DOE/RL-2021-40
Revision 0

Performance Assessment Closure Plan for the Active Low-Level Burial Ground Trenches 31, 34, and 94 at the Hanford Site

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

U.S. DEPARTMENT OF ENERGY | Richland Operations Office

P.O. Box 550
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Executive Summary

This report documents the closure plan for the active trenches within the Low-Level Burial Grounds of the Hanford Site, namely Trenches 31 and 34 in the 200 West Area and Trench 94 in 200 East Area. This closure plan is developed to meet the requirements of DOE O 435.1, *Radioactive Waste Management*[1]. It is one of the several technical basis documents, along with the performance assessment (DOE/RL-2021-26, *Performance Assessment of Active Trenches in 200 East and West Low-Level Burial Grounds at the Hanford Site*[2]), which is required for maintaining the Operating Disposal Authorization Statement as described in DOE-STD-5002-2017, *Disposal Authorization Statement and Tank Closure Documentation*[3].

Following the completion of all disposal activities, an engineered barrier will be installed as a closure cap over Trenches 31, 34, and 94. An interim cover will be emplaced after the trenches are filled followed by a final cover. The final closure cap design involves constructing a modified *Resource Conservation and Recovery Act of 1976*[4] Subtitle C surface barrier to meet applicable federal and state requirements. Attributes of the cover design include ensuring long-term integrity of the closed facility and the cover system, preventing long-term degradation of the cover, ensuring structural stability, limiting infiltration, limiting consequences of human intrusion, and achieving compliance with facility performance objectives.

This closure plan is intended to be a living document and will be revised periodically through the operational life of Trenches 31, 34, and 94.

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[1] DOE O 435.1 Chg 1 (PgChg), 2001, *Radioactive Waste Management*, U.S. Department of Energy, Washington, D.C. Available at: https://www.directives.doe.gov/directives-documents/400-series/0435.1-BOrder-chg1-PgChg/@@images/file.

[2] DOE/RL-2021-26, 2023, *Performance Assessment of Active Trenches in 200 East and West Low-Level Burial Grounds at the Hanford Site*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

[3] DOE-STD-5002-2017, 2017, *Disposal Authorization Statement and Tank Closure Documentation*, U.S. Department of Energy, Washington, D.C. Available at: https://www.standards.doe.gov/standards-documents/5000/5002-astd-2017/@@images/file.

[4] *Resource Conservation and Recovery Act of 1976*, 42 USC 6901, et seq. Available at: https://www.gpo.gov/fdsys/pkg/STATUTE-90/pdf/STATUTE-90-Pg2795.pdf.

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Terms

AEA	*Atomic Energy Act of 1954*
CAT1 (or WC1)	Category 1
CAT3 (or WC3)	Category 3 and Greater Than Category 3
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CY	calendar year
DAS	Disposal Authorization Statement
DOE	U.S. Department of Energy
Ecology	Washington State Department of Ecology
ET	evapotranspiration
FFS	focused feasibility study
HELP	Hydrologic Evaluation of Landfill Performance (model)
HIC	high-integrity container
HMS	Hanford Meteorological Station
HSU	hydrostratigraphic unit
HWMA	*Hazardous Waste Management Act*
LCRS	leachate collection and recovery system
LDR	land disposal restriction
LLBG	low-level burial ground
LLW	low-level waste
MLLW	mixed low-level waste
NEPA	*National Environmental Policy Act of 1969*
OU	operable unit
PA	performance assessment
PHB	Prototype Hanford Barrier
RCRA	*Resource Conservation and Recovery Act of 1976*
ROD	record of decision
SW-EIS	Hanford Site Solid (Radioactive and Hazardous) Waste Environmental Impact Statement

SWITS	Solid Waste Information Tracking System
TC & WM EIS	Tank Closure and Waste Management Environmental Impact Statement
TEDF	Treated Effluent Disposal Facility

1 Introduction

Since July 1, 2004, the only active trenches in the 200 West Area Low-Level Burial Grounds (LLBGs) are the lined Trenches 31 and 34 used for the disposal of containerized LLW and mixed low-level waste (MLLW), and the only active trench in the 200 East Area LLBGs is the unlined Trench 94 used for the disposal of defueled naval reactor compartments (Figure 1-1). In order to maintain the Operating Disposal Authorization Statement for U.S. Department of Energy's (DOE) low-level radioactive waste disposal facility certain technical basis documents need to be developed including a closure plan (DOE-STD-5002-2017, *Disposal Authorization Statement and Tank Closure Documentation*). This is required to comply with the DOE O 435.1, *Radioactive Waste Management* and DOE M 435.1-1, *Radioactive Waste Management Manual*.

This document provides the closure plan for Trenches 31, 34, and 94 following the completion of waste disposal for ensuring the long-term protection of the public and the environment[5]. It is one of several technical basis documents required for maintaining the Operating Disposal Authorization Statement. Other supporting technical documents are:

- Performance Assessment (PA) (DOE/RL-2021-26, *Performance Assessment of Active Trenches in 200 East and West Low-Level Burial Grounds at the Hanford Site*)
- Monitoring Plan (DOE/RL-2021-39, *Performance Assessment Monitoring Plan for Active Low-Level Burial Ground Trenches 31, 34, and 94 at the Hanford Site*)
- Maintenance Plan (DOE/RL-2021-38, *Performance Assessment Maintenance Plan for Active Low-Level Burial Ground Trenches 31, 34, and 94 at the Hanford Site*)
- Composite Analysis (DOE/RL-2019-52, *Composite Analysis for Low-Level Waste Disposal in the Hanford Site Central Plateau (FY 2020)*)

As much as possible this document follows the general outline and content guidelines that are identified in DOE-STD-5002-2017. The document is comprised of the following additional chapters:

- Chapter 2, "Summary of Facility Description"
- Chapter 3, "Summary of Closure Approach"
- Chapter 4, "Summary of Key Assumptions"
- Chapter 5, "Disposal Facility Summary"
- Chapter 6, "Approach to Closure"
- Chapter 7, "Compliance"
- Chapter 8, "Institutional Controls"
- Chapter 9, "References"

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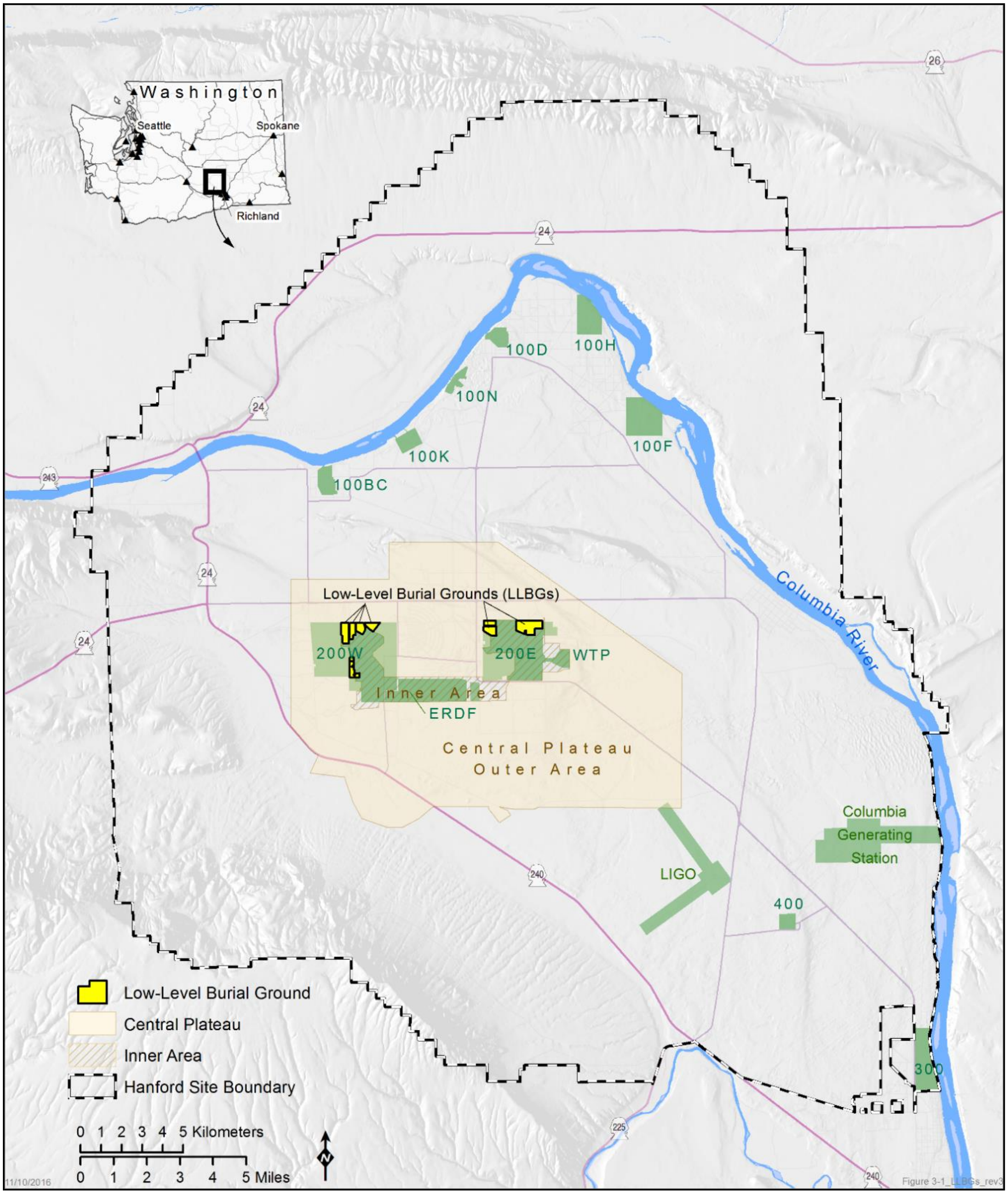
[5] The long-term needs for continued disposal of LLW and MLLW at the Hanford Site have been evaluated in DOE/EIS-0391, *Final Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington* (TC & WM EIS). The record of decision (ROD) (78 FR 75913, "Final Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington"), issued by the DOE on December 13, 2013, identifies the selection of Waste Management Alternative 2 as the preferred alternative for waste disposal. In Waste Management Alternative 2, disposal of LLW and MLLW in Trenches 31 and 34 continues until the trenches are filled. The defueled reactor compartment ROD (61 FR 41596, "National Environmental Policy Act Record of Decision for the Disposal of Decommissioned, Defueled Cruiser, Ohio Class, and Los Angeles Class Naval Reactor Plants") identifies land burial of the defueled naval reactor compartments at the Hanford Site as the preferred alternative.



