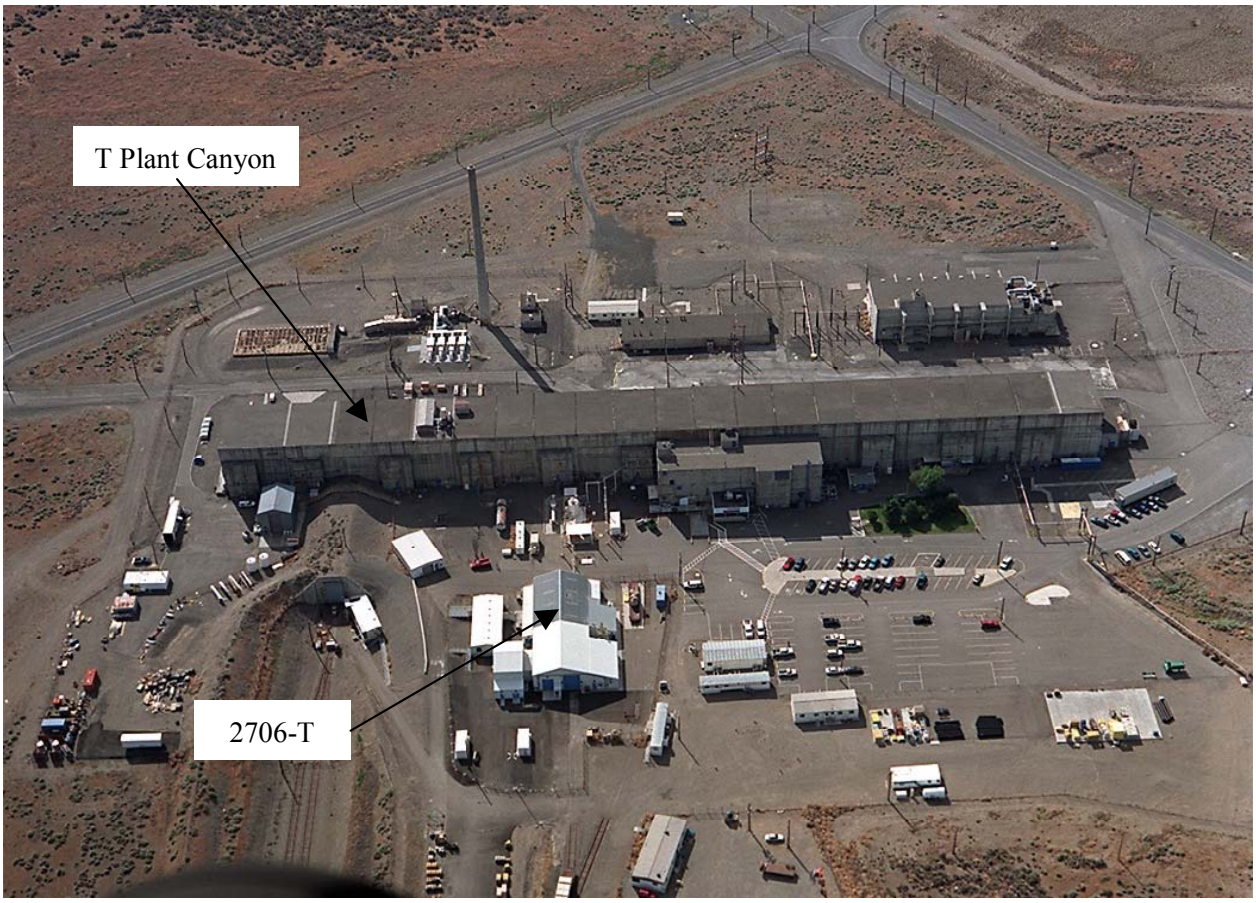

Figure 2.10. View of the T Plant Complex with 2706-T Facility and the T Plant Canyon Noted

The T Plant canyon was built of reinforced concrete during 1943 and 1944 as a chemical reprocessing plant for defense program materials and was subsequently converted to decontamination and support functions in 1957. The building is 21 m (68 ft) wide, 259 m (850 ft) long, and 23 m (74 ft) high. The 37 cells within the building are designed to accommodate very high levels of radioactivity, and most cells have concrete shielding that is 2.1 m (7 ft) thick.

Inspection, verification, opening, sampling, sorting, and limited treatment and repackaging of LLW, MLLW, and TRU waste are performed in the 2706-T Facility and other areas in the T Plant Complex. The 2706-T Facility, initially constructed during 1959 and 1960, was remodeled in 1998 to expand decontamination and treatment capabilities.

New/Modified Treatment Facility: Modified T Plant

In MLLW Alternative 1 and TRU Waste Alternative 1, the T Plant Complex would be modified to meet Tri-Party Agreement (TPA) M-91 Milestone requirements. Milestone M-91 was established to ensure that the capabilities would be developed to treat/process waste for which no treatment capability currently exists. Several waste streams addressed in the HSW EIS are covered by the M-91 Milestone (these include RH MLLW, MLLW in oversized packages, RH TRU waste, CH TRU waste in oversized containers, and PCB-commingled TRU waste). Specific capabilities provided by this modified T Plant include stabilization, macroencapsulation, deactivation, sorting, sampling, repackaging NDE, and NDA.

MLLW would be treated so that it can be disposed of in the MLLW trenches. TRU waste would be processed and shipped to WIPP.

New/Modified Treatment Facility: New M-91 Facility

As part of MLLW Alternative 2 and TRU Waste Alternative 2, a new facility would be constructed to meet the TPA M-91 Milestone requirements as noted above for specific MLLW and TRU waste streams. The facility would process/treat the same waste streams and have all of the capabilities identified above for the modified T Plant Complex.

As part of the MLLW Alternative 2 and LLW Alternative 2, CH MLLW in standard containers, non-conforming LLW, elemental lead, and elemental mercury would also be treated in this new facility. (As part of MLLW Alternative 1 and LLW Alternative 1, these waste streams would be treated through new and or modified commercial treatment contracts.) Specific capabilities provided by the new facility to treat these waste streams could include stabilization, macroencapsulation, thermal desorption, and mercury amalgamation.

The new facility location is assumed to be in the 200 West Area near WRAP; consistent with previous DOE proposals for a modular complex to process MLLW and TRU waste. The new facility would be expected to be larger in size than WRAP (FH 2002).

MLLW would be treated to meet LDRs so that it can be disposed of in the MLLW trenches. TRU waste would be processed and shipped to WIPP.

2.2.3 Disposal Facilities

Facilities used for LLW and MLLW disposal at Hanford consist of the LLBGs, which are described in this section.

TRU wastes are disposed of at the WIPP in New Mexico, which is the DOE geologic repository for TRU wastes. Hanford began shipping TRU waste to WIPP in the summer of 2000 and would continue shipping TRU waste to WIPP for disposal. The transportation and disposal of TRU waste was evaluated in previous DOE EIS documents (DOE 1997a, b) and is not reconsidered in this EIS.

Disposal Facilities

Existing Facilities

- LLBGs
  - LLW Trenches
  - MLLW Trenches

New/Modified Facilities

- LLBGs
  - Current Design LLW Trenches
  - Enhanced Design LLW Trenches
  - Current Design MLLW Trenches
  - Enhanced Design MLLW Trench
  - Melter Trench
  - Closure Caps

LLW has been buried on the Hanford Site since the start of the defense materials production mission. Six LLBGs are located in the 200 West Area (218-W-3A, 218-W-3AE, 218-W-4B, 218-W-4C, 218-W-5, and 218-W-6) and two LLBGs are in the 200 East Area (218-E-10 and 218-E-12B). These eight disposal facilities are collectively referred to as the LLBGs. See Appendix D for additional information about each LLBG. The LLBGs have historically been used for temporary storage of some waste (these functions were previously described). Figure 2.11 shows a picture of a burial ground.

Figure 2.11. Aerial View of a Low Level Burial Ground

The total volume of LLW placed in the LLBGs between 1962 and 1999 was about 283,000 m^3 (10,000,000 ft^3). The waste occupies an area of 141 ha (348 ac). The LLBGs occupy a total area of 425 ha (1,050 ac); thus, approximately two-thirds of the LLBGs would be available for future waste disposal.

Within the LLBGs several techniques can be used to provide extra confinement for Cat 3 LLW and approved GTC3 LLW. These techniques include placement of higher activity LLW deep within the trench, burial in HICs, and in-trench grouting. The higher activity LLW is usually placed in the bottom of the trenches with Cat 1 wastes placed on top of the Cat 3 and GTC3 LLW. This is intended to reduce the risk of intrusion into the higher hazard wastes.

HICs are large cement boxes or cylinders into which the Cat 3 LLW and approved GTC3 LLW are placed for burial. The HIC is first placed within the burial trench and the waste is loaded into the HIC. Figure 2.12 shows four loaded HICs in the bottom of a burial trench. The HIC is then sealed with a lid and buried along with other waste. The HIC provides additional containment for higher activity waste while the radioactivity decays. The concrete used to construct the HICs also changes the chemistry of the soil in the immediate vicinity of the waste, which reduces the mobility of certain radionuclides. When water is exposed to concrete, the pH of the water increases, thereby decreasing the solubility of some waste elements.

Figure 2.12. High-Integrity Containers in a Low-Level Waste Disposal Trench

In-trench grouting involves placing the CH Cat 3 LLW and approved CH GTC3 LLW on a cement pad or on spacers, installing reinforcement steel and forms around the waste, and covering the waste with fresh concrete to encapsulate the waste within a concrete barrier. The process is limited to CH wastes because of the need for workers to be in close contact with the waste to place cement forms around them. Steel fibers are incorporated into the concrete to increase its strength. The resulting monoliths, such as the one shown in Figure 2.13, have a maximum size of 6.4 m (21 ft) long, 4 m (13 ft) high, and 2.7 m (9 ft) wide with a minimum wall thickness of 0.15 m (0.5 ft). After curing, the encased waste is covered with at least 2.4 m (8 ft) of soil. As with the HICs, in-trench grouting provides additional containment for the waste and retards migration of some radionuclides from the LLBGs. In-trench grouting is a more economical method for encapsulation of Cat 3 and GTC3 LLW than using the HIC.

The use of HICs versus in-trench grouting for CH waste is determined on a case-by-case basis. Generally HICs are used for RH wastes while CH wastes are in-trench grouted. However, HICs can be used for either RH or CH waste.

The amount of waste that can be disposed of in a trench varies depending on the specific characteristics of the waste (e.g., CH vs. RH, Cat 1 vs. Cat 3) and how much cover soil is placed on the waste. Typically, about 30 percent to 50 percent of the total trench volume is filled with waste.

Figure 2.13. Trench Grouted Wastes

2.2.3.1 Existing LLW Trenches

The LLW trenches currently comprise a series of relatively long, narrow trenches for disposal of LLW. The dimensions of existing trenches in the LLBGs vary with location. Typically, trenches are about 12 m (40 ft) wide and "V" shaped; however, some trenches are wider with flat bottoms. The trenches are excavated to a depth of 4-6 m (12-20 ft), partially filled with waste, and then a 2.6-m (8-ft) layer of soil is placed over the waste so the surface is near the original grade. Layouts of the trenches within each LLBG are shown in Appendix D.

New/Modified Disposal Facility: Current Design LLW Trenches

Under the LLW No Action and LLW Alternative 2, trenches of the current design would be used to expand LLBG disposal capacity. Dimensions are nominally 12 m (39 ft) wide at the base, 6.1 m (20 ft) deep, 20 m (66 ft) wide on top and length is 350 m (1150 ft). However, the dimensions of each trench are modified to fit within the available space of each specific burial ground. The number of new trenches will depend on the amount and type of waste received.

New/Modified Disposal Facility: Enhanced Design LLW Trenches

Under the LLW Alternative 1, LLW trenches of enhanced (deeper, wider) design would be used to expand LLBG disposal capacity. The reference design for enhanced LLW trenches was assumed to be 67 m (220 ft) wide at the top, 7 m (23 ft) wide at the bottom, and about 18 m (60 ft) deep. The length was assumed to be 350 m (1150 ft). However, the dimensions of each trench are modified to fit within the available space of each specific burial ground. The number of new trenches will depend on the amount and type of waste received.

2.2.3.2 Existing MLLW Trenches

The two existing MLLW trenches (218-W-5, trenches 31 and 34) are located within a LLBG but, for the HSW EIS, they are considered separately from the other LLW disposal trenches. The trenches were permitted by Ecology for MLLW disposal (DOE-RL 1997). One trench (see Figure 2.14) is currently being used as a MLLW disposal unit. The floor dimensions of the trenches are about 30.5 m (100 ft) wide by 76.2 m (250 ft) long and 9.1-10.7 m (30-35 ft) deep. The floor slopes to allow collection of leachate. The surface dimensions are approx 91 m (300 ft) wide by 137 m (450 ft) long and encompass approx 1.3 ha (3.2 ac) of land. RCRA regulations (WAC 173-303) require that waste trenches contain liners to collect any leachate that contacts the waste during the operating period. All liquids collected in the leachate collection system would be treated before disposal as discussed in Section 2.2.2.3. The permit for the existing MLLW trenches requires that disposal areas be capped after they are filled to capacity.

Figure 2.14. Mixed Low-Level Waste Disposal Trench

New/Modified Disposal Facility: Current Design MLLW Trenches

Additional trenches of the current design would be needed in MLLW Alternative 2. New current design MLLW trenches would be the same as those described above for the existing MLLW trenches. Regulations require that waste trenches contain liners to collect any leachate that contacts the waste during the operating period. All liquids collected in the leachate collection system would be treated before disposal. The trenches would be capped after they are filled in accordance with the state permit.

New/Modified Disposal Facility: Enhanced Design MLLW Trench

In MLLW Alternative 1 a higher capacity (deeper and wider) trench would be constructed to increase the efficiency and reduce the cost of future MLLW disposal at Hanford. The enhanced MLLW trench would be 80 m (262 ft) wide as the base and 188 m (617 ft) wide at the top, with a depth of 18 m (59 ft). The length of the trench would be 170 m (558 ft) long for the lower bound volume and 340 m (1115 ft) long for the upper bound volume. Regulations require that waste trenches contain liners to collect any leachate that contacts the waste during the operating period. All liquids collected in the leachate collection system would be treated before disposal. The trench would be capped after it is filled in accordance with the state permit.

New/Modified Disposal Facility: Melter Trench

The vitrification of high-level tank waste on the Hanford Site would result in the need to dispose of used melters. These items would be treated at the vitrification facility so as to be ready for disposal. For MLLW Alternatives 1 and 2, the large melters would be taken to a special trench designed for them. The dimensions for the melter trench would be as follows: 270 m (886 ft) long, 120 m (165 ft) wide, and 21 m (70 ft) deep. To place the melters into the trench a ramp with a 6 percent grade into the trench is planned. Leachate from the melter trench would be treated along with other MLLW trench leachate. The trench would be capped after it is filled in accordance with the state permit.

New/Modified Disposal Facility: LLBG Closure Cap

MLLW trenches are required by state permit to be capped and closed soon after they are filled. The LLBGs would be closed and capped beginning in 2046. While the final design for the closure cap has not yet been decided, the RCRA modified Subtitle C Cap illustrated in Figure 2.15 has been used for the HWS EIS analysis. Up to ~ 3,700,000 m^3 (~ 5,000,000 yd^3) of sand, gravel, rock, and silt/loam would be required as a mineral resource for the surface barriers on Hanford LLW and MLLW trenches. A discussion of the borrow pits to be used for this material is contained in Appendix D.

2.2.4 Transportation Capabilities

Solid waste is currently transported on the Hanford Site by truck. The Site also has a rail system. The system is currently inactive but is planned to be reactivated in FY 2002. The 26 km (16 mi) of track from Columbia Center to Horn Rapids Road were transferred to the Port of Benton in October 1998. Section 4.8.5 provides additional information on the Hanford transportation system features. DOE is considering shipping TRU waste to WIPP by rail, if rail shipments become available. LLW and MLLW could be received by rail from offsite generators. Shipments of waste by rail may require constructing a spur from the existing rail lines.

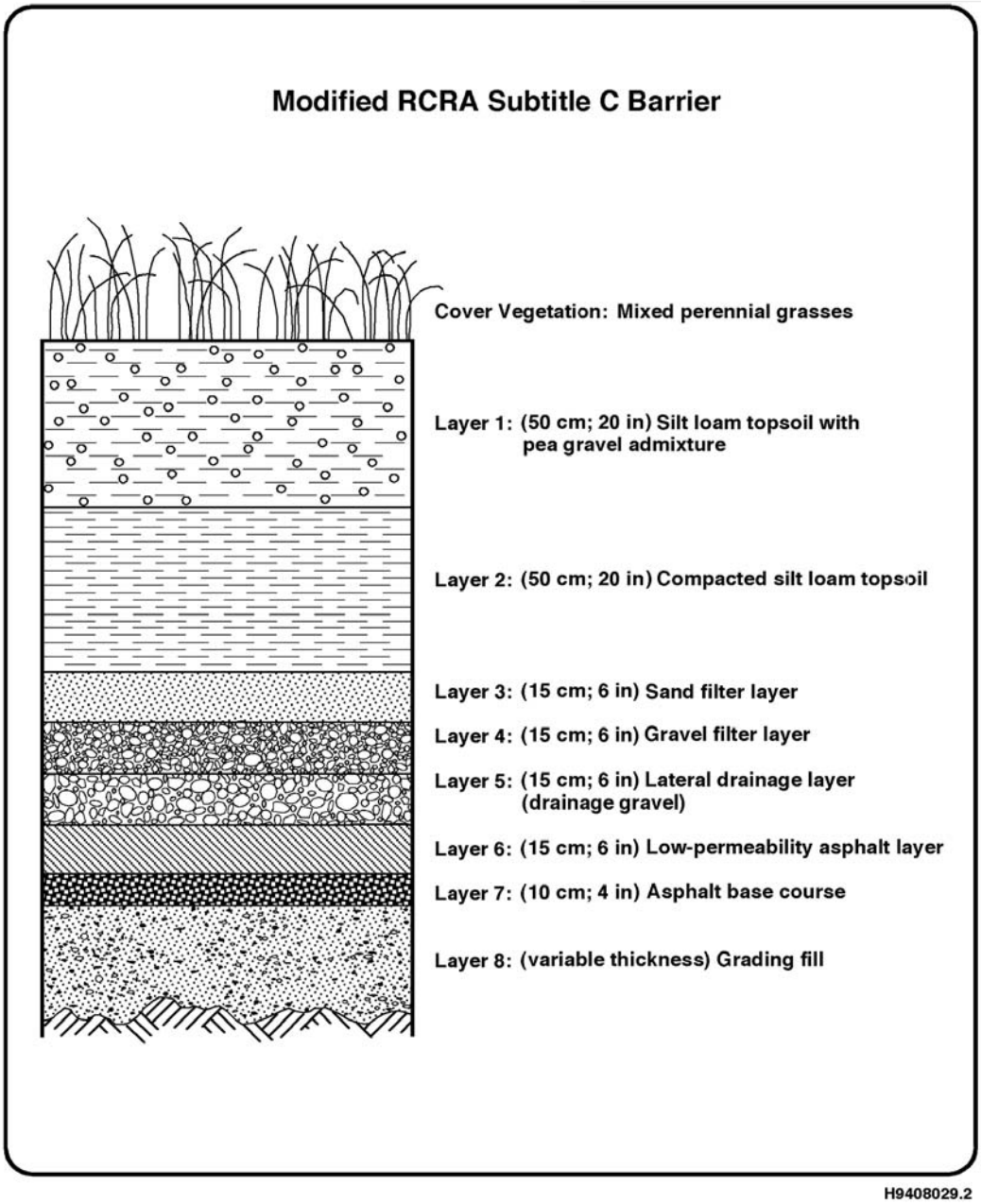

Figure 2.15. Cross-Section of a Proposed Cover Design for Mixed Low-Level Waste Trenches and the Low Level Burial Grounds

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3.0 Description and Comparison of Alternatives

This section describes the alternatives analyzed for management of low-level waste (LLW), mixed low-level waste (MLLW), and post-1970 transuranic (TRU) waste at Hanford (Sections 3.1, 3.2, and 3.3, respectively). With the exception of the No Action Alternatives, each is consistent with decisions made as part of the Waste Management Programmatic Environmental Impact Statement (WM PEIS) (DOE 1997). Table 3.1 provides a summary of these alternatives. More detailed tables and flowcharts describing the alternatives by waste stream are located in Appendix B.

Following the descriptions of the alternatives is a discussion of the volumes of waste that will be analyzed under each alternative (Section 3.4). Other alternatives that were considered are addressed in Section 3.5. A summary of the costs for the alternatives is included in Section 3.6, and a summary comparison of the environmental impacts of the alternatives is provided in Section 3.7. The U.S. Department of Energy (DOE) preferred alternative is discussed in Section 3.8. Descriptions of each of the waste streams and the existing and proposed facilities that are discussed in this section are presented in Sections 2.1 and 2.2 and described in greater detail by Fluor Hanford, Inc. (FH 2002).

The alternatives are organized by waste type: LLW, MLLW, and TRU waste. Alternative 1 reflects current plans for managing the wastes with existing facilities and possibly reducing resources by using commercial treatment capabilities where they are available, including modifying existing DOE Hanford facilities and using more efficient disposal configurations. Alternative 2 maximizes the treatment of wastes within DOE Hanford facilities, constructs a major new treatment facility, and uses existing disposal configurations. The third alternative, No Action, identifies measures that could be taken using existing facilities and not constructing new treatment and disposal facilities; however, it does require the construction of additional storage facilities.

Within both Alternatives 1 and 2, upper and lower bounds of waste volumes are evaluated for LLW and MLLW. The lower bound is based on the current forecasts for radioactive and mixed waste receipts at the Hanford Site. The upper bound considers additional shipments to Hanford from offsite generators.

3.1 Alternatives for Management of Low-Level Waste

In the WM PEIS record of decision (ROD) (65 FR 10061), DOE decided that its sites would perform minimum treatment of their own LLW to prepare it for disposal. Sites that have existing disposal capacity would continue to dispose of their own LLW to the extent practicable. In addition, DOE decided in the ROD that the Hanford Site or the Nevada Test Site would receive and dispose of LLW from other DOE sites. Such offsite waste sent to Hanford would need to meet the *Hanford Site Solid Waste Acceptance Criteria* (HSSWAC; FH 2001). The focus of this environmental impact statement (EIS) for LLW is to aid DOE in determining how best to implement the WM PEIS LLW ROD as it applies to the Hanford Site. DOE needs to determine what, if any, modifications to the Hanford Site disposal facilities or operations may be appropriate for managing DOE LLW.

Table 3.1. Summary of Alternatives Analyzed in the Hanford Solid Waste EIS

	Alternative 1	Alternative 2	No Action
Low-Level Waste (LLW)			
Storage	No indefinite storage needed.	No indefinite storage needed.	Wastes that cannot be treated to HSSWAC would remain in storage in the Central Waste Complex (CWC) indefinitely.
Treatment	Non-conforming wastes treated commercially. Category 3 (Cat 3) and greater than Category 3 (GTC3) wastes emplaced in high-integrity containers (HICs) or in-trench grouted.	Non-conforming wastes treated in a new M-91 facility. Cat 3 and GTC3 wastes emplaced in HICs or in-trench grouted.	Non-conforming wastes not treated. Cat 3 and GTC3 wastes emplaced in HICs or in-trench grouted.
Disposal	Future LLW trenches would be of the enhanced design. Cap Low Level Burial Grounds (LLBGs) at closure.	Future trenches would be of the current design. Cap LLBGs at closure.	Future trenches would be of the current design. No capping of trenches.
Mixed Low-Level Waste (MLLW)			
Storage	No indefinite storage needed.	No indefinite storage needed.	Untreated wastes, including remote-handled (RH) wastes, and wastes in excess of current disposal capacity would be indefinitely stored in an expanded CWC.
Treatment	Commercial treatment used for most contact-handled (CH) wastes. Modify the T Plant Complex to provide treatment for other MLLW.	Limited commercial treatment. Build new M-91 facility to provide treatment for all other MLLW.	Limited commercial treatment only. Most MLLW remains untreated.
Disposal	Use enhanced design MLLW trenches after filling current trenches. A melter trench would be provided for used vitrification melters. Trenches capped when filled.	Use current design MLLW trenches after filling current trenches. A melter trench would be provided for used vitrification melters. Trenches capped when filled.	Use only existing trenches. Store additional wastes indefinitely. Existing trenches capped when filled.
Post-1970 Transuranic (TRU) Waste			
Storage	Continued use of CWC and LLBGs. No indefinite storage needed.	Continue use of CWC and LLBGs. No indefinite storage needed.	RH and oversized CH containers would be stored indefinitely in an expanded CWC.
Processing	Process standard CH wastes in Waste Receiving and Processing Facility (WRAP). Process RH and oversized containers in modified T Plant Complex.	Process standard CH wastes in WRAP. Process RH and oversized containers in new M-91 Facility.	Process standard CH wastes in WRAP. RH and oversized containers would not be processed.
Disposal	Ship all certified wastes to Waste Isolation Pilot Plant (WIPP).	Ship all certified wastes to WIPP.	Ship all certified wastes to WIPP.

3.1.1 LLW Alternative 1 – Enhanced Trench Design with Closure Cap

LLW would be prepared for disposal with minimal treatment to meet the HSSWAC. Cat 1 wastes would be placed directly into the LLBGs following verification. Cat 3 and GTC3 wastes would be either emplaced in HICs or in-trench grouted. DOE would treat Hanford's non-conforming LLW using offsite commercial facilities and dispose of this treated waste in the LLBGs. For LLW disposal, DOE would fill the existing trenches and construct new enhanced trenches of a wider and deeper design. The new trenches would be backfilled with soil consistent with current operations. A closure cap would be applied to the LLBGs at the end of the operational period. The analyses under this alternative use both the upper bound and lower bound LLW volumes.

3.1.2 LLW Alternative 2 – Existing Trench Design with Closure Cap

LLW would be prepared for disposal as under Alternative 1 except that DOE would treat Hanford's non-conforming LLW using a new M-91 facility and dispose of this treated waste in the LLBGs. For LLW disposal, DOE would construct new trenches as needed in the current trench design. The new trenches would be backfilled with soil consistent with current operations. A closure cap would be applied to the LLBGs at the end of the operational period. The analyses under this alternative use both the upper bound and lower bound LLW volumes.

3.1.3 LLW No Action – Current Mode of Operations

LLW would be prepared for disposal as under Alternative 1 except that Hanford's non-conforming waste would continue to be stored in the CWC. DOE would continue the practice of building LLW disposal trenches in the LLBGs using the current trench design as additional disposal capacity is needed. DOE would backfill the trenches with soil, but the trenches would not be capped. Only the lower bound volume is considered for this alternative.

3.2 Alternatives for Management of MLLW

In the WM PEIS ROD (65 FR 10061), DOE decided its sites will treat their MLLW at the Hanford Site, the Idaho National Engineering and Environmental Laboratory, the Oak Ridge Reservation, the Savannah River Site, or at the generator sites, consistent with DOE Site Treatment Plans negotiated with host states and the U.S. Environmental Protection Agency (EPA) under the Federal Facility Compliance Act (42 USC 6901). DOE also decided that the Hanford Site and the Nevada Test Site would dispose of their own MLLW onsite and would receive and dispose of MLLW generated by other sites. These decisions do not preclude the use of commercial treatment and/or disposal facilities in accordance with DOE policy.

The focus of this EIS for MLLW is to aid DOE in determining how best to implement the WM PEIS MLLW decision as it applies to the Hanford Site. DOE needs to determine what, if any, modifications to the Hanford Site treatment, storage, and/or disposal facilities or operations may be appropriate for managing DOE MLLW.

3.2.1 MLLW Alternative 1 – Use Commercial Treatment, Modify the T Plant Complex, and Construct Additional Disposal Trenches with an Enhanced Trench Design

In this alternative DOE would use commercial facilities to treat most of Hanford's CH MLLW. DOE would modify the T Plant Complex to treat CH MLLW in oversized containers and RH MLLW to prepare this waste for disposal. DOE would also continue to use existing treatment and processing capabilities at WRAP and the T Plant Complex. DOE would store MLLW awaiting treatment at the CWC and the modified T Plant Complex. Offsite DOE generators that intend to dispose of MLLW at Hanford would treat their waste elsewhere before shipping it to Hanford for disposal.

DOE would continue to use the two existing MLLW trenches up to their capacity and construct an enhanced design MLLW trench using a deeper, wider trench design relative to the existing trenches. A separate trench would be constructed to dispose of melters from the Hanford tank waste treatment plant. After the trenches are filled, DOE would cap and close them according to applicable regulations.

Leachate from the MLLW trenches would be collected, and sent by truck to the 200 East Area Effluent Treatment Facility (ETF). Following closure of the ETF, leachate would be treated using pulse driers. Solids from that treatment would be sent to the MLLW trenches for disposal. The analyses under this alternative use both the upper and lower bounds of MLLW volumes. Capacity of the new trenches would correspond to the upper bound and lower bound MLLW volumes.

3.2.2 MLLW Alternative 2 – Construct a New M-91 Facility to Treat Waste Onsite and Construct Additional Disposal Trenches Similar to the Current Trench Design

In this alternative, DOE would construct a new facility to treat most Hanford MLLW, as well as MLLW from offsite generators. Commercial treatment of MLLW would be limited to minimum quantities specified in existing contracts. DOE would store MLLW awaiting treatment at the CWC and at the T Plant Complex.

DOE would construct a new M-91 facility in the 200 West Area near WRAP to augment existing treatment capabilities and provide treatment for waste from onsite and offsite generators, including the ability to treat miscellaneous waste such as lead- and mercury-contaminated MLLW. In this alternative, DOE would provide a capability in the new M-91 facility to treat CH MLLW from onsite and offsite generators packaged in standard containers. The new M-91 facility would use non-thermal technology to treat organic solids and debris. The other treatment technologies analyzed under this alternative are the same as those analyzed under MLLW Alternative 1. As needed, DOE would also continue to use existing treatment capabilities at the T Plant Complex and WRAP (amalgamation of mercury, neutralization of alkaline and acid wastes, solidification of liquids, macroencapsulation and stabilization by addition of sorbent or grout).

For MLLW disposal, DOE would continue to use the two existing MLLW trenches up to their capacity, then construct new MLLW disposal trenches as needed in the 200 Areas. DOE would construct the new trenches using the current MLLW trench design. A separate trench would be constructed to dispose of melters from the Hanford tank waste treatment plant. After the trenches are filled, DOE would cap and close them according to applicable regulations.

Leachate from the MLLW trenches would be collected, and sent by truck to the ETF for treatment. Following closure of the ETF, leachate would be treated using pulse driers. Solids from that treatment would be sent to the MLLW trenches for disposal. The analyses under this alternative use both the upper and lower bound MLLW volumes. Capacity of the new trenches would be determined by the upper bound and lower bound MLLW volumes.

3.2.3 MLLW No Action – Continue Current Mode of Operations

MLLW treated and ready for disposal would be directly disposed of in the two existing MLLW trenches as long as space is available. Treatment of solid MLLW would be limited to the existing commercial treatment contracts and the limited capacity of the T Plant Complex and other onsite facilities. Disposal of MLLW would occur only in the existing MLLW trenches. After the trenches are filled, DOE would cap and close them according to applicable regulations.

Leachate from the MLLW trenches would be collected and sent by truck to the 200 East Area ETF for treatment. When the ETF closes, leachate would be treated using a pulse drier. Solids from that treatment would be sent to the MLLW trenches for disposal or to CWC for indefinite storage. Most of the MLLW would be stored indefinitely in CWC due to the lack of disposal space and the lack of treatment capability. Additional storage space would be constructed at CWC due to the increased storage needs. Only the lower bound MLLW volume is considered for this alternative.

3.3 Alternatives for Management of Post-1970 TRU Waste

In the WM PEIS ROD for processing and storage of TRU waste (63 FR 3629), DOE decided its sites will process and certify TRU waste at the site where it was generated and store it there until it is shipped to WIPP for disposal (except for the Sandia National Laboratory, which would ship its TRU waste to Los Alamos National Laboratory for processing, certification, and storage prior to disposal at WIPP). DOE also stated in the WM PEIS ROD that, in the future, the Hanford Site, the Idaho National Engineering and Environmental Laboratory, the Oak Ridge Reservation, and the Savannah River Site may receive TRU waste from sites where it is not practical or cost-effective to prepare it for disposal, and would manage this waste until it is shipped to WIPP. If, in the future, DOE identifies a need to ship TRU waste to Hanford from sites where it is not practical or cost-effective to prepare this waste for disposal, DOE would conduct additional National Environmental Policy Act (NEPA) reviews as appropriate.

3.3.1 Post-1970 TRU Waste Alternative 1 – Modify the T Plant Complex

DOE would continue to prepare and certify existing stored (including CWC, T Plant Complex, and LLBGs) and newly generated CH TRU waste packaged in standard containers for shipment to and disposal at WIPP. DOE would continue to operate WRAP until 2032 to perform this function. After closure of WRAP, individual Hanford generators would be responsible for certifying and shipping their own waste. DOE would continue drum head space gas sampling at the T Plant Complex.

DOE would modify the T Plant Complex to prepare TRU waste that cannot be processed at WRAP for shipment to WIPP. The modifications would involve installing equipment to process a variety of incoming waste containers, including size reduction equipment. The modified T Plant Complex would process CH TRU waste in non-standard containers and RH TRU waste that is currently stored aboveground or that would be newly generated in the future. This would include the K Basin sludge and other wastes containing polychlorinated biphenyls (PCBs). For the purposes of analysis, this EIS assumes that WIPP would have the necessary administrative and permitting authority to accept these wastes. All of the certified waste would be shipped to WIPP for disposal.

3.3.2 Post-1970 TRU Waste Alternative 2 – Construct a New M-91 Facility

DOE would continue to process and certify existing stored and newly generated CH TRU waste packaged in standard containers for shipment to and disposal at WIPP. DOE would continue to operate WRAP until 2032 to perform this function. After closure of WRAP, individual Hanford generators would be responsible for certifying and shipping their own waste. DOE would continue drum head space gas sampling at the T Plant Complex.

DOE would construct a new M-91 facility to prepare CH TRU waste that cannot be processed at WRAP and RH TRU waste for shipment to WIPP. DOE would process CH TRU waste in non-standard containers and RH TRU waste that is currently stored aboveground or that would be generated in the future. This waste would include the K Basin sludge and other wastes containing PCBs. For the purposes of analysis, this EIS assumes that WIPP would have the necessary administrative and permitting authority to accept these wastes. All of the certified waste would be shipped to WIPP for disposal.

3.3.3 Post-1970 TRU Waste No Action – Continue Current Mode of Operations with No New Facilities

DOE would continue to use WRAP and the T Plant Complex to prepare and certify existing stored and newly generated CH TRU waste packaged in standard containers for shipment to and disposal at WIPP. DOE would continue to operate WRAP until 2032 to perform this function. After closure of WRAP, individual generators would be responsible for certifying and shipping their own waste.

All CH TRU waste that cannot be processed at WRAP (for example, oversized items) and RH waste, including waste currently stored aboveground at the CWC, PCB-commingled TRU waste, and newly generated waste, would be stored at the CWC or T Plant Complex indefinitely. The CWC would be expanded as needed. K Basin sludge would be stored indefinitely at the T Plant Complex.

3.4 Volumes of Waste Considered in Each Alternative

The LLW, MLLW, and post-1970 TRU waste to be managed by the Hanford solid waste program would come from three sources: the current inventory, newly generated wastes from Hanford Site generators, and newly generated wastes from offsite generators. A variety of information sources have been used to develop estimates for the quantities and characteristics of the wastes to be managed. Primarily, these sources include the Solid Waste Information Tracking System (SWITS; FH 2002) for the current inventory of waste, the Solid Waste Integrated Forecast Technical (SWIFT) report (Barcot 1999, 2002) for newly generated waste expected to be received over the life cycle of the Hanford Site, and *Accelerating Cleanup: Paths to Closure* (DOE 1998) to identify potential wastes that could be sent to Hanford for disposal.

The volumes used for each waste type are presented in the following sections. A more detailed description of the development of the waste volumes for each type of waste is included in Appendix C. The number of significant figures shown in the volume tables can exceed the accuracy of the forecasts but are maintained in the document for consistency of calculations.

3.4.1 LLW Volumes

Two waste volumes were analyzed for LLW to provide a broad range of potential waste receipt scenarios. The first volume scenario provides a lower bound volume for LLW disposal. This lower bound volume represents the expected receipt of LLW based on forecasts provided by Hanford Site generators and offsite waste generators whose waste is currently approved for acceptance at Hanford. The second volume scenario provides an upper bound volume and includes forecasted wastes from both the currently approved waste generators and additional generators that could potentially send waste to Hanford as a result of the WM PEIS ROD for LLW (65 FR 10061). The lower bound volume scenario is analyzed for all LLW alternatives. The upper bound volume scenario is analyzed for LLW Alternatives 1 and 2. The volumes of each LLW stream expected under each scenario are listed in Table 3.2. For LLW Cat 1 and Cat 3, additional waste may be received from offsite generators as a result of the WM PEIS ROD.

Table 3.2. Estimated Volumes of LLW Waste Streams through 2046

Waste Streams	Lower Bound (cubic meters)[(a)]	Upper Bound (cubic meters)[(a)]
Category 1	107,883	287,129
Category 3	41,333	60,932
Greater than Category 3	<1	<1
Non-conforming	299	299
Previously buried waste in LLBG	283,067	283,067
Total	432,582	631,427
(a) To convert to cubic feet, multiply by 35.3.		

3.4.2 MLLW Volumes

As with LLW, the lower bound MLLW volume estimate is based on forecasts by waste generators at Hanford and currently approved offsite waste generators. The upper bound volume estimate includes the lower bound estimate plus generators that could potentially ship waste to Hanford as a result of the WM PEIS ROD. (It is assumed in this EIS that most wastes from these generators would be treated prior to receipt at Hanford and that the waste can therefore be disposed of directly.) Only the lower bound estimate was analyzed under the MLLW No Action Alternative because the limited disposal capacity of this alternative would not accommodate the additional offsite wastes. Under MLLW Alternatives 1 and 2, both the lower bound and upper bound estimates were analyzed to determine the impacts of accepting additional offsite wastes. The volumes of each MLLW stream for the lower and upper bound analysis are listed in Table 3.3. Additional waste from offsite generators is included in the Treated and Ready for Disposal stream.

Table 3.3. Estimated Volumes of MLLW Waste Streams Through 2046

Waste Streams[(a)]	Lower Bound (cubic meters)[(b)]	Upper Bound (cubic meters)[(b)]
Treated and Ready for Disposal	34,910	175,244
RH and Oversized Packages	2,906	2,906
CH Inorganic Solids and Debris	20,111	20,111
CH Organic Solids and Debris	6,789	6,789
Elemental Lead	608	608
Elemental Mercury	20	20
Total	65,344	205,678

(a) Leachate from MLLW trenches has not been included in this table because the volumes are dependent upon the selected alternative.
(b) To convert to cubic feet, multiply by 35.3.

3.4.3 TRU Waste Volumes

In the Hanford Site TRU waste forecast, both maximum and baseline volume estimates were provided by generators. The maximum volume was about 10 percent greater than the baseline volume. Because these volumes are relatively similar, only the maximum volume of TRU waste was evaluated for the TRU waste alternatives. Only small quantities of TRU waste are forecast from offsite generators. The volume of each TRU waste stream is shown in Table 3.4.

Table 3.4. Estimated Volumes of TRU Waste Streams through 2046

Waste Streams	Volume (cubic meters)[a]
Waste from trenches	14,552
Waste from caissons	23
Commingled PCB waste	95
Newly generated and existing CH standard containers	27,728
Newly generated and existing CH oversized containers	1,077
Newly generated and existing RH	2,191
K Basin sludge	140
Total TRU waste	45,806
(a) To convert to cubic feet, multiply by 35.3.	

3.5 Other Alternatives Considered

This section describes alternatives that were considered as possible methods for management of one or more of the waste types.

3.5.1 Storage Options

3.5.1.1 Storage of Waste at the Generator Sites

Storage of waste at either Hanford or offsite generator sites could potentially reduce the storage requirements at CWC for the No Action Alternatives. The majority of the wastes requiring additional storage in the No Action Alternatives would require indefinite storage at the generator sites. Storage at multiple sites would not allow DOE to take advantage of the economies of scale possible by consolidating the wastes at the CWC. Lastly, most generators are not permitted to store MLLW longer than 90 days. Most onsite and offsite generators do not have onsite storage available, and the need to increase storage capacity could impact cleanup and closure activities. Alternatives 1 and 2 do not require additional storage beyond the existing CWC capacity.

3.5.1.2 Shipment of GTC3 Wastes to Other Sites for Longer-Term Storage

The volume of GTC3 LLW would be relatively small. A cost saving might be achieved if the waste were combined with similar wastes at other sites. Because the amount of storage required for this waste is so small compared with other wastes, storing this waste at Hanford is not expected to affect the required capacity at CWC in any of the alternatives. In addition, no other DOE sites were identified with significant storage capacity for such wastes. Shipment of GTC3 wastes from Hanford to other DOE sites would not be consistent with the WM PEIS ROD for LLW.

3.5.2 Treatment Options

3.5.2.1 Privatize WRAP

To privatize WRAP means that DOE would lease the facility to a privately owned entity that would operate the facility to treat DOE wastes. Privatization only identifies who manages the facility. Privatization of the waste management operations would not appreciably alter the environmental impacts.

3.5.2.2 Use of the T Plant Complex for Treatment of CH MLLW

The alternative of using T Plant Complex for treatment of CH MLLW similar to that evaluated for the new M-91 facility under MLLW Alternative 2 was considered. The operational impacts are considered to be similar to those from operating the new M-91 facility outlined in MLLW Alternative 2.

3.5.2.3 Use of the New M-91 Facility Except for Treatment of CH MLLW

The alternative of using the new M-91 facility for treatment of oversized containers of MLLW and RH MLLW was considered. CH MLLW in standard containers would be treated offsite. The impacts would be about the same as for treatment of MLLW at the modified T Plant Complex in MLLW Alternative 1.

3.5.2.4 Use of Offsite DOE Treatment Facilities

The consolidation of waste management functions at designated DOE sites was a major focus of the WM PEIS (DOE 1997). However, treatment capacity is limited at other DOE sites. The environmental consequences associated with these options have been analyzed in the WM PEIS; however, the resulting MLLW ROD mandates using existing facilities at each respective site (65 FR 10061). Impacts would be similar to commercial treatment. Hanford may ship small volume waste streams to other DOE sites when specialized facilities are available.

3.5.2.5 Mobile Treatment Facilities

Development of mobile treatment facilities has been considered. The technical and regulatory issues, however, remain unresolved. Mobile treatment would be most applicable to small volumes of waste. It would typically involve less risk to ship the small waste volume than to ship the mobile treatment facility that becomes a radioactive shipment after its first use.

3.5.2.6 Use of the ETF for Non-Conforming LLW

Much of the existing non-conforming LLW stream (299 cubic meters [10,600 ft^3]) at Hanford consists of organic-based liquid. Treating these liquids in the 200 East Area ETF was considered. However, organic-based liquid wastes are not compatible with the aqueous-based ETF treatment system.

3.5.3 Disposal Options

3.5.3.1 Use of the ERDF for LLW and MLLW

The Environmental Restoration Disposal Facility (ERDF) is used to dispose of LLW and MLLW. It is authorized for disposing of waste generated during Hanford Site remediation activities under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA; 42 USC 9601 *et seq*.). ERDF was rejected as an option because none of the LLW or MLLW under evaluation in the HSW EIS would be generated by CERCLA actions.

3.5.3.2 Use of Canyon Facilities for Disposal of Specific Wastes

An ongoing CERCLA study is considering the use of the major canyon facilities for disposal of some waste types that are included in the HSW EIS (Hanford Advisory Board 1997; Richland Environmental Restoration Project 2001). As currently envisioned, higher hazard waste such as Cat 3 LLW would be placed inside the canyons, and other wastes (Cat 1 LLW, for example) would be placed above and outside the canyon. The entire facility would then be covered with a layer of soil and capped. The canyons, with their thick cement walls, would provide significant protection to the wastes inside and retard their dispersal over the long term. The wastes outside the canyons should, at a minimum, be as well contained as wastes placed in the LLBGs.

3.5.3.3 Use of the HLW Repository for Disposal of Higher Activity LLW

Some of the higher activity LLW, such as the GTC3 waste that requires disposal approval for each waste shipment, may not be suitable for disposal at Hanford. One potential disposal alternative would be using the proposed commercial spent fuel and high-level waste repository. Disposal of GTC3 waste at the HLW repository is not authorized.

3.5.3.4 Use of the U.S. Ecology Disposal Facility

The U.S. Ecology, Inc. commercial LLW disposal site is located within the Hanford Site boundary and could receive some of the LLW expected to be buried in the LLBGs. Because the wastes would be disposed of within the Hanford Site boundary, in a location near the LLBGs, the impacts are expected to be similar to those determined for burial of wastes in the LLBGs. A separate draft EIS has been issued for the U.S. Ecology facility (WDOH and Ecology 2000).

3.5.3.5 Use of the Nevada Test Site or Other DOE Sites for Disposal of Hanford LLW or MLLW

The WM PEIS evaluated the disposal of Hanford-generated LLW and MLLW, and DOE decided that all Hanford LLW and MLLW should be disposed of at Hanford.

3.5.3.6 Use of Envirocare MLLW Disposal Facility

The WM PEIS evaluated the disposal of Hanford-generated LLW and MLLW, and DOE decided that all Hanford LLW and MLLW should be disposed of at Hanford. However, generators have the option to ship MLLW to Envirocare for disposal (65 FR 10061).

3.5.3.7 Disposal at Hanford Locations Other than the LLBGs

Consistent with the decisions made as part of the *Hanford Comprehensive Land Use Plan Environmental Impact Statement* (DOE 1999), the Industrial-Exclusive Area on the 200 Area Plateau is the only part of Hanford available for the disposal of LLW and MLLW.

3.6 Comparison of Environmental Impacts Among the Alternatives

In Table 3.1 and Sections 3.1 through 3.3, three alternatives were defined for each waste type considered in the HSW EIS (LLW, MLLW, and post-1970 TRU waste). For purposes of comparison in this section, impacts associated with the corresponding alternative actions for each waste type have been combined to provide a consolidated analysis of waste management operations. These consolidated analyses retain the designations corresponding to the alternatives for each waste type described in Table 3.1. Therefore, the impacts associated with the consolidated analysis designated Alternative 1 include the combined activities described in LLW Alternative 1, MLLW Alternative 1, and TRU waste Alternative 1. Similarly, Alternative 2 includes the combined activities described for Alternative 2 within each waste type, and the No Action Alternative analysis consists of the combined No Action Alternatives for each waste type. This approach facilitates comparative presentation of impacts for all solid waste program operations and is necessary where analyses are performed for facilities that are used to manage more than one type of waste. In these latter consolidated alternatives, each of the waste types is considered, and the impacts were either analyzed directly or were bounded by like analysis where appropriate.

Within each consolidated alternative analysis, a range of waste volumes was considered as described in Section 3.4. The lower bound waste volume for the consolidated analysis in Alternatives 1 and 2 consists of the lower bound volumes for LLW and MLLW and the maximum forecast volume for TRU waste. The upper bound waste volume for those alternatives consists of the upper bound volumes for LLW and MLLW and the maximum forecast volume for TRU waste. The No Action Alternative was evaluated for the lower bound LLW and MLLW waste volumes and the maximum forecast volume for TRU waste.

Potential environmental impacts resulting from implementing any of the alternatives are summarized in comparative form in Table 3.5. Supporting analyses for the entries in Table 3.5 are provided in Section 5.0 and its appendixes.

Table 3.5. Comparison of Impacts Among the Alternatives

Environmental Consequence Category	Units[a]	Alternatives				
		Alternative 1		Alternative 2		No Action Alternative
		Lower Bound Volume	Upper Bound Volume	Lower Bound Volume	Upper Bound Volume	
Land Use						
Total Permanently Committed - LLBGs	ha	146	153	162	178	149
Percent of Historically Designated LLBG Area	%	34	36	38	42	35
Total Including Treatment and Storage Facilities	ha	333	343	364	390	343
Percent of 200 Areas Industrial-Exclusive Area	%	6.7	6.9	7.3	7.8	6.9
Air Quality Impacts - Maximums						
PM_{10} - 24-Hour Limit	% of limit	13	13	14	15	25
SO_2 - 1-Hour Annual Limit	% of limit	2	2	5	7	3
CO - 8 - Hour Limit	% of limit	1	1	3	4	2
NO_2 - Annual Limit	% of limit	0.4	0.4	0.4	0.4	0.3
Maximums for borrow pit activities: PM_{10}: 4%, SO_2: 18%, CO: 17%, NO_2: 0.02%						
Water Quality Index - Maximum Concentrations as Percent of EPA Drinking Water Standards						
EPA Drinking Water Standard [DWS]: Technetium-99 = 900 pCi/L; Iodine-129 = 1 pCi/L						
(EPA Drinking Water Standards are not applicable at these locations, but are used as benchmarks of water quality.)						
Maximum nuclide concentrations in wells 1 km downgradient from LLBGs						
Technetium-99	% of DWS	28	28	28	28	28
Iodine-129	% of DWS	110	110	110	110	180
Maximum nuclide concentrations in well near Columbia River						
Technetium-99	% of DWS	0.4	0.4	0.9	0.9	1.6
Iodine-129	% of DWS	2.1	2.1	3.5	3.5	4.6
Average nuclide concentrations in Columbia River at time of maximum concentrations						
Technetium-99	% of DWS	6E-05	6E-05	1E-04	6E-05	2E-04
Iodine-129	% of DWS	3E-04	3E-04	5E-04	5E-04	7E-04
Ecological Resources						
Temporary Shrub-Steppe Habitat Destruction[b]	ha	76	86	107	133	86
Cultural Resources, Aesthetics, and Scenic Resources						
Low Potential for Cultural Resources, Aesthetics and Scenic Resources, or Noise Impacts for All Alternatives						
Socioeconomics and Environmental Justice						
Maximum Annual Employment	# workers	494	504	520	530	519
Total Labor (through 2046)	worker-yrs	15600	16300	15800	16600	20600
Low Potential for Impacts on Community Infrastructure and Environmental Justice for All Alternatives						
Commitment of Non-Renewable Resources						
Diesel Fuel	m^3	22,000	36,000	27,000	42,000	2400
Gasoline	m^3	170	280	290	400	80
Propane	m^3	16,000	16,000	19,000	22,000	1600
Public Health and Safety						
Anticipated Conditions (Routine Operations) - Postulated Scenarios						
Individuals						
Resident Gardener - Air Pathway						
Lifetime dose	mrem	0.0018	0.0027	0.0023	0.0032	0.0013
Probability of latent cancer fatality	#	9.2E-10	1.4E-09	1.1E-09	1.6E-09	6.7E-10
Probability of cancer incidence from chemicals	#	1.7E-10	4.2E-10	7.0E-09	7.3E-09	8.9E-11
Populations						
Air Pathway - Within 80 km radius						
Lifetime dose	person-rem	0.13	0.19	0.16	0.22	0.095
Latent cancer fatalities - radiological	#	None (6E-5)	None (1E-4)	None (8E-5)	None (1E-4)	None (5E-5)
Cancer fatalities - non-radiological chemicals	#	None (1E-5)	None (3E-5)	None (5E-4)	None (5E-4)	None (6E-6)
Tri-Cities, WA Drinking Water Scenario						
Cumulative 10,000-year dose	person-rem	0.70	0.71	0.72	0.96	0.82
Latent cancer fatalities	#	None (4E-4)	None (4E-4)	None (4E-4)	None (5E-4)	None (4E-4)

Table 3.5. (contd)

Incident-free Transportation						
Latent cancer fatalities (LCFs), crew	#	1 (0.64)	1 (0.73)	None (0.089)	None (0.18)	None (0.086)
LCFs, public - radiological	#	None (0.27)	None (0.36)	None (0.098)	None (0.19)	None (0.084)
LCFs, public - non-radiological emissions	#	1 (0.86)	2 (1.6)	1 (0.74)	1 (1.4)	1 (0.60)
Postulated Accidents and Unplanned Events						
Operational						
Highest risk facility accident (frequency x consequences		Beyond design basis earthquake at CWC				
Estimated frequency - upper bound	#/yr	0.0033				
Duration of risk	years	30				Indefinite
Population dose - if accident occurred	person-rem	56,000				
Latent cancer fatalities (LCFs) - for given dose	#	28				
Transportation						
Transport fatalities (non-radiological)	#	1	1	None (0.2)	None (0.4)	None (0.1)
Post Disposal						
Hypothetical Intruder - Resident Gardener - Groundwater Pathway - with/without sauna (S) or sweat lodge (SL)						
1-km Well Scenario						
Maximum lifetime dose with sauna or sweat lodge	rem	3.0	3.0	6.0	6.9	10
Probability of LCF - with sauna or sweat lodge	#	0.0015	0.0015	0.0030	0.0034	0.0050
Maximum lifetime dose w/o sauna or sweat lodge	rem	0.11	0.11	0.12	0.12	0.18
Probability of LCF - w/o sauna or sweat lodge	#	5.5E-05	5.5E-05	6.0E-05	6.0E-05	9.0E-05
Approximate time to maximum dose	years	10,000	10,000	10,000	10,000	1,000
Near River Well Scenario						
Maximum Lifetime dose with sauna or sweat lodge	mrem	60	61	120	130	230
Probability of LCF - with sauna or sweat lodge	#	3.0E-05	3.1E-05	6.0E-05	6.5E-05	1.2E-04
Maximum Lifetime dose w/o sauna or sweat lodge		3.8	3.8	4.4	3.8	5.9
Probability of LCF w/o sauna or sweat lodge		1.9E-06	1.9E-06	2.2E-06	1.9E-06	3.0E-06
Approximate time to maximum dose	years	10,000	10,000	10,000	10,000	1,000
Intruder - Resident Gardener - Soil Contaminated from Drilling Through LLBG						
Maximum lifetime dose at 100 years (2146)	rem	330				
Probability of latent cancer fatality	#	0.33				
Maximum lifetime dose at 300 years (2346)	rem	3				
Probability of latent cancer fatality	#	0.0016				
Maximum lifetime dose at 500 years (2546)	rem	0.10				
Probability of latent cancer fatality	#	5E-05				
Intruder - Resident Gardener - Soil Contaminated from Excavation for Basement in LLBG						
Maximum lifetime dose at 100 years (2146)	rem	**Scenario not credible for capped LLBGs**				70,000
Probability of latent cancer fatality	#	If fatality does not arise from acute effects ->				1
Maximum lifetime dose at 100 years (2346)	rem					650
Probability of latent cancer fatality	#					1 (0.64)
Maximum lifetime dose at 100 years (2546)	rem					22
Probability of latent cancer fatality	#					0.022
Worker Health and Safety						
Routine Operations						
Involved Facility Workers						
47-yr Collective Dose	person-rem	320	327	325	326	446
Latent cancer fatalities	#	None (0.1)	None (0.1)	None (0.1)	None (0.1)	None (0.2)
Non-involved facility workers						
Maximum lifetime dose	mrem	0.58	0.88	0.60	0.92	0.58
Probability of latent cancer fatality	#	2.3E-07	3.5E-07	2.4E-07	3.7E-07	2.3E-07
Accidents and Unplanned Events						
Non-radiological Industrial Accidents	lost workdays	6100	6300	6200	6400	8000
Non-Involved Workers						
Highest radiological-risk facility accident (frequency x consequences)		Beyond design basis earthquake at CWC				
Estimated frequency - Upper Bound	events/yr	0.0033				
Duration of risk	years	30				Indefinite
Dose - if accident occurred	rem	5900				
Probability of latent fatal cancer, if event occurred	#	1 (If fatality does not arise from acute effects.)				

(a) To convert from hectares (ha) to acres (ac), multiply by 2.47. To convert m^3 to k-gal, multiply by 0.265.

(b) It is assumed that the shrub-steppe habitat destroyed by the June 2000 range fire will have re-established itself by the time construction/excavation activities are undertaken. In time native habitat will likely re-establish itself on the LLBG closure caps.

3.7 Costs of Alternatives

Consolidated cost estimates were prepared for the continued operation of existing facilities, the modification of existing facilities, construction of new facilities, and operation of the new or modified facilities (FH 2002). Some operations, such as capping the LLBGs and treatment of leachate from mixed waste trenches, would continue beyond 2046. These operations have been included as a separate category. The cost of each major facility for each consolidated alternative is shown in Table 3.6. The increased costs for the operation of the LLBGs with the increased volume of waste in the upper bound estimates can be seen. Because the additional wastes in the upper bound volume do not need treatment, the costs for treatment facilities do not change. In the No Action Alternative, the increased needs for storage of MLLW and the limited volume of waste disposed of are reflected in the relative costs of the CWC and the MLLW trenches. The increased costs for the baseline operation of the T Plant Complex for the consolidated No Action Alternatives compared to Alternatives 1 and 2 result from the continuing need to store the K Basin sludges in the No Action Alternative. The combination of commercial MLLW treatment and modification of the T Plant Complex in Alternative 1 is less expensive than the construction of a new facility with DOE doing the majority of the treatment onsite in Alternative 2.

Although the No Action Alternative is the lowest cost option through 2046, it should be remembered that the majority of the MLLW and difficult-to-treat TRU waste (including K Basin sludge) resides in indefinite storage. These wastes would need to be treated and disposed of at some point in the future at a substantial cost. Of the consolidated action alternatives, Alternative 1 is the lower-cost option. Treatment and disposal of upper bound volumes would cost about 10 percent more than for the lower bound volumes.

Table 3.6. Consolidated Cost Estimates for Alternatives in Millions of Dollars

Cost Category	Alternative 1 Lower Bound	Alternative 1 Upper Bound	Alternative 2 Lower Bound	Alternative 2 Upper Bound	No Action[(a)]
LLBGs	339	484	340	485	345
CWC	566	566	566	566	1,090
WRAP	710	710	710	710	710
T Plant (baseline operations)	376	376	376	376	511
Commercial MLLW treatment	229	229	17	17	17
M-91 capabilities (T Plant modification or new M-91 facility)	457	457	830	830	0
MLLW trenches	244	393	290	429	152
Post-2046 costs	103	116	110	125	0
Total	3,024	3,331	3,239	3,538	2,825

(a) Does not account for cost of storage, treatment, or eventual disposal of waste remaining in storage after 2046.

3.8 DOE Preferred Alternative

Based on the results of the environmental consequences analyses presented in Table 3.5, in addition to cost and other considerations, DOE has identified a preferred alternative for the HSW EIS. At this time, the DOE preferred alternative consists of LLW Alternative 1, MLLW Alternative 1, and post-1970 TRU waste Alternative 1, as described in Sections 3.1 through 3.3. In general, these three alternatives provide the most cost-effective and environmentally preferable approach to waste management at Hanford for the range of waste volumes that might be managed at the Site as a result of WM PEIS decisions. However, DOE will consider all comments received during the public comment period for this draft EIS before preparing the final EIS and publishing a ROD regarding Hanford solid waste program operations.

3.9 References

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4.0 Affected Environment

The purpose of this section is to provide a description of the environment that might be affected by the alternatives discussed in Section 3.0. Because the Hanford Site is so large, the description includes much of the Site itself, as well as the surrounding areas. Information used in this section was taken from the *Hanford Site National Environmental Policy Act (NEPA) Characterization Report* (Neitzel 2001), unless otherwise noted.

The affected environment section includes:

- Land Use
- Meteorology and Air Quality
- Geology, Soils, and Seismology
- Hydrology
- Biology and Ecology
- Cultural Resources
- Socioeconomics
- Noise
- Occupational Safety.

4.1 Introduction

The focus of solid waste management activities relating to the Hanford Solid (Radioactive and Hazardous) Waste Environmental Impact Statement (HSW EIS) is within the existing boundaries of the Hanford Site 200 Areas, a region of approximately 16 km^2 (6 mi^2). Located on the Central Plateau (i.e., 200 Area Plateau) of the Hanford Site, the 200 East and 200 West Areas are approximately 8 and 11 km (5 and 7 mi), respectively, south and west of the Columbia River. The 200 Areas facilities were built to process irradiated fuel from the production reactors. Subsequent liquid wastes, produced as a result of the fuel processing, were placed in tanks in the 200 Areas. The 200 Areas are the focal point of waste management activities. Treatment, storage, and disposal of solid wastes are accomplished in the 200 Areas.

The U.S. Department of Energy (DOE) Hanford Site (Figure 4.1) lies within the semiarid Pasco Basin of the Columbia Plateau in southeastern Washington State. The Site occupies an area of about 1517 km^2 (586 mi^2) north of the confluence of the Yakima River with the Columbia River. The Hanford Site measures approximately 50 km (31 mi) north to south and 40 km (25 mi) east to west. The major portion of this land, with restricted public access, provides a buffer for the smaller areas currently used for nuclear materials storage, waste storage, and waste disposal.

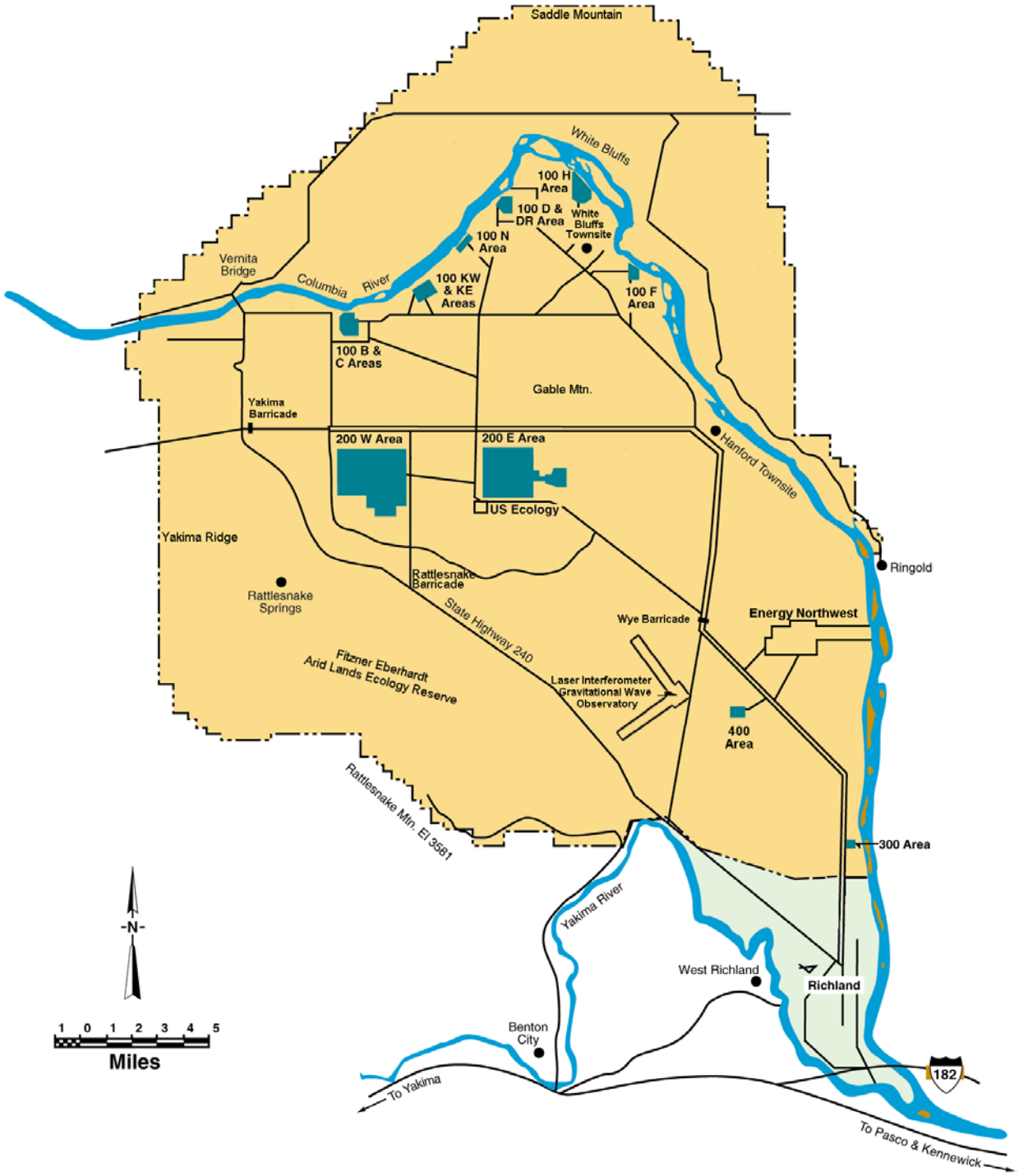


Figure 4.1. Department of Energy – Hanford Site (after Neitzel 2001)

The Columbia River flows through the northern part of the Hanford Site and, turning south, forms part of the eastern Site boundary. The Yakima River runs near the southern boundary of the Hanford Site, joining the Columbia River at the city of Richland that bounds the Hanford Site on the southeast. Rattlesnake Mountain, Yakima Ridge, and Umtanum Ridge form the southwestern and western boundaries. The Saddle Mountains constitute the northern boundary of the Hanford Site. Two small east-west ridges, Gable Butte and Gable Mountain, rise above the plateau in the central part of the Hanford Site. Adjoining lands to the west, north, and east are principally agricultural and rangeland. The cities of Kennewick, Pasco, and Richland (Tri-Cities) and the city of West Richland constitute the nearest population centers and are located south-southeast of the Hanford Site.

4.2 Land Use

DOE completed the Hanford Comprehensive Land-Use Plan EIS (HCP EIS; DOE 1999) in September 1999. A record of decision (ROD) was issued on November 2, 1999 (64 FR 61615), which adopted the Preferred Alternative as discussed in the EIS. The purpose of this land-use plan and its implementing policies and procedures is to facilitate decision-making about Hanford Site uses and facilities over at least the next 50 years. The Preferred Alternative map from the Final Hanford Comprehensive Land-Use Plan EIS shown in Figure 4.2 represents the DOE future land-management values, goals, and objectives. The land-use plan consists of several key elements that are included in the DOE Preferred Alternative in the Final HCP EIS (DOE 1999). These elements include a land-use map that addresses the Hanford Site as five geographic areas—Wahluke Slope, Columbia River Corridor, Central Plateau, all other areas of the site, and the Fitzner/Eberhardt Arid Lands Ecology Reserve (ALE). The key elements of the Hanford Comprehensive Land-Use Plan include a map that depicts the planned future uses, a set of land-use designations defining the allowable uses for each area of the Hanford Site, and the planning and implementing policies and procedures that will govern the review and approval of future land uses. Together these four elements create the Hanford Comprehensive Land-Use Plan. Much of the land is undeveloped, providing a buffer area for the smaller operations areas. Public access to most facility areas is restricted.

The key features of the Hanford Site that form the basis for the five geographic areas used in the environmental impact analysis and land-use plans are summarized as follows:

- **Wahluke Slope**. The area north of the Columbia River and the Hanford Site proper encompasses approximately 357 km^2 (138 mi^2) of relatively undisturbed or recovering shrub-steppe habitat managed by the U.S. Fish and Wildlife Service (FWS) for DOE. These lands consist of two wildlife management units within the Hanford Reach National Monument/Saddle Mountain National Wildlife Refuge, the 130 km^2 (50 mi^2) Saddle Mountain Unit, and the 225 km^2 (87 mi^2) Wahluke Unit. Portions of the Saddle Mountain Unit, which is closed to public access, still serve as buffer areas for the Hanford Site. The Wahluke Unit is open to public recreational access. A small strip of land approximately 1.62 km^2 (0.63 mi^2) located between State Route (SR) 243 and the Columbia River west of SR 24 is managed by the Washington State Department of Fish and Wildlife.

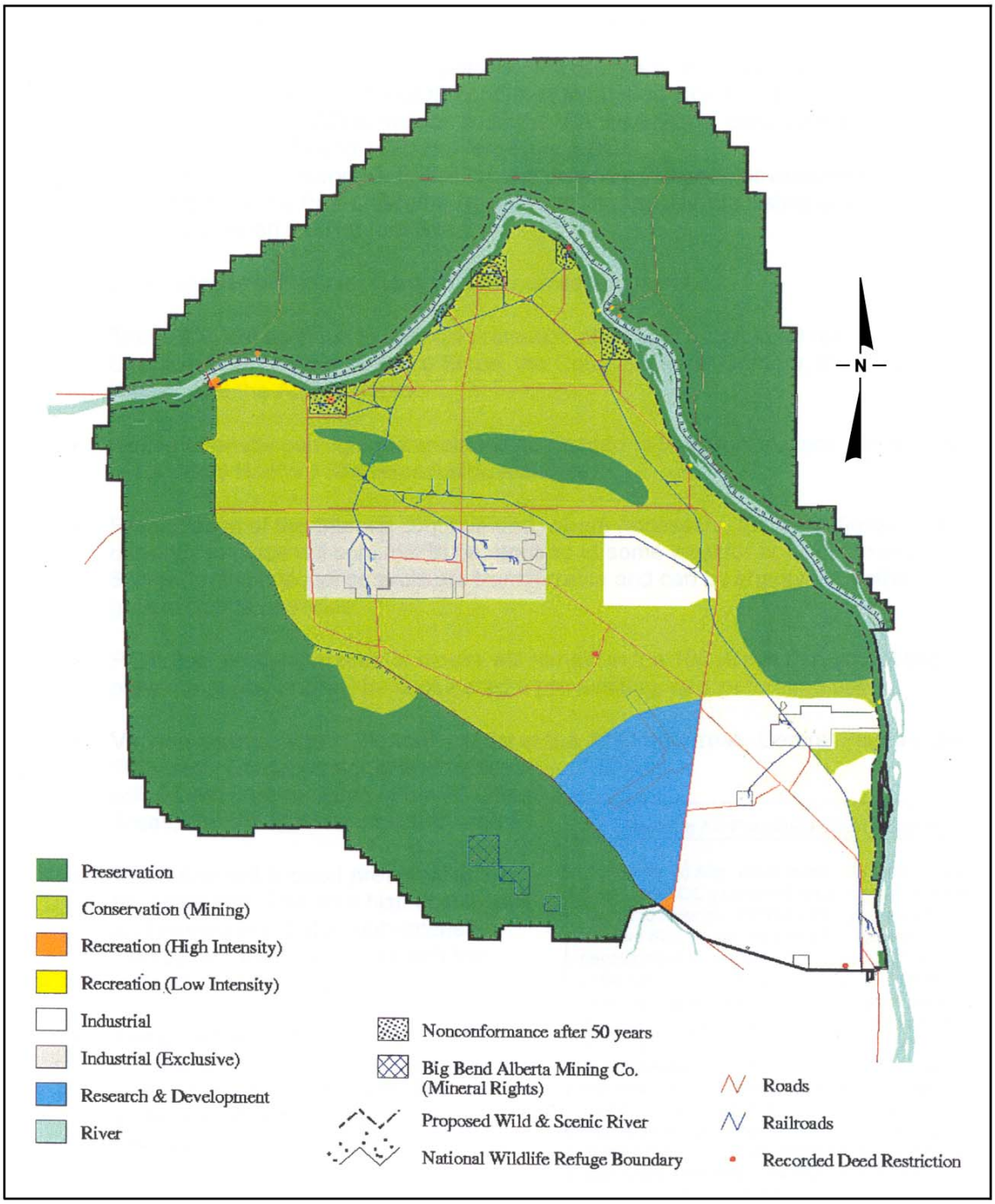


Figure 4.2. DOE Preferred Alternative for Land Use on the Hanford Site from the Final Hanford Comprehensive Land-Use Plan EIS (DOE 1999)

- **Columbia River Corridor**. The 111.6 km^2 (43.1 mi^2) Columbia River Corridor, which is adjacent to and runs through the Hanford Site, is used for boating, water skiing, fishing, and hunting of upland game birds and migratory waterfowl. Although public access is allowed on certain islands, access to other islands and adjacent areas is restricted because of unique habitats and the presence of cultural resources.

  The area within the Columbia River Corridor known as the Hanford Reach includes an average of a 402-m (1320-ft) strip of public land on either side of the Columbia River, as well as the islands and water surface area. Along the southern shoreline of the Columbia River Corridor, the 100 Areas occupy approximately 68 km^2 (26 mi^2). The facilities in the 100 Areas include nine retired plutonium production reactors, associated facilities, and structures. Resource Conservation and Recovery Act of 1976 (RCRA) closure permit restrictions have been placed in the vicinity of the 100-H Area that are associated with the 183-H Solar Evaporation Basins. Institutional controls are expected for the RCRA post-closure and Comprehensive Environmental Restoration, Compensation, and Liability Act of 1980 (CERCLA) remediation areas.

- **Central Plateau**. The 200 East and 200 West Areas occupy approximately 51 km^2 (19.5 mi^2) in the Central Plateau (the 200 Area Plateau) of the Hanford Site. Facilities located on the 200 Area Plateau were built to process irradiated fuel from the production reactors. The operation of these facilities resulted in the need for treatment, storage, and disposal facilities for radioactive and hazardous wastes. Unplanned releases of radioactive and non-radioactive waste have contaminated some parts of the 200 Areas. The Environmental Restoration Disposal Facility (ERDF) for CERCLA cleanup wastes is located in the 200 Area Plateau. Other federal agencies, such as the Department of the Navy, also use Hanford nuclear waste treatment, storage, or disposal facilities. Institutional controls are expected for CERCLA remediation areas in the 200 Area Plateau.

  A commercial LLW disposal facility, operated by U.S. Ecology, Inc., currently occupies 0.4 km^2 (0.16 mi^2) of the 200 Area Plateau. The facility is located on a portion of the 100 ac (originally 1000 ac) leased by the State of Washington from the federal government and subleased to U.S. Ecology, Inc.

- **All Other Areas**. All Other Areas comprise 689 km^2 (266 mi^2) and contain the 300, 400, and 1100 Areas, Energy Northwest facilities, and a section (2.6 km^2 [1 mi^2]) of land currently owned by the State of Washington for the disposal of hazardous substances.

  The Hanford 1100 Area and the Hanford railroad southern connection (from Horn Rapids Road to Columbia Center) have been transferred from DOE ownership to Port of Benton ownership to support future economic development. Although the 1100 Area is no longer under DOE control, it was included in the HCP EIS to support the local governments with their State Environmental Policy Act (SEPA) EIS analyses of the Hanford sub-area of Benton County under the State of Washington Growth Management Act.

The 300 Area is located just north of the city of Richland and covers 1.5 km^2 (0.6 mi^2). The 300 Area is the site of former reactor fuel fabrication facilities and is also the principal location of nuclear research and development facilities serving the Hanford Site.

The 400 Area, located southeast of the 200 East Area, is the site of the Fast Flux Test Facility (FFTF). As a result of the Final Programmatic Environmental Impact Statement (DOE 2000), and the January 2001 ROD (66 FR 7877), DOE decided to permanently shut down this facility.

Energy Northwest currently operates Columbia Generating Station on land leased from DOE. The land is approximately 10 km (6 mi) north of the city of Richland. The land was leased for the operation of three nuclear power plants. Construction of two of the plants was halted. Other industrial options for the site are currently being considered. Under the terms of the lease agreements, DOE would need to approve alternative uses of the land.

In 1980, the federal government sold a 2.6 km^2 (1 mi^2) section of land (known as Section 1.0) south of the 200 East Area, near SR 240, to the State of Washington for the purpose of non-radioactive hazardous waste disposal. To date, this parcel has not been used for hazardous waste disposal. The deed requires that if it were used for any purpose other than hazardous waste disposal, ownership would revert to the federal government.

Additional activities in the All Other Areas include:

(1) *A specialized training center*: The Hazardous Materials Management and Emergency Response (HAMMER) Volpentest Training and Education Center is used to train hazardous materials response personnel. It is located north of the former 1100 Area and covers about 0.3 km^2 (0.12 mi^2).

(2) *A regional law-enforcement training facility*: The Hanford Patrol Training Academy, located adjacent to HAMMER, provides a range of training environments including classrooms, library resources, practice shoot houses, an exercise gym, and an obstacle course.

(3) *A national research facility*: The Laser Interferometer Gravitational Wave Observatory (LIGO), built by the National Science Foundation for scientific research, is designed to detect cosmic gravitational waves. The facility consists of two optical tube arms, each 4 km (2.5 mi) long, arrayed in an L shape, and is extremely sensitive to vibrations.

(4) *Fitzner/Eberhardt Arid Lands Ecology Reserve Unit:* The 308.7 km^2 (119.2 mi^2) ALE, a Research Natural Area, is part of the Hanford Reach National Monument and is managed by the FWS. ALE is located in the southwestern portion of the Hanford Site and is managed as a wildlife reserve and environmental research center. The public is currently restricted from the site.

4.2.1 Hanford Reach National Monument

On June 9, 2000, portions of the Hanford Site including ALE, Saddle Mountain Wildlife Refuge, Wahluke Slope, White Bluffs, the sand dune area northwest of the Energy Northwest Site, historic structures (including homesteads from small towns established along the riverbanks in the early 20th century), and land .8 km (¼ mi) inland on the south and west shores of the 82-km (51-mi) long Hanford Reach, the last free-flowing, non-tidal stretch of the Columbia River, were designated as a National Monument (Figure 4.3) by President Clinton (65 FR 37253). Also included were the McGee Ranch and Riverlands area and the federally owned islands within the portion of the Columbia River.

On June 14, 2001, U.S. Department of Energy – Richland Operation Office (DOE-RL) and the FWS signed an amended Memorandum of Understanding (MOU) delegating management responsibilities for the Hanford Reach National Monument. As a result of the MOU, the FWS is the lead agency in producing a Comprehensive Conservation Plan (CCP) for management of the Hanford Reach National Monument. Development of the CCP will be a public process, including input from local governments, affected Native American Tribes, stakeholders, and others, including the recently initiated Federal Advisory Committee for the Hanford Reach National Monument. The DOE will participate in writing the CCP, and, in cooperation with the FWS, approve the plan. Under the MOU, which is intended to remain in effect for 25 years, DOE and FWS will produce agreements for site access, security, emergency preparedness, mutual assistance, wildland fire response, and cultural and biological resource management.

4.2.2 200 Areas

The focus of the HSW EIS is on waste storage, treatment, transportation, and disposal activities. For a description of the facilities, refer to Section 2.0. The Central Waste Complex (CWC) is located in the 200 West Area (Figure 4.4). Low-level waste (LLW), mixed low-level waste (MLLW), and transuranic (TRU) waste from onsite and offsite generators are stored in CWC pending treatment and/or disposal.

The Waste Receiving and Processing Facility (WRAP) is located in the 200 West Area. It began operations in 1997 and can process TRU waste, certify TRU waste and LLW for disposal, and provide limited treatment of MLLW. The 4800 m^2 (52,000 ft^2) facility is located near the CWC, and is designed to process 6800 drums and 70 boxes of waste annually for 30 years (Poston *et al.* 2001).

T Plant Complex, located in the northeast corner of the 200 West Area, consists of two major facilities: T Plant canyon and 2706-T Facility. T Plant Complex is used for waste verification, decontamination of equipment, repackaging of radioactive wastes, and storage of pressurized water reactor spent fuel from an offsite reactor. It is also capable of stabilization of toxic characteristic regulated soils, land disposal restrictions determination for mixed waste soils, macroencapsulation of debris and contaminated equipment, and neutralization and repackaging of organic and inorganic lab packs. Presently, the T Plant Complex is storing 27 metric tons (30 tons) of spent reactor fuel (from Shippingport, Pennsylvania). This fuel will be dried and moved out of the T Plant canyon. K Basins sludge will be moved to the T Plant pool cells or stored in dry cells.