Note: The Environmental Restoration Disposal Facility is covered under a separate performance assessment (WCH-520, *Performance Assessment for the Environmental Restoration Disposal Facility, Hanford Site, Washington*).

Figure 1-1. Location of the Low-Level Burial Grounds in the 200 East and 200 West Areas of the Inner Area of the Hanford Site Central Plateau

2 Summary of Facility Description

There are four LLBGs in the 200 West Area (218-W-3A, 218-W-3AE, 218-W-4C, and 218-W-5) and two in the 200 East Area (218-E-10 and 218-E-12B) that received radioactive waste after September 26, 1988, and hence are subject to the requirements of the DOE O 435.1. Initial PAs for these burial grounds (WHC-EP-0645, *Performance Assessment for the Disposal of Low-level- Waste in the 200 West Area Burial Grounds*, and WHC-SD-WM-TI-730, *Performance Assessment for the Disposal of Low-Level Waste in the 200 East Area Burial Grounds*), were completed in 1995 (with an addendum in 1996[6]) and 1996 (with an addendum in 1997)[7], respectively under the requirements of DOE Order 5820.2A, *Radioactive Waste Management* that preceded DOE O 435.1. These initial PAs provide the basis for waste acceptance and disposal authorization in the trenches contained within the six burial grounds in the 200 East and 200 West Area LLBGs. These initial PAs have been maintained in accordance with a maintenance plan (RFSH-9755566, "Transmittal of Program Plan for Maintenance of Hanford Burial Ground Performance Assessment (PA) Analyses, that Fulfills Performance Agreement WM 1.8.1") since they were approved with the DOE-issued DAS (Scott, 2018, "Disposal Authorization for the Hanford Site Low-Level Waste Disposal Facilities – Revision 2").

Since July 1, 2004, the only active trenches in the 200 West Area used for the disposal of containerized LLW and MLLW are the lined Trenches 31 and 34 within 218-W-5 LLBG, and the only active trench in the 200 East Area is the unlined Trench 94 within 218-E-12B LLBG used for the disposal of naval reactor compartments. These three active trenches are the subject of this closure plan for the PA (DOE/RL-2021-26). The remaining inactive trenches located within the four LLBGs in the 200 West Area and two in the 200 East Area are not evaluated in the PA. They will be evaluated separately as they also contain wastes that are subject to the *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA) and *Resource Conservation and Recovery Act* (RCRA) regulatory decisions as part of the 200-SW-2 Operable Unit (OU). The 200-SW-2 OU is composed of 24 past-practice landfills and about 20 caissons (or vertical pipe units).

2.1 Facility Description

Trenches 31 and 34 are intended to accept wastes until they are filled. Trench 94 will accept naval reactor compartments and be expanded as necessary to meet the needs of the U.S. Navy. Figure 1-1 shows the location of the 200 West and 200 East Area LLBGs in relation to the Central Plateau inner and outer areas, and other facilities in the Hanford Site. Figure 2-1 provides a site map showing the specific waste trench configuration for the 200 West Area LLBGs, including active Trenches 31 and 34. Figure 2-2 provides a site map showing the specific waste trench configuration for the 200 East Area LLBGs, including Trench 94. The closure plan presented in this document describes the closure process and cover design for Trenches 31 and 34 shown in Figure 2-3 and for Trench 94 dangerous waste management unit shown in Figure 2-4, respectively.

Trenches 31 and 34 were excavated in 1994. The floor of the trenches is about 76 m (249 ft) long in a west-east direction and 31 m (102 ft) wide in a north-south direction. The top of the trench liner system (i.e., where the trench side slopes intersect the land surface) is about 137 m (449 ft) long in a west-east direction and 91 m (299 ft) wide in a north-south direction. The trench floor is sloped towards the east

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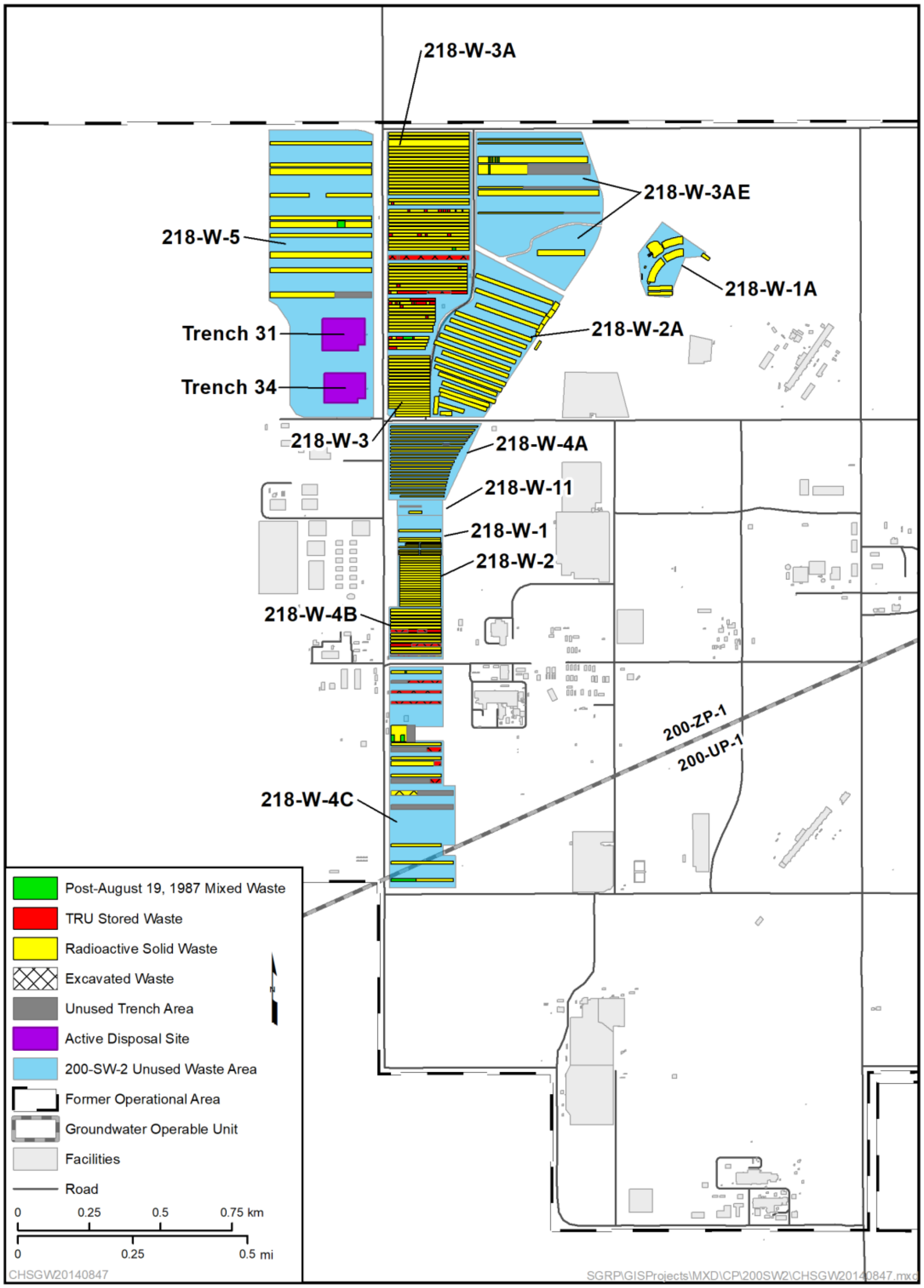
[6] HNF-SD-WM-TI-798, *Addendum to the Performance Assessment Analysis for Low-Level Waste Disposal in the 200 West Area Active Burial Grounds*

[7] HNF-2005, *Addendum to the Performance Assessment Analysis for Low-Level Waste Disposal in the 200 East Area Active Burial Grounds.*

where a sump is located to collect leachate during operations period and for some time during the postclosure period. Trench 94 is a relatively wide and deep excavation, 540 m (1,770 ft) long by 140 m (460 ft) wide at the top, and 494 m (1,620 ft) long by 98 m (320 ft) wide at the base, and typically about 15 m (49 ft) in depth. When naval reactor compartment disposal activities are concluded in Trench 94, a separate engineering design will be necessary to ensure that fill is placed and compacted in an adequate manner to prepare this trench for closure. Disposed reactor compartments are regulated as mixed waste. Closure of the trenches will consist of placing a modified RCRA Subtitle C surface barrier above the last waste and operations layer, which is required to meet DOE O 435.1 requirements.

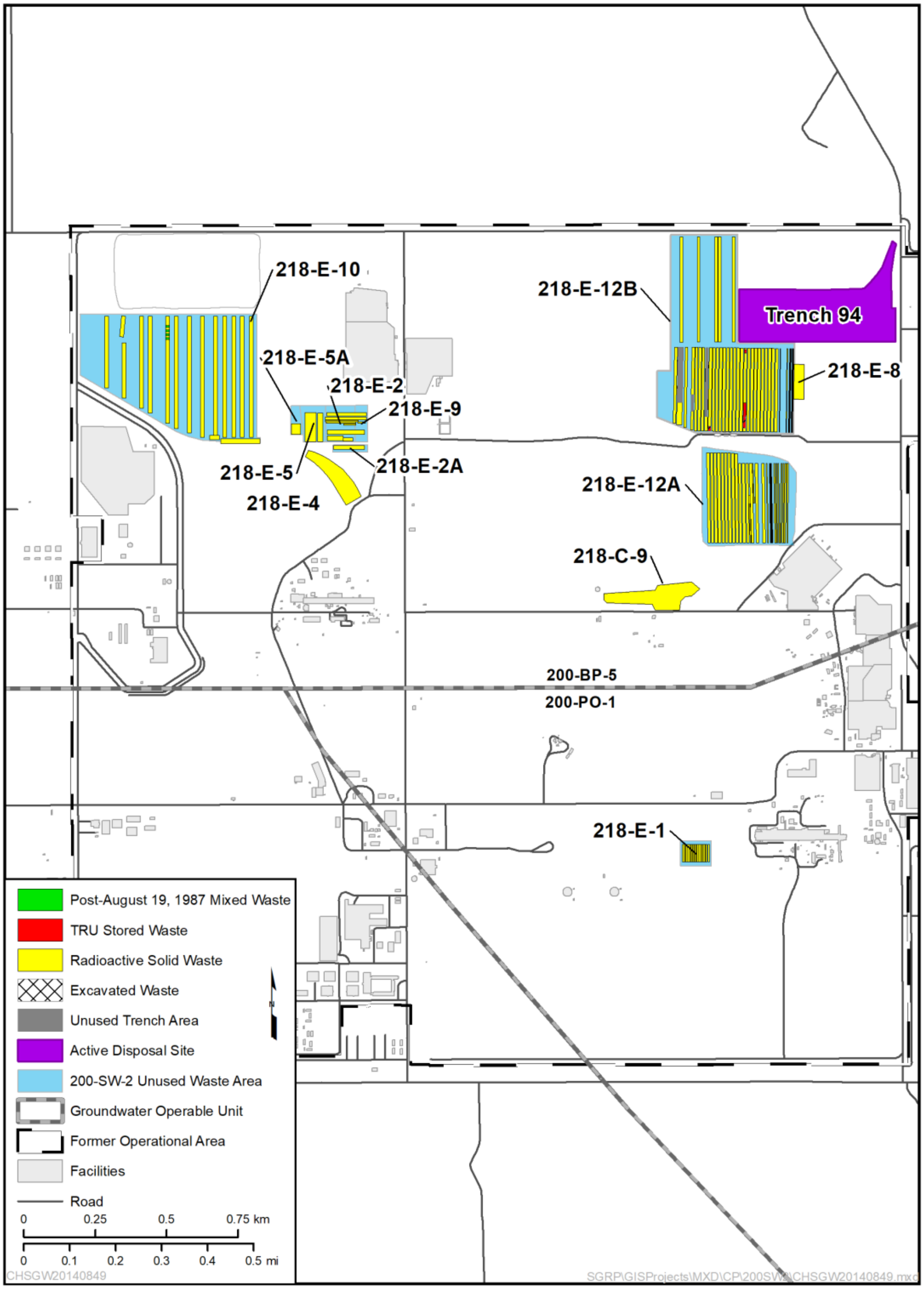
The process design capacity for disposal of mixed waste in Trenches 31 and 34 is approximately 21,408 m^3 (28,001 yd^3) per landfill for a total process design capacity of 42,816 m^3 (56,001 yd^3). The process design capacity of the Trench 94 disposal cell is approximately 1,500,000 m^3 (1,962,000 yd^3). The combined process design capacity for Trenches 31, 34, and 94 disposal is approximately 1,542,816 m^3 (2,018,001 yd^3) (DOE/RL-2015-74, *Hanford Facility Dangerous Waste Part B Permit Application; Low Level Burial Grounds Trenches 31, 34, 94, T Plant Complex, and Central Waste Complex Waste Receiving and Processing Facility*).



Note: Trenches 31 and 34 in 218-W-5 Burial Ground are the only active low-level waste disposal areas within the 200 West Area LLBGs.

Source: Figure 1-3 of DOE/RL-2021-26, *Performance Assessment of Active Trenches in 200 East and West Low-Level Burial Grounds at the Hanford Site.*

Figure 2-1. Location of Low-Level Waste Burial Grounds in 200 West Area



Note: Trench 94 in 218-E-12B Burial Ground is the only active low-level waste disposal area within the 200 East LLBGs.

Source: Figure 1-4 of DOE/RL-2021-26, *Performance Assessment of Active Trenches in 200 East and West Low-Level Burial Grounds at the Hanford Site*.

Figure 2-2. Location of Low-Level Waste Burial Grounds in 200 East Area

Sources: Figure 1-6 of DOE/RL-2021-26, *Performance Assessment of Active Trenches in 200 East and West Low-Level Burial Grounds at the Hanford Site*.
Google® Maps.

Notes: Uranium billet monolith and other encasement cells are visible in eastern half of Trench 34. Grouted waste container encasements are located to the north and south of the uranium billet monolith.

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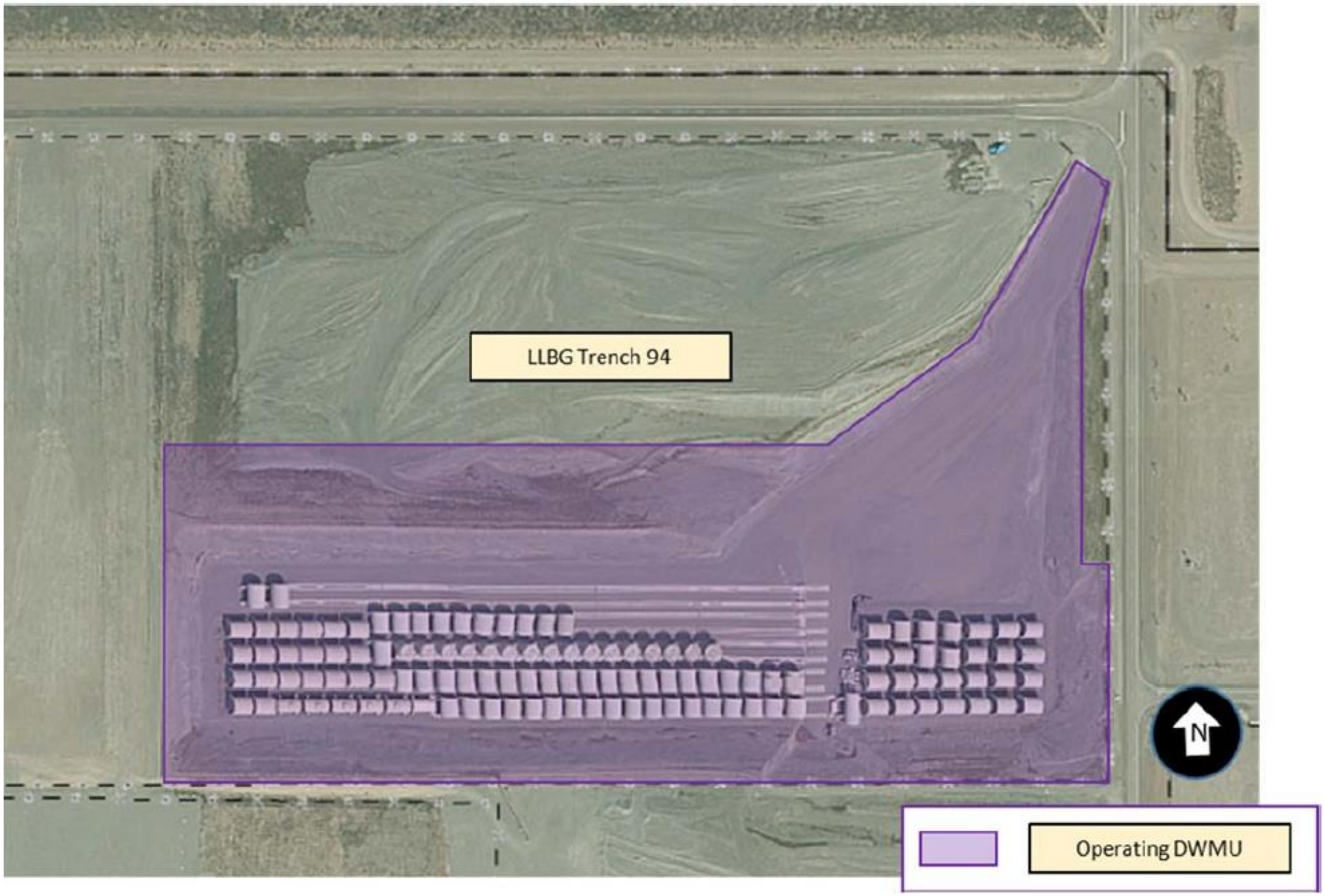
Figure 2-3. 200 West Area Low-Level Burial Ground Trenches 31 and 34



Source: Figure H-C1 in DOE/RL-2015-74, *Hanford Facility Dangerous Waste Part B Permit Application; Low-Level Burial Grounds Trenches 31, -34, -94, T Plant Complex, and Central Waste Complex-Waste Receiving and Processing Facility*.

Figure 2-4. Naval Reactor Compartment Packages in Trench 94

2.2 Design Features

In general, Trenches 31, 34, and 94 include several engineered design features that contribute to the overall safety of the facility. These design features work in concert with the natural features of the site to limit releases of radionuclides to the natural environment and protect public health and safety. The natural and engineered features, and their associated functions that contribute to the overall safety of the facility (i.e., safety or barrier functions), are described in Section 1.3.2 of the PA document (DOE/RL-2021-26).

The key engineered design features for the active trenches consist of the following:

- Modified RCRA Subtitle C surface barrier placed above the waste in Trenches 31 and 34 to limit water from contacting the waste, minimize the potential for biointrusion into the waste, and limit the release of gaseous radionuclides, including radon, from the facility.
- Waste containers placed around the waste forms to limit water from contacting the waste during disposal operations and provide structural support for overlying waste and backfill.
- Engineered backfill placed between and above waste containers to provide structural support during operations.
- Cementitious waste forms and concrete barrier within containers to limit advective or diffusive release of radionuclides from the Category 3 and Greater Than Category 3 (CAT3 or WC3) waste into water in the backfill that surrounds the waste forms and containers.
- The naval reactor compartments disposed in Trench 94 are comprised of corrosion resistant carbon steel and highly corrosion-resistant stainless steel. The corrosion-resistant carbon steel is also used for the associated bulkheads, as well as for the reactor pressure vessel and tank structure.
- Liner to limit any water collected during operations and the institutional control period from entering the natural system beneath the facility (Trenches 31 and 34 only).
- For Trench 94, a cover that is of typical Hanford landfill cover and similar to Trenches 31 and 34 will be designed (WA7890008967, *Hanford Facility Resource Conservation and Recovery Act (RCRA) Permit, Dangerous Waste Portion for the Treatment, Storage, and Disposal of Dangerous Waste*, Part III, *Unit-Specific Conditions for Final Status Operations*, Operation Unit Group 18, "Low-Level Burial Grounds Trench 94 (OUG 18)," Addendum H, Draft) and emplaced on closure.

2.3 Waste Characteristics

Trenches 31 and 34 are designed for disposal of miscellaneous dry wastes from various operations at the Hanford Site and from offsite facilities. Trenches 31 and 34 began receiving low-level mixed dry waste in 2005 and 1999, respectively. The source of waste includes compactable and noncompactable debris and nondebris solid waste from different Hanford Site locations. The types of waste include paper, plastic, wood, concrete rubble, activated metal, and sludge. Mixed waste disposed in Trenches 31 and 34 include bulk wastes, containerized wastes, inherently stable waste, and long-length contaminated equipment. A diverse range of waste containers can be disposed at Trenches 31 and 34 including, but not limited to, containers/drums, waste boxes, and miscellaneous equipment. Commonly observed radionuclides in these wastes include strontium-90, cesium-137, and uranium. Lesser but significant activities of carbon-14, iodine-129, and technetium-99 are also present.