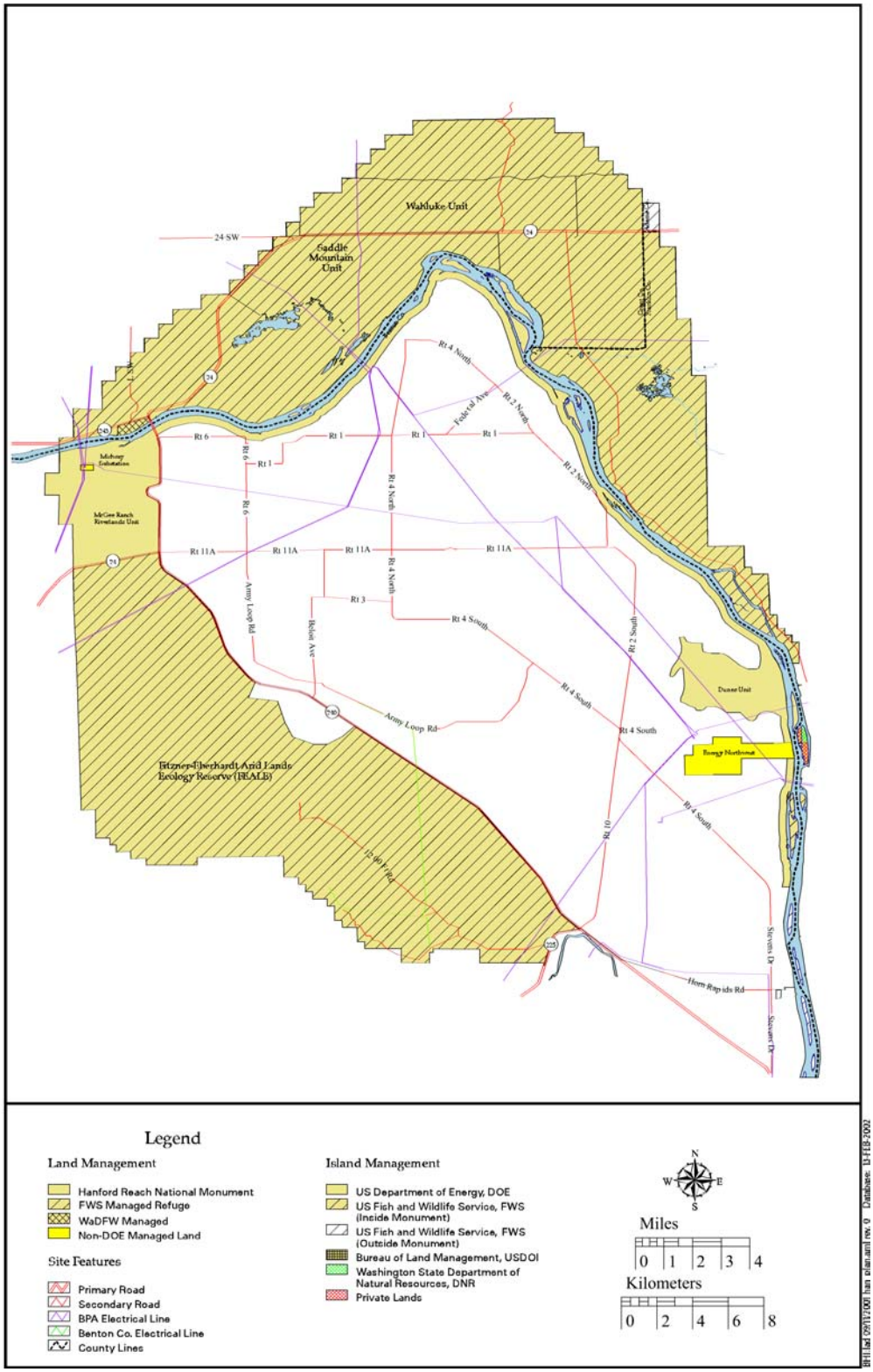


Figure 4.3. Hanford Reach National Monument

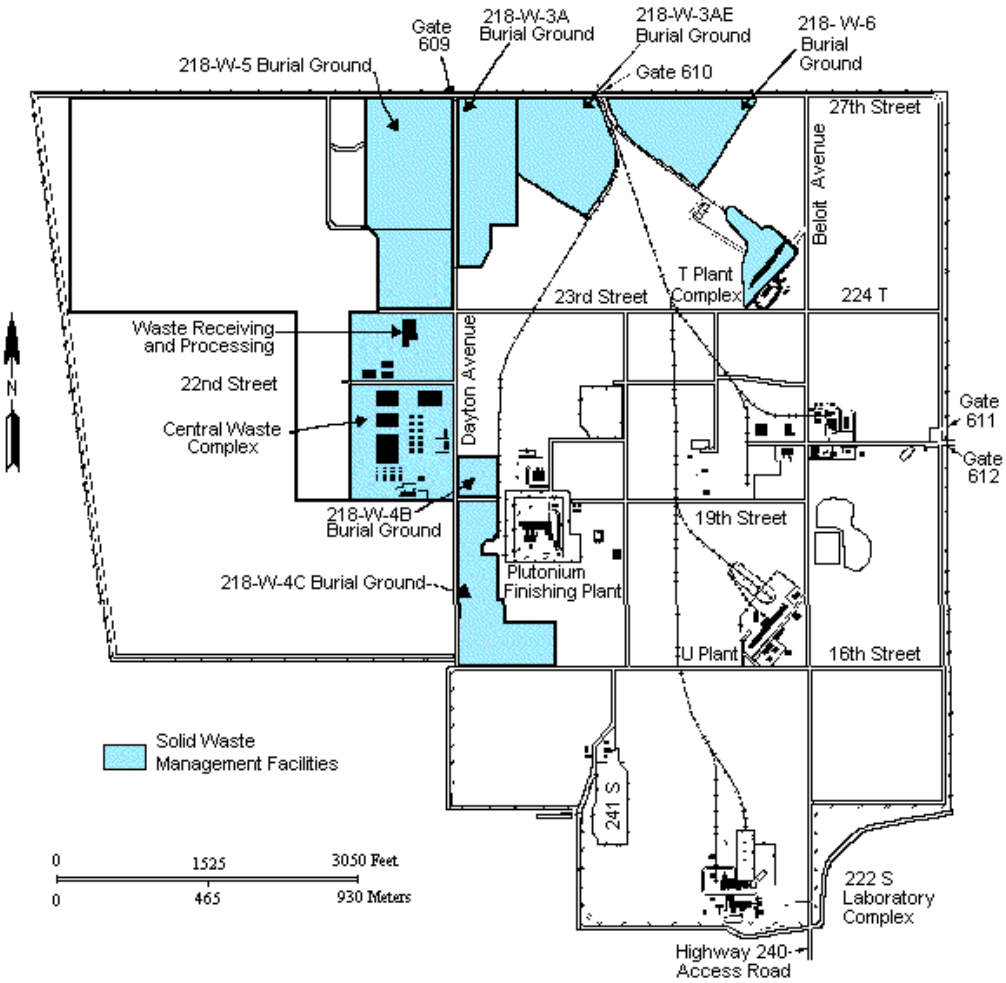


Figure 4.4. 200 West Area

The 200 Areas Effluent Treatment Facility (ETF), located in the 200 East Area (Figure 4.5), provides treatment and storage for hazardous and radioactive liquid waste. Liquid effluents are treated to remove metals, radionuclides, and ammonia, as well as to destroy organic compounds. The facility, in operation since 1995, is capable of treating 570 L (150 gal) per minute. Treated effluent is stored in verification tanks, sampled and analyzed, and discharged to the State-Approved Land Disposal Site, north of the 200 West Area (Poston *et al.* 2001).

The Liquid Effluent Retention Facility (LERF), located in the 200 East Area, consists of three RCRA-compliant surface impoundments for the temporary storage of process condensate from the 242-A evaporator and other aqueous wastes. Each basin has a capacity of 29.5 million L (7.8 million gal) and is constructed of two flexible high-density polyethylene membrane liners. Beneath the secondary liner is a soil/bentonite barrier. Each basin is covered by a mechanically tensioned floating membrane cover, designed to minimize evaporation of the contents and screen unwanted material from entering the basin. The facility began operation in 1994 and receives liquid waste from the RCRA- and CERCLA-regulated cleanup activities.

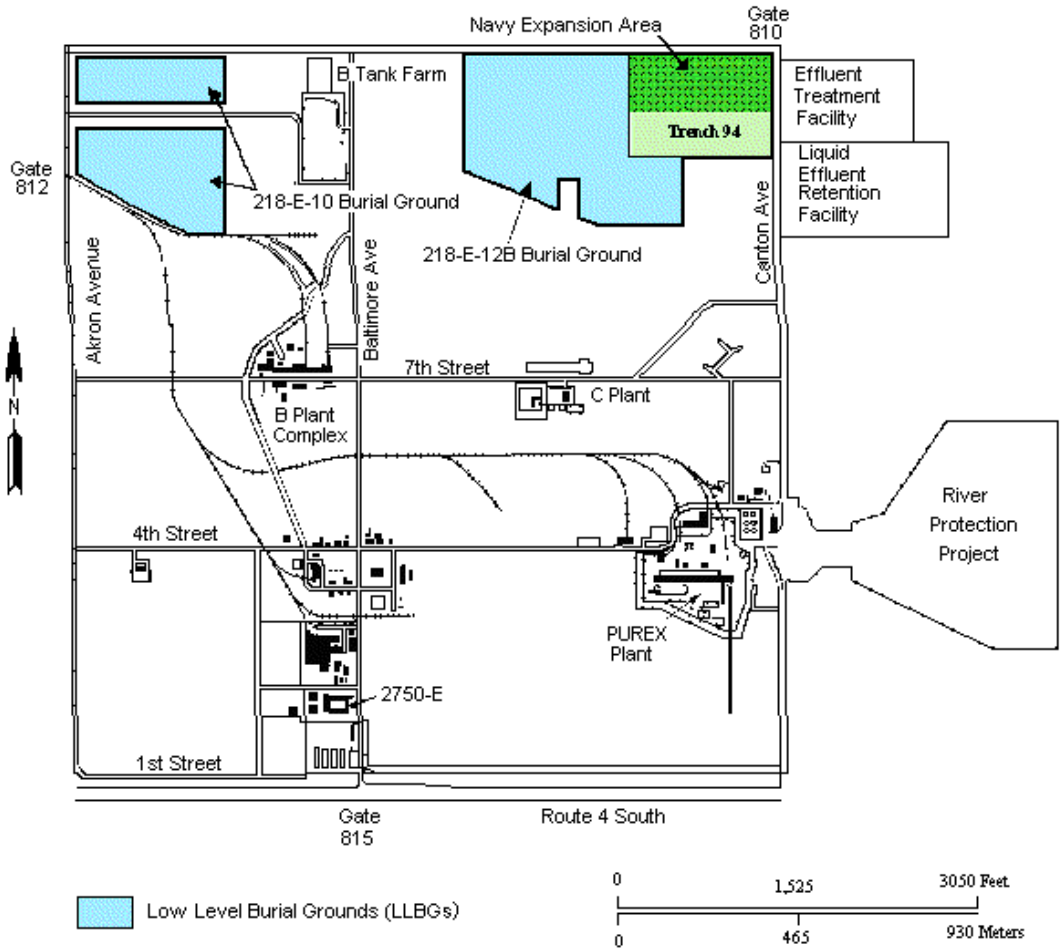


Figure 4.5. 200 East Area

The 200 Areas Treated Effluent Disposal Facility (TEDF) began operation in 1995 and is a collection and disposal system for non-RCRA-permitted waste streams. It includes about 18 km (11 mi) of underground pipeline connecting three pumping stations, one disposal sample station (6653 Building), and two 2-hectare (5-ac) disposal ponds located east of the 200 East Area. TEDF has a capacity of 12,900 L/min (3400 gal/min).

The Low Level Burial Grounds (LLBGs) are eight separate waste disposal areas located in the 200 Areas. They are regulated under the Atomic Energy Act. Information summarizing specifics concerning the LLBGs are found in Appendix D.

The 200 Areas, including some LLBGs, contain relatively small areas of surface contamination as a result of biotic intrusion by deep-rooted plants or burrowing animals. Surface contamination is present in three of the older LLBGs (218-E-10, 218-E-12B, and 218-W-3AE) and amounts to less than 0.1 ha (0.25 ac) of contaminated surface area compared to a total of about 100 ha (250 ac) in the 200 East and 200 West Areas. Areas of underground contamination, such as the LLBGs, cribs, ponds, ditches, trenches, and inactive disposal sites are cleaned up and stabilized as needed to prevent further spread of

surface contamination. As part of the near-facility monitoring and biological control programs, areas of surface contamination are posted, monitored, and surveyed at least annually to document their radiological status. Personal protective clothing and special procedures are required for entry into these surface contamination areas. However, surveys of the 200 Area contaminated soil sites during 2000 indicated that radionuclide concentrations were below soil concentration limits established to protect onsite workers (Poston *et al.* 2001).

4.3 Meteorology and Air Quality

Air resources addressed in this section include climate and meteorology, atmospheric dispersion, and ambient air quality.

4.3.1 Climate and Meteorology

The Hanford Site is categorized as a mid-latitude semiarid region. Summers are warm and dry, while winters are cool with occasional precipitation. Intense heating during the day and nocturnal cooling produce large diurnal temperature variations. The Cascade Mountain range, beyond Yakima to the west, greatly influences the climate of the Hanford Area by means of its rain shadow effect. The Cascades limit the Pacific Ocean maritime influence by blocking the passage of frontal systems and causing less rain and cloud-cover on the lee side of the mountains. This mountain range also serves as a source of cold air drainage with a considerable effect on the wind regime at the Hanford Site.

Climatological data for the Hanford Site are compiled at the Hanford Meteorology Station (HMS). The HMS is located just outside the northeast corner of 200 West Area and about 4 km (3 mi) west of the 200 East Area. Data from the HMS are representative of the general climatic conditions for the region and describe the specific climate of the 200 Area Plateau. Meteorological measurements have been made at the HMS since late 1944. Prior to the establishment of the HMS, local meteorological observations were made at the old Hanford townsite (1912 through late 1943) and in Richland (1943-1944). A climatological summary for Hanford is provided in Hoitink *et al.* (2001). To accurately characterize meteorological differences across the Hanford Site, the HMS operates a network of automated monitoring stations. These stations, which currently number 30, are located throughout the site and in neighboring areas (Figure 4.6). A 124-m (408-ft) instrumented meteorological tower operates at the HMS, station 21. A 61-m (200-ft) instrumented tower operates at each of the 100-N, 300, and 400 Area meteorology-monitoring sites. Most of the other network stations utilize short-instrumented towers with heights of about 9 m (30 ft). Instrumentation on each tower is described in Table 4.1. Data are collected and processed at each monitoring site and key information is transmitted to the HMS every 15 min. This monitoring network has been in full operation since the early 1980s.

Wind. Wind data at the HMS are collected at 2.1 m (7 ft) above the ground and at the 15.2-, 61.0-, and 121.9-m (50-, 200-, and 400-ft) levels on the 124-m (408-ft) tower. Each of the three 61-m (200-ft) towers has wind-measuring instrumentation at the 10-, 25-, and 60-m (33-, 82-, and 197-ft) levels. The short towers measure winds at 9.1-m (30-ft) aboveground level.

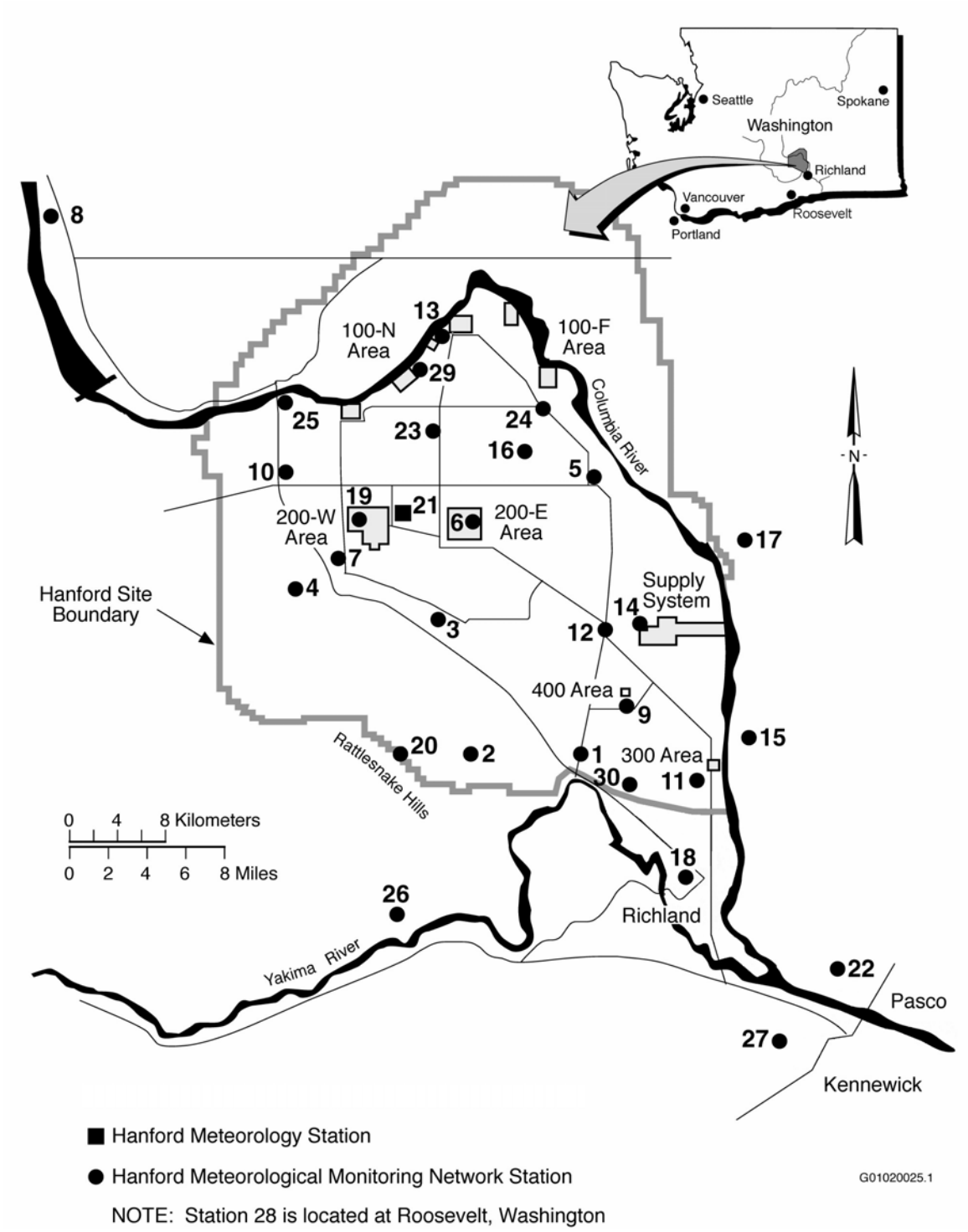


Figure 4.6. Hanford Meteorological Monitoring Network (after Hoitink *et al.* 2001)

Table 4.1. Station Numbers, Names, and Meteorological Parameters for Each Hanford Meteorological Monitoring Network Site (Hoitink *et al.* 2001)

Site Number	Site Name	Meteorological Parameter
1	Prosser Barricade	WS, WD, T, P
2	EOC	WS, WD, T, P
3	Army Loop Road	WS, WD, T, P
4	Rattlesnake Springs	WS, WD, T, P
5	Edna	WS, WD, T
6	200 East Area	WS, WD, T, P, AP
7	200 West Area	WS, WD, T, P
8	Beverly	WS, WD, T, P
9	FFTF (61 m or 200 ft)	WD, T, TD, DP, P, AP
10	Yakima Barricade	WS, WD, T, P, AP
11	300 Area (61 m or 200 ft)	WS, WD, T, TD, DP, P, AP
12	Wye Barricade	WS, WD, T, P
13	100-N Area (61 m or 200 ft)	WS, WD, T, TD, DP, P, AP
14	Energy Northwest (Supply System)	WS, WD, T, P
15	Franklin County	WS, WD, T
16	Gable Mountain	WS, WD, T
17	Ringold	WS, WD, T, P
18	Richland Airport	WS, WD, T, AP
19	Plutonium Finishing Plant	WS, WD, T, AP
20	Rattlesnake Mountain	WS, WD, T, P
21	Hanford Meteorology Station (125 m or 410 ft)	WS, WD, T, P, AP
22	Tri-Cities Airport	WS, WD, T, P
23	Gable West	WS, WD, T
24	100-F Area	WS, WD, T, P
25	Vernita Bridge	WS, WD, T
26	Benton City	WS, WD, T, P
27	Vista	WS, WD, T, P
28[(a)]	Roosevelt, Washington	WS, WD, T, P, AP
29	100-K Area	WS, WD, T, P, AP
30	HAMMER	WS, WD, T

Legend:

AP - Atmospheric Pressure
DP - Dew Point Temperature
P - Precipitation
T - Temperature
TD - Temperature Difference (between 10-m and 60-m tower levels)
WD - Wind Direction
WS - Wind Speed

(a) Roosevelt is located on the Columbia River 92 km (57 mi) west/southwest of the site.

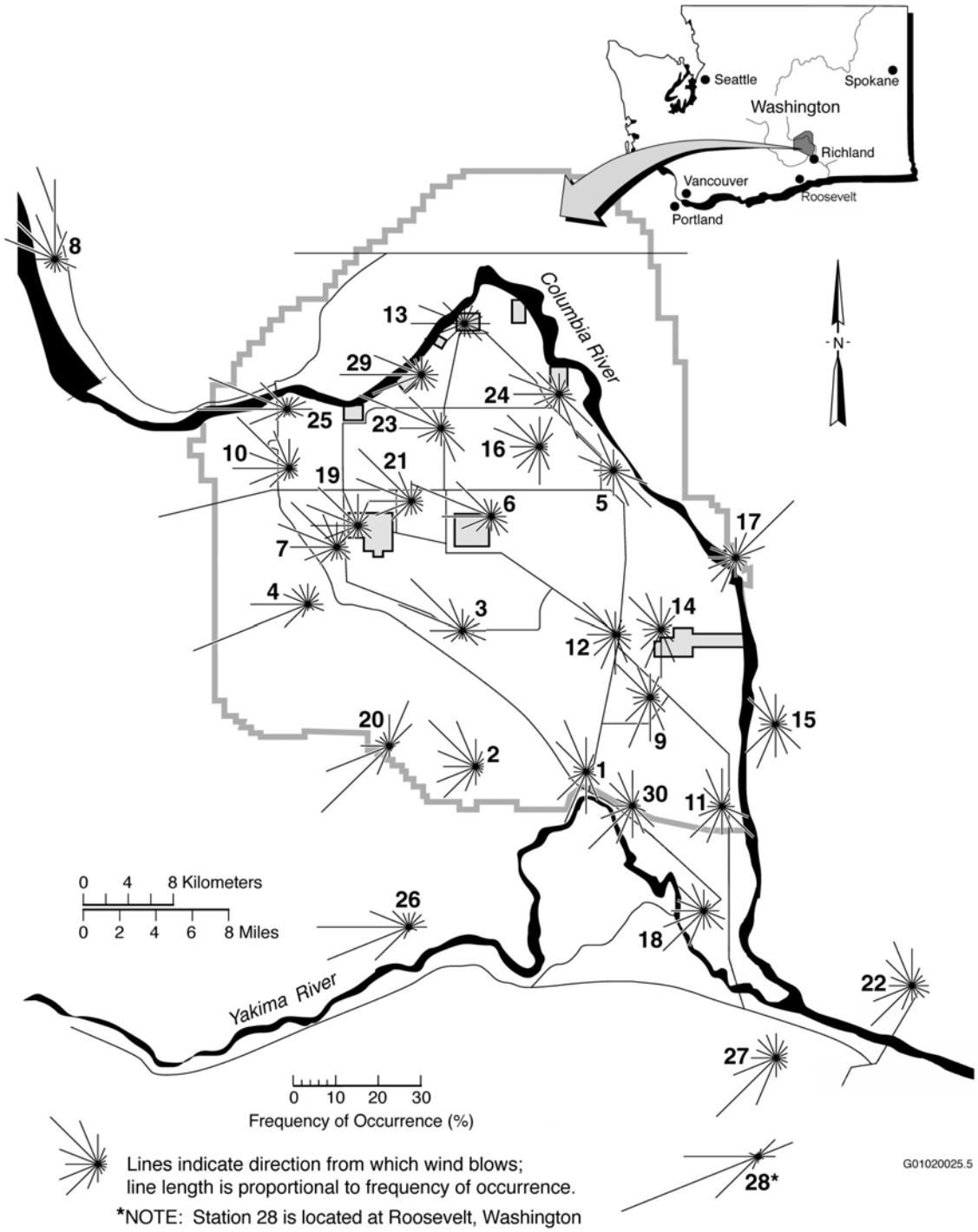


Figure 4.7. Wind Roses at the 9.1-m (30-ft) Level of the Hanford Meteorological Monitoring Network, 1982 to 2000 (after Hoitink *et al.* 2001)

Prevailing wind directions near the surface on the Hanford 200 Area Plateau are from the northwest in all months of the year (Figure 4.7). Winds from the northwest occur most frequently during the winter and summer. Winds from the southwest also have a high frequency of occurrence on the 200 Area Plateau. During the spring and fall, the frequency of winds from the southwest increases and winds from the northwest correspondingly decrease.

Monthly and annual joint-frequency distributions of wind direction versus wind speed for the HMS are reported in Hoitink *et al.* (2001). Monthly average wind speeds at 15.2 m (50 ft) above the ground are lower during the winter months, averaging 2.7 to 3.1 m/s (6- to 7-mph), and highest during the summer, averaging 3.6 to 4.0 m/s (8 to 9 mph). The highest wind speeds at the HMS are usually associated with flow from the southwest. However, the summertime drainage winds from the northwest frequently exceed speeds of 13 m/s (30 mph). The maximum speed of the drainage winds (and their frequency of occurrence) tends to decrease toward the southeast across the Hanford Site.

Surface features have less influence on winds aloft than winds near the surface. However substantial spatial variations are found in the wind distributions across Hanford at 61 m (200 ft) aboveground level (Figure 4.8). For releases at greater heights, the most representative data may come from the closest representative 61-m (200-ft) tower rather than the nearest 9.1-m (30-ft) tower.

Table 4.2 presents information on number of days, by month and annually, with wind gusts ≥ 11 m/s (25 mph) and 16 m/s (35 mph) for the HMS. The table also includes record high and low values.

Temperature and Humidity. Monthly averages and extremes of temperature, dew point, and humidity are presented in Hoitink *et al.* (2001). Based on data collected from 1946 through 2000, the average monthly temperatures at the HMS range from a low of -0.7°C (31°F) in January to a high of 24.7°C (76°F) in July. The highest winter monthly average temperatures were 6.9°C (44°F) in February 1958 and February 1991, and the lowest average monthly temperature was -11.1°C (12°F) in January 1950. The highest monthly average temperature was 27.9°C (82°F) in July 1985, and lowest summer monthly average temperature was 17.2°C (63°F) in June 1953. Ranges of daily maximum temperatures vary from an average of 2°C (35°F) in late December and early January to 36°C (96°F) in late July. The record maximum temperature is 45°C (113°F), and the record minimum temperature is -31°C (-23°F).

Relative humidity/dew point temperature measurements are made every 15 minutes at the 200 Area HMS (Station 21). The annual average relative humidity at the HMS is 55 percent. It is highest during the winter months, averaging about 76 percent, and lowest during the summer, averaging about 36 percent. The annual average dewpoint temperature at the HMS is 1°C (34°F). In the winter the dewpoint temperature averages about -3°C (27°F), and in the summer it averages about 6°C (43°F).

Precipitation. Precipitation measurement records have been kept at the HMS since 1945. Average annual precipitation at the HMS is 17 cm (6.8 in). In the wettest year on record, 1995, 31.3 cm (12.3 in) of precipitation was measured; in the driest year, 1976, only 7.6 cm (3 in) was measured. Most precipitation occurs during the late autumn and winter, with more than half of the annual amount occurring from November through February. Average snowfall ranges from 0.25 cm (0.1 in) in October to a maximum of 13.2 cm (5.2 in) in December and decreases to 0.8 cm (0.3 in) in March. Snowfall accounts for about 38 percent of all precipitation from December through February.

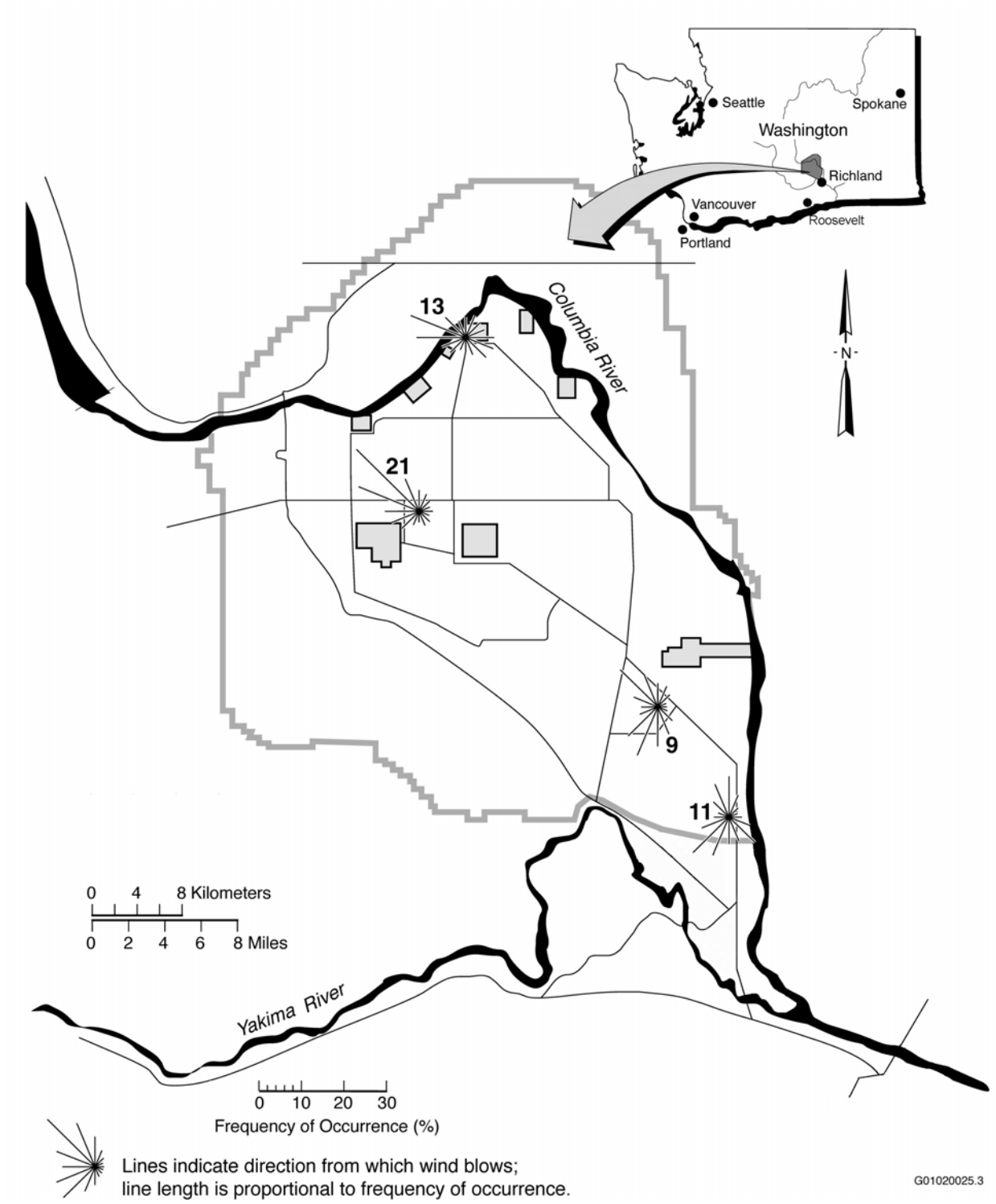


Figure 4.8. Wind Roses at the 60-m (197-ft) Level of the Hanford Meteorological Monitoring Network, 1986 to 2000 (after Hoitink *et al.* 2001)

Table 4.2. Number of Days with Peak Gusts Above Specific Thresholds at 15-m (50-ft) Level, 1945 through 2000 (Hoitink *et al.* 2001)

Days with Peak Gusts ≥11 m/s (25 mph)						Days with Peak Gusts ≥16 m/s (35 mph)				
Month	**Avg**	**Max**	**Year**	**Min**	**Year**	**Avg**	**Max**	**Year**	**Min**	**Year**
January	7.6	21	1953	0	1985[(a)]	4.0	14	1953	0	1985[(a)]
February	8.7	17	1976[(a)]	2	1952[(a)]	3.8	14	1976	0	2000[(a)]
March	12.9	21	1977	4	1992	5.4	14	1997	0	1992
April	16.9	26	1954	8	1946	6.3	12	1972	1	1967
May	18.7	26	1978	9	1945	6.1	10	2000[(a)]	0	1957
June	19.6	26	1963	11	1950[(a)]	6.2	12	1973	1	1982
July	19.4	26	1995	11	1955	5.5	11	1994[(a)]	1	1982[(a)]
August	15.8	24	2000	7	1945	4.1	12	1996	0	1978[(a)]
September	11.2	17	1971	7	1975[(a)]	3.3	7	1992[(a)]	0	1975
October	8.8	17	1985[(a)]	3	1987[(a)]	3.1	11	1997	0	1993[(a)]
November	8.3	16	1990	0	1979	3.8	10	1998	0	1997[(a)]
December	7.5	15	1968	0	1985	4.2	11	1957	0	1985[(a)]
Annual	155.7	192	1999	123	1952	55.9	83	1999[(a)]	31	1978

(a) Most recent of multiple occurrences.

Fog and Visibility. Fog has been recorded during every month of the year on the 200 Area Plateau; however, 89 percent of the occurrences are from November through February, with less than 3 percent from April through September. Fog is reported any time horizontal visibility is reduced to 9.6 km (6 mi) or less because of the suspension of water droplets in the surface layer of the atmosphere. Dense fog is reported when horizontal visibility is reduced to 0.4 km (0.25 mi) or less.

Other phenomena causing restrictions to visibility (visibility less than or equal to 9.6-km [6 mi]) include dust, blowing dust, and smoke from field burning. Few such days occur; an average of 5 d/yr have dust or blowing dust and <1 d/yr has reduced visibility from smoke.

Severe Weather. The average occurrence of thunderstorms on the 200 Area Plateau is 10 per year. Using the National Weather Service (NWS) criteria for classifying a thunderstorm as severe (i.e., hail with a diameter ≥19 mm [3/4 in] or wind gusts of ≥25.9 m/s [58 mph]), only 1.9 percent of all

thunderstorm events surveyed at the HMS have been "severe" storms, and they met the NWS criteria based on their wind gusts. High-speed winds at Hanford are more commonly associated with strong cold frontal passages. In rare cases, intense low-pressure systems can generate winds of near hurricane force. Estimates of the extreme winds, based on peak gusts, are given in Hoitink *et al.* (2001).

The National Climatic Data Center maintains a database that provides information on the incidence of tornados reported in each county in the United States. (This database can be accessed via the Internet at http://www.ncdc.noaa.gov/ol/climate/severeweather/extremes.html.) This database reports that in the 10 counties closest to the Hanford Site (Benton, Franklin, Grant, Adams, Yakima, Klickitat, Kittitas, and Walla Walla counties in Washington, Umatilla, and Morrow counties in Oregon), only 18 tornadoes were recorded from 1950 through March 2001. Of these, 12 tornadoes had maximum wind speeds estimated to be in the range of 18 to 32 m/s (40 to 72 mph), 3 had maximum wind speeds in the range of 33 to 50 m/s (73 to 112 mph), and 3 had maximum wind speeds in the range of 51 to 71 m/s (113 to 157 mph). No deaths or substantial property damage were associated with any of these tornadoes.

Ramsdell and Andrews (1986) report that for the area in which the Hanford Site is located (a 5° block centered at 117.5° west longitude and 47.5° north latitude), the expected path length of a tornado is 7.6 km (4.7 mi). The expected width is 95 m (312 ft), and the expected area is about 1.5 km^2 (0.6 mi^2). The estimated probability of a tornado striking any point at Hanford, also from Ramsdell and Andrews (1986), is 9.6 x 10^{-6}/yr. The probabilities of extreme winds associated with tornadoes striking a point can be estimated using the distribution of tornado intensities for the region. These probability estimates are given in Table 4.3.

Table 4.3. Estimate of the Probability of Extreme Winds Associated with Tornadoes Striking a Point at Hanford (Ramsdell and Andrews 1986)

Wind Speed		Probability Per Year
(m/s)	(mph)	
28	62	2.6 x 10^{-6}
56	124	6.5 x 10^{-7}
83	186	1.6 x 10^{-7}
111	249	3.9 x 10^{-8}

4.3.2 Atmospheric Dispersion

Atmospheric dispersion is defined as the transport and diffusion of gases and particles within the atmosphere. It is a function of wind speed, duration and direction of wind, mixing depth, and the intensity of atmospheric turbulence (wind motions at very small time scales that act to disperse gas and particles rather than transporting them downwind). Atmospheric turbulence is not measured directly at the Hanford Site; instead, the impact of turbulence on atmospheric dispersion is characterized using atmospheric stability. Atmospheric stability describes the thermal stratification or vertical temperature

structure of the atmosphere. Generally, six or seven different classes of atmospheric stability are used to describe the atmosphere. These classes range from extremely unstable (when atmospheric turbulence is greatest) to extremely stable (when atmospheric mixing is at a minimum and wind speeds are low). When the atmosphere is unstable, pollutants can rapidly diffuse through a wide volume of the atmosphere. When the atmosphere is stable, pollutants will diffuse much more slowly in a vertical direction. Horizontal dispersion may be limited during stable conditions; however, plumes may also fan out horizontally during stable conditions, particularly when the wind speed is low. Most major pollutant incidents are associated with stable conditions when inversions can trap pollutants near the ground.

Favorable dispersion conditions are most common in the summer when neutral and unstable stratification is present—about 56 percent of the time (Stone *et al.* 1983). Less favorable dispersion conditions may occur when the wind speed is light and the mixing layer is shallow. These conditions are most common during the winter, when moderately to extremely stable stratification is present, about 66 percent of the time (Stone *et al.* 1983). Low dispersion conditions also occur periodically for surface and low-level releases in all seasons from about sunset to about an hour after sunrise, as a result of ground-based temperature inversions and shallow mixing layers. Occasionally, extended periods of poor dispersion conditions are associated with stagnant air in the stationary high-pressure systems that occur primarily during the winter months (Stone *et al.* 1983).

Stone *et al.* (1972) estimated the probability of extended periods of poor dispersion conditions. The probability of an inversion, once established, persisting more than 12 hr varies from a low of about 10 percent in May and June to a high of about 64 percent in September and October. These probabilities decrease rapidly when the duration of the inversion is more than 12 hr. Table 4.4 summarizes the probabilities associated with extended surface-based inversions.

Table 4.4. Percent Probabilities for Extended Periods of Surface-Based Inversions (based on data from Stone *et al.* 1972)

Months	**Inversion Duration**		
	12 hr	**24 hr**	**48 hr**
	Percent		
January-February	54.0	2.5	0.28
March-April	50.0	<0.1	<0.1
May-June	10.0	<0.1	<0.1
July-August	18.0	<0.1	<0.1
September-October	64.0	0.11	<0.1
November-December	50.0	1.2	0.13

Many simple dispersion models use the joint frequency distribution of atmospheric stability, wind speed, and wind direction to compute diffusion factors for both chronic and acute releases. Joint frequency distributions of atmospheric stability, wind speed, and transport direction for the measurements taken in the 200 Areas at 10 m (33 ft) are found in Appendix F, Table F. 33. The values in the joint frequency distributions represent the percentage of the time that pollutants would initially be transported toward the direction listed[a] (for example, S, SSW, SW).

4.3.3 Air Quality

The U.S. Environmental Protection Agency (EPA) has issued regulations (40 CFR 50) setting national ambient air quality standards. Individual States have the primary responsibility for assuring that air quality within the State meets the national ambient air quality standards through State implementation plans (SIP) that are approved by EPA. Areas that meet ambient air quality standards are said to be in attainment. Areas that do not meet one or more ambient air standards are designated as non-attainment areas. The Hanford Site is in attainment with all national ambient air quality standards (40 CFR 81.348).

Ambient air quality 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). Ambient air is that portion of the atmosphere, external to buildings, to which the general public has access (40 CFR 50.1). EPA has issued ambient air standards for sulfur oxides (measured as sulfur dioxide), nitrogen dioxide, carbon monoxide, particulates with an aerodynamic diameter less than or equal to a nominal 10 micrometers (PM_{10}) and 2.5 micrometers ($PM_{2.5}$), lead, and ozone. The standards specify the maximum pollutant concentrations and frequencies of occurrence that are allowed for specific averaging periods. The averaging periods vary from 1 hr to 1 yr, depending on the pollutant.

In 1994, DOE and EPA signed the Federal Facility Compliance Agreement for Radionuclides National Emission Standards for Hazardous Air Pollutants (NESHAP) (EPA 1994). This agreement provides a compliance plan and schedule designed to bring the Hanford Site into compliance with Clean Air Act requirements under 40 CFR 61, Subpart H, for the continuous measurement of emissions from applicable airborne emissions sources. The Hanford Site air emissions are below the standard of 10 mrem/yr.

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 total suspended particulates (Washington State Administrative Code [WAC 173-470]), radionuclides (WAC 246-247), and fluorides (WAC 173-481). The State standards for carbon monoxide, nitrogen dioxide, PM_{10}, and lead are identical to the national standards. The Hanford Site is in compliance with the State ambient air standards. Table 4.5 summarizes the relevant air quality standards (federal and supplemental State standards).

(a) The transport direction and the wind direction are different methods of reporting the same basic information. Wind direction and transport direction are always out of phase by 180°.

Table 4.5. Federal and Washington State Ambient Air Quality Standards[a] (after Neitzel 2001)

Pollutant	Federal Primary	Federal Secondary	Washington State
Total Suspended Particulates			
Annual geometric mean	NS(b)	NS	60 μg/m^3
24-hr average	NS	NS	150 μg/m^3
PM10			
Annual arithmetic mean	50 μg/m^3	50 μg/m^3	50 μg/m^3
24-hr average	150 μg/m^3	150 μg/m^3	150 μg/m^3
PM2.5			
Annual arithmetic mean	15 μg/m^3	15 μg/m^3	NS
24-hr average	65 μg/m^3	65 μg/m^3	
Sulfur Dioxide			
Annual average	0.03 ppm (80 μg/m^3)	NS	0.02 ppm (50 μg/m^3)
24-hr average	0.14 ppm (365μg/m^3)	NS	0.10 ppm (260 μg/m^3)
3-hr average	NS	0.50 ppm (1.3 mg/m^3)	NS
1-hr average	NS	NS	0.40 ppm (1.0 mg/m^3)(c)
Carbon Monoxide			
8-hr average	9 ppm (10 mg/m^3)	9 ppm (10 mg/m^3)	9 ppm (10 mg/m^3)
1-hr average	35 ppm (40 mg/m^3)	35 ppm (40 mg/m^3)	35 ppm (40 mg/m^3)
Ozone			
8-hr average	0.08 ppm (157 μg/m^3)	0.08 ppm (157 μg/m^3)	NS
1-hr average	0.12 ppm (235 μg/m^3)	0.12 ppm (235 μg/m^3)	0.12 ppm (235 μg/m^3)
Nitrogen Dioxide			
Annual average	0.053 ppm (100 μg/m^3)	0.053 ppm (100 μg/m^3)	0.053 ppm (100 μg/m^3)
Lead			
Quarterly average	1.5 μg/m^3	1.5 μg/m^3	1.5 μg/m^3
Radionuclides	(d)	NS	(e)
Fluorides			
12-hr average	NS	NS	3.7 μg/m^3
24-hr average			2.9 μg/m^3
7 day average			1.7 μg/m^3
30 day average			0.84 μg/m^3

Abbreviations: ppm = parts per million; μg/m^3 = micrograms per cubic meter; mg/m^3 = milligrams per cubic meter

(a) Source: 40 CFR 50 and WAC 173-470 – 173-481. Annual standards are never to be exceeded; short-term standards are not to be exceeded more than once per year unless otherwise noted. Particulate pollutants are in micrograms per cubic meter. Gaseous pollutants are in parts per million and equivalent microgram (or milligram) per cubic meter.

(b) NS = no standard.

(c) 0.25 ppm not to be exceeded more than twice in any 7 consecutive days.

(d) Maximum dose equivalent of 10 mrem/yr (40 CFR 61).

(e) Emissions of radionuclides in the air shall not cause a maximum accumulated dose equivalent of more than 25 mrem/yr to the whole body or 75 mrem/yr to a critical organ of any member of the public. Doses due to radon-220, radon-222, and their respective decay products are excluded from these limits. (WAC 173-480-040) Whenever another federal or State regulation or limitation in effect controls the emission of radionuclides to ambient air, the more stringent control of emissions shall govern. [WAC 173-480-050 (3)] Standards for radioactive air emissions in the State of Washington are contained in WAC 173-480-040, -050, and -060 and in 40 CFR 61, published in the *Federal Register* on December 15, 1989. In accordance with WAC 173-480-050(3), the Washington State Department of Health (WDOH) enforces the most stringent standard in effect (WAC 246-247-040).

4.3.3.1 Emissions of Non-radiological Pollutants

Non-radiological pollutants are emitted mainly from power-generating and chemical-processing facilities located on the Hanford Site. Table 4.6 summarizes the year 2000 airborne emission rates of non-radiological constituents from these facilities. The 100, 400, and 600 Areas have no non-radioactive emission sources of regulatory concern (Poston *et al.* 2001).

Table 4.6. Non-radioactive Constituents Emitted to the Atmosphere for the Year 2000[a,b] (Poston *et al.* 2001)

	Emission, kg (lb)			
Constituent	**200 Areas**		**300 Area**	
Particulate matter	900	(1,984)	677	(1,477)
Nitrogen oxides	24,000	(52,920)	3,500	(7,717)
Sulfur oxides	3,400	(7,497)	29	(64)
Carbon monoxide	18,000	(39,690)	12,000	(26,460)
Lead	0.53	(1.2)	0.0	(0.0)
Volatile organic compounds [c]	5,700	(2,569)	800	(1,764)
Ammonia[d]	12,000	(26,460)	NE [e]	
Other toxic air pollutants [f]	2,500	(5,512)	NE	

(a) The estimate of volatile organic compound emissions does not include emissions from certain laboratory operations.
(b) None of these releases exceed any of the ambient air quality standards.
(c) Produced from burning fossil fuels for steam generation and electrical generators, calculated estimates from the 200 East and 200 West Area tank farms, and operation of the 242-A Evaporator and the 200 Areas Effluent Treatment Facility.
(d) Ammonia releases are from the 200 East Area tank farms, 200 West Area tank farms, and operation of the 242-A Evaporator, and the 200 Areas Effluent Treatment Facility.
(e) NE = no emissions.
(f) Releases are a composite of calculated estimates of toxic air pollutants, excluding ammonia, from the 200 East and 200 West Area tank farms, and operation of the 242-A Evaporator and the 200 Areas Effluent Treatment Facility.

4.3.3.2 Radiological Air Quality

Air emissions that may contain radioactive constituents are monitored at the Hanford Site. Samples are analyzed for gross alpha and gross beta activity, as well as for selected radionuclides.

Radioactive airborne emissions during 2000 (the most recent year for which data are published) originated in the 100, 200, 300, and 400 Areas. The 100 Area emissions originated from normal evaporation from K Basins (irradiated fuel stored in two water-filled storage basins), the newly constructed Cold Vacuum Drying Facility in the 100-K Area, and a low-level radiochemistry laboratory. The 200 Area emissions originated from the Plutonium Finishing Plant, T Plant Complex, 222-S Laboratory, tank farms, waste evaporators, and the inactive PUREX Plant. Emissions from the 300 Area originated from

the 324 Waste Technology Engineering Laboratory, 325 Applied Chemistry Laboratory, 327 Post-Irradiation Laboratory, and 340 Vault and Tanks. The 400 Area emissions originated from the FFTF, and the Maintenance and Storage Facility (Poston *et al.* 2001). A summary of radiological air emissions is provided in Table 4.7.

The potential air pathway dose from stack emissions to a maximally exposed individual was calculated to be 0.022 mrem/yr, which represents 0.3 percent of the EPA standard (Poston *et al.* 2001).

Table 4.7. Radionuclides Emitted to the Atmosphere at the Hanford Site, 2000 (Poston *et al.* 2001)

Radionuclide	Half-Life	Emission, Ci [(a)]				
		100 Areas	200 East Area	200 West Area	300 Area	400 Area
Tritium (as HT)[(b)]	12.3 yr	NM [(a)]	NM	NM	4.3E+01	NM
Tritium (as HTO)[(b)]	12.3 yr	NM	NM	NM	7.9E+01	8.8E-01
Cobalt-60	5.3 yr	3.4E-08	ND[(a)]	ND	ND	NM
Strontium-90	29.1 yr	4.1E-05	9.1E-05[(c)]	1.9E-04[(c)]	1.0E-05[(c)]	NM
Technetium-99	2.13×10^5 yr	NM	NM	NM	1.7E-08	NM
Antimony-125	2.77 yr	ND	1.8E-06	ND	ND	NM
Iodine-129	1.6×10^7 yr	NM	1.2E-03	NM	NM	NM
Cesium-137	30 yr	1.1E-04	6.7E-05	2.1E-09	1.6E-06	3.5E-06[(d)]
Plutonium-238	87.7 yr	8.4E-07	9.8E-08	1.1E-05	7.6E-09	NM
Plutonium-239, 240	2.4×10^4 yr	5.4E-06	2.5E-06[(e)]	5.1E-04[(e)]	8.2E-07[(e)]	NM[(f)]
Plutonium-241	14.4 yr	6.8E-05	6.1E-06	3.1E-04	NM	NM
Americium-241	432 yr	2.6E-06	4.8E-06	8.7E-05	3.4E-08	NM
Americium-243	7,380 yr	NM	NM	NM	ND	NM

(a) 1 Ci = 3.7 E+10 Bq; NM = not measured; ND = not detected (i.e., either the radionuclide was not detected in any sample during the year or the average of all the measurements for that given radionuclide or type of radioactivity made during the year was below background levels).
(b) HTO = tritiated water vapor; HT = elemental tritium.
(c) This value includes gross beta release data. Gross beta and unspecified beta results assumed to be strontium-90 for dose calculations.
(d) This value includes gross beta release data. Gross beta results assumed to be cesium-137 for dose calculations from FFTF emissions.
(e) This value includes gross alpha release data. Gross alpha and unspecified alpha results assumed to be plutonium-239/240 for dose calculations.
(f) Analyses were conducted for gross alpha activity, but none was detected. If detected, it would have been assumed to be plutonium-239/240 for dose calculations.

4.3.4 Background Radiation

For the year 2000, the average external dose rate near the Hanford Site boundary was measured at 89 ± 4 mrem/yr using thermoluminescent dosimeters (Poston *et al.* 2001). Similarly for communities nearby the site, such as Richland, Pasco, Kennewick, Mattawa, Othello, Basin City, and Benton City the average dose rate was measured at 78 ± 3 mrem/yr. The average external dose rate measured for distant communities, such as Toppenish and Yakima, was 69 ± 1 mrem/yr. The national average for external radiation dose from naturally occurring sources is about 55 mrem/yr (NCRP 1987), but it varies significantly with elevation and geological conditions. At a given location, the annual variation in external dose rate is on the order of 5 mrem. External radiation is but one part of total effective dose equivalent received from naturally occurring sources. The information presented here are representative of the external dose rate, excluding radon and presence of radionuclides internal to the body. Naturally occurring sources of ionizing radiation include primordial radionuclides, such as potassium-40 and the uranium series; cosmogenic radionuclides, such as carbon-14 and tritium; and cosmic radiation. The radionuclides are present in varying amounts in nearly all media, soil, air, water, food and biota, including humans.

4.4 Geologic Resources

Geologic considerations for the Hanford Site include topography and geomorphology, stratigraphy, soil characteristics, and seismicity. This section, which provides an overview of the Hanford Site subsurface environment, focuses primarily on the 200 Area Plateau, located in the center of the site.

4.4.1 Topography and Geomorphology

The sites associated with the Hanford solid waste program are located on a broad flat area of the Hanford Site commonly referred to as the Central Plateau. The Central Plateau is within the Pasco Basin, a topographic, structural depression in the southwest corner of the Columbia Basin physiographic subprovince. This subprovince is characterized by generally low-relief hills with deeply carved river drainage. The elevation of the Central Plateau is approximately 200 m (650 ft) to 230 m (750 ft) above sea level. The Plateau decreases in elevation to the north, northwest, and east toward the Columbia River. Plateau escarpments have elevation changes of 15 m (50 ft) to 30 m (100 ft). The Pasco Basin is an area of generally low relief ranging from 120 m (390 ft) above mean sea level at the Columbia River level, to 230 m (750 ft) above mean sea level in the 200 East Area. The Pasco Basin is bounded on the north by the Saddle Mountains; on the west by Umtanum Ridge, Yakima Ridge, and the Rattlesnake Hills; on the south by Rattlesnake Mountain and the Rattlesnake Hills; and on the east by the Palouse Slope. The Pasco Basin is shown in Figure 4.9.

Surface topography at the Hanford Site is the result of the uplift of anticlinal ridges, Pleistocene cataclysmic flooding, Holocene eolian activity, and landslides (Delaney *et al.* 1991). Uplift of the ridges began in the Miocene Epoch (24 to 5 million years ago), concurrent with the eruption of the flood basalts. Cataclysmic flooding occurred when glacial ice dams in western Montana and northern Idaho were breached, allowing large volumes of water to spill across eastern and central Washington State.

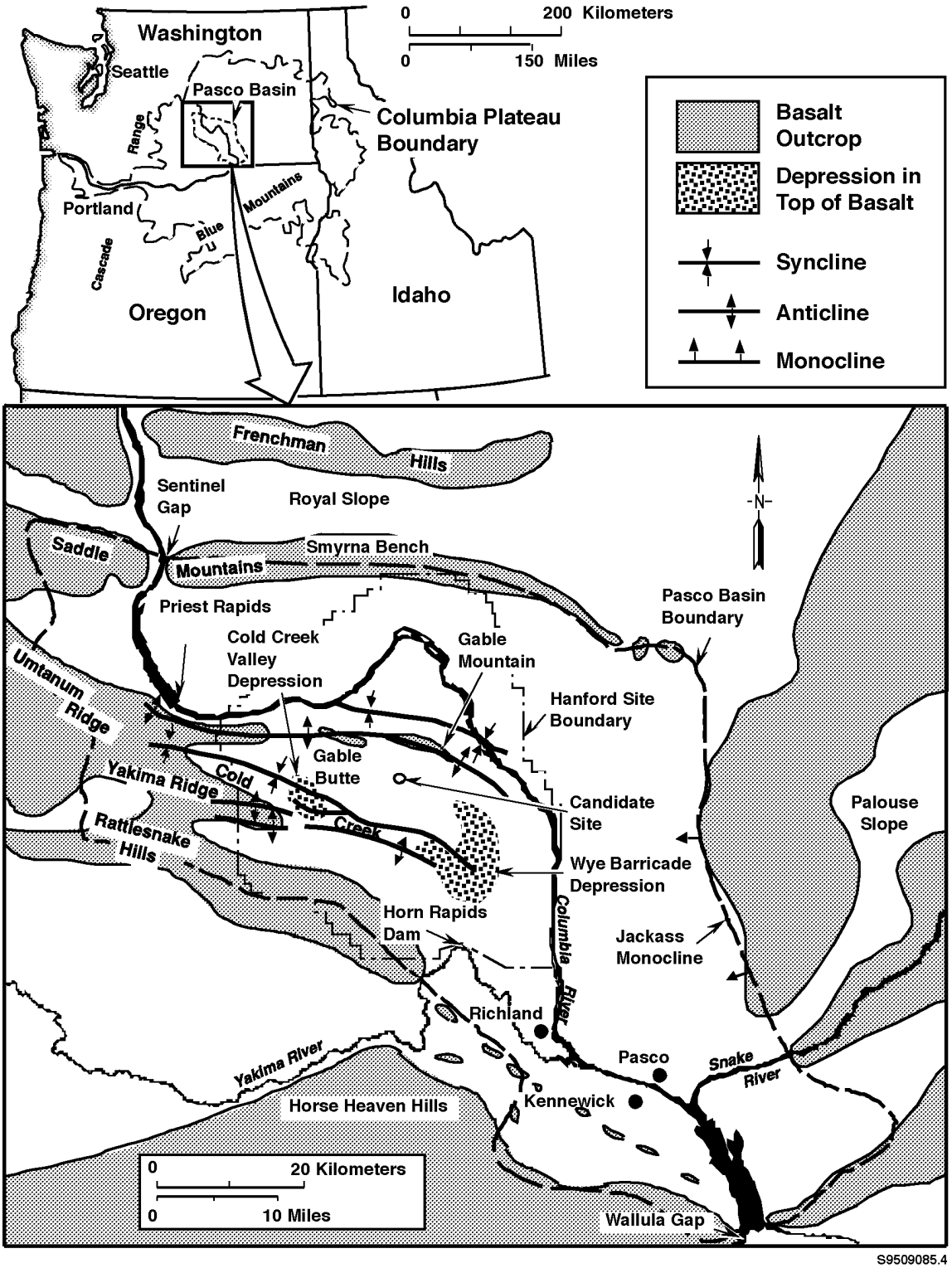


Figure 4.9. Geographic Setting and General Structural Geology of the Pasco Basin and Hanford Site (Bergstrom et. al 1983)

Much of the landscape in the path of the floodwater was stripped of sediments and basalt bedrock was scoured, forming scabland topography (elevated areas underlain by flat-lying basalt flows that generally exhibit deep, dry channels scoured into the surface). The last major flood occurred approximately 13,000 years ago during the late Pleistocene Epoch. Since then, winds have locally reworked the flood sediments, depositing dune sands in the lower elevations and loess (windblown silt) around the margins of the Pasco Basin. Anchoring vegetation has stabilized many sand dunes. Where human activity and/or natural events have disturbed this vegetation, dunes have been reactivated. For example, dunes have been reactivated by the removal of vegetation as a consequence of a large wildfire that occurred on the Hanford site in July 2000.

The 200 Areas are situated between the Gable Mountain anticline and the Cold Creek syncline. The Gable Mountain anticline is of particular importance to the groundwater flow. Portions of this anticline have been uplifted to a point where basalt is above the current water table. These basalts have a low hydraulic conductivity and act as a barrier to horizontal groundwater flow in the unconfined aquifer.

4.4.2 Stratigraphy

The stratigraphy of the Hanford Site consists of Miocene-age and younger rocks. Older Cenozoic sedimentary and volcaniclastic rocks underlying the Miocene rocks are not exposed at the surface. Figure 4.10 summarizes the Hanford Site stratigraphy. A generalized west to east cross-section depicting site structure and topography is shown as Figure 4.11.

Over 100 basalt flows of the Columbia River Basalt Group, with a total thickness exceeding 3000 m (10,000 ft), lie beneath the Hanford Site. Interbedded between many of these basalt flows are sedimentary rocks of the Ellensburg Formation, a series of sand, gravel, or silt layers that were deposited by the ancestral Columbia River system. Sediments up to 230 m (750 ft) thick overlie the Columbia River Basalt Group, and include the Ringold and Hanford formations. Thin, laterally discontinuous sedimentary deposits, referred to as the Plio-Pleistocene unit, pre-Missoula gravels, and early Palouse soil, locally separate the Ringold Formation from the overlying Hanford formation.

The Ringold Formation consists of siltstones, sandstones, and conglomerates deposited by the ancestral Columbia River system between 8 and 3 million years ago. The Ringold Formation reaches 180 m (600 ft) in thickness in the Cold Creek syncline south of the 200 West Area but thins and pinches out to the north. It is subdivided into five gravel layers referred to as Units A, B, C, D, and E that are separated by finer-grained units, including the lower mud (Figure 4.10).

The Hanford formation was deposited between 2 million years and 10,000 years ago by cataclysmic flooding from glacial Lake Missoula. The Hanford formation consists of pebble to boulder gravel, fine to coarse-grained sand, and silt, and is thickest (up to 65 m [210 ft]) under the 200 Areas. Gravel dominates the Hanford formation in the northern part of the area, while sand-dominated material is found most commonly in the central to southern parts. Holocene surficial deposits consisting of silt, sand, and gravel form a thin (less than 10-m [33-ft]) surface layer across much of the Hanford Site. Eolian (wind) and alluvial processes deposited these surficial materials.

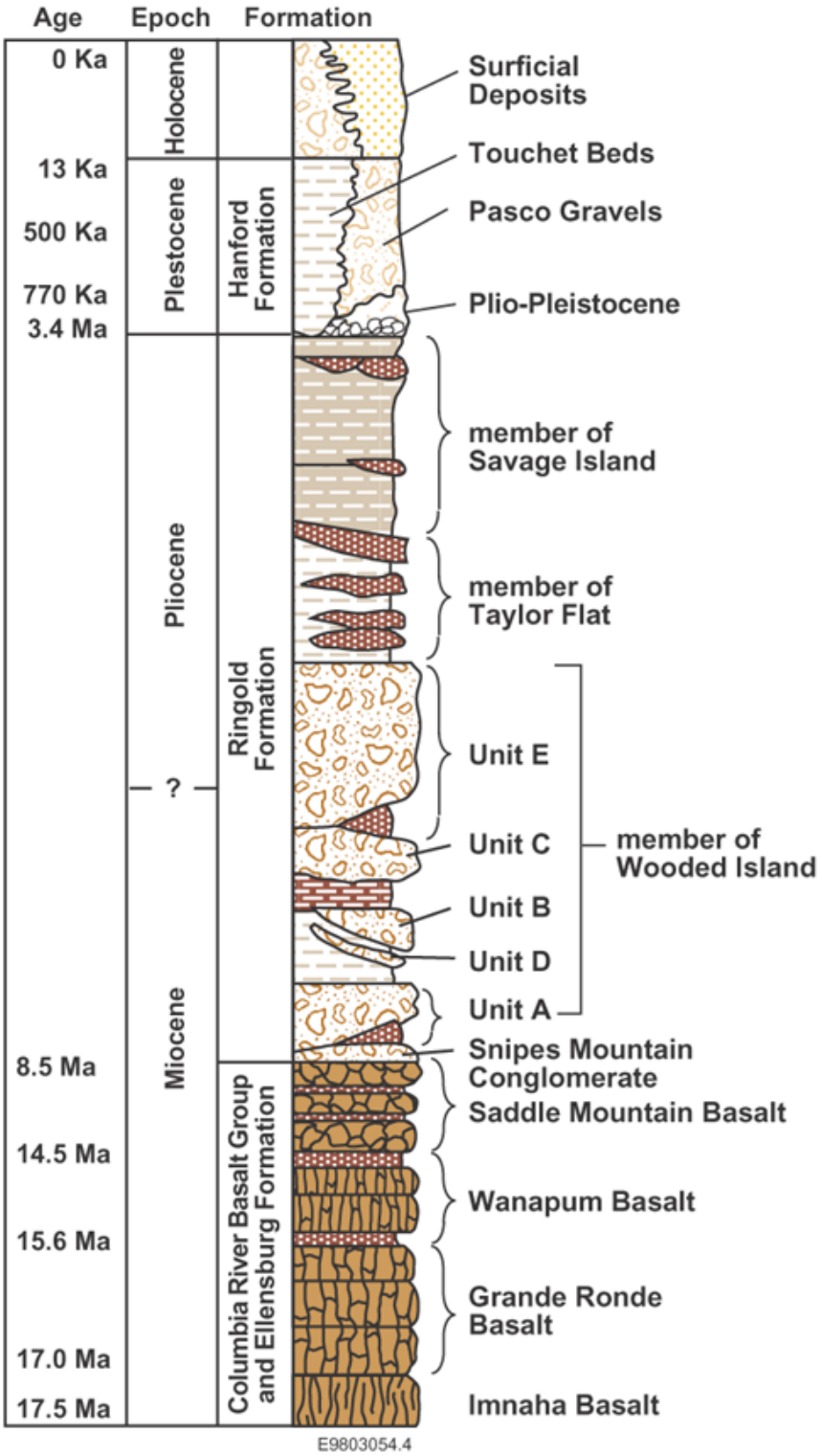


Figure 4.10. Stratigraphic Column for the Hanford Site (Reidel *et al.* 1992; Ka = thousand years; Ma = million years)

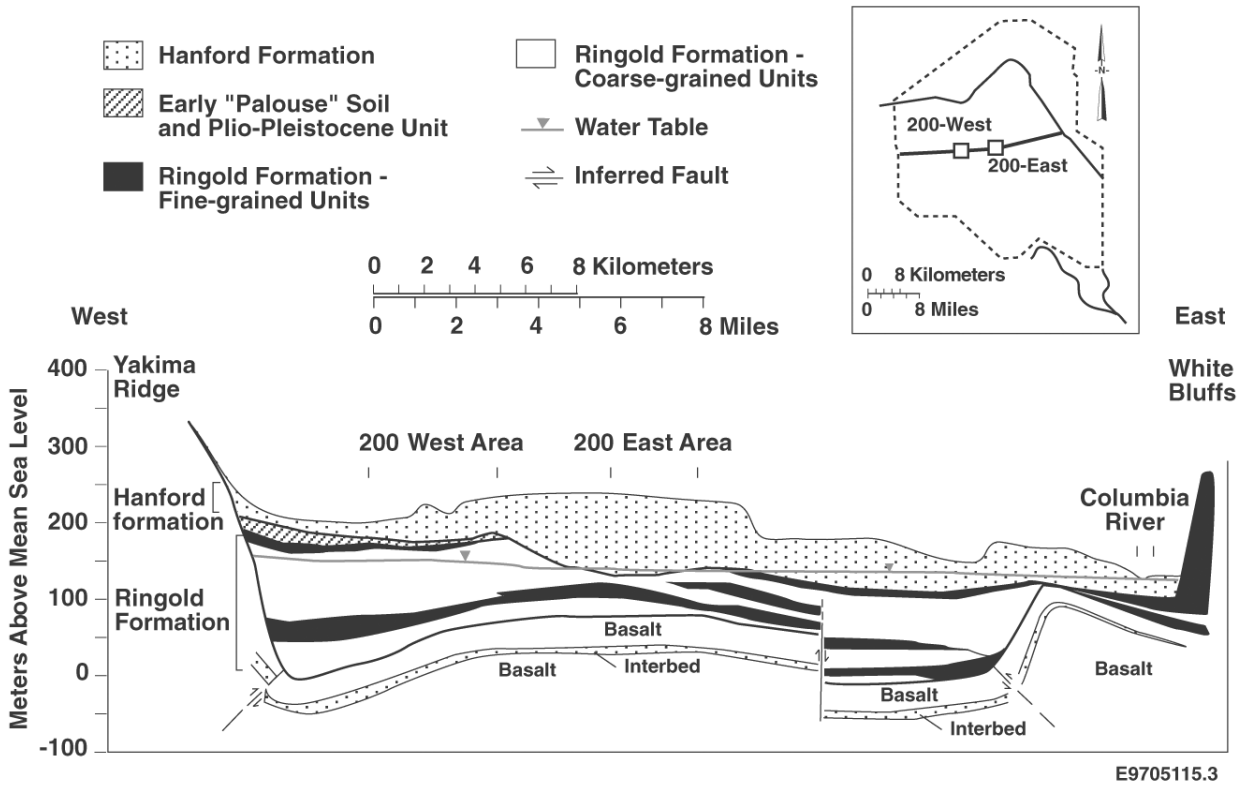


Figure 4.11. Generalized West to East Cross-Section of the Hanford Site Structure and Topography (DOE-RL 1999)

The geology in the 200 West Area is notably different from the 200 East Area, considering a distance of only 6 km (4 mi) separates them. One of the most complete suprabasalt stratigraphic sections on the Hanford Site containing most Ringold units, the Plio-Pleistocene unit, early Palouse soil, and the Hanford formation, is present in the 200 West Area.

In the 200 East Area, most of the Ringold Formation units are present in the southern part but have been eroded in a complex pattern to the north. On the north side of the 200 East Area, the Hanford formation rests directly on the basalt, and no Ringold sediments are present. Erosion by the ancestral Columbia River and catastrophic flooding are believed to have removed the Ringold Formation from this area. A unit of questionable origin locally overlies basalt within the B-BX-BY Waste Management Area (Schalla *et al.* 2000). This unit, referred to informally as H/PP deposits, may be equivalent or partially equivalent to the Plio-Pleistocene unit or it may represent the earliest ice-age flood deposits overlain by a locally thick sequence of fine-grained non-flood deposits.

4.4.3 Soils

Hajek (1966) describes 15 different soil types on the Hanford Site, varying from sand to silty and sandy loam. These soils are shown in Figure 4.12 and briefly described in Table 4.8.

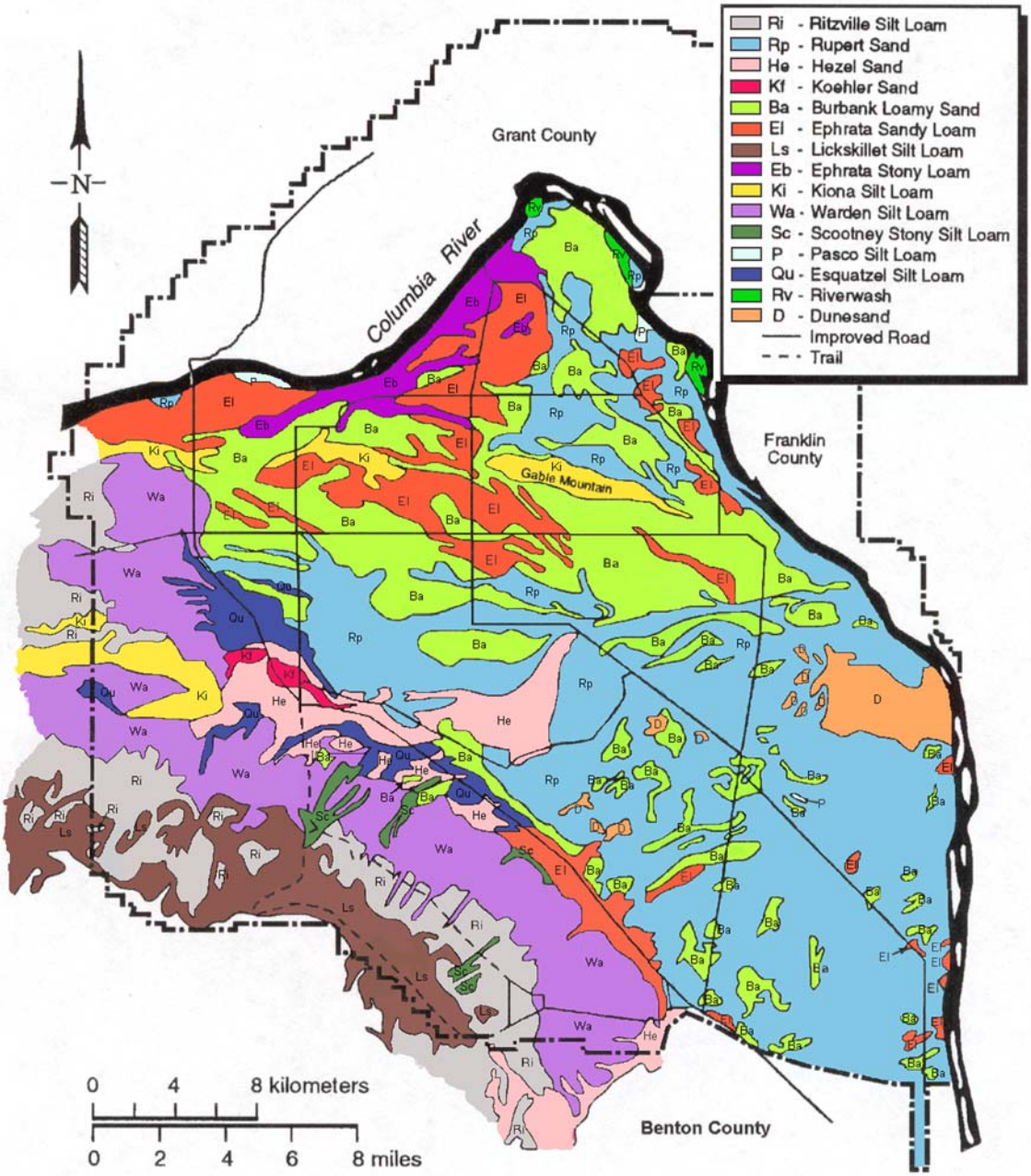


Figure 4.12. Soil Map of the Hanford Site (after Hajak 1966)

Table 4.8. Soil Types on the Hanford Site (after Hajek 1966)

Name (symbol)	Description
Ritzville Silt Loam (Ri)	Dark-colored silt loam soils midway up the slopes of the Rattlesnake Hills. Developed under bunch grass from silty wind-laid deposits mixed with small amounts of volcanic ash. Characteristically greater than 150 cm (60 in) deep, but bedrock may occur between 75 and 150 cm (30 and 60 in).
Rupert Sand (Rp)	One of the most extensive soils on the Hanford Site. Brown-to grayish-brown coarse sand grading to dark grayish-brown at 90 cm (35 in). Developed under grass, sagebrush, and hopsage in coarse sandy alluvial deposits that were mantled by wind-blown sand. Hummocky terraces and dune-like ridges.
Hezel Sand (He)	Similar to Rupert sands; however, laminated grayish-brown strongly calcareous silt loam subsoil is usually encountered within 100 cm (39 in) of the surface. Surface soil is very dark brown and was formed in wind-blown sands that mantled lake-laid sediments.
Koehler Sand (Kf)	Similar to other sandy soils on the Hanford Site. Developed in a wind-blown sand mantle. Differs from other sands in that the sand mantles a lime-silica cemented Hardpan layer. Very dark grayish-brown surface layer is somewhat darker than Rupert. Calcareous subsoil is usually dark grayish-brown at about 45 cm (18 in).
Burbank Loamy Sand (Ba)	Dark-colored, coarse-textured soil underlain by gravel. Surface soil is usually about 40 cm (16 in) thick but can be 75 cm (30 in) thick. Gravel content of subsoil ranges from 20 percent to 80 percent.
Ephrata Sandy Loam (El)	Surface is dark colored and subsoil is dark grayish-brown medium-textured soil underlain by gravelly material that may continue for many feet. Level topography.
Lickskillet Silt Loam (Ls)	Occupies ridge slopes of Rattlesnake Hills and slopes greater than 765 m (2509 ft) elevation. Similar to Kiona series except the surface soils are darker. Shallow over basalt bedrock, with numerous basalt fragments throughout the profile.
Ephrata Stony Loam (Eb)	Similar to Ephrata sandy loam. Differs in that many large hummocky ridges are made up of debris released from melting glaciers. Areas between hummocks contain many boulders several feet in diameter.
Kiona Silt Loam (Ki)	Occupies steep slopes and ridges. Surface soil is very dark grayish-brown and about 10 cm (4 in) thick. Dark-brown subsoil contains basalt fragments 30 cm (12 in) and larger in diameter. Many basalt fragments are found in surface layer. Basalt rock outcrops present. A shallow stony soil normally occurring in association with Ritzville and Warden soils.

Table 4.8. (contd)

Name (symbol)	Description
Warden Silt Loam (Wa)	Dark grayish-brown soil with a surface layer usually 23 cm (9 in) thick. Silt loam subsoil becomes strongly calcareous at about 50 cm (20 in) and becomes lighter colored. Granitic boulders are found in many areas. Usually greater than 150 cm (60 in) deep.
Scootney Stony Silt Loam (Sc)	Developed along the north slope of Rattlesnake Hills; usually confined to floors of narrow draws or small fan-shaped areas where draws open onto plains. Severely eroded with numerous basaltic boulders and fragments exposed. Surface soil is usually dark grayish-brown grading to grayish-brown in the subsoil.
Pasco Silt Loam (P)	Poorly drained very dark grayish-brown soil formed in recent alluvial material. Subsoil is variable, consisting of stratified layers. Only small areas found on the Hanford Site, located in low areas adjacent to the Columbia River.
Esquatzel Silt Loam (Qu)	Deep dark-brown soil formed in recent alluvium derived from loess and lake sediments. Subsoil grades to dark grayish-brown in many areas, but color and texture of the subsoil are variable because of the stratified nature of the alluvial deposits.
Riverwash (Rv)	Wet, periodically flooded areas of sand, gravel, and boulder deposits that make up overflowed islands in the Columbia River and adjacent land.
Dunesand (D)	Miscellaneous land type that consists of hills or ridges of sand-sized particles drifted and piled up by wind. Are either actively shifted or so recently fixed or stabilized that no soil horizons have developed.

The majority of the 200 West Area soils are Rupert Sand; the remaining third is Burbank Loamy Sand. The 200 East Area soils are composed of Ephrata Sandy Loam, Rupert Sand, and Burbank Loamy Sand.

4.4.4 Seismicity

The Hanford Site lies in an area of relatively low seismic activity. Figure 4.13 shows the locations of all earthquakes that occurred in the Columbia Plateau between 1850 and 1969 with a modified Mercalli intensity (MMI) of V or more and at Richter magnitude 4.0 or more. The largest earthquake that may have occurred in the eastern Washington area shown in Figure 4.13 happened in 1872, with MMI IX and estimated magnitude near 7.0, but its location has been variously estimated from Wenatchee to British Columbia. Figure 4.14 shows the locations of all earthquakes that occurred from 1969 to 2000 at Richter magnitudes of 3.0 or more. The largest known earthquake in the Columbia Plateau occurred in 1936 near Milton-Freewater, Oregon. This earthquake had a Richter magnitude of approximately 6.0 and a maximum MMI of VII, and was followed by a number of aftershocks indicating a northeast-trending fault plane. Other earthquakes with Richter magnitudes $\geq$ 5 and/or MMI of VI occurred 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 MMI VI earthquakes have occurred within the Columbia Plateau, including one event in the Milton-Freewater, Oregon, 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 earthquakes that occurred in 1918 and 1973. These two events were magnitude 4.4 and intensity V, and were located north of the Hanford Site near Othello.

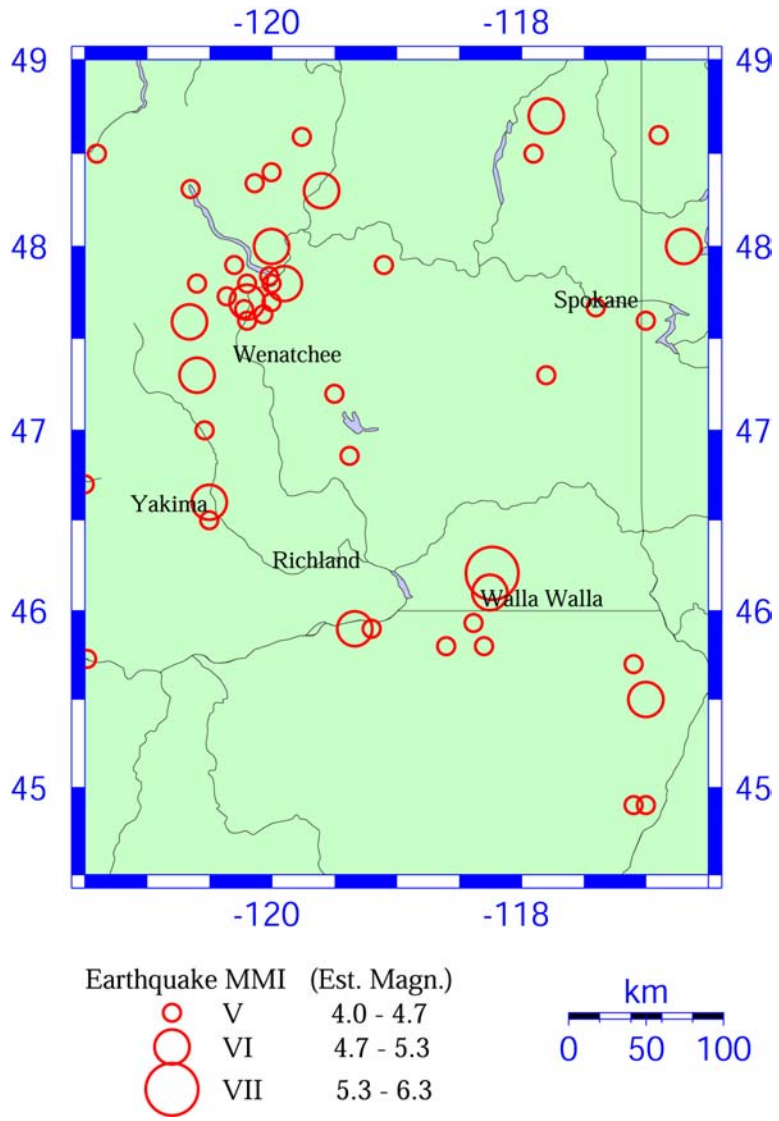


Figure 4.13. Historical Seismicity of the Columbia Plateau and Surrounding Areas. All earthquakes between 1850 and March 20, 1969, with a Modified Mercalli Intensity of V or larger or a Richter magnitude of 4.0 or larger, are shown (Rohay 1989). The magnitude ranges correspond to the original intensity estimated historically. Symbol sizes are only approximately related to those used in Figure 4.14. The uncertain location of the 1872 earthquake is not shown.