The dangerous wastes managed at Trenches 31 and 34 are described in DOE/RL-2015-74 and managed in accordance with WA7890008967. Trenches 31 and 34 may manage any of the dangerous wastes identified in Table 2-2 of SGW-59564, *Engineering Evaluation Report for Low Level Burial Grounds Trenches 31 and 34 Groundwater Monitoring*. Mixed waste destined for disposal in Trenches 31 and 34 must meet the land disposal restriction (LDR) requirements (WAC 173-303-140, "Dangerous Waste Regulations," "Land Disposal Restrictions," which includes, by reference, 40 CFR 268, "Land Disposal Restrictions") and 69 FR 39449, *Record of Decision for the Solid Waste Program, Hanford Site, Richland, WA: Storage and Treatment of Low-Level Waste and Mixed Low-Level Waste; Disposal of Low-Level Waste and Mixed Low-Level Waste, and Storage, Processing, and Certification of Transuranic Waste for Shipment to the Waste Isolation Pilot Plant*. A site-specific treatability variance approved by the Washington State Department of Ecology (Ecology) must be obtained for waste not meeting these requirements.

Specifically, the waste must meet the waste acceptance criteria specified in HNF-EP-0063, *Hanford Site Solid Waste Acceptance Criteria*. The criteria for waste acceptance to Trenches 31 and 34 include the current requirements for the radiological characterization of the waste (Section 2.5 of HNF-EP-0063), for radiological concentration limits (Section 3.4 and Appendix A of HNF-EP-0063), and radiological treatment and segregation (Section 2.6 of HNF-EP-0063). The categorization of the waste into Category 1 (CAT1 or WC1) and CAT3 (or WC3) waste containers is based on the radiological characterization compared to the limits presented in Table A-2 of HNF-EP-0063. An important distinction between CAT1 and CAT3 wastes is that CAT1 wastes do not require stabilization prior to their disposal due to their low inventory concentration while CAT3 waste do require stabilization with barriers against intruders, if any, for 500 years.

The waste characterization and categorization are used to determine the completeness of the reported radionuclide inventory. The categorization of that inventory into different waste streams and container configurations is used in the PA for active trenches of the 200 East and 200 West LLBG (DOE/RL-2021-26) to model the release of radionuclides from the different waste forms to the natural system.

The defueled reactor compartments disposed in Trench 94 comprise of corrosion-resistant carbon steel bulkheads. Such a compartment contains reactor vessels and other components. The highly corrosion-resistant stainless steel or ICONEL® alloy 600 are used for the reactor vessel internal structure.

2.4 Technical Approach to Closure

The current plan is to continue to dispose of compliant wastes in Trenches 31 and 34 until they are filled and expand Trench 94 until no more space is needed. Interim closure is planned within 2 years after the trenches are filled. This is followed by the final closure. For analysis purposes, it is assumed the trenches are filled and the closure process begins for each trench in calendar year (CY) 2035.

2.5 Compliance with Performance Objectives

The primary laws and regulations which govern cleanup and closure processes of the trenches include the following:

- *National Environmental Policy Act of 1969* (NEPA)
- *Hanford Federal Facility Agreement and Consent Order* (Ecology et al., 1989)

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- RCRA/*Hazardous Waste Management Act* (HWMA) (RCW 70.105, "Hazardous Waste Management")
- *Atomic Energy Act of 1954* (AEA)
- *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA)

DOE O 435.1 prescribes numerous post closure requirements that an LLW disposal facility must satisfy to obtain authorization to continue to operate (Table 2-1). For some of these requirements, relevant exposure scenarios must be constructed and evaluated in a PA analysis to demonstrate compliance with the requirements. Chapter IV, *Low-Level Waste Requirements*, in DOE M 435.1-1 defines the LLW requirements and performance objectives that must be achieved by the LLW disposal facility as follows:

- Dose to representative members of the public shall not exceed 25 mrem in a year total effective dose equivalent from all exposure pathways, excluding the dose from radon and its progeny in air.
- Dose to representative members of the public via the air pathway shall not exceed 10 mrem in a year total effective dose equivalent, excluding the dose from radon and its progeny.
- Release of radon shall be less than an average flux of 20 $pCi/m^2/s$ (0.74 $Bq/m^2/s$) at the surface of the disposal facility.

2.6 Interim and Final Detailed Closure Activities

During Interim and Final Closure**,** measures will be taken to improve the bearing capacity of trench fills to support the weight of a final cover, and a cover will be constructed over the site. Cover construction will be coordinated with remediation of adjacent facilities, including inactive LLBGs (the currently inactive portions of the LLBGs, including past-practice burial grounds and trenches, are separately managed as part of the 200-SW-2 Source OU. Wastes were disposed in these landfills from the mid-1940s to 2004). The cover will limit water infiltration and inadvertent intrusion to meet performance objectives as described in the facility PAs. Land use adjacent to the burial grounds is currently limited to Hanford operations. In the region surrounding the Hanford Site, land use is typically agricultural.

Table 2-1. Exposure Scenarios, Performance Objectives and Measures, and Points of Assessment for the Active Trenches of the Low-Level Burial Grounds Performance Assessment

Exposure Scenario	Performance Objective and Measures	Point of Assessment	
		Operational and Active Institutional Control Periods[a]	Post-Institutional Control Period
All pathway[b]	25 mrem/yr[c]	20,000 m – nearest offsite receptor in direction of prevailing wind	100 m (328 ft)[d]
Air pathway[b]	10 mrem/yr[c]	20,000 m – nearest offsite receptor in direction of prevailing wind	100 m (328 ft)[d]
Radon[b]	20 pCi/m^2/s	Flux rate at facility surface	Flux rate at facility surface
	0.5 pCi/L[e]	Facility boundary	100 m (328 ft)[d]
Water resources	Washington State Department of Ecology requirements on concentrations of radionuclides and hazardous chemicals	At the source and 100 m (328 ft)[d]	100 m (328 ft)[d]
Intruder[b]	100 mrem/yr chronic[c,f]	Not applicable	Facility
	500 mrem acute[c,f]	Not applicable	Facility

Source: Table 1-3 in DOE/RL-2021-26, *Performance Assessment of Active Trenches in 200 East and West Low-Level Burial Grounds at the Hanford Site*.

a. Active institutional control period includes final closure.

b. Chapter IV, *Low-Level Waste Requirements* of DOE M 435.1-1, *Radioactive Waste Management Manual*.

c. Excluding radon in air.

d. Point of highest projected dose or concentration beyond a 100 m (328 ft) buffer zone from the edge of the disposed waste.

e. Alternative radon performance objective.

f. Performance measure.

3 Summary of Closure Approach

In this chapter, the closure actions and designs are provided to demonstrate that closure conditions will achieve stability of the disposal facility, reduce the need for active maintenance, and meet the requirements of DOE O 435.1. The primary information/data related to the site, facility, final inventory, and closure activities can be found in the following documents:

- Trench 31, 34, and 94 PA document: DOE/RL-2021-26, *Performance Assessment of Active Trenches in 200 East and West Low-Level Burial Grounds at the Hanford Site*
- Inventory and volume at closure: ECF-HANFORD-19-0069, *Inventory for the Active Trenches of the Low-Level Burial Grounds, Hanford Site, Washington*
- Reference information related to the closure activities and the cover design:
  - DOE/RL-2015-74, *Hanford Facility Dangerous Waste Part B Permit Application; Low-Level Burial Grounds Trenches 31, -34, -94, T Plant Complex, and Central Waste Complex-Waste Receiving and Processing Facility*
  - DOE/RL-2000-70, *Closure Plan for Active Low-Level Burial Grounds*
  - DOE/RL-93-33, *Focused Feasibility Study of Engineered Barriers for Waste Management Units in the 200 Areas*

The following sections provide more detailed descriptions and information.

3.1 Final Closure Inventory

The final closure inventory has been recently estimated based on HNF-58315, *Solid Waste Information and Tracking System (SWITS) User's Manual – Waste Generation*) (SWITS) database records. The inventory includes the disposed waste (radionuclide activity and volume for each category of waste accepted as early as 1977 to December 31, 2018) and projected waste (radionuclide activity and volume for each category of waste from January 1, 2019, to December 31, 2034) at the assumed closure date January 1, 2035. More descriptions are given in Section 5.3.3. Table 3-1 lists the final waste volume for each waste category in Trenches 31 and 34. The volume of Trench 94 is assumed to be expandable upon the need to dispose naval reactor compartments thereby no volume at closure is estimated. As an example, key radionuclide inventory in Trenches 31, 34, and 94 at the closure date is listed in Table 3-2. The final inventory for the total 120 radionuclides in Trenches 31 and 34, and Trench 94 is listed in Table 2-7 and Table 2-9, respectively, of the PA document (DOE/RL-2021-26).

Table 3-1. Trenches 31 and 34 Waste Volumes at Closure

Trench and Waste Category	Total Volume (m^3)
Trench 31 Category 1 waste	7,800
Trench 31 Category 3 waste	6,500
Trench 34 Category 1 waste	6,100
Trench 34 Category 3 waste	6,300

Source: Based on Table 2-4 DOE/RL-2021-26, *Performance Assessment of Active Trenches in 200 East and West Low-Level Burial Grounds at the Hanford Site*.

Note: Waste volume developed from Solid Waste Information Tracking System database is based on the volumes of containers and hence excludes the spaces used for operation, backfill, and/or grout between containers, used for encasing monoliths, as well as between layers of the emplaced wastes.

Table 3-2. Waste Inventories at Closure for Key Radionuclides in Trenches 31, 34, and 94

Source/Parameter	Tc-99	I-129	U-238
Trench 31 CAT1 inventory	8.75E-02	6.31E-04	4.28E-02
Trench 31 CAT3 inventory	1.42E+00	3.04E-03	4.01E+00
U billets inventory	1.41E+02	0.00E+00	2.74E+02
Trench 34 CAT1 inventory	6.92E-02	1.43E-04	3.03E-02
Trench 34 CAT3 inventory	1.25E+00	6.11E-03	5.81E+00
Trench 94 CAT1 inventory	2.28E-02	5.28E-06	1.70E-15
Trench 94 CAT3 inventory	7.85E-01	2.94E-03	8.63E-16

Source: Based on Table 2-7 and Table 2-9 in DOE/RL-2021-26, *Performance Assessment of Active Trenches in 200 East and West Low-Level Burial Grounds at the Hanford Site*.

Note: All values recorded in Curies.

CAT1 = Category 1

CAT3 = Category 3 and Greater Than Category 3

3.2 Closure Actions

The following section presents a two-phase approach to closure of Trenches 31 and 34. The two key elements of the approach are as follows:

- Increase the bearing capacity of trench fills (consisting of disposed waste and cover soil) to support the weight of a closure cover without excessive long-term settlement or subsidence.
- Construct engineered covers as final remedial actions over Trenches 31 and 34. Covers will be designed specifically to minimize moisture infiltration, resist natural degradation processes, minimize maintenance, and control releases of radionuclides for a period of at least 500 years after closure.

3.2.1 Interim Closure

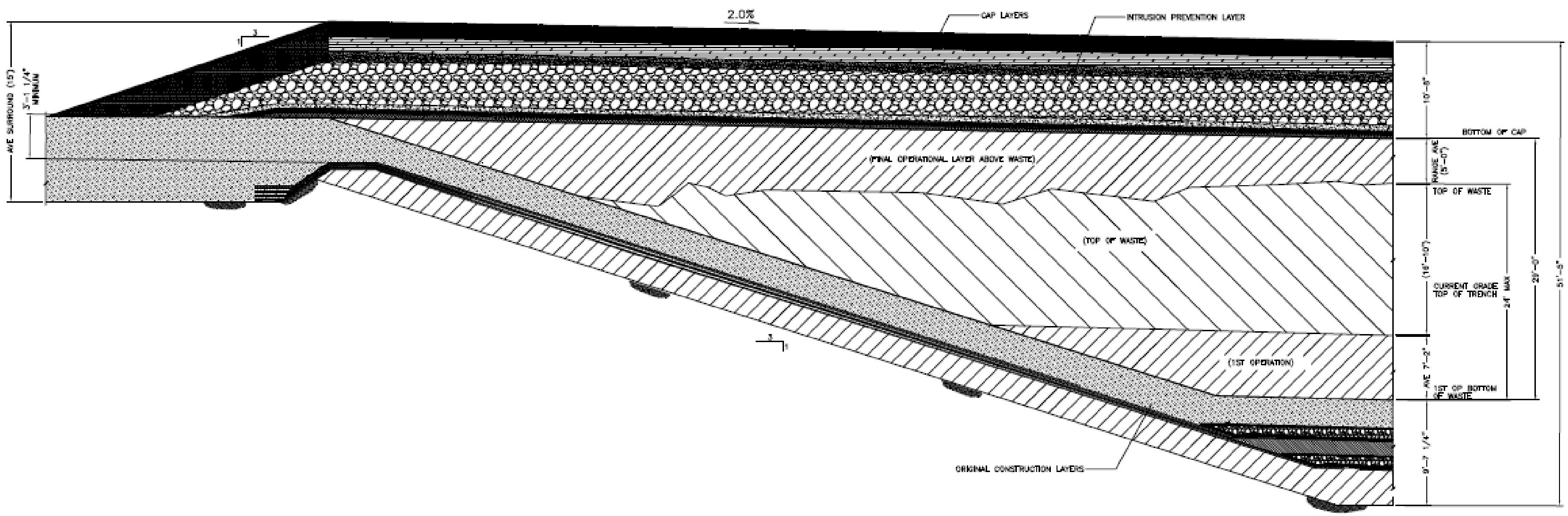
Measures will be implemented to improve the bearing capacity of trench fills during the Interim Closure period. Trench fills will be stabilized by applying a number of subgrade modification methods to compact trench fill materials, eliminate large voids (either by compaction or by void-fill grouting), and/or bond larger volumes of trench contents together by cement grouting. Subgrade modification may be performed once or several times as necessary to achieve an adequate bearing capacity value within trench fills to support the distributed weight of cover materials over the closed facility.

3.2.2 Final Closure

During the Final Closure period, engineered surface barriers will be constructed over Trenches 31 and 34. A generic conceptual cover design, which is a development of the Environmental Restoration Program at the Hanford Site, is described in this plan as the current planning basis for capping Trenches 31 and 34. The modified RCRA Subtitle C surface barrier conforms to all applicable state and Federal regulatory requirements (DOE O 435.1) for landfill closure of sites containing CAT3 LLW and hazardous/dangerous waste. This design also is assumed as the final cover treatment over Trenches 31 and 34 for evaluation of future waste management alternatives in the Hanford Site Solid (Radioactive and Hazardous) Waste Environmental Impact Statement (SW-EIS) (DOE/EIS-0286F, *Final Hanford Site Solid (Radioactive and Hazardous) Waste Program Environmental Impact Statement, Richland, Benton County, Washington*).

3.2.3 Cover Design

The plans for closure of Trenches 31, 34, and 94 summarized in DOE/RL-2015-74 include the use of a modified RCRA Subtitle C surface barrier closure cap. The barrier is designed to act as a barrier to intrusion and provide hydrologic protection and containment for a performance period of 500 years. The specific choice of barrier materials, barrier thickness, and degree of capping barrier slope will be tailored to the function and performance requirements for these uppermost layers as the design of the surface cap progresses. Figure 3-1 shows the initial choice of barrier materials, barrier thickness, and degree of capping barrier slope for the active trenches. Table 3-3 provides a summary of the design criteria.



Source: Figure 2-59 in DOE/RL-2021-26, *Performance Assessment of Active Trenches in 200 East and West Low-Level Burial Grounds at the Hanford Site*.

Figure 3-1. General Depiction of Liner, Operational Layers, and Modified RCRA Subtitle C Cap for Trench 31 in 200 West Area Low-Level Burial Grounds

Table 3-3. Summary of Design Criteria for the Hanford Modified RCRA Subtitle C Surface Barrier

No.	Summary
1	Minimize moisture infiltration through the cover.
2	Design a multilayer cover of materials that are resistant to natural degradation processes.
3	Design a durable cover that needs minimal maintenance during its design life.
4	Design a cover with a functional life of 500 years.
5	Prevent plants from accessing and mobilizing contamination (i.e., prevent root penetration into the waste zone).
6	Prevent burrowing animals from accessing and mobilizing contamination.
7	Ensure that the top of the waste is at least 5 m (16 ft) below final grade or include appropriate design provisions to limit inadvertent human intrusion.
8	Facilitate drainage and minimize surface erosion by wind and water.
9	Design the low-permeability layer of the cover to have a permeability less than or equal to any natural subsoil present.
10	Design the cover to prevent the migration and accumulation of topsoil material within the lateral drainage layer (i.e., clogging of the lateral drainage layer).
11	For frost protection, the lateral drainage layer and the low-permeability asphalt layer must be located at least 0.76 m (2.5 ft) below final grade.

Source: Table 2-5 in DOE/RL-93-33, *Focused Feasibility Study of Engineered Barriers for Waste Management Units in the 200 Areas*.

The modified RCRA Subtitle C surface barrier design will be effective in controlling releases of radionuclides from the trenches after closure. The barrier will control releases of radionuclides by (1) minimizing infiltration of precipitation into and through disposed waste, (2) preventing bio-intrusion into buried waste, and (3) minimizing adverse consequences of inadvertent human intrusion in the future if there is a loss of active institutional control. The proposed cover system is designed to eliminate virtually all moisture infiltration by evapotranspiration (ET). Bio-intrusion will be prevented by incorporation of a low-permeability layer that cannot be penetrated by plant roots or burrowing animals. Buried waste will be covered with at least 5 m (16.7 ft) of layered soil, rock, and asphaltic materials. The overall thickness of material and the low-permeability layer will effectively isolate buried waste from inadvertent intrusion.

The cover design incorporates two independent strategies for elimination of soil moisture. The design includes a two-layer topsoil treatment. Compaction of the lower topsoil layer and a capillary barrier at the interface between the topsoil and underlying materials will retard moisture migration through the topsoil, increasing the time available for removal of moisture by ET. The thickness of the two topsoil layers is designed to support a healthy stand of perennial vegetation. Moisture that infiltrates through the topsoil system will be eliminated by lateral drainage.

The modified RCRA Subtitle C surface barrier system will be constructed of durable materials and includes design features that will minimize susceptibility to erosion of the topsoil surface. The upper topsoil layer includes a pea gravel admix treatment that will limit erosion by forming a surface armoring layer during any extended periods of wind erosion. The cover surface will be sloped at a minimum of 2%, which is sufficient to induce runoff during severe storm events, but low enough to limit susceptibility to erosion by wind. Established cover vegetation, consisting of a mix of perennial grass species, should limit topsoil losses to an acceptably low value. In combination, these strategies should enable the cover to remain functional with minimum active maintenance for a performance period of at least 500 years.

The design is tailored to the Hanford Site's semiarid climate conditions and the local availability of suitable construction materials. The capillary barrier feature, the compacted topsoil layer, and the selection of perennial grasses as cover vegetation are all treatments designed to maintain successful vegetative cover at a semiarid site. The pea gravel admix treatment, low surface slope, and cultivation of vegetative cover are designed to minimize soil losses from wind erosion (Table 2-5 in DOE/RL-93-33).

3.3 Measures for Long-Term Stability

Water and wind erosion can impact the integrity of a surface cover. The low precipitation, the low intensity of precipitation events, the absence of surface run-on features at the Hanford Site, and stability monitoring of the Hanford Prototype Barrier (PHB) (PNNL-18845, *200-BP-1 Prototype Hanford Barrier – 15 Years of Performance Monitoring*) all support the assumption that water erosion will not be a significant factor for the planned covers for Trenches 31 and 34. The engineered cover system surface will be seeded and fertilized to promote plant growth. Vegetation will minimize erosion and accelerate removal of water from the water storage layer through transpiration. The vegetation will consist of local plant species based on vegetation studies performed for Hanford Site disturbed areas.

Leachate collected from the sumps of the leachate collection and recovery system (LCRS) will be removed and treated throughout the operational period. At the end of the operational period, and for a period of 30 years postclosure, the leachate collection system will continue to be monitored and maintained as required by WAC 173-303-610(7), "Closure and Post-Closure."

Following the recommendations in DOE-0431, *Recommendations for Institutional Control Time Period for Conducting DOE Order 435.1 Performance Assessments at the Hanford Site*, the institutional control period used for purposes of excluding inadvertent human intrusion into Trenches 31 and 34 is assumed to extend to CY 2278. This assumption is based on the longest institutional control period identified in existing CERCLA and RCRA decision documents, and the latest version of DOE/RL-2001-41, *Sitewide Institutional Controls Plan for Hanford CERCLA Response Actions and RCRA Corrective Actions*.