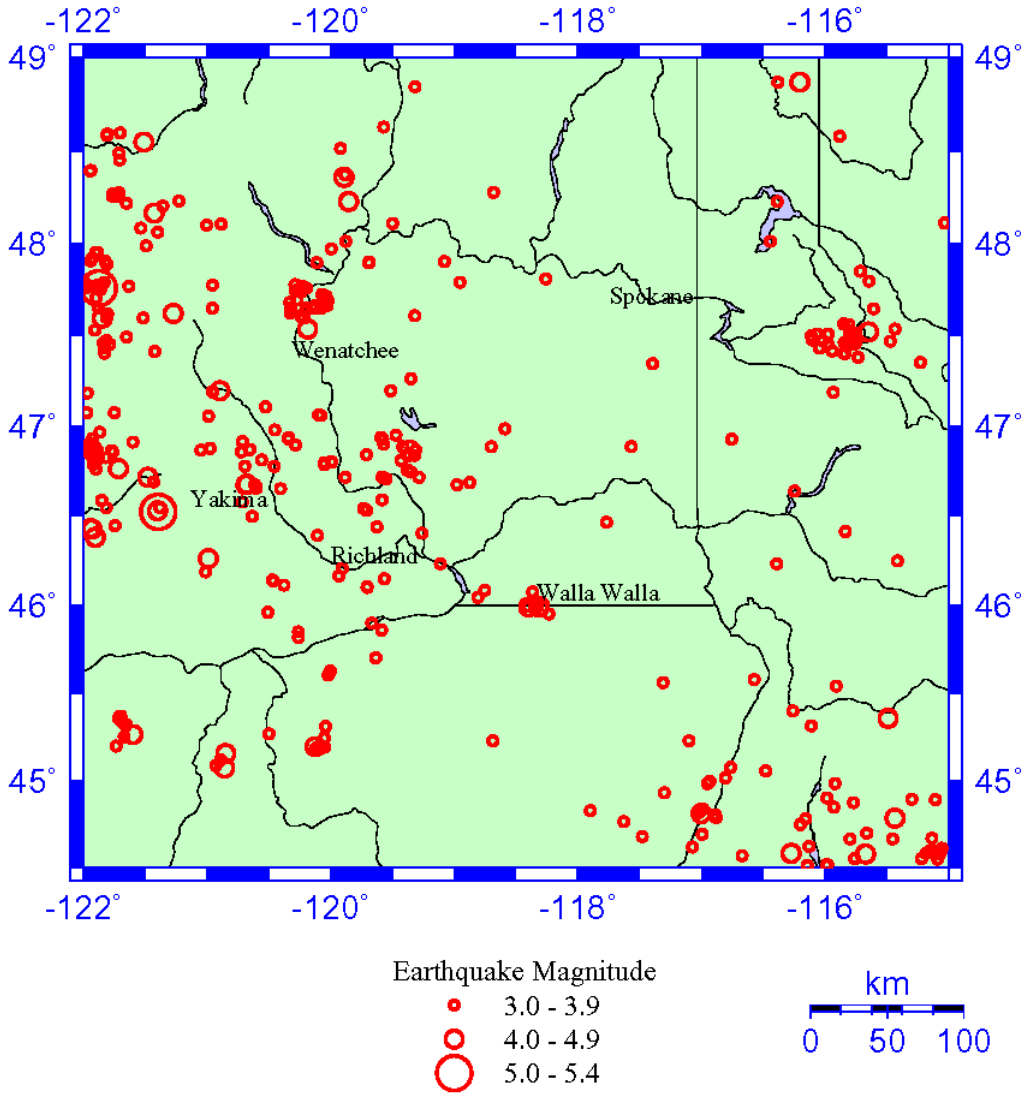


Figure 4.14. Seismicity of the Columbia Plateau and Surrounding Areas as Measured by Seismographs. All earthquakes from 3/20/1969 to 12/31/2000 with Richter magnitude 3 or larger are shown. Data sources: Council of the National Seismic System (CNSS 2001), University of Washington Geophysics Program (UWGP 2001).

In addition, earthquake swarms of small magnitudes that are not associated with mapped faults occur on and around the Hanford Site. 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. The frequency of earthquakes in a swarm tends to gradually increase and decay with no one outstanding large event within the sequence. Roughly 90 percent of the earthquakes in swarms have Richter magnitudes of 2 or less. These earthquake swarms generally occur at shallow depths, with 75 percent of the events located at depths < 4 km (< 2.5 mi). Each earthquake swarm typically lasts several weeks to months, consists of several to 100 or more earthquakes, and the locations are clustered in an area 5 to 10 km (3 to 6.2 mi) in lateral dimension.

The Pacific Northwest National Laboratory (PNNL) and the University of Washington (UW) operate a 40-station seismic monitoring network in eastern Washington, which has been used to determine the locations and magnitudes of earthquakes since 1969. In addition, PNNL operates a network of five strong motion accelerometers near Hanford facilities to measure ground motion levels from larger earthquakes (Hartshorn 2001).

4.5 Hydrology

Hydrology considerations at the Hanford Site include surface water, the vadose zone, and groundwater. The vadose zone is the unsaturated or partially saturated region between ground surface and the saturated zone. Water in the vadose zone is called soil moisture. Groundwater refers to water within the saturated zone. Permeable saturated units in the subsurface are called aquifers.

4.5.1 Surface Water

Surface water at Hanford includes the Columbia River, Columbia riverbank seepage, springs, and ponds. Intermittent surface streams, such as Cold Creek, may also contain water after large precipitation or snowmelt events. In addition, the Yakima River flows near a short section of the southern boundary of the Hanford Site (Figure 4.15).

4.5.1.1 Columbia River

In terms of total flow, the Columbia River is the second largest river in the contiguous United States and is the dominant surface-water body on the Hanford Site. The original selection of the Hanford Site for plutonium production and processing was based, in part, on the abundant water provided by the Columbia River.

Originating in the mountains of eastern British Columbia, Canada, the Columbia River drains an area of about 680,000 km^2 (260,000 mi^2) en route to the Pacific Ocean. The primary uses of the Columbia River include the production of hydroelectric power, irrigation of cropland in the Columbia Basin, and transportation of materials by barge. Many communities located on the Columbia River rely on the river as their source of drinking water (see Section 4.8.9). The Columbia River is also used as a source of drinking water and industrial water for several Hanford Site facilities (Dirkes 1993). In addition, the Columbia River is used extensively for recreation that includes fishing, bird hunting, boating, sail boarding, water skiing, diving, and swimming.

4.5.1.2 Springs and Streams

Rattlesnake Springs and Snively Springs, two small spring-fed streams on ALE, are the only naturally occurring streams on the Hanford Site. Rattlesnake Springs, located 10 km (6 mi) west of the 200 West Area, forms a small surface stream that flows for approximately 2.5 km (1.6 mi) before it disappears into the ground as a result of seepage. Base flow of this stream is about 0.01 m^3/s (0.4 ft^3/s) (Cushing and Wolf 1982). Snively Springs is located to the west and at a higher elevation than Rattlesnake Springs.

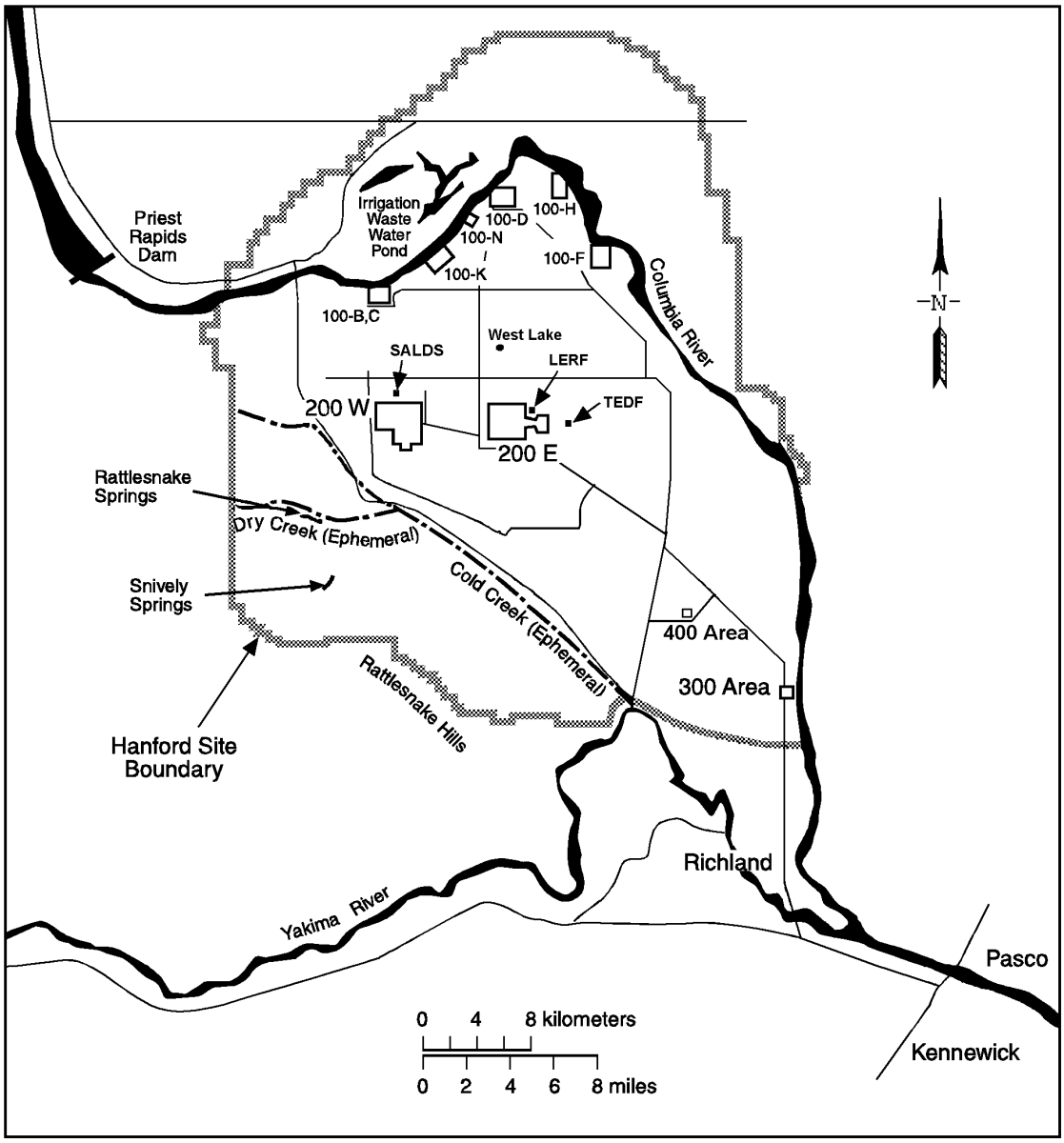


Figure 4.15. Surface Water Features Including Rivers, Ponds, Major Springs, Ephemeral Streams, and Artificial Ponds on the Hanford Site (after Neitzel 2001; SALDS = State-Approved Land Disposal Structure)

Cold Creek and its tributary, Dry Creek, are ephemeral streams within the Yakima River drainage system in the southwestern portion of the Hanford Site. These streams drain areas to the west of the Hanford Site and cross the southwestern part of the site toward the Yakima River. When it occurs, surface flow infiltrates rapidly and disappears into the surface sediments in the western part of the site.

4.5.1.3 Columbia Riverbank Seepage

The seepage of groundwater into the Columbia River has been known to occur for many years. Riverbank seeps were documented along the Hanford Reach long before Hanford operations began during the Second World War (Jenkins 1922). Seepage occurs below the river surface and also on the exposed riverbank, particularly noticeable at low-river stage. The seeps flow intermittently, apparently influenced primarily by changes in river level. Groundwater contaminants attributed to Hanford Operations reach the Columbia River through these seeps.

4.5.1.4 Onsite Ponds and Artificial Water Bodies

West Lake is the only naturally occurring pool on the Hanford Site. West Lake is several hectares in size and is located approximately 8 km (5 mi) northeast of the 200 West Area and about 3 km (2 mi) north of the 200 East Area. It is situated in a topographically low-lying area and is sustained by groundwater inflow resulting from an intersection with the groundwater table. Water levels of West Lake fluctuate with water table elevation, which is influenced by wastewater discharge in the 200 Areas. The water level and size of the lake has been decreasing over the past several years because of reduced wastewater discharge. West Lake water quality samplings demonstrate elevated dissolved solids and nitrates, caused from evaporation of groundwater at the lake, which has no outlet. Total dissolved solids are approximately 15,000 mg/L, and pH is over 9. Nitrate concentrations are about 1.8 mg/L and ammonia concentrations are about 2.6 mg/L (Neitzel 2001). Evaporation has also led to relatively high levels of uranium due to concentration of natural sources (Poston *et al.* 1991).

The Nature Conservancy (Hall 1998) has documented the existence of several naturally occurring vernal ponds near Gable Mountain and Gable Butte. These ponds appear to occur where a depression is present in a relatively shallow buried basalt surface. Water collects within the depression over the winter, resulting in a shallow pond that dries during the summer months. The formation of these ponds in any particular year depends on the amount and temporal distribution of precipitation and snowmelt events. The vernal ponds ranged in size from about 6.1 m x 6.1 m to 45.73 m x 30.5 m (20 ft x 20 ft to 150 ft x 100 ft), and were found in three clusters. Approximately ten vernal ponds were documented at the eastern end of Umtanum Ridge, six or seven were observed in the central part of Gable Butte, and three were found at the eastern end of Gable Mountain.

The 200 Areas TEDF consists of two man-made disposal ponds. These ponds are each 0.02 km^2 (0.008 mi^2) in size and receive industrial wastewater permitted in accordance with Ecology's State Waste Discharge Permit Program (WAC 173-216). The wastewater percolates into the ground from the disposal ponds.

The Liquid Effluent Retention Facility (LERF) is a wastewater holding facility consisting of three RCRA-compliant surface impoundments with a total capacity of 29.5 million L (7.8 million gal) each. The LERF provides storage until the waste is transferred to the ETF for final treatment. These ponds are equipped with double liners, a leak detection system, and floating covers (Poston *et al.* 2001). The LERF also includes piping and pumping systems, utilities, and a basin operations structure. Aqueous waste from the LERF is transferred to the ETF via pipelines.

The SALDS is located north of the 200 West Area. It is a Washington State permitted location containing drain fields where wastewater discharge is authorized.

4.5.1.5 Floodplains and Runoff

No floodplains are found in the 200 Areas. Although floods in Cold Creek and Dry Creek have occurred historically, no flood events have been observed in the 200 Areas. The flooding of Cold Creek and Dry Creek infiltrated into the permeable sediments before reaching the 200 Areas.

Natural runoff generated onsite or from offsite up-gradient sources is not known to occur in the 200 Areas. Measurable runoff occurs during brief periods in two locations, Cold Creek Valley and Dry Creek Valley west and southwest of the 200 West Area (Newcomb *et al.* 1972). This surface runoff either infiltrates into the valley floor or evaporates. During periods of unusually rapid snowmelt or heavy rainfall, surface runoff extends beyond Rattlesnake Springs in the upper part of Dry Creek. However, this runoff quickly infiltrates into the alluvial sediments of Cold Creek Valley.

4.5.2 Hanford Site Vadose Zone

The vadose zone is that part of the subsurface found between the ground surface and the top of the water table. At the Hanford Site, the thickness of the vadose zone ranges from 0 m (0 ft) near the Columbia River to greater than 100 m (328 ft) beneath parts of the central plateau (Hartman 2000). Unconsolidated glacio-fluvial sands and gravels of the Hanford formation make up most of the vadose zone. In some areas, however, such as west and south of 200 East Area and in some of the 100 Areas, the fluvial-lacustrine sediments of the Ringold Formation make up the lower part of the vadose zone.

Moisture movement through the vadose zone is important at the Hanford Site because it is the driving force for migration of most contaminants. Radioactive and hazardous wastes in the soil column from past intentional liquid-waste disposals, unplanned leaks, solid waste disposal, and underground tanks are potential sources of future vadose zone and groundwater contamination. Contaminants may continue to move downward for long periods (tens to hundreds of years depending on recharge rates) after termination of liquid waste disposal.

Except for SALDS, the 200 Area TEDF ponds, and septic drain fields, artificial recharge (the process by which excess surface water is directed into the ground) to the vadose zone ended in the mid-1990s. Natural infiltration in the vadose zone causes older preexisting water to be displaced downward by newly infiltrated water. The amount of recharge at any particular site is highly dependent on the soil type and the presence of vegetation. Usually, vegetation reduces the amount of infiltration through the biological process of evapotranspiration.

Although most natural recharge is probably uniform flow (Jones *et al.* 1998), the vadose zone stratigraphy influences the movement of liquid through the soil column. Where conditions are favorable, lateral spreading of liquid effluent and/or local perched water zones may develop. Perched water zones form where downward moving moisture accumulates on top of low-permeability soil lenses or highly cemented horizons.

Preferential flow may also occur along discontinuities, such as clastic dikes and fractures. Clastic dikes are a common geologic feature in the suprabasalt sediments at the Hanford Site. Their most important feature is their potential to either enhance or inhibit vertical and lateral movement of contaminants in the subsurface, depending on textural relationships.

Subsurface source characterization, sediment sampling and characterization, and vadose zone monitoring are employed to describe the current and future configuration of contamination in the vadose zone.

4.5.2.1 Vadose Zone Contamination

The Hanford Site has more than 800 former (referred to as past-practice) liquid-disposal facilities. Radioactive liquid waste was discharged to the vadose zone through reverse (injection) wells, French drains, cribs, ponds, trenches, and ditches. Over the last 56 years, 1.5 to 1.7 billion m^3 (396 to 449 billion gal) of effluent were disposed to the soils (Gephart 1999). Most effluent was released in the 200 Areas. The major groundwater contaminant plumes emanating from the 200 Areas are tritium and nitrate. The major source for both contaminants was discharge resulting from chemical processing.

Also of concern are technetium-99 and iodine-129 that, like tritium and nitrate, are mobile in groundwater. The major sources of technetium-99 and iodine-129 were discharges to liquid disposal facilities. Vadose zone sources for these contaminants almost certainly remain beneath many past-practice disposal facilities.

Approximately 280 unplanned releases in the 200 Areas also contributed contaminants to the vadose zone (DOE-RL 1997). Many of these were releases from underground tanks and have contributed significant contamination to the vadose zone. In addition, approximately 50 active and inactive septic tanks and drain fields and numerous radioactive and non-radioactive landfills and dumps have impacted the vadose zone (DOE-RL 1997). The landfills are and were used to dispose of solid wastes, which, in most instances, are easier to locate, retrieve, and remediate than are liquid wastes.

A total of 149 single-shell tanks and 28 double-shell tanks have been used to store high-level radioactive and mixed wastes in the 200 Areas. The wastes resulted from uranium and plutonium recovery processes and, to a lesser extent, from strontium and cesium recovery processes. Of the single-shell tanks, 67 are assumed to have leaked an estimated total of 2839 to 3975 m^3 (750,000 to 1,050,000 gal) of contaminated liquid to the vadose zone (Hanlon 2001). The three largest tank leaks were 435,320 L (115,000 gal), 37,850 to 1,048,560 L (10,000 to 277,000 gal), and 265,980 L (70,365 gal). The average tank leak was between 41,640 and 60,565 L (11,000 and 16,000 gal) (Hanlon 2001).

The amount of contamination remaining in the vadose zone is uncertain. Several compilations of vadose zone contamination have been formulated through the past years. DOE-RL (1997) and Kincaid *et al.* (1998) contain the most recent inventories of contaminants disposed to past-practice liquid disposal facilities in the 200 Areas. Dorian and Richards (1978) list contaminant inventories disposed to most 100 Area past-practice facilities. Anderson (1990) lists inventories of effluents sent to

single-shell tanks. A series of reports estimate the curies of gamma-emitting radionuclides and the volumes of contaminated soil associated with each single-shell tank farm. (See the series of online reports at the Hanford Tank Farm Vadose Zone Project http://www.doegjpo.com/programs/hanf/HTFVZ.html). Their estimates for all locations for the three most widespread contaminants are 8901 Ci of cesium-137 in 395,550 m^3 of soil, 0.8611 Ci of europium-154 in 30,133 m^3 of soil, and 0.7424 Ci of cobalt-60 in 74,369 m^3 of soil.

The quantities of contaminants remaining in the vadose zone beneath both tanks and past-practice liquid disposal sites depend on the amounts flushed through the vadose zone to groundwater, which is unknown. However, significant inventories of contaminants are expected to remain in the vadose zone, especially beneath these liquid disposal sites that received small amounts of liquid containing large amounts of contaminants.

4.5.2.2 Vadose Zone Monitoring and Characterization Activities

Although disposal of untreated wastewater to the ground stopped in 1995 (Schmidt *et al.* 1996), contaminant movement still occurs in the soil column beneath past-practice sites. Vadose zone monitoring/characterization is one approach for evaluating the status of possible leaks or remobilization of contaminants caused by natural or artificial infiltration. The objectives of vadose-zone monitoring/characterization are to document the location of the contamination, determine the moisture and contaminant movement in the soil column, and assess the effectiveness of remedial actions.

DOE has been conducting an expedited response action to treat carbon tetrachloride contamination since 1992 at the 200-ZP-2 Operable Unit, located in the 200 West Area, with the concurrence of the EPA and the Washington State Department of Ecology (Ecology). Soil-vapor extraction is being used to remove carbon tetrachloride from the vadose zone as part of this expedited response action (Rohay 1999; Hartman *et al.* 2001). To track the effectiveness of the remediation effort, measurement of soil-vapor concentrations of chlorinated hydrocarbons are made at the inlet to the soil-vapor-extraction system and at individual off-line wells and probes through the soil-vapor extract sites. As of September 1999, 76,500 kg (168,683 lb) of carbon tetrachloride had been removed from the groundwater and vadose zone beneath the 200 West Area. The soil-vapor concentrations monitored deep within the vadose zone during the past few years suggest that soil vapor-extraction remediation has removed much of the carbon tetrachloride from the vadose zone (Hartman *et al.* 2001).

Baseline vadose zone characterization has been conducted at the single-shell tank farms since 1995. Spectral gamma-ray logging detectors were used in approximately 800 boreholes at the 149 single-shell tanks to locate man-made gamma-emitting radionuclides in the soil. During the initial logging of the drywells, several areas were found with levels of contamination high enough to effectively saturate the gamma-ray detectors. Those areas were relogged in 2000 with more robust systems. The maximum concentration of radionuclides found was about 100 million pCi/g. In addition, during 2000, 88 boreholes that were logged previously were relogged to determine whether contamination continues to move in the vadose zone. Data acquired in 22 of the 88 boreholes showed increases in concentration, suggesting possible continued contaminant movement through the vadose zone (Hartman *et al.* 2001).

During 1999, boreholes around 25 inactive 200 East Area facilities, termed specific retention facilities, were monitored by spectral gamma-ray and neutron moisture methods. Specific retention facilities were designed to use the moisture-retention capability of the soil to retain contaminants. Ideally, liquids disposed to specific retention facilities would be limited to less than about 10 percent of the soil volume between the facility and the groundwater, resulting in retention of the liquid in the soils (Waite 1991). Significant quantities of radionuclides and chemicals were discharged to specific retention trenches with some trenches receiving up to 1570 Ci of cesium-137, 475 Ci of strontium-90, and 89 Ci of technetium-99. The volume of liquid discharged to each trench is thought to be insufficient to flush contaminants through the vadose zone to groundwater. Therefore, the discharged contaminants remain in the soil column and these sites represent potential sources for future groundwater contamination at the Hanford Site. Of the 29 boreholes logged, four had previous spectral gamma-logs for comparison. Logs from two of those boreholes showed that changes in subsurface distribution of man-made radionuclides had occurred since 1992 (Horton and Randall 2000), indicating continued movement of contaminants in the vadose zone years after the facilities ceased operations.

4.5.3 Groundwater

Groundwater originates as surface water, either from natural recharge, such as rain, streams, and lakes, or from artificial recharge, such as reservoirs, excess irrigation, canal seepage, deliberate augmentation, industrial processing, and wastewater disposal.

4.5.3.1 Hanford Site Aquifer System

Groundwater beneath the Hanford Site is found in both an upper unconfined aquifer system and deeper basalt-confined aquifers. The unconfined aquifer system is also referred to as the suprabasalt aquifer system because it is within the sediments that overlie the basalt bedrock. Low-permeability layers of fine-grained sediment locally confine portions of the suprabasalt aquifer system. However, because the entire suprabasalt aquifer system is interconnected on a sitewide scale, it is referred to in this report as the Hanford unconfined aquifer system.

Basalt-Confined Aquifer System. Relatively permeable sedimentary interbeds and the more porous tops and bottoms of basalt flows form the confined aquifers within the Columbia River Basalts. The horizontal hydraulic conductivities of most of these aquifers fall in the range of 10^{-10} to 10^{-4} m/s (3×10^{-10} to 3×10^{-4} ft/s). Saturated but relatively impermeable dense interior sections of the basalt flows have horizontal hydraulic conductivities ranging from 10^{-15} to 10^{-9} m/s (3×10^{-15} to 3×10^{-9} ft/s), about five orders of magnitude lower than some of the confined aquifers that lie between these basalt flows (DOE 1988). Hydraulic-head information indicates that groundwater in the basalt-confined aquifers generally flows toward the Columbia River and, in some places, toward areas of enhanced vertical communication with the unconfined aquifer system (Hartman *et al.* 2001; DOE 1988; Spane 1987).

Recharge to the upper basalt-confined aquifer is believed to occur along the margins of the Pasco Basin as a result of precipitation infiltration and surface water where the basalt and interbeds are exposed at ground surface. Recharge may also occur through the Hanford/Ringold aquifer system, where a

downward hydraulic gradient exists between the Ringold Formation and the confined and upper basalt-confined aquifers or from deeper basalt aquifers having an upward gradient.

South of the Umtanum Ridge/Gable Mountain area, groundwater in the upper basalt-confined aquifer system generally flows from west to east across the Hanford Site toward the Columbia River. The elevated regions to the west and southwest of the Site are believed to be recharge areas for the system, and the Columbia River represents a discharge area. The Yakima River may also be a source of recharge.

Unconfined Aquifer System. The unconfined aquifer is generally located in the unconsolidated to semi-consolidated Ringold and Hanford formation sediments that overlie the basalt bedrock. Where it is below the water table, the coarse-grained Hanford formation makes up the most permeable zones of the unconfined aquifer system.

The saturated thickness of the unconfined aquifer on the Hanford Site is greater than 61 m (200 ft) in some areas but pinches out along the flanks of the basalt ridges. Depth to the water table ranges from less than 0.3 m (1 ft) near the Columbia River to more than 106 m (348 ft) near the 200 Areas. Perched water-table conditions have been encountered in sediments above the unconfined aquifer in the 200 West Area (Airhart 1990; Last and Rohay 1993) and in irrigated offsite areas east of the Columbia River (Brown 1979). Because the Ringold sand and gravel sediments are more consolidated and are partially cemented, they are about 10 to 100 times less permeable than the sand and gravel sediments of the overlying Hanford formation. Horizontal hydraulic conductivities of sand and gravel facies within the Ringold Formation generally range from about 1 to 100 m/d (0.3 to 330 ft/d), compared to 100 to 5000 m/s (330 to 17,000 ft/d) for the Hanford formation (DOE 1988). Mud-dominated units with the Ringold Formation are impermeable.

Groundwater in the unconfined aquifer at Hanford generally flows from recharge areas in the elevated region near the western boundary of the Hanford Site, and toward the Columbia River on the eastern and northern boundaries. The Columbia River is the primary discharge area for the unconfined aquifer. A map showing water table elevations for the Hanford Site and adjacent areas across the Columbia River is displayed in Figure 4.16. Figure 4.17 details the water table elevations for the 200 Areas. The Yakima River borders the Hanford Site on the southwest and is generally regarded as a source of recharge. Along the Columbia River shoreline, daily river level fluctuations may result in water table elevation changes of up to 3 m (10 ft). As the river stage rises, a pressure wave is transmitted inland through the groundwater.

Natural area recharge from precipitation across the entire Hanford Site ranges from about 0 to 10 cm/yr (0 to 4 in/yr), but is probably less than 2.5 cm/yr (1 in/yr) over most of the site (Gee and Heller 1985; Bauer and Vaccaro 1990; Fayer and Walters 1995). Between 1944 and the mid-1990s, the volume of artificial recharge from Hanford wastewater disposal was significantly greater than the natural recharge. An estimated 1.7×10^{12} L (4.44×10^{11} gal) of liquid was discharged to disposal ponds, trenches, and cribs during this period (Hartman *et al.* 2001). Because of the reduction in discharges, groundwater levels are falling, particularly around the operational areas (Hartman 2000)

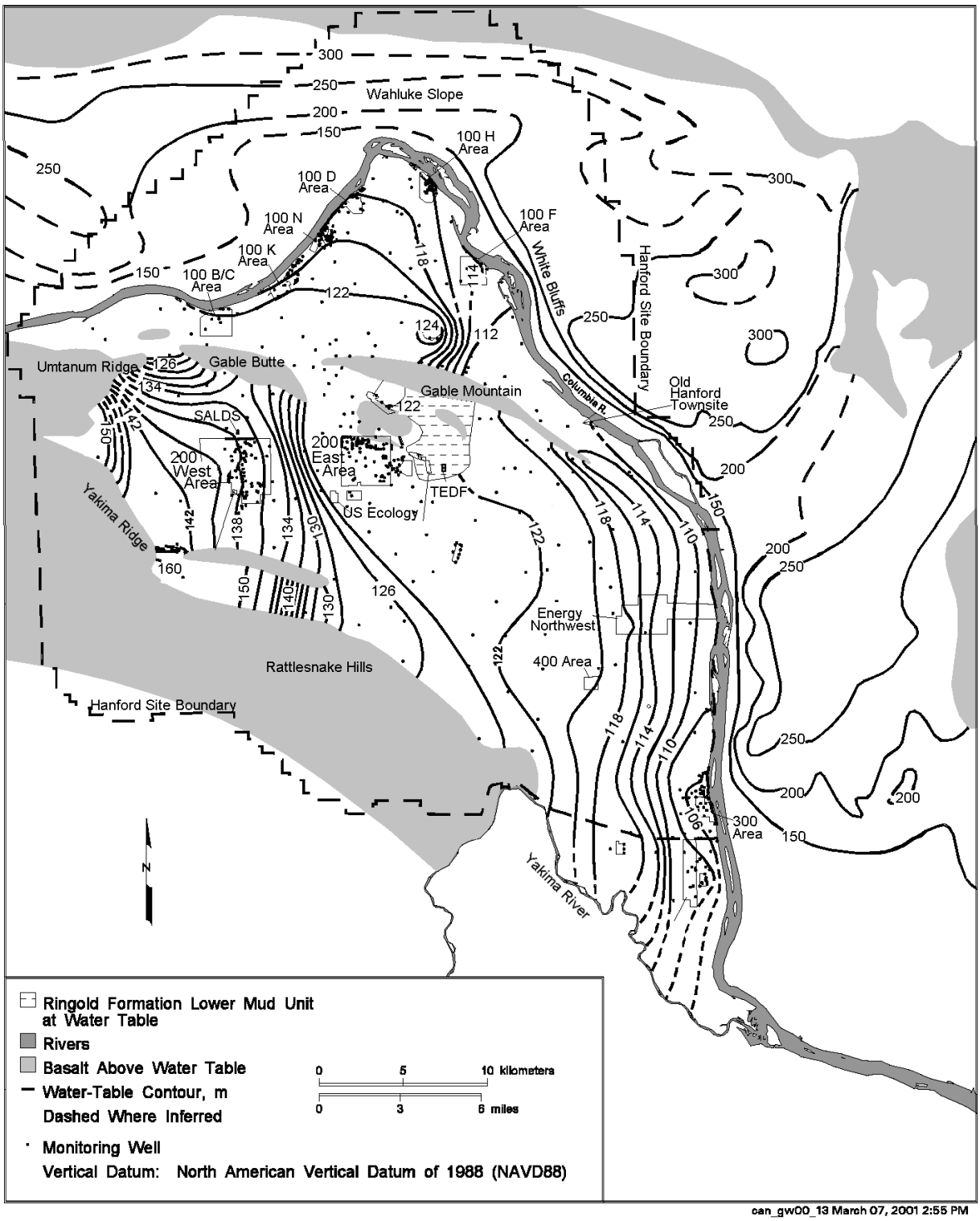


Figure 4.16. Water Table Elevations for the Unconfined Aquifer at Hanford, March/April 2000 (after Hartman *et al.* 2001)

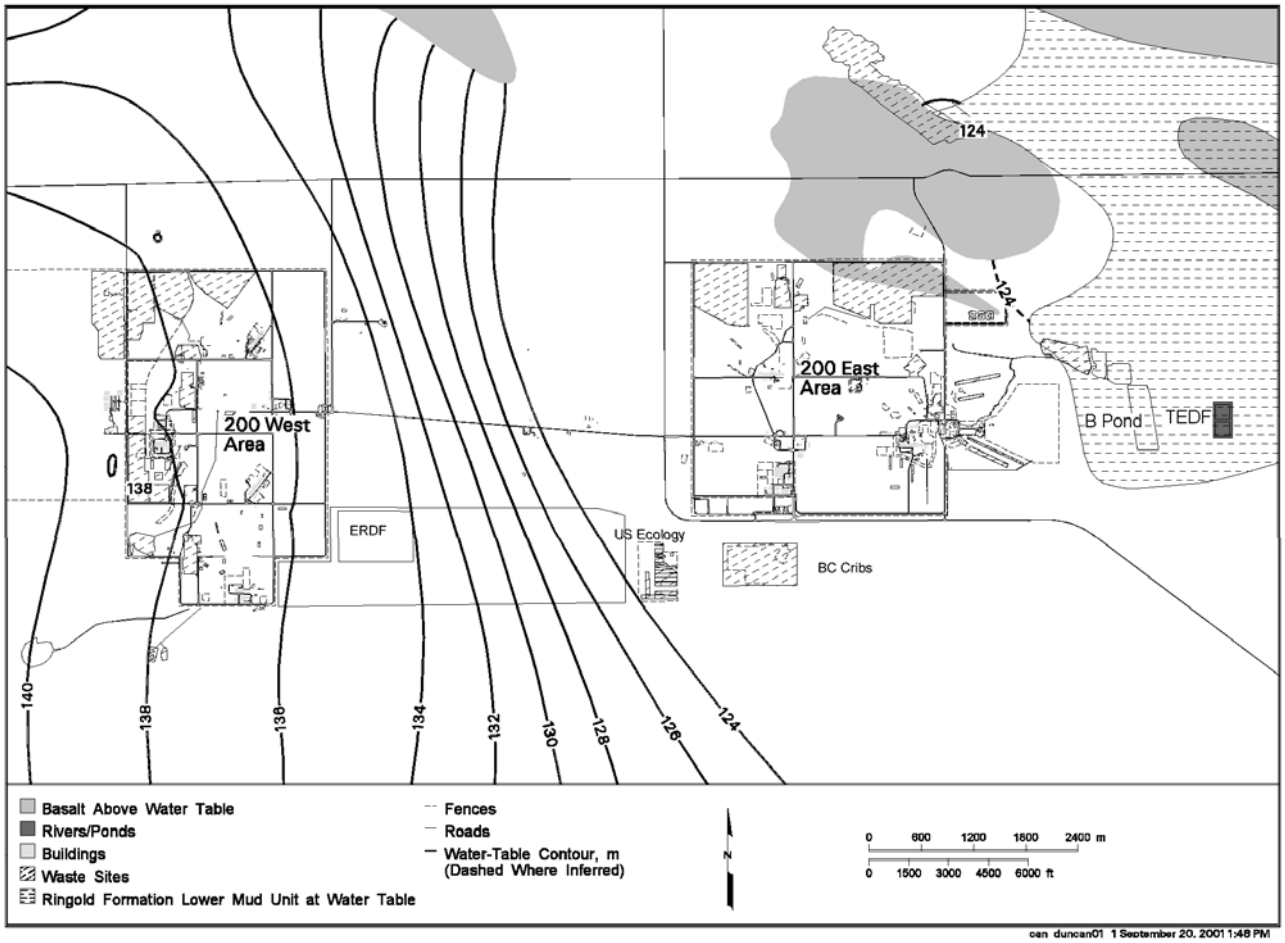


Figure 4.17. Water Table Elevations for the Unconfined Aquifer at the 200 Areas (after Hartman *et al.* 2001)

After the beginning of Hanford operations, the water table rose about 27 m (89 ft) under the U Pond disposal area in the 200 West Area and about 9 m (30 ft) under disposal ponds near the 200 East Area. The volume of water that was discharged to the ground at the 200 West Area was actually less than that discharged at the 200 East Area. However, the lower conductivity of the aquifer near the 200 West Area inhibited groundwater movement in this area resulting in a higher groundwater mound. The presence of the groundwater mounds locally affected the direction of groundwater movement, causing radial flow from the discharge areas. Zimmerman *et al.* (1986) documented changes in water table elevations between 1950 and 1980. Until about 1980, the edge of the mounds migrated outward from the sources over time. Water levels have declined over most of the Hanford Site since 1984 because of decreased wastewater discharges (Hartman 2000). Although the reduction of wastewater discharges has caused water levels to drop significantly, a residual groundwater mound beneath the 200 West Area is still shown by the curved water table contours near this area (Figure 4.16 and Figure 4.17). Small groundwater mounds also exist near the 200 Areas TEDF and the SALDS wastewater disposal sites. The contour interval in Figure 4.16 is too large to show these groundwater mounds.

The saturated thickness and flow conditions in the unconfined aquifer are expected to return to pre-Hanford conditions with the decline and eventual cessation of artificial discharges at Hanford. Water levels have dropped in the vicinity of central areas in the site where the basalt crops out above the water table. Analyses by Cole *et al.* (1997) suggest the saturated thickness of the unconfined aquifer will decrease and areas of the aquifer may actually dry out. With this thinning and drying of the aquifer, which is predicted to occur in the area between Gable Butte and the outcrop south of Gable Mountain, the potential exists for the northern area of the unconfined aquifer to become hydrologically separated from the area south of Gable Mountain and Gable Butte. Therefore, flow from the 200 West Area and the northern half of the 200 East Area, that currently migrates through the gap between Gable Butte and Gable Mountain, will be effectively cut off in the next 200 to 300 years. In time, the overall water table (including groundwater mounds near the 200 East and West Areas) will decline, and groundwater movement from the 200 Area Plateau will shift to a dominantly west-to-easterly pattern of flow toward points of discharge along the Columbia River between the Old Hanford townsite and the Energy Northwest facility.

During 2000, the groundwater mounds have become less prominent. Water levels east of the 200 East Area have dropped below the top of a fine-grained confining unit, creating a barrier to movement in the surrounding unconfined aquifer (Hartman *et al.* 2001). Beneath this confining unit, the uppermost aquifer is a transmissive unit in the Ringold Formation. Groundwater flow in the confined aquifer is still influenced by the recharge mound.

4.5.3.2 Groundwater Quality

Groundwater beneath large areas of the Hanford Site has been impacted by radiological and chemical contaminants resulting from past Hanford Site operations. These contaminants were primarily introduced through wastewater discharged to cribs, ditches, injection wells, trenches, and ponds (Kincaid *et al.* 1998). Additional contaminants from spills, leaking waste tanks, and burial grounds (landfills) have also impacted groundwater in some areas. Contaminant concentrations in the existing groundwater plumes are expected to decline through radioactive decay, chemical degradation, and dispersion. However, contaminants also exist within the vadose zone beneath waste sites (see Section 4.5.2), as well as in waste storage and disposal facilities. These contaminants have a potential to continue to move downward into the aquifer. Some contaminants, such as tritium, move with the groundwater while the movement of other contaminants is slower because they react with or are sorbed on the surface of minerals within the aquifer or the vadose zone. Groundwater contamination is monitored and is being actively remediated in several areas through pump-and-treat operations.

Contaminant concentrations in groundwater were compared with established drinking water standards as a benchmark for quality of the groundwater resource. These benchmark standards include the maximum contaminant level (MCL) and drinking water standard (DWS) for specific chemicals and radionuclides, which are legally enforceable limits for public drinking water supplies set by EPA or the WDOH. DOE has also established a standard for dose from radionuclides in public drinking water supplies operated by DOE or its contractors. The dose limit is 4 mrem/yr from consumption of water at 2 L/day, which provides protection equivalent to that of the EPA and State standards. The published DOE derived concentration guide (DCG) for a specific radionuclide in drinking water may also be used as a

benchmark for groundwater quality in the same manner as the EPA and State standards. The DCG represents the concentration of each radionuclide in drinking water that would result in a dose of 100 mrem/yr at a consumption rate of 2 L/day. Therefore, the DOE standard for a given radionuclide in drinking water corresponds to 4 percent of the DCG for that radionuclide.

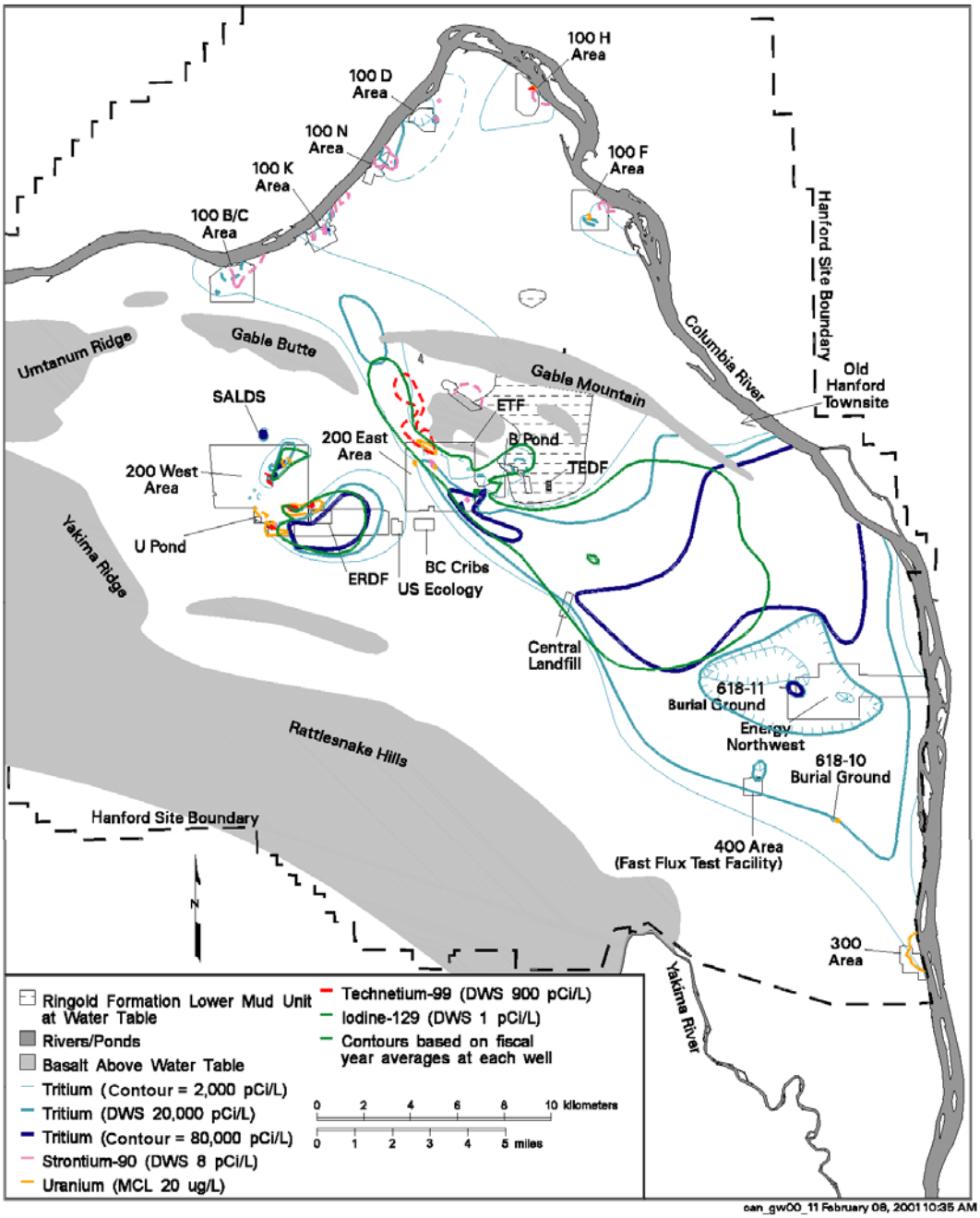


Figure 4.18. Distribution of Major Radionuclides in Groundwater at Concentrations Above the Drinking Water Standards During FY 2000 (after Hartman *et al.* 2001). Maximum concentrations are listed in Table 4.9.

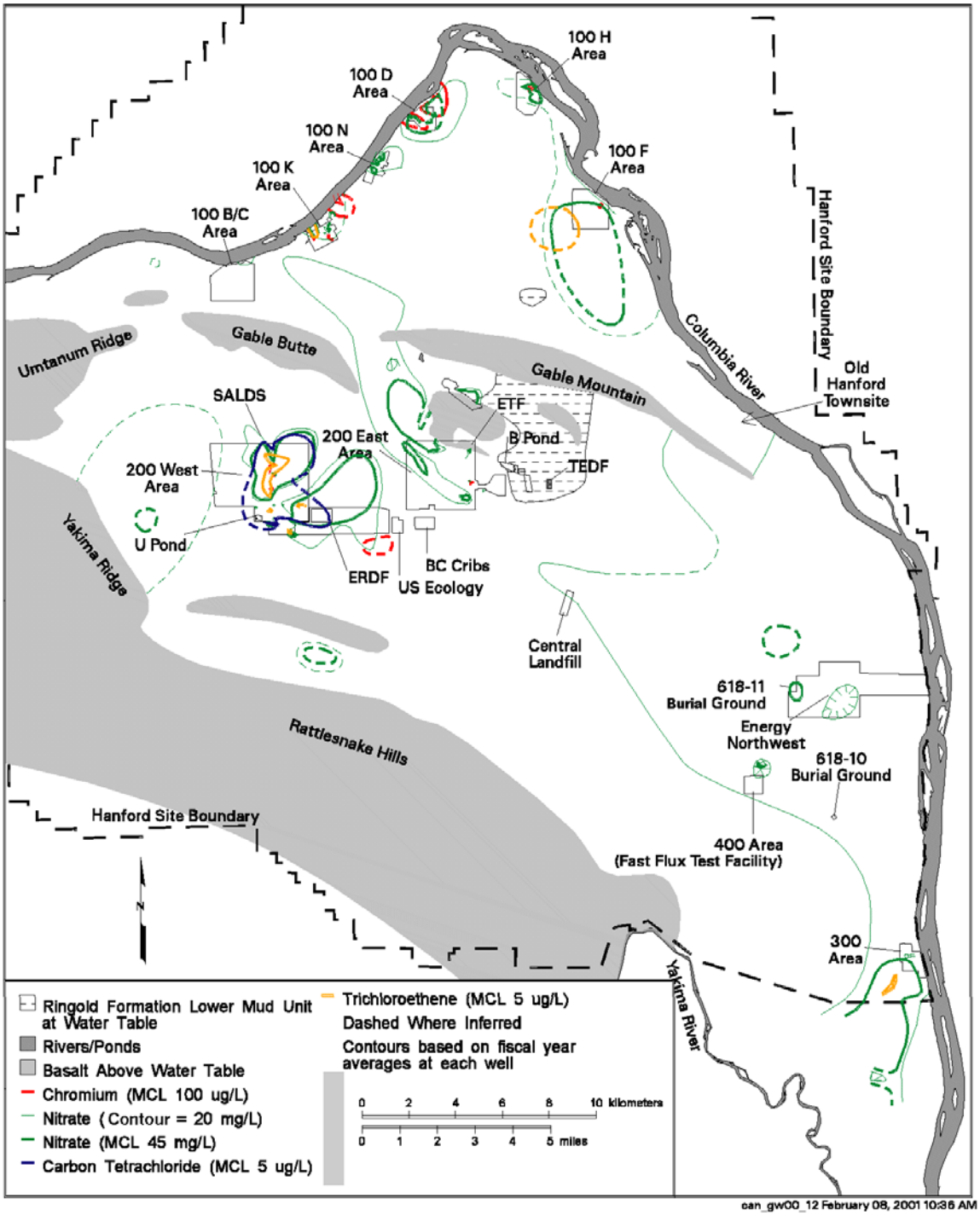


Figure 4.19. Distribution of Major Hazardous Chemicals in Groundwater at Concentrations Above the Drinking Water Standards During FY 2000 (after Hartman *et al.* 2001). Maximum concentrations are listed in Table 4.9.

Table 4.9. Maximum Concentrations of Groundwater Contaminants at Hanford in FY 2000 (Hartman et al. 2001)

Contaminant (alphabetical order)	DWS or MCL [DCG][a]	Units	100-B/C Wells	100-B/C Shore[b]	100-K Wells	100-K Shore[b]	100-N Wells	100-N Shore[b]	100-D Wells	100-D Shore[b]	100-H Wells	100-H Shore[b]	100-F Wells	100-F Shore	200 West Wells
Carbon tetrachloride	5	µg/L													**7,900**
Carbon-14	2,000 [70,000]	pCi/L			**35,600**	639									
Cesium-137	200 [3,000]	pCi/L													undetected
Chloroform	100	µg/L													**250**
Chromium (filtered)	100	µg/L	77	**115**	**474**	76	**122**	34	**2,260**	**641**	**178**	49	**208**	23	**542**
Cobalt-60	100 [5,000]	pCi/L													
Cyanide	200	µg/L													
cis-1,2 Dichloroethene	70	µg/L													
Fluoride	4	mg/L									0.25				**9.8**
Gross alpha	15	pCi/L									**131**				**692**
Gross beta	50	pCi/L	**133**	**67.1**	**22,300**	4.4	**21,500**	**3,680**		10.5	**593**	21	**553**	15.8	**23,000**
Iodine-129	1 [500]	pCi/L													**52**
Manganese (filtered)	50	µg/L					**5,320**								
Nitrate (as NO_3^-)	45	mg/L	30	39	**98**	22	**104**	18	**100**	18	**387**	**60**	**144**	**54**	**1,213**
Nitrite (as NO_2)	3.3	mg/L							2.3						**36**
Plutonium 239/240	NA [30]	pCi/L													undetected
Strontium-90	8 [1,000]	pCi/L	**66**	**17**	***6,970***	ND	***17,700***	***14,700***	**8.5**	4.8	**55**	**9.6**	**265**	1.5	**74.3**
Sulfate	250	mg/L					**370**	38	**744**						
Technetium-99	900 [100,000]	pCi/L									**1,070**				**63,700**
Tetrachloroethene	5	µg/L													
Trichloroethene	5	µg/L			**8**								**18**		**32**
Tritium	20,000 [2,000,000]	pCi/L	**39,900**	**36,600**	**1,360,000**	6,660	**45,000**	**29,100**	**20,000**	15,700	5,580	978	**36,900**	1,450	***2,940,000***
Uranium	30 [790]	µg/L									157		20		***2,100***

Table 4.9. (contd)

Contaminant (alphabetical order)	DWS or MCL [DCG][a]	Units	200 East Wells	200 East Shore[b]	400 Wells	600 Wells	300 Wells	300 Shore[b]	618-11 Wells	Richland North Wells	Basalt-Confined Wells
Carbon tetrachloride	5	µg/L				1					
Carbon-14	2,000 [70,000]	pCi/L									
Cesium-137	200 [3,000]	pCi/L	122[c]								
Chloroform	100	µg/L				7.7					
Chromium (filtered)	100	µg/L	**3,250**			200					
Cobalt-60	100 [5,000]	pCi/L	78.2								
Cyanide	200	µg/L	**411**								
cis-1,2 Dichloroethene	70	µg/L					**170**				
Fluoride	4	mg/L								4.8	
Gross alpha	15	pCi/L	**240**				**60.2**	**228**	**30**	**65.4**	
Gross beta	50	pCi/L	**10,300**	48.6				49	**74**	**46**	
Iodine-129	1 [500]	pCi/L	**12.1**	0.41							undetected
Manganese (filtered)	50	µg/L	141			6.5					
Nitrate (as NO_3^-)	45	mg/L	**562**	36	**92**	**54**	**101**	29	**149**	**203**	11
Nitrite (as NO_2)	3.3	mg/L			0.43				**3.9**		
Plutonium 239/240	NA [30]	pCi/L	9.4[c]								
Strontium-90	8 [1,000]	pCi/L	***1,210***[c]				4.1	0.28			
Sulfate	250	mg/L				55					28
Technetium-99	900 [100,000]	pCi/L	**13,300**	120							
Tetrachloroethene	5	µg/L					0.65				
Trichloroethene	5	µg/L				1.4	3.5			3.7	
Tritium	20,000 [2,000,000]	pCi/L	***2,510,000***	**106,000**	**58,800**	**65,900**	11,600	11,300	***8,380,000***	546	5,770
Uranium	30 [790]	µg/L	**353**				**234**	**301**	**30.8**	13.6	

Note: Table lists highest concentration for FY 2000 in each geographic region. Concentrations in **bold** exceed drinking water standards. Concentrations in ***bold italic*** exceed DOE derived concentration guides. Blank spaces indicate the constituent is not of concern in the given area.

(a) DWS = drinking water standard; MCL = maximum contaminant level; DCG = derived concentration guide. See PNNL-13080 (Hartman 2000) for more information on these standards.

(b) Shoreline sampling includes aquifer sampling tubes, seeps, and shoreline wells from fall 1999. 200 East Area plumes monitored at Old Hanford Townsite.

(c) Well typically showing highest concentrations near 216-B-5 injection well not sampled in FY 2000.

Radiological constituents, including carbon-14, cesium-137, cobalt-60, iodine-129, strontium-90, technetium-99, total alpha, total beta, tritium, uranium, and plutonium 239/240, were detected at levels greater than the DWS in one or more onsite wells within the unconfined aquifer. Concentrations of strontium-90, tritium, uranium, and plutonium were detected at levels greater than their respective DOE DCGs. Certain nonradioactive chemicals regulated by the EPA and/or the State of Washington (carbon tetrachloride, chloroform, chromium, cyanide, cis-1, 2 dichloroethene, fluoride, manganese, nitrate, sulfate, tetrachloroethene, and trichloroethene) were also present in Hanford Site groundwater. Figure 4.18 shows the distribution of some radiological contamination in Hanford Site groundwater and Figure 4.19 shows the distribution of some hazardous chemical constituents above the applicable DWS. The area of contaminant plumes on the Hanford Site with concentrations exceeding drinking water standards was estimated to be 231 km^2 (89.2 mi^2) in FY 2000. This estimate is 9 percent smaller than the one for FY 1999. The decrease is primarily due to shrinkage of tritium plume from 200 East Area, which was caused primarily by radioactive decay. Table 4.9 shows the maximum concentrations of groundwater contaminants observed on the Hanford Site during FY 2000, along with DWS and DCG figures (Hartman *et al.* 2001).

The upper basalt-confined aquifer is monitored by about 40 wells that are sampled annually to triennially. Most of these wells are located near the 200 Areas. During the year 2000, nine upper basalt-confined aquifer wells were sampled. Tritium, iodine-129 and nitrate were sampled in most of the wells, as they are most mobile in groundwater, the most widespread in the overlying unconfined aquifer, and provide an early warning of potential contamination in the upper basalt-confined aquifer. Results for each of these constituents were less than their respective drinking water standards for 2000. Monitoring results for the groundwater in the upper basalt-confined aquifer in 2000 indicate a tritium concentration of 5770 pCi/L beneath B Pond. Levels of tritium in this location have declined since 1996, and are believed to be as a result of downward migration from the overlying unconfined aquifer. The highest nitrate concentration, 11 mg/L, was found just north of the 200 East Area. Iodine-129 was not detected in 2000.

4.5.3.3 200 Areas Hydrology

In the 200 West Area, the water table occurs almost entirely in the Ringold Unit E gravels, while in the 200 East Area, it occurs primarily in the Hanford formation and in the Ringold Unit A gravels. Along the southern edge of the 200 East Area, the water table is in the Ringold Unit E gravels. The upper Ringold facies were eroded in most of the 200 East Area by the Missoula floods that subsequently deposited Hanford gravels and sands on the remains of the Ringold Formation. Because the Hanford formation sand and gravel deposits are much more permeable than the Ringold gravels, the water table is relatively flat in the 200 East Area, but groundwater flow velocities are higher. On the north side of the 200 East Area, evidence appears of erosional channels that may allow communication between the unconfined and uppermost basalt-confined aquifer (Graham *et al.* 1984; Jensen 1987).

Groundwater occurs in the 200 West Area within the Ringold Formation primarily under unconfined conditions, approximately 70 m (230 ft) beneath the surface. The saturated section is 110 m (360 ft) thick. Hydraulic conductivities measured in the 200 West Area in the Ringold Unit E aquifer range from approximately 0.02 to 60 m/day (0.06 to 200 ft/day). Hydraulic conductivities range from 0.5 to 1.2 m/day (1.6 to 4 ft/day) in the semi-confined to confined Ringold Unit A gravels. Groundwater in the

200 West Area generally flows east toward the 200 East Area. In the northwest corner of the 200 West Area, groundwater flows northward. Also, it appears that flow from the 200 West Area branches out east of Gable Butte, with a flow component northerly toward the gap between Gable Butte and Gable Mountain and the remaining flow branching eastward and southeastward toward the Columbia River.

Natural recharge from precipitation falling on the Hanford Site is highly variable both spatially and temporally, ranging from near zero to more than 100 mm/yr, depending on climate, vegetation, and soil texture (Gee *et al.* 1992; Fayer and Walters 1995). Areas with shrubs and fine-textured soils like silt loams tend to have low recharge rates, while areas with little vegetation and coarse-textured soils, such as dune sands, tend to have high recharge rates. Recharge is also generally higher near the basalt ridges because of greater precipitation and runoff. Past estimates of recharge have been summarized in earlier status reports (Thorne and Chamness 1992; Thorne *et al.* 1993). Fayer and Walters (1995) developed a natural recharge map for 1979 conditions to support the Hanford Site three-dimensional groundwater and transport model. The distributions of soil and vegetation types were mapped first. A recharge rate was then assigned to each combination on the basis of data from lysimeters, tracer studies, neutron probe measurements, and computer modeling. Estimated recharge rates for 1992 were found to range from 2.6 to 127 mm/yr, and the total volume of natural recharge from precipitation over the Hanford Site was estimated at 8.47×10^6 m^3/yr. This value is of the same order of magnitude as the artificial recharge to the 200 Area waste disposal facilities during 1992 and is about half the volume of discharge to these facilities during 1979 (Fayer and Walters 1995).

The other source of recharge to the unconfined aquifer is artificial recharge from wastewater disposal. Over the past 50 years, the large volume of wastewater discharged to disposal facilities at the Hanford Site has significantly affected groundwater flow and contaminant transport in the unconfined aquifer (Figure 3.3). The volume of artificial recharge has decreased significantly during the past 10 years and continues to decrease. Wurstner *et al.* (1995) summarized the major discharge facilities incorporated in the three-dimensional model. Cole *et al.* (1997) summarized the major wastewater discharges from both past and future sources.

Depth to groundwater in the 200 East Area ranges from 97 m (320 ft) in the southeast to 37 m (120 ft) in the vicinity of the 216-B-3C pond (B Pond mound). A downward gradient has formed in the B Pond vicinity due to groundwater mounding from discharges. Groundwater flow in the 200 East Area is to the southeast. Interconnection between the unconfined and lower confined aquifer is possible across the Central Plateau. However, except for the area near the erosional windows that occur in the basalt several kilometers north of the 200 East Area and B Pond vicinity in the 200 East Area, no indication is shown of aquifer interconnection. Several kilometers north of the 200 East Area, an absence of confining layer(s) is associated with an erosional window that has resulted in enhanced interconnection of the aquifers in this area. Hydraulic conductivities of the unconfined aquifer in the 200 East Area range from 150 to 300 m/day (500 to 1000 ft/day). Flow may split east of Gable Butte, one path heading north toward the gap between Gable Butte and Gable Mountain, and the other path east to the Columbia River.

Groundwater is monitored in the vicinity of the LLBGs as a result of interim status requirements of WAC 173-303. The LLBGs are divided into five low-level waste management areas (LLWMAs). Since

1996, groundwater has not been monitored within LLWMA-5, the location of the 218-W-6 Burial Ground, as the site has never received waste.

LLWMA-1 consists of the 218-E-10 Burial Ground. Well 299-E33-34, a downgradient monitoring well, exceeded the critical mean for specific conductance in 2000, but this was related to the nitrate plume with an upgradient source in the northern portion of this LLWMA (Poston *et al.* 2001).

LLWMA-2 is located in the 200 East Area and includes all of the 218-E-12B Burial Ground. Upgradient well 299-E34-7 exceeded the critical mean value for specific conductance in 2000. Sulfate and calcium are the major contributors to the increase and their source is not known. However, only 0.6 m (2 ft) of water remains in this well, which is at the top of the basalt, and the increases may be due to basalt chemistry. Well 299-E34-7 also exceeded the comparison value for total organic carbon in 2000. Results for volatile and semi-volatile organics were less than detection limits, with the exception of bis (2-ethylhexyl) phthalate at 1.7 µg/L.

LLWMA-3 includes the 218-W-3A, 218-W-3AE, and 218-W-5 Burial Grounds in the 200 West Area. Indicator parameter data from upgradient wells were statistically evaluated and values from downgradient wells were compared to established values from upgradient wells in 2000. The critical mean value for specific conductance was exceeded in an upgradient well, but is due to increases in sulfate and nitrate from upgradient sources. None of the other wells in LLWMA-3 exceeded contamination parameters during 2000. Several of the wells in LLWMA-3 have gone dry, as the water table continues to decline. The WDOH and DOE annually negotiate installation of future monitoring wells under an Interim Milestone agreement (M-24).

LLWMA-4 is located in the 200 West Area and includes 218-W-4B and 218-W 4C Burial Grounds. Indicator parameter data from upgradient wells were statistically evaluated and values from downgradient wells were compared to established values from upgradient wells in 2000. The critical mean value for total organic halides was exceeded in one downgradient well in 2000, caused by carbon tetrachloride from an upgradient source. Groundwater in LLWMA-4 is being actively remediated using pump-and-treat methods. The groundwater removed during pump-and-treat operations does not require treatment based on its radionuclide content.

4.6 Biological and Ecological Resources

The Hanford Site is characterized as a shrub-steppe ecosystem (Daubenmire 1970). Such ecosystems are typically dominated by a shrub overstory with a grass understory. In the early 1800s, the dominant plant in the area was big sagebrush underlain by perennial Sandberg's bluegrass and bluebunch wheatgrass. With the advent of settlement, livestock grazing and agricultural production contributed to colonization by nonnative vegetation species that currently dominate the landscape. Although agriculture and production of livestock were the primary activities at the beginning of the twentieth century, these activities ceased when the site was established in 1943. Remnants of past agricultural practices are still evident.

The Columbia River borders the DOE-managed portion of the Hanford Site to the east. Operation of Priest Rapids Dam upstream of the site accommodates maintenance of intakes at the Hanford Site and helps to manage anadromous fish populations. The Columbia River and associated riparian zones provide habitat for numerous wildlife and vegetation.

Large areas of the Hanford Site have experienced range fires that have greatly influenced the vegetation canopy and distribution of wildlife. In 1984, a major fire burned across 800 km^2 (310 mi^2) of the Hanford Site (Price *et al.* 1986). From June 27 through July 2, 2000, the *24 Command Fire* burned across the Hanford Site consuming most of the shrub-steppe habitat on the ALE Unit, a small section of the McGee-Riverlands Unit, and other southwestern portions of the site. The fire consumed a total of 655 km^2 (250 mi^2) of federal, State, and private lands before it was controlled (BAER 2000). These range fires are a component of natural plant succession.

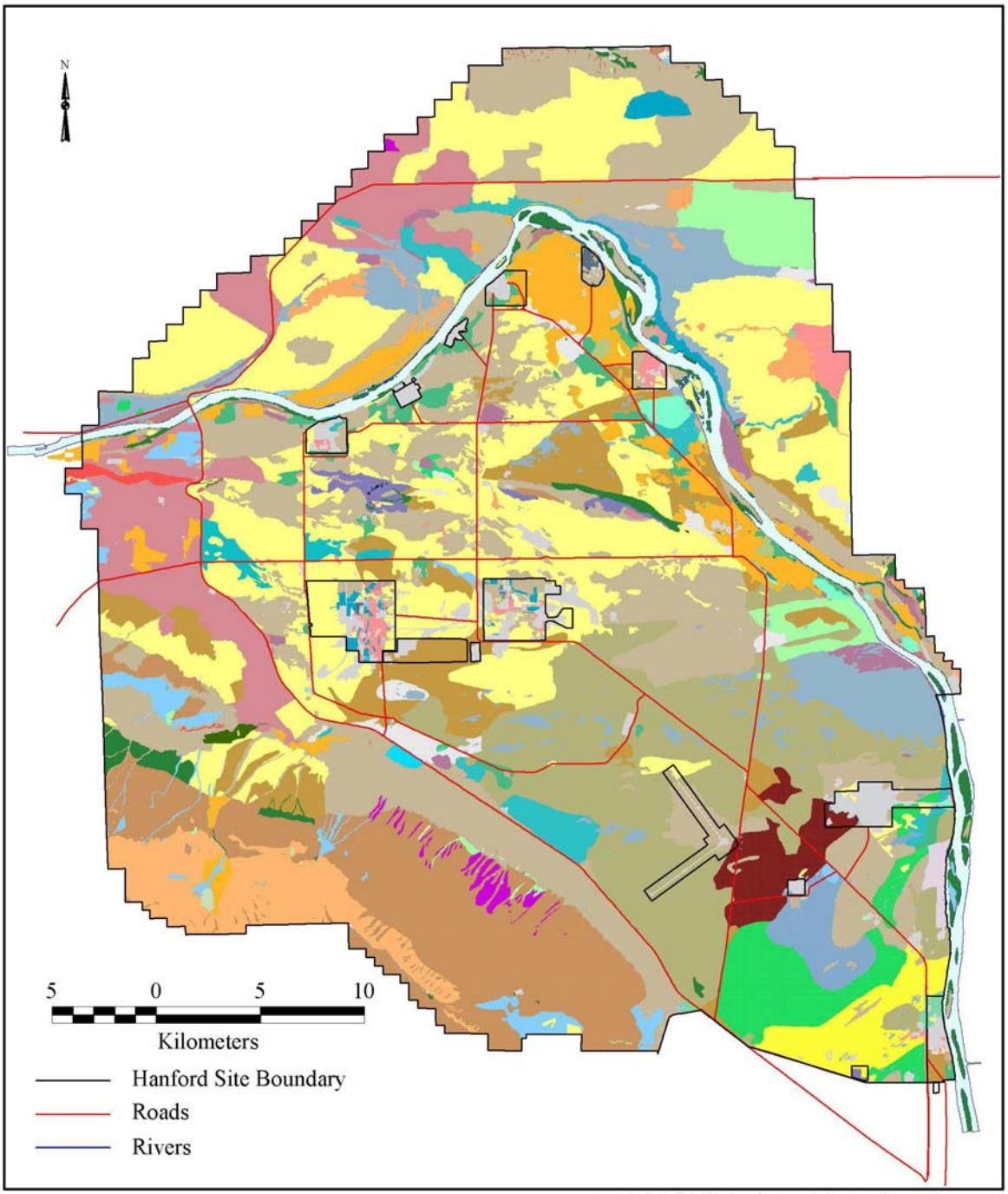
A Hanford Site Wildland Fire Management Plan has been prepared and provides a guide to managing the wildland and prescribed fire programs on the Hanford Site. This plan is designed to ensure safety, protect facilities and resources, and restore and perpetuate natural processes.

4.6.1 Vegetation

Plants at the Hanford Site are adapted to low annual precipitation, low water-holding capacity of the rooting substrate (sand), dry summers, and cold winters. Range fires that burn through the area during dry summers have reduced species that are less resistant to fire (for example, big sagebrush) and have allowed more opportunistic and fire-resistant species a chance to become established. Native perennial shrubs and bunchgrasses generally dominate plant communities on the site. However, Euro-American settlement and development have resulted in the proliferation of nonnative species. Of the 590 species of vascular plants recorded on the Hanford Site, approximately 20 percent of the species are considered nonnative (Sackschewsky *et al.* 1992). Cheatgrass is the dominant nonnative species. It is an aggressive colonizer and has become well established across the site (Rickard and Rogers 1983). The biodiversity inventories conducted by The Nature Conservancy of Washington (Soll *et al.* 1999) have identified 85 additional taxa, establishing the actual number of plant taxa on the Hanford Site at 675.

The Nature Conservancy of Washington also conducted rare plant surveys. The Conservancy found 112 populations/occurrences of 28 rare plant taxa on the Hanford Site. When combined with observations preceding the 1994-1999 inventories, a total of 127 populations of 30 rare species have been documented on the Hanford Site (Soll *et al.* 1999).

Figure 4.20 shows existing vegetation and land use areas on the Hanford Site, prior to the *24 Command Fire* that occurred in late June 2000. Table 4.10 presents a list of common plant species in shrub-steppe and riparian areas.



Data Collected: 1994, 1997/The Nature Conservancy
1991, 1999 Pacific Northwest National Laboratory
Map Created: September 1999/Pacific Northwest National Laboratory

Figure 4.20. Distribution of Vegetation Types and Land Use Areas on the Hanford Site Prior to the *24 Command Fire* of 2000 (Neitzel 2001). Legend on following page.

Figure 4.20. Legend for Figure 4.20 (contd)

Table 4.10. Common Vascular Plants on the Hanford Site
(Taxonomy follows Hitchcock and Cronquist 1973)

A. Shrub-Steppe Species	Scientific Name
Shrub	
Big sagebrush	*Artemisia tridentata*
Bitterbrush	*Purshia tridentata*
Gray rabbitbrush	*Chrysothamnus nauseosus*
Green rabbitbrush	*Chrysothamnus viscidiflorus*
Snow buckwheat	*Eriogonum niveum*
Spiny hopsage	*Grayia (Atriplex) spinosa*
Threetip sagebrush	*Artemisia tripartita*
Perennial Grasses	
Bluebunch wheatgrass	*Agropyron spicatum*
Bottlebrush squirreltail	*Sitanion hystrix*
Crested wheatgrass	*Agropyron desertorum (cristatum)*[(a)]
Indian ricegrass	*Oryzopsis hymenoides*
Needle-and-thread grass	*Stipa comata*
Prairie Junegrass	*Koeleria cristata*
Sand dropseed	*Sporobolus cryptandrus*
Sandberg's bluegrass	*Poa sandbergii (secunda)*
Thickspike wheatgrass	*Agropyron dasytachyum*
Perennial Forbs	
Bastard toad flax	*Comandra umbellata*
Buckwheat milkvetch	*Astragalus caricinus*
Carey's balsamroot	*Balsamorhiza careyana*
Cusick's sunflower	*Helianthus cusickii*
Cutleaf ladysfoot mustard	*Thelypodium laciniatum*
Douglas' clusterlily	*Brodiaea douglasii*
Dune scurfpea	*Psoralea lanceolata*
Franklin's sandwort	*Arenaria franklinii*
Gray's desertparsley	*Lomatium grayi*
Hoary aster	*Machaeranthera canescens*
Hoary falseyarrow	*Chaenactis douglasii*
Longleaf phlox	*Phlox longifolia*

Table 4.10. (contd)

A. Shrub-Steppe Species	Scientific Name
Perennial Forbs (cont)	
Munro's globemallow	*Sphaeralcea munroana*
Pale evening primrose	*Oenothera pallida*
Sand beardtongue	*Penstemon acuminatus*
Stalked-pod milkvetch	*Astragalus sclerocarpus*
Threadleaf fleabane	*Erigeron filifolius*
Turpentine spring parsley	*Cymopteris terebinthinus*
Winged dock	*Rumex venosus*
Yarrow	*Achillea millefolium*
Yellow bell	*Fritillaria pudica*
Annual Forbs	
Annual Jacob's ladder	*Polemonium micranthum*
Blue mustard	*Chorispora tenella*[(a)]
Bur ragweed	*Ambrosia acanthicarpa*
Clasping pepperweed	*Lepidium perfoliatum*
Indian wheat	*Plantago patagonica*
Jagged chickweed	*Holosteum umbellatum*[(a)]
Jim Hill's tumblemustard	*Sisymbrium altissimum*[(a)]
Matted cryptantha	*Cryptantha circumscissa*
Pink microsteris	*Microsteris gracilis*
Prickly lettuce	*Lactuca serriola*[(a)]
Rough wallflower	*Erysimum asperum*
Russian thistle (tumbleweed)	*Salsola kali*[(a)]
Slender hawksbeard	*Crepis atrabarba*
Spring whitlowgrass	*Draba verna*[(a)]
Storksbill	*Erodium cicutarium*[(a)]
Tall willowherb	*Epilobium paniculatum*
Tarweed fiddleneck	*Amsinckia lycopsoides*
Threadleaf scorpion weed	*Phacelia linearis*

Table 4.10. (contd)

A. Shrub-Steppe Species	Scientific Name
Annual Forbs (contd)	
Western tansymustard	*Descurainia pinnata*
White cupseed	*Plectritis macrocera*
Whitestem stickleaf	*Mentzelia albicaulis*
Winged cryptantha	*Cryptantha pterocarya*
Yellow salsify	*Tragopogon dubius*[(a)]
Annual Grasses	
Cheatgrass	*Bromus tectorum*[(a)]
Slender sixweeks	*Festuca octoflora*
Small sixweeks	*Festuca microstachys*
Trees and Shrubs	
Black cottonwood	*Populus trichocarpa*
Black locust	*Robinia pseudo-acacia*
Coyote willow	*Salix exigua*
Dogbane	*Apocynum cannabinum*
Peach, apricot, cherry	*Prunus* spp.
Peachleaf willow	*Salix amygdaloides*
Willow	*Salix* spp.
White mulberry	*Morus alba*[(a)]
B. Riparian Species	**Scientific Name**
Perennial Grasses and Forbs	
Bentgrass	*Agrostis* spp.[(b)]
Blanket flower	*Gaillardia aristata*
Bulrushes	*Scirpus* spp.[(b)]
Cattail	*Typha latifolia*[(b)]
Columbia River gumweed	*Grindelia columbiana*
Hairy golden aster	*Heterotheca villosa*
Heartweed	*Polygonum persicaria*
Horsetails	*Equisetum* spp.

Table 4.10. (contd)

B. Riparian Species	Scientific Name
Perennial Grasses and Forbs (contd)	
Horseweed tickseed	*Coreopsis atkinsoniana*
Lovegrass	*Eragrostis* spp.[(b)]
Lupine	*Lupinus* spp.
Meadow foxtail	*Alopecurus aequalis*[(b)]
Pacific sage	*Artemisia campestris*
Prairie sagebrush	*Artemisia ludoviciana*
Reed canary grass	*Phalaris arundinacea*[(b)]
Rushes	*Juncus* spp.
Russian knapweed	*Centaurea repens*[(a)]
Sedge	*Carex* spp.[(b)]
Water speedwell	*Veronica anagallis-aquatica*
Western goldenrod	*Solidago occidentalis*
Wild onion	*Allium* spp.
Wiregrass spikerush	*Eleocharis* spp.[(b)]
Aquatic Vascular	
Canadian waterweed	*Elodea Canadensis*
Columbia yellowcress	*Rorippa columbiae*
Duckweed	*Lemna minor*
Pondweed	*Potamogeton* spp.
Spiked water milfoil	*Myriophyllum spicatum*
Watercress	*Rorippa nasturtium-aquaticum*

(a) Introduced.
(b) Perennial grasses and graminoids.

200 Areas Plants. Waste management areas and crib sites are generally either barren or vegetated by invasive species, including Russian thistle (tumbleweed), tumble mustard, and cheatgrass. Russian thistle and gray rabbitbrush occurring in these areas are deep rooted and have the potential to accumulate radionuclides and other buried contaminants, functioning as a pathway to other parts of the ecosystem (Landeen *et al.* 1993). Russian thistle, an annual weed, accumulates nitrates and soluble oxalates, and has significant seed dispersion. Vegetation samples are collected annually from the 200/600 Areas and analyzed for uranium, cobalt-60, strontium-90, cesium-137, and plutonium-239/240.

The portions of the 200 Areas undisturbed by DOE and its predecessor agencies, but previously disturbed by farmers and ranchers, are characterized as sagebrush/cheatgrass or Sandberg's bluegrass communities of the 200 Area Plateau. Cheatgrass provides half of the total plant cover. Most of the waste disposal and storage sites are covered by nonnative vegetation or are kept in a vegetation-free condition with the use of herbicides, because the plants could potentially accumulate waste constituents. Figure 4.21 and Figure 4.22 illustrate existing vegetation and land use areas mapped prior to the *24 Command Fire* for the 200 West Area and 200 East Area, respectively. Early observations suggest the soil structure and seed bank may have been damaged to the point where vegetative recovery will be slower than in other areas, and the resulting community may not resemble the sagebrush-steppe that existed before the fire.

West Lake and its immediate basin represent a unique habitat that is characterized by highly saline conditions (Poston *et al.* 1991). Water levels of the pond fluctuate with groundwater levels. Predominant plants include salt grass, plantain, and rattlebox. Three-spine bulrush grows along the shoreline.

4.6.2 Wildlife

Three hundred species of terrestrial vertebrates have been observed on the Hanford Site. The species list includes approximately 42 species of mammals, 246 species of birds, 5 species of amphibians, and 12 species of reptiles (Soll and Soper 1996; Brandt *et al.* 1993).

The shrub and grassland habitat of the Hanford Site supports many groups of terrestrial wildlife. Species include large game animals like Rocky Mountain elk and mule deer; predators such as coyote, bobcat, and badger; and herbivores like deer mice, harvest mice, ground squirrels, voles, and black-tailed jackrabbits. The most abundant mammal on the Hanford Site is the Great Basin pocket mouse.

Mule deer rely on shoreline vegetation and bitterbrush shrubs for browse (Tiller *et al.* 1997). Elk, which are more dependent on open grasslands for forage, seek the cover of sagebrush and other shrub species during the summer months. Elk first appeared on the Hanford Site in 1972 (Fitzner and Gray 1991), and have increased from approximately 8 animals in 1975 to 900 in 1999. The Rattlesnake Hills elk herd that inhabits the Hanford Site primarily occupies ALE and private lands that adjoin the reserve to the north and west. Elk are occasionally seen on the 200 Area Plateau and have been sighted at the White Bluffs boat launch on the Hanford Site. The herd tends to congregate on ALE in the winter and disperses during the summer months to higher elevations on ALE, private land to the west of ALE, and the U.S. Army Yakima Training Center. Approximately 300 elk have been relocated or removed by special hunts during 1999-2000. Elk relocation continued in 2002. The *24 Command Fire* in June 2000

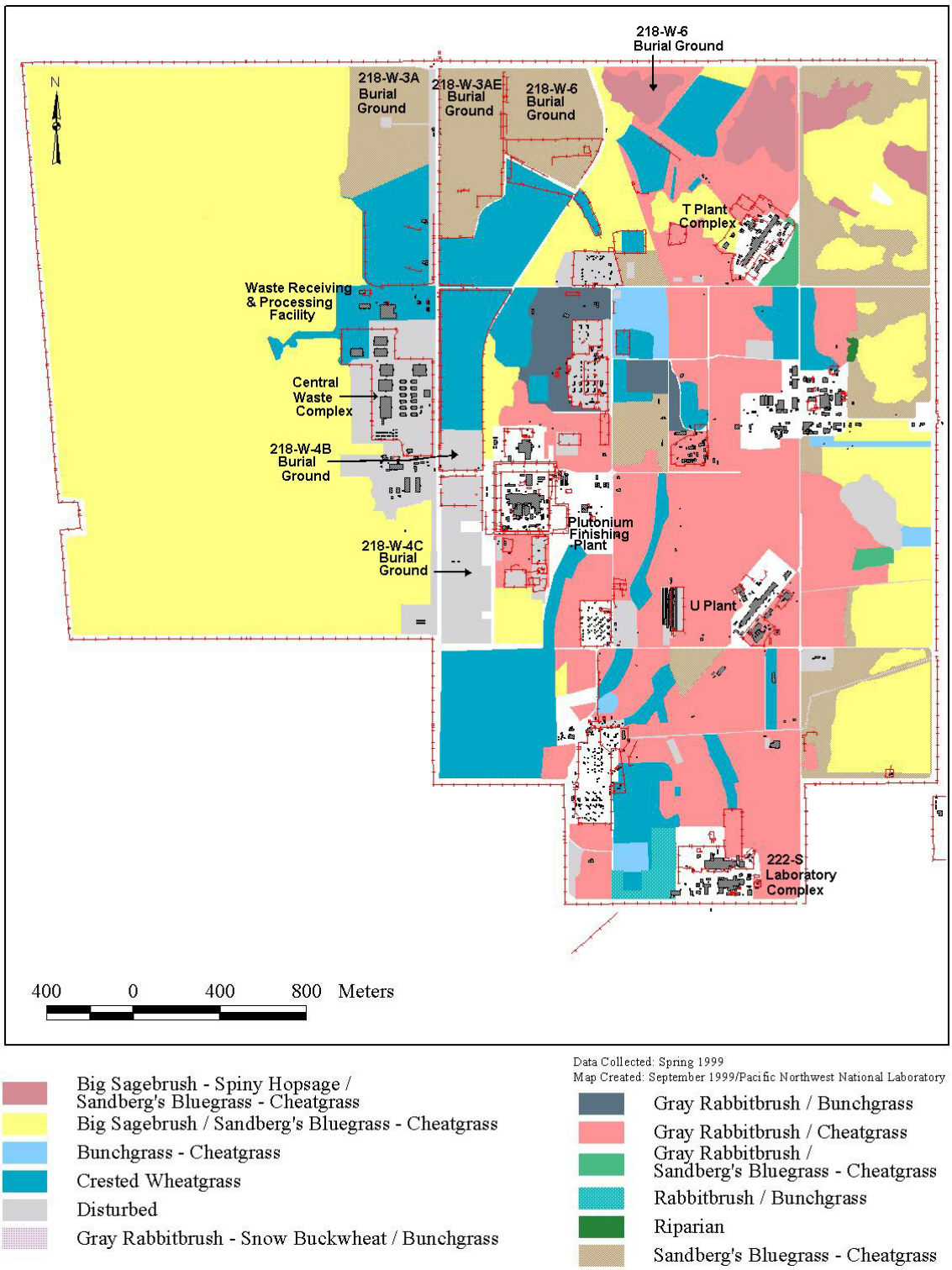


Figure 4.21. Distribution of Vegetation Types and Land Use Areas in the 200 West Area Prior to the *24 Command Fire* (DOE-RL 2001)

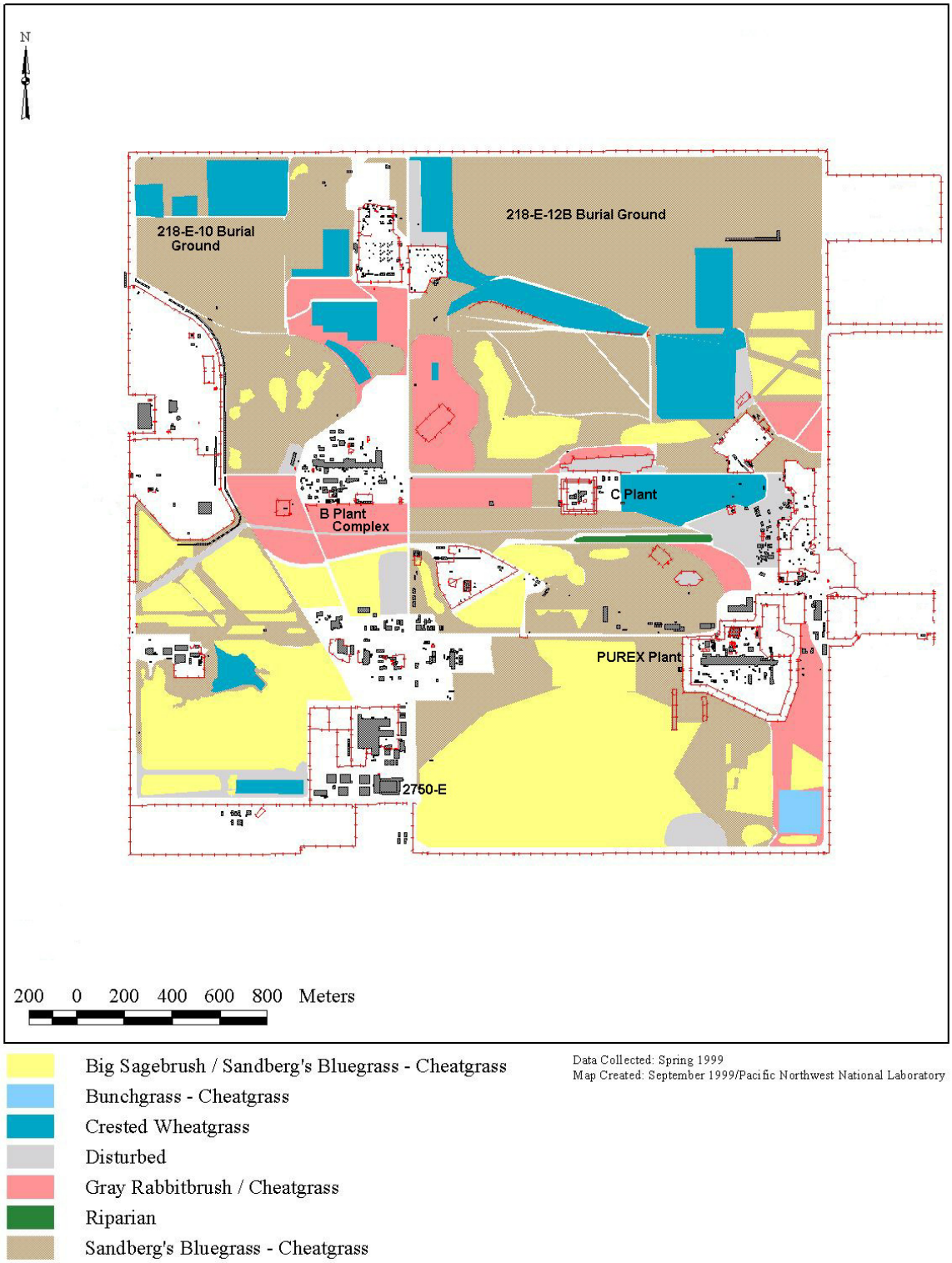


Figure 4.22. Distribution of Vegetation Types and Land Use Areas in the 200 East Area Prior to the *24 Command Fire* (DOE-RL 2001)

destroyed nearly all the elk forage on ALE. The herd moved onto unburned private land west of the site, to unburned areas on central Hanford, and along the Columbia River near the 100-B/C and 100-K Areas. Post-fire surveys suggest very low mortality of adult elk as a result of the wildfire. However, the wildfire occurred in the middle of calving season, which may have an impact on the number of calves and their survival to adulthood. A cougar sighting on ALE was reported during the elk relocation effort in March 2000.

Shrubland and grassland provide nesting and foraging habitat for many passerine bird species. Surveys conducted during 1993 (Cadwell 1994) reported the occurrence of western meadowlarks and horned larks more frequently in shrubland habitats than in other habitats on the site. Soll *et al.* (1999) reported a total of 41 species that are considered steppe or shrub-steppe habitat dependent. Long-billed curlews and vesper sparrows were also noted as commonly occurring species in shrubland habitat. Species that are dependent on undisturbed shrub habitat include sage sparrow, sage thrasher, and loggerhead shrike. Both the sage sparrow and loggerhead shrike tend to roost and nest in sagebrush or bitterbrush that occurs at lower elevations (**DOE-RL 2001**). Ground-nesting species that occur in grass-covered uplands include long-billed curlews, western meadowlark, and burrowing owls.

Common upland gamebird species that occur in shrub and grassland habitat include chukar partridge, California quail, and Chinese ring-necked pheasant. Chukars are most numerous in the Rattlesnake Hills, Yakima Ridge, Umtanum Ridge, Saddle Mountains, and Gable Mountain areas of the Hanford Site. Less common species include western sage grouse, Hungarian partridge, and scaled quail. Western sage grouse were historically abundant on the Hanford Site. However, populations have declined since the early 1800s because of the conversion of sagebrush-steppe habitat. Surveys conducted by the WDFW and PNNL during late winter and early spring 1993, and biodiversity inventories conducted by The Nature Conservancy in 1997, did not observe western sage grouse in sagebrush-steppe habitat at ALE. However, sage grouse have been observed on ALE in 1999 and 2000 (Tiller 2000).

Among the more common raptor species that use shrubland and grassland habitats are American kestrel, red-tailed hawk, Swainson's hawk, and ferruginous hawks. Northern harriers, sharp-shinned hawks, rough-legged hawks, and golden eagles also occur in these habitats but are not sighted as frequently. In 1994, nesting by red-tailed, Swainson's, and ferruginous hawks included 41 nests located across the Hanford Site on high voltage transmission towers, trees, cliffs, and basalt outcrops. In recent years, the number of nesting ferruginous hawks on the Hanford Site has increased, in part as a result of their acceptance of steel power line towers in the open grass and shrubland habitats.

Many species of insects occur throughout all habitats on the Hanford Site. Butterflies, grasshoppers, and darkling beetles are among the most conspicuous of the approximately 1500 species of insects that have been identified from specimens collected on the Hanford Site (Soll *et al.* 1999). The actual number of insect species occurring on the Hanford Site may reach as high as 15,500. A total of 1509 species-level identifications were completed in 1999 and 500 more are expected. Recent surveys performed by The Nature Conservancy included the collection of 40,000 specimens and have resulted in the identification of 43 new taxa and 142 new findings in the State of Washington (Soll *et al.* 1999). The

high diversity of insect species on the Hanford Site is believed to reflect the size, complexity, and quality of the shrub-steppe habitat.

The side-blotched lizard is the most abundant reptile species that occurs on the Hanford Site. Short-horned and sagebrush lizards are reportedly found on the site, but occur infrequently. The most common snake species include gopher snake, yellow-bellied racer, and Pacific rattlesnake. The Great Basin spadefoot toad, Woodhouse's toad, Pacific tree frog, tiger salamander, and bullfrog are the only amphibians found on the site (Soll *et al.* 1999; Brandt *et al.* 1993).

With the cessation of production activities at Hanford, the amount of water discharged to the ground in the 200 Area Plateau has significantly decreased. West Lake has shrunk and is presently a group of small isolated pools and mud flats. Avocets and sandpipers still use the site, but it does not support coots or other nesting waterfowl.

4.6.3 Aquatic Ecology

Two types of natural aquatic habitats are found on the Hanford Site: the Columbia River that flows along the northern and eastern edges of the site, and the small spring-streams and seeps located mainly on ALE in the Rattlesnake Hills.

The Columbia River is the dominant aquatic ecosystem on the Hanford Site and supports a large and diverse community of plankton, benthic invertebrates, fish, and other communities. It has a drainage area of about 680,000 km^2 (260,000 mi^2), an estimated average annual discharge of 6600 m^3/s (71,000 ft^3/s), and a total length of about 2000 km (1240 mi) from its origin in British Columbia to its mouth at the Pacific Ocean. The Columbia has been dammed both upstream and downstream of the Hanford Site, and the Hanford Reach flowing through the Site is the last free-flowing, but regulated, section of the Columbia River in the United States above Bonneville Dam. Plankton populations in the Hanford Reach are influenced by communities that develop in the reservoirs of upstream dams, particularly Priest Rapids Reservoir, and by manipulation of water levels below by dam operations in upstream and downstream reservoirs. Phytoplankton and zooplankton populations provide food for herbivores such as immature insects that are then consumed by predaceous species. These phytoplankton and zooplankton are largely transient, flowing from one reservoir to another. There is generally insufficient time for characteristic endemic groups of phytoplankton and zooplankton to develop in the Hanford Reach. No tributaries enter the Columbia during its passage through the Hanford Site; however, there are several irrigation water return canals that discharge into the Columbia River along the Franklin County shoreline.

Gray and Dauble (1977) listed 43 species of fish in the Hanford Reach of the Columbia River. The brown bullhead, collected since 1977, brings the total number of fish species identified in the Hanford Reach to 44. Of these species, chinook salmon, sockeye salmon, coho salmon, and steelhead trout use the river as a migration route to and from upstream spawning areas and are of the greatest economic importance. Additionally, fall chinook salmon and steelhead trout spawn in the Hanford Reach.

Small interrupted streams, such as Rattlesnake and Snively springs, contain diverse biotic communities and are extremely productive (Cushing and Wolf 1984). Dense blooms of watercress occur

and aquatic insect production is high compared with mountain streams (Gaines 1987). The macrobenthic biota varies from stream to stream and is related to the proximity of colonizing insects and other factors. Rattlesnake Springs is of ecological importance because it provides a source of water to terrestrial animals in an otherwise arid part of the site. Snively Springs, located farther west and at a higher elevation than Rattlesnake Springs, is a source of drinking water for terrestrial animals. The major rooted aquatic plant, which in places may cover the entire width of the stream, is watercress (*Rorippa nasturtium-aquaticum*). Isolated patches of bulrush (*Scirpus* sp.), spike rush (*Eleocharis* sp.), and cattail (*Typha latifolia*) occupy less than 5 percent of the streambed.

4.6.4 Threatened and Endangered Species

The federal Endangered Species Act defines endangered species as plants and animals in danger of extinction within the foreseeable future throughout all or a significant portion of its range. Threatened species are those likely to become endangered within the foreseeable future throughout all or a significant portion of its range. Candidate species are plants and animals with a status of concern, but more information is needed before they can be proposed for listing.

No plants or mammals on the Federal list of threatened and endangered wildlife and plants (50 CFR 17) are known to occur on the Hanford Site. However, the bald eagle and two species of fish (steelhead and spring-run chinook salmon), currently found on the Federal list of threatened and endangered species, are present on the Hanford Site on a regular basis. A survey of the 200 Areas observed no threatened or endangered species (Sackschewsky 2001).

Threatened and endangered plants and animals identified on the Hanford Site, as listed by the Federal government (50 CFR 17) and Washington State (Washington Natural Heritage Program 2000), are shown in Table 4.11. Several species of both plants and animals are under consideration for formal listing by the Federal government and Washington State. The FWS reviews the status of candidate species for listing under the Endangered Species Act on an annual basis. The results of these reviews are posted on the FWS homepage http://www.fws.gov. Anadromous fish are reviewed and listed by the National Marine Fisheries Service (NMFS) http://www.nwr.noaa.gov.

Washington State defines endangered species as wildlife species native to the State of Washington that are seriously threatened with extinction throughout all or a significant portion of their ranges within the State. Threatened species include wildlife species native to the State of Washington that are likely to become an endangered species within the foreseeable future throughout a significant portion of their ranges within the State (WAC 232-12-297). A State of Washington sensitive species is a wildlife species native to the State of Washington that is vulnerable or declining and is likely to become endangered or threatened throughout a significant portion of its range within the State without cooperative management or removal of threats. The common loon (*Gavia immer*) is the only Washington State sensitive animal species found on the Hanford Site. Table 4.12 lists the Washington State-designated candidate animal species that potentially are found on the Hanford Site and are under consideration for possible addition to the threatened or endangered list. A State candidate species is one that is being reviewed for possible listing as a State Endangered, Threatened, or Sensitive species as specified in Washington Department of Fish and Wildlife Policy M-6001 (WDFW 1998).

Table 4.11. Federal or Washington State Listed Threatened (T) and Endangered (E) Species Occurring on the Hanford Site (Neitzel 2001)

Common Name	Scientific Name	Federal	State[a]
Plants			
Columbia milkvetch	*Astragalus columbianus*	SC[b]	T
Dwarf evening primrose	*Camissonia (= Oenothera) pygmaea*		T
Hoover's desert parsley	*Lomatium tuberosum*	SC	T
Loeflingia	*Loeflingia squarrosa var. squarrosa*		T
Persistent sepal yellowcress	*Rorippa columbiae*	SC	T
Umtanum desert buckwheat	*Eriogonum codium*	C[c]	E
White Bluffs bladderpod	*Lesquerella tuplashensis*	C	E
White eatonella	*Eatonella nivea*		T
Fish			
Spring-run chinook	*Oncorhynchus tshawytscha*	E	C
Steelhead	*Oncorhynchus mykiss*	E	C
Birds			
American white pelican	*Pelecanus erythrorhychos*		E
Bald eagle[d]	*Haliaeetus leucocephalus*	T	T
Ferruginous hawk	*Buteo regalis*	SC	T
Sandhill crane	*Grus canadensis*		E
Greater sage grouse	*Centrocercus urophasianus phaios*	SC	T

(a) http://www.wa.gov/wdfw/ select Habitat, Priority Habitats and Species List, Species of Concern List, Endangered Species (WAC 232-12-297)
(b) SC = Federal species of concern, 50 CFR 17 http://www.fws.gov.
(c) C = Federal candidate, 50 CFR 17 http://www.fws.gov.
(d) Currently under review for change in status.

Washington State considers pristine shrub-steppe habitat as a priority habitat because of its relative scarcity in the State and because of its requirement as nesting/breeding habitat by several State and Federal species of concern (see Figure 4.20 for vegetation habitat coverage). Designation and characterization of priority habitat serves to provide a basis for sound and defensible land management planning and assists the DOE in implementing sound stewardship activities into site management to protect regulated species.

Table 4.12. Washington State Candidate Animal Species Found on the Hanford Site (Neitzel 2001)

Common Name	Scientific Name
Molluscs	
Giant Columbia River spire snail[a] Giant Columbia River limpet	*Fluminicola (= Lithoglyphus) columbiana* *Fisherola* (= *Lanx*) *nuttalli*
Fish	
Spring-run chinook[b] Steelhead[b]	*Oncorhynchus tshawytscha* *Oncorhynchus mykiss*
Insects	
Columbia River tiger beetle[c]	*Cicindela columbica*
Birds	
Burrowing owl[a]	*Athene cunicularia*
Golden eagle	*Aquila chrysaetos*
Loggerhead shrike[a]	*Lanius ludovicianus*
Merlin Northern goshawk[a,d]	*Falco columbarius* *Accipter gentilis*
Sage Sparrow	*Amphispiza belli*
Sage Thrasher	*Preoscoptes montanus*
Reptiles	
Striped whipsnake	*Masticophis taeniatus*
Mammals	
Black-tailed jackrabbit	*Lepus californicus*
Merriam's Shrew	*Sorex merriami*
Washington ground squirrel[e]	*Spermophilus washingtoni*
White-tailed jackrabbit	*Lepus townsendi*

(a) Information from Washington Department of Fish and Wildlife http://www.wa.gov/wdfw/ select Habitat, Priority Habitats and Species List, Species of Concern List) (WDFW Policy M-6001).
(b) Federal endangered.
(c) Probable, but not observed on the Hanford Site.
(d) Reported, but seldom observed on the Hanford Site.
(e) Federal candidate.

Table 4.13 lists Washington State plant species of concern that are currently listed as sensitive or are in one of three monitored groups (Washington Natural Heritage Program 2000; Soll *et al.* 1999). The Washington Natural Heritage Program established the ratings reported in Table 4.13 as Sensitive (vulnerable or declining and could become Endangered or Threatened), Review 1 (more field work needed), and Review 2 (unresolved taxonomic problems).

Figure 4.23 shows the general locations of species of concern on the Hanford Site prior to the wildfire, and the *24 Command Fire* coverage. The wildfire burn intensity was low, allowing belowground portions of some perennial plants and seeds to survive. Most of the rare plants are expected to recover within 1-3 years, although their populations may be reduced.

Table 4.13. Washington State Plant Species of Concern Occurring on the Hanford Site, as Determined by Washington Natural Heritage Program 2000 (Neitzel 2001)

Common Name	Scientific Name	State Listing
Annual paintbrush	*Castilleja exilis*	R1
Awned halfchaff sedge	*Lipocarpha (= Hemicarpha) aristulata*	R1
Basalt milk-vetch	*Astragalus conjunctus var. rickardii*	R1
Bristly combseed	*Pectocarya setosa*	W
Brittle prickly pear	*Opuntia fragilis*	R1
Canadian St. John's wort	*Hypericum majus*	S
Chaffweed	*Centunculus minimus*	R1
Columbia River mugwort	*Artemesia lindleyana*	W
Coyote tobacco	*Nicotiana attenuata*	S
Crouching milkvetch	*Astragalus succumbens*	W
Desert dodder	*Cuscuta denticulata*	S
Desert evening-primrose	*Oenothera caespitosa*	S
False pimpernel	*Lindernia dubia anagallidea*	R2
Fuzzytongue penstemon	*Penstemon eriantherus whitedii*	R1
Geyer's milkvetch	*Astragalus geyeri*	S
Grand redstem	*Ammannia robusta*	R1
Gray cryptantha	*Cryptantha leucophaea*	S
Great Basin gilia	*Gilia leptomeria*	R1
Hedge hog cactus	*Pediocactus simpsonii var. robustior*	R1
Kittitas larkspur	*Delphinium multiplex*	W
Lowland toothcup	*Rotala ramosior*	R1
Miner's candle	*Cryptantha scoparia*	R1
Piper's daisy	*Erigeron piperianus*	S
Robinson's onion	*Allium robinsonii*	W
Rosy balsamroot	*Balsamorhiza rosea*	W
Rosy pussypaws	*Calyptridium roseum*	S
Scilla onion	*Allium scilloides*	W
Shining flatsedge	*Cyperus bipartitus (rivularis)*	S
Small-flowered evening-primrose	*Camissonia (= Oenothera) minor*	R1
Small-flowered nama	*Nama densum var. parviflorum*	R1
Smooth cliffbrake	*Pellaea glabella simplex*	W
Snake River cryptantha	*Cryptantha spiculifera (= C. interrupta)*	S
Southern mudwort	*Limosella acaulis*	W
Stalked-pod milkvetch	*Astragalus sclerocarpus*	W
Suksdorf's monkey flower	*Mimulus suksdorfii*	S
Winged combseed	*Pectocarya linearis*	R1
The following species have been reported as occurring on the Hanford Site, but the known collections are questionable in terms of location or identification, and have not been collected recently on the site.		
Beaked spike-rush	*Eleocharis rostellata*	S
Dense sedge	*Carex densa*	S
Few-flowered collinsia	*Collinsia sparsiflora var. bruciae*	S
Giant helleborine	*Epipactis gigantea*	S
Medic milkvetch	*Astragalus speirocarpus*	W
Orange balsam	*Impatiens aurella*	R2
Palouse milkvetch	*Astragalus arrectus*	S
Palouse thistle	*Cirsium brevifolium*	W
Porcupine sedge	*Carex hystericina*	S
Thompson's sandwort	*Arenaria franklinii thompsonii*	R2

S = Sensitive (i.e., taxa vulnerable or declining) and could become endangered or threatened without active management or removal of threats.
R1 = Taxa for which there are insufficient data to support listing as threatened, endangered, or sensitive (formerly monitor group 1).
R2 = Taxa with unresolved taxanomic questions (formerly monitor group 2).
W = Taxa that are more abundant and/or less threatened than previously assumed (formerly monitor group 3).

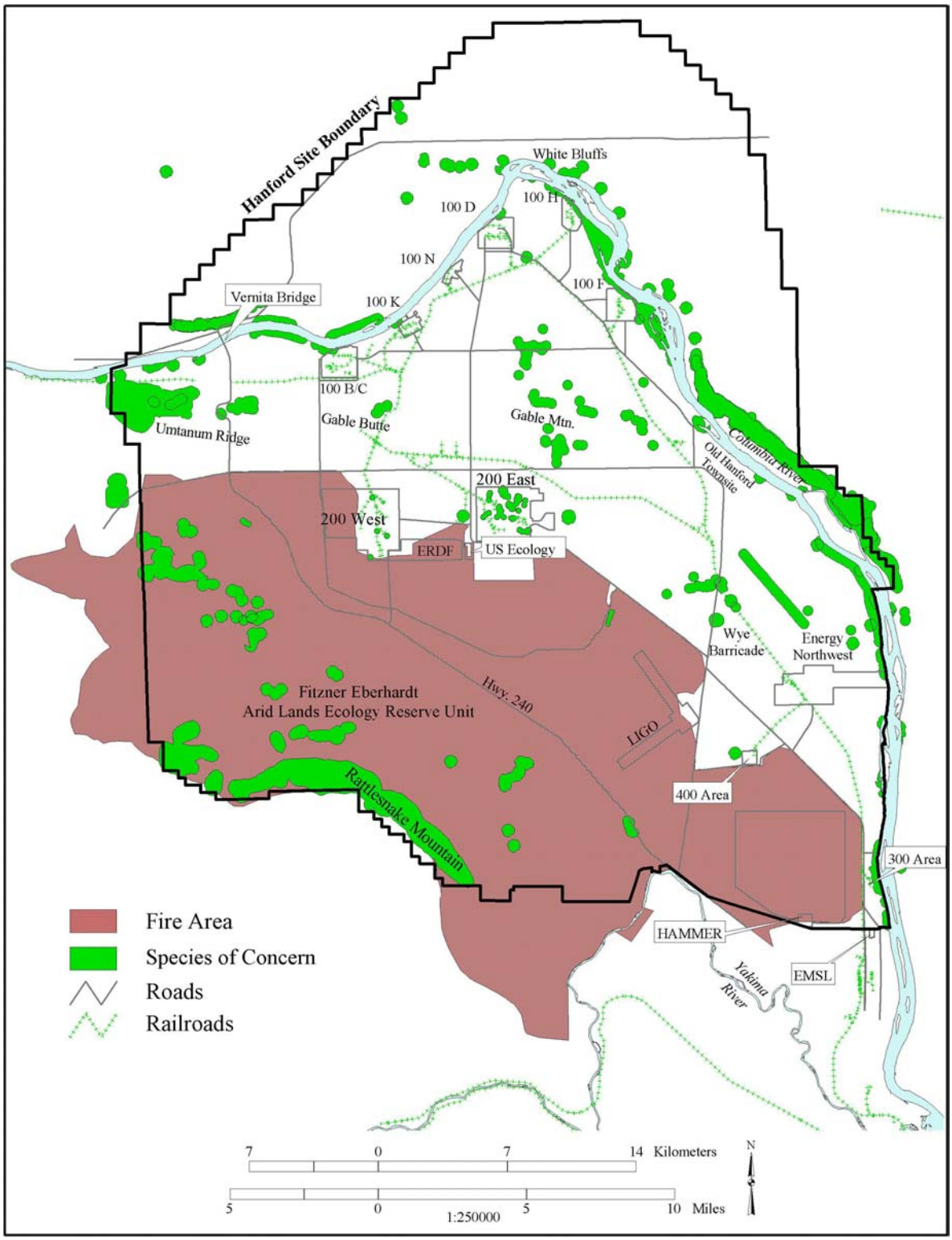


Figure 4.23. Species of Concern on the Hanford Site and the *24 Command Fire* Area (after DOE-RL 2001 and BAER 2000)

200 Areas. The annual of the LLBGs was conducted in April of 2001 (Sackschewsky 2001). Due to access restrictions, visual observations from the Burial Ground perimeters were performed. The LLBGs include 218-E-10 and 218-E-12B in the 200 East Area, and 218-W-3A, 218-W-3AE, 218-W-4B, 218-W-4C, 218-W-5, and 218-W-6 in the 200 West Area. The western half of 218-W-6, the undeveloped portion of 218-W-4C (along 16th Street), and the undeveloped portion of the 218-E-10 Burial Ground (north of the existing powerline) were not reviewed during recent evaluations.

Crouching milkvetch (*Astragalus succumbens*) and stalked-pod milkvetch (*Astragalus sclerocarpus*), State of Washington watch list species, were observed within 218-W-4C and the extreme western edge of the 218-W-5 Burial Ground. Crouching milkvetch was also observed in the south end of the 218-W-6 Burial Ground. Piper's daisy (*Erigeron piperianus*), a State of Washington sensitive species was noted in the 218-E-12B and 218-E-10 Burial Grounds in previous years.

Birds observed within the 200 East Area LLBGs include long-billed curlews (*Numenius americanus*), killdeer (*Charadrius viociferus*), horned larks (*Eremophila alpestris*), Say's phoebe (*Sayornis saya*), American robin (*Turdus migratorius*), American kestrel (*Falco sparverius*), western meadowlark (*Sturnella neglecta*), and common raven (*Corvus corax*). Two bird species, loggerhead shrike (*Lanius ludovicianus*) and sage sparrow (*Amphispiza belli*), Washington State candidate species, have been sighted in the vicinity of the 218-W-4C Burial Grounds. Burrowing owls (*Athene cunicularia*), Washington State candidate species, have been observed in the vicinity of the 218-W-6 Burial Grounds.

4.7 Cultural, Archaeological, and Historical Resources

The Hanford vicinity is one of the most culturally rich resource areas in the western Columbia Plateau. Traditional Native American religion is manifest in the earth, the water, the sky, and all animate or inanimate beings that inhabit a given location. The National Historic Preservation Act (16 USC 470), the Native American Graves Protection and Repatriation Act (25 USC 3001), the Archaeological Resources Protection Act, and the DOE American Indian Policy (DOE 2000b), among other legislation and guidelines, require the identification and protection of areas and resources of concern to the Native American community (see Sections 6.13 and 6.14). The site comprises a series of cultural landscapes containing the cumulative record of multiple occupations by Native and non-Native Americans. These landscapes contain numerous well-preserved archaeological sites representing prehistoric, ethnographic, and historic periods. Period resources include sites with cultural materials that are thousands of years old, traditional cultural places, and buildings and structures from the pre-Hanford, Manhattan Project, and Cold War eras.

4.7.1 Native American Cultural Resources and Archaeological Resources

In prehistoric and early historic times, Native Americans of various tribal affiliations populated the Hanford Reach of the Columbia River. The Wanapum and the Chamnapum bands dwelt along the Columbia River from south of Richland upstream to Vantage (Relander 1956; Spier 1936). Some of their descendants (Wanapum) still live nearby at Priest Rapids; others live on 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 east bank of the

river (Relander 1956; Trafzer and Scheuerman 1986). Many descendants of the Palus now live on the Colville Reservation. The Nez Perce, Walla Walla, and Umatilla, and other Native American peoples also made periodic visits to fish in the area. Descendants of these people retain traditional secular and religious ties to the region and many have knowledge of the ceremonies and life ways of their ancestral culture.

The Hanford Reach and the greater Hanford Site, geographic centers for regional Native American religious belief, are central to the practice of Indian religion of the region, and many believe the creator made the first people here (DOI 1994). Indian religious leaders, such as Smoholla, a prophet of Priest Rapids who brought the Washani religion to the Wanapum and others during the late nineteenth century, began their teachings here. Native plant and animal foods, some of which can be found on the Hanford Site, are used in the ceremonies performed by tribal members. Certain landforms, especially Rattlesnake Mountain, Gable Mountain, Gable Butte, and various sites along and including the Columbia River, remain sacred to them. Aesthetic and scenic resources are discussed in Section 4.8.10. The Gable Mountain Block Survey conducted by tribal members in 2000, recorded important attributes that contribute to the significance of Gable Mountain to Native Americans (Poston *et al.* 2001). Native American traditional cultural places within the Hanford Site include, but are not limited to, a wide variety of places and landscapes: archaeological sites, cemeteries, trails and pathways, campsites and villages, fisheries, hunting grounds, plant gathering areas, holy lands, landmarks, important places in Indian history and culture, places of persistence and resistance, and landscapes of the heart (Bard 1997). Traditional cultural places of importance to Native Americans are determined through methods that are mutually agreed upon by DOE and the Native American community.

The Yakama and Umatilla Nations ceded the land to the Federal government in the Treaties of 1855 (see Section 6.14). The Hanford Site is within the ceded lands. The Nez Perce Nation signed a treaty on June 11, 1855 (see Section 6.14), whereas the Wanapum Band did not sign a treaty.

People have inhabited the Middle Columbia River region since the end of the glacial period. More than 8000 years of prehistoric human activity in this largely arid environment have left extensive archaeological deposits along the river shores (Chatters 1989; Greengo 1982; Leonhardy and Rice 1970). Well-watered areas inland from the river also show evidence of concentrated human activity (Chatters 1982, 1989; Daugherty 1952; Greene 1975; Leonhardy and Rice 1970; Rice 1980), and recent surveys have indicated extensive, although dispersed, use of arid lowlands for hunting. 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 at numerous sites. However, by virtue of their inclusion in 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 largely have not been destroyed.

Archaeological sites and isolated finds totaling 439 associated with the prehistoric period have been recorded on the site; of these, approximately 68 contain historic components as well. Prehistoric period sites common to the Hanford Site include remains of numerous pit house villages, various types of open campsites, spirit quest monuments (rock cairns), hunting camps, game drive complexes, and quarries in nearby mountains and rocky bluffs (Rice 1968a,b; Rice 1980); 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 (Drucker 1948; Krieger 1928; Rice 1968a,b). Much of this early archaeologycal survey and reconnaissance activity concentrated on islands and on a strip of land about 400 m (1300 ft) wide on either side of the river (Rice 1980). Reconnaissance of selected locations conducted through the mid-1980s added to the recorded site inventories, as well as systematic archaeological surveys conducted from the middle 1980s through 1996 (Chatters 1989; Chatters and Cadoret 1990; Chatters and Gard 1992; Chatters *et al.* 1990; 1991, 1992; Last *et al*. 1994; Andrefsky *et al.* 1996).

During his reconnaissance of the Hanford Site in 1968, Rice (1968b) inspected portions of Gable Mountain, Gable Butte, Snively Canyon, Rattlesnake Mountain, and Rattlesnake Springs. Rice also inspected additional portions of Gable Mountain and part of Gable Butte in the late 1980s (Rice 1987). Some reconnaissance of the Basalt Waste Isolation Project (BWIP) Reference Repository Location (Rice 1984), a proposed land exchange in T. 22 N., R. 27 E., Section 33 (Rice 1981), and three narrow transportation and utility corridors (ERTEC 1982; Morgan 1981; Smith *et al.* 1977) were also conducted. Other large-scale project areas completed in recent years include: the 100 Areas from 1991 through 1993 and 1995 (Chatters *et al.* 1992; Wright 1993); McGee Ranch (Gard and Poet 1992); the Laser Interferometer Gravitational Wave Observatory Project; the Environmental Restoration Disposal Facility; and the Washington State University 600 Area Block Survey (Andrefsky *et al.* 1996). To date, approximately 12 percent of the Hanford Site has been surveyed for archaeological resources.

4.7.2 Historic Archaeological Resources

Two of the early Euro-Americans who passed near the Hanford Site were Lewis and Clark, who traveled along the Columbia and Snake rivers during their 1803 to 1806 exploration of the Louisiana Territory. The first European explorer to cross the Hanford Site was David Thompson, who traveled along the Columbia River from Canada during his 1811 exploration of the Columbia River. Other visitors included fur trappers, military units, and miners who traveled through the Hanford Site on their way to lands up and down the Columbia River 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 soon began to work the gravel bars for gold. Cattle ranches were established in the 1880s, and farmers soon followed. Agricultural development, irrigation districts, and roads soon dotted the landscape, particularly in the eastern portion of the central Hanford Site. Several small thriving towns, including Hanford, White Bluffs, Richland, and Ringold, grew up along the riverbanks in the early twentieth century. Community accessibility to outside markets grew with the arrival in 1913, of the Chicago, Milwaukee, and St. Paul Railroad branch line (Priest Rapids-Hanford Line) from Beverly, Washington. Ferries were established at Richland, Hanford, Wahluke, White Bluffs, and Richmond. The towns and nearly all other structures were razed in the years after the U.S. government acquired the land for the Hanford Engineer Works in 1943 (Chatters 1989; ERTEC 1981; Rice 1980).

Since 1987, the Hanford Cultural Resources Laboratory (HCRL) has recorded 655 historic archaeological sites associated with the pre-Hanford (Euro-American) era, the Manhattan Project, and Cold War era, including an assortment of farmsteads, corrals, dumps, and military sites. Of these, 56 sites contain prehistoric components as well. Archaeological resources from the pre-Hanford period are scattered over the entire Hanford Site and include numerous areas of gold mining features along the riverbanks of the Columbia and remains of homesteads, building foundations, agricultural equipment and fields, ranches, and irrigation features. Properties from this period include the Hanford Irrigation Ditch; former Hanford Townsite; Wahluke ferry landing; White Bluffs Townsite; Richmond ferry landing; Arrowsmith Townsite; White Bluffs road; and the Chicago, Milwaukee, and St. Paul Railroad.

Areas of traditional cultural importance to pre-Hanford residents are also found on the Hanford Site. These areas include places and structures that are important to descendents of pre-1943 settlers in the former White Bluffs, Hanford, Allard, and Cold Creek areas.

4.7.3 Historic Built Environment

A number of buildings associated with the pre-Hanford Site era have been documented. They include the Hanford Irrigation and Power Company pumping plant at Coyote Rapids, the high school and the electrical substation at the Hanford Townsite, White Bluffs bank, Bruggemann's fruit warehouse, and the blacksmith cabin at the East White Bluffs ferry landing.

Historic built resources documented from the Manhattan Project and Cold War eras include buildings and structures found in the 100, 200, 300, 400, 600, 700, and former 1100 and 3000 Areas. The most important of these are the plutonium production and test reactors, chemical separation and plutonium finishing buildings, and fuel fabrication/manufacturing facilities. The first reactors, 100-B, 100-D, and 100-F, were constructed during the Manhattan Project. Plutonium for the first atomic explosion and the bomb that destroyed Nagasaki to end World War II was produced at the Hanford Site. Additional reactors and processing facilities were constructed after World War II during the Cold War period. All reactor containment buildings still stand, although many ancillary structures have been removed, and the C, D, DR, F, and H reactors have been considerably modified.

Historic contexts were completed for the Manhattan Project and Cold War eras as part of a National Register Multiple Property Documentation Form prepared for the Hanford Site to assist with the evaluation of National Register of Historic Places (National Register) eligibility of buildings and structures sitewide (DOE 1997b). Additionally, historical narratives and individual building documentations have been completed for the draft *History of the Plutonium Production Facilities at the Hanford Site Historic District, 1943-1990* and have been placed in the Public Reading Room for public review and comment. At the Site, 528 Manhattan Project and Cold War era buildings/structures and complexes have been determined to be eligible for the *National Register* as contributing properties within the designated Hanford Site Manhattan Project and Cold War era Historic District. Of that number, 190 were recommended for individual documentation (Marceau 1998).

4.7.4 200 Areas

Much of the 200 East and West Areas have been disturbed by construction of facilities associated with the chemical separations process as part of the Manhattan Project and Cold War Era. Other facilities have been constructed as part of ongoing cleanup efforts for the Hanford Site. Comprehensive efforts were made in 1986 and 1989 to inventory the undisturbed portions of the 200 East and West Areas for cultural resources. The 1989 survey was "an intensive pedestrian survey of all undisturbed portions of the 200 East Area and a stratified random survey [of the undisturbed portions] of the 200 West Area" (Chatters and Cadoret 1990). No cultural resources are known to exist within currently active borrow areas (DOE 2001b).

The 1989 survey located two historic-archaeological sites (can and glass scatters), four isolated historic artifacts, one isolated cryptocrystalline flake, and an extensive linear feature (that is, the White Bluffs Road). These were the only materials older than 50 years discovered during the field survey. Only the White Bluffs Road, in its entirety, was determined eligible for listing in the National Register. This road, which passes diagonally southwest to northeast through the 200 West Area, originated as a Native American trail. It has been in continuous use since antiquity and continued to play a role in Euro-American immigration, development, agriculture, and Hanford Site operations. Within the 200 West Area, two intact segments of the road are considered contributing elements: 1) the southwest segment from the perimeter fence to approximately 19th Street at Dayton Avenue, and 2) the extreme northeast segment above T Plant Complex to the perimeter fence. A 100-m (328-ft) easement has been created to protect these segments of the road from uncontrolled disturbance. The remaining portions of the road within the 200 West Area have been disturbed or destroyed by previous construction-related activities and are classified as non-contributing. In 1996, an inventory was completed of the remainder of the undisturbed ground; an area totaling 2.2 km^2 (0.85 mi^2). Although six isolated finds and two historic debris scatters were located, none were considered to be eligible for the National Register.

Although other areas of undisturbed land in the 200 East and 200 West Areas have been surveyed as part of cultural resource reviews of proposed projects, no new significant cultural resources have been located. Reviews include the 1989 permit application for the LLBGs (218-E-10, 218-E-12B, 218-W-3A, 218-W-3AE, 218-W-4B, 218-W-4C, 218-W-5, 218-W-6) (Hanford Cultural Resources Case (HCRC) # 89-200-008; see Table K.1). Previous borrowing and burying activities at the grounds had extensively disturbed the majority of the LLBGs. However, portions of 218-E-12B, 218-W-5 and 218-W-6 were undisturbed. These areas were surveyed and reviewed by the HCRL in the summer of 1988 as part of HCRC# 88-200-038 (see Table K.1) and clearance for the project was granted. The ETF location was reviewed for the presence or absence of cultural resources in 1990 (HCRC# 89-200-023; see Table K.1). The WRAP location was reviewed in 1993 (HCRC# 93-200-074; see Table K.2) and the CWC was reviewed in 1995 (HCRC# 95-200-104; see Table K.1). No significant resources were identified. Over the past 15 years, 50 cultural resource reviews were conducted on the LLBGs for grouting, geologic testing, subsidence repair and maintenance, removal of contaminated soils, retrieval of vented drums, culvert installation, drilling to install HICs, and trench construction.

Chemical separations facilities (processing plants and their ancillary and support services) were located in the 200 Areas. Irradiated fuel elements were dissolved and desired materials such as plutonium

were separated out. Historic property inventory forms have been completed for 72 buildings and structures in the 200 Area. Of that number, 58 have been determined eligible for the National Register as contributing properties within the Historic District recommended for mitigation. Included are the 234-5Z Plutonium Finishing Plant, 236-Z Plutonium Reclamation Facility, 242-Z Water Treatment Facility, 231-Z Plutonium Metallurgical Laboratory, 225-B Encapsulation Building, 221-T Canyon (T Plant) Building, 202-A Purex Building, 222-S Redox Plant, 212-N Lag Storage Facility, 282-E Pumphouse and Reservoir Building, 283-E Water Filtration Plant, and 284-W Power House and Steam Plant. The 232-Z Waste Incinerator Facility and the 233-S Plutonium Concentration Building, determined eligible for the National Register, have been documented to Historic American Engineering Record standards (DOE-RL 1998).

Completed in December 1944, T Plant (221-T) was the world's first large-scale plutonium (chemical) separation facility. T Plant, like the other chemical separation buildings at Hanford, is a massive, concrete, canyon-like structure measuring 800 feet long, 65 feet wide, and 80 feet high. Because of its role as the primary chemical separations plant at the Hanford Site from 1944 until the opening of the REDOX Plant in 1952, T Plant was found to be eligible for inclusion in the National Register of Historic Places as a contributing property within the Hanford Site Manhattan Project and Cold War Era Historic District and recommended for individual documentation (mitigation). Mitigation of T Plant has been completed and consisted of a Historic American Engineering Record documentation of the facility and a walkthrough/assessment of the building's contents. One stipulation of the Programmatic Agreement for the Built Environment (DOE/RL-96-77) requires DOE to undertake an assessment of the contents of the historic buildings and structures prior to any deactivation, decommissioning or decontamination activities. The purpose of these assessments is to locate any artifacts that may have interpretive and or educational value as exhibits within local, state or national museums. Industrial artifacts in T Plant and other facilities in the T Plant complex were identified and tagged for future exhibit purposes.

4.8 Socioeconomic Activity

Activity on the Hanford Site plays a dominant role in the socioeconomic activity of the Tri-Cities and other parts of Benton and Franklin counties. The agricultural community also has a significant effect on the local economy. Any major changes in the Hanford mission could potentially affect the Tri-Cities and other areas of Benton and Franklin counties.

4.8.1 Local Economy

Three major sectors have been the principal driving forces of the economy in the Tri-Cities since the early 1970s: 1) DOE and its contractors operating the Hanford Site; 2) Energy Northwest (formerly the Washington Public Power Supply System) in its construction and operation of nuclear power plants; and 3) the agricultural community, including a substantial food-processing component. 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 outside the Tri-Cities. In addition to the direct employment andpayrolls, these major sectors also support a sizable number of jobs in the local economy through their procurement of equipment, supplies, and business services.

In addition to these three major employment sectors, three other components can be readily identified as contributors to the economic base of the Tri-Cities: payrolls from the five major non-Hanford employers in the region, tourism, and pension benefits from former employees.

4.8.1.1 Employment and Income

DOE Hanford Site Employment. During FY 2000, the DOE Office of River Protection (ORP) and its prime contractors CH2M Hill Hanford Group, Inc. and Bechtel National, Inc.; DOE-RL and its prime contractors Fluor Hanford, Inc. (and its principal subcontractors); PNNL; Bechtel Hanford, Inc.; and the Hanford Environmental Health Foundation (HEHF) employed an average of 10,590 employees. FY 2000 year-end employment at Hanford was 10,870. In FY 1999, average employment was 10,290, compared to an average employment of 11,940 in 1996. The drop between FY 1996 and FY 1999 reflects both employment decline and reorganization of the DOE contractors under the Project Hanford Management Contract (PHMC) created in 1996. Under the PHMC, almost 2200 employees of the former management and operations contractor were moved into six enterprise companies and were no longer counted as official Hanford employees. The number of employees at Hanford is down considerably from a peak of 19,200 in FY 1994, but still represents nearly 12 percent of the total jobs in the local economy (89,500) (Neitzel 2001).

A model created by PNNL indicates that in 1999 about 21,350 Tri-Cities jobs were supported directly or indirectly by the Hanford payroll, and about 6900 by procurements and affiliate company contracts, for a total of 28,250 jobs. This represents 32 percent of the non-farm jobs in the economy. About 35 percent of the non-farm wage and proprietor income in the economy ($1.08 billion out of $3.08 billion) may depend directly or indirectly on Hanford payrolls and spending (DOE-RL 2000).

Based on employee residence records as of April 2001, 91 percent of the direct employees of Hanford live in Benton and Franklin counties. Approximately 74 percent of Hanford employees reside in Richland, Pasco, or Kennewick. More than 36 percent are Richland residents, 9 percent are Pasco residents, and 29 percent live in Kennewick. Residents of other areas of Benton and Franklin counties, including West Richland, Benton City, and Prosser, account for about 17 percent of total Hanford Site employment (Neitzel 2001).

Energy Northwest. Although activity related to commercial nuclear power plant construction ceased with the completion of the WNP-2 reactor in 1983 (now named Columbia Generating Station), Energy Northwest continues to be a major employer in the Tri-Cities area. Headquarters personnel based in Richland oversee the operation of the Columbia Generating Station. Decommissioning of mothballed nuclear power plants (WNP-1 and WNP-4), which never were completed, began in 1995. In FY 1999, Energy Northwest employed around 29 people at the two plants (one-third of the 90 people who were employed in 1994 as a result of decommissioning activities). As part of an effort to reduce electricity production costs, Energy Northwest headquarters decreased the size of its workforce from over 1900 in 1994 to 1016 at the end of 1999. As part of a refueling and maintenance project, employment had grown to 1117 in April 2001.

Agriculture. In 1999, agricultural production in the bi-county area generated about 10,395 wage and salary jobs, or about 13 percent of the total area employment, as represented by the employees covered by unemployment insurance (LMEA 2000a). Seasonal farm workers are not included in that total but are estimated by the U.S. Department of Labor (DOL) for the agricultural areas in the State of Washington. In 2000, an average of 5877 seasonal farm workers was estimated per month in Benton, Franklin, and Walla Walla counties, ranging from 1106 workers during the winter pruning season to 10,095 workers at the peak of harvest. An estimated average of 5432 seasonal workers were classified as local (ranging from 1102 to 10,074); an average of 30 were classified as intrastate (ranging from 0 to 172), and an average of 416 were classified as interstate (ranging from 0 to 1174). The weighted seasonal wage for year 2000 ranged from $6.52/hr to $7.33/hr with an average wage of $6.82/hr (DOL 2000).

According to the U.S. Department of Commerce Regional Economic Information System (REIS), about 2656 people were classified as farm proprietors in 1999. Farm proprietors' income, according to this same source, was estimated to be $18.5 million (DOC 2000).

The area farms and ranches generate a sizable number of jobs in supporting activities, such as agricultural services (for example, application of pesticides and fertilizers and irrigation system development) and wholesale trade (farm supply and equipment sales, and fruit packing). 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.

Other Major Employers. In 2000, the five largest non-Hanford Site employers employed approximately 5300 people in Benton and Franklin counties. These companies include: 1) Lamb Weston, which employed 1808; 2) Iowa Beef Processing Inc., which employed 1700; 3) Framatome ANP, Richland Inc. (formerly Siemens Power Corporation), which employed 750; 4) Boise Cascade Corporation, which employed 700, and 5) J.R. Simplot, which employed 350. Both Boise Cascade and Iowa Beef are located in western Walla Walla County, but most of their workforce resides in the Tri-Cities area (TRIDEC 2001).

Employment and Income Figures. In 2000, nonagricultural employment rose over 3 percent. An average of 76,200 jobs were in the Tri-Cities in 2000, up approximately 2300 from 1999. Gains in employment ranged from 100 workers in the manufacturing and contract construction sectors to 900 in wholesale and retail trade, while the finance, insurance, and real estate sector lost about 100 workers (LMEA 2000b).

In 1999, the total personal income for Benton County was $3.4 billion, Franklin County was $840 million, and Washington State was $174.9 billion. Per capita income in 1999 for Benton County was $25,004, Franklin County was $17,961, and Washington State was $30,380 (DOC 2000). The preliminary estimate of median household income in 2000 for Benton County is $46,316; Franklin County is estimated at $32,398, and Washington State is estimated at $50,152 (OFM 2000a).

4.8.1.2 Tourism

A significant rise in the number of visitors to the Tri-Cites over the last several years has resulted in tourism playing an increasing role in helping to diversify and stabilize the area economy. The Tri-Cities Visitors and Convention Bureau reported that 96,560 people attended conventions and sporting events, spending an estimated $31.8 million in the Mid-Columbia in 2000. The number of people attending convention and group events has more than doubled since 1995 and more than tripled since 1991.

The importance of tourism is evidenced by the amount of money spent on local goods and services. Overall tourism expenditures in the Tri-Cities were roughly $204.7 million in 1999, up from $187.2 million in 1998. Travel-generated employment in Benton and Franklin counties was about 4090 with an estimated $44.7 million in payroll, up from an estimated 3180 employed and a $37.1 million payroll in 1998. In addition, tourism generated $3.2 million in local taxes and $14.4 million in State taxes in 1999 (OTED 2000).

4.8.1.3 Retirees

Although Benton and Franklin counties have a relatively young population (approximately 53 percent under the age of 35) 18,855 people over the age of 65 resided in Benton and Franklin counties in 2000. The portion of the total population 65 years and older in Benton and Franklin counties accounts for 9.8 percent of the total population, which is below the 11.2 percent for Washington State (Census 2001a). 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.

4.8.2 Environmental Justice

Executive Order 12898, "Federal Actions to Address Environmental Justice in Minority Populations and Low-income Populations," (59 FR 7629), directs Federal agencies in the Executive Branch to consider environmental justice so that their programs will not have "…disproportionately high and adverse human health or environmental effects…" on minority and low-income populations. Executive Order 12898 further directed Federal agencies to consider effects to "populations with differential patterns of subsistence consumption of fish and wildlife." The Executive Branch agencies also were directed to develop plans for complying with the order. The Council on Environmental Quality (CEQ) provided additional guidance later for integrating environmental justice into the NEPA process in a December 1997 document, *Environmental Justice Guidance under the NEPA* (CEQ 1997).

Minority populations are defined as all nonwhite individuals, plus all individuals of Hispanic origin, as reported in the 2000 Census (Census 2001b). Low-income persons are defined as living in households that report an annual income less than the United States official poverty level, as reported by the Census Bureau. The poverty level varies by size and relationship of the members of the household. The year 2000 poverty level was $17,761 for a family of four (Census 2001b). Nationally, in 1999, 29.9 percent of all persons were minorities, and 11.8 percent of all persons lived in households that had incomes less than the poverty level (which was $17,029 for a family of four in that year) (Census 2000a,b). The most recent available State and county area poverty estimates report that Washington had 10.3 percent of its

population living in poverty in 1997, while Benton County and Franklin County had 9.3 percent and 17.7 percent, respectively (Census 2000c).

The year 2000 census data indicate that a total population of approximately 511,500 people resided within an 80-km (50-mi) radius of the Hanford Site. Based on the 2000 census, the 80-km (50-mi) area surrounding the Hanford Site had a total minority population of about 185,000. The ethnic composition of the minority population is primarily White Hispanic (24 percent), self-designated "other" races (54 percent), American Native (6 percent), and two or more races (9 percent). Asians and Pacific Islanders (4 percent) and African American (3 percent) make up the remainder. The Hispanic population resides predominantly in Franklin, Yakima, Grant, and Adams counties. Native Americans within the 80-km (50-mi) area reside primarily on the Yakama Reservation and upstream of the Hanford Site near the town of Beverly, Washington.

Figure 4.24 shows the location of Census block groups from the 2000 Census that had either a majority of residents who were members of a minority group (racial minority or Hispanic), or whose percentage of residents belonging to any minority group was at least 20 percentage points greater than the corresponding percentage of the State population (Census 2001a,c). Table 4.14 presents population estimates and percentages by race and Hispanic origin for Benton and Franklin counties.

Detailed area income statistics will not be available from the 2000 Census of Population until the summer of 2002. The 1990 low-income population was approximately 70,440 or 17 percent of the total population residing in the 80-km (50-mi) radius of the Hanford Site. The majority of these households were located to the southwest and north of the Site, and in the city of Pasco.

Table 4.15 shows the estimated numbers and percentages of people living below the poverty level in the counties touched by the 80-km (50-mi) circle in Figure 4.25 for 1998[(a)] and 1990. The 1998 values are Census Bureau model-based estimates; therefore, the differences between 1989 and 1998 reflect differences in methods, as well as actual changes in the incidence of poverty. Even so, it appears the 80-km (50-mi) region surrounding Hanford has a lower percentage of low-income persons than at the 1990 Census. The low-income population of the area is dispersed throughout this region with the highest concentrations occurring in Franklin, Yakima, Grant, and Adams counties.

(a) Census model estimates are not available for low-income households. The data appearing in Table 4.15 are for all persons in low-income status.

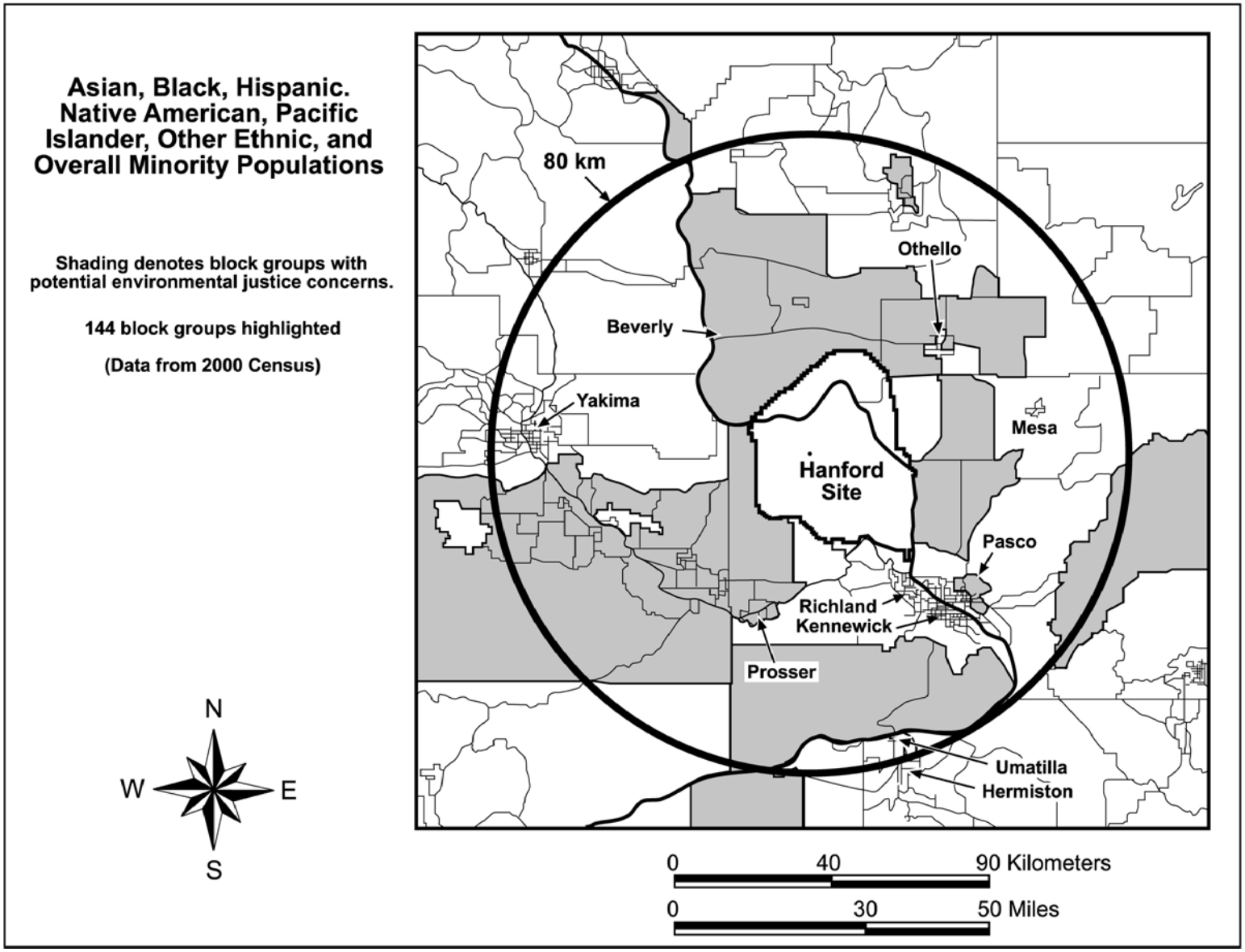


Figure 4.25. Location of Minority Populations Near the Hanford Site

Table 4.14. Population Estimates and Percentages by Race and Hispanic Origin, 1999 [(a)]

Subject	WA State	Percent	Benton/ Franklin	Percent	Benton County	Franklin County
Total population	5,894,121	100.0	191,822	100.0	142,475	49,347
Single Race	5,680,602	96.4	185,948	96.9	138,646	47,302
White	4,821,823	81.8	153,432	80.0	122,879	30,553
Black or African American	190,267	3.2	2,549	1.3	1,319	1,230
American Indian/Alaska Native	93,301	1.6	1,527	0.8	1,165	362
Asian	322,335	5.5	3,934	2.1	3,134	800
Native Hawaiian/Pacific Islander	23,953	0.4	220	0.1	163	57
Other Race	228,923	3.9	24,286	12.7	9,986	14,300
Two or More Races	213,519	3.6	5,874	3.1	3,829	2,045
Hispanic Origin (of any race)[(b)]	441,509	7.5	40,838	21.3	17,806	23,032

(a) Census 2000a.
(b) Hispanic origin is not a racial category: it may be viewed as the ancestry, nationality group, lineage, or country of birth of the person or person's parents or ancestors before arrival in the United States. Persons of Hispanic origin may be of any race and are counted in the racial categories shown.

4.8.3 Demography

Census 2000 reports population totals for Benton and Franklin counties were 142,475 and 49,347, respectively (Census 2001a). Benton and Franklin counties grew at a faster pace in the 1990s than Washington State did as a whole. The population of Benton County grew 26.6 percent up from 112,560 in 1990. The population of Franklin County grew 31.7 percent, up from 37,473 in 1990 (Census 2001a).

Within each county, census figures indicate the distribution of the Tri-Cities population by city as follows: Richland 38,708; Pasco 32,066; and Kennewick 54,693. The combined populations of Benton City, Prosser, and West Richland totaled 15,847 in 2000. The unincorporated population of Benton County was 33,227. In Franklin County, incorporated areas other than Pasco had a total population of 3595. The unincorporated population of Franklin County was 13,886 (Census 2001a).

The 2000 population figures for Benton and Franklin counties, indicate that Asians represent a lower proportion, and individuals of Hispanic origin represent a higher proportion of the racial distribution than those in the State of Washington. Countywide, Benton and Franklin counties exhibit varying racial distributions.

Table 4.15. Number and Percentages of Persons Defined as Low-Income Living in Counties Near the Hanford Site, 1998 and 1989

Washington:	Number of Low-Income Persons		Percentage of Persons to Total County Population in Low Income	
	1998 (Model-Based Estimate)	1989 (1990 Census)	1997 (Model-Based Estimate)	1989 (1990 Census)
Adams County	2,464	2,360	16.1	17.5
Benton County	13,547	12,402	10.0	11.1
Chelan County	8,330	7,844	13.8	15.3
Columbia County	546	757	13.1	19.4
Franklin County	8,145	8,491	17.5	23.0
Grant County	10,810	10,631	15.3	19.6
Kittitas County	3,998	4,913	12.7	20.2
Klickitat County	2,934	2,786	15.0	17.0
Walla Walla County	6,829	7,144	12.7	16.0
Yakima County	39,617	37,486	18.1	20.2
Oregon:				
Morrow County	1,080	1,141	10.3	15.1
Umatilla County	10,393	9,419	15.8	16.5
Union County	3,581	3,627	14.4	15.8
Total	112,274	109,001		
Source: Census 1990a, 1990b, 1999, 2000d, 2000e.				

In 2000, Benton and Franklin counties accounted for 3.3 percent of Washington's population. The population demographics of Benton and Franklin counties are quite similar to those found within Washington. The population in Benton and Franklin counties under the age of 35 is 53.1 percent, compared to 49.4 percent for Washington State. In general, the population of Benton and Franklin counties is somewhat younger than that of Washington. The 0- to 14-yr old age group accounts for 25.6 percent of the total bi-county population as compared to 21.3 percent for Washington. In 2000, the 65-yr old and older age group constituted 9.8 percent of the population of Benton and Franklin counties, compared to 11.2 percent for Washington (Census 2001a).

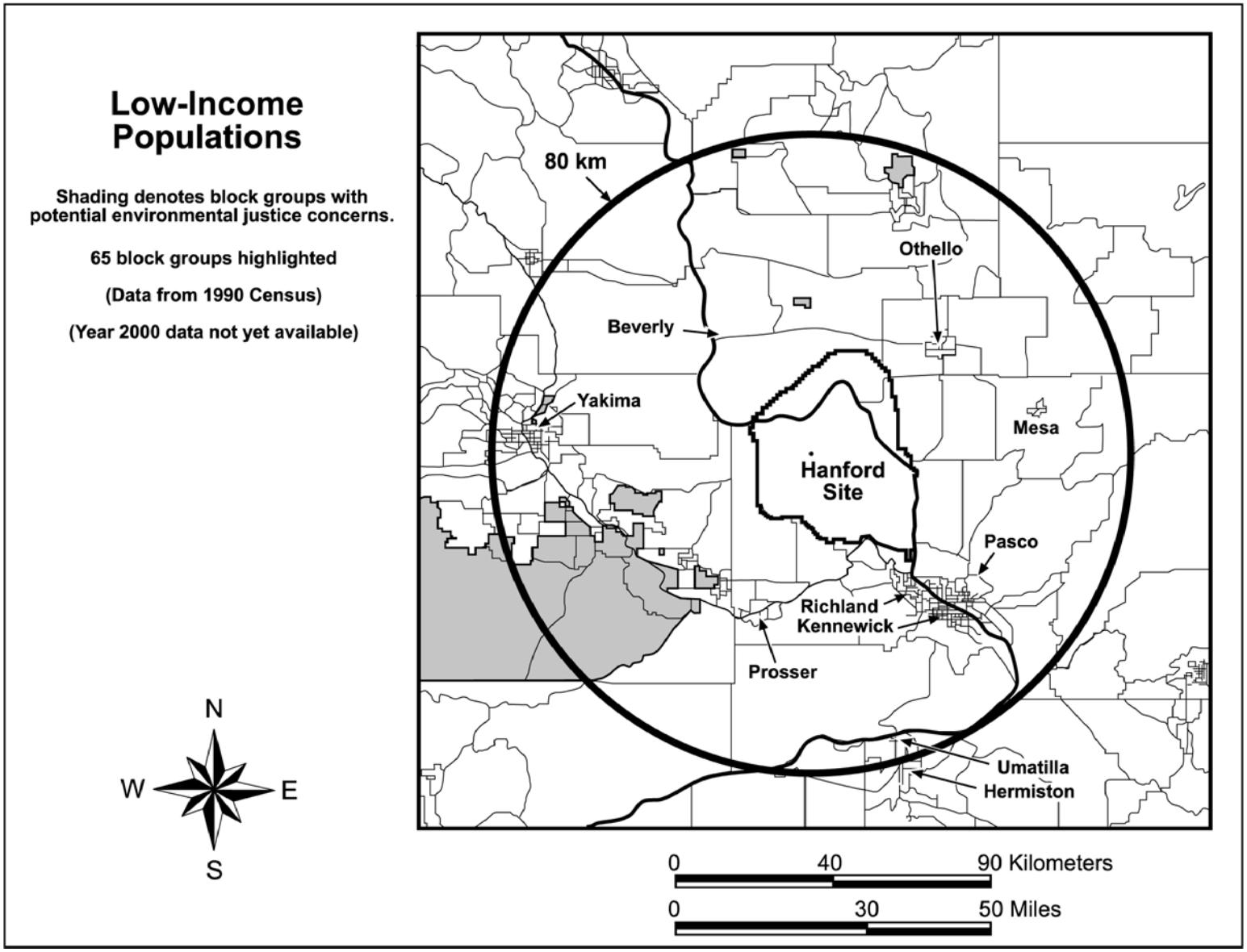


Figure 4.25. Location of Low-Income Populations Near the Hanford Site (Census 1991)

4.8.4 Housing

In FY 2000, 2195 houses were sold in the Tri-Cities at an average price of $128,928, compared to 2176 houses sold at an average price of $123,428 in 1999 (TCAR 2000). In FY 2000, 760 single-family houses were built, up 1.6 percent from the 748 that were built in 1999, but down from a peak of 1117 in 1994 (WCRER 2000a).

As of April 1, 2000, 73,982 housing units were located in Benton and Franklin counties, 44,009 of which were single units, 15,946 were two or more units, and 14,027 were manufactured homes. The number of total units has increased 26.4 percent from 58,541 in 1990 (OFM 2000b). The number of apartments has increased from 8225 in 1990 to 10,226 in 2000. The vacancy rate of apartments in Benton and Franklin counties in September 2000 was 4.3 percent, and the average rent was $530. These figures are up from the 3.3 percent vacancy rate and $489 average rent in 1999 (WCRER 2000b).

4.8.5 Local and Regional Transportation

The Tri-Cities serves as a regional transportation and distribution center with major air, land, and river connections. The Burlington Northern Santa Fe and Union Pacific provide direct rail service. Union Pacific operates the largest fleet of refrigerated rail cars in the United States and is essential to food processors that ship frozen food from this area. Amtrak provides passenger rail service with a station in Pasco.

Docking facilities at the Ports of Benton, Kennewick, and Pasco are important aspects of the regional infrastructure. These facilities are located on the 525-km (326-mi) long commercial waterway that includes the Snake and Columbia Rivers and extends from the ports of Lewiston-Clarkston in Idaho to the deep-water ports of Portland, Oregon, and Vancouver, Washington. The average shipping time from the Tri-Cities to these deep-water ports by barge is 36 hr (Evergreen Community Development Association 1986).

Daily air passenger and freight services connect the area with most major cities through the Tri-Cities Airport, located in Pasco. This modern commercial airport links the Tri-Cities to major hubs and provides access to destinations anywhere in the world. Delta Airlines, United Express, and Horizon Air offer 33 flights into and out of the Tri-Cities daily connecting to domestic and international flights through Salt Lake City, Seattle, Denver, Spokane, and Portland. The Tri-Cities Airport set a record of 209,434 passengers in 2000, surpassing the 1999 total of 202,408. Projections indicate the terminal can serve almost 300,000 passengers annually. The Tri-Cities region has three general aviation airports that serve private aircraft. Air freight shippers that service the region include Airborne from the Richland airport, United Parcel Service from the Kennewick airport, and Federal Express from the Tri-Cities airport in Pasco.

Mass transit in the area is provided by the Ben Franklin Transit system. The system covers more than 286 km^2 (110 mi^2) and provides frequent service to most local communities. The Ben Franklin transit system consists of 54 buses, 31 Dial-a-Ride para-transit vehicles, and 75 Van Pool vans. Two local taxi

companies provide radio-dispatched taxicab service 24 hr per day: A-1 Tri-Cities Cab and AMR Transportation. Intercity bus transportation is available.

The regional transportation network in the Hanford vicinity includes the areas in Benton and Franklin counties from which most of the commuter traffic associated with the Site originates. Interstate (I) highways that serve the area are I-82 and I-182. I-82 is 8 km (5 mi) south-southwest of the Site. I-182, a 24-km (15-mi) long urban connector route, located 8 km (5 mi) south-southeast of the Site, provides an east-west corridor linking I-82 to the Tri-Cities area. I-90, located north of the Site, is the major link to Seattle and Spokane and extends to the East Coast. I-82 serves as a primary link between Hanford and I-90, as well as I-84. I-84, located south of the Site in Oregon, is a major corridor leading to Portland, Oregon. SR 224, also south of the Site, serves as a 16-km (10-mi) link between I-82 and SR 240. SR 24 enters the Site from the west, continues eastward across the northernmost portion of the Site, and intersects SR 17 approximately 24 km (15 mi) east of the Site boundary. SR 17 is a north-south route that links I-90 to the Tri-Cities and joins U.S. Route 395, continuing south through the Tri-Cities. U.S. Route 395 north also provides direct access to I-90. SR 240 and 24 traverse the Site and are maintained by Washington State.

A DOE-maintained road network within the Hanford Site consists of 607 km (377 mi) of asphalt-paved road, and provides access to the various work centers (Figure 4.26). Primary access roads on the Hanford Site are Routes 2, 4, 10, and 11A. The 200 East Area is accessed primarily by Route 4 South from the east and from Route 4 North off Route 11A from the north and from Route 11A for vehicles entering the site at the Yakima Barricade. A new access road was opened in late 1994 to provide access directly to the 200 Areas from SR 240. Public access to the 200 Areas and interior locations of the Hanford Site has been restricted by guarded gates at the Wye Barricade (at the intersection of Routes 10 and 4), the Yakima Barricade (at the intersection of SR 240 and Route 11A), and Rattlesnake Barricade south of the 200 West Area. None of the previously listed roadways have experienced any substantial congestion except Route 4 (WHC 1994).

Access to the Hanford Site is via three main routes, Hanford Route 4S from Stevens Drive or George Washington Way in the City of Richland, Route 10 from SR 240 near its intersection with SR 225, or via Route 11A from SR 240 near its intersection with SR 240. Another route, through the Rattlesnake Barricade, is located 35 km (22 mi) northwest of Stevens Drive and is for passenger vehicle access only. The estimated total number of commuters to this area is 3100. Approximately 87 percent of the workers commuting to the 200 Areas are from the Tri-Cities, West Richland, Benton City, and Prosser (Perteet *et al.* 2001).

The portion of SR 240 most affected by 200 Area commuters is between U.S. 395 and Stevens Drive. Portions of this roadway currently operate below the minimum level of service established by the Regional Transportation Planning Organization. Peak annual average daily traffic (AADT) on the section from Columbia Center Boulevard to I-182 is 54,000 (Perteet *et al.* 2001).

Figure 4.26. Transportation Routes on the Hanford Site

I-182 has peak traffic counts of 35,000 AADT in the vicinity of SR 240. I-182 also has current deficiencies at the interchanges with Queensgate Drive and 20th Avenue. Van Giesen transports most of the commuters from West Richland and Benton City to SR 240. The intersection of SR 224 and SR 240 is the only section of SR 224 with current level of service (LOS) deficiencies. LOS is a qualitative measure of the roadway ability to accommodate vehicular traffic, ranging from free flow conditions (LOS A) to extreme congestion (LOS F). LOS D is considered the lower end of acceptable LOS (Perteet *et al.* 2001).

Stevens Drive has peak traffic counts of 8300 AADT at Horn Rapids Road and 22,000 AADT just north of its intersection with SR 240. Currently this roadway experiences LOS deficiencies. George Washington Way is the principal north-south arterial through Richland. AADT at the entrance of the Hanford Site on George Washington Way is 1800. Counts north of McMurray are 18,000 AADT and on George Washington Way just north of I-182 are 43,000 AADT. George Washington Way has LOS deficiencies between I-182 and Swift Boulevard (Perteet *et al.* 2001).

Private vehicles account for 91 percent of the person trips to the Hanford Site. The remaining person trips are by forms of High Occupancy Vehicles (mostly Ben-Franklin Vanpools). Of the 91 percent of private vehicles only 3 percent are by carpool with the remaining 88 percent being single occupancy vehicles. The Draft Regional Transportation Plan identifies 11,468 employees working at Hanford. Based on 88 percent of the trips carrying a single person to Hanford, 10,092 single occupancy trips are made daily or an AADT of 10,184 (Perteet *et al.* 2001).

The Hanford Site rail system originally consisted of approximately 210 km (130 mi) of track. It connected to the Union Pacific commercial track at the Richland Junction (at Columbia Center in Kennewick) and to a now abandoned commercial right-of-way (Chicago, Milwaukee, St. Paul, and Pacific railroads) near Vernita Bridge in the northwest section of the site. Prior to 1990, annual railcar movements numbered about 1400 sitewide, transporting materials including coal, fuel, hazardous process chemicals, and radioactive materials and equipment (DOE 1996). In October 1998, 26 km (16 mi) of track from Columbia Center to Horn Rapids Road were transferred to the Port of Benton and are currently operated by the Tri-City Railroad.

4.8.6 Educational Services

The majority of primary and secondary education in the Tri-Cities area is served by the Richland, Pasco, Kennewick, and Benton City School Districts. The total 2000 fall enrollment for all districts in Benton and Franklin counties was 39,702 students, an increase of 1.3 percent from the 1999 total of 39,202 students. The 2000 totals include 9464 from the Richland School District, up from 9343 in 1999, 8850 students from the Pasco School District, up from 8537 in 1999, 13,629 students from the Kennewick School District, up from 13,535 in 1999, and 1673 from the Benton City School District, down from 1733 in 1999 (OSPI 2001).

Several private elementary and secondary schools are located in the Tri-Cities, including Bethlehem Lutheran (K-8) and St. Josephs (K-8) in Kennewick, Christ the King (K-8) and Liberty Christian (K-12) in Richland, Faith Christian (K-12), Country Haven Academy (9-12), St. Patrick's (K-8), Tri-City Junior

Academy (K-10), and Tri-Cities Prep Catholic High School in Pasco (9-12). Fall 2000 enrollment at these schools totaled 2312 students, an increase of 3 percent from the 1999 total of 2244 (OSPI 2001). Home schooling is prevalent in the Tri-Cities, with students totaling 544. Richland School District reports 205 students are home schooled within their jurisdiction (Neitzel 2002), Pasco School District reports 113 (Neitzel 2002), and Kennewick School District has 226 students home schooled (Neitzel 2002).

Post-secondary education in the Tri-Cities area is provided by Columbia Basin College (CBC), City University, and Washington State University, Tri-Cities branch campus (WSU-TC). The 2000 fall/winter enrollment was approximately 7069 at CBC, 100 at City University, and 1157 at WSU-TC. Many of the programs offered by these three institutions are geared toward the vocational and technical needs of the area. In 1999-2000, CBC offered 25 Associate in Applied Science degree programs. City University offers 2 associate degree programs, 4 undergraduate, and 3 graduate programs, plus access to several more programs through Distance Learning. WSU-TC offers 10 undergraduate and 19 graduate programs, as well as access to 8 more graduate programs via satellite (OSPI 2001).

4.8.7 Health Care and Human Services

The Tri-Cities area has three major hospitals and five minor emergency centers, as well as a cancer treatment center. All three hospitals offer general medical services and each includes a 24-hr emergency room, basic surgical services, intensive care, and neonatal care.

The Tri-Cities offers a broad range of social services. State human service offices in the Tri-Cities include the Job Service Center within the Employment Security Department; food stamp offices; the Developmental Disabilities Division; financial and medical assistance; the Child Protective Service; emergency medical service; a senior companion program; and vocational rehabilitation.

The Tri-Cities is also served by a large number of private agencies and voluntary human service organizations. United Way incorporates 21 participating agencies offering 38 programs. These member agencies had a cumulative budget total of $27 million in 2000. In addition, 572 organizations received funds as part of the United Way Benton-Franklin County donor designation program (Davis 2000).

4.8.8 Police and Fire Protection

The Benton and Franklin County sheriff departments, local municipal police departments (Pasco, Kennewick, Richland, West Richland), and the Washington State Patrol Division in Kennewick provide local police protection.

Fire protection in the Tri-Cities area is provided by fire departments in Kennewick, Richland, and Pasco, a volunteer fire department in West Richland, and three rural fire departments in Benton County.

The Hanford Site Fire Department has fire stations onsite, and the Benton County Sheriff Department provides onsite law enforcement. Site security is provided onsite by the Hanford Patrol.

4.8.9 Utilities

The principal sources of water in the Tri-Cities and the Hanford Site are the Columbia River and groundwater. The water systems of Richland, Pasco, and Kennewick drew a large portion of the 51.5 billion L (13.6 billion gal) used in 2000 from the Columbia River. Each city operates its own supply and treatment system. The Richland water supply system derives about 90 percent of its water directly from the Columbia River, while the remainder is split between a well field in North Richland (which is recharged from the river) and groundwater wells. Richland's total usage in 2000 was 27.6 billion L (7.3 billion gal). The Pasco system also draws from the Columbia River for its water needs. In 2000, Pasco consumed 10.6 billion L (2.8 billion gal). The Kennewick system uses two wells and the Columbia River for its supply. These wells serve as the sole source of water between November and March and can provide approximately 40 percent of the total maximum supply of 30 billion L (8 billion gal). Total 2000 usage in Kennewick was 13.0 billion L (3.4 billion gal) (Neitzel 2001).

The Benton County Public Utility District, Benton Rural Electric Association, Franklin County Public Utility District, and City of Richland Energy Services Department provide the Tri-Cities with electricity. All the power these utilities provide in the local area is purchased from the Bonneville Power Administration (BPA) that also provides power to the Hanford Site. Natural gas, provided by the Cascade Natural Gas Corporation, serves approximately 11,000 customers in the Tri-Cities, as well as the 300 Area of the Hanford Site.

4.8.10 Aesthetic and Scenic Resources

Broad basins and plateaus interspersed with ridges characterize the Hanford Site landscape. The wide vistas comprising much of the area are interrupted by numerous large industrial facilities (for example, reactors and processing facilities). However, DOE and its predecessors have disturbed only about 6 percent of the site. The remainder lies undeveloped and includes natural areas and abandoned agricultural lands that remain undisturbed because of restricted public access.

The Columbia River flows through the northern portion of the Hanford Site before turning south and forming the eastern site boundary. The White Bluffs, steep whitish-brown cliffs adjacent to the Columbia River, comprise a striking natural feature of the landscape. Rattlesnake Mountain, rising to 1092 m (3581 ft) above mean sea level forms the southeastern boundary of the Hanford Site. Gable Mountain and Gable Butte are the highest landforms within the Hanford Site. Large rolling hills are located to the west and north.

SR 240 provides public access through the southwestern portion of the Hanford Site. Views along this highway include the open lands of ALE in the foreground to the west, with the prominent peak of Rattlesnake Mountain and the extended ridgelines of the Rattlesnake Hills in the background. To the east, the views include relatively flat terrain with the structures of the 200 East and 200 West Areas visible in the central area with Gable Butte and Gable Mountain in the background. From the highway, the Saddle Mountains can be seen in the distance to the north and steam plumes from the Energy Northwest reactor cooling towers are often visible in the distance to the east. The views along SR 240 are expansive due to the flat terrain and the predominantly short, treeless, vegetation cover.

Hanford Site facilities can also be seen from elevated locations, such as Gable Mountain, Gable Butte, Rattlesnake Mountain, and other parts of the Rattlesnake Hills along the western perimeter. Facilities are visible from the Columbia River as well. Because of the vast expanse, terrain, and distances involved, only portions of the site are visible from any one point.

The acquisition of spiritual guidance and assistance through personal vision quests is deeply rooted in the religious practices of the indigenous people of the Columbia Basin. High spots were selected because they afforded extensive views of the natural landscape and seclusion for quiet meditation. These practices, and the areas where they took place, are critical in maintaining the continuing cultural identity of the Native American community, and, as such, are eligible for inclusion in the National Register of Historic Places. The high points of the Hanford Site, including Gable Mountain, Rattlesnake Mountain, and Wahluke Slope, are representative of locations where vision quests were conducted. The physical landscape visible from each location is a means to determine areas and resources of concern. Taken together, these points encompass the whole of the Hanford Site.

4.9 Noise

Noise is technically defined as sound waves that are unwanted and perceived as a nuisance by humans. Sound waves are characterized by frequency, measured in Hertz (Hz), and sound pressure expressed as decibels (dB). Humans have a perceptible hearing range of 31 to 20,000 Hz. The decibel is a value equal to 10 times the logarithm of the ratio of a sound pressure squared to a standard reference sound-pressure level (20 micropascals) squared. The threshold of audibility ranges from about 60 dB at a frequency of 31 Hz to less than about 1 dB between 900 and 8000 Hz. (For regulatory purposes, noise levels for perceptible frequencies are weighted to provide an A-weighted sound level [dBA] that correlates highly with individual community response to noise.) Sound pressure levels outside the range of human hearing are not considered noise in a regulatory sense, even though wildlife may be able to hear at these frequencies.

Noise levels are often reported as the equivalent sound level (L_{eq}). The L_{eq} is expressed in dBA over a specified period of time, usually 1 or 24 hr. The L_{eq} is the equivalent steady sound level that, if continuous during a specified time period, would contain the same total energy as the actual time-varying sound over the monitored or modeled time period.

Environmental noise measurements were made on the Hanford Site in 1981 during site characterization for the Skagit/Hanford Nuclear Power Plant Site (NRC 1982). Measurements were also made at five locations during 1987 when the Hanford Site was considered for a geologic waste repository (BWIP) for spent commercial nuclear fuel and other high-level nuclear waste. Additionally, noise levels as a result of field activities, such as well drilling and sampling, were measured. Baseline offsite noise measurements attributable to automobile traffic were also determined.

During site characterization for the Skagit/Hanford Nuclear Power Plant (NRC 1982), 15 sites were monitored and noise levels were found to range from 30 to 60.5 dBA (L_{eq}). The values for isolated areas ranged from 30 to 38.8 dBA. Measurements taken around the sites where Energy Northwest was constructing nuclear power plants (WNP-1, WNP-2, and WNP-4) ranged from 50.6 to 64 dBA.

Measurements taken along the Columbia River near the intake structures for WNP-2 were 47.7 and 52.1 dBA, compared with more remote river noise levels of 45.9 dBA (measured about 4.8-km [3 mi] upstream of the intake structures). Community noise levels in north Richland (Horn Rapids Road and Highway 240) were 60.5 dBA.

Background noise levels were determined at five locations within the Hanford Site for studies supporting the BWIP. Noise levels are expressed as L_{eqs} for 24 hr (L_{eq-24}). On the dates tested, the average noise level for the five sites was 38.9 dBA. Wind was identified as the primary contributor to background noise levels, with winds exceeding 19 km/hr (12 mi/hr) significantly affecting noise levels. Background noise levels in undeveloped areas at Hanford can best be described as a mean L_{eq-24} of 24 to 36 dBA. Periods of high wind that normally occur in the spring would elevate background noise levels.

Baseline noise levels as a result of automobile traffic were determined for two locations: SR 24, leading from the Hanford Site west to Yakima, and SR 240, south of the site and west of Richland where the route handles maximum traffic volume (DOE 1991). Traffic volumes were predicted based on an operational workforce and a construction workforce. Both peak (rush hour) and off-peak hours were modeled. Noise levels were expressed in L_{eq} for 1-hr periods in dBA at a receptor located 15 m (49 ft) from the road edge. Baseline noise levels during the construction phase were 62 dBA for SR 24 and 70.2 dBA for SR 240. Levels based on the operational phase ranged from 62 to 65.7 dBA for SR 24 and 70.2 to 74.1 dBA for SR 240. Adverse community responses would not be expected at increases of 5 dBA over background noise levels.