4 Summary of Key Assumptions

The projected performance of the natural and engineered features of Trenches 31, 34, and 94 is dependent on the representativeness of the conceptual models, numerical models, and parameter values used to evaluate the release and subsequent transport of radionuclides from the waste forms and trenches. It is therefore important to identify the key assumptions associated with model and parameter uncertainties and associated data gaps. Those aspects of the system typically become the focus of the sensitivity/ uncertainty analysis and are relevant to trench closure. Although dose during the 1,000-year compliance period is principally affected by the atmospheric release pathway, the dose resulting from that pathway is very low, as noted in Chapters 5, 6, and 8 of the PA document (DOE/RL-2021-26). Dose resulting from the groundwater exposure pathway occurs outside the 1,000-year compliance period (Chapter 8 of DOE/RL-2021-26). A thorough review of Trench 31 and 34 PA assumptions is presented in the PA maintenance plan (DOE/RL-2021-38). In this section, the focus is the connection between the PA assumptions and the closure plan. Other key assumptions related to closure are also discussed.

4.1 Key PA Assumptions

This section first reviews the key PA assumptions listed in the PA document (Section 1.8 in DOE/RL-2021-26). This is followed by the mapping of these assumptions with the closure plan.

4.1.1 Key Assumptions Related to the Active Trenches at Closure

The assumptions associated with the Trenches 31 and 34 at closure affect both the air and groundwater pathways. The following assumptions involve the physical conditions and circumstances of the trenches, and the contaminant inventory within the trenches at closure.

- Trenches 31 and 34 are assumed to be filled to their design capacity and facility closure is assumed to occur in the year 2035 for the purpose of analysis. Trench 94 is assumed to complete disposing future Navy reactor components in the year 2035.

- A modified RCRA Subtitle C surface barrier is assumed to be constructed at closure (DOE/RL-93-33). The design will, at a minimum, comply with applicable RCRA requirements found at 40 CFR 264, “Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities,” Subpart N, “Landfills.” The surface barrier will be designed to retain moisture and promote ET. The upper surface of the soil cover will be composed of an admixture of silt and gravels to enhance resistance of the cover to burrowing animals and long-term wind erosion. The barrier is assumed to provide containment and long-term hydrologic protection for a period of at least 500 years. The revegetation of the surrounding area is assumed to restore shrub-steppe after closure and exert the same control on recharge as a vegetated natural soil surface.

  The thickness of the modified RCRA Subtitle C surface barrier will ensure that the top of the waste is at least 5 m (16.4 ft) belowgrade, as indicated in CP-ENG-0020, *Functional Requirements Document and Conceptual Design for Trench 31 and 34, Modified RCRA Subtitle C, Cap Cover* and DOE/RL-93-33. This depth is sufficient to exclude from the analysis the ecological receptor pathway, according to WAC 173-340-7490, “Model Toxics Control Act—Cleanup,” “Terrestrial Ecological Evaluation Procedures,” and DOE/RL-2019-46, *Central Plateau Inner Area Cleanup Principles and Parameters*, and the inadvertent human intrusion excavation pathway, according to WAC 173-340-740(6)(d), “Unrestricted Land Use Soil Cleanup Standards,” and DOE/RL-2019-46.

- The compaction of waste in the trenches must be sufficient to ensure that any long-term differential settlement under the load of surface barrier is within the design criteria of the surface barrier. The waste disposed in the trenches will be compacted to minimize settlement to meet the compaction acceptance criteria for the trenches.
- The double-leachate liners and collection and removal system are assumed to be extant during the entire operational period and for the first 100 years postclosure, during which time leachate is removed to prevent buildup on the liners.
- The postclosure exposure scenarios assume that no residents live on top of the trenches, and a resident groundwater receptor will have to be at least 100 m (328 ft) downgradient from the facility.
- A combination of land-use restrictions, institutional controls, and active and passive barriers will be placed on and around the trenches and their adjacent buffer zone to deter inadvertent intrusion for at least 243 years (DOE-0431) after closure (i.e., CY 2278 [= 2035 + 243]).

4.1.2 Key Assumptions Related to the Air Exposure Pathway

The key assumptions associated with the air exposure pathway include the following:

- For purposes of calculating the release of gaseous radionuclides to the surface, it has been assumed that the containers are not air-tight, and release of gaseous radionuclides can occur immediately on closure of the facility.
- All radon produced is conservatively assumed to be available for gaseous transport (an emanation factor of unity).

4.1.3 Key Assumptions Related to the Groundwater Exposure Pathway

The key assumptions associated with the groundwater exposure pathway may be broadly classified as those that affect the following subsystems or safety functions:

- The estimated inventory at closure
- Radionuclide release from the engineered waste forms and from the engineered facility
- Net infiltration through the engineered cover and surrounding environments
- Radionuclide transport through the vadose zone
- Radionuclide transport in the saturated zone
- Model domain and boundary conditions

Among the above-listed aspects, the key assumption related to the net infiltration through the engineered cover is relevant to this closure plan, to be repeated below (from Section 1.8.3.2 in DOE/RL-2021-26):

> The engineered cover for the trenches in the burial grounds is not yet designed but is assumed to be similar in design to the modified RCRA Subtitle C surface barrier described in DOE/RL-93-33 that limits infiltration through the waste primarily by ET processes. These ET processes are not modeled directly. The estimated net infiltration is applied to the area under the engineered cover and is varied temporally as appropriate according to the estimated or assumed time-dependent performance of a surface barrier.
>
> Net infiltration through and around the margins of the surface barrier are expected to change with time, although the performance and effectiveness of the engineered surface barrier may remain unchanged indefinitely into the future (PNNL-14744, *Recharge Data*

Package for the 2005 Integrated Disposal Facility Performance Assessment). Net infiltration rates outside the ET barrier vary spatially and temporally according to the assumptions made regarding the impacts of apparent surface disturbances, and the effectiveness of future surface revegetation.

4.1.4 Mapping between PA Assumptions and Closure Actions

The key assumptions related to the final closure can be mapped as shown in Table 4-1.

Table 4-1. Mapping of Final Closure Activities with Key PA Assumptions

ID*	Final Closure Activity	Key PA Assumption
1	Limit the net infiltration rate to no more than 0.1 cm/yr for a period of at least 500 years after closure.	The net infiltration rate is 0.5 mm/yr for the first 500 years after closure.
2	Retain moisture and encourage evapotranspiration, maintaining the average recharge through the surface barrier to less than 0.5 mm/yr for 500 years under reasonably expected natural conditions	The net infiltration rate is 0.5 mm/yr for the first 500 years after closure.
3	Provide a physical barrier against intrusion	Protection of inadvertent intruders may be accomplished through active and passive barriers (institutional control, disposal depth, control of waste concentration, and intruder barrier).
4	Include armoring on the sides to prevent wind and rain erosion	The upper surface of the soil cover will be composed of an admixture of silt and gravels to enhance resistance of the cover to burrowing animals and long-term wind erosion.
5	Configure to divert surface water away from the vaults and extend beyond the boundary of the facility.	The cover surface will be sloped at minimum 2%, which is sufficient to induce runoff during severe storm events, but low enough to limit susceptibility to erosion by wind.
6	Provide the surface barrier so that the top of the waste is at least 5 m below the top of the surface barrier.	The cover is assumed to be 5 m

*Identification number for the key assumptions.

4.2 Land Use and Institutional Control Assumptions

For nearer term land-use planning, the ROD (64 FR 61615, *Record of Decision: Hanford Comprehensive Land Use Plan Environmental Impact Statement [HCP EIS]*) for DOE/EIS-0222-F, *Final Hanford Comprehensive Land-Use Plan Environmental Impact Statement*, identifies near-term land uses for the Hanford Site. The ROD prescribes the use in the 200 Areas as exclusively industrial (primarily waste management) with much of the surrounding land having the use of preservation or conservation. Despite the Industrial Exclusive designation of the Central Plateau, including the area encompassed by the LLBGs, the assumption under issued DOE-0431, is that control of the site and institutional records (e.g., deed restrictions) associated with its designation as Industrial Exclusive are not implemented

243 years after assumed facility closure (CY 2278). These assumptions do not represent an administrative intention by DOE to release the site from its Industrial Exclusive designation but are only assumptions made as a basis for PA evaluations conducted under DOE O 435.1. For more details on future land use, see Section 2.1 of the PA document (DOE/RL-2021-26).

4.3 Key Schedule Assumptions

Schedule information presented in Chapter 6 of this closure plan relies on the following assumptions:

- Availability of contractors and equipment for subgrade modification is currently limited, because of the specialty nature of the work and limited demand for these services. It is envisioned that this constraint will continue into the future. Therefore, it is assumed that only one burial ground will undergo subgrade modification at any given time.
- Aside from the constraint on subgrade modification, there will be no other constraints on labor, equipment, or materials. For scheduling purposes, it has been assumed that Trenches 31, 34, and 94 will proceed from Interim Closure, Final Closure, and Institutional Control without schedule gaps. Schedule delays could occur in conjunction with facility transition.

5 Disposal Facility Summary

The description of the disposal facility includes the relevant site characteristics that could affect closure, the facility characteristics, and the waste characteristics. The site characteristics are summarized in Section 5.1. The facility characteristics are summarized in Section 5.2 and emphasize those features important for the long-term performance of the disposal system, including a detailed description of the cover barrier selected for Trenches 31 and 34. Section 5.3 describes the waste characteristics and provides information on the different waste form types, container designs, and the volumes and radionuclide inventory.

5.1 Summary of Site Characteristics

This section presents information on the relevant natural and demographic characteristics and data for the area near Trenches 31, 34, and 94. Additional information on site characteristics can be found in the Chapter 2 of the PA document (DOE/RL-2021-26) and data packages and related reports associated with it. The following sections provide synopsis description of the disposal site, along with the geography and demography, surface water, climatological, geological, and geographical conditions of the 200 Area Plateau.

5.1.1 Geography and Demography

The 200 Area LLBGs are located on the Hanford Site in south-central Washington State (Figure 1-1). The Hanford Site is an area of approximately 1,517 km^2 (approximately 586 mi^2) in Benton, Franklin, and Grant counties, located within the semi-arid Pasco Basin of the Columbia Plateau. The Hanford Central Plateau is approximately 198 to 229 m (649 to 751 ft) above mean sea level. The major features of regional geography are the nearby rivers (Columbia and Yakima) and mountains (Saddle Mountains and Umtanum to the north, Cascade Mountains to the west, Yakima Ridge to the southwest, and Rattlesnake Ridge to the south). The Columbia River, which forms the eastern boundary of the developed areas of the Hanford Site, is an important source of water and hydroelectric power for the region. Other important rivers near the Hanford Site are the Yakima River to the southwest and the Snake River to the east. The Cascade Mountains, which are about 160 km (100 mi) to the west, have an important influence on the climate of the area because of their rain shadow, which includes the Hanford Site.