In the interest of protecting Hanford workers and complying with Occupational Safety and Health Administration (OSHA) standards for noise in the workplace, HEHF has monitored noise levels resulting from several routine operations performed at Hanford. Occupational sources of noise propagated in the field include well sampling, well drilling, water wagon operation, trucks, compressors, and generators. Noise levels from these activities ranged from 74.8 to 125 dBA (Neitzel 2001) and have the potential for disturbing sensitive wildlife.

4.10 Occupational Safety

Total occupational work hours at the Hanford Site for the 5-yr period, 1996 through 2000, were 121,552,993 hr, or about 63,975 worker-years (DOE 2001a). The DOE records occupational injuries and illnesses in four categories pertinent to NEPA analysis. Total recordable cases (TRCs) are work-related deaths, illnesses, or injuries that resulted in loss of consciousness, restriction of work or motion, transfer to another job, or required medical treatment beyond first aid. Lost workday cases (LWCs) represent the number of recordable cases that resulted in days away from work or days of restricted work activity, or both, for affected employees. Lost workdays (LWDs) are the total number of workdays (consecutive or not), after the day of injury or onset of illness, during which employees were away from work or limited to restricted work activity because of an occupational injury or illness. Fatalities are the number of occupationally related deaths. Information on Hanford Site occupational safety is updated quarterly and is available at http://tis.eh.doe.gov/cairs.

Occupational injury and illness incidence rates at the Hanford Site have been decreasing since 1996. Figure 4.27 shows 4.4 TRC per 200,000 worker-hr (100 worker-yrs) in 1996. By 2000 the rate had decreased to 2.0 cases per 200,000 worker-hr. Over the 5-yr period from 1996 through 2000, the average Hanford Site incidence rate, 2.9 cases per 200,000 worker-hr, was similar to the average incidence rate for the entire DOE complex, 3.1 cases per 200,000 worker-hr. The Hanford Site and DOE-wide average TRC rates were well below the Bureau of Labor Statistics (BLS) rates for U.S. private industry during the same period.

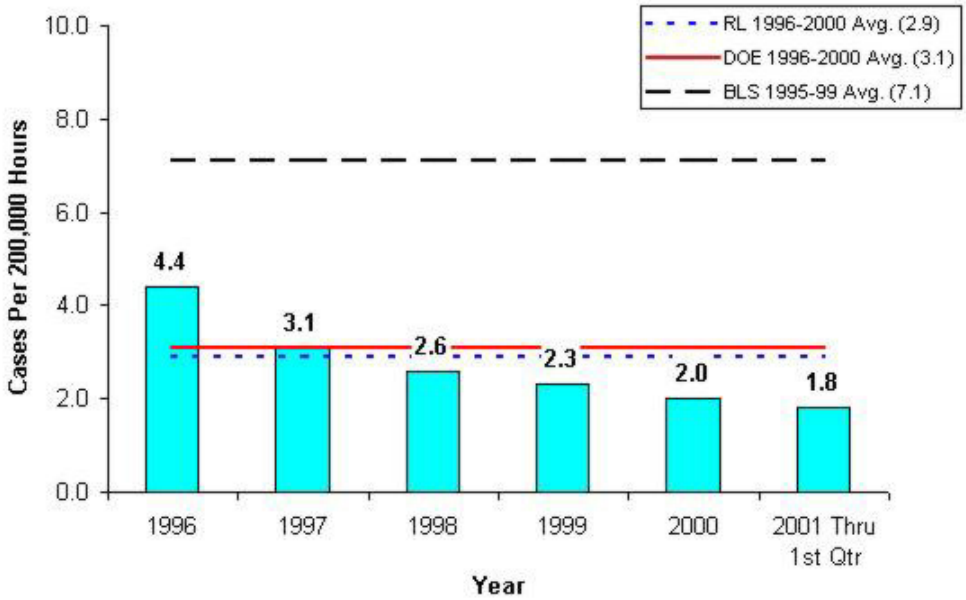


Figure 4.27. Occupational Injury and Illness Total Recordable Case Rates at the Hanford Site (DOE 2001a)

Table 4.16. Occupational Injury, Illness, and Fatality Incidence Rates for Department of Energy Facilities and Private Industries, 1996-2000 Averages (DOE 2001a)[(a)]

	Total Recordable Cases	Lost Work Cases	Lost Work Days	Fatalities
Bureau of Labor Statistics [(b)]	7.1	3.3	N/A[(c)]	0.0048
U.S. Department of Energy [(d)]	3.1	1.4	42.8	0.0015
DOE Richland Operations Office (DOE-RL), Hanford Site [(d)]	2.9	1.8	66.8	0

(a) Per 200,000 worker-hr (100 worker-yr).
(b) BLS values are average rates for the private sector from 1995 to 1999.
(c) N/A = data not available.
(d) DOE-wide and Hanford Site values are average rates from 1996 through 2000.

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5.0 Environmental Consequences

The results of analyses performed to assess potential environmental consequences, or impacts, of implementing any of the alternatives are presented in the following sections. For each category of potential environmental impacts considered, brief descriptions of the impact analysis method and the analysis results are given. Details of analytical methods, where applicable, are provided in appendices, as noted within each section. Because the type and level of analysis typically needed for each environmental aspect of interest varies widely, the level of detail in the results presented in the following sections vary commensurate with the nature of the analysis and the potential for consequences associated with that environmental aspect.

In Section 3.0, "Description and Comparison of Alternatives," three alternatives were defined for each waste type – low-level waste (LLW), mixed low-level waste (MLLW), and post-1970 transuranic (TRU) waste – considered in the Hanford Solid (Radioactive and Hazardous) Waste Program Environmental Impact Statement (HSW EIS). For purposes of analysis in this section, consequences associated with the corresponding alternative actions for each waste type have been combined to provide a consolidated analysis of waste management operations. In the following sections, these consolidated analyses retain the designations corresponding to the alternatives for each waste type described in Section 3.0 and Table 3.1: Alternative 1, Alternative 2, and No Action Alternative. This approach facilitates presentation of impacts for all solid waste program operations and also is necessary in order to evaluate facilities that are used to manage more than one type of waste. In these latter consolidated alternatives, each of the waste types is considered, and the impacts are either analyzed directly or are bounded by like analysis where appropriate.

The alternatives analyzed in detail, together with a brief description of principal aspects of the alternatives that might give rise to environmental impacts, are described as follows.

Alternative 1: This analysis consists of the combined impacts associated with LLW Alternative 1, MLLW Alternative 1, and TRU waste Alternative 1, as described in Section 3.0. The lower bound waste volume for the evaluation consists of the lower bound volumes for LLW and MLLW and the maximum forecast volume for TRU waste as defined in Section 3.0. Similarly, the upper bound waste volume for evaluation purposes consists of the upper bound volumes for LLW and MLLW and the maximum forecast volume for TRU waste. Actions evaluated for these alternatives include the following:

- modification of the T Plant Complex to provide the M-91 Capability for treating some MLLW and for processing and certification of some TRU waste

- treatment of other MLLW and some non-conforming LLW at commercial facilities, followed by return to the Hanford Site for disposal

- continued operation of the Waste Receiving and Processing Facility (WRAP) to process and certify some TRU waste

- disposal of LLW and MLLW in the Low Level Burial Grounds (LLBGs) in trenches of enhanced design (deeper and wider than those currently employed)

- capping LLW and MLLW trenches in the LLBGs with a Resource Conservation and Recovery Act (RCRA) Subtitle C cover at closure

- processing and certification of all TRU waste for disposal at the Waste Isolation Pilot Plant (WIPP).

Alternative 2: This analysis consists of the combined impacts associated with LLW Alternative 2, MLLW Alternative 2, and TRU waste Alternative 2, as described in Section 3.0. The lower and upper bound waste volumes for evaluation purposes are the same as those defined for the Alternative 1 analysis. Actions evaluated for these alternatives include the following:

- construction of a new facility in the 200 Areas to provide the M-91 Capability and for treating most other MLLW and non-conforming LLW onsite

- treatment of a limited quantity of MLLW at commercial facilities, followed by return to the Hanford Site for disposal

- continued operation of WRAP to process and certify some TRU waste

- disposal of LLW and MLLW in the LLBGs in trenches of a design similar to those currently employed

- capping LLW and MLLW trenches in the LLBGs with a RCRA Subtitle C cover at closure

- processing and certification of all TRU waste for disposal at WIPP.

No Action Alternative: This analysis consists of the combined impacts associated with the LLW No Action Alternative, the MLLW No Action Alternative, and the TRU waste No Action Alternative, as described in Section 3.0. A single waste volume was used for evaluation purposes, consisting of the lower bound volumes for LLW and MLLW and the maximum forecast volume for TRU waste as defined in Section 3.0. The No Action Alternatives consist essentially of the continuation of current solid waste management practices. Actions evaluated for these alternatives include the following:

- treatment of a limited quantity of MLLW at commercial facilities, followed by return to the Hanford Site

- disposal of LLW in the LLBGs in trenches of a design similar to those currently employed

- backfilling LLW trenches to grade with no cap

- disposal of MLLW in the 2 existing MLLW trenches

- capping the 2 MLLW trenches with a RCRA Subtitle C cover as required by regulation

- processing and certification of some TRU waste at WRAP for disposal at WIPP

- expansion of the Central Waste Complex (CWC) for indefinite storage of some non-conforming LLW, untreated MLLW, treated MLLW that exceeds the capacity of the two existing MLLW trenches, and TRU waste that cannot be certified for disposal at WIPP.

Except where otherwise specified, all construction and operations engineering data that form the basis for environmental impact analysis of the alternatives are provided in the *Technical Information Document* prepared by Fluor Hanford (FH 2002).

A comparison of major impacts among the alternatives appears in Table 3.6.

5.1 Land Use

Impacts on Land Use are considered in terms of commitment of land for a proposed use to the exclusion of other possible uses. Land occupied by LLBGs is considered to be permanently committed to the designated use, whereas land occupied by treatment and storage facilities is considered committed only for the life of the facility, some of which are assumed in this analysis to continue through the year 2046.

In Alternative 1 and Alternative 2 all LLW and MLLW would be disposed of in LLBGs. TRU waste would be disposed of at the WIPP. In the No Action Alternative a substantial amount of the waste would remain in storage for an indefinite time because of the lack of appropriate treatment capabilities to permit disposal.

Except for offsite commercial treatment of some MLLW, treatment, storage, and disposal activities associated with Alternative 1 and Alternative 2 would occur in the 200 East Area and 200 West Area which together occupy about 16 km^2 (6 mi^2) in the 200 Area Plateau. This area falls under the Industrial-Exclusive designation, as defined in the *Final Hanford Comprehensive Land-Use Plan Environmental Impact Statement* (HCP EIS) (DOE 1999). In addition, materials for capping the LLBGs at closure would be obtained from borrow pits in Area C located south of SR 240 (SR 240) outside of, but adjacent to, the Fitzner/Eberhardt Arid Lands Ecology Reserve (ALE). ALE is included within the boundary of the Hanford Reach National Monument. Area C consists of about 926 ha (2287 ac) designated for Conservation (Mining) in the record of decision (ROD) for the HCP (64 FR 61615). About 81 ha (200 ac) would be excavated to provide capping materials for closure of the LLBGs.

In Alternative 1 for the lower and upper bound waste volumes respectively, about 12 to 19 ha (39 to 47 ac) would be permanently committed for disposal in addition to the 134 ha (331 ac) of land within the LLBGs already committed to LLW and MLLW disposal. This addition would amount to an increase of about 9 to 14 percent.

In Alternative 2 for the lower and upper bound waste volumes respectively, an addition of about 28 to 44 ha (69 to 110 ac) would be permanently committed for LLW and MLLW disposal. This addition would amount to an increase of about 21 to 33 percent over the 134 ha (331 ac) currently occupied.

Details of land use (including new construction) associated with the HSW EIS alternatives are provided in Table 5.1.

In the No Action Alternative the increase in permanent commitment of land would amount to about 15 ha (37 ac), an increase of about 11 percent over the 134 ha (331 ac) currently occupied. In addition, about 66 ha (163 ac) would be committed indefinitely to storage of wastes for which treatment for disposal would not be available.

Table 5.1. Land Use Commitments[a]

Facility or Burial Ground (LLBG) (ha)[b]	Area Designated for Facility or LLBG (ha)	Area Currently Occupied (ha)	Alternative 1 Area Required (ha)		Alternative 2 Area Required (ha)		No Action Alternative Area Required (ha)
			Lower Bound Waste Volume	Upper Bound Waste Volume	Lower Bound Waste Volume	Upper Bound Waste Volume	
LLBG							
218-W-3A[c]	20.4	20.4	20.4	20.4	20.4	20.4	20.4
218-W-3AE	20.0	12	12.2	12.2	20.0	20.0	20.0
218-W-4B[c]	3.5	3.5	3.5	3.5	3.5	3.5	3.5
218-W-4C[c]	20.0	4.7	4.7	4.7	4.7	4.7	4.7
218-W-5	37.2	26	30.4	35.0	35.0	37.2	32.2
218-W-5 Exp.[d]	202	0	0	0	0	0	0
218-W-6	16	0	0	0	0	7.0	0
200 W Sub-Total	319	66.6	71.2	75.8	83.6	92.8	80.8
218-E-10	36.1	22.7	22.7	22.7	23.2	25.6	23.2
218-E-12B[c,e]	70.1	41	52.4	54.0	55.4	59.9	45.0
200 E Sub-Total	106	63.7	75.1	76.7	78.6	85.5	68.2
LLBG Sub-Total	425	130	146	153	162	178	149
Facilities							
CWC	86	50	50	50	50	50	86
CWC Expansion	30	0	0	0	0	0	30
WRAP	4	4	4	4	4	4	4
New M-91 Facility	0	0	0	0	4	4	0
T Plant Complex	8	8	8	8	8	8	8
ETF[f]	15	15	15	15	15	15	15
LERF[g]	50	50	50	50	50	50	50

Table 5.1. (contd)

Facility or Burial Ground (LLBG) (ha)[b]	Area Designated for Facility or LLBG (ha)	Area Currently Occupied (ha)	Alternative 1 Area Required (ha)		Alternative 2 Area Required (ha)		No Action Alternative Area Required (ha)
			Lower Bound Waste Volume	Upper Bound Waste Volume	Lower Bound Waste Volume	Upper Bound Waste Volume	
Area C (Borrow Pit)	926	3	60	63	71	81	1
Facilities Sub-Total	1119	130	187	190	202	212	194
Total	1544	260	333	343	364	390	343

(a) Actual assignment of disposal areas to a particular LLBG would depend on operational efficiency.
(b) To obtain areas in acres multiply hectares (ha) by 2.47.
(c) Area contains some retrievably stored TRU waste.
(d) 218-W-5 Exp. is a contingency expansion of the 218-W-5 burial ground for operational flexibility.
(e) Trench 94 in 218-E-12B consisting of about 7.4 ha (18 ac) is for disposal of decommissioned Naval reactor compartments and is included in the area designated. A like area is also included for future expansion of reactor compartment disposal (a total of 20.4 ha). These reactor compartments are not within the scope of the HSW EIS. (Navy 1984, 1996).
(f) Effluent Treatment Facility (ETF) is expected to end operations in 2026. Plans are to replace the facility with pulse driers.
(g) Liquid Effluent Retention Facility.

At most, a total of about 180 ha (440 ac), or 4 percent, out of about 5000 ha (13,000 ac) of the land designated as Industrial-Exclusive in the ROD for the HCP EIS would be permanently committed to disposal of LLW and MLLW within the scope of this EIS.

5.2 Air Quality

Air quality impacts covered in this section focus on the onsite emission of four criteria pollutants[a]—nitrogen dioxide (NO_2), sulfur dioxide (SO_2), carbon monoxide (CO), and particulate matter with aerodynamic diameters of 10 μm or smaller (PM_{10}). Details of the analytical methods used to develop the air quality impacts presented in this section can be found in Appendix E. Air quality impacts associated with the transportation of waste materials are presented in Section 5.8. The potential consequences to workers and the public of the releases of radiological and hazardous chemicals are discussed in Section 5.11.

(a) The Clean Air Act authorizes the U.S. Environmental Protection Agency to set permissible levels of exposure for selected air pollutants using health-based criteria. These selected pollutants are called "criteria pollutants," and their permissible exposure levels are defined in 40 CFR 50, "National Primary and Secondary Ambient Air Quality Standards."

The maximum air quality impacts from Hanford solid waste program activities were estimated by atmospheric dispersion modeling using the Industrial Source Complex Short-Term (ISCST3) Dispersion Model (EPA 1995). The ISCST3 model is approved by the U.S. Environmental Protection Agency (EPA) for calculating the maximum, time-averaged air concentrations at key receptor locations. The model provides results for averaging periods of 1 hr, 3 hr, 8 hr, 24 hr, and 1 yr to correspond to the time periods specified in national and state ambient air quality standards. Four years of hourly Hanford Site meteorological data were used in modeling atmospheric dispersion.

Pollutant emission data used in this modeling were derived from Hanford Solid Waste Technical Information Document (FH 2002). Detailed assessments of pollutant emissions for each major program element were developed. To derive maximum pollutant emission rates, emissions were combined from all activities that could potentially occur at the same time.

In modeling maximum air quality impacts, all emissions from Hanford solid waste program activities in the 200 Area were assumed to come from a combined single ground-level point source. This includes emissions from diesel-fueled construction equipment, propane-fired equipment, and fugitive dust sources. The use of a single point source was a very conservative assumption because it concentrates pollutants at a single release location even though pollutant emissions would actually occur at multiple locations. Although project activities would be conducted only during dayshift hours, dispersion modeling examined the impacts of pollutant releases occurring over 24 hr. This assumption was conservative, as pollutant dispersion conditions are often at their worst at night because the atmosphere tends to be more stable at night and mixing heights[(a)] are typically lower. Another conservative assumption involved modeling pollutants as if they were non-decaying and non-depositing. In actuality, active chemical decay and deposition processes would act to reduce pollutant concentrations and associated air quality impacts. As a result, estimates of short-term and long-term maximum air quality impacts from 200 Area activities were much larger than would actually be experienced.

In each alternative, activities would be conducted also at the Area C borrow pits located south of SR 240. Emissions associated with excavating and stockpiling capping materials in Area C were modeled using conservative assumptions. Borrow pit emissions were modeled as a small area source to represent the zone of emissions for earthmoving equipment and fugitive dust sources. This area source was positioned slightly closer to SR 240 than the 150-m [500-ft] minimum distance specified in project plans (FH 2002). Pollutants also were modeled as being non-decaying and non-depositing.

Pollutant emissions associated with the transportation of capping materials from the borrow pit area to the 200 Area also are included in this assessment. Pollutant emissions associated with the operation of the trucks include exhaust emissions and fugitive dust. A very conservative assumption was made that all truck emissions would be split between two locations—Area C and the 200 Area. This assumption concentrates emissions at only two locations rather than spreading them across a much broader area, thereby maximizing estimates of air quality impacts.

(a) The mixing height is the height from the surface to the top of the atmosphere layer through which pollutants can freely diffuse.

Pollutant emission rates from diesel-fueled engines were conservatively assumed to comply with current emissions standards. No credit is taken for the substantial reduction in the sulfur content of diesel fuel (from a 500-ppm to a 15-ppm limit) scheduled to be phased in beginning in June 2006 or a tightening of the emission standards for nitrogen dioxide and particulate matter scheduled to be phased in beginning in 2007 (EPA 2000).

To meet regulatory requirements, emissions from program activities must not result in air concentrations of criteria pollutants that exceed regulatory limits. Locations for the maximum air quality impacts from 200 Area and borrow pit emissions are provided in Tables 5.2 and 5.3, respectively.

Table 5.2. 200 Area Emissions: Location and Dispersion Factors Used to Determine Maximum Air Quality Impacts

Averaging Time Period	Maximum Impact Location and Corresponding Public Access	Distance and Direction of Impact Location from Pollutant Release Location[(a)]	Unit Dispersion Factor for Maximum Impact Location (s/m^3)[(b)]
1 hr	SR 240	7.3 km – S	9.68E-5
3 hr	SR 240	10.4 km – WNW	3.74E-5
8 hr	SR 240	10.4 km – WNW	2.35E-5
24 hr	Hanford Site boundary	15.5 km – WNW	7.45E-6
Annual	Hanford Site boundary	19.6 km – N	1.92E-7

(a) Distance and direction determined by dispersion modeling.

(b) Values are computed by the ISCST3 model. To convert to a concentration estimate ($\mu g/m^3$), a unit dispersion factor (s/m^3) is multiplied by the actual pollutant release rate ($\mu g/s$).

Table 5.3. Borrow Pit Emissions: Location and Dispersion Factors Used to Determine Maximum Air Quality Impacts

Averaging Time Period	Maximum Impact Location and Corresponding Public Access	Distance from Pollutant Release Location to Maximum Public Impact Location[(a)]	Unit Dispersion Factors for Maximum Impact Location (s/m^3)[(b)]
1 hr	SR 240	150 m	3.0E-3
3 hr	SR 240	150 m	2.3E-3
8 hr	SR 240	150 m	1.4E-3
24 hr	Hanford Site boundary	15 km (north of Area C)	2.8E-6
Annual	Hanford Site boundary	10 km (northwest of Area C)	5.0E-9

(a) Distance determined by dispersion modeling.

(b) Values are computed by the ISCST3 model. To convert to a concentration estimate ($\mu g/m^3$), the unit dispersion factor (s/m^3) is multiplied by the actual pollutant release rate ($\mu g/s$).

In the following sections, the results of the air quality analysis are presented for each of the three alternatives. Separate results are provided for air quality impacts for borrow pit and 200 Area emissions. A General Conformity Review analysis (also provided in Appendix E) concludes that a General Conformity Determination would not be needed.

5.2.1 Alternative 1

A variety of project activities would generate air quality impacts under Alternative 1. These activities include the use of diesel-fueled equipment to construct new trenches of deeper and wider design than current trenches, backfilling of trenches, capping the LLBGs at closure, performing routine CWC and T Plant operations, modifying T Plant for the M-91 Capability, and the excavation and transportation of materials from the borrow pit. In addition, propane-fueled pulse driers would be used to treat leachate from the MLLW trenches beginning in 2026. Fugitive dust emissions would be associated with many major construction, transportation, and operation activities.

For Alternative 1, the largest air quality impacts would occur following the end of disposal operations in 2046. At this time, LLW capping, final MLLW capping, and borrow pit operations would be going on simultaneously. Some other minor sources of air pollutants, such as MLLW leachate treatment operations, also would be ongoing. Estimates of the maximum air quality impacts from 200 Area operations are presented in Table 5.4. Estimates of the maximum air quality impacts from borrow pit activities are presented in Table 5.5. These maximum air quality impacts from the borrow pit are the same for all alternatives.

Table 5.4. Maximum Air Quality Impacts from 200 Area Activities for Alternative 1

Pollutant	Averaging Time	Ambient Air Quality Standard ($\mu g/m^3$)	Lower Bound Volume		Upper Bound Volume	
			Maximum Air Quality Impacts ($\mu g/m^3$)	Percent of Standard	Maximum Air Quality Impacts ($\mu g/m^3$)	Percent of Standard
PM_{10}	24 hr	150	19	13	19	13
	Annual	50	0.42	0.84	0.42	0.84
SO_2	1 hr	1,000	21	2.1	21	2.1
	3 hr	1,300	8.2	0.63	8.2	0.63
	24 hr	260	0.65	0.25	0.65	0.25
	Annual	50	0.007	0.01	0.008	0.02
CO	1 hr	40,000	460	1.2	460	1.2
	8 hr	10,000	110	1.1	110	1.1
NO_2	Annual	100	0.36	0.36	0.39	0.39

Table 5.5. Maximum Air Quality Impacts from Borrow Pit Activities

Pollutant	Averaging Time	Ambient Air Quality Standard (μg/m^3)	Maximum Air Quality Impacts	
			Maximum Polluant Concentration (μg/m^3)	Percent of Standard
PM_{10}	24 hr	150	5.6[(a)]	3.7
	Annual	50	0.010[(a)]	0.020
SO_2	1 hr	1,000	180	18
	3 hr	1,300	140	11
	24 hr	260	0.17	0.065
	Annual	50	0.001	0.002
CO	1 hr	40,000	3,600	9.0
	8 hr	10,000	1,700	17
NO_2	Annual	100	0.017	0.017

(a) Air quality impacts assume only minimal dust control at the borrow pits. In practice, an aggressive dust control program would substantially reduce emissions.

Even in the years with the greatest potential air quality impacts, ambient air quality standards would not be exceeded under Alternative 1. The greatest potential impacts with respect to the air quality standards would result from SO_2 and CO emissions in the borrow pit area. Maximum air quality impacts are conservatively estimated to be about 18 percent of the 1-hr SO_2 standard and 17 percent of the 8-hr CO standard. The greatest potential impacts from emissions within the 200 Areas would involve the 24-hr PM_{10} standard. Using the worst-case assumptions employed in the air dispersion modeling, this maximum air quality impact is only 13 percent of the 24-hr PM_{10} standard.

5.2.2 Alternative 2

A variety of project activities would generate air quality impacts under Alternative 2. These project activities include the use of diesel-fueled equipment to construct additional trenches of current design, backfilling and capping activities in the LLBGs, construction of a new facility for the M-91 Capability, and the excavation of materials at the borrow pit. In addition, propane-fueled engines would be used at the CWC and to operate driers used to treat leachate from the MLLW trenches. Fugitive dust emissions would be associated with all major construction and operation activities.

Two years are representative of maximum air quality impacts for Alternative 2. In 2007, air quality impacts for 1-hr through 24-hr averaging periods would reach their maximum values. During 2007, LLW construction, MLLW trench construction, and final MLLW capping would be occurring in the 200 Area. After disposal operations cease in 2046, annual air quality impacts would reach their maximum values, because LLW capping, MLLW capping, and MLLW leachate operations would be occurring in the 200 Areas during 2047. Borrow pit operations would be conducted in both years. Estimates of the maximum air quality impacts from 200 Area operations are presented in Tables 5.6 and 5.7. Estimates of the maximum air quality impacts from Area C operations were presented in Table 5.5.

Table 5.6. Maximum Air Quality Impacts from 200 Area Activities for Alternative 2 in 2007

			Lower Bound Volume		Upper Bound Volume	
Pollutant	**Averaging Time**	**Ambient Air Quality Standard ($\mu g/m^3$)**	**Maximum Air Quality Impacts ($\mu g/m^3$)**	**Percent of Standard**	**Maximum Air Quality Impacts ($\mu g/m^3$)**	**Percent of Standard**
PM_{10}	24 hr	150	17	11	22	15
	Annual	50	0.14	0.28	0.16	0.32
SO_2	1 hr	1,000	48	4.8	65	6.5
	3 hr	1,300	19	1.4	24	1.8
	24 hr	260	1.4	0.53	1.8	0.69
	Annual	50	0.005	0.01	0.006	0.01
CO	1 hr	40,000	1000	2.5	1400	3.5
	8 hr	10,000	250	2.5	320	3.2
NO_2	Annual	100	0.24	0.24	0.30	0.30

Table 5.7. Maximum Air Quality Impacts from 200 Area Activities for Alternative 2 in 2047

			Lower Bound Volume		Upper Bound Volume	
Pollutant	**Averaging Time**	**Ambient Air Quality Standard ($\mu g/m^3$)**	**Maximum Air Quality Impacts ($\mu g/m^3$)**	**Percent of Standard**	**Maximum Air Quality Impacts ($\mu g/m^3$)**	**Percent of Standard**
PM_{10}	24 hr	150	21	14	21	14
	Annual	50	0.40	0.8	0.4	0.80
SO_2	1 hr	1,000	30	3.0	30	3.0
	3 hr	1,300	11	0.84	11	0.84
	24 hr	260	0.90	0.34	0.90	0.34
	Annual	50	0.007	0.011	0.007	0.014
CO	1 hr	40,000	640	1.6	640	1.6
	8 hr	10,000	160	1.6	160	1.6
NO_2	Annual	100	0.35	0.35	0.35	0.35

All air quality impacts from Alternative 2 would be well within ambient air quality standards. The greatest potential impact from SO_2 and CO would result from emissions in the borrow pit area. In 2007, the largest potential air quality impacts from 200 Area emissions involve the 24-hr PM_{10} air concentration. Even using the worst-case assumptions employed in the dispersion modeling, this maximum air quality impact would be only about 15 percent of the applicable air quality standard for the upper bound case. In 2047, annual impacts are slightly greater than in 2007 but still represent 1 percent or less of the applicable standards. Compared to the other alternatives, Alternative 2, Upper Bound Waste Volume, would produce slightly greater air quality impacts for SO_2 and CO from 200 Area emissions. Impacts associated with borrow pit operations would be the same as presented in Table 5.5

5.2.3 No Action Alternative

A variety of project activities would generate air quality impacts under the No Action Alternative. Under the No Action Alternative, diesel-fueled equipment would be used during construction of additional trenches of current design, 66 CWC buildings, backfilling the LLW and MLLW trenches, capping two existing MLLW trenches, and excavation of materials at the borrow pits. A propane-fueled pulse drier would be used to treat MLLW trench leachate beginning in 2026. Fugitive dust emissions would be associated with all major construction and operation activities. The No Action Alternative requires the consumption of the greatest amount of diesel fuel and disturbs the greatest area.

A representative year for maximum pollutant emissions and air quality impacts for the No Action Alternative would be 2007. During this period, LLW construction, MLLW capping, and CWC building construction would be occurring in the 200 Area. Borrow pit operations also would be conducted. Estimates of the maximum air quality impacts from 200 Area operations are presented in Table 5.8. Estimates of the maximum air quality impacts from borrow pit operations were presented in Table 5.5.

All air quality impacts during this year would be well within ambient air quality standards. The greatest potential impact from SO_2 and CO would result from emissions in the borrow pit area. The greatest potential air quality impacts from 200 Area activities are associated with the 24-hr PM_{10} standards. The maximum air quality impact for 24-hr PM_{10} would be about 25 percent of the applicable air quality standard. Compared to the other alternatives, the No Action Alternative would produce slightly larger air quality impacts for PM_{10}.

Although there are some differences among the alternatives in maximum air quality impacts, these differences are relatively small. No combination of activities addressed in these alternatives is calculated to exceed ambient air quality standards. The use of less conservative (that is, more realistic) assumptions in estimating emissions and modeling atmospheric dispersion would substantially lower estimates of the maximum air quality impacts.

Table 5.8. Maximum Air Quality Impacts from 200 Area Activities for the No Action Alternative in 2007

Pollutant	Averaging Time	Ambient Air Quality Standard ($\mu g/m^3$)	Maximum Air Quality Impacts	
			Maximum Pollutant Concentration ($\mu g/m^3$)	Percent of Standard
PM_{10}	24 hr	150	37	25
	Annual	50	0.80	1.6
SO_2	1 hr	1000	28	2.8
	3 hr	1300	15	1.2
	24 hr	260	0.80	0.31
	Annual	50	0.007	0.01
CO	1 hr	40,000	600	1.5
	8 hr	10,000	150	1.5
NO_2	Annual	100	0.30	0.30

5.3 Water Quality

This section discusses short-term impacts on water quality from operations and construction of LLBGs and other related facilities and long-term impacts on groundwater and the Columbia River from contaminant releases from LLBGs after site closure in 2046. Short-term potential impacts during the period of operations and construction are discussed in Section 5.3.1. An overview of assessment methods used to determine the long-term impacts to groundwater and the Columbia River are presented in Section 5.3.2. Results of the impact assessment for up to 10,000 yr after the operational period ends in 2046 are summarized in Section 5.3.3. Detailed information on the long-term assessment methods and results are provided in Appendix G. Details from the water quality analysis presented in this section and in Appendix G are used in the preparation of estimates of impacts on public health and safety in terms of radiation dose to individuals and populations as provided in Section 5.11.

As a result of wastewater management activities during past Hanford Site operations, groundwater beneath the 200 Areas has been contaminated with radionuclides and non-radioactive chemicals. The contaminants emanating from the 200 Areas are moving toward the Columbia River. None of these contaminants are thought to have originated from the LLBGs.

Radioactive contaminants present in groundwater beneath the 200 Areas that exceed the cited standards in Table 4.9 (Section 4.5.3) are tritium, strontium-90, technetium-99, iodine-129, plutonium, cesium-137, total alpha, total beta, and uranium. Hazardous chemical contaminants present at levels exceeding standards include nitrate, fluoride, chromium, carbon tetrachloride, trichloroethene, cyanide, and tetrachloroethene, and cis-1,2-dichloroethene.

5.3.1 Short-term Impacts of Operations and Construction Activities

Water derived from the Hanford Site Export Water System would be used sitewide for dust suppression during operations and construction. The Hanford Site Export Water System extracts water from the Columbia River for use on the 200 Area Plateau from intake locations in 100-D Area. Water from the export system is also expected to be used at existing sanitary facilities and would be disposed of after treatment. Since most of these operational water discharges would occur in uncontaminated areas, they would not be expected to have a substantial affect on the groundwater system; and groundwater quality impacts would not be expected. In the case of capping of LLBGs at closure where water is used for short-term dust suppression, the 25-cm (10-in) layer of asphalt at the base of the cap is expected to divert water away from the waste and would not be expected to result in impacts on groundwater quality.

Potential water quality impacts to groundwater are not expected from LLW currently contained or slated for future disposal in the LLBGs during the operational period. The thick vadose zone (see Section 4.5) between the LLBGs and the underlying water table is expected to limit any release of contaminants from the LLBGs to groundwater until well after the time of site closure. Interim status detection monitoring being done under RCRA at the Low-Level Waste Management Areas 1 through 4 (which contain many of the LLBGs) has indicated no groundwater contamination from the LLBGs (Hartman *et al.* 2001).

LLW, disposed in the LLBGs, are largely dry solid waste disposals. Category (Cat) 1 and 3 LLW disposed of since 1988 follow stringent Hanford Site Solid Waste Acceptance Criteria (HSSWAC) for waste containment and content (i.e., use of steel boxes, drums, high-integrity containers, and grouted waste forms) that will minimize leaching and release of contaminants during the period of operations. In addition, MLLW are being disposed of in RCRA-compliant trenches with a liner system to facilitate leachate monitoring, management, and treatment during the period of operations. Because less rigorous requirements for waste contaminant and content were used prior to 1988, contaminants contained in LLW disposed of prior to 1988 offer the highest potential for leaching and release into the vadose zone prior to the time of site closure. However, releases to groundwater from these earlier disposals are not expected to occur during the period of operations.

5.3.2 Methods for Assessment of Long-term Impacts

The groundwater exposure pathway considers the long-term release of contaminants from a variety of LLW and MLLW downward through the vadose zone underlying the LLBGs, and laterally through the unconfined aquifer immediately underlying the vadose zone to the Columbia River. The LLBGs are all located in the 200 East Area and the 200 West Area and the physical area of potential groundwater impact is the unconfined aquifer bounded laterally by the Rattlesnake Hills to the west and southwest, by the Columbia River to the north and east, and by the Yakima River to the south (Figure 4.1).

The sequence of calculations used in the long-term assessment required estimating the cumulative dose using a suite of process models that estimated source-term release, vadose zone flow and transport, and groundwater flow and transport. The computational framework for these process models and the relationship of software elements is schematically illustrated in Figure 5.1.

Wastes considered in this assessment include previously disposed LLW and LLW to be disposed in the LLBGs as follows:

- LLW disposed of between 1962 and 1970 (referred to as pre-1970 LLW in this section)
- LLW buried after 1970 but before 1988 (referred to as 1970-1988 LLW in this section)
- Cat 1 LLW disposed of after 1988 including LLW forecasted to be disposed of through 2046 (referred to as Cat 1 LLW in this section)
- Cat 3 and greater than Cat 3 (GTC3) LLW disposed of after 1988 including LLW forecasted to be disposed of through 2046 (referred to collectively as Cat 3 LLW in this section)
- MLLW disposed of after 1988 including waste forecasted to be disposed of through 2046 (referred to as MLLW in this section).

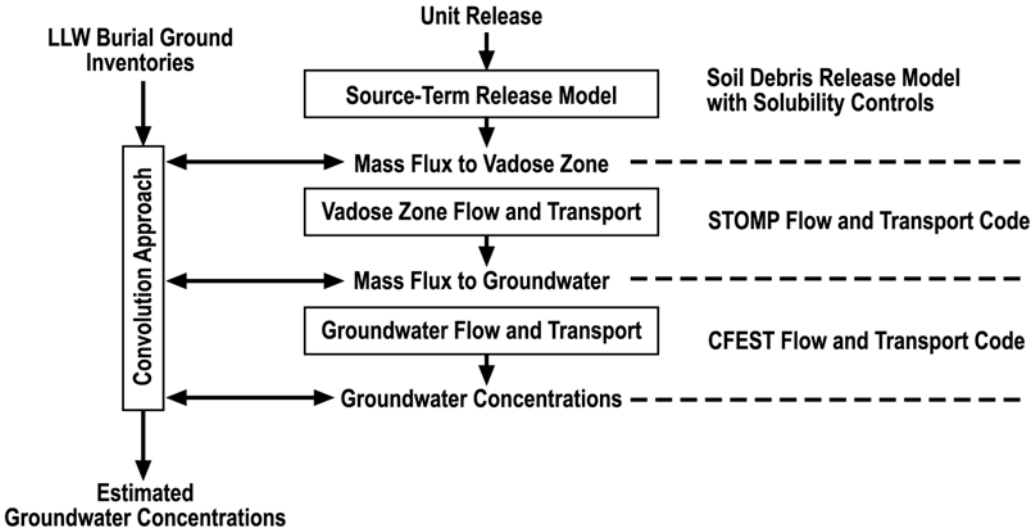

Figure 5.1. Schematic Representation of Computational Framework and Codes Used in the HSW EIS

These waste types, which are provided somewhat differently than as described in Section 2.0, were categorized so that wastes with similar or related disposal configurations and waste characteristics could be grouped together and the total number of calculations used in the assessment could be minimized.

Inventories of retrievably stored TRU waste in trenches and caissons located in the LLBGs were not considered because they will eventually be retrieved and sent to the WIPP for disposal.

The groundwater assessment has been performed using a combination of screening techniques and numerical modeling. The groundwater modeling results estimate contaminant concentrations in the groundwater associated with selected alternatives evaluated in this HSW EIS from the end of waste operations in 2046 up to 10,000 yr from 2046.

The points of assessment for this analysis were located on the Hanford Site at hypothetical wells located approximately 1 km (0.6 mi) down gradient of the 200 East and the 200 West Area LLBGs and at a hypothetical well near the Columbia River located down gradient from both areas (see Figure 5.2). All well locations were selected based on simulated transport results of unit releases at selected LLBGs locations used in this assessment. Details of these unit release calculations are presented in Appendix G. The hypothetical wells 1 km down gradient from the LLBGs were selected to represent contaminant concentrations in the unconfined aquifer immediately down gradient of the LLBGs. A hypothetical well near the Columbia River is representative of a well dug in the unconfined aquifer for domestic uses and as a surrogate for conditions at river shore springs. In addition the concentrations of nuclides at the near river well were used to estimate quantities of nuclides reaching the Columbia River. The near river well location was found based on contaminant plume shape to be close to the Old Hanford Town Site.

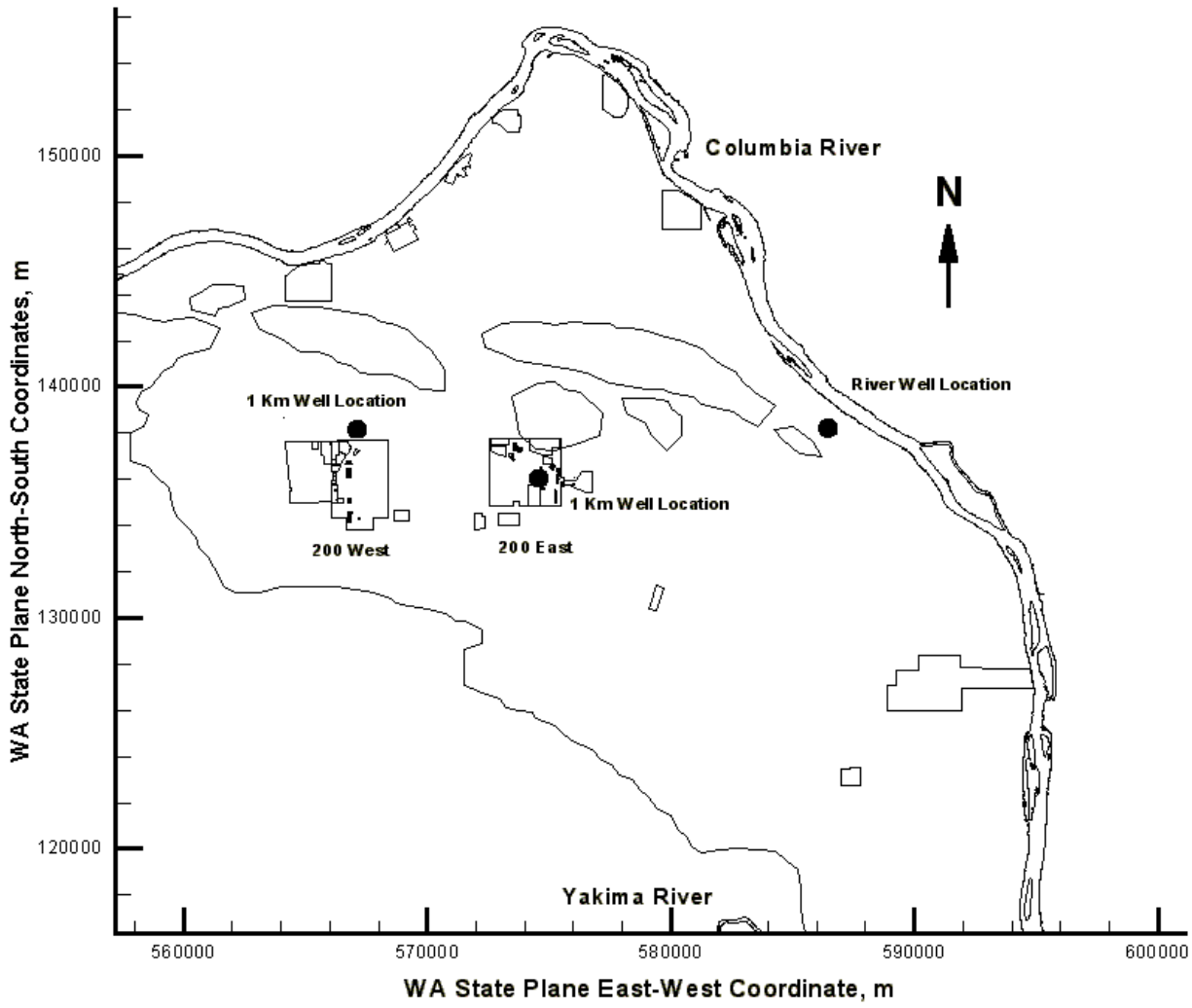

Figure 5.2. Location of Hypothetical Well Locations Used in Assessing Long-term Water Quality Impacts

The LLBGs contain over 100 radioactive and non-radioactive waste constituents. Potential impacts to groundwater within the period of interest were based primarily on the overall mobility of the constituents. To establish the relative mobility of the constituents, they were grouped based on their mobility in the vadose zone and underlying unconfined aquifer. Contaminant groupings were used rather than the individual mobility of each contaminant because of the uncertainty involved in determining the mobility of individual constituents. The groups were selected based on relatively narrow ranges of mobility, and constituents were placed in the more mobile group if uncertainty existed about which group was appropriate. Some of the constituents, such as iodine and technetium, would move at the same rate as water whether they were in the vadose zone or underlying groundwater. The movement of other constituents in water, such as americium and cesium, would be retarded by interaction with soil and rock.

The Subsurface Transport Over Multiple Phases (STOMP) (White and Oostrom 1996; White and Oostrom 1997; Nichols *et al.* 1997) and the Coupled Fluid, Energy, and Solute Transport (CFEST) flow and transport models (Gupta *et al.* 1987; Cole *et al.* 1988; Gupta 1996) accounted for the retardation of contaminant movement, using a distribution coefficient or K_d (mL/g). This parameter is a measure of sorption and is the ratio of the quantity of the solute adsorbed per gram of solid to the amount of solute remaining in solution (Kaplan *et al.* 1995). Values of K_d for the constituents range from 0 mL/g (in which the contaminant movement in water is not retarded) to more than 40 mL/g (in which the contaminant moves at a much slower rate than water).

The constituents in the LLW inventory were grouped and modeled according to the reported or assumed K_d of each constituent. The contaminant groups, based on mobility and examples of common or potential constituents of concern, are described in the following text. A complete listing of solid LLW constituents by K_d is provided in Appendix G. The constituent groups used for modeling include the following:

- **Group 1** – Contaminants were modeled as non-sorbing (that is, $K_d = 0$) and would not be retarded in the soil-water system. Contaminant K_d values in this group ranged from 0 to 0.59 mL/g and included all the isotopes of iodine, technetium, selenium, chlorine, and tritium.

- **Group 2** – Contaminants were modeled as slightly sorbing (that is, $K_d = 0.6$) and would be slightly retarded in the soil-water system. Contaminant K_d values in this group ranged from 0.6 to 0.99 mL/g and included all the isotopes of uranium and carbon.

- **Group 3** – Contaminants were modeled as slightly more sorbing (that is, $K_d = 1$). Contaminant K_d values in this group ranged from 1 to 9.9 mL/g and included all the isotopes of barium.

- **Group 4** – Contaminants were modeled as moderately sorbing (that is, $K_d = 10$). Contaminant K_d values in this group ranged from 10 to 39.9 mL/g and included all the isotopes of neptunium, palladium, protactinium, radium, and strontium.

- **Group 5** – Contaminants were modeled as strongly sorbing (that is, $K_d = 40$). Contaminant K_d values in this group were 40 mL/g or greater and included all the isotopes of actinium, americium, cobalt, curium, cesium, iron, europium, gadolinium, niobium, nickel, lead, plutonium, samarium, tin, thorium, and zirconium.

With some exceptions, forecast inventories of hazardous chemical constituents associated with MLLW disposal are small. No specific analysis of hazardous chemical inventories was performed. Exceptions included lead and mercury associated with MLLW that were estimated at 336 kg (741 lb) and 2.5 kg (5.5 lb), respectively. Because of its affinity to be sorbed onto Hanford Sediments, lead falls within the K_d Group 5 ($K_d = 40$ mL/g) and would not release to groundwater within the 10,000-yr period of interest in this analysis. The inventory estimated for mercury is small and would not substantially contribute to groundwater contamination. Even the most conservative estimates of release (including the assumption that the $K_d = 0$ mL/g) would yield estimated groundwater concentrations at levels of two orders of magnitude below the current standard of 0.002 mg/L.

The source term is the quantification of when and which constituents (by mass or activity) would be released. This source term includes the water flux into the vadose zone that results from precipitation infiltrating the waste and mass or activity solubilized from dissolution of waste in the LLBGs. A detailed description of the source term and the rates of release of constituents into the groundwater are contained in Appendix G. Methods used for calculating source release and transport of constituents in the vadose zone and groundwater are also described in Appendix G.

TRU waste retrievably stored in trenches and caissons would be retrieved, treated, repackaged as necessary, processed, and shipped for final disposal at WIPP, hence no impacts on Hanford groundwater quality would be expected from these wastes and are not considered further.

5.3.2.1 Previously Buried Waste and Category 1 Low-Level Waste

Previously buried LLW and Cat 1 LLW were evaluated using similar modeling approaches. Previously buried LLW consists of waste emplaced in the LLBGs from 1962 to 1970 and between 1970 and 1987; Cat 1 LLW consists of wastes emplaced since 1988 and forecasted to be emplaced in the future in 200 East Area and 200 West Area.

Assumptions for analysis of these LLW include:

- All LLW would be buried by 2046. Current estimates of inventories decayed to conditions at closure are available for release at the beginning of the release period (for example, 2046). At the beginning of the analysis period, all constituents of concern are assumed to be available for transport via infiltrating precipitation to the vadose zone and for eventual arrival at groundwater. This assumption is considered conservative because the actual release would likely occur spanning a number of decades from initial disposal of wastes in the LLBGs to final burial of all LLW in 2046.

- Source-term release for the LLW was estimated using the soil-debris release model. In this model, the waste itself is assumed to have the same hydraulic characteristics of the surrounding soil materials. The inventory in the LLW is assumed to be immediately available for leaching and would be leached out of the LLBGs at the assumed infiltration rate. A specific case for leaching was used to estimate the release of uranium from the LLW. For uranium, the release was controlled at a solubility limit of 0.2 g/L (Buck *et al.* 1996).

- The infiltration rate was assumed to be 0.05 cm/yr to reflect the effective recharge through the assumed RCRA Subtitle C barrier placed over all the LLBGs. In the absence of the RCRA cover, the assumed infiltration rate used was 0.5 cm/yr.

- The infiltration rate used in the overall travel time for flow and transport was assumed to be 0.5 cm/yr to reflect natural recharge in the surrounding environment of naturally vegetated surface soil conditions. In the absence of artificial recharge, vadose simulation results based on this assumed infiltration rate indicated a travel time to the water table of about 500 yr in the 200 East Area and 900 yr in the 200 West Area.

- Depth of the LLW was assumed to be 6 m (20 ft) for disposal in existing design trenches and 18 m (59 ft) for the enhanced designed waste trenches.

5.3.2.2 Category 3 Low-Level Waste

Assumptions for analysis of Cat 3 LLW that differ from those of Cat 1 LLW follow:

- Because all LLW in this category is buried in high-integrity containers (HICs) constructed of concrete or in-trench grouted, the release calculations considered a 300-yr delay in release (expected lifetime of an individual HIC). Source-term release of carbon-14 and iodine-129 was estimated using the soil debris release model with the assumed delay in release to account for containment of the LLW in either HIC or disposed by in-trench grouting. In this model, the inventory in the LLW was assumed to be immediately available for leaching. The exception to this approach was technetium-99 and uranium in LLW. The technetium-99 LLW was assumed to be disposed within the HIC in a macroencapsulated grout form, and the release of technetium-99 was assumed to be controlled by diffusion through the grout.

- The leaching of uranium, because of the presence of cement, was controlled at an assumed solubility limit of 0.2 mg/L. This solubility limit reflects a conservative estimate of uranium solubility in the presence of grouted LLW at Hanford estimated by Wood *et al.* (1996) for LLW in 200 West Area.

5.3.2.3 Mixed Low-Level Waste

MLLW analyzed in this section includes wastes emplaced since 1988 and waste forecasted to be emplaced in the future. Trenches 31 and 34 in LLBG 218-W-5 in the 200 West Area have been constructed specifically for disposal of MLLW. MLLW in excess of the capacity of these trenches is assumed to be disposed in newly constructed MLLW trenches in LLBG 218-E-12B in 200 East Area. A new disposal trench will also be constructed in LLBG 218-E-12B in 200 East Area to accommodate disposal of melters from on-site tank waste vitrification.

Assumptions for analysis of MLLW that differ from those of Cat 1 LLW follow:

- Some of the MLLW would be disposed of in a matrix of macroencapsulated grout similar to Cat 3 LLW.

- Depth of the MLLW disposed in 200 West Area in trench 31 and 34 within LLBG 218-W-5 is 6 m (20 ft). Depth of the MLLW disposed in 200 East Area in the enhanced trench within LLBG 218-E-12B was assumed to be 18 m (59 ft). Depth of the MLLW disposed in 200 East Area in the melter trench within LLBG 218-E-12B was assumed to be 21 m (69 ft).

5.3.3 Long-term Impacts on Water Quality

Of the suite of waste constituents disposed in LLW in the LLBGs, only, technetium-99 and iodine-129 in Group 1 and carbon-14 and the uranium isotopes in Group 2 were considered to be in

sufficient quantity, long-lived, and mobile enough to warrant detailed analysis of groundwater impacts. Although three of the constituents in Group 1, selenium, chlorine, and tritium, are considered very mobile, they were screened out due to other factors. Selenium and chlorine were not considered in the assessment because the total inventories for both of these constituents were estimated to be less than 0.01 Ci. Tritium, because of its relatively short half-life, would not reach groundwater from the LLBGs.

Preliminary estimates of transport times of constituents in Groups 3, 4, and 5 that considered their affinity to be sorbed onto Hanford sediments indicated their release through the thick vadose zone to the unconfined aquifer beneath the LLBGs would be beyond the 10,000-yr period of analysis. Thus, all constituents in these groups were eliminated from further consideration.

Although not applicable in a regulatory sense to groundwater beneath the 200 East Area and the 200 West Area, Federal Drinking Water Standards are used as benchmarks or reference standards against which potential contamination levels may be compared. For the contaminants of concern, except for uranium, the standards (40 CFR 141.16) are interim standards and are based on a calculated dose equivalent of 4 mrem/yr to the maximally exposed internal organ or total body. Uranium has a currently proposed standard of 0.03 mg/L, based on chemical toxicity that is more restrictive than the radiological dose standard. Hazardous chemical drinking water standards for Washington State are stated in WAC 173-200 and WAC 246-290. Federal standards are given in 40 CFR 141 and 40 CFR 143.

Comparisons of maximum concentrations of technetium-99 and iodine-129 as percentages of Federal Drinking Water Standards for all LLW types disposed in 200 East and 200 West Areas for the 1-km well and the near Columbia River well as functions of volumes of LLW and alternative are provided in Tables 5.9 and 5.10, respectively. Estimated times of maximum concentration and principal contributing waste types are also provided.

Table 5.9. Maximum Concentrations of Tc-99 and I-129 as Percent of Drinking Water Standard (DWS) at a Hypothetical Well 1 km Down Gradient from the LLBG

	200 East Area				**200 West Area**			
	Tc-99	**Years to Maximum Concen.**	**I-129**	**Years to Maximum Concen.**	**Tc-99**	**Years to Maximum Concen.**	**I-129**	**Years to Maximum Concen.**
DWS, pCi/L	900		1		900		1	
Alternative 1								
Lower Bound Volume	1.4	740	5.2	740	28	1200	110	1200
Upper Bound Volume	1.0	740	5.2	740	28	1200	110	1200
Primary Contributor	MLLW		MLLW		MLLW		MLLW	
Alternative 2								
Lower Bound Volume	3.5	690	13	690	28	1200	110	1200
Upper Bound Volume	2.5	690	13	690	28	1200	110	1200
Primary Contributor	MLLW		MLLW		MLLW		MLLW	
No Action Alternative								
Lower Bound Volume	2.6	620	11	630	28	1200	180	1100
Primary Contributor	Pre-1970 LLW		Post-1970 LLW		MLLW		Pre-1970 LLW	

Table 5.10. Maximum Concentrations of Tc-99 and I-129 as Percent of Drinking Water Standard (DWS) at a Hypothetical Well Near the Columbia River

	200 East Area				200 West Area			
	Tc-99	Years to Maximum Concen.	I-129	Years to Maximum Concen.	Tc-99	Years to Maximum Concen.	I-129	Years to Maximum Concen.
DWS, pCi/L	900		1		900		1	
Alternative 1								
Lower Bound Volume	0.1	930	0.6	1050	0.4	1800	2.1	1800
Upper Bound Volume	0.1	1050	0.6	1050	0.4	1800	2.1	1800
Primary Contributor	Pre-1970 LLW		1970-1988 LLW		1970-1988 LLW		Pre-1970 LLW	
Alternative 2								
Lower Bound Volume	0.5	980	2.1	980	0.9	1800	3.5	1800
Upper Bound Volume	0.4	980	2.1	980	0.9	1800	3.5	1800
Primary Contributor	MLLW		MLLW		MLLW		MLLW	
No Action Alternative								
Lower Bound Volume	0.4	810	1.6	810	1.6	1800	4.6	1500
Primary Contributor	Pre-1970 LLW		1970-1988 LLW		1970-1988 LLW		Pre-1970 LLW	

Concentration levels of both carbon-14 and the uranium isotopes, which are given in Appendix G, were well below the Drinking Water Standards (DWS) for all waste types and in all alternatives (at most less than 5 percent). For most of the LLW categories, concentration levels of these contaminants do not reach peak concentrations in groundwater in less than 10,000 yr. For LLW disposed in 200 West Area, carbon-14 and uranium were not released from the vadose zone to the groundwater in 10,000 yr.

Additional details on concentrations and times of arrival at the 1-km (.6 mi) and near river wells are provided by contaminant of concern, LLW type, and alternative in Appendix G.

Predicted discharges into the Columbia River in areas where affected groundwater would discharge are on the order of a few tenths of m^3/s (nominally taken as 0.5 m^3/s). Concentration levels in the Columbia River after groundwater discharges of this magnitude are introduced and mixed with the annual total river flow (at 3300 m^3/s) would be significantly diluted. Maximum concentrations in river water at the City of Richland water supply intakes would be at least 3 to 4 orders of magnitude less than current maximum levels predicted in groundwater at the near river well.

5.4 Geologic Resources

Impacts on geologic resources would result principally from extraction of basalt, sand, gravel, and silt/loam from the Area C borrow pit for use in capping the LLBGs upon closure. Geologic resources would also be used for construction of trenches and facilities as well as routine maintenance and operations. The amounts of these geologic resources committed in the alternatives are quantified in Section 5.10. Impacts on scenic aspects of topography are described in Section 5.12. No other impacts on geologic resources were identified.

5.5 Ecological Resources

Potential impacts on ecological resources as a result of implementing Alternative 1, Alternative 2, or the No Action Alternative are discussed in the following sections. Additional information is provided in Appendix I.

Near-term impacts on ecological resources relate primarily to surface disturbance associated with LLBGs, borrow sites from which capping materials are obtained, and construction sites for new facilities. Consideration of long-term impacts is associated with eventual migration of radionuclides and other hazardous chemicals through the vadose zone, to groundwater, and on to the Columbia River, and their potential for impact on aquatic organisms.

The Hanford Site range-fire (24 Command Fire) of June 2000 removed large amounts of vegetation in areas of interest, particularly in the western half of the 200 West Area, and westward and southward from that area. The fire did not reach the 200 West LLBGs or the 200 East Area. The absence of vegetation has resulted in considerable movement of soil by wind. In the absence of similar fires in the future, ecological resources might be naturally restored over the life of the project. In the near term, nuisance species such as Russian thistle and cheatgrass are likely to be abundant.

Impacts on ecological resources are sufficiently similar among the alternatives that they would not be expected to be an important discriminator in the selection process.

Conclusions regarding potential impacts were based in part on field surveys made in February 2002 and might need to be modified as a result of surveys made during the growing season.

5.5.1 Alternative 1

LLBGs

Currently, the 200 East Area LLBGs contain about 106 ha (262 ac) of which about 64 ha (158 ac) have been cleared or utilized for solid waste management activities. Most of the vegetation originally in the LLBGs in the 200 East Area has been cleared. Cheatgrass (*Bromus tectorum*) and Sandberg's bluegrass (*Poa sandbergii*) dominate approximately two-thirds of these burial grounds. The planted perennial, crested wheatgrass (*Agropyron cristatum*), dominates the other third. Continued use of these burial grounds, or new disturbance of the plant communities of about 11 ha (28 ac) to about 22 ha (54 ac) within these LLBGs, would not result in the loss of any habitats designated by Washington State as priority habitat.

Several plant "species of concern" have been noted within the 200 East Area LLBGs, the most notable of which is Piper's daisy (*Erigeron piperianus*), listed by Washington State as a "sensitive species." A large population of this species was noted on the 218-E-12B LLBG during the spring of 1998. Spraying of herbicides on the burial ground during the fall of 1998 and the spring of 1999 decreased or eliminated this population, although it might regenerate from seed if spraying ceases.

Other plant species of concern that have been observed within the LLBGs include two state Watch List Species, the crouching milkvetch (*Astragalus succumbens*) and the stalked-pod milkvetch (*Astragalus sclerocarpus*). Both of these species are relatively common on the 200 Areas Plateau. Mitigation (beyond avoidance and minimization) for Watch List Species is not normally required under the Hanford Site Mitigation Strategy (DOE-RL 2001).

Wildlife affected by disturbance of the 200 East and 200 West Areas LLBGs includes the Great Basin pocket mouse (*Perognathus parvus*) and side-blotched lizard (*Uta stansburiana*), and several migratory birds. The Great Basin pocket mouse and side-bloched lizard are common on the 200 Area Plateau. Therefore, disturbance of those individuals on the LLBGs is not expected to adversely affect local populations. Ground-nesting birds observed within the 200 East and 200 West Areas LLGBs include the long-billed curlew (*Numenius americanus*), horned lark (*Eremophila alpestris*), killdeer (*Charadrius vociferous*) and western meadowlark (*Sturnella neglecta*). To avoid impacts to the nests, eggs, and young of these species, ground-disturbing activities are conducted outside the nesting season (i.e., generally March 1 through July 31). Disturbance of this habitat outside the nesting season would displace future nesting individuals to similar habitat available elsewhere on the Site.

Currently, the 200 West Area LLBGs contain about 319 ha (788 ac), of which about 67 ha (166 ac) have been cleared or utilized for solid waste management activities. Most of the active areas to be used in Alternative 1 are currently maintained without vegetation and contain essentially no habitat value for native species. Continued use, or expansion of these areas by 5 ha (11 ac) to 26 ha (65 ac) within the existing 319 ha (788 ac), would have minimal additional adverse ecological impacts. The 202 ha (499 ac) 218-W-5 Expansion Area, reserved for operational flexibility and of relatively undisturbed mature sagebrush-steppe habitat, was essentially denuded by the 2000 range fire. Any mitigation for plant and animal species of concern within the 200 Areas would follow DOE policy (DOE-RL 2001, 1996a).

Facilities

The CWC and WRAP lie in an industrialized area of about 90 ha (220 ac). Continued operation of these facilities would be unlikely to jeopardize species or habitats of concern.

The T Plant Complex, which occupies an area of about 8 ha (20 ac), also lies within an industrial area and provides habitat only for those birds associated with buildings. Because new construction at the T Plant Complex for the M-91 Capability would be carried out within the T Plant, no additional impacts to those that currently exist would be expected.

Borrow Pit

Basalt, gravel, and silt/loam for use in capping the LLBGs would be obtained from borrow pits in Area C, an area of about 926 ha (2287 ac). This area was also burned in the 2000 range fire; however, some of the pre-fire shrub and understory vegetation survived and these areas have not been as severely affected by wind erosion. The stockpile area east of State Route (SR) 240 and the areas for roads to the 200 Areas are in an area composed mostly of sand; any vegetation present was removed by the fire.

Acquisition of capping materials would require disturbance of about 60 ha (148 ac) and 63 ha (156 ac) out of the 926 ha (2287 ac) for the lower and upper bound waste volumes, respectively. Impacts to habitats and species will largely depend on the location of these areas of disturbance within Area C. The habitats within Area C that may be impacted are discussed in Appendix I.

5.5.2 Alternative 2

LLBGs

The discussion regarding impacts on ecological resources in Alternative 2 would be essentially the same as that for Alternative 1. Although the area occupied by LLW and MLLW in Alternative 2 would be somewhat larger because of the need for a larger disposal area, this area would still be within the boundaries of the existing LLBGs. Thus, continued use of the LLBGs, and expansion of the disposal area within them, would not be expected to have any additional impacts on ecological resources.

Facilities

Consideration of impacts from operation of CWC and WRAP would be essentially the same as that described for Alternative 1.

The New Facility for the M-91 Capability would be located just west of WRAP. Constructing this facility would disturb about 4 ha (9 ac) of habitat. No protected plants or wildlife occur in the area, although crouching milkvetch (Washington State watch list plant species) has been observed there. The area described was also burned in the June 2000 range fire, and no additional impacts on wildlife and habitat would be expected.

Borrow Pit

Impacts associated with use of the Area C borrow pit for capping resources in Alternative 2 would be similar to those of Alternative 1; however, the areas of disturbance would increase to about 71 ha (180 ac) and 81 ha (200 ac) for the lower and upper bound waste volumes, respectively.

5.5.3 No Action Alternative

LLBGs

As in Alternative 1, there would be minimal additional impacts on ecological resources from continued use of the LLBGs or from additional disturbance within the LLBGs of 19 ha (47 ac).

Facilities

Continued operation of WRAP and the T Plant Complex and operation of existing and additional CWC buildings would not be expected to jeopardize species or habitats of concern.

Storage of waste would necessitate building an additional 66 CWC buildings that would occupy about 66 ha (163 ac). Of this area, 30 ha (74 ac) would be south of the CWC, and the remaining 36 ha (89 ac) would be to the west of CWC. This area was also burned, and no additional impacts on habitat would be expected.

5.5.4 Threatened or Endangered Species

DOE initiated consultation with the National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service (FWS) regarding the LLBG in November 1998, and a listing was requested of federally protected species that might occur in these and other areas potentially disturbed by waste management activities. The FWS response (FWS 1998), identifying species protected under the Endangered Species Act, contained no species known to occur in the LLBGs and other project areas covered under the 1998 consultation. In addition, these same areas have been surveyed annually under the DOE Ecological Compliance Assessment Project (DOE-RL 1995a), and no federally protected species have been documented. However, the footprint of potential surface disturbance has since expanded well beyond that of 1998 (e.g., addition of Area C). Consequently, DOE re-initiated consultation with NMFS and FWS in March 2002 (Appendix I). The NMFS and FWS responses to these most recent requests are pending.

5.5.5 Impacts on Aquatic Ecology in the Long-term

Leaching of radionuclides and other hazardous chemicals from the waste via infiltrating precipitation would eventually result in small quantities of long-lived mobile nuclides reaching the Columbia River. There was no evidence for adverse impacts on aquatic biota for any of the alternatives.

5.6 Socioeconomics

The primary socioeconomic region of interest is the Richland-Kennewick-Pasco Metropolitan Statistical Area, comprising Benton and Franklin Counties in Washington State (Tri-Cities region), where the vast majority of the socioeconomic impacts would be expected. Because the Tri-Cities region is the major retail and service center for the Hanford Site and its employees, the vast majority of whom also live in Benton and Franklin Counties, relatively little impact would be expected on the economies of the surrounding counties (Grant, Adams, Yakima, and Walla Walla Counties in Washington, or Umatilla County in Oregon) as a result of actions related to management of solid waste at Hanford. The socioeconomic impacts are classified in terms of primary and secondary impacts. Changes in Hanford employment and non-labor expenditures associated with the various alternatives for dealing with LLW, MLLW, and TRU waste are classified as primary impacts. Additional changes that result in the general regional economy and community as a result of these primary changes are classified as secondary effects. Examples of secondary impacts include changes in retail and service employment or changes in demand for housing. The total socioeconomic impact in the region is the sum of the primary and secondary impacts. Based on this analysis implementation of any of the HSW EIS alternatives would appear to have minimal impact on the local socioeconomic infrastructure, including housing, schools, medical support, traffic, etc.

Estimates of total employment impacts were calculated using a variant of the IMPLAN regional economic model (MIG 1993) for the Tri-Cities region. These estimates were checked for consistency

with the less-detailed estimates produced for the DOE WM PEIS (DOE 1997a) using the Regional Input-Output Modeling System (RIMS) of the U.S. Bureau of Economic Analysis. Allowing for differences in methods, the more-detailed estimates produced for the HSW EIS are in general agreement but at the lower end of the range with those produced by the earlier, less-detailed analysis in the WM PEIS. The HSW EIS estimate reports the changes in employment and earnings based on the most recently available historical data. They indicate that 93 percent of Hanford employees reside in the Benton-Franklin County region and that about 81 percent of all non-labor procurements made by Hanford management and operations contractors occur in the same region.

Impacts other than employment and income are largely based on changes in population, in view of current capacities of the local roads, schools, waste and water treatment, and other elements of local infrastructure. Historical geographic patterns of settlement are assumed to persist.

For purposes of this analysis, a baseline forecast of budgets and employment at Hanford was constructed that reflected October 2001 budget plans and estimates at DOE-RL, DOE Office of River Protection (ORP), and Pacific Northwest National Laboratory for DOE and non-DOE work. The baseline was necessary to provide perspective on the size of changes in Hanford activity that may occur as a result of actions to manage Hanford solid waste. Table 5.11 shows the baseline scenario.

Because the time pattern of spending is different under each of the three alternatives, Figure 5.3 depicts the level of Hanford employment as a simple way of showing how the solid waste program scenarios compare both with each other and total Hanford activity over time. Figure 5.4 shows solid waste program employment in each case relative to the 2002 level. The time patterns of total spending are similar for Alternative 1 and Alternative 2, as shown in Figure 5.5. Non-labor costs play a relatively larger role in the No Action Alternative, so that total costs peak in about 2013 at $107 million in that case and then decline, while employment increases until 2032. In analyzing the socioeconomic impacts of the three alternatives, emphasis was placed on finding years between 2002 and 2046 showing the largest impacts, either positive or negative. Because the time pattern of spending is different under each of the three alternatives, the largest impacts (positive or negative) sometimes occur in different years.

Table 5.11. Hanford Budget and Direct Employment Associated with Baseline Conditions

Variable	2002-2009	2010-2020	2021-2033	2034-2046
Budget (in Millions)[(a) (b)]	$2,000-$2,300	$1,464-$2,240	$784-$2,033	$540-732
Hanford Jobs[(b)]	11,700-15,200	9,200-11,700	7,500-9,200	6,150-7,200

(a) Budget is in 2002 dollars.
(b) Maximum and minimum during the period. Jobs rounded to nearest 50. These values provide bounds for impacts.

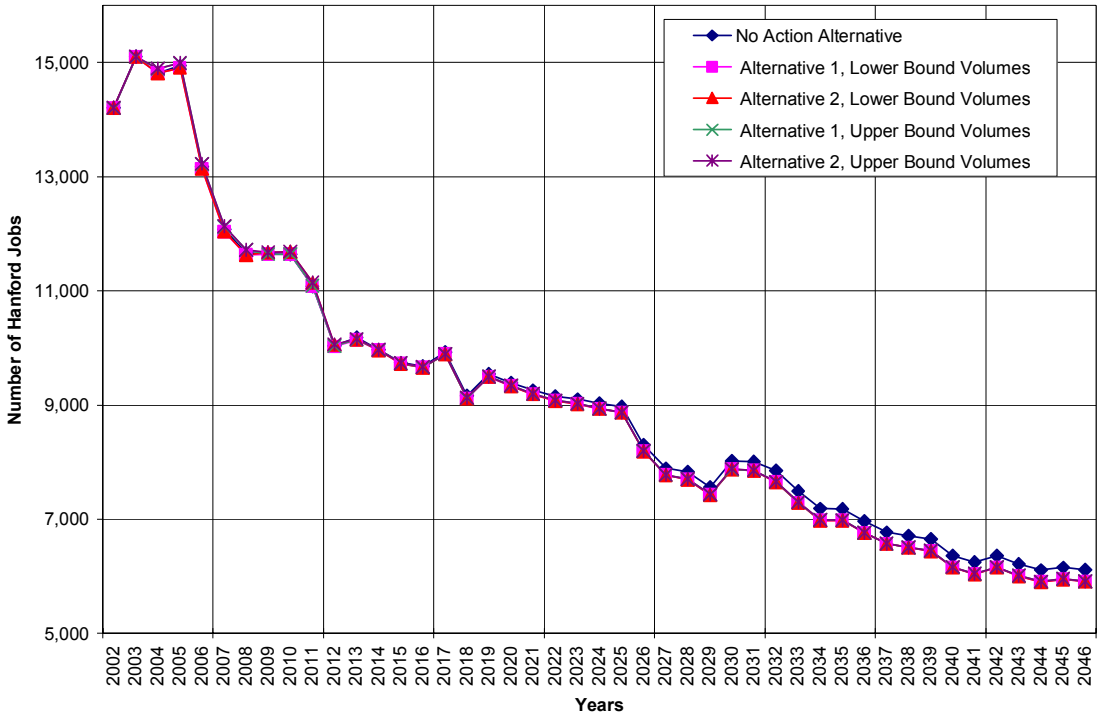

Figure 5.3. Impact of HSW EIS Alternatives on Total Hanford Employment

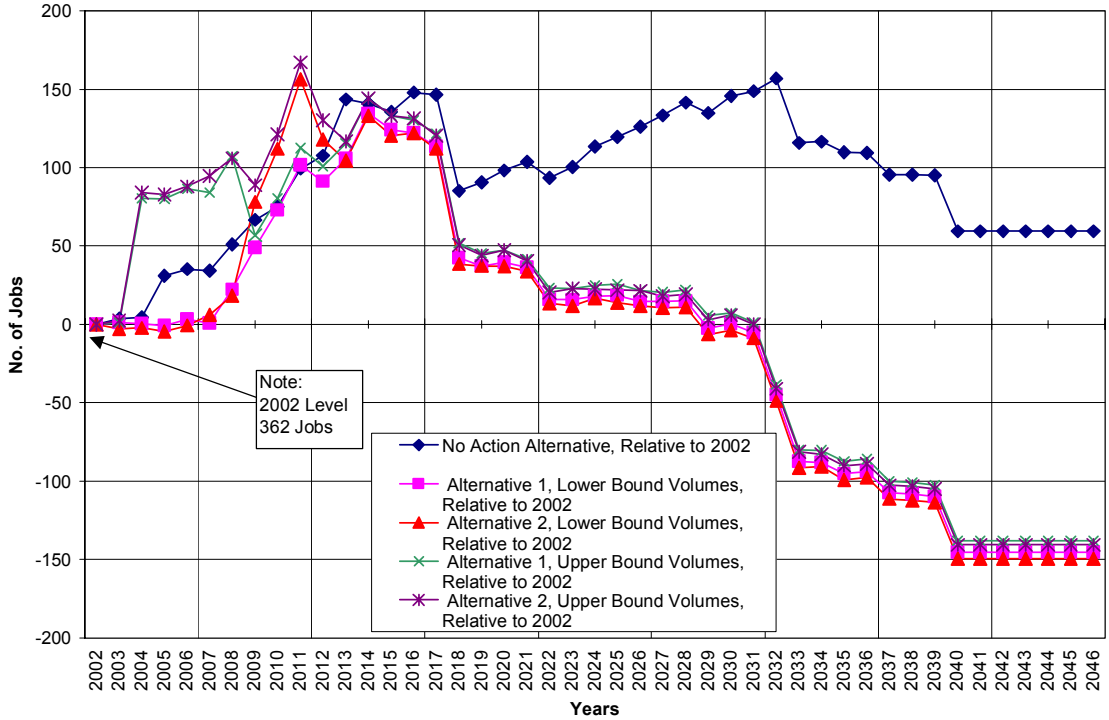

Figure 5.4. Impact of HSW EIS Alternatives on Solid Waste Program Employment

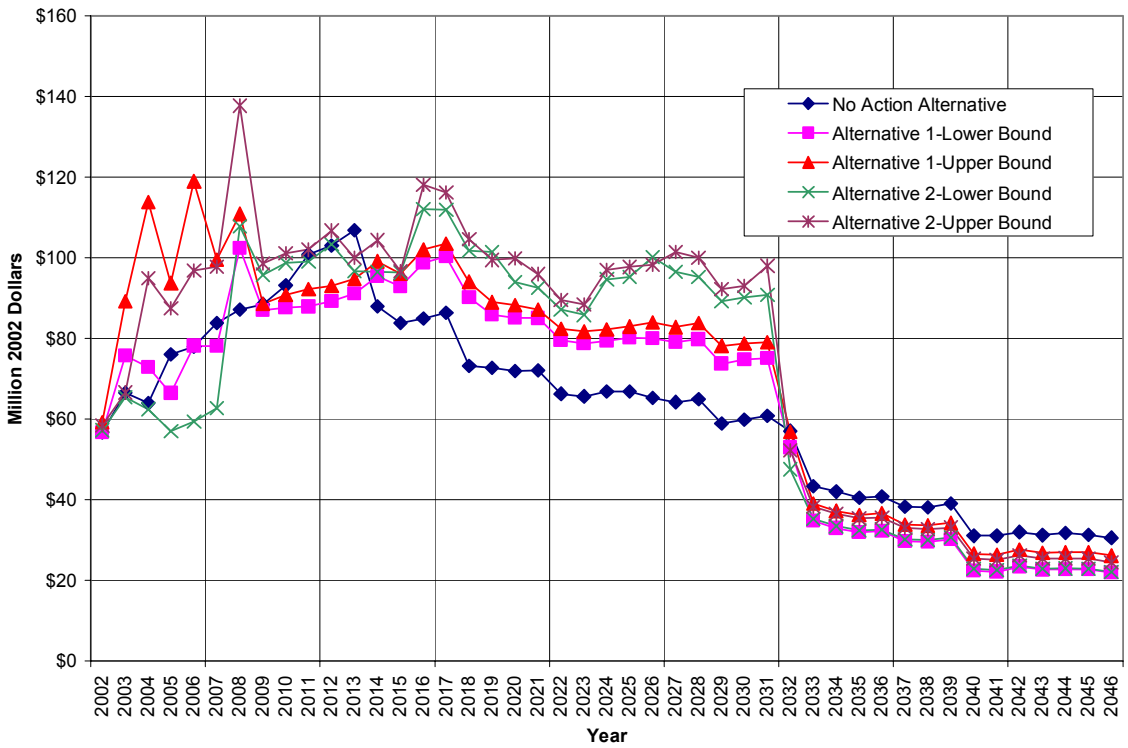

Figure 5.5. Impact of HSW EIS Alternatives on Solid Waste Program Total Cost

5.6.1 Alternative 1

Table 5.12 shows the employment and population changes related to construction and operations of the additional required facilities, relative to those expected under baseline conditions for certain key years.

For purposes of this analysis, the general level of employment and budget at the Hanford Site is assumed to otherwise follow the level discussed previously under the baseline conditions. Population impacts were calculated at 1.3 times total employment impacts, consistent with DOE (1996a). An unknown number of current Hanford workers could be reassigned to operations activities, reducing immigration to the region below the estimates shown in this section. Construction activity is assumed to require a normal proportion of new construction workers coming into the region.

Estimates of Hanford primary jobs and budget are provided in Fluor Hanford, Inc. (FH 2002). For construction activity, FH (2002) reports the construction year or years, total labor-years required, and schedule. This procedure results in an estimate of the number of jobs by year, consistent with the peak year and total labor-years required.

The solid waste program budget under Alternative 1 is projected to peak in 2016-2017, with employment slightly higher in 2014. In 2016, solid waste program employment is about 500 for both upper bound volumes and lower bound volumes, an increment of about 150 to the baseline; and there is an increment to non-labor procurements of over $60 million relative to the baseline (see Table 5.12). The

Table 5.12. Socioeconomic Impacts Associated with Alternative 1, Relative to Baseline Conditions[a]

Alternative 1	2011	2016	2033	2046
Solid Waste Program Total Budget (Million 2002$)				
Upper Bound Volumes	92.2	102.0	39.0	26.2
Lower Bound Volumes	87.9	98.8	34.8	22.0
Hanford Jobs[b]				
Solid Waste Program Total, Upper Bound Volumes	450	500	250	200
Solid Waste Program Total, Lower Bound Volumes	450	500	250	200
Impact, Upper Bound Volumes	100	150	(100)	(150)
Impact, Lower Bound Volumes	100	100	(100)	(150)
Non-labor Procurements (Million 2002$)[b]				
Solid Waste Program Total, Upper Bound Volumes	57.7	65.9	18.4	9.8
Solid Waste Program Total, Lower Bound Volumes	54.2	63.3	14.8	6.2
Impact, Upper Bound Volumes	25.0	33.2	(14.3)	(22.9)
Impact, Lower Bound Volumes	23.9	33.1	(15.5)	(24.1)
Tri-Cities Region Jobs Impacts[c]				
Upper Bound Volumes	650	850	(400)	(700)
Lower Bound Volumes	650	850	(450)	(750)
Population Change Impacts[c]				
Upper Bound Volumes	850	1,100	(550)	(900)
Lower Bound Volumes	800	1,100	(600)	(950)

(a) Numbers in parentheses denote lower level of activity (negative impact) relative to baseline conditions. Region jobs and population rounded to nearest 50.
(b) Solid waste program totals (1st two lines) and positive or negative impact, relative to 2002 (2nd two lines). These values provide bounds for impacts.
(c) Maximum positive or negative impact only (based on 2002 Tri-Cities economy).

largest total impact on community employment (Hanford and non-Hanford workers) in Tri-Cities region would be about 800-850 relative to the baseline in 2016. In Alternative 1, the level of solid waste program employment and spending drops below No Action Alternative spending almost immediately, and below 1999 levels beginning about the year 2032, reflecting an incremental reduction in the DOE mortgage (i.e., ongoing annual costs of managing and safekeeping facilities and wastes from former activities) at the Hanford Site as the CWC role is reduced and the T Plant Complex and M-91 Facility begin transition activity. As a result, a slight negative impact on the economy would occur after about 2032.

Population impact is expected to peak in 2016, with an increase in population to about 1,100. This represents an increase of about 0.5 percent over the 2000 Census[(a)] population of 191,822. Because most communities can usually handle an increases in population of up to about 5 percent without disruption in services (Gilmore and Duff 1975), the effects on demand for community infrastructure and services would be negligible due to the impact of the solid waste program alone. The impact of the long-term reduction in population of 950 shown in Table 5.6-2 is less than 0.5 percent of the 2000 baseline and likely would be very small.

5.6.2 Alternative 2

Table 5.13 shows the employment and population changes related to construction and operations of the additional required facilities, relative to those expected under baseline conditions for certain key years. Alternative 2 achieves its peak positive impact on economic activity in 2016-2017, with peak total Tri-Cities employment impact reaching about 1,050 above baseline conditions in the lower bound volume case and 1,150 in the upper bound volume case. The peak total of Tri-Cities employment increases represents a 1.3 percent increase over the 1999 baseline of 88,100 (DOE-RL 2000), the last year for which complete data are available. After 2030, the largest negative impact on employment is the loss of 700 to 750 jobs relative to the baseline in the year 2046.

Corresponding population increases and decreases range from +1,400 to +1,500 in 2016 to -900 to -950 in 2046, an increase of about 0.8 percent relative to the 2000 Census[(a)] population of 191,822, and a decrease to 0.5 percent relative to the 2000 Census value.[(a)] By themselves, these figures imply that incremental impact on demand for community infrastructure and services likely would be very small.

5.6.3 No Action Alternative

Overall, the activity associated with the No Action Alternative would result in increases in annual budgets between 2002 and 2032 to a total of as much as $106.8 million in 2013 (an increase of $50.1 million from the level in 2002) and up to 150 additional jobs onsite. After this time, employment in solid waste management operations would fall to about the baseline value, as shown in Table 5.14, while the budget would decline below the 2002 level. Overall, the Tri-Cities socioeconomic conditions would

(a) http://quickfacts.census.gov/qfd/

Table 5.13. Socioeconomic Impacts Associated with Alternative 2, Relative to Baseline Conditions[(a)]

Alternative 2	2011	2016	2033	2046
Solid Waste Program Total Budget (Million 2002$)				
Upper Bound Volumes	102.0	118.0	38.3	24.5
Lower Bound Volumes	99.0	112.0	35.3	22.1
Hanford Jobs[(b)]				
Solid Waste Program Total, Upper Bound Volumes	550	5004	300	200
Solid Waste Program Total, Lower Bound Volumes	500	500	250	200
Impact, Upper Bound Volumes	150	150	(100)	(141)
Impact, Lower Bound Volumes	150	100	(100)	(150)
Non-labor Procurements (Million 2002$)[(b)]				
Solid Waste Program Total, Upper Bound Volumes	63.7	81.7	17.6	8.2
Solid Waste Program Total, Lower Bound Volumes	61.4	76.3	15.2	6.3
Impact, Upper Bound Volumes	32.0	49.9	(14.1)	(23.6)
Impact, Lower Bound Volumes	30.9	45.8	(15.3)	(24.2)
Tri Cities Region Jobs Impacts[(c)]				
Upper Bound Volumes	900	1,150	(400)	(700)
Lower Bound Volumes	850	1,050	(450)	(750)
Population Change Impacts[(c)]				
Upper Bound Volumes	1,150	1,500	(550)	(900)
Lower Bound Volumes	1,100	1,400	(600)	(950)

(a) Numbers in parentheses denote lower level of activity (negative impact) relative to baseline conditions. Region jobs and population rounded to nearest 50.
(b) Solid waste program totals (1st two lines) and positive or negative impact, relative to 2002 (2nd two lines). These values provide bounds for impacts.
(c) Maximum positive or negative impact only.

continue as they currently are with employment increasing and fluctuating in the short run but generally declining over the long-term. Total employment at Hanford is currently expected to increase (by as much as 3,000 jobs from the level of 12,000 in 2001, the last year of historical data) through 2010, as the Hanford Tank Waste Treatment and Immobilization Plant is constructed and begins operations.

Table 5.14 shows the current solid waste program budget, employment, and estimated non-labor procurements that would continue under the No Action Alternative.

Table 5.14. Socioeconomic Impacts Associated with the No Action Alternative, Relative to Baseline Conditions[a]

No Action Alternative	2011	2013	2032	2046
Solid Waste Program Total Budget (Million 2002$)				
	100.7	106.8	57.1	30.6
Hanford Jobs[b]				
Solid Waste Program Total	450	500	500	400
Impacts	100	150	150	50
Non-labor Procurements (Million 2002$)[b]				
Solid Waste Program Total	67.1	69.9	18.9	0.4
Impacts	37.0	39.8	(11.2)	(30.5)
Tri Cities Region Impacts				
Tri-Cities Region Jobs Impacts[c]	850	1,000	150	(400)
Population Change Impacts[c]	1,100	1,300	200	(550)

(a) Numbers in parentheses denote lower level of activity (negative impact) relative to baseline conditions. Region jobs and population rounded to nearest 50.
(b) Solid waste program total (1st line) and positive or negative impact, relative to 2002 (2nd line). These values provide bounds for impacts.
(c) Maximum positive or negative impact only.

In 2002, the solid waste program required a total budget of about $57 million and employed slightly over 350 workers. As shown in Figure 5.6, in 2032 the highest direct employment year, about 150 additional employees beyond 2002 levels are needed to operate and support the solid waste program (500 total). However, the largest total impact on total community employment (Hanford and non-Hanford workers) is the year 2013, with about 1,000 workers needed beyond baseline levels (see Table 5.6-4). This impact relative to 2002 is noticeable but not large (about 0.7 percent of the 1999 base of 88,100 total non-farm jobs) (DOE-RL 2000). Population might increase above baseline by as many as 1,300 people, about 0.7 percent of the 2000 Census population of 191,822. [a]

5.7 Cultural Resources Impacts

This section describes the potential impact of implementing the alternatives on Hanford Site cultural resources, namely archaeological sites, archaeological features, artifacts, and historic buildings. In addition, several places in the vicinity of the 200 Areas have had, and continue to have, traditional roles in Native American creation beliefs and the cultural heritage of the Wanapum, the Confederated Tribes of

(a) http://quickfacts.census.gov/qfd/

the Umatilla Indian Reservation, the Nez Perce Tribe, and the Yakama Nation. These places include Gable Mountain, Gable Butte, and Rattlesnake Mountain.

Archaeological surveys of all undeveloped portions of the 200 East Area and a random sample of 50 percent of undeveloped portions of the 200 West Area indicate no findings of archaeological sites. However, some small sites exist within the boundaries of the 200 East Area and 200 West Area (Chatters and Cadoret 1990). The only evaluated historic site is the former White Bluffs freight road that crosses diagonally through the 200 West Area. The road, originally an American Indian trail, has been in continuous use as a transportation route since pre-contact history and has played a role in Euro-American immigration, regional development, agriculture, and recent Hanford Site operations. As such, the property is eligible for the National Register of Historic Places, although the segment that passes through the 200 West Area is a noncontributing element. A 100-m (328-ft) restricted zone has been created to protect the road from uncontrolled disturbance. In addition, 49 buildings in the 200 East and 200 West Areas have been evaluated and nine of these buildings are eligible for the National Register of Historic Places (DOE 1999).

For activities associated with this EIS, cultural surveys have been made of Area C (a potential borrow pit site), the T Plant Complex, and the CWC and 218-W-5 LLBG expansion areas. Details are provided in Appendix K, as are copies of consultation letters with the State of Washington Office of Archaeology and Historic Preservation.

Section 5.18 provides information regarding the protection of cultural resources discovered during construction or operations.

5.7.1 Alternative 1

The principal potential for impacts on cultural resources in Alternative 1 (both lower bound volume and upper bound volume) is associated with obtaining materials for the modified RCRA type barrier placed over the LLBGs at closure. This material, which includes basalt, sand, gravel, and silt/loam, would be obtained from a borrow pit in Area C, the location of which is shown in Figure D.9 and Figure D.10. The borrow pit is within an area of about 926 ha (2287 ac), of which about 70 ha (172 ac) would be the maximum area excavated.

Area C has been the setting for human activity from the prehistoric period through 1943. Previous archaeological investigations and historical research indicate that Native Americans used sites throughout the Cold Creek Valley, primarily near water sources, for campgrounds, ceremonial uses, plant gathering, hunting, and possibly the grazing of cattle and horses. Ethno-historic research indicates that Native American use of Area C was apparently limited to travel through the vicinity to destinations on the Columbia and Yakima rivers. Native American use prior to Euro-American contact and extending back as far as 10,000 yr possibly occurred. If so, the archaeological remains associated with that area and time period likely have been buried by sand dune activity and wind blown deposition.

Both Native Americans and Euro-Americans used trails and roads, such as White Bluffs Road to the west and north of Area C. Research also indicates a well used trail connected the Benson Ranch, on the

western boundary of Area C, to Rattlesnake Springs. Historic maps show the Ellensburg to Yakima River Road passed through Rattlesnake Springs and traversed the central and southern sections of Area C as early as 1881. A four-wheel drive dirt road in the northern section of Area C, parallel to Dry Creek, connected Cold Creek Valley with the City of Richland, prior to the construction of SR 240 through the Hanford Site. Historic occupations in the Cold Creek Valley seem to have been centered on sheep and cattle grazing, and the raising of horses. Farmsteads have been identified west of Area C where irrigation water from Rattlesnake Springs allowed for the cultivation of alfalfa and other grains.

In terms of cultural risk that construction and excavation activities associated with Area C might have on Native American spirituality is not known at this point, particularly with respect to the potential relationships between Area C and Rattlesnake Mountain. Because Area C is within the viewshed from Rattlesnake Mountain, the project might have an indirect effect on the characteristics that contribute to the cultural and religious significance of Rattlesnake Mountain to local tribes. Additional information on aesthetic and scenic impacts of these activities is presented in Section 5.12.

There is a reasonable probability that archaeological sites are located within Area C. However, any sites are likely to be buried, as the field reconnaissance failed to locate any on the surface. Little is known about the pre-contact use of the Cold Creek Valley; thus, any sites located there would provide an opportunity to gain new knowledge about prehistoric life. Further, if campsites or village sites were found, human remains and possibly cemeteries might also be located there.

Prior to construction activities associated with waste management operations, additional research as well as a 100 percent pedestrian archaeological survey would be needed to address potential cultural impacts. Given the possibility for buried deposits, some methodology would likely be needed to observe the subsurface. Ground-penetrating radar, shovel testing, or backhoe testing might be appropriate, as would monitoring for cultural resources during construction.

Modifications to T Plant are not expected to impact cultural resources. Due to the historic nature of T Plant, additional surveys and consultations would be required.

5.7.2 Alternative 2

In Alternative 2, the potential for impacts on cultural resources at the Area C borrow pit would be about 40 percent larger than for Alternative 1, based on the area disturbed (81 ha [200 ac]) to obtain the materials required for the RCRA Subtitle C cap for the LLBGs.

In this alternative, a new facility to accommodate the M-91 Capability would be located directly west of WRAP in the 200 West Area. Previous cultural resources surveys conducted in the CWC expansion area concluded that no known historic properties or archaeological resources are located within the footprint of the new facility.

5.7.3 No Action Alternative

In the No Action Alternative, materials would only be needed for a RCRA Subtitle C cap over the two MLLW trenches at closure. Thus, the amount of material required from the borrow pit would be substantially smaller than for Alternative 1 or Alternative 2. Regardless, the same approach would be necessary to protect presently undisclosed cultural resources in the Area C.

In addition, the CWC would be expanded to store MLLW and TRU waste that could not be treated or disposed of elsewhere. About 36 ha (89 ac) directly south of the existing CWC buildings would be needed, as would about 30 ha (74 ac) in the 218-W-5 Expansion Area just to the west of the CWC. Staff of the Hanford Cultural Resources Laboratory conducted a records and literature search that revealed the CWC expansion area has been previously surveyed for cultural resources. The cultural resource surveys concluded that no known historic properties or archaeological resources are located within the CWC expansion area.

5.8 Traffic and Transportation

This section evaluates the impacts of onsite shipments of LLW, MLLW, and TRU waste to treatment and disposal facilities, offsite shipments of MLLW from Hanford to offsite treatment facilities, and shipment of construction and capping materials. This section does not analyze the impacts of shipments of radioactive waste from offsite generators to Hanford treatment and disposal facilities or shipments of TRU waste from Hanford to the WIPP. Estimated impacts of transporting these materials are covered in the WM PEIS (DOE 1997a) and WIPP EIS (DOE 1997b), the Oak Ridge Reservation environmental assessment (DOE 2001c), and the Savannah River Site environmental assessment (DOE 2001d).

The types of impacts evaluated in this section include radiological and non-radiological impacts. The types of impacts evaluated and the approaches taken to quantify the transportation impacts are summarized as follows:

Radiological impacts of routine (incident-free) transport. These impacts result from routine or incident-free transportation of radioactive materials where the shipments arrive at their destinations without releasing any of the shipment contents. The impacts arise from exposing truck crews and the population on or near the highways to low radiation dose rates emitted from shipping containers that carry radioactive materials. The RADTRAN 4 computer code (Neuhauser and Kanipe 1992) was used to quantify the impacts of incident-free transportation of waste materials.

Radiological impacts of accidents. These impacts result from accidental releases of radioactive material in transit. Accident impacts are determined by combining the probabilities and consequences of potential transportation accidents, ranging from minor to severe accidents, and then integrating them over the entire shipping campaign. The RADTRAN 4 computer code was used to quantify these impacts.

Non-radiological impacts of routine transportation. Non-radiological impacts of routine transportation are the health effects that result from routine emissions of hydrocarbon pollutants and dust from the truck tractors used to haul waste and capping, and construction materials. These impacts are not related

to the radioactive nature of the waste shipments. They are calculated using a unit factor approach (that is, latent cancer fatalities per km) using data taken from Rao et al. (1982) that has been used in many past EISs.

Non-radiological impacts of traffic accidents. These impacts result from physical trauma and possible fatalities caused by traffic accidents involving the heavy trucks used to transport waste, construction, and capping materials. A unit factor approach based on accidents and fatalities per km was used to develop the non-radiological accident impacts. Unit factor data was taken from Green et al. (1996) for onsite shipments and from Saricks and Tompkins (1999) for offsite shipments.

Hazardous chemical accident impacts. These impacts are the result of potential accidental releases of hazardous chemicals that are shipped as co-contaminants with radioactive material in certain waste shipments, as well as certain shipments of hazardous chemicals, such as lead and mercury. A maximum credible accident approach was used to quantify the impacts. Hazardous chemical release and atmospheric dispersion calculations were performed to determine the maximum downwind concentration to which an individual would be exposed. The downwind concentrations were compared to safe exposure levels for each chemical to determine the potential public and worker impacts.

All of these methods are commonly used in DOE environmental documents. Detailed descriptions of these methods, the input data that were used in the transportation impact analysis, and detailed results are presented in Appendix H.

Table 5.15 presents the results of the analysis of radiological routing and accident impacts, as well as non-radiological accident and routine emission impacts. All of the impacts provided in this table are in fatalities, except for the estimated number of traffic accidents. Fatalities are expressed in latent cancer fatalities (LCFs) for radiological impacts and routine non-radiological emissions and in terms of physical trauma induced fatalities for non-radiological accidents. Note that many of the entries in the table are expressed as fractional fatalities; for example, 1E-01 or 0.1 fatalities. This format indicates a 1-in-10 probability over the entire shipping campaign that one fatality would result from the shipments. Also note the totals for each alternative are expressed both as fractions and as whole numbers. The whole number totals are provided by rounding the fractional totals to the nearest whole number.

The results in the table indicate the No-Action alternative results in the lowest transportation impacts of all the alternatives, primarily because no shipments of capping materials or offsite shipments of MLLW are made to offsite treatment facilities. However, the differences in impacts among the alternatives are small.

The results of the hazardous chemical impact analysis are presented in Table 5.16. The results indicate that downwind concentrations of only four hazardous chemicals would exceed the Temporary Emergency Exposure Limit 2 (TEEL-2) guidelines (see Appendix H for a definition of TEEL-2) following a severe transportation accident. These four chemicals are elemental lead, elemental mercury,

Table 5.15. Summary of Radiological and Non-radiological Transportation Impacts – All Alternatives

	Radiological - Incident-free (LCFs)		Radiological Accidents (LCFs)	Number of Traffic Accidents	Non-radiological	
	Crew	Public [(a)]			Traffic Fatalities	Emissions (LCFs)
Alternative 1 - Lower Bound Volume						
LLW	6.6E-02	7.0E-02	8.3E-02	6.3E-01	6.9E-02	5.5E-01
MLLW	5.7E-01	1.5E-01	9.1E-03	7.1E-01	4.8E-01	6.3E-01
TRU Waste	5.8E-03	6.9E-03	4.3E-03	5.3E-02	5.8E-03	4.6E-02
Construction Material	0.0E+00	0.0E+00	0.0E+00	3.0E+00	1.3E-01	0.0E+00
Total	1 (6.4E-01)	0 (2.7E-01)	0 (9.0E-02)	4 (3.9E+00)	1 (1.2E+00)	1 (8.6E-01)
Alternative 1 - Upper Bound Volume						
LLW	1.1E-01	1.2E-01	1.2E-01	1.1E+00	1.2E-01	9.5E-01
MLLW	6.1E-01	2.3E-01	5.0E-03	6.4E-01	1.1E+00	5.9E-01
TRU Waste	5.8E-03	6.9E-03	4.3E-03	5.3E-02	5.8E-03	4.6E-02
Construction Material	0.0E+00	0.0E+00	0.0E+00	4.0E+00	1.7E-01	0.0E+00
Total	1 (7.3E-01)	0 (3.6E-01)	0 (1.3E-01)	6 (5.8E+00)	1 (1.4E+00)	2 (1.6E+00)
Alternative 2 - Lower Bound Volume						
LLW	6.6E-02	7.0E-02	8.3E-02	6.3E-01	6.9E-02	5.5E-01
MLLW	1.7E-02	2.1E-02	4.8E-03	1.3E-01	1.5E-02	1.2E-01
TRU Waste	5.9E-03	6.9E-03	4.3E-03	5.3E-02	5.8E-03	4.6E-02
Construction Material	0.0E+00	0.0E+00	0.0E+00	3.4E+00	1.4E-01	0.0E+00
Total	0 (8.9E-02)	0 (9.8E-02)	0 (9.2E-02)	4 (4.2E+00)	0 (2.3E-01)	1 (7.1E-01)
Alternative 2 - Upper Bound Volume						
LLW	1.1E-01	1.2E-01	1.2E-01	1.1E+00	1.2E-01	9.5E-01
MLLW	5.7E-02	6.4E-02	6.5E-03	5.1E-01	5.6E-02	4.5E-01
TRU Waste	5.9E-03	6.9E-03	4.3E-03	5.3E-02	5.8E-03	4.6E-02
Construction Material	0.0E+00	0.0E+00	0.0E+00	4.7E+00	2.0E-01	0.0E+00
Total	0 (1.8E-01)	0 (1.9E-01)	0 (1.3E-01)	6 (6.4E+00)	0 (3.8E-01)	1 (1.4E+00)
No-Action						
LLW	6.6E-02	7.0E-02	8.3E-02	6.4E-01	7.0E-02	5.5E-01
MLLW	1.4E-02	7.6E-03	2.6E-03	5.9E-03	2.2E-02	6.0E-03
TRU Waste	5.5E-03	5.9E-03	3.5E-03	5.1E-02	5.6E-03	4.5E-02
Construction Material	0.0E+00	0.0E+00	0.0E+00	8.8E-01	3.2E-02	0.0E+00
Total	0 (8.6E-02)	0 (8.4E-02)	0 (8.9E-02)	2 (1.6E+00)	0 (1.3E-01)	1 (6.0E-01)

(a) Includes non-involved workers.

Table 5.16. Hazardous Chemical Concentrations (mg/m ^{3}) 100 m (109 yd) Downwind from Severe Transportation Accidents

Hazardous Constituent	Concentration, mg/m^3					
	TEEL-2 Value[(a)]	MLLW [(b)]	TRU Waste [(b)]	Elemental Mercury	Elemental Lead	Comments
Acetone	8500	0.49	0	0	0.004	
Ammonium Fluoride	12.5	0.19	0	0	0	
Ammonium Nitrate	50	0.19	0	0	0	
Ammonium Sulfate	500	0.38	0	0	0	
Beryllium	0.025	0.14	0.0049	0	0	IDLH = 10 mg/m^3[(c)]
Butyl Alcohol	50	0.03	0.012	0	0	
Carbon Tetrachloride	100	0.89	0.024	0	0	
Cyclohexane	1300	0.09	0	0	0	
Ethanol	3300	0.49	0.0049	0	0	
Hydrazine	0.8	0.21	0	0	0	
Isopropyl Alcohol	400	0.71	0	0	0	
Lead	0.25	0	0	0	5.0	IDLH = 700 mg/m^3[(c)]
Mercury	0.1	0	0	0.67	0	IDLH = 10 mg/m^3[(c)]
Methanol	1000	0.95	0	0	0	
Methyl Ethyl Ketone	0.2	0.58	0	0	0	IDLH = 9000 mg/m^3[(c)]
Methyl Isobutyl Ketone	500	0.80	0	0	0	
Nitric Acid	15	1.48	0.0049	0	0	
Phosphoric Acid	500	1.27	0.0073	0	0	
Potassium Hydroxide	2	1.37	0	0	0	
Propane	2100	0	0.0097	0	0	
Sodium Hydroxide	40	1.86	0.15	0	0	
Styrene	250	0.04	0	0	0	
Sulfuric Acid	10	0.08	0.036	0	0	
Tetrahydrofuran	2000	0.07	0	0	0	
Toluene	300	2.53	0	0	0	
Uranium	1	0.009	0	0	0	
Xylene	200	1.26	0.10	0	0	

(a) Source: Craig (2001).
(b) Inventory represents bounding quantities for either CH or RH wastes.
(c) IDLH = Immediately Dangerous to Life and Health. Source: National Institute for Occupational Safety and Health (NIOSH 1990).

methyl ethyl ketone (synonym, 2-butanone), and beryllium. For these four chemicals, the Immediately Dangerous to Life and Health (IDLH) values are provided in the table for additional perspective. IDLH concentrations are defined as:

IDLH: The maximum concentration from which, in the event of respirator failure, a person could escape within 30 minutes without a respirator and without experiencing any escape-impairment (for example, severe eye irritation) or irreversible health effects.

The downwind concentrations of all four of the IDLH chemicals are well below their respective IDLH values. Based on these observations, the conclusion was that releases of hazardous chemicals from transportation accidents involving waste materials are unlikely to result in a fatality.

5.9 Noise

Noise is technically defined as sound that is unwanted and perceived as a nuisance by humans, in this case the public in the environs of the Hanford Site.

Potential impacts of noise on the public from implementing the alternatives are addressed in the following sections. The analytical methods used to arrive at the conclusions drawn in this section are presented in Appendix J.

In the course of implementing any of the alternatives, various waste management construction and operations activities would generate noise. The total workforce associated with the alternatives would not likely exceed 600, which would cause a negligible addition to traffic noise.

For protection of the public the Washington Administrative Code (WAC 173-60) has established a limit for daytime residential noise levels of 70 dBA at industrial site boundaries. No actual human habitations would be located within 10 km (~6 mi) of the 200 Areas boundary, or the borrow pit area north of SR 240 on the south, thus assuring that WAC limits would not be exceeded.

The closest point of transient public access to the 200 Areas is about 2 km (~1 mi) on SR 240, however there are only emergency turnouts on SR 240 in that area.

Although in the above noise is defined in terms of human perception, sound can also be disturbing to wildlife. Since wildlife can freely relocate to areas of less sound intrusion, no substantial adverse sound based impacts from waste management activities are anticipated.

Again, although not noise in the above sense, a potential for impacts on research conducted at the Laser Interferometer Gravitational Wave Observatory (LIGO) from ground vibrations might exist. The major source of such ground vibrations would be associated with excavation for capping materials in Area C where the closest distance to one of the LIGO detection arms is about 9 miles. The impacts, if any, would be similar for any of the alternatives, however these have not been quantified.

5.9.1 Alternative 1

The principal activities associated with Alternative 1 (for either the lower bound volume or upper bound volume) would be modification of the T Plant Complex for the M-91 Capability; construction of deeper and wider trenches; loading, backfilling, and closure of the LLBGs; operation of WRAP, T Plant, and CWC; operation of pulse driers for MLLW leachate; onsite transport of construction materials and waste; transport of MLLW offsite for treatment; and transport of construction materials to the Site. Because of the distance from the sources of noise from these activities, noise levels would be less than 70 dBA at the Site boundary.

Material for capping LLBGs at closure would be acquired from the borrow pit at Area C south of SR 240 and would result in higher, but localized, noise levels from use of heavy equipment, which in the absence of prolonged presence of the public in the vicinity would not likely result in a noticeable impact. Because there are no residential areas in the vicinity, Washington State standards for noise would not be exceeded.

Incremental noise in communities through which relatively small amounts of MLLW is transported for offsite treatment would be negligible when compared to background highway noise.

5.9.2 Alternative 2

The principal activities associated with Alternative 2 (for either the lower bound volume or upper bound volume) would be construction and operation of a new facility for the M-91 Capability; construction of current design rather than deeper and wider trenches, loading, backfilling, and closure of the LLBGs; operation of WRAP, T Plant Complex, and CWC; operation of pulse driers for MLLW leachate beginning in 2026; onsite transport of construction materials and waste; transport of MLLW offsite for treatment; and transport of construction materials to the Site. As in the case of Alternative 1, noise levels resulting from these activities would be less than 70 dBA at the Site boundary.

The volume of capping materials required in Alternative 2 would be about 40 percent more than in Alternative 1, but would result in similar noise levels, and the activities would extend over a longer period of time.

5.9.3 No Action Alternative

The principal activities associated with the No Action Alternative would be construction of 66 additional CWC buildings for storage of MLLW and TRU waste; construction of additional LLW trenches of current design, loading, and backfilling; capping of existing MLLW trenches; operation of WRAP, T Plant Complex, and CWC; operation of pulse driers for MLLW leachate beginning in 2026; onsite transport of construction materials and waste; transport of MLLW offsite for treatment; and transport of construction materials to the Site. Again, noise levels resulting from these activities would be less than 70 dBA at the Site boundary.

About 3 percent of the volume of capping materials required in Alternative 1 (for the lower bound volume) would be required to cap MLLW trenches per regulation. The noise levels associated with extraction from the borrow pit would be similar to those for Alternative 1, but the activities would occur over a much shorter time.

5.10 Resource Commitments

Various energy and material resources would be committed in the implementation of any of the three alternatives. Estimates of major resources committed are summarized by alternative in Table 5.17.

Table 5.17. Resource Commitment Summary by Alternative

Resource	Alternative 1		Alternative 2		No Action Alternative
	Lower Bound Volume	Upper Bound Volume	Lower Bound Volume	Upper Bound Volume	
Energy					
Electricity					
Total Electrical Energy - GWhr	709	739	843	873	685
Peak Annual Energy - GWhr	39	42	56	59	24
Diesel Fuel – m^3 (1,000 gal)	22,000 (5,800)	36,000 (9,700)	27,000 (7,000)	42,000 (11,000)	2,400 (630)
Gasoline – m^3 (1,000 gal)	170 (45)	280 (71)	290 (76)	400 (110)	80 (21)
Propane – m^3 (1,000 gal)	16,000 (4,300)	16,000 (4,300)	19,000 (5,000)	22,000 (5,800)	1,600 (410)
Materials					
Asphalt – 1,000 m^3 (1,000 yd^3)	260 (330)	280 (360)	300 (390)	350 (460)	5.7 (7.4)
Gravel/Sand – 1,000 m^3 (1,000 yd^3)	1,300 (1,800)	1,400 (1,900)	1,600 (2,000)	1,800 (2,400)	10 (13)
Silt/Loam – 1,000 m^3 (1,000 yd^3)	490 (630)	530 (690)	570 (740)	670 (880)	30 (40)
Basalt –1,000 m^3 (1,000 yd^3)	370 (480)	400 (520)	430 (560)	510 (660)	8.1 (11)
Bentonite clay – 1,000 tonnes (1,000 tons)	22 (24)	43 (47)	24 (26)	48 (52)	0
Steel – tonnes (tons)	2,600 (2,900)	4,500 (5,000)	2,700 (3,000)	4,700 (5,300)	9,400 (10,000)
Concrete – 1,000 m^3 (1,000 yd^3)	55 (70)	78 (100)	57 (75)	97 (100)	86 (110)
Total Water Usage – 1,000 m^3 (M gal)	150 (40)	640 (170)	160 (44)	650 (170)	140 (36)
Lead – tonnes (tons)	45 (50)	45 (50)	45 (50)	45 (50)	45 (50)

As shown in Table 5.17, resource commitments within an alternative are generally proportional to the volume of waste to be managed. Furthermore, Alternative 2 requires more resources primarily due to the use of the current trench design versus the enhanced (deeper/wider) trench design accounted for in Alternative 1. The most notable difference in resource usage is within the No Action Alternative. The No Action Alternative shows increased steel and concrete usage relative to the other alternatives due to the construction of 66 new CWC facilities provided in the No Action Alternative. However, the No Action Alternative also shows the least amount of diesel, propane, gasoline, capping materials, and water usage. The resource commitments presented in Table 5.17 would not be expected to impact available supplies or activities requiring these same resources.

In the event that LLW trenches were constructed with liners, similar to MLLW trenches, the commitment for propane would increase due to the need to process the leachate collected from the LLW trenches. The commitment for bentonite would also increase due to construction of the trench liners. In other respects, impacts of LLW trenches would be similar to the impacts for MLLW trenches.

5.11 Human Health and Safety Impacts

Health impacts to workers and the public are presented in this section. The methods used to estimate health impacts from radiological and chemical sources are described in Appendix F. The health impacts included in this section are those related to:

- airborne release of radionuclides and chemicals from routine and accident conditions (excluding transportation)
- waterborne releases (via groundwater) over the long-term
- construction activities
- fugitive releases of criteria pollutants
- inadvertent intrusion into burial grounds.

Potential health effects are included in this section for the following receptors:

1. <u>construction workers</u> – workers involved with construction activities
2. <u>involved workers</u> – workers directly involved in the activity being discussed
3. <u>non-involved workers</u> – workers physically near the activity being discussed, but not directly involved in the activity
4. <u>maximally exposed individuals (MEI) from atmospheric release</u> – hypothetical member of the public who receives, through airborne emissions, the highest health impacts from onsite activities

5. maximally exposed individuals from waterborne releases – hypothetical, member of the public who receives, through waterborne emissions, the highest health impact from onsite activities

6. local populations – the population within 50 miles (80 km) of the center of the Hanford Site exposed to airborne releases

7. downstream populations –the entire population of Pasco, Kennewick, and Richland (Tri-Cities), Washington, or of Portland, Oregon

8. maximally exposed individuals from inadvertent intrusion into burial grounds – hypothetical, individual receiving the highest impact following inadvertent intrusion into the burial grounds

Impacts from construction activities include injuries to workers and impacts on air quality. Details of the air quality impact analysis for construction are presented in Section 5.2. The analysis of impacts on water quality (from waterborne releases to groundwater) is described in Section 5.3. Those sections compare air and water concentrations to appropriate limits. Results from those analyses have been extended to the estimates of human health impacts that are presented in this section. The analysis of impacts from potential releases and exposures to radionuclides and chemicals, as a result of transportation of wastes, is described in Section 5.8.

Health impacts are presented by alternative. The methods, assumptions, and related information for routine release assessment and accident analysis are provided in Appendix F.

Construction worker injuries are estimated using standard construction worker accident rate information (described in Section 4.10) and the construction workforce projections for each facility that involves construction for a given alternative. The analysis includes all of the operations involving construction for each alternative. Consideration is also given to the type of construction activity (i.e., heavy equipment operation versus building construction). Worker injuries during normal operations are evaluated using incident rates for industrial accidents.

Radiation doses as total effective dose equivalent (TEDE) for workers involved in waste management activities were estimated using historical worker dose rates for Hanford facilities and the projection of the workforce involved (FH 2002).

Releases of radionuclides and chemicals to the atmosphere are evaluated for each solid waste facility based on the projected waste throughput volumes. Estimates are made of the annual release of pollutants to the atmosphere based on these processing volumes, the concentration of radionuclides and chemicals, and the release fractions for each facility. These release rates are used to estimate air concentrations at points of maximum exposure for the onsite worker and the offsite MEI. Individuals are assumed to be exposed to these transported pollutants through exposure pathways defined for each of two hypothetical exposure scenarios: industrial and resident gardener. The industrial scenario is used to evaluate the maximum health impacts for onsite non-involved workers who are assumed to be located at 100 m (329 ft) from the release point. The resident gardener scenario is used to evaluate potential public

exposures. Consequences from accidental releases are based primarily on previously reported accident assessments for the facilities involved in the alternatives.

Releases of radionuclides and chemicals to the unsaturated soil beneath the LLBGs may occur as the waste packages degrade and water seeps through the waste. The potential sources of groundwater contamination are wastes contained in LLBGs in the 200 East and 200 West Areas.

The movement of pollutants from these releases to the affected environment has been analyzed and described in Section 5.3. Users of the groundwater down gradient from the waste disposal sites may be exposed to contaminants in the water. Potential human health impacts from use of such groundwater were estimated for three locations. The first two are hypothetical wells at 1 km down gradient from the 200 East and 200 West Areas. The third location is a well near the Hanford Townsite on the Columbia River[(a)] representing a reasonable point of access by a resident gardener. Details of these exposure scenarios are presented in Appendix F.

The impacts to populations downstream of Hanford have also been evaluated for Tri-Cities, Washington, and Portland, Oregon. The entire populations of the cities were assumed to use the Columbia River as the sole source of drinking water (presently not the case for Portland nor for the Tri-Cities). The concentration in the river is based on the total amount of radionuclides reaching the river over the next 10,000 yr, as evaluated for the water quality analysis of Section 5.3. For the present analysis, a conservative discharge rate of 0.5 m^3/sec has been used. The release to the river is diluted in the average Columbia River flow rate at two exposure locations of about 3300 m^3/sec at the Tri-Cities and about 5300 m^3/sec at Portland.

Results of the consequence analyses are presented as annual radiation dose and lifetime radiation dose for individual exposures, and as cumulative radiation dose for population exposures. The associated human health impacts are represented as the lifetime risk of a LCF based on recommendations of the International Commission on Radiological Protection (ICRP 1991).[(b)] For workers, the LCF estimates are based on a conversion factor of 0.0004 LCFs per person-rem TEDE.[(c)] For the public, the estimates are based on 0.0005 LCFs per person-rem TEDE.

For radiological accidents discussed in this EIS, the doses estimated for some hypothetical events may be greater than the doses at which the ICRP health effects coefficients were intended to apply. Depending on the radionuclides involved and the exposure pathways considered, the LCF risk may be up to twice that indicated by the LCF conversion factors for doses greater than 20 rem but less than a few

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(a) Although water might be drawn directly from the river for irrigation, it would be likely that well water would be used for domestic purposes.

(b) For an individual, the probability of a latent cancer fatality cannot exceed one (certainty). Similarly, the number of LCFs among population groups occurs as whole numbers; the calculated value is given in parentheses. This calculated value represents an inferred incremental contribution to total cancer deaths in the exposed population.

(c) The ICRP estimates are similar to those developed by other organizations (for example, Eckerman *et al*. 1999).

hundred rem. For doses greater than a few hundred rem, there is a potential for short-term health effects other than cancer and hereditary effects, again depending on the radionuclides and exposure pathways associated with a particular accident scenario. Because of the uncertainties surrounding these dose and risk estimates, the health risks presented in this document do not attempt to account for variations in risk due to dose level or dose rate. Additional information on the basis for radiological health consequences is given in Appendix F.

The routine operations health impacts from carcinogenic chemicals are presented as the lifetime risk of cancer incidence from exposure in the given scenario. For non-carcinogenic chemicals, the impacts are expressed as a Hazard Quotient. Both types of impacts are presented as the sum over all chemicals in the release of the given type. A Hazard Quotient of one represents an exposure level that is considered safe for most members of the population (EPA 1991). A value greater than one may represent an exposure that is detrimental to public health.

The health impacts to workers from chemicals due to accidents are evaluated by comparing chemical air concentrations to emergency response planning guideline (ERPG), or TEEL. These are described in Appendix F. Although ERPGs are the official, preferred measure, ERPGs have not been established for many chemicals. Where ERPGs were not available, the TEELs were used.

The following sections present details of the human health impact analyses for the three alternatives considered in this EIS. For a summary comparison of impacts among the alternatives, see Table 3.6 in Section 3.6.

5.11.1 Alternative 1

The following sections present the potential human health impacts for Alternative 1 for both the upper and lower bound volume cases.

5.11.1.1 Construction

Primary impacts from construction activities would be air quality and injuries to construction workers. The construction activities would result in the emission of Criteria Pollutants (40 CFR 50) from the use of combustion engines and earthmoving activities. Impacts are measured by comparison of air concentrations with regulatory limits at the point of maximum potential public exposure. The air quality analysis (Section 5.2) indicates that maximum emissions of all Criteria Pollutants (including sulfur dioxide, carbon monoxide, nitrogen dioxide, and PM_{10}) from construction activities would result in air concentrations below 15 percent of the regulatory limits. As a consequence, no impacts on public health from emissions would be expected. Impacts from industrial accidents during construction are discussed in Section 5.11.1.4.

5.11.1.2 Normal Operations

Potential impacts to public health from normal operations include impacts from atmospheric releases of radionuclides and chemicals from waste management operations. Radiation doses for workers

involved with waste management operations are also evaluated. Long-term impacts of releases to groundwater from LLBGs are discussed in Section 5.11.1.3.

Alternative 1 involves operations that may result in routine releases of radionuclides and chemicals to the atmosphere. These operations include waste package verification, treatment, and packaging at WRAP, treatment and packaging of waste at the modified T Plant Complex, as well as treatment of leachate from MLLW trenches using pulse driers. The annual releases have been estimated for each year of operation for the facilities involved in this alternative. Details of the release calculations are presented in Appendix F.1.

5.11.1.2.1 Health Impacts from Routine Radionuclide Releases

See Table 5.18 for the calculated doses and health impacts to non-involved workers and public from routine atmospheric releases of radionuclides for the lower bound volume case. See Table 5.19 for the upper bound volume case. The tables present the maximum annual dose to the non-involved workers and the public, the cumulative dose to the public, and the associated risk of LCF for these exposures occurring during the period covered by Alternative 1. Given that the doses and cancer risk estimates are small, no adverse health impacts would be expected from radionuclide releases.

5.11.1.2.2 Health Impacts from Chemical Releases

Releases of chemicals to the atmosphere could occur for the same processes involving radionuclide release when wastes with hazardous chemicals are involved. The potential health impacts from chemical releases to the atmosphere are presented in Table 5.20 for both the lower and upper bound volume cases. Since the peak Hazard Quotients are all less than 1, and because the cancer risk estimates are small, minimal adverse health impacts would be expected from chemical releases. Chemical releases from leachate treatment using a pulse drier are believed to be small compared to other processing (for example, WRAP) and are not included in the analysis of chemical health impacts.

5.11.1.2.3 Worker Occupational Radiation Exposure

The radiation dose received by workers involved with waste operations is estimated using historical exposure data for the facilities involved in the alternative (FH 2002). The exposure to involved workers is summarized in Table 5.21 for the lower bound volume case and in Table 5.22 for the upper bound volume case. The worker category Other includes engineers, maintenance and construction personnel, and general support staff (for example, administrative and clerical workers). All estimated health impacts to workers from radiation are below levels of concern.

5.11.1.3 Post Closure Assessment

This section considers potential impacts on human health over long time periods. The impacts are evaluated for releases to soil and groundwater, with subsequent transport to the Columbia River, and for inadvertent intrusion into the LLBGs in the absence of institutional controls.

Table 5.18. Non-Involved Worker and Public Health Impacts from Routine Atmospheric Releases of Radionuclides for the Alternative 1 Lower Bound Volumes

Exposed Group	Exposure Scenario[a]	Facility	Lifetime Dose mrem	Probability of LCFs[b]	Maximum Annual Dose	
					Year	Dose mrem
Worker Onsite (non-involved)	Industrial	WRAP	1.4E-3	5.7E-10	2004	1.6E-4
		Modified T Plant Complex	5.7E-1	2.3E-7	2003	4.7E-2
		Leachate Treatment[c,f]	5.7E-8	2.3E-14	2026	3.2E-9
		Total	5.8E-1	2.3E-7	2003	4.8E-2
MEI Offsite	Resident Gardener	WRAP	1.2E-4	5.8E-11	2004	1.2E-5
		Modified T Plant Complex	1.7E-3	8.6E-10	2003	1.2E-4
		Leachate Treatment	3.0E-11	1.5E-17	2026	1.6E-12
		Total	1.8E-3	9.2E-10	2003	1.3E-4
			person-rem	**Number of LCFs[e]**	**Year**	**person-rem**
Population[d]	Population within 80 km (50 mi)	WRAP	8.3E-3	0 (4E-6)	2004	8.8E-4
		Modified T Plant Complex	1.2E-1	0 (6E-5)	2003	8.5E-3
		Leachate Treatment	2.1E-9	0 (1E-12)	2026	1.1E-10
		Total	1.3E-1	0 (6E-5)	2003	9.4E-3

(a) The exposure duration for the industrial scenario is 20 yr and for the resident gardener 30 yr. The exposure scenarios are described in Appendix F.
(b) LCF = latent cancer fatality. For individuals, the LCF value is the risk of cancer death as the result of the postulated exposure. For population impacts, LCFs are the expected number of cancer deaths in the exposed population.
(c) Leachate treatment is pulse drier operation.
(d) The population lifetime impacts are based on exposure for the same exposure pathways impacting the resident gardener MEI.
(e) The value in parentheses is the calculated value based on the population dose and the appropriate health effects conversion factor. The actual number of LCFs must be a whole number (deaths).
(f) If LLW trenches were to be lined, the doses from leachate collection and treatment might be as much as three times the leachate treatment values shown in the table above.

Table 5.19. Non-Involved Worker and Public Health Impacts from Routine Atmospheric Releases of Radionuclides for the Alternative 1 Upper Bound Volume

Exposed Group	Exposure Scenario[a]	Facility	Lifetime Dose mrem	Probability of LCFs[b]	Maximum Annual Dose	
					Year	mrem
Worker Onsite (non-involved)	Industrial	WRAP	2.1E-3	8.6E-10	2004	1.9E-4
		Modified T Plant Complex	8.8E-1	3.5E-7	2006	7.2E-2
		Leachate Treatment[c,f]	1.1E-7	4.3E-14	2026	5.9E-9
		Total	8.8E-1	3.5E-7	2006	7.2E-2
MEI Offsite	Resident Gardener	WRAP	2.1E-4	1.1E-10	2004	1.6E-5
		Modified T Plant Complex	2.5E-3	1.2E-9	2006	1.7E-4
		Leachate Treatment	5.6E-11	2.8E-17	2026	2.9E-12
		Total	2.7E-3	1.4E-9	2006	1.9E-4
			person-rem	**Number of LCFs[e]**	**Year**	**person-rem**
Population[d]	Population within 80 km (50 mi)	WRAP	1.5E-2	0 (8E-6)	2004	1.1E-3
		Modified T Plant Complex	1.8E-1	0 (9E-5)	2006	1.2E-2
		Leachate Treatment	3.9E-9	0 (2E-12)	2026	2.0E-10
		Total	1.9E-1	0 (1E-4)	2006	1.3E-2

(a) The exposure duration for the industrial scenario is 20 yr and for the resident gardener 30 yr. The exposure scenarios are described in Appendix F.
(b) LCF = latent cancer fatality. For individuals, the LCF value is the risk of cancer death as the result of the postulated exposure. For population impacts, the LCF is the expected number of cancer deaths in the exposed population.
(c) Leachate Treatment is pulse drier operation.
(d) Population lifetime impacts are based on the same exposure pathways impacting the resident gardener MEI.
(e) The value in parentheses is the calculated value based on the population dose and the appropriate health effects conversion factor. The actual number of LCFs must be a whole number (deaths).
(f) If LLW trenches were to be lined, the doses from leachate collection and treatment might be as much as three times the leachate treatment values shown in the table above.

Table 5.20. Non-Involved Worker and Public Health Impacts from Routine Atmospheric Releases of Chemicals for Alternative 1 Lower and Upper Bound Volumes

Volume	Exposed Group	Exposure Scenario [(a)]	Facility	Risk of Cancer Incidence[(b)]	Peak Annual Hazard Quotient[(b)]
Lower Bound	Worker Onsite (non-involved)	Industrial	WRAP	1.2E-9	8.9E-5
			Modified T Plant Complex	3.2E-8	2.3E-3
			Total	3.4E-8	2.4E-3
	MEI Offsite	Gardener	WRAP	5.6E-11	3.4E-6
			Modified T Plant Complex	1.1E-10	9.9E-6
			Total	1.7E-10	1.3E-5
	Population	Population within 80 km (50 mi)	WRAP	0 (4E-6)[(c)]	NA[(d)]
			Modified T Plant Complex	0 (8E-6)[(c)]	NA
			Total	0 (1E-5)[(c)]	NA
Upper Bound	Worker Onsite (non-involved)	Industrial	WRAP	5.3E-9	6.8E-4
			Modified T Plant Complex	1.8E-7	2.4E-3
			Total	1.8E-7	2.5E-2
	MEI Offsite	Gardener	WRAP	2.2E-10	2.5E-5
			Modified T Plant Complex	2.0E-10	2.5E-5
			Total	4.2E-10	5.1E-5
	Population	Population within 80 km (50 mi)	WRAP	0 (2E-5)[(c)]	NA[(d)]
			Modified T Plant Complex	0 (1E-5)[(c)]	NA
			Total	0 (3E-5)[(c)]	NA

(a) The exposure duration for the industrial scenario is 20 yr and for the resident gardener 30 yr. The exposure scenarios are described in Appendix F.
(b) The individual risk of cancer incidence is evaluated for the exposure duration defined for the given exposure scenario starting in the year that provides the highest total impact. Hazard Quotients are reported for the year of highest exposure.
(c) Population risk from cancer is expressed as the inferred number of fatal and non-fatal cancers in the exposed population over the lifetime of the population from intakes during the remediation period. The actual value must be a whole number (cancers).
(d) Hazard Quotients are designed as a measure of impacts on an individual and are not meaningful for population exposures.

Table 5.21. Occupational Radiation Exposure for Alternative 1 Lower Bound Volumes

Facility	Operating Period	Worker Category	Workers (FTE)[a]	Average Dose Rate, mrem/yr	Workforce Dose, person-rem	Workforce LCF[c]
LLW and MLLW Trenches	2002- 2046	Operator	14	54	34	0 (1.4E-2)
		RCT[b]	4	45	8.5	0 (3.4E-3)
		Other	66	35	104	0 (4.1E-2)
CWC	2002- 2046	Operator	12	54	29	0 (1.2E-2)
		RCT	4	45	8.6	0 (3.5E-3)
		Other	55	17	42	0 (1.7E-2)
WRAP	2002- 2032	Operator	13	18	7.3	0 (2.9E-3)
		RCT	9	36	10	0 (4.0E-3)
		Other	29	13	12	0 (4.7E-3)
	2033- 2039	Operator	9	18	1.2	0 (4.7E-4)
		RCT	6	36	1.6	0 (6.5E-4)
		Other	21	13	1.9	0 (7.5E-4)
Modified T Plant Complex	2002- 2032	Operator	20	9	5.6	0 (2.2E-3)
		RCT	18	13	7.3	0 (2.9E-3)
		Other	38	7	8.2	0 (3.3E-3)
	2033- 2046	Operator	14	9	1.7	0 (7.0E-4)
		RCT	13	13	2.3	0 (9.3E-4)
		Other	27	7	2.6	0 (1.0E-3)
	2013 – 2031 (M-91 Facility)	Operator	10	13	2.6	0 (1.0E-3)
		RCT	10	13	2.4	0 (9.5E-4)
		Other	20	13	4.9	0 (2.0E-3)
Generator Staff[d]	2002-2019	Operator	15	34	9.2	0 (3.7E-3)
		RCT	12	35	8	0 (3.0E-3)
	2020-2026	Operator	5	34	1.2	0 (4.8E-4)
		RCT	3	35	0.7	0 (2.9E-4)
	2027-2044	Operator	1	34	0.6	0 (2.4E-4)
		RCT	1	35	0.6	0 (2.5E-4)
Pulse Driers	2026- 2077	Operator	0.9	54	2.6	0 (7.2E-4)
Total for Alternative 1 Lower Bound Volume Case					320	0 (1.3E-1)

(a) The number of workers is the average necessary for the facility during the indicated period.
(b) RCT – Radiation Control Technician
(c) Workforce LCFs are the inferred number of cancer deaths in the exposed workforce, which must be a whole number (deaths). The value in parentheses is the calculated value based on the workforce dose and the appropriate health effects conversion factor.
(d) Staff in the solid waste support services group that work as needed in various solid waste facilities.

Table 5.22. Occupational Radiation Exposure for Alternative 1 Upper Bound Volumes

Facility	Operating Period	Worker Category	Workers (FTE)[a]	Average Dose Rate, mrem/yr	Workforce Dose, person-rem	Workforce LCF[c]
LLW and MLLW Trenches	2002- 2046	Operator	14	54	34	0 (1.4E-2)
		RCT	4	45	8.5	0 (3.4E-3)
		Other	66	35	104	0 (4.1E-2)
CWC	2002-2046	Operator	12	54	29	0 (1.2E-2)
		RCT	4	45	8.6	0 (3.5E-3)
		Other	55	17	42	0 (1.7E-2)
WRAP	2002-2032	Operator	13	18	7.3	0 (2.9E-3)
		RCT	9	36	10	0 (4.0E-3)
		Other	29	13	12	0 (4.7E-3)
	2033-2039	Operator	9	18	1.2	0 (4.7E-4)
		RCT	6	36	1.6	0 (6.5E-4)
		Other	32	13	2.9	0 (1.2E-3)
Modified T Plant Complex	2002-2032	Operator	20	9	5.5	0 (2.2E-3)
		RCT	18	13	7.4	0 (2.9E-3)
		Other	38	7	8.2	0 (3.3E-3)
	2033-2046	Operator	14	9	1.7	0 (7.0E-4)
		RCT	13	13	2.3	0 (9.3E-4)
		Other	27	7	2.6	0 (1.0E-3)
	2013 – 2031 (M-91 Facility)	Operator	10	13	2.6	0 (1.0E-3)
		RCT	10	13	2.4	0 (9.5E-4)
		Other	20	13	4.9	0 (2.0E-3)
Generator Staff[d]	2002-2019	Operator	20	34	12	0 (4.9E-3)
		RCT	13	35	8.2	0 (3.3E-3)
	2020-2026	Operator	7	34	1.7	0 (6.7E-4)
		RCT	5	35	1.2	0 (4.9E-4)
	2027-2044	Operator	3	34	1.8	0 (7.3E-4)
		RCT	2	35	1.3	0 (5.0E-4)
Pulse Driers	2026-2077	Operators	0.9	54	2.5	0 (1.0E-3)
Total for Alternative 1 Upper Bound Volume Case					327	0 (1.3E-1)

(a) The number of workers is the average necessary for the facility during the indicated period.
(b) RCT – Radiation Control Technician
(c) Workforce LCFs are the inferred number of cancer deaths in the exposed workforce, which must be a whole number (deaths). The value in parentheses is the calculated value based on the workforce dose and the appropriate health effects conversion factor.
(d) Staff in the solid waste support services group that work as needed in various solid waste facilities.

The potential consequences to the MEI, using the resident gardener scenario for the 1-km wells evaluated over a period of 10,000 yr from closure of the LLBGs, are presented in Table 5.23 for lower bound volume case and Table 5.24 for the upper bound volume case. The potential consequences for the same scenario and evaluation period for a well near the Columbia River are presented in Table 5.25 for the lower bound volume case and in Table 5.26 for the upper bound volume case.

The cumulative population impacts are evaluated over a period of 10,000 yr from closure of the LLBGs are presented in Table 5.27 for the lower bound volume case and in Table 5.28 for the upper bound volume case. All estimated health impacts to downstream populations are below levels expected to result in any LCF.

Table 5.23. Potential Individual Human Health Impacts to a Resident Gardener at the 1-km Well from Radionuclides in the Groundwater Over 10,000 Years for Alternative 1 Lower Bound Volumes

Waste Category	Source Location	Exposure Scenario	Maximum Annual Dose		Lifetime Dose rem	Probability of an LCF[(b)]
			Years Post-2046[(a)]	Dose rem		
Previously Disposed Waste (Pre-1970)						
LLW	200 West Area	Resident Gardener	1,300	8.3E-4	2.5E-2	1.3E-5
	200 East Area	Resident Gardener	10,000	5.2E-3	1.6E-1	7.9E-5
Previously Disposed Waste (1970 – 1988)						
LLW	200 West Area	Resident Gardener	1,300	2.8E-3	8.3E-2	4.2E-5
	200 East Area	Resident Gardener	10,000	3.4E-2	1.0E+0	5.1E-4
Newly Generated Waste (1988 forward)						
LLW Cat 1[(c)]	200 West Area	Resident Gardener	1,500	8.0E-5	2.4E-3	1.2E-6
LLW Cat 3	200 West Area	Resident Gardener	2,700	3.5E-5	1.1E-3	5.3E-7
MLLW	200 West Area	Resident Gardener	1,200	5.4E-3	1.6E-1	8.1E-5
	200 East Area	Resident Gardener	10,000	5.1E-2	1.5E+0	7.6E-4

(a) The number of years post-2046 in which the maximum annual dose occurs over the 10,000-yr period.
(b) Health impacts are expressed as lifetime risk of fatal cancer from the indicated lifetime radiation dose. The probability of a latent cancer fatality is the calculated value using the appropriate linear health effects conversion factor. The actual probability cannot be greater than one.
(c) Results are not reported for cases that had no inventory reported for the waste (for example, LLW Cat 1 for 200 East Area).

Table 5.24. Potential Individual Human Health Impacts to a Resident Gardener at the 1-km Well from Radionuclides in the Groundwater Over 10,000 Years for Alternative 1 Upper Bound Volumes

Waste Category	Source Location	Exposure Scenario	Maximum Annual Dose		Lifetime Dose rem	Probability of an LCF[b]
			Years Post-2046[a]	Dose rem		
Previously Disposed Waste (Pre-1970)						
LLW	200 West Area	Resident Gardener	1,300	8.3E-4	2.5E-2	1.3E-5
	200 East Area	Resident Gardener	10,000	5.2E-3	1.6E-1	7.9E-5
Previously Disposed Waste (1970 – 1988)						
LLW	200 West Area	Resident Gardener	1,300	2.8E-3	8.3E-2	4.2E-5
	200 East Area	Resident Gardener	10,000	3.4E-2	1.0E+0	5.1E-4
Newly Generated Waste (1988 forward)						
LLW Cat 1[c]	200 West Area	Resident Gardener	1,500	8.0E-5	2.4E-3	1.2E-6
LLW Cat 3	200 West Area	Resident Gardener	2,700	3.6E-5	1.1E-3	5.3E-7
MLLW	200 West Area	Resident Gardener	1,200	5.4E-3	1.6E-1	8.1E-5
	200 East Area	Resident Gardener	10,000	5.2E-2	1.6E+0	7.9E-4

(a) The number of years post-2046 in which the maximum annual dose occurs over the 10,000-yr period.
(b) Health impacts are expressed as lifetime risk of fatal cancer from the indicated lifetime radiation dose. The probability of a latent cancer fatality is the calculated value using the appropriate linear health effects conversion factor. The actual probability cannot be greater than one.
(c) Results are not reported for cases that had no inventory reported for the waste (for example, LLW Cat 1 for 200 East Area).

Table 5.25. Potential Individual Human Health Impacts to a Resident Gardener at a Well Near the Columbia River from Radionuclides in the Groundwater Over 10,000 Years for Alternative 1 Lower Bound Volumes

Waste Category	Source Location	Exposure Scenario	Maximum Annual Dose		Lifetime Dose rem	Probability of an LCF[b]
			Years Post-2046[a]	Dose rem		
Previously Disposed Waste (Pre-1970)						
LLW	200 West Area	Resident Gardener	1,700	2.3E-5	7.0E-4	3.5E-7
	200 East Area	Resident Gardener	10,000	1.1E-4	3.4E-3	1.7E-6
Previously Disposed Waste (1970 – 1988)						
LLW	200 West Area	Resident Gardener	1,700	7.7E-5	2.3E-3	1.2E-6
	200 East Area	Resident Gardener	10,000	6.7E-4	2.0E-2	1.0E-5
Newly Generated Waste (1988 forward)						
LLW Cat 1	200 West Area	Resident Gardener	2,200	3.4E-6	1.0E-4	5.2E-8
LLW Cat 3[c]	200 West Area	Resident Gardener	2,700	1.7E-6	5.0E-5	2.5E-8
MLLW	200 West Area	Resident Gardener	1,800	1.8E-4	5.3E-3	2.6E-6
	200 East Area	Resident Gardener	10,000	9.4E-4	2.8E-2	1.4E-5

(a) The number of years post-2046 in which the maximum annual dose occurs over the 10,000-yr period.
(b) Health impacts are expressed as lifetime risk of fatal cancer from the indicated lifetime radiation dose. The probability of a latent cancer fatality is the calculated value using the appropriate linear health effects conversion factor. The actual probability cannot be greater than one.
(c) Results are not reported for cases that had no inventory reported for the waste (for example, LLW Cat 3 for 200 East Area).

Table 5.26. Potential Individual Human Health Impacts to a Resident Gardener at a Well Near the Columbia River from Radionuclides in the Groundwater Over 10,000 Years for Alternative 1 Upper Bound Volumes

Waste Category	Source Location	Exposure Scenario	Maximum Annual Dose		Lifetime Dose rem	Probability of an LCF[b]
			Years Post-2046[a]	Dose		
Previously Disposed Waste (Pre-1970)						
LLW	200 West Area	Resident Gardener	1,700	2.3E-5	7.0E-4	3.5E-7
	200 East Area	Resident Gardener	10,000	1.1E-4	3.4E-3	1.7E-6
Previously Disposed Waste (1970 – 1988)						
LLW	200 West Area	Resident Gardener	1,700	7.7E-5	2.3E-3	1.2E-6
	200 East Area	Resident Gardener	10,000	6.7E-4	2.0E-2	1.0E-5
Newly Generated Waste (1988 forward)						
LLW Cat 1[c]	200 West Area	Resident Gardener	2,200	3.4E-6	1.0E-4	5.2E-8
LLW Cat 3	200 West Area	Resident Gardener	2,700	1.7E-6	5.0E-5	2.5E-8
MLLW	200 West Area	Resident Gardener	1,800	1.8E-4	5.3E-3	2.6E-6
	200 East Area	Resident Gardener	10,000	9.7E-4	2.9E-2	1.5E-5

(a) The number of years post-2046 in which the maximum annual dose occurs over the 10,000-yr period.
(b) Health impacts are expressed as lifetime risk of fatal cancer from the indicated lifetime radiation dose. The probability of a latent cancer fatality is the calculated value using the appropriate linear health effects conversion factor. The actual probability cannot be greater than one.
(c) Results are not reported for cases that had no inventory reported for the waste (for example, LLW Cat 3 for 200 East Area).

Table 5.27. Population Health Impacts from Drinking Water Downstream of Hanford Over 10,000 Years for Alternative 1 Lower Bound Volumes

Exposure Location	Waste Source	Waste Type	Population Dose person-rem	Estimated Cancer Fatalities
Tri-Cities, Washington	200 East	Previously Buried (Pre-1970)	1.4E-2	0 (7.0E-6) [(a)]
		Previously Buried (1970-1988)	2.2E-2	0 (1.1E-5)
		Cat 1 LLW	0.0E+0	0 (0.0E+0)
		Cat 3 LLW	0.0E+0	0 (0.0E+0)
		MLLW	1.5E-1	0 (7.5E-5)
	200 West	Previously Buried (Pre-1970)	8.1E-2	0 (4.0E-5)
		Previously Buried (1970-1988)	1.1E-1	0 (5.6E-5)
		Cat 1 LLW	9.2E-3	0 (4.6E-6)
		Cat 3 LLW	1.5E-2	0 (7.3E-6)
		MLLW	3.0E-1	0 (1.5E-4)
	Total		7.0E-1	0 (3.5E-4)
Portland, Oregon	200 East	Previously Buried (Pre-1970)	3.9E-2	0 (2.0E-5)
		Previously Buried (1970-1988)	6.2E-2	0 (3.1E-5)
		Cat 1 LLW	0.0E+0	0 (0.0E+0)
		Cat 3 LLW	0.0E+0	0 (0.0E+0)
		MLLW	4.2E-1	0 (2.1E-4)
	200 West	Previously Buried (Pre-1970)	2.3E-1	0 (1.1E-4)
		Previously Buried (1970-1988)	3.2E-1	0 (1.6E-4)
		Cat 1 LLW	2.6E-2	0 (1.3E-5)
		Cat 3 LLW	4.1E-2	0 (2.0E-5)
		MLLW	8.4E-1	0 (4.2E-4)
	Total		2.0E+0	0 (9.8E-4)

(a) The numbers expressed in parentheses are the calculated numbers of fatalities using the appropriate linear health effects conversion factor. The actual value must be an integer.

Table 5.28. Population Health Impacts from Drinking Water Downstream of Hanford Over 10,000 Years for Alternative 1 Upper Bound Volumes

Exposure Location	Waste Source	Waste Type	Population Dose person-rem	Estimated Cancer Fatalities
Tri-Cities, Washington	200 East	Previously Buried (Pre-1970)	1.4E-2	0 (7.0E-6) [(a)]
		Previously Buried (1970-1988)	2.2E-2	0 (1.1E-5)
		Cat 1 LLW	0.0E+0	0 (0.0E+0)
		Cat 3 LLW	0.0E+0	0 (0.0E+0)
		MLLW	1.5E-1	0 (7.7E-5)
	200 West	Previously Buried (Pre-1970)	8.1E-2	0 (4.0E-5)
		Previously Buried (1970-1988)	1.1E-1	0 (5.6E-5)
		Cat 1 LLW	9.2E-3	0 (4.6E-6)
		Cat 3 LLW	1.5E-2	0 (7.3E-6)
		MLLW	3.0E-1	0 (1.5E-4)
	Total		7.1E-1	0 (3.5E-4)
Portland, Oregon	200 East	Previously Buried (Pre-1970)	3.9E-2	0 (2.0E-5)
		Previously Buried (1970-1988)	6.2E-2	0 (3.1E-5)
		Cat 1 LLW	0.0E+0	0 (0.0E+0)
		Cat 3 LLW	0.0E+0	0 (0.0E+0)
		MLLW	4.3E-1	0 (2.2E-4)
	200 West	Previously Buried (Pre-1970)	2.3E-1	0 (1.1E-4)
		Previously Buried (1970-1988)	3.2E-1	0 (1.6E-4)
		Cat 1 LLW	2.6E-2	0 (1.3E-5)
		Cat 3 LLW	4.1E-2	0 (2.1E-5)
		MLLW	8.4E-1	0 (4.2E-4)
	Total		2.0E+0	0 (9.9E-4)

(a) The numbers expressed in parentheses are the calculated numbers of fatalities using the appropriate linear health effects conversion factor. The actual value must be an integer.

5.11.1.4 Accidents

The impacts of accidents involving radiological and chemical contaminants, and industrial accidents are evaluated in this section. Waste management operations under Alternative 1 would involve a continuing potential for industrial accidents and accidental release of contaminants in four Hanford facilities: the CWC for waste storage, WRAP, the modified T Plant Complex for waste treatment, and the LLBGs for waste disposal. Accident information for each of these facilities is presented in the following sections. Additional information on radiological and chemical accidents is provided in Appendix F.

Non-radiological consequences were evaluated by comparing estimated air concentrations to the TEEL or the ERPG for a given chemical. Additional information, including definitions of ERPG/TEEL levels, is presented in Appendix F.

Radiological consequences to involved workers from these accidents could be highly variable depending upon whether or not a worker was directly in the plume of immediately released material. Workers might also be injured or killed by physical injuries received during the accident. For example, the drum explosion and ion exchange module explosion accidents might affect involved workers, including the potential for fatalities, if the workers were in the explosion blast zone. If not in the immediate vicinity of these accidents, involved workers would be able to evacuate immediately and could avoid exposure. Involved workers might be substantially affected by the seismic events, with potential for worker fatalities, depending upon their location at the time of the accident. Burial ground workers would likely be less affected by falling debris than workers in facilities.

Anticipated health impacts to all workers from industrial accidents during construction and operations would be 420 to 440 total recordable cases, 180 lost workday cases, and 6100 to 6300 lost workdays. A total of about 15,600 to 16,200 worker years would be required to complete all activities over the operational period. Of that total about 2800 to 3400 worker years are for site support and waste generator services that do not appear in the direct facility worker and impact estimates in the following sections. About 97 to 99 percent of these health impacts are from operations.

5.11.1.4.1 Storage – Central Waste Complex

No new storage would be needed at the CWC under Alternative 1; therefore, no new construction would be required. Operations would continue at existing levels, near-term, possibly increasing, then declining as waste is processed.

Radiological Consequences. Six postulated accident scenarios involving radioactive material at the CWC were evaluated as part of the Interim Safety Basis (Vail 2001a). These accidents included a handling/forklift-caused drum failure, a drum handling fire, a flammable gas explosion, a truck impact and fire, a design basis earthquake, and a beyond design basis earthquake. They were selected for analysis through a hazard identification and assessment process, and have estimated annual frequencies of occurrence ranging from 0.11 per year to 4 E-6 per year, categorized as Anticipated and Extremely Unlikely, respectively. Accident consequences, shown in terms of radiation dose and of potential LCFs, are presented in Table 5.29.

The largest consequences to the offsite MEI would be from a beyond design basis earthquake. This MEI would receive a dose of about 13 rem and have a 6.3 E-3 probability of a latent cancer fatality. This accident also results in the largest consequences to the population. About 28 latent cancer fatalities would be expected. Latent cancer fatalities in the population would be expected for all analyzed accidents except a handling/forklift drum failure.

Table 5.29. Radiological Consequences of Accidents at the Central Waste Complex

Accident	Estimated Annual Frequency	Offsite MEI		Population		Non-involved Worker	
		Dose (rem)	Prob. LCF[(a)]	Dose (person -rem)	Number LCFs[(b)]	Dose (rem)	Prob. LCF[(a)]
Handling/Forklift Drum Failure	1.1E-01	0.0026	1.3E-06	11.5	0 (5.8E-3)	1.2	0.00049
Drum Handling Fire	1.1E-04	0.7	3.4E-04	3000	2	310	0.12
Flammable Gas Explosion	4.2E-04	1.0	4.8E-04	4300	2	460	0.18
Truck Impact and Fire	4.0E-06	11.0	5.3E-03	47,000	23	4900	1
Design Basis Earthquake	3.3E-03	1.1	5.3E-04	4700	2	480	0.19
Beyond Design Basis Earthquake	[(c)]	13	6.3E-03	56,000	28	5900	1

(a) Prob. LCF = the probability of a latent cancer fatality in the hypothetically exposed individual.
(b) Number LCFs = the number of latent cancer fatalities in the hypothetically exposed population. Probability indicated in parentheses if less than 1 fatality estimated.
(c) Not quantified in reference but frequency less than design basis earthquake.

The largest consequences to a non-involved worker would be from a truck impact and fire and a beyond design basis earthquake. The non-involved worker would receive a dose of about 4900 rem and 5900 rem, respectively. Both of these doses would result in a calculated probability of one (certainty) of a latent cancer fatality.

Non-radiological (Chemical) Consequences. Given that MLLW is also stored in CWC buildings, non-radioactive hazardous materials may be involved in the same accident scenarios as radioactive materials. The radiological accident analysis determined that two accidents having the largest consequences are: 1) the flammable gas explosion and 2) the truck impact and fire. Potential non-radiological consequences of these two accident scenarios were assumed in the safety analysis (Vail 2001a) to provide a reasonable upper limit for all accidents. Accident consequences are presented in Table 5.30, which shows the ratio of estimated concentrations to TEEL values. A value less than 1 indicates an acceptable condition. A blank ratio in the table indicates a more restrictive level was met (for example, the ratio was less than 1), subsequently, and evaluation of higher-level ratios is unnecessary.

The air concentration at the location of the offsite MEI would be well below the TEEL/ERPG-1 level for all chemicals, except beryllium. The air concentration at the location of the MEI would exceed the TEEL/ERPG-1 level beryllium because of the truck impact and fire accident. A hypothetically exposed individual would not be expected to experience or develop irreversible or other serious health effects or symptoms that might impair their ability to take protective action. No impacts would be expected.

Table 5.30. Non-radiological Air Concentrations for Accidents at the Central Waste Complex

	Onsite Worker Conc. mg/m^3	Offsite MEI Conc. mg/m^3	TEEL-1, mg/m^3	TEEL-2, mg/m^3	TEEL-3, mg/m^3	Onsite[(a)] TEEL-1 Ratio	Onsite TEEL-2 Ratio	Onsite TEEL-3 Ratio	Offsite[(b)] TEEL-1 Ratio	Offsite TEEL-2 Ratio	Offsite TEEL-3 Ratio
Drum Explosion											
Ammonium fluoride	1.0E+00	2.3E-03	2.5	2.5	40	4.2E-01			9.3E-04		
Ammonium nitrate	1.0E+00	2.3E-03	10	10	500	1.0E-01			2.3E-04		
Ammonium sulfate	2.1E+00	4.5E-03	125	500	500	1.7E-02			3.6E-05		
Beryllium	7.7E-01	1.6E-03	0.005	0.025	0.1	1.5E+02	3.1E+01	7.7E+00	3.3E-01		
Carbon tetrachloride	4.9E+00	1.1E-02	125	600	4000	4.0E-02	8.2E-03		8.5E-05		
Hydrofluoric acid	7.0E+00	1.5E-02	1.5	15	40	4.7E+00	4.7E-01		1.0E-02		
Nitric acid	8.2E+00	1.7E-02	2.5	12.5	50	3.3E+00	6.5E-01		7.0E-03		
Phosphoric acid	7.0E+00	1.5E-02	3	5	500	2.3E+00	1.4E+00	1.4E-02	5.2E-03		
Potassium hydroxide	7.5E+00	1.6E-02	2	2	150	3.8E+00	3.8E+00	5.0E-02	8.2E-03		
Sodium hydroxide	1.0E+01	2.1E-01	0.5	5	50	2.1E+01	2.1E+00	2.1E-01	4.3E-01		
Sulfuric acid	4.4E-01	9.7E-04	2	10	30	2.2E-01			4.8E-04		
Truck Impact and Fire											
Ammonium fluoride	3.5E-01	7.4E-04	2.5	2.5	40	1.4E-01			3.0E-04		
Ammonium nitrate	3.5E-01	7.4E-04	10	10	500	3.5E-02			7.4E-05		
Ammonium sulfate	6.8E-01	1.4E-03	125	500	500	5.4E-03			1.2E-05		
Beryllium	6.0E+00	1.4E-02	0.005	0.025	0.1	1.2E+03	2.4E+02	6.0E+01	2.7E+00	5.4E-01	
Carbon tetrachloride	1.6E+00	3.5E-03	125	600	4000	1.2E-02			2.8E-05		
Hydrofluoric acid	2.3E+00	4.9E-03	1.5	15	40	1.5E+00	1.5E-01		2.5E-03		
Nitric acid	1.0E+01	2.1E-02	2.5	12.5	50	4.2E+00	8.3E-01		8.5E-03		
Phosphoric acid	2.3E+00	4.9E-03	3	5	500	7.5E-01			1.6E-03		
Potassium hydroxide	2.4E+00	5.3E-03	2	2	150	1.2E+00	1.2E+00	1.6E-02	2.7E-03		
Sodium hydroxide	1.4E+01	3.0E-02	0.5	5	50	2.8E+01	2.8E+00	2.8E-01	6.0E-02		
Sulfuric acid	1.4E-01	3.1E-04	2	10	30	6.9E-02			1.5E-04		
Mercury	1.7E+00	3.8E-03	0.025	0.1	10	6.9E+01	1.7E+01	1.7E-01	3.8E-02		
Cadmium	1.7E+00	3.8E-03	0.03	4	9	5.8E+01	4.3E-01		1.3E-01		
Polychlorinated biphenyls (PCBs)	3.5E-01	7.5E-04	3	5	5	1.2E-01	6.9E-02		2.5E-04		
Lead	1.7E+00	3.8E-03	0.15	0.25	100	1.2E+01	6.9E+00	1.7E-02	2.5E-02		

(a) Onsite = non-involved worker.
(b) Offsite = Offsite MEI.

For the onsite non-involved worker, the TEEL/ERPG-3 level might be exceeded for beryllium for both of these accidents. This individual may experience or develop a life-threatening effect. TEEL/ERPG-2 levels might also be exceeded for mercury, lead, potassium hydroxide, phosphoric acid, and sodium hydroxide, but no serious health effects or symptoms would be expected. The TEEL/ERPG-1 levels might also be exceeded for cadmium, nitric acid, and hydrofluoric acid.

Like the radiological consequences to involved workers, non-radiological consequences could be highly variable—ranging from no exposure to high concentrations of chemicals—depending upon whether or not a worker was directly in the plume of immediately released material and for how long.

Industrial Accidents-Construction. No new construction would take place at the CWC under Alternative 1, and no industrial accidents from construction would occur.

Industrial Accidents-Operations. Direct operations staffing in the CWC would total 3200 worker years. Estimated health and safety impacts would be 85 total recordable cases, 36 lost workday cases, and 1200 lost workdays.

5.11.1.4.2 Treatment – Waste Receiving and Processing Facility

Radiological Consequences. Seven accident scenarios involving radioactive material at WRAP facility were evaluated in the Safety Analysis Report (Tomaszewski 2001). These accident scenarios included a handling/forklift drum failure, a drum handling fire, a container handling explosion, a fire in a process enclosure (glovebox), an explosion in process enclosure (glovebox), design-basis earthquake, and beyond-design-basis earthquake. These accidents were selected for analysis through a hazard identification and assessment process. Estimated annual frequencies of occurrence are described qualitatively and quantitatively. They range from Anticipated (with an associated annual frequency range of 1 to 0.01) to an undeclared frequency for the beyond design basis earthquake. Accident consequences, shown in terms of radiation dose and potential LCF, are presented in Table 5.31.

The largest consequences to the MEI would be from a beyond design basis earthquake. The MEI would receive a dose of about 1.1 rem and have a 5.4 E-4 probability of a latent cancer fatality. Five of the seven accidents examined would result in one or two latent cancer fatalities in the population.

The largest consequences to a non-involved worker would be from a beyond design basis earthquake. The non-involved worker would receive a dose of about 500 rem and have a 0.2 probability of a latent cancer fatality.

Potential radiological impacts to involved workers would have the same variability as discussed for the LLW trenches.

Table 5.31. Radiological Consequences of Accidents at WRAP

Accident	Estimated Annual Frequency	Offsite MEI		Population		Non-involved Worker	
		Dose (rem)	Prob. LCF[(a)]	Dose (person -rem)	Number LCFs[(b)]	Dose (rem)	Prob. LCF[(a)]
Handling/Forklift Drum Failure	Anticipated [(c)]	0.0014	6.8E-07	6.0	0 (0.003)	0.6	0.00025
Drum Handling Fire	2×10^{-3}	0.31	1.5E-04	1400	1 (0.7)	140	0.057
Container Handling Explosion	3×10^{-3}	0.74	3.7E-04	3300	2	340	0.14
Process Enclosure Fire	2×10^{-3}	0.20	1.0E-04	900	0 (0.4)	100	0.038
Process Enclosure Explosion	3×10^{-3}	0.67	3.3E-04	2900	2	300	0.12
Design Basis Earthquake	1×10^{-3}	0.92	4.6E-04	4100	2	420	0.17
Beyond Design Basis Earthquake	[(c)]	1.1	5.4E-04	4800	2	500	0.20

(a) Prob. LCF = the probability of a latent cancer fatality in the hypothetically exposed individual.
(b) Number LCFs = the number of latent cancer fatalities in the hypothetically exposed population.
(c) Not quantified in reference.

Non-radiological (Chemical) Consequences. Because MLLW would also be handled at WRAP, non-radioactive hazardous materials may be involved in accidents. A process enclosure fire was evaluated for non-radiological consequences. The accident scenario for this analysis is the same as evaluated for radiological consequences of the process enclosure fire, where containers rupture and burn. A fire in the process enclosures is postulated due to the mixing of incompatible materials or damage to the packaging of pyrophoric material that allows ignition to take place. Since no mitigation credit is taken for the process enclosure, the consequence of this event bounds any container fire at WRAP. Accident consequences are presented in Table 5.32.

The air concentration at the location of the offsite MEI could exceed the TEEL/ERPG-1 level for beryllium, cadmium, and mercury. Hypothetically exposed individuals would not be expected to experience or develop irreversible or other serious health effects or symptoms that might impair their ability to take protective action.

For the onsite non-involved worker, the TEEL/ERPG-3 level might be exceeded for beryllium, cadmium, mercury, and sodium oxide. This hypothetically exposed individual may experience or develop a life-threatening effect. The TEEL/ERPG-2 level could also be exceeded for uranyl nitrate hexahydrate, nitric acid, phosphoric acid, sodium, sodium hydroxide, and naphthylamine tritium. An individual might experience or develop irreversible or other serious health effects or symptoms that might impair the ability to take protective action. No other chemical would exceed the TEEL/ERPG-1 levels. No serious health effects or symptoms would be expected.

Table 5.32. Non-radiological Air Concentrations for a Process Enclosure Fire Accident at WRAP

	Onsite Worker Conc. mg/m^3	Offsite MEI Conc. mg/m^3	TEEL-1, mg/m^3	TEEL-2, mg/m^3	TEEL-3, mg/m^3	Onsite[(a)] TEEL-1 Ratio	Onsite TEEL-2 Ratio	Onsite TEEL-3 Ratio	Offsite[(b)] TEEL-1 Ratio	Offsite TEEL-2 Ratio	Offsite TEEL-3 Ratio
Ammonia	3.9E-01	8.5E-04	15	100	500	2.6E-02			5.7E-05		
Ammonium nitrate	6.9E+00	1.5E-02	10	10	500	6.9E-01			1.5E-03		
Beryllium	6.1E+00	1.3E-02	0.005	0.025	0.1	1.2E+03	2.4E+02	6.1E+01	2.7E+00	5.3E-01	
Butyl alcohol	7.0E-01	1.5E-03	150	150	4000	4.7E-03			1.0E-05		
Cadmium	7.8E+01	1.7E-01	0.03	4	9	2.6E+03	2.0E+01	8.7E+00	5.7E+00	4.3E-02	
Carbon tetrachloride	1.3E+01	2.9E-02	125	600	4000	1.1E-01			2.3E-04		
Cyclohexane	3.3E+00	7.1E-03	3000	4000	4000	1.1E-03			2.4E-06		
Dichloroethane	1.0E+00	2.2E-03	7.5	200	200	1.4E-01			2.9E-04		
Dioxane	2.2E+01	4.8E-02	75	350	1500	2.9E-01			6.3E-04		
Ethyl acetate (acetic ether)	7.8E-01	1.7E-03	1500	1500	7500	5.2E-04			1.1E-06		
Hydrogen peroxide	4.4E-01	9.5E-04	12.5	60	125	3.5E-02			7.6E-05		
Indole-2-C14 picrate	8.6E-05	1.9E-07	0.3	0.5	10	2.9E-04			6.2E-07		
Manganese	5.2E-02	1.1E-04	3	5	500	1.7E-02			3.8E-05		
Mercury	3.8E+01	8.3E-02	0.025	0.1	10	1.5E+03	3.8E+02	3.8E+00	3.3E+00		
Methanol	1.1E+00	2.4E-03	250	1250	6000	4.4E-03			9.5E-06		
Napthylamine tritium	8.6E+01	1.9E-01	7.5	50	300	1.1E+01	1.7E+00	2.9E-01	2.5E-02		
Nitric acid	3.0E+01	6.6E-02	2.5	12.5	50	1.2E+01	2.4E+00	6.1E-01	2.7E-02		
Phosphoric acid	4.4E+01	9.5E-02	3	5	500	1.5E+01	8.7E+00	8.7E-02	3.2E-02		
Propane	7.8E-01	1.7E-03	3500	3500	3500	2.2E-04			4.9E-07		
Sodium	2.3E+00	4.9E-03	2	2	10	1.1E+00			2.5E-03		
Sodium hydroxide	3.2E+01	7.0E-02	0.5	5	50	6.4E+01	6.4E+00	6.4E-01	1.4E-01		
Sodium hypochlorite	6.5E-03	1.4E-05	75	500	500	8.6E-05			1.9E-07		
Sodium oxide	4.1E+01	9.0E-02	10	10	10	4.1E+00	4.1E+00	4.1E+00	9.0E-03		
Styrene	2.4E+00	5.3E-03	200	1000	4000	1.2E-02			2.6E-05		
Tetrahydrofuran	1.2E+00	2.7E-03	750	3000	6000	1.7E-03			3.6E-06		
Tetralin	8.6E-05	1.9E-07	NA	NA	NA						
Toluene	7.6E-01	1.6E-03	150	1000	3500	5.0E-03			1.1E-05		
Uranyl nitrate hexahydrate	5.3E+00	1.2E-02	0.6	0.6	10	8.8E+00	8.8E+00	5.3E-01	1.9E-02		
Vinyl acetate	2.4E+00	5.3E-03	150	250	1500	1.6E-02			3.5E-05		
Vinyl chloride	3.6E+00	7.8E-03	12.5	12.5	200	2.9E-01			6.3E-04		
Zirconium	7.5E-01	1.6E-03	10	10	50	7.5E-02			1.6E-04		

(a) Onsite = non-involved worker.
(b) Offsite = Offsite MEI.

Like the radiological consequences to involved workers, non-radiological consequences could be highly variable – ranging from no exposure to high concentrations of chemicals – depending upon whether or not a worker was directly in the plume of immediately released material and for how long.

Industrial Accidents. Direct operations staffing in WRAP would total 1800 worker years. Estimated health and safety impacts would be 48 total recordable cases, 20 lost workday cases, and 710 lost workdays.

5.11.1.4.3 Treatment – Modified T Plant Complex

Radiological Consequences – continuing T Plant activities. Six postulated accident scenarios involving current activities and radioactive material at T Plant were evaluated as part of the Interim Safety Basis (Bushore 1999, 2001). These accidents included a spray release in the 221-T canyon, railcar spill in the 221-T rail tunnel, filter fire in 2706-T Facility, LLW drum storage fire in the 214-T Building, filter bank fire in the 219-T building, and seismic event.