Except for a few natural basalt hills (e.g., Gable Butte and Gable Mountain), the central area of the Hanford Site is relatively flat, with a topographic low at the Columbia River (about 100 to 120 m [300 to 390 ft] above sea level) and a gradual increase in elevation toward the north-central part of the site. The 200 Area LLBGs are located in this region (Figure 5-1), commonly referred to as the 200 Area Plateau. The elevation of the burial grounds is about 225 m (738 ft).

The nearest population center consists of three small cities (Richland, Kennewick, and Pasco, referred to as the Tri-Cities) that are situated to the southeast of the site on the Columbia River. The population living within 80 km (50 mi) of the burial grounds is about 375,000 (WHC-SD-WM-EE-004, *Performance Assessment of Grouted Double-Shell Tank Waste Disposal at Hanford*).

The land use around the Hanford Site varies from urban to rural. Most of the land south of the site is urban, including the Tri-Cities, while much of the land to the north and east is irrigated cropland. Most of the irrigation water comes from the Bureau of Reclamation's Columbia Basin Project, which uses the water behind Grand Coulee Dam as the primary water source. The land to the west of the Hanford Site is used for irrigated agriculture near the Yakima River and dryland farming at the higher elevations.

Although DOE activities, agriculture, and food processing are the dominant industries, there has been a substantial rise in the number of visitors to the Tri-Cities over the last several years, resulting in tourism playing an increasing role in helping to diversify and stabilize the area's economy. Overall tourism expenditures for 2011 were $393 million, up from $299 million in 2005. The socioeconomics of the area surrounding the Hanford Site are more fully described in Section 4.7 of PNNL-6415, *Hanford Site National Environmental Policy Act (NEPA) Characterization*.

5.1.2 Climate and Meteorology

Average annual precipitation at the Hanford Meteorological Station (HMS) is 18.1 cm (7.1 in.) (Table 2-1 in DOE/RL-2021-26). During 1995, the wettest year on record, 31.2 cm (12.3 in.) of precipitation was measured; during 1976, the driest year, only 7.6 cm (3 in.) was measured. The wettest season on record was the winter of 1996-1997 with 14.1 cm (5.6 in.) of precipitation; the driest season was the summer of 1973, when only 0.1 cm (0.04 in.) of precipitation was measured. Most precipitation occurs during the late autumn and winter, with more than half of the annual amount occurring from November through February. Days with greater than 1.3 cm (0.51 in.) precipitation occur on average less than once each year.

Average snowfall ranges from 0.25 cm (0.1 in.) during October to a maximum of 13.2 cm (5.2 in.) during December and decreases to 1.3 cm (0.5 in.) during March. The record monthly snowfall of 59.4 cm (23.4 in.) occurred during January 1950. The seasonal record snowfall of 142.5 cm (56.1 in.) occurred during the winter of 1992-1993. Snowfall accounts for about 38% of all precipitation from December through February.

Concerns about severe weather usually center on hurricanes, tornadoes, and thunderstorms. Fortunately, hurricanes do not reach the interior of the Pacific Northwest. The estimated probability of a tornado striking a point at the Hanford Site is 9.6×10^{-6}/yr (Section 2.1 in DOE/RL-2021-26). Severe winds are associated with thunderstorms or the passage of strong cold fronts.

5.1.3 Hydrogeology

The detailed regional geology and hydrogeology and in vicinity of Trenches 31, 34, and 94 have been provided in Section 2.1 of the PA document (DOE/RL-2021-26) that will not be repeated in this document. The geological settings of the trenches are briefly summarized. This is followed by the summary of recharge and surface water hydrology that is more closely related to the cover design.

5.1.3.1 Trenches 31 and 34

The geology of the vadose zone underlying Trenches 31 and 34 forms the media through which the contaminants move and provides the basis with which to interpret and assign the physical and geochemical properties that control the migration and distribution of contaminants. Of interest are the interrelationships between the coarser and fine-grained sediments, and the degree of contrast in their physical, hydraulic, and geochemical properties. While the exact distribution of these alternating units is not known, the contrast between them appears to have a strong influence on the moisture content and contaminant transport. For example, the Cold Creek fine-textured (silty) sediments have a higher moisture holding capacity than the relatively coarse-textured Hanford formation sediments; the fine-textured sediments typically tend to have a lower saturated hydraulic conductivity than the coarse-textured sediments.

Source: Figure 2-1 in DOE/RL-2021-26, *Performance Assessment of Active Trenches in 200 East and West Low-Level Burial Grounds at the Hanford Site*.

Figure 5-1. Location Map for Hanford Site 200 Area

The geological setting information presented here is a summary and synopsis of the information presented in Chapter 3 of LLBG Natural System Data Package (CP-63758, *Natural System Data Package for the Active Trenches of the Low-Level Burial Grounds, Hanford Site, Washington*). The vadose zone is approximately 77 m (252 ft) thick, and there are approximately 66 m (216 ft) between the base of Trenches 31 and 34 and the present-day water table. The trenches lie within the Hanford formation unit 2. Between the water table and ground surface, this area of the Hanford Site has the following hydrostratigraphic units (HSUs) (from bottom to top):

- Ringold Formation member of Wooded Island – unit E
- Ringold Formation member of Taylor Flat
- Cold Creek unit caliche
- Cold Creek unit silt
- H formation unit 2, subdivided into sand-dominated lithofacies (Hanford formation units B and D)
- Hanford formation unit 1, subdivided into gravel-dominated lithofacies (Hanford formation units A and C)
- Eolian sediments

The water table is situated in the Ringold Formation member of Wooded Island – unit E.

5.1.3.2 Trench 94

Again, the geological setting information presented here is a summary and synopsis of the information presented in Chapter 3 of the LLBG Natural System Data Package (CP-63758). Currently, no unconfined aquifer exists beneath Trench 94. As indicated in Chapter 3, Trench 94 has the following HSUs (from bottom to top):

- Hanford formation unit 3
- Hanford formation unit 2
- Hanford formation unit 1

Based on borehole 299-E34-7 (CP-63758), the Trench 94 vadose zone is approximately 62.5 m (205 ft) thick to top of the basalt. For a 16.4 m (53.8 ft) high naval reactor compartment, the thickness of the vadose zone below the reactor is approximately 46.1 m (151.2 ft).

5.1.3.3 Surface Water Hydrology

Surface water at the Hanford Site 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 along a short section of the southern boundary of the Hanford Site (Figure 5-2), and there is surface water associated with irrigation east and north of the site.

The Columbia River is the dominant surface-water body on the Hanford Site. The river flows through the northern part and along the eastern border of the Hanford Site with these areas of the Hanford Site draining into the Columbia River. Except for the Columbia River estuary, the only un-impounded stretch of the river in the United States is the Hanford Reach, which extends from Priest Rapids Dam (located upstream of the Site) downstream approximately 82 km (51 mi) to the northern upstream extent of Lake Wallula (formed by McNary Dam), which begins above Richland. The Hanford Reach of the Columbia River was recently incorporated into the land area established as the Hanford Reach National Monument. Flows in the Hanford Reach are directly affected by releases from Priest Rapids Dam; however, Priest Rapids operates as a run-of-the-river dam rather than a storage dam. Flows are controlled to generate power and promote salmon egg and embryo survival. Several drains and intakes are also present along the Hanford Reach, including irrigation outfalls from the Columbia Basin Irrigation Project, intakes at the Columbia Generating Station operated by Energy Northwest, and Hanford Site intakes for onsite water use.

The Yakima River, which follows a small length of the southwest boundary of the Hanford Site, has much lower flows than the Columbia River. The Yakima River System drains surface runoff from approximately one-third of the Hanford Site. Contaminant plumes in groundwater that originate from the Hanford Site do not reach the Yakima River and, because the elevation of the river surface is higher than the adjacent water table (based on well water-level measurements), groundwater is expected to flow from the Yakima River into the aquifer underlying the site rather than from the aquifer into the river.

The probable maximum flood for the Columbia River downstream of Priest Rapids Dam has been calculated to be 40,000 m^3/s (1.4 million ft^3/s) (Figure 5-3) and is greater than the 500-year flood. This flood would inundate parts of the 100 Area adjacent to the Columbia River, but the central portion of the Hanford Site would remain unaffected [DOE/RW-0070, *Nuclear Waste Policy Act (Section 112), Environmental Assessment, Reference Repository Location, Hanford Site, Washington*]. The U.S. Army Corps of Engineers has derived the Standard Project Flood with both regulated and unregulated peak discharges given for the Columbia River downstream of Priest Rapids Dam (USACE, 1989, *Water Control Manual for McNary Lock and Dam, Columbia River, Oregon and Washington*). The regulated Standard Project Flood for this part of the river is given as 15,200 m^3/s (536,800 ft^3/s) and the 100-year regulated flood is given as 12,400 m^3/s (438,000 ft^3/s). Impacts to the Hanford Site are negligible and would be less than the probable maximum flood.

The Treated Effluent Disposal Facility (TEDF) in the 200 Areas consists of two disposal ponds. These ponds are each 0.02 km^2 (0.008 mi^2) in size and receive industrial wastewater permitted in accordance with WAC 173-216, "State Waste Discharge Permit Program." The wastewater percolates into the ground from the disposal ponds. Disposal ponds (i.e., 200 Area TEDF) have an artificial influence on net contributions to the water table. The disposal activities within the 200 Areas are not expected to exist after current operations end, so their long-term influence is not considered in this PA for Trenches 31, 34, and 94.