These accidents were selected for analysis through a hazard identification and assessment process. Estimated annual frequencies of occurrence are described qualitatively and quantitatively. They range from less than 1.0 E-2 to 1.9 E-5 for the 291-T filter bank fire, categorized as unlikely and extremely unlikely, respectively. Accident consequences, shown in terms of radiation dose and potential LCF, are presented in Table 5.33.

Table 5.33. Radiological Consequences of Accidents at the Modified T Plant Complex for Continuing T Plant Activities

Accident	Estimated Annual Frequency	Offsite MEI		Population		Non-involved Worker	
		Dose (rem)	Prob. LCF[a]	Dose (person-rem)	Number LCFs[b]	Dose (rem)	Prob. LCF[a]
Spray Release, 221-T Canyon	2 E-5	0.31	1.5E-4	2100	1	220	8.8E-2
Railcar Spill, 221-T rail tunnel	< 0.01 [c]	0.10	4.8E-5	650	0 (0.33)	68	2.7E-2
2706-T Outdoor Drum Fire	1 E-3 to 2.5 E-4 [c]	0.70	3.5E-4	4800	2	500	2.0E-1
214-T LLW Drum Storage Fire	< 0.01 [c]	0.15	7.6E-5	1000	1 (0.52)	110	4.3E-2
291-T Filter Bank Fire	1.9 E-5	0.02	1.0E-5	140	0 (0.070)	15	5.8E-3
Seismic Event	[c, d]	0.27	1.4E-4	1900	1 (0.93)	190	7.7E-2

(a) Prob. LCF = the probably of a latent cancer fatality in the hypothetically exposed individual.
(b) Number LCFs = the number of latent cancer fatalities in the hypothetically exposed population. Probability indicated in parentheses if less than one fatality estimated.
(c) These less quantitative frequencies are also from Bushore 2001.
(d) For a design basis earthquake, an annual frequency would be about 1 x 10^{-3} or less.

The largest consequences to the MEI would be from an outdoor drum handling accident with fire at the 2706-T facility. The MEI would receive a dose of about 0.70 rem and have a 3.5 E-4 probability of an LCF. Within the population, this accident would result in 2 latent cancer fatalities, and three of the other accidents examined would result in one LCF.

The largest consequences to a non-involved worker would also be from an outdoor drum handling accident with fire at the 2706-T Facility. The non-involved worker would receive a dose of about 500 rem and have a 2.0 E-1 probability of an LCF.

Potential radiological impacts to involved workers would have the same variability as discussed for the LLW trenches.

Radiological Consequences – M-91 Capability. Six accidents for the proposed M-91 Capability in the modified T Plant Complex were evaluated, based upon the analysis and results of the preliminary safety evaluation for WRAP Module 2 (WHC 1991). These accidents included both a mitigated and unmitigated box drop, a design basis earthquake with fire, a tank farm pump spill, and a drop of a melter from the HWVP. These accidents were selected for analysis through a hazard identification and assessment process. Estimated annual frequencies of occurrence range from anticipated (with an annual frequency range of 1 to 0.01) to an extremely unlikely accident (with an annual frequency range of 1 E-4 to 1 E-6). Accident consequences, shown in terms of radiation dose and potential LCFs, are presented in Table 5.34.

Table 5.34. Radiological Consequences of Accidents for the Modified T Plant Complex with M-91 Capability

Accident	Estimated Annual Frequency	Offsite MEI		Population		Non-involved Worker	
		Dose (rem)	Prob. LCF[(a)]	Dose (person -rem)	Number LCFs[(b)]	Dose (rem)	Prob. LCF[(a)]
Box drop, filtered	1 E-2	8.9E-05	4.4E-08	0.21	0 (1E-4)	2.2E-02	8.9E-06
Box drop, unfiltered	1 E-2	1.8E-01	8.9E-05	430	0 (0.21)	4.5E+01	1.8E-02
Design basis earthquake and fire, unmitigated	1 E-4	3.1E-01	1.5E-04	740	0 (0.37)	7.7E+01	3.1E-02
Tank farm pump handling accident	7.7 E-4	2.6E-09	1.3E-12	6.3E-06	0 (3.1E-9)	6.5E-07	2.6E-10
HWVP melter drop (filtered)	3.1 E-4	1.7E-05	8.7E-09	0.042	0 (2.1E-5)	4.4E-03	1.7E-06
HWVP melter drop (unfiltered)	3.1 E-4	3.5 E-2	1.7E-05	84	0 (4.2E-2)	8.7E+00	3.5E-03

(a) Prob. LCF = the probability of a latent cancer fatality in the hypothetically exposed individual.
(b) Number LCFs = the number of latent cancer fatalities in the hypothetically exposed population. Probability indicated in parentheses if less than one fatality estimated.

The largest consequences to the MEI would be from a design basis earthquake and fire. The MEI would receive a dose of about 0.31 rem and have a 1.5 E-4 probability of an LCF. This accident also results in the largest consequences to the population, but no LCFs would be expected.

The largest consequences to a non-involved worker would also be from a design basis earthquake and fire. The non-involved worker would receive a dose of about 77 rem and have a 3.1 E-2 probability of a latent cancer fatality.

Radiological consequences to involved workers from these accidents could be highly variable depending upon whether or not a worker was directly in the plume of immediately released material.

Non-radiological (Chemical) Consequences – continuing T Plant activities. The Interim Safety Basis (Bushore 2001) does not contain an analysis of the potential consequences of accidents involving non-radiological constituents of waste streams. The non-radiological consequences of accidents at WRAP, presented previously (5.11.1.4.3), are assumed to represent potential non-radiological consequences in T Plant since radiological consequences of accidents are similar.

Non-radiological (Chemical) Consequences – M-91 Capability. Non-radiological consequences for the M-91 Capability have not been evaluated in detail. However, potential non-radiological impacts from accidents in WRAP and the T Plant Complex are expected to be representative for potential impacts from M-91 activities. Potential impacts from accidents in the CWC and LLBGs would likely be bounding for accidents in the modified T Plant Complex with M-91 capabilities.

Industrial Accidents-Construction. Employment for the T Plant modification would total 120 worker years. Estimated health and safety impacts would be 10 total recordable cases, 3 lost workday cases, and 66 lost workdays.

Industrial Accidents-Operations. Direct operations staffing in the modified T Plant Complex would total 3,900 worker years. Estimated health and safety impacts would be 100 total recordable cases, 42 lost workday cases, and 1,500 lost workdays.

5.11.1.4.4 Disposal – Low-Level Burial Grounds

Disposal and storage of solid radioactive waste generated at the Hanford Site would continue in the LLBGs of the 200 West or 200 East Areas. Accidents involving the LLW trenches and the MLLW trenches were evaluated in the Solid Waste Burial Grounds Interim Safety Basis (Vail 2001c), and the Solid Waste Burial Grounds Interim Safety Analysis (Vail 2001b).

Radiological Consequences – Low-Level Waste Trenches. The radiological consequences associated with the disposal of LLW (Cat 1, Cat 3, and GTC3) are addressed in this section. Non-radiological (chemical) consequences were not evaluated due to the nature of the waste.

Five credible accidents at the trenches were evaluated as part of the Interim Safety Basis (Vail 2001c) and the Interim Safety Analysis (Vail 2001b). They include a heavy equipment accident with fire, a

heavy equipment accident without fire, a drum explosion, an explosion involving an ion exchange module, and a seismic event. Two other accidents involving HICs — a heavy equipment accident with fire and a seismic event — were also addressed.

These postulated accidents were selected for analysis through a hazard identification and assessment process and have estimated annual frequencies of occurrence ranging from 4E-2 per year to 5.3E-4 per year, categorized as Anticipated and Unlikely, respectively. Accident consequences, shown in terms of both radiation dose and latent cancer fatalities, are presented in Table 5.35.

Table 5.35. Radiological Consequences of Postulated Accidents at the Low-level Waste Trenches

Accident	Estimated Annual Frequency	Offsite MEI		Population		Non-involved Worker	
		Dose (rem)	Prob. LCF[(a)]	Dose (person -rem)	Number LCFs[(b)]	Dose (rem)	Prob. LCF[(a)]
Heavy Equipment Accident with Fire	5.3 E-4	0.027	1.4E-05	140	0 (0.068)	14	0.0056
Heavy Equipment Accident without Fire	1.3 E-2	0.0022	1.1E-06	11	0 (0.0054)	1	0.00045
Drum Explosion	4.0 E-2	0.049	2.5E-05	250	0 (0.12)	26	0.010
Explosion in Ion Exchange Module	1.0 E-2	0.019	9.7E-06	97	0 (0.048)	10	0.0040
Seismic Event[(c)]	1.0 E-3	0.016	7.9E-06	79	0 (0.040)	8.3	0.0033
HIC Operations							
Heavy Equipment Accident with Fire	5.3E-4	0.39	2.0E-04	2000	1 (0.99)	210	0.084
Seismic Event	1.0E-3	0.045	2.2E-05	220	0 (0.11)	23	0.0093

(a) Prob. LCF = the probability of a latent cancer fatality in the hypothetically exposed individual.
(b) Number LCFs = the number of latent cancer fatalities in the hypothetically exposed population. Probability indicated in parentheses if less than 1 fatality estimated.
(c) Assumes breach of 500 drums. Adjusted from Vail 2001c, which used 1,200 drums, the number of containers breached for an onsite worker to receive a dose at the site radiological risk guideline. An analysis to provide justification for 1,200 drums or to estimate the actual number of drums that could be breached was not performed. It was considered unlikely that this large number of containers would be breached by a seismic event so 500 drums were used instead.

The largest consequences to the MEI would be from a heavy equipment accident with fire involving the HICs. The MEI would receive a dose of about 0.39 rem and have a 2E-4 probability of a latent cancer fatality. This accident also results in the largest consequences to the population, with one latent cancer fatality.

The largest consequences to a non-involved worker would be from a heavy equipment accident with fire involving the HICs. The non-involved worker would receive a dose of about 210 rem and have a 8.4E-2 probability of an LCF.

Radiological Consequences – Mixed Low-Level Waste Trenches. The radiological consequences of five postulated accidents at the MLLW trenches were evaluated as part of the Interim Safety Analysis (Vail 2001b). These accidents included a heavy equipment (bulldozer) accident with fire, a heavy equipment accident with no fire, a drum explosion, a seismic event, and a leachate collection system spray release. These postulated accidents were selected for analysis through a hazard identification and assessment process. Estimated annual frequencies of occurrence range from 1.3E-2 per year to $1x10^{-2}$ to $1x10^{-4}$ per year (categorized as anticipated and unlikely, respectively). Accident consequences, shown in terms of both radiation dose and LCFs, are presented in Table 5.36.

Table 5.36. Radiological Consequences of Accidents at the Mixed Low-Level Waste Trenches

Accident	Estimated Annual Frequency	Offsite MEI		Population		Non-involved Worker	
		Dose (rem)	Prob. LCF[(a)]	Dose (person-rem)	Number LCFs[(b)]	Dose (rem)	Prob. LCF[(a)]
Heavy Equipment Accident with Fire	5.4E-4	0.029	1.4E-05	140	0 (0.072)	14	0.0056
Heavy Equipment Accident without Fire	1.3 E-2	0.0022	1.1E-06	11	0 (0.0054)	1.1	0.00045
Drum Explosion	4.0 E-2	0.049	2.4E-05	240	0 (0.12)	26	0.010
Seismic Event[(c)]	1.0 E-3	0.017	8.3E-06	83	0 (0.042)	9	0.0035
Leachate Collection System Spray Release	Unlikely[(d)]	0.00048	2.4E-07	2.4	0 (0.0012)	0.25	0.0010

(a) Prob. LCF = the probability of a latent cancer fatality in the hypothetically exposed individual.
(b) Number LCFs = the number of latent cancer fatalities in the hypothetically exposed population. Probability indicated in parentheses if less than one fatality estimated.
(c) Assumes breach of 500 drums. Adjusted from Vail 2001c, which used 34,000 drums, the number of containers breached for an onsite worker to receive a dose at the site radiological risk guideline. An analysis to provide justification for 34,000 drums or to estimate the actual number of drums that could be breached was not performed. It was considered highly unlikely that this large number of containers would be breached by a seismic event so 500 drums were used instead.
(d) No frequency provided. Estimated at "unlikely" (1E-2 to 1E-4).

The largest consequences to the MEI would be from a drum explosion. The MEI would receive a dose of about 4.9E-2 rem and have a 2.4 E-5 probability of a latent cancer fatality. This accident also results in the largest consequences to the population but no latent cancer fatalities would be expected.

The largest consequences to a non-involved worker would also be from a drum explosion. The non-involved worker would receive a dose of about 26 rem and have a 1E-2 probability of an LCF.

Potential radiological impacts to involved workers would be the same as discussed for the LLW trenches.

Non-radiological (Chemical) Consequences. The quantity and form of hazardous constituents in the MLLW trenches are subject to Land Disposal Restrictions and other regulations that are prescriptive in how mixed waste must be treated prior to emplacement. No organic chemicals would be present. The

Interim Safety Analysis evaluated four of the previous accidents for non-radiological consequences at the MLLW trenches, including the heavy equipment accident with fire, a heavy equipment accident with no fire, a drum explosion, and a seismic event. Chemicals were assumed to be at the maximum allowable concentrations and the waste was in bulk form (i.e., not in containers). Accident consequences are presented in Tables 5.37 through 5.40.

For all accidents, the air concentration at the location of the offsite MEI would be well below the TEEL/ERPG-1 level for all chemicals. No impacts would be expected. For the onsite non-involved worker, the TEEL/ERPG-3 levels could be reached or exceeded for three chemicals — molybdenum, nickel, and selenium for the heavy equipment accident with fire and only selenium for the seismic event. A hypothetically exposed individual may experience or develop a life-threatening effect as a result of a 1-hr exposure to any one of these chemicals. The TEEL/ERPG-2 levels would be exceeded for 16 chemicals for the heavy equipment accident with fire, and 13 chemicals for the seismic event. An individual might experience or develop irreversible or other serious health effects or symptoms that might impair the ability to take protective action.

LLBGs Industrial Accidents. This section addresses potential health and safety impacts from construction and operation of LLW and MLLW trenches and supporting facilities (pulse driers) in the LLBGs. Estimated health and safety impacts from construction and operation of MLLW trenches is included in totals for the LLBGs presented below.

LLBGs Industrial Accidents-Construction. Construction of new trenches and pulse driers for MLLW trenches would require a total of 7 to 10 worker years. The estimated health and safety impacts would be less than one total recordable case, less than one lost workday cases.

LLBGs Industrial Accidents-Operations. Direct operations staffing in the LLBGs would total 3800 worker years. Estimated health and safety impacts would be 100 total recordable cases, 42 lost workday cases, and 1500 lost workdays.

5.11.2 Alternative 2

Alternative 2 is similar to Alternative 1 except that use of commercial treatment facilities would be minimized with construction of a new M-91 Facility, instead of modifying the T Plant Complex to meet the function of M-91. New LLW and MLLW trenches would be constructed using the current design instead of the enhanced trench designs. Alternative 2 would involve the same waste processing and the same waste management approaches. The action includes the establishment of necessary facilities for storage, inspection, treatment, and final disposal or shipment offsite for all included waste streams. It includes the same sources, waste streams, and volumes of waste as Alternative 1.

As in Alternative 1, all of the wastes would be removed from storage and treated as necessary for disposal in the LLBGs or sent to the WIPP. After about 10 yr, wastes would only be held in storage for short periods of time to allow their characterization and evaluation, prior to treatment or disposal. Under Alternative 2, the analyses use both the upper and lower bound of forecasted disposal volumes for LLW and MLLW as was used for Alternative 1.

Table 5.37. Non-radiological Air Concentrations for a Heavy Equipment Accident with Fire at the Low Level Burial Grounds

	Onsite Worker Conc. mg/m^3	Offsite MEI Conc. mg/m^3	TEEL-1, mg/m^3	TEEL-2, mg/m^3	TEEL-3, mg/m^3	Onsite[(a)] TEEL-1 Ratio	Onsite TEEL-2 Ratio	Onsite TEEL-3 Ratio	Offsite[(b)] TEEL-1 Ratio	Offsite TEEL-2 Ratio	Offsite TEEL-3 Ratio
Aluminum	2.0E+02	3.9E-01	30	50	250	6.8	4.1	0.8	1.3E-02		
Antimony	1.0E+01	2.0E-02	1.5	2.5	50	6.8	4.1	0.2	1.3E-02		
Arsenic	2.0E-01	3.9E-04	0.03	1.4	5	6.8	0.15		1.3E-02		
Barium	1.0E+01	2.0E-02	1.5	2.5	12.5	6.8	4.1	0.8	1.3E-02		
Beryllium	1.0E-03	2.0E-06	0.005	0.025	0.1	0.2			4.0E-04		
Cadmium	4.1E-02	7.8E-05	0.03	4	9	1.4	0.01		2.6E-03		
Calcium hydroxide	1.0E+02	2.0E-01	15	25	500	6.8	4.1	0.2	1.3E-02		
Chromium	1.0E+01	2.0E-02	1.5	2.5	250	6.8	4.1	0.04	1.3E-02		
Cobalt	4.1E-01	7.8E-04	0.1	0.1	20	4.1	4.1	0.02	7.8E-03		
Copper	2.0E+01	3.9E-02	3	5	100	6.8	4.1	0.2	1.3E-02		
Iron oxide dust	1.0E+02	2.0E-01	15	25	500	6.8	4.1	0.2	1.3E-02		
Lead	1.0E+00	2.0E-03	0.15	0.25	100	6.8	4.1	0.01	1.3E-02		
Magnesium	1.0E+02	2.0E-01	30	50	250	3.4	2.0	0.4	6.5E-03		
Manganese	1.0E+02	2.0E-01	3	5	500	34	20	0.2	6.5E-02		
Mercury	2.1E-02	4.0E-05	0.025	0.1	10	0.8			1.6E-03		
Molybdenum	1.0E+02	2.0E-01	15	25	60	6.8	4.1	1.7	1.3E-02		
Nickel	2.0E+01	3.9E-02	4.5	10	10	4.5	2.0	2.0	8.7E-03		
Potassium hydroxide	4.1E-01	8.0E-04	2	2	150	0.2			4.0E-04		
Selenium	4.1E+00	7.8E-03	0.6	1	1	6.8	4.1	4.1	1.3E-02		
Silver	2.0E-01	3.9E-04	0.3	0.5	10	0.7			1.3E-03		
Sodium hydroxide	4.1E-01	8.0E-04	0.5	5	50	0.8			1.6E-03		
Thallium	2.0E+00	3.9E-03	0.3	2	15	6.8	1.0	0.1	1.3E-02		
Vanadium pentoxide	1.0E-01	2.0E-04	0.075	0.5	35	1.4	0.2		2.7E-03		
Zinc oxide	2.0E+02	3.9E-01	15	15	500	14	14	0.41	2.6E-02		

(a) Onsite = non-involved worker.
(b) Offsite = Offsite MEI.

Table 5.38. Non-radiological Air Concentrations for a Heavy Equipment Accident Without Fire at the Low Level Burial Grounds

	Onsite Worker Conc. mg/m^3	Offsite MEI Conc. mg/m^3	TEEL-1, mg/m^3	TEEL-2, mg/m^3	TEEL-3, mg/m^3	Onsite[(a)] TEEL-1 Ratio	Onsite TEEL-2 Ratio	Onsite TEEL-3 Ratio	Offsite[(b)] TEEL-1 Ratio	Offsite TEEL-2 Ratio	Offsite TEEL-3 Ratio
Aluminum	4.1E+00	7.8E-03	30	50	250	1.4E-01			2.6E-04		
Antimony	2.0E-01	3.9E-04	1.5	2.5	50	1.4E-01			2.6E-04		
Arsenic	4.1E-03	7.8E-06	0.03	1.4	5	1.4E-01			2.6E-04		
Barium	2.0E-01	3.9E-04	1.5	2.5	12.5	1.4E-01			2.6E-04		
Beryllium	2.1E-05	4.0E-08	0.005	0.025	0.1	4.2E-03			8.0E-06		
Cadmium	8.2E-04	1.6E-06	0.03	4	9	2.7E-02			5.2E-05		
Calcium hydroxide	2.0E+00	3.9E-03	15	25	500	1.4E-01			2.6E-04		
Chromium	2.0E-01	3.9E-04	1.5	2.5	250	1.4E-01			2.6E-04		
Cobalt	8.2E-03	1.6E-05	0.1	0.1	20	8.2E-02			1.6E-04		
Copper	4.1E-01	7.8E-04	3	5	100	1.4E-01			2.6E-04		
Iron oxide dust	2.0E+00	3.9E-03	15	25	500	1.4E-01			2.6E-04		
Lead	2.0E-02	3.9E-05	0.15	0.25	100	1.4E-01			2.6E-04		
Magnesium	2.0E+00	3.9E-03	30	50	250	6.8E-02			1.3E-04		
Manganese	2.0E+00	3.9E-03	3	5	500	6.8E-01			1.3E-03		
Mercury	4.2E-04	8.0E-07	0.025	0.1	10	1.7E-02			3.2E-05		
Molybdenum	2.0E+00	3.9E-03	15	25	60	1.4E-01			2.6E-04		
Nickel	4.1E-01	7.8E-04	4.5	10	10	9.1E-02			1.7E-04		
Potassium hydroxide	8.3E-03	1.6E-05	2	2	150	4.1E-03			8.0E-06		
Selenium	8.2E-02	1.6E-04	0.6	1	1	1.4E-01			2.6E-04		
Silver	4.1E-03	7.8E-06	0.3	0.5	10	1.4E-02			2.6E-05		
Sodium hydroxide	8.3E-03	1.6E-05	0.5	5	50	1.7E-02			3.2E-05		
Thallium	4.1E-02	7.8E-05	0.3	2	15	1.4E-01			2.6E-04		
Vanadium pentoxide	2.1E-03	4.0E-06	0.075	0.5	35	2.8E-02			5.3E-05		
Zinc oxide	4.1E+00	7.8E-03	15	15	500	2.7E-01			5.2E-04		

(a) Onsite = non-involved worker.
(b) Offsite = Offsite MEI.

Table 5.39. Non-radiological Air Concentrations for a Drum Explosion at the Low Level Burial Grounds

	Onsite Worker Conc. mg/m^3	Offsite MEI Conc. mg/m^3	TEEL-1, mg/m^3	TEEL-2, mg/m^3	TEEL-3, mg/m^3	Onsite[(a)] TEEL-1 Ratio	Onsite TEEL-2 Ratio	Onsite TEEL-3 Ratio	Offsite[(b)] TEEL-1 Ratio	Offsite TEEL-2 Ratio	Offsite TEEL-3 Ratio
Aluminum	9.3E+00	1.8E-02	30	50	250	3.1E-01			5.9E-04		
Antimony	4.6E-01	8.9E-04	1.5	2.5	50	3.1E-01			5.9E-04		
Arsenic	9.3E-03	1.8E-05	0.03	1.4	5	3.1E-01			5.9E-04		
Barium	4.6E-01	8.9E-04	1.5	2.5	12.5	3.1E-01			5.9E-04		
Beryllium	4.7E-05	9.1E-08	0.005	0.025	0.1	9.4E-03			1.8E-05		
Cadmium	1.9E-03	3.6E-06	0.03	4	9	6.2E-02			1.2E-04		
Calcium hydroxide	4.6E+00	8.9E-03	15	25	500	3.1E-01			5.9E-04		
Chromium	4.6E-01	8.9E-04	1.5	2.5	250	3.1E-01			5.9E-04		
Cobalt	1.9E-02	3.6E-05	0.1	0.1	20	1.9E-01			3.6E-04		
Copper	9.3E-01	1.8E-03	3	5	100	3.1E-01			5.9E-04		
Iron oxide dust	4.6E+00	8.9E-03	15	25	500	3.1E-01			5.9E-04		
Lead	4.6E-02	8.9E-05	0.15	0.25	100	3.1E-01			5.9E-04		
Magnesium	4.6E+00	8.9E-03	30	50	250	1.5E-01			3.0E-04		
Manganese	4.6E+00	8.9E-03	3	5	500	1.5E+00	0.9		3.0E-03		
Mercury	9.4E-04	1.8E-06	0.025	0.1	10	3.8E-02			7.3E-05		
Molybdenum	4.6E+00	8.9E-03	15	25	60	3.1E-01			5.9E-04		
Nickel	9.3E-01	1.8E-03	4.5	10	10	2.1E-01			4.0E-04		
Potassium hydroxide	1.9E-02	3.6E-05	2	2	150	9.4E-03			1.8E-05		
Selenium	1.9E-01	3.6E-04	0.6	1	1	3.1E-01			5.9E-04		
Silver	9.3E-03	1.8E-05	0.3	0.5	10	3.1E-02			5.9E-05		
Sodium hydroxide	1.9E-02	3.6E-05	0.5	5	50	3.8E-02			7.3E-05		
Thallium	9.3E-02	1.8E-04	0.3	2	15	3.1E-01			5.9E-04		
Vanadium pentoxide	4.7E-03	9.1E-06	0.075	0.5	35	6.3E-02			1.2E-04		
Zinc oxide	9.3E+00	1.8E-02	15	15	500	6.2E-01			1.2E-03		

(a) Onsite = non-involved worker.
(b) Offsite = Offsite MEI.

Table 5.40. Non-radiological Air Concentrations for a Seismic Event Without Fire at the Low Level Burial Grounds

	Onsite Worker Conc. mg/m^3	Offsite MEI Conc. mg/m^3	TEEL-1, mg/m^3	TEEL-2, mg/m^3	TEEL-3, mg/m^3	Onsite[(a)] TEEL-1 Ratio	Onsite TEEL-2 Ratio	Onsite TEEL-3 Ratio	Offsite[(b)] TEEL-1 Ratio	Offsite TEEL-2 Ratio	Offsite TEEL-3 Ratio
Aluminum	7.4E+01	1.4E-01	30	50	250	2.5	1.5	0.3	4.8E-03		
Antimony	3.7E+00	7.1E-03	1.5	2.5	50	2.5	1.5	0.07	4.8E-03		
Arsenic	7.4E-02	1.4E-04	0.03	1.4	5	2.5	0.05		4.8E-03		
Barium	3.7E+00	7.1E-03	1.5	2.5	12.5	2.5	1.5	0.3	4.8E-03		
Beryllium	3.8E-04	7.3E-07	0.005	0.025	0.1	0.08			1.5E-04		
Cadmium	1.5E-02	2.9E-05	0.03	4	9	0.5			9.5E-04		
Calcium hydroxide	3.7E+01	7.1E-02	15	25	500	2.5	1.5	0.1	4.8E-03		
Chromium	3.7E+00	7.1E-03	1.5	2.5	250	2.5	1.5	0.01	4.8E-03		
Cobalt	1.5E-01	2.9E-04	0.1	0.1	20	1.5	1.5	7.4E-03	2.9E-03		
Copper	7.4E+00	1.4E-02	3	5	100	2.5	1.5	0.07	4.8E-03		
Iron oxide dust	3.7E+01	7.1E-02	15	25	500	2.5	1.5	0.1	4.8E-03		
Lead	3.7E-01	7.1E-04	0.15	0.25	100	2.5	1.5	0.004	4.8E-03		
Magnesium	3.7E+01	7.1E-02	30	50	250	1.2	0.7		2.4E-03		
Manganese	3.7E+01	7.1E-02	3	5	500	12	7.4	0.07	2.4E-02		
Mercury	7.6E-03	1.5E-05	0.025	0.1	10	0.3			5.8E-04		
Molybdenum	3.7E+01	7.1E-02	15	25	60	2.5	1.5	0.6	4.8E-03		
Nickel	7.4E+00	1.4E-02	4.5	10	10	1.6	0.7		3.2E-03		
Potassium hydroxide	1.5E-01	2.9E-04	2	2	150	0.08			1.5E-04		
Selenium	1.5E+00	2.9E-03	0.6	1	1	2.5	1.5	1.5	4.8E-03		
Silver	7.4E-02	1.4E-04	0.3	0.5	10	0.2			4.8E-04		
Sodium hydroxide	1.5E-01	2.9E-04	0.5	5	50	0.3			5.8E-04		
Thallium	7.4E-01	1.4E-03	0.3	2	15	2.5	0.4		4.8E-03		
Vanadium pentoxide	3.8E-02	7.3E-05	0.075	0.5	35	0.5			9.7E-04		
Zinc oxide	7.4E+01	1.4E-01	15	15	500	5	5	0.15	9.5E-03		

(a) Onsite = non-involved worker.
(b) Offsite = Offsite MEI.

5.11.2.1 Construction

New construction activities are anticipated for LLBG trenches and the new M-91 Facility. The primary impacts from construction activities would be to air quality and injuries to construction workers. No impacts to construction workers are expected from radiation and chemicals because new construction activities would be performed away from areas of known contamination. Also, impacts to non-involved workers (from other onsite activities) are expected to bound potential exposures to construction workers. Impacts from industrial accidents during construction are discussed in Section 5.11.2.4.

The construction activities may involve emission of criteria pollutants from the use of combustion engines and earthmoving activities. The potential impacts from these activities have been described in Section 5.2 and are summarized here. Impacts are measured by comparison of air concentrations at the point of maximum potential public exposure. The analysis indicated that emissions of criteria pollutants (including sulfur dioxide, carbon monoxide, nitrogen dioxide, and PM_{10}) from construction activities would result in air concentrations below 15 percent of the regulatory limits. As a consequence, no impacts on health would be expected from these emissions.

5.11.2.2 Normal Operations

Potential impacts to public health from normal operations include air quality impacts from atmospheric releases of radionuclides and chemicals from waste operations. Long-term impacts from releases to groundwater from LLBGs are discussed in Sections 5.11.2.3 and 5.3.

Alternative 2 involves operations that may result in routine releases of radionuclides and chemicals to the atmosphere. These operations include waste package verification, treatment, and packaging at WRAP, processing of materials and equipment at T Plant Complex, treatment and processing of waste in the new M-91 Facility, and treatment of leachate from MLLW trenches using pulse driers. The annual releases have been estimated for each year of operation for the facilities involved in this alternative. Details of the release calculations are described in Appendix F.

5.11.2.2.1 Health Impacts from Routine Radionuclide Releases

The expected doses and health impacts to non-involved workers and public from routine atmospheric releases of radionuclides are presented in Table 5.41 for the lower bound volume case and in Table 5.42 for the upper bound volume case. The table presents the maximum annual dose to the workers and the MEI, and the collective dose to public along with the probability of developing a LCF for the individual and the number of LCFs expected for the public. Because the doses and cancer risk estimates are small, no adverse health impacts would be expected from the radionuclide releases.

Table 5.41. Non-Involved Worker and Public Health Impacts from Routine Atmospheric Releases of Radionuclides for Alternative 2 Lower Bound Volume Case

Exposed Group	Exposure Scenario[a]	Facility	Lifetime Dose mrem	Prob. of LCFs[b]	Maximum Annual Dose	
					Year	Dose mrem
Worker Onsite (non-involved)	Industrial	WRAP	1.4E-3	5.7E-10	2004	1.6E-4
		T Plant Complex	5.7E-1	2.3E-7	2003	4.7E-2
		M-91 Facility	2.8E-2	1.1E-8	2015	2.0E-3
		Leachate Treatment[c,f]	6.9E-8	2.7E-14	2027	4.9E-9
		Total	6.0E-1	2.4E-7	2003	5.0E-2
MEI Offsite	Resident Gardener	WRAP	1.2E-4	5.8E-11	2004	1.2E-5
		T Plant Complex	1.2E-3	6.1E-10	2003	9.5E-5
		M-91 Facility	9.7E-4	4.8E-10	2015	6.7E-5
		Leachate Treatment[c,f]	3.5E-11	1.8E-17	2027	2.4E-12
		Total	2.3E-3	1.1E-9	2003	1.8E-4
			Dose person-rem	**Number of LCFs[e]**	**Year**	**Dose person-rem**
Population[d]	Population within 80 km (50 mi)	WRAP	8.3E-3	0 (4E-6)	2004	8.8E-4
		T Plant Complex	8.6E-2	0 (4E-5)	2003	6.7E-3
		M-91 Facility	6.8E-2	0 (3E-5)	2015	4.7E-3
		Leachate Treatment[c,f]	2.5E-9	0 (1E-12)	2027	1.7E-10
		Total	1.6E-1	0 (8E-5)	2003	1.2E-2

(a) The exposure scenarios are described in Appendix F. The exposure duration for the industrial scenario is 20 yr and for the resident gardener 30 yr.
(b) LCF = latent cancer fatality. For individuals, the LCF value is the risk of cancer death as the result of the postulated exposure. For population impacts, LCFs are the expected number of cancer deaths in the exposed population.
(c) Leachate treatment is pulse drier operation.
(d) The population lifetime impacts are based on exposure for the same exposure pathways impacting the resident gardener MEI.
(e) The value in parentheses is the calculated value based on the population dose and the appropriate health effects conversion factor. The actual number of LCF must be a whole number (deaths).
(f) If LLW trenches were to be lined, the doses from leachate collection and treatment might be as much as three times the leachate treatment values shown in the table above.

Table 5.42. Non-Involved Worker and Public Health Impacts from Routine Atmospheric Releases of Radionuclides for Alternative 2 Upper Bound Volume Case

Exposed Group	Exposure Scenario[a]	Facility	Lifetime Dose mrem	Prob. of LCFs[b]	Maximum Annual Dose	
					Year	mrem
Worker Onsite (non-involved)	Industrial	WRAP	2.1E-3	8.4E-10	2004	1.9E-4
		T Plant Complex	8.8E-1	3.5E-7	2006	7.2E-2
		M-91 Facility	2.8E-2	1.1E-8	2015	2.0E-3
		Leachate Treatment[c,f]	8.1E-8	3.2E-14	2028	5.6E-9
		Total	9.2E-1	3.7E-7	2006	7.4E-2
MEI Offsite	Resident Gardener	WRAP	2.1E-4	1.1E-10	2004	1.6E-5
		T Plant Complex	2.0E-3	9.9E-10	2006	1.5E-4
		M-91 Facility	9.7E-4	4.8E-10	2015	6.7E-5
		Leachate Treatment[c,f]	4.1E-11	2.1E-17	2028	2.7E-12
		Total	3.2E-3	1.6E-9	2006	2.3E-4
			Dose person-rem	**Number of LCFs[e]**	**Year**	**Dose person-rem**
Population[d]	Population within 80 km (50 mi)	WRAP	1.5E-2	0 (8E-6)	2004	1.1E-3
		T Plant Complex	1.4E-1	0 (7E-5)	2006	1.0E-2
		M-91 Facility	6.8E-2	0 (3E-5)	2015	4.7E-3
		Leachate Treatment	2.9E-9	0 (1E-12)	2028	1.9E-10
		Total	2.2E-1	0 (1E-4)	2006	1.6E-2

(a) The exposure scenarios are described in Appendix F. The exposure duration for the industrial scenario is 20 yr and for the resident gardener 30 yr.
(b) LCF = latent cancer fatality. For individuals, the LCF value is the risk of cancer death as the result of the postulated exposure. For population impacts, LCFs are the expected number of cancer deaths in the exposed population.
(c) Leachate treatment is pulse drier operation.
(d) The population lifetime impacts are based on exposure for the same exposure pathways impacting the resident gardener MEI.
(e) The value in parentheses is the calculated value based on the population dose and the appropriate health effects conversion factor. The actual number of LCF must be a whole number (deaths).
(f) If LLW trenches were to be lined, the doses from leachate collection and treatment might be as much as three times the leachate treatment values shown in the table above.

5.11.2.2.2 Health Impacts from Chemical Releases

Releases of chemicals to the atmosphere could occur for the same processes involving release of radionuclides when wastes with hazardous chemicals are involved. The potential health impacts from chemical releases to the atmosphere are presented in Table 5.43 for both the lower and upper bound volume cases. Because all the peak Hazard Quotients are less than 1, and because the cancer risk estimates are small, no adverse health impacts would be expected from chemical releases.

5.11.2.2.3 Worker Occupational Radiation Exposure

The radiation dose received by workers involved with waste operations is estimated using historical exposure data for the facilities involved in the alternative as provided in FH (2002). Table 5.44 summarizes the potential radiation exposure to workers for Alternative 2 lower bound volume case. Table 5.45 presents the results for the Alternative 2 upper bound volume case.

5.11.2.3 Post Closure Assessment

This section considers potential impacts on human health over long time periods following closure of the LLBGs under Alternative 2. The impacts are evaluated for releases to soil and groundwater with subsequent transport to the Columbia River and for inadvertent intrusion into the LLBGs in the absence of active institutional controls.

Releases of radionuclides and chemicals to the unsaturated soil beneath the LLBGs may occur as the waste packages degrade and water seeps through the waste. The potential sources of groundwater contamination are wastes contained in the LLBGs and the mixed waste trenches in the 200 East and the 200 West Areas. These wastes include LLW disposed of before 1970, and 1970-1988. In addition, LLW categories disposed after 1988 include Cat 1 wastes, Cat 3 wastes, and MLLW.

Details of these exposure scenarios are presented in Appendix F. The potential consequences to the MEI using the resident gardener scenario, evaluated over a period of 10,000 yr from closure of the LLBGs, are presented in Table 5.46 for the lower bound volumes and in Table 5.47 for the upper bound volumes. The potential consequences for the same scenario and evaluation period for a well near the Columbia River are presented in Table 5.48 for the lower bound volumes and in Table 5.49 for the upper bound volumes.

The downstream cumulative population doses and health impacts are presented in Table 5.50 for the lower bound volume case and in Table 5.51 for the upper bound volume case. All estimated health impacts to downstream populations are below levels that would be expected to result in any latent cancer fatalities.

Table 5.43. Non-Involved Worker and Public Health Impacts from Routine Atmospheric Releases of Chemicals for Alternative 2 Lower and Upper Bound Volume Cases

Volume	Exposed Group	Exposure Scenario[(a)]	Facility	Risk of Cancer Incidence[(b)]	Peak Annual Hazard Quotient[(b)]
Lower Bound	Worker Onsite (non-involved)	Industrial	WRAP	1.2E-9	8.9E-5
			T Plant Complex	3.2E-8	2.3E-3
			M-91 Facility	1.7E-7	9.1E-3
			Total	2.0E-7	1.1E-2
	MEI Offsite	Gardener	WRAP	5.6E-11	3.4E-6
			T Plant Complex	3.3E-11	1.9E-6
			M-91 Facility	6.9E-9	3.8E-4
			Total	7.0E-9	3.8E-4
	Population	Population within 80 km (50 mi)	WRAP	0 (4E-6)[(c)]	NA[(d)]
			T Plant Complex	0 (2E-6)[(c)]	NA
			M-91 Facility	0 (5E-4)[(c)]	NA
			Total	0 (5E-4)[(c)]	NA
Upper Bound	Worker Onsite (non-involved)	Industrial	WRAP	5.3E-9	6.8E-4
			T Plant Complex	1.8E-7	2.4E-2
			M-91 Facility	1.7E-7	9.1E-3
			Total	3.5E-7	3.4E-2
	MEI Offsite	Gardener	WRAP	2.2E-10	2.5E-5
			T Plant Complex	1.7E-10	2.0E-5
			M-91 Facility	6.9E-9	3.8E-4
			Total	7.3E-9	4.2E-4
	Population	Population within 80 km (50 mi)	WRAP	0 (2E-5)[(c)]	NA[(d)]
			T Plant Complex	0 (1E-5)[(c)]	NA
			M-91 Facility	0 (5E-4)[(c)]	NA
			Total	0 (5E-4)[(c)]	NA

(a) The exposure scenarios are described in Appendix F. The exposure duration for the industrial scenario is 20 yr and for the resident gardener 30 yr.
(b) The individual risk of cancer incidence is evaluated for the exposure duration defined for the given exposure scenario starting in the year that provides the highest total impact. Hazard Quotients are reported for the year of highest exposure.
(c) Population risk from cancer is expressed as the inferred number of fatal and non-fatal cancers in the exposed population over the lifetime of the population from intakes during the remediation period. The actual value must be a whole number (cancers).
(d) Hazard Quotients are designed as a measure of impacts on an individual and are not meaningful for population exposures.
NA = Not applicable.

Table 5.44. Occupational Radiation Exposure for Alternative 2 Lower Bound Volumes

Facility	Operating Period	Worker Category	Workers (FTE)[a]	Average Dose Rate, mrem/yr	Workforce Dose, person-rem	Workforce LCFs[c]
LLW and MLLW Trenches	2002-2046	Operator	14	54	34	0 (1.4E-2)
		RCT[b]	4	45	8.5	0 (3.4E-3)
		Other	66	35	104	0 (4.1E-2)
CWC	2002-2046	Operator	12	54	29	0 (1.2E-2)
		RCT	4	45	8.6	0 (3.5E-3)
		Other	55	17	42	0 (1.7E-2)
WRAP	2002 – 2032	Operator	13	18	7.3	0 (2.9E-3)
		RCT	9	36	10	0 (4.0E-3)
		Other	29	13	12	0 (4.7E-3)
	2033 – 2039	Operator	9	18	1.1	0 (4.5E-4)
		RCT	6	36	1.6	0 (6.5E-4)
		Other	20	13	1.9	0 (7.4E-4)
T Plant Complex	2002 – 2032	Operator	20	9	5.6	0 (2.2E-3)
		RCT	18	13	7.3	0 (2.9E-3)
		Other	38	7	8.2	0 (3.3E-3)
	2033 – 2046	Operator	14	9	1.7	0 (7.0E-4)
		RCT	13	13	2.3	0 (9.3E-4)
		Other	27	7	2.6	0 (2.7E-3)
M-91 Facility	2013 – 2031	Operator	10	13	2.6	0 (1.0E-3)
		RCT	10	13	2.4	0 (9.5E-4)
		Other	20	13	4.9	0 (2.0E-3)
Generator Staff[d]	2002-2019	Operator	15	34	9.2	0 (3.7E-3)
		RCT	12	35	7.6	0 (3.0E-3)
	2020-2026	Operator	5	34	1.2	0 (4.8E-4)
		RCT	3	35	0.7	0 (2.9E-4)
	2027-2044	Operator	1	34	0.6	0 (2.4E-4)
		RCT	1	35	0.6	0 (2.5E-4)
Pulse Driers	2026 – 2077	Operator	2.7	54	7.6	0 (2.7E-3)
Total for Alternative 2 Lower Bound Volume Case					325	0 (1.3E-1)

(a) The number of workers is the average necessary for the facility during the indicated period.
(b) RCT – Radiation Control Technician.
(c) Workforce LCFs are the inferred number of cancer deaths in the exposed workforce, which must be a whole number (deaths). The value in parentheses is the calculated value based on the workforce dose and the appropriate health effects conversion factor.
(d) Staff in the solid waste support services group that work as needed in various solid waste facilities.

Table 5.45. Occupational Radiation Exposure for Alternative 2 Upper Bound Volumes

Facility	Operating Period	Worker Category	Workers (FTE)[a]	Average Dose Rate, mrem/yr	Workforce Dose, person-rem	Workforce LCFs[c]
LLW and MLLW Trenches	2002- 2046	Operator	14	54	34	0 (1.4E-2)
		RCT[b]	4	45	8.5	0 (3.4E-3)
		Other	66	35	104	0 (4.1E-2)
CWC	2002-2046	Operator	12	54	29	0 (1.2E-2)
		RCT	4	45	8.6	0 (3.5E-3)
		Other	55	17	42	0 (1.7E-2)
WRAP	2002 – 2032	Operator	13	18	7.3	0 (2.9E-3)
		RCT	9	36	10	0 (4.0E-3)
		Other	29	13	12	0 (4.7E-3)
	2033 – 2039	Operator	9	18	1.2	0 (4.5E-4)
		RCT	6	36	1.6	0 (6.5E-4)
		Other	21	13	1.9	0 (7.4E-4)
T Plant Complex	2002 – 2032	Operator	20	9	5.6	0 (2.2E-3)
		RCT	18	13	7.3	0 (2.9E-3)
		Other	38	7	8.2	0 (3.3E-3)
	2033 – 2046	Operator	14	9	1.7	0 (7.0E-4)
		RCT	13	13	2.3	0 (9.3E-4)
		Other	27	7	2.6	0 (1.0E-3)
M-91 Facility	2013 – 2031	Operator	10	13	2.6	0 (1.0E-3)
		RCT	10	13	2.4	0 (9.5E-4)
		Other	20	13	4.9	0 (2.0E-3)
Generator Staff[d]	2002-2019	Operator	20	34	12	0 (6.4E-3)
		RCT	13	35	8.2	0 (4.4E-3)
	2020-2026	Operator	7	34	1.7	0 (6.7E-4)
		RCT	5	35	1.2	0 (4.9E-4)
	2027-2044	Operator	3	34	1.8	0 (7.3E-4)
		RCT	2	35	1.3	0 (5.0E-4)
Pulse Driers	2026 – 2077	Operator	0.9	54	2.5	0 (1.0E-3)
Total for Alternative 2 Upper Bound Volume Case					326	0 (1.3E-1)

(a) The number of workers is the average necessary for the facility during the indicated period.
(b) RCT – Radiation Control Technician.
(c) Workforce LCFs are the inferred number of cancer deaths in the exposed workforce that must be a whole number (deaths). The value in parentheses is the calculated value based on the workforce dose and the appropriate health effects conversion factor.
(d) Staff in the solid waste support services group that work as needed in various solid waste facilities.

Table 5.46. Potential Individual Human Health Impacts to a Resident Gardener at the 1-km Well from Radionuclides in the Groundwater Over 10,000 Years for Alternative 2 Lower Bound Volumes

Waste Category	Source Location	Exposure Scenario	Maximum Annual Dose		Lifetime Dose rem	Probability of an LCF[(b)]
			Years Post-2046[(a)]	Dose rem		
Previously Disposed Waste (Pre-1970)						
LLW	200 West Area	Resident Gardener	1,300	8.3E-4	2.5E-2	1.3E-5
	200 East Area	Resident Gardener	10,000	5.2E-3	1.6E-1	7.8E-5
Previously Disposed Waste (1970 – 1988)						
LLW	200 West Area	Resident Gardener	1,300	2.8E-3	8.3E-2	4.2E-5
	200 East Area	Resident Gardener	10,000	3.4E-2	1.0E+0	5.1E-4
Newly Generated Waste (1988 forward)						
LLW Cat 1	200 West Area	Resident Gardener	1,360	1.7E-4	5.1E-3	2.5E-6
	200 East Area	Resident Gardener	690	3.6E-6	1.1E-4	5.4E-8
LLW Cat 3	200 West Area	Resident Gardener	2,710	3.7E-5	1.1E-3	5.5E-7
	200 East Area	Resident Gardener	10,000	3.0E-6	9.0E-5	4.5E-8
MLLW	200 West Area	Resident Gardener	1,900	5.4E-3	1.6E-1	8.1E-5
	200 East Area	Resident Gardener	10,000	1.5E-1	4.5E+0	2.3E-3

(a) The number of years post-2046 in which the maximum annual dose occurs over the 10,000-yr period.
(b) Health impacts are expressed as lifetime risk of fatal cancer from the indicated lifetime radiation dose. The probability of a LCF is the calculated value using the appropriate linear health effects conversion factor. The actual probability cannot be greater than one.

Table 5.47. Potential Individual Human Health Impacts to a Resident Gardener at the 1-km Well from Radionuclides in the Groundwater Over 10,000 Years for Alternative 2 Upper Bound Volumes

Waste Category	Source Location	Exposure Scenario	Maximum Annual Dose		Lifetime Dose Rem	Probability of an LCF[(b)]
			Years Post-2046[(a)]	Dose rem		
Pre-1970 Previously Disposed Waste						
LLW	200 West Area	Resident Gardener	1,300	8.3E-4	2.5E-2	1.3E-5
	200 East Area	Resident Gardener	10,000	5.2E-3	1.6E-1	7.8E-5
Previously Disposed Waste (April 1970 – September 1988)						
LLW	200 West Area	Resident Gardener	1,300	2.8E-3	8.3E-2	4.2E-5
	200 East Area	Resident Gardener	10,000	3.4E-2	1.0E+0	5.1E-4
Newly Generated (1988 forward) Low-Level Waste						
LLW Cat 1	200 West Area	Resident Gardener	1,400	1.7E-4	5.1E-3	2.5E-6
	200 East Area	Resident Gardener	690	3.6E-6	1.1E-4	5.4E-8
LLW Cat 3	200 West Area	Resident Gardener	2,700	3.9E-5	1.2E-3	5.8E-7
	200 East Area	Resident Gardener	10,000	9.3E-4	2.8E-2	1.4E-5
MLLW	200 West Area	Resident Gardener	1,200	5.4E-3	1.6E-1	8.1E-5
	200 East Area	Resident Gardener	10,000	1.8E-1	5.4E+0	2.7E-3

(a) The number of years post-2046 in which the maximum annual dose occurs over the 10,000-yr period.
(b) Health impacts are expressed as lifetime risk of fatal cancer from the indicated lifetime radiation dose. The probability of a LCF is the calculated value using the appropriate linear health effects conversion factor. The actual probability cannot be greater than one.

Table 5.48. Potential Individual Human Health Impacts to a Resident Gardener at a Well Near the Columbia River from Radionuclides in the Groundwater Over 10,000 Years for Alternative 2 Lower Bound Volumes

Waste Category	Source Location	Exposure Scenario	Maximum Annual Dose		Lifetime Dose rem	Probability of an LCF[(b)]
			Years Post-2046[(a)]	Dose rem		
Previously Disposed Waste (Pre-1970)						
LLW	200 West Area	Resident Gardener	1,700	2.3E-5	7.0E-4	3.5E-7
	200 East Area	Resident Gardener	10,000	1.1E-4	3.4E-3	1.7E-6
Previously Disposed Waste (1970 – 1988)						
LLW	200 West Area	Resident Gardener	1,700	7.7E-5	2.3E-3	1.2E-6
	200 East Area	Resident Gardener	10,000	6.7E-4	2.0E-2	1.0E-5
Newly Generated Waste (1988 forward)						
LLW Cat 1	200 West Area	Resident Gardener	2,000	6.5E-6	2.0E-4	9.8E-8
	200 East Area	Resident Gardener	840	1.4E-7	4.1E-6	2.0E-9
LLW Cat 3	200 West Area	Resident Gardener	2,700	1.7E-6	5.1E-5	2.5E-8
	200 East Area	Resident Gardener	10,000	6.2E-8	1.9E-6	9.3E-10
MLLW	200 West Area	Resident Gardener	1,900	1.8E-4	5.3E-3	2.6E-6
	200 East Area	Resident Gardener	10,000	3.1E-3	9.2E-2	4.6E-5

(a) The number of years post-2046 in which the maximum annual dose occurs over the 10,000-yr period.
(b) Health impacts are expressed as lifetime risk of fatal cancer from the indicated lifetime radiation dose. The probability of a LCF is the calculated value using the appropriate linear health effects conversion factor. The actual probability cannot be greater than one.

Table 5.49. Potential Individual Human Health Impacts to a Resident Gardener at a Well Near the Columbia River from Radionuclides in the Groundwater Over 10,000 Years for Alternative 2 Upper Bound Volumes

Waste Category	Source Location	Exposure Scenario	Maximum Annual Dose		Lifetime Dose rem	Probability of an LCF[(b)]
			Years Post-2046[(a)]	Dose rem		
Previously Disposed Waste (Pre-1970)						
LLW	200 West Area	Resident Gardener	1,700	2.3E-5	7.0E-4	3.5E-7
	200 East Area	Resident Gardener	10,000	1.1E-4	3.4E-3	1.7E-6
Previously Disposed Waste (1970 – 1988)						
LLW	200 West Area	Resident Gardener	1,700	7.7E-5	2.3E-3	1.2E-6
	200 East Area	Resident Gardener	10,000	6.7E-4	2.0E-2	1.0E-5
Newly Generated Waste (1988 forward)						
LLW Cat 1	200 West Area	Resident Gardener	1,700	6.5E-6	2.0E-4	9.8E-8
	200 East Area	Resident Gardener	840	1.4E-7	4.1E-6	2.0E-9
LLW Cat 3	200 West Area	Resident Gardener	2,700	1.8E-6	5.3E-5	2.7E-8
	200 East Area	Resident Gardener	10,000	1.8E-5	5.3E-4	2.7E-7
MLLW	200 West Area	Resident Gardener	1800	1.8E-4	5.3E-3	2.6E-6
	200 East Area	Resident Gardener	10,000	3.3E-3	9.9E-2	4.9E-5

(a) The number of years post-2046 in which the maximum annual dose occurs over the 10,000-yr period.
(b) Health impacts are expressed as lifetime risk of fatal cancer from the indicated lifetime radiation dose. The probability of a LCF is the calculated value using the appropriate linear health effects conversion factor. The actual probability cannot be greater than one.

Table 5.50. Population Health Impacts from Drinking Water Downstream of Hanford Over 10,000 Years for Alternative 2 Lower Bound Volumes

Exposure Location	Waste Source	Waste Type	Population Dose person-rem	Estimated Cancer Fatalities
Tri-Cities, Washington	200 East	Previously Buried (Pre-1970)	1.4E-2	0 (7.0E-6) [(a)]
		Previously Buried (1970-1988)	2.2E-2	0 (1.1E-5)
		Cat 1 LLW	1.1E-4	0 (5.4E-8)
		Cat 3 LLW	1.9E-4	0 (9.3E-8)
		MLLW	1.6E-1	0 (8.2E-5)
	200 West	Previously Buried (Pre-1970)	8.1E-2	0 (4.0E-5)
		Previously Buried (1970-1988)	1.1E-1	0 (5.6E-5)
		Cat 1 LLW	8.9E-3	0 (4.5E-6)
		Cat 3 LLW	1.4E-2	0 (7.0E-6)
		MLLW	3.0E-1	0 (1.5E-4)
	Total		7.2E-1	0 (3.6E-4)
Portland, Oregon	200 East	Previously Buried (Pre-1970)	7.8E-3	0 (3.9E-6)
		Previously Buried (1970-1988)	1.2E-2	0 (6.2E-6)
		Cat 1 LLW	6.1E-5	0 (3.0E-8)
		Cat 3 LLW	1.0E-4	0 (5.2E-8)
		MLLW	9.1E-2	0 (4.6E-5)
	200 West	Previously Buried (Pre-1970)	4.5E-2	0 (2.3E-5)
		Previously Buried (1970-1988)	6.3E-2	0 (3.1E-5)
		Cat 1 LLW	5.0E-3	0 (2.5E-6)
		Cat 3 LLW	7.8E-3	0 (3.9E-6)
		MLLW	1.7E-1	0 (8.4E-5)
	Total		4.0E-1	0 (2.0E-4)

(a) The numbers expressed in parentheses are the calculated numbers of fatalities using the appropriate linear health effects conversion factor. The actual value must be an integer.

Table 5.51. Population Doses and Health Impacts from Drinking Water Downstream of Hanford Over 10,000 Years for Alternative 2 Upper Bound Volumes

Exposure Location	Waste Source	Waste Type	Population Dose person-rem	Estimated Cancer Fatalities
Tri-Cities, Washington	200 East	Previously Buried (Pre-1970)	1.4E-2	0 (7.0E-6) [(a)]
		Previously Buried (1970-1988)	2.2E-2	0 (1.1E-5)
		Cat 1 LLW	1.1E-4	0 (5.4E-8)
		Cat 3 LLW	6.3E-3	0 (3.2E-6)
		MLLW	4.0E-1	0 (2.0E-4)
	200 West	Previously Buried (Pre-1970)	8.1E-2	0 (4.0E-5)
		Previously Buried (1970-1988)	1.1E-1	0 (5.6E-5)
		Cat 1 LLW	8.9E-3	0 (4.5E-6)
		Cat 3 LLW	1.5E-2	0 (7.3E-6)
		MLLW	3.0E-1	0 (1.5E-4)
	Total		9.6E-1	0 (4.8E-4)
Portland, Oregon	200 East	Previously Buried (Pre-1970)	3.9E-2	0 (2.0E-5)
		Previously Buried (1970-1988)	6.2E-2	0 (3.1E-5)
		Cat 1 LLW	3.0E-4	0 (1.5E-7)
		Cat 3 LLW	1.8E-2	0 (8.9E-6)
		MLLW	1.1E+0	0 (5.7E-4)
	200 West	Previously Buried (Pre-1970)	2.3E-1	0 (1.1E-4)
		Previously Buried (1970-1988)	3.2E-1	0 (1.6E-4)
		Cat 1 LLW	2.5E-2	0 (1.3E-5)
		Cat 3 LLW	4.1E-2	0 (2.1E-5)
		MLLW	8.4E-1	0 (4.2E-4)
	Total		2.7E+0	0 (1.3E-3)

(a) The numbers expressed in parentheses are the calculated numbers of fatalities using the appropriate linear health effects conversion factor. The actual value must be an integer.

5.11.2.4 Accidents

Continuing waste management operations under Alternative 2 would involve a continuing potential for accidental release that would be very similar to those discussed for Alternative 1 in four Hanford facilities: the CWC for waste storage, WRAP, the T Plant Complex for waste treatment, and the LLBGs for waste disposal. Alternative 2 also adds a new treatment facility, the M-91 Facility, for which potential health impacts from accidents were evaluated. Health and safety impacts from industrial accidents would differ only slightly from Alternative 1 from construction activities for the M-91 Facility and LLBGs under Alternative 2.

Anticipated health impacts to all workers from industrial accidents during construction and operations would be 440 to 460 total recordable cases, 180 to 190 lost workday cases, and 6200 to 6400 lost workdays. A total of about 15,800 to 16,400 worker years would be required to complete all activities. Of these worker years about 2800 to 3400 are site support and waste generator-paid workers that do not appear in the direct facility worker and impact estimates in the following sections. About 94 to 97 percent of these health impacts are from operations.

5.11.2.4.1 Storage – Central Waste Complex

Potential radiological, non-radiological, and industrial accidents and impacts for the CWC would be the same as for Alternative 1 (see Section 5.11.1.4.1).

5.11.2.4.2 Treatment – Waste Receiving and Processing Facility

Potential radiological, non-radiological, and industrial accidents and impacts for WRAP would be the same as for Alternative 1 (see Section 5.11.1.4.2).

5.11.2.4.3 Treatment – T Plant Complex

Potential radiological, non-radiological, and industrial accidents and impacts for the T Plant Complex would be the same as for continuing T Plant activities described under Alternative 1 (see Section 5.11.1.4.3).

5.11.2.4.4 Treatment – M-91 Facility

The DOE would construct a new M-91 treatment facility in the 200 West Area, to augment existing capabilities for treatment of CH MLLW. DOE would provide onsite treatment for CH MLLW at this facility, in addition to oversized, RH MLLW, and TRU waste.

Radiological Consequences. Radiological consequences of accidents would be the same as described for the modified T Plant Complex with M-91 Capability described under Alternative 1 (see Section 5.11.1.4.3).

Non-radiological (Chemical) Consequences. Non-radiological consequences for the M-91 Facility have not been evaluated in detail. However, potential non-radiological impacts from accidents in WRAP and the T Plant Complex are expected to be representative for potential impacts from the M-91 Facility. Potential impacts from accidents in the CWC and LLBGs would likely be bounding for accidents in the M-91 Facility.

Industrial Accidents-Construction. Direct employment for the M-91 Facility construction would total 278 worker years. The estimated health and safety impacts would be 23 total recordable cases, 8 lost workday cases, and 150 lost workdays.

Industrial Accidents-Operations. Alternative 2 direct operations staffing in the M-91 Facility would be the same as described for the modified T Plant Complex under Alternative 1 (see Section 5.11.1.4.3).

5.11.2.4.5 Disposal – Low Level Burial Grounds

Potential radiological and non-radiological (chemical) accidents and impacts for the LLBGs, under Alternative 2, would be the same as for Alternative 1. Industrial accidents are discussed below.

Industrial Accidents-Construction. Slightly more impacts would be expected for LLBG construction under Alternative 2 than Alternative 1 and would require 54 to 83 worker years. The estimated health and safety impacts would be 32 to 36 total recordable cases, 10 to 12 lost workday cases, and 210 to 240 lost workdays.

Industrial Accidents-Operations. Industrial accidents from LLBG operations would be the same as Alternative 1 (see Section 5.11.1.4.4).

5.11.3 No Action Alternative

Under the No Action Alternative, DOE would continue operation of the waste management facilities and activities that are ongoing at the Hanford Site. Additional storage facilities would be constructed as needed, but no new treatment facilities would be constructed. DOE would continue operation of WRAP and the T Plant Complex. The commercial contracts for thermal treatment and stabilization would be used only at their minimum levels and the other wastes would remain in storage.

With the No Action Alternative, burial of LLW and MLLW would continue in existing trenches in the LLBGs. New trenches for LLW would be constructed using current design. When existing MLLW trenches are full, additional MLLW would be stored in an expanded CWC. Only certified TRU wastes would be sent to the WIPP. The No Action Alternative provides for continued storage of the wastes through 2046.

5.11.3.1 Construction

As part of the No Action Alternative, new construction activities are anticipated for expanded waste management facilities at the CWC and the LLBGs. Additional storage facilities would be constructed at the CWC to meet needs for expected volumes of TRU waste, continued generation of RH and large boxes of MLLW, and CH MLLW. Under this alternative, DOE would continue to bury LLW using the existing trenches and new trenches within the LLBGs.

The primary impacts from construction activities would be to air quality and injury of construction workers. No impacts to construction workers are expected from radiation or chemicals because new construction activities would be performed away from areas of known contamination. Also, impacts to non-involved workers (involved in onsite activities) are expected to bound potential exposures to construction workers. Impacts from industrial accidents during construction are discussed in Section 5.11.3.4.

The construction activities would result in the emission of Criteria Pollutants from the use of combustion engines and earth moving activities. Impacts are measured by comparison of air concentrations at the point of maximum potential public exposure. The air quality analysis (Section 5.2) indicated that all emissions of Criteria Pollutants [i.e., sulfur oxides, carbon monoxide, nitrogen oxides, and particulate material (PM_{10})] from construction activities result in air concentrations below 10 percent of the regulatory limits. As a consequence, no impacts on health would be expected from these emissions.

5.11.3.2 Normal Operations

Potential impacts to public health from normal operations include impacts from atmospheric releases of radionuclides and chemicals from waste operations. Radiation dose totals to workers involved with waste operations were also evaluated. Long-term impacts from releases to groundwater from LLBGs are discussed in Section 5.11.3.3.

The No Action Alternative involves operations that may result in routine releases of radionuclides and chemicals to the atmosphere. These operations include waste package verification, treatment, and packaging at WRAP, processing of materials and equipment at the T Plant Complex, and treatment of leachate from MLLW trenches using pulse driers. The annual releases have been estimated for each year of operation for the facilities involved in the No Action Alternative. Details of the release calculations are described in Appendix F.

5.11.3.2.1 Health Impacts from Routine Radionuclide Releases

The calculated doses and health impacts to non-involved workers and public from routine atmospheric releases of radionuclides are presented in Table 5.52. The table presents the maximum annual dose to the non-involved workers and the public, the cumulative dose to the public, and the associated risk of LCF for these exposures occurring during the period covered by the No Action Alternative. No adverse health impacts would be expected from routine radionuclide releases.

Table 5.52. Non-Involved Worker and Public Health Impacts from Routine Atmospheric Releases of Radionuclides for the No Action Alternative

Exposed Group	Exposure Scenario[a]	Facility	Lifetime Dose mrem	Probability of an LCFs[b]	Maximum Annual Dose	
					Year	mrem
Worker Onsite (non-involved)	Industrial	WRAP	1.4E-3	5.7E-10	2004	1.6E-4
		T Plant Complex	5.7E-1	2.3E-7	2003	4.7E-2
		Leachate Treatment[c]	2.1E-8	8.5E-15	2029	3.6E-9
		Total	5.8E-1	2.3E-7	2003	4.8E-2
MEI	Resident Gardener	WRAP	1.2E-4	5.8E-11	2004	1.2E-5
		T Plant Complex	1.2E-3	6.1E-10	2003	9.5E-5
		Leachate Treatment	1.0E-11	5.2E-18	2029	1.8E-12
		Total	1.3E-3	6.7E-10	2003	1.1E-4
			Dose person-rem	**Number of LCFs[b]**	**Year**	**person-rem**
Population[d]	Population within 50 mi. (80 km)	WRAP	8.3E-3	0 (4E-6)	2004	8.8E-4
		T Plant Complex	8.6E-2	0 (4E-5)	2003	6.7E-3
		Leachate Treatment	7.3E-10	0 (4E-13)	2029	1.2E-10
		Total	9.5E-2	0 (5E-5)	2003	7.6E-3

(a) The exposure duration for the industrial scenario is 20 yr and for the resident gardener 30 yr. The exposure scenarios are described in Appendix F.
(b) LCF = latent cancer fatality. For individuals, the LCF value is the risk of cancer death as the result of the postulated exposure. For population impacts, LCFs are the expected number of cancer deaths in the exposed population.
(c) Leachate treatment is pulse drier operation.
(d) The population lifetime impacts are based on exposure for the same exposure pathways impacting the resident gardener MEI.
(e) The value in parentheses is the calculated value based on the population dose and the appropriate health effects conversion factor. The actual number of LCFs must be a whole number (deaths).

Potential impacts to public health from normal operations include impacts from atmospheric releases of radionuclides and chemicals from waste operations. Radiation dose to workers involved with waste operations is also evaluated. Long-term impacts of releases to groundwater from LLBGs are discussed in Section 5.11.1.3.

5.11.3.2.2 Health Impacts from Chemical Releases

Releases of chemicals to the atmosphere could occur for the same processes involving radionuclide release when wastes with hazardous chemicals are involved. The potential health impacts from chemical releases to the atmosphere are presented in Table 5.53. Given that the peak hazard quotients are all less than 1, and because the cancer risk estimates are small, no adverse health impacts would be expected from chemical releases.

Table 5.53. Non-Involved Worker and Public Health Impacts from Routine Atmospheric Releases of Chemicals for the No Action Alternative

Exposed Group	Exposure Scenario[a]	Facility	Risk of Cancer Incidence[b]	Peak Annual Hazard Quotient[b]
Worker Onsite (non-involved)	Industrial	WRAP	1.2E-9	8.9E-5
		T Plant Complex	3.2E-8	2.3E-3
		Total	3.4E-8	2.4E-3
MEI Offsite	Gardener	WRAP	5.6E-11	3.4E-6
		T Plant Complex	3.3E-11	2.0E-6
		Total	8.9E-11	5.4E-6
Population	Population within 50 mi. (80 km)	WRAP	0 (4E-6)[c]	NA[d]
		T Plant Complex	0 (2E-6)[c]	NA
		Total	0 (6E-6)[c]	NA

(a) The exposure duration for the industrial scenario is 20 yr and for the resident gardener 30 yr. The exposure scenarios are described in Appendix F.
(b) The individual risk of cancer incidence is evaluated for the exposure duration defined for the given exposure scenario starting in the year that provides the highest total impact. Hazard Quotients are reported for the year of highest exposure.
(c) Population risk from cancer is expressed as the inferred number of fatal and non-fatal cancers in the exposed population over the lifetime of the population from intakes during the remediation period. The actual value must be a whole number (cancers).
(d) Hazard Quotients are designed as a measure of impacts on an individual and are not meaningful for population exposures.

5.11.3.2.3 Worker Occupational Radiation Exposure

The radiation dose received by workers involved with waste operations is estimated using historical exposure data for the facilities involved in the No Action Alternative, as provided in FH (2002). The exposure to involved workers is summarized in Table 5.54. The worker category Other includes engineers, maintenance personnel, and general support staff (i.e., administrative and clerical workers). All estimated health impacts to workers from radiation indicate that no latent cancer fatalities would be expected.

5.11.3.3 Post Closure Assessment

This section considers potential impacts on human health over long time periods following closure of the LLBGs under the No Action Alternative. The impacts are evaluated for releases to soil and groundwater, with subsequent transport to the Columbia River, and for inadvertent intrusion into the waste LLBGs in the absence of active institutional controls. The potential consequences to the MEI using the resident gardener scenario, evaluated over a period of 10,000 yr from closure of the LLBGs, are presented in Table 5.55 for a well at 1 km (0.6 mi). The potential consequences for the same scenario and evaluation period for a well near the Columbia River are presented in Table 5.56.

Table 5.54. Occupational Radiation Exposure for the No Action Alternative

Facility	Operating Period	Worker Category	Total Number of Workers (FTE[a])[b]	Average Dose Rate, mrem/yr	Workforce Dose, person-rem	Workforce LCFs[d]
LLW and MLLW trenches	2002- 2046	Operator	14	54	34	0 (1.4E-2)
		RCT[c]	4	45	8.5	0 (3.4E-3)
		Other	66	35	103	0 (4.1E-2)
CWC	2002- 2008	Operator	12	54	4.5	0 (1.8E-3)
		RCT	4	45	1.3	0 (5.0E-4)
		Other	55	17	6.5	0 (2.6E-3)
	2009- 2032	Operator	30	54	39	0 (4.9E-3)
		RCT	10	45	11	0 (1.4E-3)
		Other	140	17	57	0 (7.1E-3)
	2033- 2046	Operator	48	54	36	0 (1.5E-2)
		RCT	17	45	11	0 (4.3E-3)
		Other	218	17	52	0 (2.1E-2)
WRAP	2002- 2032	Operator	13	18	7.3	0 (2.9E-3)
		RCT	9	36	10	0 (4.0E-3)
		Other	29	13	12	0 (4.7E-3)
	2033- 2039	Operator	9	18	1.2	0 (4.7E-4)
		RCT	6	36	1.6	0 (6.5E-4)
		Other	21	13	1.9	0 (7.5E-4)
T Plant Complex	2002- 2032	Operator	20	9	5.6	0 (2.2E-3)
		RCT	18	13	7.3	0 (2.9E-3)
		Other	38	7	8.2	0 (3.3E-3)
	2033- 2046	Operator	14	9	1.7	0 (7.0E-4)
		RCT	13	13	2.3	0 (9.3E-4)
		Other	27	7	2.6	0 (1.0E-3)
Generator Staff[e]	2002-2019	Operator	15	34	9.2	0 (3.7E-3)
		RCT	12	35	7.6	0 (3.0E-3)
	2020-2026	Operator	5	34	1.2	0 (4.8E-4)
		RCT	3	35	0.7	0 (2.9E-4)
	2027-2044	Operator	1	34	0.6	0 (7.0E-4)
		RCT	1	35	0.6	0 (2.4E-4)
Pulse Driers	2026-2039	Operator	1.1	54	0.8	0 (2.5E-4)
Total for No Action Alternative					446	0 (1.8E-1)

(a) FTE = full-time employee.
(b) The number of workers is the average necessary for the facility during the indicated period.
(c) RCT = Radiation Control Technician.
(d) Workforce LCFs are the inferred number of cancer deaths in the exposed workforce, which must be a whole number (deaths). The value in parentheses is the calculated value based on the workforce dose and the appropriate health effects conversion factor.
(e) Staff in the Solid Waste support services group that work as needed in various solid waste facilities.

Table 5.55. Potential Individual Human Health Impacts to a Resident Gardener at the 1 km Well from Radionuclides in the Groundwater Over 10,000 Years for the No Action Alternative

Waste Category	Source Location	Exposure Scenario	Maximum Annual Dose		Lifetime Dose rem	Prob. of LCF[(b)]
			Years Post-2046[(a)]	Dose rem		
Previously Disposed Waste (Pre-1970)						
LLW	200 West Area	Resident Gardener	1,100	1.9E-3	5.9E-2	2.9E-5
	200 East Area	Resident Gardener	10,000	3.9E-2	1.2E+0	5.9E-4
Previously Disposed Waste (1970 – 1988)						
LLW	200 West Area	Resident Gardener	1,100	6.5E-3	1.9E-1	9.7E-5
	200 East Area	Resident Gardener	10,000	3.1E-1	9.3E+0	4.6E-3
Newly Generated Waste (1988 forward)						
LLW Cat 1	200 West Area	Resident Gardener	1,200	3.7E-4	1.1E-2	5.5E-6
	200 East Area	Resident Gardener	600	9.8E-6	2.9E-4	1.5E-7
LLW Cat 3	200 West Area	Resident Gardener	2,700	4.2E-5	1.2E-3	6.2E-7
	200 East Area	Resident Gardener	10,000	6.1E-5	1.8E-3	9.2E-7
MLLW[(c)]	200 West Area	Resident Gardener	1,200	5.4E-3	1.6E-1	8.1E-5

(a) The number of years post-2046 in which the maximum annual dose occurs over the 10,000-yr period.
(b) Health impacts are expressed as lifetime risk of fatal cancer from the indicated lifetime radiation dose. The probability of a LCF is the calculated value using the appropriate linear health effects conversion factor. The actual probability cannot be greater than one.
(c) Results are not reported or cases that had no inventory reported for the waste (for example, MLLW 200 East Area).

Table 5.56. Potential Individual Human Health Impacts at a Well Near the Columbia River from Radionuclides in the Groundwater Over 10,000 Years for the No Action Alternative

Waste Category	Source Location	Exposure Scenario	Maximum Annual Dose		Lifetime Dose rem	Prob. of LCF[b]
			Years Post-2046[a]	Dose rem		
Previously Disposed Waste (Pre-1970)						
LLW	200 West Area	Resident Gardener	1,500	5.0E-5	1.5E-3	7.5E-7
	200 East Area	Resident Gardener	10,000	6.4E-4	1.9E-2	9.6E-6
Previously Disposed Waste (1970 – 1988)						
LLW	200 West Area	Resident Gardener	1,500	1.7E-4	5.0E-3	2.5E-6
	200 East Area	Resident Gardener	10,000	6.6E-3	2.0E-1	9.8E-5
Newly Generated Waste (1988 forward)						
LLW Cat 1	200 West Area	Resident Gardener	1,600	1.1E-5	3.3E-4	1.6E-7
	200 East Area	Resident Gardener	700	3.9E-7	1.2E-5	5.8E-9
LLW Cat 3	200 West Area	Resident Gardener	2,700	1.8E-6	5.3E-5	2.6E-8
	200 East Area	Resident Gardener	10,000	9.9E-7	3.0E-5	1.5E-8
MLLW[c]	200 West Area	Resident Gardener	1,800	1.8E-4	5.3E-3	2.6E-6

(a) The number of years post-2046 in which the maximum annual dose occurs.
(b) Health impacts are expressed as lifetime risk of fatal cancer from the indicated lifetime radiation dose. The probability of a LCF is the calculated value using the appropriate linear health effects conversion factor. The actual probability cannot be greater than one.
(c) Results are not reported or cases that had no inventory reported for the waste (for example, MLLW for 200 East Area).

The impacts to populations downstream of Hanford have also been evaluated for the Tri-Cities and for Portland, Oregon. The population impacts from this use are presented in Table 5.57. All estimated health impacts to downstream populations are below levels of concern.

5.11.3.4 Accidents

Continuing waste management operations under the No Action Alternative would involve a continuing potential for accidental release that would be very similar to those discussed for Alternative 1 in four Hanford facilities: the CWC for waste storage, WRAP and the modified T Plant Complex for waste treatment, and the LLBGs for waste disposal. Potential health impacts to workers from industrial accidents would be the same as Alternative 1 for treatment activities in WRAP and are not discussed further. Differences would be expected for the CWC, T Plant Complex, and LLBGs and are discussed below.

Anticipated health impacts to all workers from industrial accidents during construction and operations would be 560 total recordable cases, 230 lost workday cases, and 8000 lost workdays. A total of about 20,400 worker years would be required to complete all activities. Of these worker years about 2600 are

Table 5.57. Population Doses and Health Impacts from Drinking Water Downstream of Hanford Over 10,000 Years for the No Action Alternative

Exposure Location	Waste Source	Waste Type	Population Dose Person-rem	Estimated Cancer Fatalities
Tri-Cities, Washington	200 East	Previously Buried (Pre-1970)	1.8E-2	0 (8.8E-6) [(a)]
		Previously Buried (1970-1988)	5.1E-2	0 (2.5E-5)
		Cat 1 LLW	1.1E-4	0 (5.5E-8)
		Cat 3 LLW	1.8E-4	0 (9.0E-8)
	200 West	Previously Buried (Pre-1970)	8.1E-2	0 (4.0E-5)
		Previously Buried (1970-1988)	1.1E-1	0 (5.6E-5)
		Cat 1 LLW	8.6E-3	0 (4.3E-6)
		Cat 3 LLW	1.3E-2	0 (6.6E-6)
		MLLW	5.3E-1	0 (2.7E-4)
	Total		8.2E-1	0 (4.1E-4)
Portland, Oregon	200 East	Previously Buried (Pre-1970)	4.9E-2	0 (2.5E-5)
		Previously Buried (1970-1988)	1.4E-1	0 (7.1E-5)
		Cat 1 LLW	3.1E-4	0 (1.5E-7)
		Cat 3 LLW	5.0E-4	0 (2.5E-7)
	200 West	Previously Buried (Pre-1970)	2.3E-1	0 (1.1E-4)
		Previously Buried (1970-1988)	3.2E-1	0 (1.6E-4)
		Cat 1 LLW	2.4E-2	0 (1.2E-5)
		Cat 3 LLW	3.7E-2	0 (1.9E-5)
		MLLW	1.5E+0	0 (7.5E-4)
	Total		2.3E+0	0 (1.1E-3)

(a) The numbers expressed in parentheses are the calculated numbers of fatalities using the appropriate linear health effects conversion factor. The actual value must be an integer.

site support and waste generator-paid workers that do not appear in the direct facility worker and impact estimates in the following sections. About 95 to 97 percent of these health impacts are from operations.

5.11.3.4.1 Storage – Central Waste Complex

Potential radiological and non-radiological accidents and impacts for the CWC, under the No Action Alternative, would be the same as for Alternative 1 (see Section 5.11.1.4.1). Industrial accidents are discussed below.

Industrial Accidents-Construction. Construction of long-term storage buildings at the CWC would require 330 worker years. The estimated health and safety impacts would be 27 recordable cases, 9 lost workday cases, and 180 lost workdays.

Industrial Accidents-Operations. Direct operations staffing in the CWC would require 8700 worker years. The estimated health and safety impacts would be 560 recordable cases, 230 lost workday cases, and 8000 lost workdays

5.11.3.4.2 Treatment – Waste Receiving and Processing Facility

Potential radiological, non-radiological, and industrial accidents and impacts for WRAP, under the No Action Alternative, would be the same as for Alternative 1 (see Section 5.11.1.4.2).

5.11.3.4.3 Treatment – T Plant Complex

Potential radiological, non-radiological (chemical) accidents and impacts for T Plant Complex under the No Action Alternative would be the same as for the continuing T Plant activities under Alternative 1 (see Section 5.11.1.4.3).

Industrial Accidents-Construction. Under the No Action Alternative, there would be no new construction at the T Plant Complex and no construction impacts would occur.

Industrial Accidents-Operations. Direct operations staffing would be less than either Alternative 1 or 2, requiring 3100 worker years. The estimated health and safety impacts would be 82 total recordable cases, 34 lost workday cases, and 1200 lost workdays. These estimates are based on Hanford Site non-construction occupational injury statistics from 1996 through 2000 (see Section 4.9).

5.11.3.4.4 Disposal – Low Level Burial Grounds

Under the No Action Alternative, potential radiological and non-radiological accidents and impacts for the LLBGs would be the same as for Alternative 1 (see Section 5.11.1.4.4). Industrial accidents are discussed below.

Industrial Accidents-Construction. Construction under the No Action Alternative would require 44 worker years, slightly less than the lower bound of Alternative 2 but more than Alternative 1. The estimated health and safety impacts would be 4 total recordable cases, 1 lost workday cases, and 24 lost workdays.

Industrial Accidents-Operations. Industrial accidents from LLBG operations would be the same as Alternative 1 and are not discussed further.

5.11.4 Intrusions into Waste Sites

Inadvertent intrusion into LLBGs by humans or other biota is possible if institutional controls were absent. The impacts of such intrusions are presented in this section. Both intrusion by humans and biotic organisms are considered.

5.11.4.1 Inadvertent Human Intrusion

It is assumed that an individual has no knowledge of the below ground hazards. Two scenarios were analyzed: excavating a basement for a dwelling and drilling a well. It is assumed that waste extracted from the LLBGs was indistinguishable from the soil, with the exception of metals, grout, and asphalt. Details of the exposure scenarios are presented in Appendix F.

Consideration was given to analyzing intrusion into LLW sites, MLLW sites, HICs, and in-trench grouted waste. Drilling into, or excavation of, HICs and grout monoliths were dismissed from analysis because continued drilling into the concrete and steel containers was believed sufficient to alert the intruder that a possibly hazardous deposit had been encountered and that drilling or excavation at that location should cease. Intrusion into a LLW site may not be so obvious and has been retained in this analysis.

The inventory used in this analysis was based on maximum radionuclide concentrations for waste disposed in the LLBGs.

5.11.4.1.1 Drilling Scenario

It is assumed that a well is drilled directly through waste buried under an RCRA barrier. A 5-m (16-ft) long, 30-cm (12-in.) diameter core of waste was removed and mixed instantaneously into the top 15 cm (6 in.) of clean soil. A garden was cultivated in the now contaminated soil. For a given radionuclide, doses were calculated as a function of time with the assumptions of leaching or not leaching radionuclides from the soil during crop growth. Pathways included in the derivation of the dose conversion factors included: ingestion of vegetables grown in the contaminated soil; ingestion of contaminated soil; inhalation of radionuclides; external exposure to contaminated soil while working in the garden or residing in the house built on top of the waste site. Details of the dose estimation methods are provided in Appendix F.

Dose estimates and probabilities of LCF are presented in Table 5.58 for intrusion 100, 300, and 500 yr after the RCRA barrier is placed on the waste site in 2046. Table entries are given for consideration of no leaching from the surface soil layer because both leaching assumptions resulted in nearly identical impacts: leaching causes only a small reduction in estimated doses and health impacts. No radiological consequences in the form of LCF would be anticipated from intrusion, via drilling, into the LLBGs.

Table 5.58. Impacts to an Individual from Drilling into Low-Level Burial Grounds

Consequence	Time Since Year 2046		
	100 yr	300 yr	500 yr
Dose to MEI (rem)	330	3.1	0.10
Prob. of LCF[(a)]	0.13	0.0022	4.1E-5
(a) The probability of a latent cancer fatality is calculated using a health effects conversion factor. The actual probability cannot be greater than 1.			

5.11.4.1.2 Excavation Scenario

The excavation scenario provided the greatest estimated impacts for intruder scenarios. This result was because the excavation intruder exhumed the most waste and contaminated soil that was spread about the garden. Total doses and the associated probability of a LCF from the excavation scenario are listed in Table 5.59. For intrusion by excavation in the year 2146, the intruder's lifetime dose was estimated to be 70,000 rem and the probability of the intruder contracting a fatal cancer is high. Although this dose is accumulated over an assumed 50-yr period, some form of acute adverse health effects would likely result.

Table 5.59. Impacts to an Individual from Excavation into Low-Level Burial Grounds

Consequence	Time Since Year 2046		
	100 yr	300 yr	500 yr
Dose to MEI (rem)	70,000	650	22
Prob. of LCF[(a)]	1	0.26	0.0088
(a) The probability of a latent cancer fatality is calculated using a health effects conversion factor. The actual probability cannot be greater than 1.			

5.11.4.2 Biotic Intrusion

Intrusions into LLBGs by deep-rooted plants and burrowing animals are known vectors for contamination migration to the surface environment and thus might pose a potential for radiological exposure for onsite workers (Johnson *et al*. 1994). In addition, intrusion into LLBGs by small burrowing animals has been documented by Hakonson (1986) and Perkins *et al*. (2001). Known biotic vectors on the LLBGs have included, in order of frequency, Russian thistle, also known as tumbleweed (*Salsola kali*), western subterranean termite (*Reticulitermes hesperus*), western harvester ant (*Pogonomyrmex owhyheei*), northern pocket gopher (*Thomomys talpoides*), Townsend's ground squirrel (*Spermophilus townsendii*) and badger (*Taxidea taxis*). A biological control program designed to specifically deal with biotic vectors has been in place on the Hanford Site since 1998, and incidents of biotic-related contamination spread have decreased from a high of 130 incidents in 1999 to 41 in 2001 (McKinney and Markes 2001).

During and after the operational period, the deep-rooted plant of concern is the Russian thistle (DOE-RL 1998c), a nuisance weed that has a rooting depth of up to 4.6 m (15 ft). Russian thistle grows

in any type of well-drained un-compacted soil with sunny exposure. Russian thistle could colonize un-capped LLBGs, if they were left fallow for one or more growing seasons. In particular, soil to plant concentration ratios for strontium-90 uptake in tumbleweed can exceed 10 because of a naturally occurring oxalate chelator exuded by the plant roots. In order to avoid spread of contamination in the LLBGs during the operational period, waste would be covered with clean soil and the soil surface would be kept free of weeds and burrowing animals through the use of herbicides and other control measures as needed.

In both Alternative 1 and Alternative 2, a RCRA Type C barrier would be placed over the LLBGs. Although Russian thistle roots might occur in the upper layers of the barrier, a 25-cm (10-inch) layer of asphalt just above the trench backfill (at grade) would discourage both deep-rooted plants and burrowing animals. In the No Action Alternative, only the MLLW trenches would be covered with the RCRA Type C barrier and as consequence, avoidance of surface contamination by tumbleweeds would likely rely on use of herbicides.

5.12 Aesthetic and Scenic Resources

Potential impacts on aesthetics and scenic resources arising from implementing Alternative 1, Alternative 2, or the No Action Alternative are discussed in this section. The potential impacts would arise mainly from visual intrusions on the natural landscape from expansion of existing buildings or construction of new facilities undertaken in support of the waste transport, treatment, storage, and disposal in the 200 Areas. Aesthetic and scenic resources of the Hanford Site are described more fully in Section 4.8.10.

Most facilities are not visible to the public because of the size of the facilities, the size of the Hanford Site, the location of the facilities within the Hanford Site, the terrain and restricted access to the Site, and the distance between the viewer and the activity on the Site. The exception is the construction, operation, and eventual closure of the Area C borrow pits to the south of the SR 240 and Beloit Avenue intersection.

The Area C borrow pit site is a large polygonal area located adjacent to and south of SR 240 and centered approximately at the intersection of Beloit Avenue and SR 240. This site is about 926 ha (2287 ac) in size and is located next to the ALE, but is not part of ALE nor of the Hanford Reach National Monument. The area was designated as Conservation (Mining) in the ROD (64 FR 61615) for the HCP EIS (DOE 1999). The operation of the borrow pits would not be visible from vehicles using SR 240 from the southwest until they are approximately three-quarters of the way past the site. The reason for this restriction in the viewshed is the elevated terrain adjacent to SR 240, separating Area C from the road. Travelers coming from the northwest on SR 240 would notice the site sooner and would be able to observe the activities in passing. The pits themselves would be located a minimum of 152 m (500 ft) from SR 240. During the borrow site development, the bringing of utilities from the Hanford 200 West Area to the site would be noticeable by those traveling on SR 240. The Area C borrow pits would be within the northerly viewshed from Rattlesnake Mountain.

During the operation of the Area C borrow pits, a maximum of approximately 70 pits would be excavated and about 81 ha (200 ac) would be disturbed (Alternative 2 – Upper Bound Waste Volume).

From the air and SR 240, the surface terrain will look pockmarked. During the 12 plus years of the site's operational life, stockpiles of sand, gravel, rock and silt/loam would be located within 305 m (1000 ft) of SR 240. The individual borrow pits will be restored when their useful life ends. This restoration includes replacing excavated topsoil and re-seeding the area. After extraction of resources from the borrow pit area is complete, the site pit slopes will be re-graded and irregular terrain lines installed to blend the site with the surrounding terrain. No permanent adverse aesthetic or scenic impacts would be expected.

Fugitive dust emissions associated with development and operation of the Area C borrow pits is a recognized, potential problem and, as a result, a program would be undertaken to keep fugitive dust controlled during site development and operation, even during off hours. Use of soil adhesives, the application of water, and the discontinuance of excavation and truck loading activities, when winds exceed 24 km/hr (15 mi/hr), are some of the control measures that would be employed. As a consequence, fugitive dust from the borrow pit area would not be expected to develop into an adverse aesthetic or scenic impact.

Elk occupying the ALE site are sometimes seen from SR 240. Operation of the borrow pit might reduce the likelihood of sighting these animals, as they might migrate farther away from where they might be seen from the highway, as a result of these activities.

Travelers can see some Site facilities in the 200 West Area on an 11-km (7-mi) segment of SR 240 south of the Yakima Barricade (near the junction of SR 240 and State Route 24). At the closest approach, facilities associated with waste management activities are about 3 km (2 mi) distant. Facilities throughout the 200 areas are visible from elevated locations, such as Gable Mountain, Gable Butte, Rattlesnake Mountain and, in the distance from atop the bluffs, east of the Columbia River. These locations are generally not points for public viewing because of their restricted access; however, they may be points of viewshed observation important to Native Americans.

5.12.1 Alternative 1

The potentials for aesthetic impacts in Alternative 1 would be

- those associated with the use of the T Plant Complex, as modified for the M-91 Capability
- construction of additional disposal trenches of a deeper and wider design
- extraction of capping materials from the Area C borrow pit
- construction of the LLBG caps, that would raise the surface about 1.7 m (5.5 ft) over an area of about 150 ha (370 ac).

T Plant Complex is a facility that has been in place for about 50 yr and is not considered in terms of aesthetic impacts. Trench construction and the capped LLBGs would not likely be noticeable from points of public viewing.

5.12.2 Alternative 2

The potentials for aesthetic impacts in Alternative 2 would be associated with

- use of the T Plant Complex
- construction of a new, but similar, facility for the M-91 Capability
- construction of additional disposal trenches of current design
- extraction of capping materials from the Area C borrow pit
- construction of LLBG caps, that would raise the surface about 1.7 m (5.5 ft) over an area of about 180 ha (440 ac).

As in Alternative 1, the T Plant Complex is a facility that has been in place for about 50 yr and is not considered in terms of aesthetic impacts. The new facility built for the M-91 Capability would probably be noticeable from SR 240 as one more multi-story concrete monolith with a 30-m (100-ft) stack. Even if seen, it is questionable that it would be distinguishable from the other industrial buildings in the 200 West Area. Trench construction and the capped LLBGs would likely not be noticeable from points of public viewing. The potential for aesthetic or scenic impacts related to excavation operations at the borrow pit would be essentially the same as for Alternative 1.

5.12.3 No Action Alternative

The potentials for aesthetic impacts in the No Action Alternative would be those associated with

- use of the T Plant Complex
- construction of additional disposal trenches of current design
- construction of 66 additional units in the CWC expansion area
- extraction of capping materials from the Area C borrow pit
- construction of MLLW trench caps that would raise the surface about 1.7 m (5.5 ft) over about 4.7 ha (12 ac).

As previously noted, the T Plant Complex is a facility that has been in place for about 50 yr and is not considered in terms of aesthetic impacts. Trench construction and the capped MLLW trenches would not likely be noticeable from points of public viewing. Although the new CWC buildings might be noticeable from SR 240, they are co-located with other buildings in the developed 200 West Area and would not likely be considered an adverse aesthetic impact.

The potential for aesthetic and scenic impacts related to excavation operations at the borrow pit would be substantially smaller than for either Alternative 1 or 2, as less than 3 percent of the volume of materials would be needed for MLLW trench capping.

5.13 Environmental Justice

Executive Order 12898, "Federal Actions to Address Environmental Justice in Minority Populations and Low-income Populations" (59 FR 7629), directs Federal agencies in the Executive Branch to consider environmental justice so that their programs will not have "…disproportionately high and adverse human health or environmental effects…" on minority and low-income populations. Executive Order 12898 further directed Federal agencies to consider effects to "populations with differential patterns of subsistence consumption of fish and wildlife." The Executive Branch agencies also were directed to develop plans for carrying out the order. The CEQ provided additional guidance later for integrating environmental justice into the National Environmental Policy Act process in a December 1997 document, *Environmental Justice Guidance under the National Environmental Policy Act* (CEQ 1997).

Environmental justice is concerned with assessment of disproportionate distribution of adverse impacts of an action among minority and low-income populations that is significantly greater than that experienced by the rest of the population. Adverse impacts are defined as negative changes to the existing conditions in the natural environment (for example, land, air, water, wildlife, vegetation) or in the human environment (for example, employment, health, land use). The distribution of minority and low-income groups in the Hanford environs is shown graphically in Section 4.8.

Based on the 2000 census (USCB 2000a), [(a)] the 80-km (50-mi) radius area surrounding the Hanford Site had a total population of 511,500 and a minority population of 185,000. The ethnic composition of the minority population is primarily White Hispanic (24%), self-designated "other" races (54%), Native American (6%), and two or more races (9%). Asians and Pacific Islanders (4%) and African American (3%) make up the rest. The Hispanic population resides predominantly in Franklin, Yakima, Grant, and Adams counties. Native Americans within the 80-km (50-mi) area reside primarily on the Yakama Reservation and upstream of the Hanford Site near the town of Beverly, Washington.

There are Native Americans of various tribal affiliations that live in the greater Columbia Basin that rely on natural resources for subsistence. According to Harris and Harper (1997) the Nez Perce Tribe, the Confederated Tribes of the Umatilla Indian Reservation, and the Yakama Nation depend on natural resources for dietary subsistence. For example, the treaty of 1855 with the Yakama Nation (DOE 1999) secured to the Yakamas "the exclusive right of taking fish in all the streams, where running through or bordering said reservation ...and …the right of taking fish at all usual and accustomed places, in common with the citizens of the Territory (now the State of Washington) 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 and unclaimed lands." The Wanapum historically lived along the Columbia River (a portion of their traditional lands borders the Hanford Site) and continue to live upstream of the Site. They fish on the Columbia River and gather food resources near the Hanford Site. The Confederated Tribes of the Colville Reservation traditionally fished and gathered food resources in the Hanford area. They are also recognized as having cultural and religious ties to the Hanford Site.

(a) http://quickfacts.census.gov/qfd/

The pathways through which the environmental impacts are associated with each of the alternatives and how they might disproportionately impact minority or low-income groups were reviewed for each of the associated subsections of Section 5.0. The only aspect that exhibited the potential for disproportionate impacts dealt with implications of cultural resources on the Hanford Site with respect to Native Americans. Native Americans affiliations near the Hanford Site include such places as Gable and Rattlesnake mountains and Gable Butte in their creation beliefs and cultural heritage. Thus, disproportionate adverse impacts from implementing any of the alternatives on minority or low-income populations would be limited to those that might be associated with restricted use of Native American traditional cultural places on the Hanford Site. Other impacts related to aesthetic and scenic resources are addressed in Section 5.12.

5.14 Cumulative Impacts

Potential cumulative impacts associated with implementing Alternative 1, lower and upper bound volumes, are summarized in this section. For most aspects, cumulative impacts of Alternative 2, lower and upper bound volumes or the No Action Alternative would not differ substantially. "Cumulative impact" is the impact on the environment from the incremental impact of the action when added to other past, present, and reasonably future actions regardless of what agency (federal or non-federal) or person undertakes such actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time (40 CFR 1508.7). The continuing challenge of cumulative effects analysis is to focus on important cumulative issues....(CEQ 1997).

The region of influence of cumulative impacts considered varies with the impact category and receptors of those impacts. Thus, in the case of impacts related to contaminants reaching groundwater and the Columbia River, the region of influence could reach from the Hanford Site downstream to the Pacific Ocean. The region of influence for releases to the atmosphere would typically be the area within a radius of 80 km (50 mi) of the point of release.

Discussions of past and reasonably foreseeable future actions are also limited principally to those on the Hanford Site. Other current and future actions include preparation for and disposing of tank waste and strontium and cesium capsules, CERCLA remediation projects, decontamination and decommissioning of the Hanford production reactors, operation of a commercial LLW disposal site by U.S. Ecology, and operation of the Columbia Generating Station by Energy Northwest.

5.14.1 Land Use

Because of past practices, some of the land within the 200 Area has been already committed in perpetuity for waste disposal. The reason for this commitment is the current presence in soil of radionuclides that had been discharged to ground or leaked from tanks. Because of their chemical characteristics, these radionuclides are held up in the soil and, because of their very long half-lives, they decay at a very slow rate (for example, plutonium-239 with a half-life of 24,000 yr, or cesium-135 with a half-life of 3.000,000 yr, will remain there indefinitely). Actions addressed in all alternatives in this EIS and similar future disposal actions, such as onsite disposal of immobilized low-activity tank waste, would add to that commitment.

In Alternative 1, waste management activities through 2046 (upper bound volume) would be expected to require up to a total of 343 ha (847 ac) for waste storage, treatment and disposal facilities, of which up to 153 ha (378 ac) would be permanently committed for disposal of wastes in LLBGs. Alternative 2, (upper bound volume) would require a total of up to 390 ha (963 ac) for waste storage, treatment, and disposal facilities of which about 178 ha (440 ac) would be permanently committed to LLW disposal. In the No Action Alternative, 149 ha (368 ac) would be permanently committed to LLW disposal; however, continued storage would occupy about 116 ha (286 ac) indefinitely. In any event, the largest such permanent commitment (178 ha [440 ac]) would represent about 4 percent of the 5000-ha (12,350-ac) area designated for long-term waste management activities in the HCP EIS (DOE 1999).

5.14.2 Air Quality

Air quality limits at the Hanford Site boundary are not expected to be approached; as a result of implementing any of the options described here or from reasonably foreseeable actions at the Hanford Site. For example, these activities include operation of LLW disposal by U.S. Ecology, decommissioning of unused facilities, operation of Energy Northwest's Columbia Generating Station, construction and operation of the Hanford tank waste treatment plant, and remediation and restoration activities.

5.14.3 Ecological and Cultural Resources

Cumulative impacts as they pertain to ecological resources, and cultural resources in general on the Hanford Site, can be found in the HCP EIS (DOE 1999), which is incorporated by reference. Current field surveys did not identify ecological or cultural resources that would be adversely impacted by activities considered in this EIS.

5.14.4 Socioeconomics

Increases in activity levels could strain a tight housing market if a number of projects discussed for Hanford were all built at the same time, even though the impact of Alternative 1, Alternative 2, or the No Action Alternative would each be small. The current projected baseline for Hanford shows a declining Hanford budget and employment over the long-term. This infers that, other things being equal, most community infrastructure will be adequate to accommodate any new population associated with this alternative in the long run. However, in the short run (between 2002 and 2007), the Hanford tank waste treatment plant is expected to be under construction, bringing a projected 7000 new residents to the area. Any early arrival of the up to 1150 new residents related to the Hanford solid waste program (shown in 2011 in Table 5.13) in the Tri-Cities area could further challenge the capacities of the local real estate markets, transportation network, and primary and secondary education facilities.

In addition, other projects are expected to occur at Hanford in the near term, such as operations at the Hazardous Materials Management and Emergency Response (HAMMER) facility; cleanup of several older reactors and other buildings; actions to remediate the K-Basins, the vadose zone, and groundwater on the Site. These additional projects may increase Hanford employment by a few hundred workers during the period 2002 to 2010 and, therefore, may also affect the socioeconomic context in which the effects of any LLW, MLLW, and TRU waste-related activity must be judged.

5.14.5 Public Health

Cumulative impacts for several pathways leading to potential radiological impacts on the public are presented in the following sections.

5.14.5.1 Atmospheric Pathway

A summary of cumulative impacts on public health from operations is provided in Table 5.60. The cumulative population dose, since startup of Hanford operations, was estimated to be 100,000 person-rem (DOE 1995). The number of inferred LCFs since plant startup would amount to about 50, essentially all of which would be attributed to dose received in the 1945-1952 time period.

Table 5.60. Cumulative Population Health Effects from Atmospheric Pathways due to Facility Operations in Hanford Environs[(a)]

Source of Impacts	Dose person-rem	Latent Cancer Fatalities[(b)]
Past Hanford Operations (DOE 1995)	100,000	50
Ongoing and Proposed Actions		
Hanford Operations (1997-2046) (Poston *et al.* 2001)[(c)]	15	0
Columbia Generating Station (30 yr) (DOE 1996a)	21	0
HSW EIS		
Alternative 1 – Lower Bound Volume (from Table 5.18)	0.1	0
Alternative 1 – Upper Bound Volume (from Table 5.19)	0.4	0
Alternative 2 – Lower Bound Volume (from Table 5.41)	0.2	0
Alternative 2- Upper Bound Volume (from Table 5.42)	0.2	0
No Action Alternative (from Table 5.52)	0.1	0
Reasonably Foreseeable Actions		
Plutonium Finishing Plant Stabilization (DOE 1996b)	140[(d)]	0
K Basin Fuel Treatment & Storage (DOE 1996a)	120[(d)]	0
TWRS Phased Implementation Alternative (DOE 1996c)	400[(d)]	0
Cumulative Total	100,696.4[(e)]	50
Perspective		
Cumulative Natural Background Dose – 100 yr, 1946-2046	12,000,000	6000

(a) Assumes constant population of about 380,000.
(b) One latent cancer fatality per 2000 person-rem. Values less than 0.5 rounded to zero.
(c) Assumed to continue at the 2000 population dose rate.
(d) Bounding value
(e) For the solid waste program, this includes only the value of 0.4 person-rem from Alternative 1 – Upper Bound Waste Volume activities

For perspective, since startup of the Hanford Site, the population of interest (assuming a constant population of 380,000 and an individual dose of 0.3 rem/yr) would have received about 6,000,000 person-rem, from naturally occurring radiation sources (natural background), from which 3000 LCF would be inferred.

If the Hanford Site-wide contribution to public dose from all exposure pathways were to remain through the period ending in 2046 at about the same level as in the recent past (Poston *et al.* 2001), the estimated collective dose would be about 36 person-rem. No LCFs would be expected from such a dose. This level was estimated using 0.3 person-rem/yr from DOE facilities and 0.7 person-rem/yr from Energy Northwest's Columbia Generating Station for 30 yr of operation (DOE 1995). Of the 36 person-rem, the largest contribution from solid waste management alternatives would account for about 0.2 person-rem.

Vitrification of the Hanford tank wastes could add up to about 400 person-rem (DOE 1996b) to the cumulative collective population dose, depending on the options selected. The cumulative collective population dose for the PFP could increase up to another 140 person-rem depending on the option ultimately selected. Similarly remediation of K-Basins could add another 120 person-rem depending on options selected. No other activities are foreseen that would add significantly to these doses; the total through the period ending in 2046 would not be expected to result in any LCFs.

Again for perspective, the doses to the local population from naturally occurring radioactive sources would result in about an additional 6,000,000 person-rem for the 50-yr period ending in 2046, from which another 3000 LCFs would be inferred. Thus, over about 100 yr from the start up of the Hanford Site to the year 2046, about 6000 LCFs might have resulted from naturally occurring sources. To this number of LCFs would be the inference that Hanford operations might have added about 50 LCFs as a result of releases of radioactive material during the 1945-1952 time period.

5.14.5.2 Surface Water Pathway

Past impacts associated with the water pathway were principally associated with contamination of Columbia River water that was used as once-through coolant for the Hanford production reactors. Various elements present in the incoming water were made radioactive during their passage through one or more of the eight reactors.[(a)] In addition, some of the corrosion products that formed in piping were made radioactive and entered the water. Fuel element failures (slug ruptures) also exposed the fuel to the cooling water and added contaminants to the water. On an average annual basis, the principal radionuclides contributing to potential dose were phosphorous-32, chromium-51, zinc-65, arsenic-76, and neptunium-239. Chemical contamination also occurred as a result of adding water-purifying agents with hexavalent chromium as the principal contaminant.

A very crude estimate of collective population dose to downstream users of the Columbia River from 1944 to present would amount to about 2000 person-rem, essentially all of which occurred before 1971 when the last once-through cooled reactor was shut down. The estimate was based on the dose to those

(a) A ninth reactor (N Reactor) was not a once-through cooled reactor. Its discharge to nearby trenches was the source for seepage of some contaminants into the river.

persons drinking municipally supplied water and the estimates of populations for the cities of Richland (after water plant startup in late 1963), Pasco, and Kennewick. A nominal value of 50 person-rem per year was assumed for the period 1944 until 1959, based on 1959-1962 measured concentrations of nuclides in drinking water from Pasco and Kennewick that were the principal population groups using Columbia River water prior to 1963.[(a)] From 1975 to present, the collective population dose was less than 15 person-rem. From a collective dose of 2000 person-rem, one LCF would be inferred. The annual addition to collective dose is presently about 0.1 person-rem.

No direct discharges of radioactive wastes to surface water are presently made. The presence of contaminants in surface water, as a result of inflow of groundwater, is discussed in the following subsection.

5.14.5.3 Groundwater Pathway

Leaching of radionuclides from wastes disposed of in LLBGs, within the scope of this EIS; and their transport through the vadose zone to groundwater and on to the Columbia River would, in the long-term, lead to small additional collective doses (less than 0.15 person-rem) to down stream populations as indicated in Section 5.11.

Present concentrations of various contaminants in ground water from past activities are shown in Section 4.0, Figure 4.18. Because of extremely low infiltration rates of water in the absence of process-water discharge, and with the very low rate of precipitation; it is expected that it will take centuries to millennia for the contaminants in the plumes and in the vadose zone beneath presently contaminated near-surface soils or LLBGs to be completely delivered up to the Columbia River. It is possible that contaminants associated with the solid wastes addressed in this EIS may at some point in time join others on their present course to the river. As may be noted in Section 5.3, at a maximum, the concentrations of mobile nuclides at a near-river well or spring would be small in comparison to derived permissible drinking water contaminant concentrations. Future activities, for example, disposal of low-activity tank waste, can be expected to result in small increases in concentrations of contaminants in groundwater in the distant future. Since individual contaminants will move at different rates and be spread over very long time periods, it is not expected that they would add significantly to impacts from past activities.

In terms of cumulative impacts via the groundwater pathway, an estimate was made of other occurrences of long-lived radionuclides expected to be disposed of onsite by the end of 2046. Estimates of the quantities of these radionuclides and their sources are provided in Table 5.61.

(a) Before 1971, higher doses would have been experienced by those individuals making recreational use of the Columbia River, consuming food crops grown with irrigation water derived from the river, and consuming fish and waterfowl inhabiting the river, and seafood harvested from along the Washington and Oregon coast. Due to the number of pathways and uncertainties in numbers of individuals involved, this aspect has not been quantified on a collective basis. Estimates of individual doses may be found in Farris *et al.* (1994).

Table 5.61. Cumulative Inventories of Dominant Water-Pathway/Health-Impact Radionuclides Potentially Disposed of on the Hanford Site by 2046 that Would Reach the Columbia River in 10,000 Years or Later

Caution should be used in interpreting these inventory values as the implied accuracy is not warranted.

Values in parentheses were derived from reported amounts of U-238 using U-234:U238=0.093, U-235:U238=0.016, for depleted uranium

	HSW EIS Upper Bound Inventory LLW & MLLW	US Ecology Commercial Low-Level Radioactve Disposal Site		ERDF CERCLA LLW (Casbon 2001)	Production Reactor Cores (CA)	Past Discharges to Ground & Cribs + Tank Leaks & Losses (CA)	TWRS Low-Activity Waste (CA)	SST & DST Residuals (CA)	Naval Reactor Structures (SAC & DOE/EIS-0259)	Estimated "Bounding" Hanford Site Inventory Buried or "to be" Buried Total	HWS EIS Upper Bound Inventory as percent of "Bounding" Hanford Site Inventory	Perspective: Amounts in the Columbia River expected to flow past Hanford from uptream in 10,000 yr.	Perspective: HWS EIS Upper Bound Inventory as percent of "Natural" passing by in 10,000 yr
Radionuclide	Ci	Ci		Ci	Ci	Ci	Ci	Ci	Ci	Ci	%	Ci	
C-14	790	3,900	a	120	42,000	140	7.7	53	330	47,000	2	(e)	--
Tc-99	980	62	a	170	0.11	2,800	22,000	320	6	26,000	4	20000	5
I-129	0.3	6	a	0	0	5	6.6	0.2	<0.1	18	2	20	2
U-234	1,900	6000	c	140	(<0.1)	(140)	(2)	(3)	d	8100	23	200,000	<1
U-235	72	500	c	55	(<0.1)	(20)	(0.3)	(0.6)	d	650	11	8,000	<1
U-238	2,400	10,800	b	500	<0.1	1,500	18	36	d	17,000	14	200,000	1

(a) Commercial Low-Level Radioactive Waste Disposal Site, Richland, Washington, August 2000 (WDOH and Ecology 2000)
(b) (CA) Composite Analysis (Kincaid *et al.* 1998)
(c) Estimate based on one half of U-238 activity representing natural uranium and one half representing depleted uranium. Highly uncertain - values could be substantially larger or smaller.
(d) No values given, however expected to be small.
(e) No measurements available.
Note: U-236 is omitted as it accounts for only 3 percent of uranium activity in the HSW EIS and quantities are more uncertain for other sources. SAC - System Assessment Capability

Because the occurrence of contaminants reaching the Columbia River will be over very long periods of time, the impacts would be multi-generational (that is, extend over many generations in the future) but would be smaller for any given generation than that received by the generation centered on Hanford's period of special nuclear materials production. Moreover, the contribution to collective down-river population radiation dose from these contaminants would not add significantly to the total collective dose received by these generations as a result of exposure to naturally occurring radiation sources (300 mrem per year per individual).

Plumes of contaminants (for example, tritium and Tc-99) presently in groundwater are moving down gradient toward the Columbia River. Although these contaminants would not be expected to result in substantial doses to downstream users of Columbia River water, quantities and arrival times at sources of public drinking water have not been quantified.

5.14.6 Worker Health and Safety – Radiological

Cumulative Hanford worker dose, since the startup of activities at the Hanford Site, is about 90,000 person-rem (DOE 1995), to which would be added about 10,000 person-rem from spent fuel management (DOE 1996a), about 5,000 person-rem from tank waste remediation (DOE 1996c), about 730 person-rem for PFP stabilization (DOE 1996b) , and 200 to 400 person-rem through the year 2046 from solid waste management (Tables 5.21, 5.22, 5.44, 5.45, and 5.54). Thus, for about 100 yr of Hanford operations, about 40 LCF would be inferred, none of which would be attributable to solid waste program activities. Because of DOE restrictions on worker dose, plus rigorous application of the as low as reasonably achievable (ALARA) principle, the cumulative collective worker dose associated with all future Site restoration activities would not be expected to add significantly to the worker dose to date.

5.15 Irreversible and Irretrievable Commitments of Resources

The irreversible and irretrievable commitments of resources (NEPA; 42 USC 4321) that would likely result from implementing Alternative 1, Alternative 2, or the No Action Alternative are addressed in this section. An irreversibly committed or irretrievable resource is one that is irreplaceably consumed and is non-renewable, is in limited supply, or cannot be replenished.

Implementation of Alternative 1, Alternative 2, or the No Action Alternative would result in the irretrievable use of fossil fuels and bentonite in construction activities, transport of materials and waste, and treatment processes; and land use. Those non-renewable resources that would be irreversibly or irretrievably committed are listed in Table 5.62.

Table 5.62. Irreversible and Irretrievable Commitments of Resources by Alternative

Resource	Alternative 1		Alternative 2		No Action Alternative
	Lower Bound Volume	Upper Bound Volume	Lower Bound Volume	Upper Bound Volume	
Diesel Fuel, m^3 (1,000 gal)	22,000 (5,800)	36,000 (9,700)	27,000 (7,000)	42,000 (11,000)	2,400 (630)
Gasoline, m^3 (1,000 gal)	170 (45)	280 (71)	300 (79)	410 (110)	80 (21)
Propane, m^3 (1,000 gal)	16,000 (4,300)	16,000 (4,300)	19,000 (4,300)	22,000 (5,800)	1,600 (410)
Bentonite	22 (24)	43 (47)	24 (26)	48 (52)	0
Land,[(a)] ha (ac)	146 (360)	153 (378)	162 (400)	178 (440)	149 (368)

(a) Within the Industrial-Exclusive Area described in the HCP EIS (DOE 1999).

In addition, after a few hundred years following disposal, groundwater beneath the LLBGs would be contaminated by continued slow entry of radionuclides and might, depending on concentrations at the time and down-gradient location of interest (generally easterly to north-easterly from 200 Areas to vicinity of the Old Hanford Town Site), constitute a continuing (thousands of years) commitment of a water resource. The criteria for restricted groundwater use and area extent of such commitment have not been quantified. When the groundwater reaches the Columbia River and is diluted by the large flow of the river, the contamination levels would fall well below those for which restricted use would be necessary to comply with the National Primary Drinking Water Regulations (40 CFR 141).

5.16 Relationship Between Short-term Uses of the Environment and the Maintenance or Enhancement of Long-term Productivity

For purposes of the HSW EIS, short-term use is defined to encompass the period through the year 2046 and long-term productivity is defined to encompass the period following 2046.

The principal objective Alternative 1 or Alternative 2 (both lower and upper bound volumes in either case), namely permanent disposal of LLW and MLLW, does not involve the short-term use of the environment in the usual sense.[(a)] Alternative 1 and Alternative 2 are intended to result in permanent disposal by below grade land burial, followed by back filling to grade and capping with abovegrade RCRA-type barriers. For all practical purposes, the LLBGs portion of the Hanford Site and the vadose zone beneath them have been and will continue in perpetuity to be dedicated to isolation of LLW and

(a) An example of "usual sense" in this context would be a mining operation where the acid mine drainage contaminates a nearby stream. In that case, the short-term mining operation would likely have adverse effects on the long-term productivity of the streams and river into which contamination flows.

MLLW from the environment. Thus, the LLBGs constitute perhaps the highest use of the area involved in terms of long-term productivity.

In time contaminants from past and proposed waste disposal on the Hanford Site would reach groundwater and the Columbia River. Depending on the location and time of interest, concentrations of nuclides in groundwater might be such that it would be necessary to interdict groundwater usage. When the contaminants reach the Columbia River they will be in such small concentrations that they would pose no adverse impact on the long-term productivity of the Columbia River.

In time and with the absence of human activities, flora and fauna common to the 200 Areas Plateau in the past would likely reoccupy the surface areas above the disposed waste and the surface would probably be indistinguishable from nearby undisturbed areas. However, prudence would dictate invoking land use covenants to prohibit future land disturbance by humans and to reduce the likelihood of inadvertent intrusion into a waste site or dispersal of contaminants.

In the No Action Alternative, no conclusion is made regarding short-term uses versus long-term productivity, because wastes are stored until the year 2046, with no disposition determined thereafter.

5.17 Unavoidable Adverse Impacts

Unavoidable adverse impacts that would occur if Alternative 1, Alternative 2, or the No Action Alternative were to be implemented are identified in the following sections.

5.17.1 Alternative 1

Unavoidable adverse impacts associated with implementing Alternative 1 would include the following:

- commitment in perpetuity of about 146 ha (360 ac) for disposal of the lower bound waste volume to 153 ha (378 ac) for upper bound waste volume of LLW and MLLW, an adverse impact because of the potential for groundwater contamination

- small additions of pollutants to the atmosphere as a result of operating heavy equipment during modification of the T Plant Complex for the M-91 Capability and construction of additional burial trenches, operation of facilities, trench backfilling, obtaining LLBG capping materials, capping LLBGs, and from transportation of materials and wastes

- small increments in dose to workers and the public

- potential for one radiological fatality and three non-radiological fatalities as a result of waste transport

- eventual migration of mobile radionuclides such as technetium-99 and iodine-129 to groundwater and ultimately to the Columbia River, leading to contamination of groundwater and very small additional radiation doses to downstream populations.

5.17.2 Alternative 2

Unavoidable adverse impacts associated with implementing Alternative 2 would be essentially the same as for Alternative 1, except for the following differences:

- commitment in perpetuity of about 162 ha (400 ac) for disposal of the lower bound waste volume to 178 ha (440 ac) for the upper bound waste volume of LLW and MLLW, again, an adverse impact because of the potential for groundwater contamination

- small additions of pollutants to the atmosphere as a result of operating heavy equipment during construction of a new facility for the M-91 Capability.

- potential for up to one non-radiological fatality as a result of waste transport.

5.17.3 No Action Alternative

Unavoidable adverse impacts associated with implementing the No Action Alternative would include:

- <u>indefinite storage</u> of certain MLLW and TRU wastes requiring additional land disturbance of about 66 ha (163 ac)

- consumption of resources and localized minor degradation of air quality associated with construction of 66 additional CWC storage buildings

- commitment in perpetuity of about 149 ha (368 ac) for below-grade disposal of LLW and MLLW, an adverse impact because of the potential for groundwater contamination

- small additions of pollutants to the atmosphere from operating heavy equipment during construction and operation of burial trenches, operation of facilities, and from transportation of materials and wastes

- small increments in dose to workers and the public

- eventual migration of mobile radionuclides such as technetium-99 and iodine-129 to groundwater and ultimately to the Columbia River, leading to contamination of groundwater and very small additional radiation doses to downstream populations.

- potential for up to one non-radiological fatality as a result of waste transport.

5.18 Potential Mitigation Measures

This section contains a description of mitigation measures that might be considered to avoid or reduce environmental impacts made as a result of Hanford Site operations in support of solid waste management. These measures also would be reviewed and revised as appropriate, depending on the relevant actions to be taken at a facility, the level of impact, and other pertinent factors. Following the publication of the ROD, a mitigation plan would be prepared if warranted, to address action specific to the alternative selected for implementation. That plan would be implemented as necessary to mitigate significant adverse impacts of solid waste management activities. Possible mitigation measures are generally the same for all alternatives and are summarized as follows where impacts or anticipated interest were determined to warrant such discussion.

5.18.1 Pollution Prevention/Waste Minimization

DOE is implementing Executive Order 12586 (58 FR 41981) and associated DOE Orders or guidelines by reducing toxic chemical use; improving emergency planning, response, and accident notification, and encouraging the development and use of clean technologies. Program components include waste minimization, recycling, source reduction, and buying practices that prefer 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 (DOE-RL 1998b).

The solid waste management activities have been and would continue to be conducted in accordance with this plan. Implementation of the pollution prevention and waste minimization plans would minimize the generation of secondary wastes.

5.18.2 Cultural Resources

To avoid loss of cultural resources during construction of solid waste management facilities on the Hanford Site, cultural resources surveys have been and would continue to be made of the areas of interest. If any cultural resource were discovered during construction, construction would be halted. The appropriate authorities would be notified, so the find could be evaluated to determine its appropriate management or its affect on continuation of activities.

5.18.3 Ecological Resources

By and large ecological resources in the Industrial-Exclusive Area of the 200 Areas Plateau were destroyed during the range fire of 2000, or by previous disturbances of the area. The need for mitigation of ecological impacts at the Area C borrow pit would depend on the results of surveys conducted just prior to initiating operations as those operations are not expected for a decade or more. Biological resources might be subject to mitigation based on existing conditions and applicable mitigation guidelines, such as given in the Hanford Site Biological Resources Management Plan (DOE-RL 2001) and the Hanford Site Biological Resources Mitigation Strategy (DOE-RL 1996).

5.18.4 Health and Safety – Routine Operations

It is not expected the public would experience any adverse consequences from routine waste management activities. Design, construction, and operation of waste management facilities would incorporate the best available technology to control discharge of potentially hazardous materials to the environment. When treated, packaged, and buried, little potential exists for entry of hazardous materials into the environment that would be detrimental to public health and safety.

Under routine operations, exposure of workers to radioactive or other potentially hazardous materials would be maintained within permissible limits and further would be reduced under the ALARA principle. This principle involves formal analysis by the workers, supervisors, and radiation and or chemical protection personnel of the work in a hazardous environment to reduce exposure of workers to the lowest practicable level.

There is some potential for contamination reaching the affected environment from waste in LLBGs via uptake through deep roots by nuisance weeds such as Russian thistle (tumbleweeds). Before capping of LLBGs herbicides could be used to control such weeds. After capping the LLBGs they could be planted with vegetative species (such as wheatgrass) that would in effect choke out the nuisance weeds.

5.18.5 Health and Safety – Accidents

Although the safety record for operations at Hanford and other DOE facilities is 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 Site (DOE-RL 1999). These plans were prepared in accordance with DOE Orders and other federal, state, and local regulations. The plans describe action 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. The plans also specify the level at which the hazard to workers and the public is of sufficient concern that protective action should be taken. The Site holds regularly scheduled exercises to help 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. As necessary, Hanford Site emergency response plans would be updated to include consideration of new solid waste management facilities and activities.

5.18.6 Traffic and Transportation

Transport of LLBG capping materials from the borrow pit in Area C across SR 240 to the 200 Areas was determined to have the potential for traffic congestion and accident hazards. As a consequence an underground conveyor system could be used to move the materials to a staging area east of the highway and to minimize crossings of trucks and other equipment. Further, additional safety measures would be expected to take the form of dust control, restrictions on crossings to off shift-change hours, signs and warning lights along SR 240 to the north and south and well in advance of the crossing, and a traffic control light at the crossing itself.

5.18.7 Area and Resource Management and Mitigation Plans

DOE has prepared or is the process of preparing a number of area and resource management and mitigation plans. Some of these plans have been completed and some are in draft form, or undergoing public review. These plans include the following:

- Hanford Cultural Resources Management Plan
- Hanford Biological Resources Management Plan
- Hanford Bald Eagle Management Plan
- Fire Management Plan
- Noxious Weed Management Plan
- Chinook Salmon - Upper Columbia River Spring Run Hanford Management Plan
- Steelhead - Middle Columbia River Run Hanford Management Plan
- Steelhead Upper Columbia River Run Hanford Management Plan
- Aesthetic and Visual Resources Management Plan
- Facility and Infrastructure Assessment and Strategy
- Mineral Resources Management Plan (i.e., soils, sand, gravel, and basalt)
- Hanford Site Watershed Management Plan
- Hanford Site Ground-Water Protection Management Plan
- Groundwater Vadose Zone Integration Project Summary Description
- Hanford Institutional Control Plan (i.e., long-term stewardship plan).

All of the plans listed above would be expected to be available in final form by the time the activities described in this HSW EIS would be underway and for which special management or mitigation might be appropriate.

5.19 References

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6.0 Regulatory Framework

This section describes the regulatory framework affecting the alternatives, including the permit requirements associated with the alternatives. The U.S. Department of Energy (DOE) has procedures implementing the National Environmental Policy Act (NEPA) in the Code of Federal Regulations (CFR) (10 CFR 1021). Section 1021.103 of the procedures adopts the Council on Environmental Quality (CEQ) regulations at 40 CFR 1500–1508 for implementing NEPA. This draft Hanford Solid (Radioactive and Hazardous) Waste Program Environmental Impact Statement (HSW EIS) was prepared in accordance with the DOE and CEQ NEPA implementing procedures.

6.1 Land-Use Management

In September 1999, DOE issued the *Final Hanford Comprehensive Land-Use Plan Environmental Impact Statement* (DOE 1999a). The record of decision (ROD) issued in November 1999 (64 FR 61615) states that the purpose of the land-use plan and its implementing policies is to facilitate decision making about the Hanford Site's uses and facilities over at least the next 50 years. The ROD adopts the Preferred Alternative land-use maps, designations, policies, and implementing procedures as described in the 1999 EIS and designates the Central Plateau (200 Areas) for Industrial-Exclusive use (Figure 4.2). This designation would allow for continued waste management operations in the 200 Areas.

The Hanford Reach National Monument was created on June 9, 2000, by a proclamation signed by President Clinton under the authority of the Antiquities Act of 1906 (65 FR 37253). The Monument includes 792.6 km^2 (306 mi^2) of federally owned land making up a portion of the Hanford Site (Figure 4.3). The principal components of the Monument are the Fitzner/Eberhardt Arid Lands Ecology Reserve (ALE), the McGee Ranch and Riverlands area, the Saddle Mountain National Wildlife Refuge, the quarter mile Hanford Reach Act (Hanford Reach Act [1988] as amended by Public Law 104-333) study strip along the south and west sides of the Columbia River corridor, the federally owned islands within the portion of the Columbia River included in the Monument, and the Hanford Sand Dune Field (Figure 4.3). The U.S. Fish and Wildlife Service (FWS) manages lands within ALE, and the Wahluke Slope under permit from DOE. The remainder of the Monument is managed by DOE. The June 9, 2000, proclamation does not affect the responsibilities and authority of DOE on Hanford Site lands nor does it affect DOE activities on lands not included within the Monument boundaries. In a separate memorandum to the Secretary of Energy, DOE was directed by the President to protect the natural values of the Hanford Site land not included within the Monument (Clinton 2000). DOE and FWS signed a Memorandum of Understanding on June 14, 2001, covering management responsibilities for the Monument.

6.2 Hanford Federal Facility Agreement and Consent Order

The Hanford Federal Facility Agreement and Consent Order (Tri-Party Agreement [TPA]) is an agreement between DOE, the U.S. Environmental Protection Agency (EPA), and the Washington State Department of Ecology (Ecology) (Ecology *et al.* 1989) for achieving compliance at the Hanford Site with the Resource Conservation and Recovery Act (RCRA), the Comprehensive Environmental

Response, Compensation, and Liability Act (CERCLA), and the Washington State Hazardous Waste Management Act (Revised Code of Washington [RCW] Ch. 70.105). The TPA 1) defines CERCLA and RCRA cleanup commitments and sets due dates, 2) establishes responsibilities among the agencies, and 3) reflects the goal of achieving regulatory compliance and completing remediation activities with enforceable milestones.

The TPA milestone that is most relevant to the subject matter of the HSW EIS is the M-91 milestone shown in Table 6.1.

6.3 Hazardous Waste Management

Hazardous waste management (including the management of hazardous components of radioactive mixed waste) at the Hanford Site is regulated by Ecology and EPA pursuant to RCRA (42 United States Code [USC] 6901 et seq.) and the Washington State Hazardous Waste Management Act. Hazardous waste activities at Hanford are subject to regulation under RCRA by virtue of Section 6001 of RCRA (42 USC 6901). EPA has delegated to the State of Washington much of the authority to implement the federal RCRA program. Ecology regulations are consistent with, and at least as stringent as, the EPA regulations implementing RCRA. Under RCRA, *hazardous wastes* and *acutely hazardous waste* are regulated. Ecology regulates the RCRA wastes, as well as additional substances. The waste categories used in the Ecology regulations are *dangerous wastes*, *acutely hazardous waste*, *extremely hazardous wastes*, and *special wastes*.

RCRA regulations appear at 40 CFR 260-279. The dangerous waste regulations of Washington State appear in the Washington Administrative Code (WAC) 173-303. Hazardous waste treatment, storage, and/or disposal (TSD) facilities are regulated under Section 3004 of RCRA and are required to have a permit by Section 3005 of RCRA. The Hanford Site's RCRA permit is in two portions, one portion issued by EPA Region 10 and the other portion issued by Ecology. The EPA portion of the RCRA permit covers the Hazardous and Solid Waste Amendments portion of the RCRA permit (EPA 1994). The second portion of the Hanford Site RCRA permit covers the dangerous waste provisions and was most recently modified by Ecology in February 2001 (Ecology 2001a). The Ecology portion of the RCRA permit includes standard conditions, general facility conditions, and specific conditions for individual operating treatment, storage, and disposal (TSD) units, TSD units undergoing corrective action, and TSD units undergoing closure. The RCRA permits, along with other environmental permits covering the Hanford Site, are described in the *Annual Hanford Site Environmental Permitting Status Report* (DOE 2001a).

For all alternatives, the nonradioactive hazardous components of mixed waste would be stored at the Hanford Site in accordance with EPA and Ecology regulations. Ultimate treatment and disposal would occur at RCRA interim status or permitted units at the Hanford Site or an offsite location.

Storage and disposal of waste containing polychlorinated biphenyls (PCBs) would meet the EPA requirements in 40 CFR 761. These regulations are issued under the Toxic Substances Control Act (TSCA; 15 USC 2601 et seq.).

Table 6.1. Tri-Party Agreement Milestone M-91

Milestone Control Number	Description	TPA Commitment Date	Completion Date
M-091-00	Complete the acquisition of new facilities, modification of existing facilities, and/or modification of planned facilities necessary for storage, treatment/processing, and disposal of all Hanford site TRU/TRUM, LLMW, and GTC3.[(a)]	31-Dec-2049	
M-091-01	Complete the acquisition of new facilities, modification of existing facilities, and/or modification of planned facilities necessary for storage, and treatment/processing prior to disposal of all Hanford Site post 1970 TRU/TRUM.	31-Dec-2049	
M-091-02	Initiate processing of contact handled TRU/TRUM waste at Waste Receiving And Processing Facility/WRAPI (contact handled, small container).	31-Dec-1998	18-Sep-1998
M-091-03	Submit Hanford Site TRU/TRUM waste project management plan (PMP) to ecology pursuant to agreement Section 11.5. The Hanford Site TRU/TRUM Waste PMP will include all plan elements required by agreement action plan Section 11.5. Approval of the TRU/TRUM PMP and accompanying agreement change request will establish all major project tasks and deliverables for treatment/storage of Hanford Site TRU/TRUM including commercial sector management, modification of existing facilities, and construction of new facilities.	30-Jun-2000	28-Jun-2000
M-091-04	Complete construction of small container contact handled (CH) TRU/TRUM retrieval facility(s) and initiate (Project W-113) retrieval of small container TRU/TRUM from 200 Area burial grounds. During initial facility operations, contact handled small container integrity will be evaluated and data used in the further development of the retrieval campaign.	30-Sep-2000	22-Jul-1999
M-091-05-T01	Complete and submit TRU/TRUM retrieval and processing facility engineering study/functional design criteria study to ecology. The TRU/TRUM engineering/functional design criteria study will cover activities/facilities not considered commercially viable as documented in the approved TRU/TRUM PMP and associated agreement change requests.	31-Dec-2002	
M-091-06-T01	Award necessary privatized contracts for processing remote handled (RH) and large size TRU/TRUM.	30-Sep-2003	
M-091-07	Complete Project W-113 for post 1970 CH TRU/TRUM retrieval.	30-Sep-2004	

Table 6.1. (contd)

Milestone Control Number	Description	TPA Commitment Date	Completion Date
M-091-09	Initiate operations at new central waste complex storage facilities (Project W-112).	30-Jun-1997	26-Jun-1997
M-091-10	Submit Hanford Site LLMW and greater than Class C (GTC3) Waste Project Management Plan (PMP) to Ecology pursuant to agreement action plan Section 11.5. The Hanford Site LLMW/GTC3 PMP will include all plan elements required by agreement action plan Section 11.5. Approval of the LLMW/GTC3 PMP and accompanying agreement change requests will establish all major tasks and deliverables for treatment/storage/disposal of Hanford RH and large container CH LLMW, and storage of GTC3 waste including commercial sector management activities, construction of new facilities, and modification of existing facilities.	30-Jun-1999	28-Jun-1999
M-091-11-T01	Complete and submit LLMW Treatment Facility Engineering Study/Functional Design Criteria Study to Ecology. The LLMW Treatment Facility Engineering Study/Functional Design Criteria Study will cover activities/facilities not considered commercially viable as documented in the approved LLMW/GTC3 PMP and associated agreement change request.	31-Dec-2000	3-Nov-2000
M-091-12	Complete thermal treatment and disposal of an additional 360 cubic meters of contact handled LLMW. The brings the cumulative total to at least 600 cubic meters of contact handled LLMW thermally treated and disposed of:	31-Dec-2005	
M-091-12A	Complete thermal treatment and disposal of at least 240 cubic meters of contact handled LLMW.	31-Dec-2002	
M-091-13	Initiate disposal of CH LLMW.	30-Jun-2001	1-Nov-1999
M-091-14-T01	Award commercialization contract(s) for treatment of RH and large size LLMW per approved LLMW/GTC3 PMP and associated agreement change requests.	31-Oct-2003	
M-091-15	Complete acquisition of facilities and initiate treatment of RH and large container (CH) LLMW.	30-Jun-2008	

Table 6.1. (contd)

Milestone Control Number	Description	TPA Commitment Date	Completion Date
M-091-19-T01	Complete physical activities at T Plant necessary to store floor and pit sludge. This target is complete upon declaration of completion of modifications required to store floor and pit sludge in T Plant.	30-Sep-2002	
M-091-20	T Plant is ready to receive the first canister of K Basins floor and pit sludge. This interim milestone will be complete when all T Plant readiness activities have been completed to accept pit and floor sludge. Readiness is defined as the issuance of the readiness to proceed letter by the approval authority.	31-Dec-2002	
M-091-21-T01	Complete physical activities at T Plant necessary to store canister and fuel wash sludge. This target is complete upon the declaration of completion of modifications required to store canister and fuel wash sludge in T plant.	29-Nov-2003	
M-091-22	T Plant is ready to receive canister and fuel wash sludge from K basins. This interim milestone will be complete when all T Plant readiness activities have been completed to accept canister and fuel wash sludge. Readiness is defined as the issuance of the readiness to proceed letter by the approval authority.	29-Feb-2004	

(a) The acronyms TRU, TRUM, LLMW, and GTC3 used in this table reflect their unsafe in the source document, which may differ from those used throughout the remainder of the HSW EIS. In this table TRU means transuranic waste, TRUM means transuranic mixed waste, LLMW means low-level mixed waste (equivalent to MLLW as used in the HSW EIS, and GTC3 means greater than Category 3 waste.

6.4 Radioactive Waste Management

DOE facilities used for the management, storage, treatment, and disposal of radioactive waste and radioactive mixed waste, are constructed and operated under the authority of the Atomic Energy Act (AEA; 42 USC 2011). DOE directives are issued under the authority of Section 161(i)(3) of the AEA that permits DOE to govern activities authorized by the Act to protect health and to minimize danger to life or property.

The principal DOE directive covering radioactive waste management is DOE Order 435.1, *Radioactive Waste Management* (DOE 2001b). This Order states that DOE radioactive waste shall be managed to accomplish the following:

1. Protect the public from exposure to radiation from radioactive materials. Requirements for public radiation protection are in DOE Order 5400.5, *Radiation Protection of the Public and the Environment* (DOE 1993a).

2. Protect the environment. Requirements for environmental protection are in DOE Order 5400.1, *General Environmental Protection Program* (DOE 1990), and DOE Order 5400.5, *Radiation Protection of the Public and the Environment* (DOE 1993a).

3. Protect workers. Requirements for radiation protection of workers are in 10 CFR 835, "Occupational Radiation Protection." Requirements for industrial safety are in DOE 0rder 440.1A, *Worker Protection Management for DOE Federal and Contractor Employees* (DOE 1998a).

4. Comply with applicable federal, state, and local laws and regulations; applicable Executive Orders; and other DOE directives.

5. Meet the requirements in DOE Manual 435.1-1, *Radioactive Waste Management Manual* (DOE 2001c; DOE Manual 435.1-1 has specific requirements applicable to management of TRU waste in Chapter III and low-level waste (LLW) and mixed LLW (MLLW) in Section 4.0.

6.5 Radiological Safety Oversight

Specific requirements in 10 CFR 830 apply to DOE contractors, DOE personnel, and other persons conducting activities (including providing items and services) that affect, or may affect, the safety of DOE nuclear facilities. 10 CFR 830 includes requirements for quality assurance (10 CFR 830[a]) and safety-basis requirements (10 CFR 830[b]). The safety-basis requirements require the contractor responsible for a DOE nuclear facility to analyze the facility, the work to be performed, and the associated hazards; and to identify the conditions, the safe boundaries, and the hazard controls necessary to protect workers, the public, and the environment from adverse consequences. DOE relies on these analyses and hazard controls to operate facilities safely. The requirements for nuclear safety management in 10 CFR 830 apply to the activities being considered in this draft HSW EIS.

DOE has requirements for occupational radiation protection in 10 CFR 835 that establish radiation-protection standards, limits, and program requirements for protecting individuals from ionizing radiation resulting from the conduct of DOE activities. The requirements are applicable to occupational workers involved in activities being considered in the HSW EIS that have the potential to result in the occupational exposure of an individual to radiation or radioactive material. The 10 CFR 835 requirements are further discussed in Section 6.7.

Many DOE directives that affect radiological safety apply to construction and operation of the facilities addressed in the HSW EIS. Among the more significant directives are the following:

- DOE Order 420.1, *Facility Safety* (DOE 2000a), establishes facility safety requirements related to nuclear safety design, criticality safety, fire protection, and the mitigation of phenomena related to natural hazards.

- DOE Order 425.1B, *Startup and Restart of Nuclear Facilities* (DOE 2000b), establishes DOE requirements for startup of new nuclear facilities and for the restart of existing nuclear facilities that have been shut down. The requirements specify a readiness review process that must demonstrate that it is safe to start (or restart) the applicable facility. The facility must be started (or restarted) only after documented independent reviews of readiness have been conducted and the approvals specified in the Order have been received.

- DOE Policy 441.1, *DOE Radiological Health and Safety Policy* (DOE 1996a). It is DOE policy to conduct its radiological operations in a manner that ensures the health and safety of all its employees, contractors, and the general public. The Policy states that in achieving this objective, DOE will ensure that radiation exposures to its workers and the public and releases of radioactivity to the environment are maintained below regulatory limits, and deliberate efforts are taken to further reduce exposures and releases to as low as reasonably achievable (ALARA). DOE is committed to implementing a radiological control program of the highest quality that consistently reflects this Policy.

- DOE Order 5400.5, *Radiation Protection of the Public and the Environment* (DOE 1993a), establishes standards and requirements for DOE operations for protection of members of the public and the environment against undue risk from radiation. It is DOE policy to implement legally applicable radiation-protection standards and to consider and adopt, as appropriate, recommendations by authoritative organizations, for example, the National Council on Radiation Protection and Measurements and the International Commission on Radiological Protection. It is also DOE policy to adopt and implement standards generally consistent with those of the NRC for DOE facilities and activities not subject to NRC licensing authority.

- DOE Order 5480.20A, *Personnel Selection, Qualification, and Training Requirements for DOE Nuclear Facilities* (DOE 2001d), establishes the selection, qualification, and training requirements for DOE contractor personnel involved in the operation, maintenance, and technical support of DOE nuclear reactors and non-reactor nuclear facilities. DOE objectives under this Order are to ensure the development and implementation of contractor-administered training programs that provide

consistent and effective training for personnel at DOE nuclear facilities. The Order contains minimum requirements that must be included in training and qualification programs.

6.6 Radiation Protection of the Public and the Environment

DOE standards for radiation protection of the public and the environment are set out in DOE Order 5400.5 (DOE 1993a). In addition to establishing a general standard for public dose from DOE activities, the Order requires DOE activities to be conducted in a manner that complies with regulations issued by other government agencies, as applicable. The Order also specifies standards for radiological exposures to native aquatic animals. Requirements of the DOE Order and other applicable standards are discussed in this section.

Activities associated with any alternative under consideration in this HSW EIS would be managed in accordance with Chapter II of DOE Order 5400.5, which provides that DOE activities shall be conducted so that the exposure of members of the public to radiation sources, as a consequence of all routine DOE activities, shall not cause an effective dose equivalent exceeding 1 mSv/yr (100 mrem/yr).

In addition, radioactive emissions from DOE facilities are subject to the EPA National Emission Standards for Hazardous Air Pollutants requirements at 40 CFR 61. In particular, Subpart A (General Provisions) and Subpart H (National Emission Standards for Emissions of Radionuclides Other Than Radon From Department of Energy Facilities) are applicable to all alternatives. Air emissions resulting from the implementation of any alternative would comply with the EPA 0.1 mSv/yr (10 mrem/yr) standard at 40 CFR 61.92. For all new construction or modifications to existing facilities where the estimated effective dose equivalent could exceed 1 percent of the 0.1 mSv/yr standard, an application for approval of construction or modification would be submitted to the appropriate regional EPA office under the procedures at 40 CFR 61.07 (40 CFR 61.96[b]).

New sources of radioactive emissions at Hanford are also subject to the licensing requirements of the Washington State Department of Health (WDOH) (WAC 246-247). DOE holds a license (No. FF-01) issued by the WDOH covering airborne radioactive effluents from Hanford operations. The license is incorporated as Attachment 2 in the Hanford Air Operating Permit (Ecology 2001b). DOE would submit a notice of construction to the WDOH, as required by WAC 246-247-060, before constructing or modifying any facility associated with any alternative under consideration in this HSW EIS that has projected radioactive emissions. All new construction and significant modifications of emission units would use best available radionuclide control technology (WAC 246-247-040[3], WAC 173-480-060). Standards and/or permits and license requirements (conditions) for applicable radiation and non-radiation emission unit compliance are compiled in the Hanford Air Operating Permit (Ecology 2001b).

Activities associated with any alternative under consideration in this HSW EIS would be conducted in accordance with EPA's regulation at 40 CFR 191.03(b). This regulation provides that management and storage of spent nuclear fuel or high-level or TRU radioactive wastes at DOE facilities shall be conducted in such a manner as to provide reasonable assurance that the combined annual dose equivalent to any member of the public in the general environment resulting from discharges of radioactive material and

direct radiation from such management and storage shall not exceed 0.25 mSv/yr (25 mem/yr) to the whole body and 0.75 mSv/yr (75 mrem/yr) to any critical organ.

DOE would ensure that U.S. Department of Transportation (DOT) radiation-level limitations for packaging in 49 CFR 173.441 are met and that requirements in 49 CFR 173.443 related to radioactive contamination on the external surfaces of each package offered for shipment are met. Transportation issues are further discussed in Section 6.10.

Chapter II of DOE Order 5400.5 states it is DOE policy to provide a level of protection for persons consuming water from a drinking water supply operated by DOE or its contractors that does not exceed the maximum contaminant levels at 40 CFR 141.15 and 141.16. Specifically, DOE Order 5400.5 states that DOE water-supply systems shall not cause persons consuming the water to receive an effective dose equivalent greater than 4 mrem (0.04 mSv) in a year. Combined radium-226 and radium-228 shall not exceed $5x10^{-9}$ µCi/mL and gross alpha activity (including radium-226, but excluding radon and uranium) shall not exceed $1.5x10^{-8}$ µCi/mL.[(a)] The maximum contaminant levels at 40 CFR 141.15 and 141.16 are used in this HSW EIS as a benchmark for water quality in the Hanford aquifer and the Columbia River for the long-term analysis.

Standards in DOE Order 5400.1 specify maximum radiological doses to native aquatic animals of 1 rad/day. Standards have not been established for aquatic plants, terrestrial plants, or terrestrial animals.

6.7 Occupational Safety and Occupational Radiation Exposure

Section 4(b)(1) of the Occupational Safety and Health Act of 1970 [29 USC 653(b)(1)] exempts DOE and its contractors from the occupational safety requirements of the U.S. Department of Labor Occupational Safety and Health Administration (OSHA). However, DOE Order 440.1A, *Worker Protection Management for DOE Federal and Contractor Employees* (DOE 1998a), states that DOE will implement a written worker protection program that

> (1) provides a place of employment free from recognized hazards that are causing or are likely to cause death or serious physical harm to their employees, and (2) integrates all requirements contained in paragraphs 4a – 4l of DOE Order 440.1A; 29 CFR 1960, "Basic Program Elements for Federal Employee Occupational Safety and Health Programs and Related Matters"; and other related site-specific worker protection activities.

DOE Order 5480.4, *Environmental, Safety, and Health Protection Standards* (DOE 1993b), requires that DOE and its contractors that are subject to this order are to comply with the OSHA Occupational Safety and Health Standards at 29 CFR 1910.

The DOE radiation protection standards, limits, and program requirements for protecting occupational workers from ionizing radiation resulting from the conduct of DOE activities are in 10 CFR 835. All

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(a) In December 2000, EPA issued revised maximum contaminant levels for radionuclides to be effective in December 2003 (65 FR 76708). The new rule includes requirements for uranium.

activities associated with any alternative would be conducted consistently with 10 CFR 835 requirements. The annual total effective dose equivalent (TEDE) limit for general employees is 0.05 Sv (5 rem) (10 CFR 835.202[a][1]). DOE policy is to maintain radiation exposure in controlled areas ALARA through facility and equipment design and administrative controls (10 CFR 835.1001). In addition, exposure of members of the public authorized to enter the controlled area where there are activities associated with implementing any alternative would not exceed 1 mSv (100 mrem) TEDE in a year (10 CFR 835.208). DOE Order 5480.4 specifies a number of American National Standards Institute standards applicable to radiation protection that DOE and its contractors must meet.

6.8 Non-Radioactive Air Emissions

Emissions of criteria or toxic pollutants from new sources would most likely be in small quantities under any alternative evaluated in the HSW EIS. Therefore, they would not be expected to require prevention of significant deterioration (PSD) permitting under WAC 173-400-141, because Hanford is within an area that is in attainment with the national ambient air quality standards. New source review applicability for non-PSD criteria or toxic air permitting would be evaluated on a case-by-case basis under WAC 173-400-110 and WAC 173-460. All emissions of criteria or toxic pollutants would comply with applicable standards for air sources, as specified under the general air regulation (WAC 173-400).

The EPA general conformity rule (40 CFR 93[b]) requires that federal agencies prepare a written conformity analysis and determination covering compliance with an applicable state implementation plan for proposed activities, if the total of direct and indirect emissions of a non-attainment or maintenance criteria pollutant caused by the activity would exceed the threshold emission levels shown at 40 CFR 93.153(b).

6.9 State Waste Discharge Requirements

Ecology regulates industrial waste discharges under the WAC 173-216 permit program covering discharges. The 200 Area Effluent Treatment Facility (ETF) Discharge Permit ST-4500 and the 200 Area Treated Effluent Disposal Facility (TEDF) Discharge Permit ST-4502 were approved by Ecology. These permits address requirements for discharge limitations, monitoring, reporting, record-keeping, facility loading, operations and maintenance, solid waste disposal, non-routine and unanticipated discharges, spill plan, and groundwater monitoring.

The permits were originally submitted in accordance with the provisions in Ecology Consent Order No. DE 91NM-177 (Ecology 1989) which required that discharges of liquids to soil columns at the Hanford Site comply with the requirements of the State Waste Discharge Permit Program (WAC 173-216) or the Underground Injection Control Program (WAC 173-218).

6.10 Transportation Requirements

The transportation of all radioactive and other hazardous materials associated with any alternative selected for implementation would comply with applicable DOE directives and the regulations of EPA,

DOT, and Ecology. Applicable DOE directives include DOE Order 460.1A, *Packaging and Transportation Safety* (DOE 1996b), and DOE Order 460.2, *Departmental Materials Transportation and Packaging Management* (DOE 1997a). DOE Order 460.2 states that DOE operations shall be conducted in compliance with all applicable international, federal, state, local, and tribal laws, rules, and regulations governing materials transportation that are consistent with federal regulations, unless exemptions or alternatives are approved in accordance with DOE Order 460.1A (DOE 1996b). DOE Order 460.2 also states that it is DOE policy that shipments will comply with the DOT 49 CFR 106-180 requirements, except those that infringe upon maintenance of classified information.

Transportation of waste products and contaminated equipment that is conducted entirely on DOE property, to which public access is controlled at all times through the use of gates and guards, is subject to applicable DOE directives, but is not directly subject to the DOT regulatory requirements. DOE transport of these materials over highways to which the public has access would be subject to applicable DOT, EPA, and Ecology regulations, as well as to applicable DOE directives. DOT has requirements for marking, labeling, placarding, providing emergency response information, and training of hazardous material transport personnel at 49 CFR 172. Specific packaging requirements for radioactive materials are in 49 CFR 173[i]. These requirements invoke the NRC packaging requirements for radioactive material as set forth in 10 CFR 71. DOT regulations for truck transportation of radioactive and other hazardous materials are in 49 CFR 172, 173, 177, and 397. DOT regulations for rail transportation of radioactive and other hazardous materials are in 49 CFR 172, 173, and 174. The Ecology regulations applicable to transportation of hazardous waste are in WAC 173-303-240 through 270.

6.11 Noise

Federal efforts to regulate noise derive largely from the Noise Control Act of 1972 (42 USC 4901-4918). Under the Act, federal agencies are to carry out their programs to further the purpose of the Act, which promotes an environment for all Americans that is free from noise that jeopardizes health or welfare (42 USC 4903[a]). Beyond this general obligation in the Noise Control Act, no specific requirements in the Act or in any regulations implemented under the Act prohibit or regulate the activities that will be conducted under any of the alternatives under consideration in this HSW EIS.

The Noise Control Act also requires federal agencies to meet state and local requirements relating to the abatement of noise (42 USC 4903[b]). Ecology has regulations covering maximum environmental noise levels in WAC 173-60.

OSHA has issued regulations covering noise exposure of occupational workers (29 CFR 1910.95). These regulations are applicable to operations addressed in this HSW EIS by virtue of DOE Order 5480.4 (DOE 1993b).

6.12 Cultural Resources

The DOE policy on management of cultural resources (DOE 2001e) provides that

> DOE will uphold [the National Historic Preservation Act, the Archaeological Resources Protection Act, and the Native American Graves Protection and Repatriation Act] by preserving, protecting, and perpetuating cultural resources for future generations in a spirit of stewardship to the extent feasible given the agency's mission and mandates. To do this, DOE will implement management accountability for compliance with Federal statutes, Executive orders, treaties, DOE orders, and implementation guidance. The Department also ensures that DOE contractors are obligated to implement DOE programs and projects in a manner that is consistent with this Policy and that reflects this commitment in site management contracts.

The background statement in "Management of Cultural Resources at Department of Energy Facilities" (DOE 2001f) further states that

> DOE recognizes the cultural and scientific value of the resources that may exist on the properties under its management or over which it has direct or indirect control. Therefore, DOE has implemented a program to protect these resources and ensure that all DOE facilities and programs comply with all existing cultural resource executive orders, laws, and regulations. Thus, DOE is able to preserve, protect, and perpetuate cultural resources for future generations.

The DOE management document (DOE 2001f) defines cultural resources to include "historic properties" as defined in the National Historic Preservation Act, "archaeological resources" as defined in the Archaeological Resources Protection Act of 1979, and "cultural items" as defined in the Native American Graves Protection and Repatriation Act (see Section 6.13).

The National Historic Preservation Act authorizes the Secretary of the Interior to maintain a National Register of Historic Places (16 USC 470a[a][1]). Federal agencies are to consider the effect of their actions on properties included in or eligible for inclusion in the Register and afford the Advisory Council on Historic Preservation a reasonable opportunity to comment on such actions (16 USC 470f).

The Archaeological Resources Protection Act of 1979 prohibits the excavation of material remains of past human life that have archaeological interest and are at least 100 years old without a permit from the appropriate federal land manager or an exemption (16 USC 470bb, 470ee).

DOE and Hanford Site contractor compliance with cultural resources compliance legislation is discussed in Section 2.2.14 of the *Hanford Site Environmental Report for Calendar Year 2000* (Poston *et al.* 2001).

6.13 Treaties, Statutes, and Policies Relating to Native Americans

DOE's relationship with American Indians is based on treaties, statutes, and DOE directives. Representatives of the United States negotiated treaties with leaders of various Columbia Plateau

American Tribes and Bands in June 1855 at Camp Stevens in the Walla Walla Valley. The negotiations resulted in three treaties, one with the 14 tribes and bands of the group that would become the Confederated Tribes and Bands of the Yakama Nation, one with the three tribes that would become the Confederated Tribes of the Umatilla Indian Reservation, and one with the Nez Perce Tribe. The U.S. Senate ratified the treaties in 1859. The negotiated treaties are as follows:

1. Treaty with the Walla Walla, Cayuse, etc. (June 9, 1855; 12 Stats. 945)

2. Treaty with the Yakama (June 9, 1855; 12 Stats. 951)

3. Treaty with the Nez Perce (June 11, 1855; 12 Stats. 957).[(a)]

The Confederated Tribes and Bands of the Yakama Nation, the Confederated Tribes of the Umatilla Indian Reservation, and the Nez Perce Tribe are federally recognized tribes that are eligible for funding and services from the Bureau of Indian Affairs by virtue of their status as Indian tribes (65 FR 13298).

The terms of the three preceding treaties are similar. Each of the three tribal organizations agreed to cede large blocks of land to the United States. The Hanford Site is within the ceded lands. The treaties reserved to the Tribes certain lands for their exclusive use (the three reservations). The treaties also secured to the Tribes certain rights and privileges to continue traditional activities outside the reservations. These included 1) the right to fish at usual and accustomed places in common with citizens of the United States, and 2) the privileges of hunting, gathering roots and berries, and pasturing horses and cattle on open and unclaimed lands.

The *U.S. Department of Energy American Indian and Alaska Native Tribal Government Policy* (DOE 2000c) states, in part, that DOE

- recognizes the federal trust relationship with American Indians and Alaska Native Nations and will fulfill its trust responsibilities to them

- recognizes and commits to a government-to-government relationship and will institute appropriate protocols and procedures for program and policy implementation

- compliance with applicable federal cultural resource protection and other laws and executive orders will assist in preservation and protection of historic and cultural sites and traditional religious practices.

The American Indian Religious Freedom Act (42 USC 1996) establishes that U.S. policy is to protect and preserve for American Indians their inherent rights of freedom to believe, express, and exercise their traditional religions, including access to sites, use and possession of sacred objects, and the freedom to worship through ceremonies and traditional rites.

(a) The three treaties, as well as additional treaties, are included in Appendix A of the Hanford Comprehensive Land-Use Plan EIS (DOE 1999a).

The Native American Graves Protection and Repatriation Act establishes the right of lineal descendents, Indian Tribes, and Native Hawaiian organizations to certain Native American human remains, funerary objects, sacred objects, or objects of cultural patrimony discovered on federal lands after November 16, 1990 (25 USC 3002). When discovered during an activity on federal lands, the activity is to cease and appropriate tribal governments are to be notified. Work on the activity may resume, if resumption of the activity is otherwise lawful, 30 days after the receipt of certification that tribal governments have received the notice.

Executive Order 13007, "Indian Sacred Sites," (61 FR 26771) directs federal agencies, to the extent practicable, permitted by law, and not clearly inconsistent with essential agency functions, to 1) accommodate access to and ceremonial use of American Indian sacred sites by their religious practitioners, and 2) avoid adversely affecting the physical integrity of such sacred sites. Where appropriate, agencies are to maintain the confidentiality of sacred sites.

The DOE Richland Operations Office (DOE-RL) interacts and consults regularly and directly with the three federally recognized tribes affected by Hanford Site operations, that is, the Nez Perce Tribe, the Confederated Tribes of the Umatilla Reservation, and Yakama Nation Tribe. In addition, the Wanapum people, who still live adjacent to the Hanford Site, are a non-federally recognized tribe that has strong cultural ties to the Site. The Hanford area was also used by groups whose descendants are now enrolled members of the Confederated Tribes of the Colville Reservation. The Wanapum people and the Confederated Tribes of the Colville Reservation are also consulted on cultural resource issues in accordance with DOE policy and relevant legislation.

6.14 Environmental Justice and Protection of Children

Section 2-2 of Executive Order 12898, "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations," (59 FR 7629) states that

> Each Federal agency shall conduct its programs, policies, and activities that substantially affect human health or the environment, in a manner that ensures that such programs, policies, and activities do not have the effect of excluding persons (including populations) from participation in, denying persons (including populations) the benefits of, or subjecting persons (including populations) to discrimination under, such programs, policies, and activities, because of their race, color, or national origin.

The CEQ has issued guidance for federal agencies to use in implementing Executive Order 12898 in conjunction with NEPA (CEQ 1997). DOE has also issued an information brief for DOE staff covering Executive Order 12898 (DOE 1997b).

Section 1 of Executive Order 13045, "Protection of Children from Environmental Health Risks and Safety Risks," (62 FR 19885) requires federal agencies to

1. make it a high priority to identify and assess environmental health risks and safety risks that may disproportionately affect children; and

2. ensure that their policies, programs, activities, and standards address disproportionate risks to children that result from environmental health risks or safety risks.

6.15 Chemical Management

Chemical management would be conducted according to DOE Order 5480.4, *Environmental Protection, Safety, and Health Protection Standards* (DOE 1993b), requires DOE and its contractors to comply with National Fire Protection Association Codes and Standards and the Occupational Safety and Health Standards in 29 CFR 1910. The Hanford strategy for chemical management is described in Section 2.2.3 of the *Hanford Site Environmental Report for Calendar Year 2000* (Poston *et al.* 2001).

6.16 Emergency Planning and Community Right-to-Know

Part 5 of Executive Order 13148, "Greening the Government Through Leadership in Environmental Management," (65 FR 14595) requires that federal executive branch agencies comply with the requirements for toxic chemical release reporting in Section 313 of the Emergency Planning and Community Right-To-Know Act (42 USC 11001). Compliance activities would be supplemented with any additional notification, planning, or reporting requirements that may arise.

6.17 Pollution Prevention

Part 5 of Executive Order 13148, "Greening the Government Through Leadership in Environmental Management," (65 FR 14595) requires that federal executive branch agencies comply with Section 6607 of the Pollution Prevention Act (42 USC 13106). Section 6607 requires that owners of a facility required to file an annual toxic chemical release form under Section 313 of the Emergency Planning and Community Right-To-Know Act (42 USC 11001) for any toxic chemical shall include with each such annual filing a toxic-chemical source reduction and recycling report for the preceding calendar year. If implementation of any alternative considered in this EIS were to trigger reporting under Section 313 of the Emergency Planning and Community Right-To-Know Act, DOE would comply with the reporting requirements and the requirement for a toxic-chemical source reduction and recycling report.

6.18 Endangered Species

Section 7 of the Endangered Species Act (16 USC 1536) requires that Federal agencies 1) utilize their authority in furtherance of the purposes of the Act by carrying out programs for the conservation of listed endangered and threatened species, and 2) consult with appropriate Federal agencies to ensure that any action carried out by DOE is not likely to jeopardize the continued existence of any endangered or threatened species or result in the destruction or adverse modification of critical habitat for such species. Additional information is provided in Section 4.6.4, 5.5.4, and Appendix I of this HSW EIS and in Section 2.2.12 of the *Hanford Site Environmental Report 2000* (Poston *et al.* 2001).

6.19 Permit Requirements

The CEQ NEPA regulations (40 CFR 1502.25[b]) require that a draft EIS list all federal permits, licenses, and other entitlements that must be obtained to implement the alternatives.

The principal existing Hanford facilities that are involved in implementing the alternatives in the HSW EIS are the Central Waste Complex, 200 Area ETF, Liquid Effluent Retention Facility, LLW Trenches, MLLW Trenches, T Plant Complex, and the Waste Receiving and Processing Facility. Table 6.2 indicates whether operation of each of these facilities is covered in the existing Dangerous Waste portion of the Hanford RCRA permit (Ecology 2001a), the Hanford Air Operating Permit (Ecology 2001b), or the Hanford Waste Discharge Permit (DOE 2001a). In all cases where units are covered in the Dangerous Waste portion of the Hanford RCRA permit, the coverage is in Part III of the permit that contains unit-specific conditions for final status operations. The MLLW trenches and T Plant Complex are being incorporated into the Dangerous Waste portion of the Hanford RCRA permit (DOE 2001a, Appendix A).

DOE would obtain appropriate required permits for any new or modified facility. For example, the M-91 Facility could require a variety of approvals, permits, or permit modifications, including a modification to the dangerous waste portion of the Hanford RCRA permit, submission of a notice of construction to the WDOH, modification of the Hanford Air Operating Permit, construction approval by EPA under 40 CFR 61, and/or approval from EPA under TSCA and the regulations in 40 CFR 761[d], if waste containing PCBs is treated or disposed of at the facility. Permits might be required for operation of pulse driers to process leachate.

Table 6.2. Coverage of Hanford Solid Waste Management Units in Existing Permits

Unit	Dangerous Waste Portion of Hanford RCRA Permit	Hanford Air Operating Permit	Hanford State Waste Discharge Permit
Central Waste Complex	Yes[(a)]	Yes	No
200 Area ETF	Yes[(b)]	Yes	Yes
Liquid Effluent Retention Facility	Yes[(b)]	Yes	No
LLW Trenches	No	No	No
MLLW Trenches	Yes[(c)]	Yes	No
T Plant Complex	Yes[(c)]	Yes	No
Waste Receiving and Processing Facility	Yes[(a)]	Yes	No

(a) Under appeal.
(b) Approved.
(c) In process.

DOE would obtain a site-use permit from Ecology before sending LLW to the commercial LLW disposal facility located on the Hanford Site. Some Hanford MLLW could be stabilized and treated offsite by a commercial facility or another DOE facility. One source of stabilization and treatment is the Allied Technology Group, Inc. (ATG) facility in Richland, Washington. ATG received a combined dangerous waste/TSCA permit from Ecology and EPA in May 1999. Permit requirements related to the ATG facility are discussed in two DOE environmental assessments (DOE 1998b; DOE 1999b).

6.20 References

10 CFR 71. 2001. *Energy*. Nuclear Regulatory Commission. "Packaging and Shipping of Radioactive Materials." U.S. Code of Federal Regulations. Online at: http://www.access.gpo.gov/nara/cfr/waisidx_01/10cfr71_01.html

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ENVIRONMENTAL IMPACT STATEMENT

CEQ Regulations at 40 CFR 1506.5(c), which have been adopted by the DOE (10 CFR 1021), require contractor who will prepare an EIS to execute a disclosure specifying that they have no financial or other interest in the outcome of the project. The term "financial or other interest in the outcome of the project" for purposes of this disclosure, is defined in the March 23, 1981, guidance "Forty Most Asked Questions Concerning CEQ's National Environmental Policy Act Regulations," 46 FR 18026-18038 at Questions 71a and b.

"Financial or other interest in the outcome of the project" includes "any financial benefit such as a promise of future construction or design work in the project, as well as indirect benefits the contractor is aware of (e.g., if the project would aid proposals sponsored by the firm's other clients)" 46 FR 18026-18038 at 18031.

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Financial or Other Interest

1.
2.
3.

Certified by:

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Signature

Nori Nichols
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Contracting Officer
Title

April 9, 2002
Date

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NON-GOVERNMENTAL ORGANIZATIONS

Mr. Jim Bridgman
Program Director
Alliance for Nuclear Accountability

Ms. Susan Gordon
Director
Alliance for Nuclear Accountability

Dr. Mildred McClain
Citizens for Environmental Justice, Inc.

Mr. Tom Carpenter
Government Accountability Project

Mr. Gerald Pollet
Heart of America Northwest

Mr. Jeff Parsons
Washington State Office
National Audubon Society

NON-GOVERNMENTAL ORGANIZATIONS

Dr. Thomas B. Cochran
Washington Office
Natural Resources Defense Council (NRDC)

Mr. David Beckman
Los Angeles Office
Natural Resources Defense Council (NRDC)

NON-GOVERNMENTAL ORGANIZATIONS (cont)

Ms. Maggie Coon
The Nature Conservancy

Mr. Robert K. Musil, Ph.D., M.P.H.
Physicians for Social Responsibility

OTHER REQUESTORS

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R. Garza
C. and D. Gatchel
F. Gearhart
J. Goffman, Sr.
E. Goller
M. Grainey
K. Greenough, Jr.
Capt. P. Gunter

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V. Hall
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J. Sandvig
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J. Schmidt
K. Sellinger
R. Shanks

OTHER REQUESTORS (cont)

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