5.1.3.4 Recharge

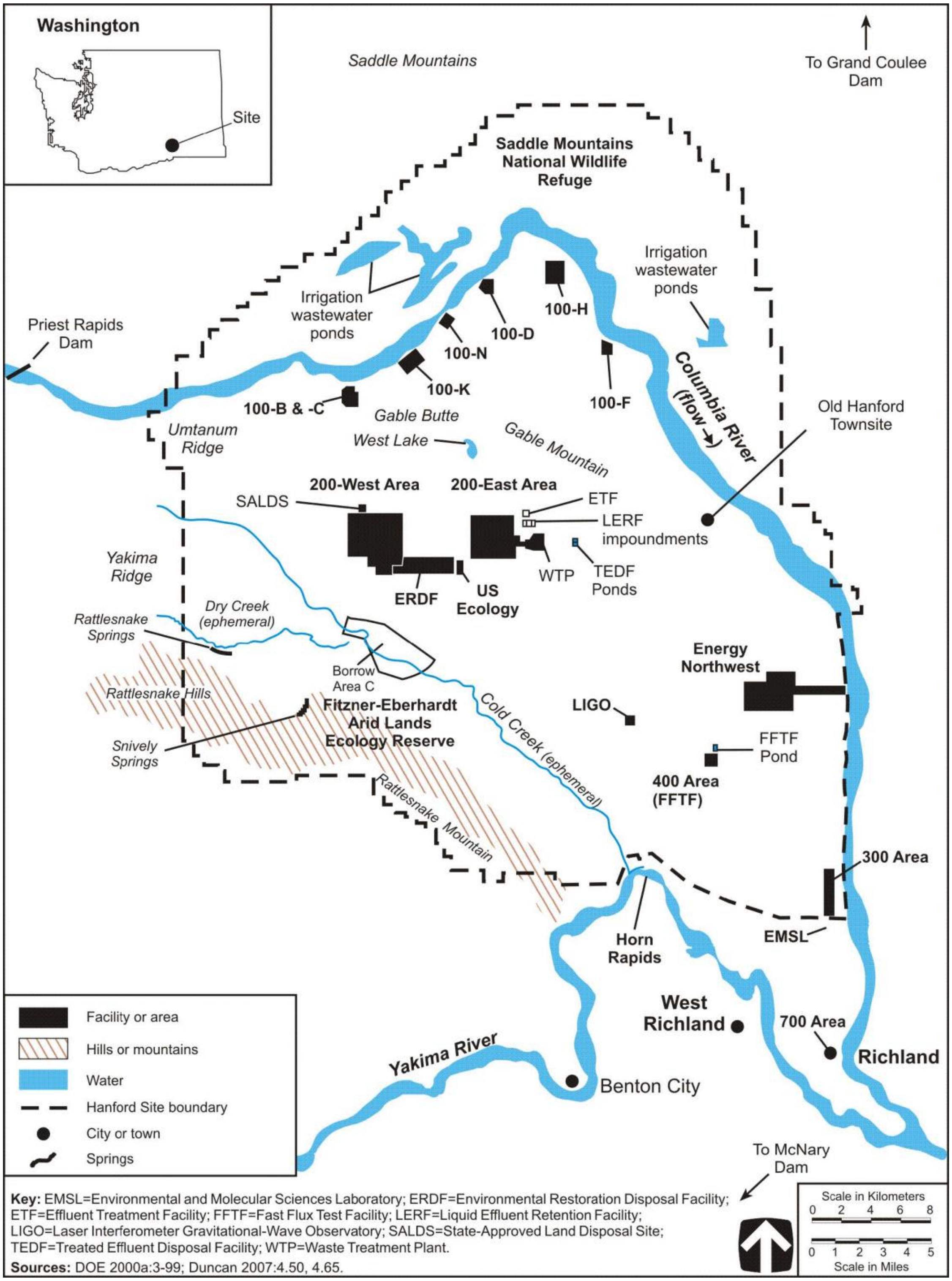
Two types of recharges, natural and anthropogenic, occur at the Hanford Site. Anthropogenic recharge occurs due to water and/or liquids applied to the surface and/or subsurface by human activities. Examples of anthropogenic recharge include intentional releases of waters and/or wastes into ponds, ditches, and/or cribs; the uncontrolled release of water from testing of fire hydrants; the use of water to wash down, excavate, and/or decontaminate equipment or facilities; the collection of water in low-lying areas with improper drainage control (i.e., ponding of snow melt or precipitation in tank farm areas); water recharge down man-made preferential pathways (i.e., unsealed wells or boreholes); or the unintentional or unplanned loss of waters and/or waste fluids or liquids from tanks and/or water and waste transfer pipelines.

Natural recharge occurs as the result of water from rain, snow, and other sources moves downward through the soil and the underlying vadose zone and reaches the top of the groundwater aquifer. Total estimated precipitation over the Pasco Basin is approximately 9×10^8 m^3 (approximately 3.2×10^{10} ft^3) annually (DOE/RW-0164, *Site Characterization Plan: Reference Repository Location*). This was calculated by multiplying the average annual precipitation averaged over the Pasco Basin by the 4,900 km^2 (1,900 mi^2) basin area. Precipitation varies both spatially and temporally with higher amounts generally falling at higher elevations. Annual precipitation measured at the HMS has varied from

6.8 to 31.3 cm (2.7 to 12.3 in.) since 1945. Most precipitation occurs during the late autumn and winter, with more than half of the annual amount occurring from November through February. Mean annual runoff from the Pasco Basin is estimated at less than 3.1×10^{7} m^3/yr (less than 1.1×10^{9} ft^3/yr), or approximately 3% of the total precipitation (DOE/RW-0164). Most of the remaining precipitation is lost through ET. Some precipitation that infiltrates the soil is not lost to evaporation or transpiration and eventually flows through the vadose zone and recharges the groundwater flow system.

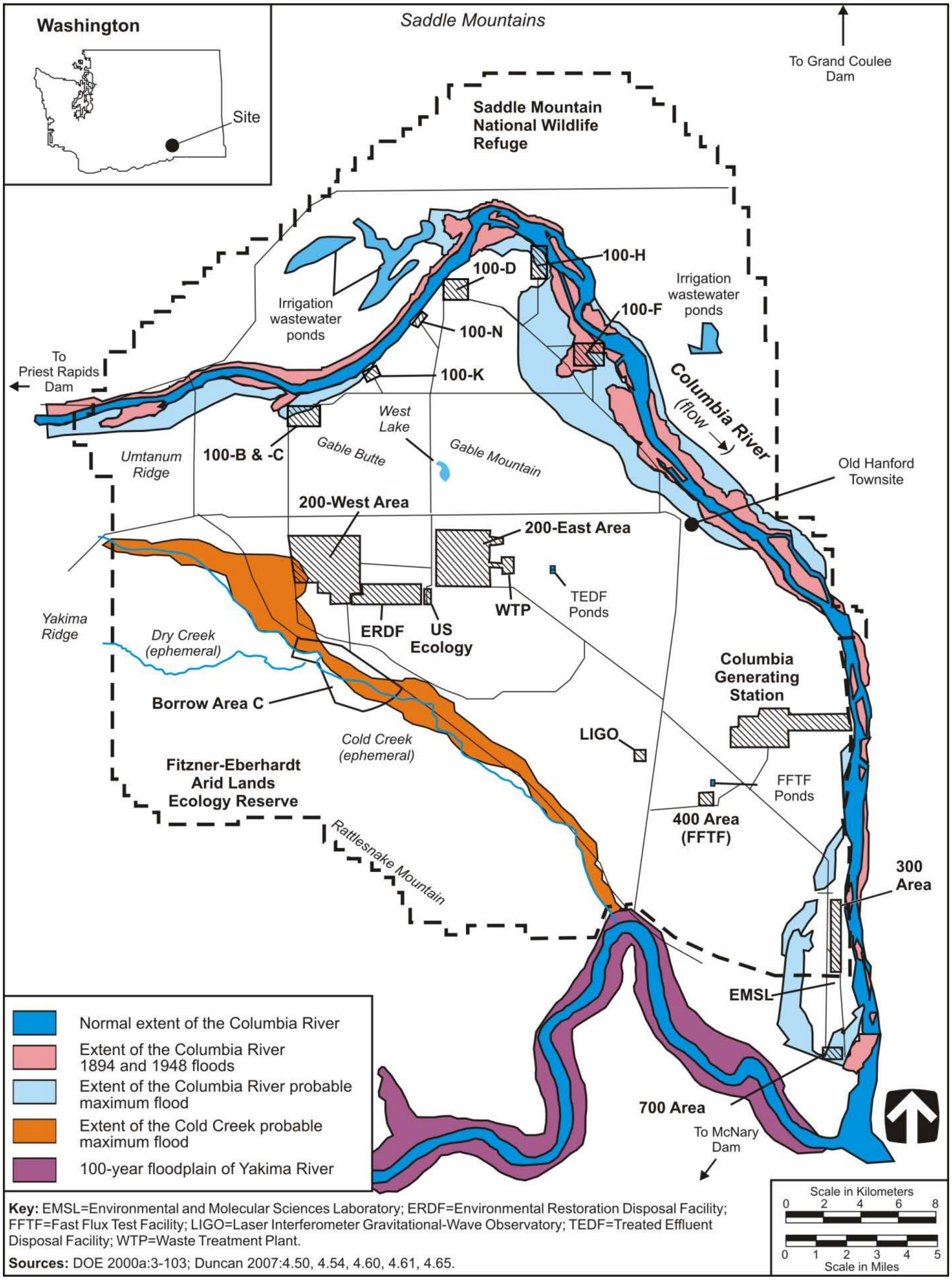
Trenches 31 and 34, as well as most of the nearby burial grounds, occupy land previously covered by vegetated Rupert sand. Estimates of net infiltration in vegetated Rupert sand range between 0.26 mm/yr measured at the 200 East deep well and 4 mm/yr measured in a borehole near the Wye Barricade (about 11 km [7 mi] southeast of the 200 East Area) (PNNL-16688, *Recharge Data Package for Hanford Single-Shell Tank Waste Management Areas*). Vegetation at the Wye Barricade site consisted predominantly of cheatgrass and Sandberg's bluegrass, with a sparse cover of gray rabbitbrush and sagebrush, and may have been affected by past range fires (PNNL-16688). PNNL-16688 recommends using the value of 1.7 mm/yr to estimate the net infiltration occurring in areas occupied by vegetated Rupert sand. PNNL-14725, *Geographic and Operational Site Parameters List [GOSPL] for Hanford Assessments*, indicates that best estimate of net infiltration where Rupert sand with shrub -steppe plant community exists outside of 200 East Area is 4 mm/yr. The TC & WM EIS (DOE/EIS-0391) analysis indicates that the net infiltration rate everywhere across the Hanford Site is 3.5 mm/yr prior to the onset of Hanford construction and operations. For Trench 31 and 34 PA, the net infiltration rate prior to the onset of burial ground construction and operation is estimated to be 3.5 mm/yr.

Trench 94, as part of the 218-E-12B Burial Grounds, occupies land previously covered by vegetated Rupert sand or Burbank loamy sand. PNNL-16688 recommends using the value of 1.9 mm/yr to estimate the net infiltration occurring in areas occupied by vegetated Burbank loamy sand. The value is based on eight tracer-based estimates from three distinct areas. To determine the recommended value, PNNL-16688 indicates that there was essentially no difference between the average values when the eight estimates were averaged together, or when the estimates from the distinct areas were first grouped into single values, and then the three distinct area values were averaged. For Trenches 31, 34, and 94 PA, the net infiltration rate prior to the onset of burial ground construction and operation is estimated to be 3.5 mm/yr instead of 1.9 mm/yr to be consistent with the natural background recharge rate representing the composite population for natural vegetated conditions accepted at the Hanford Site.



Source: Figure 3-10 in DOE/EIS-0391, *Final Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington*. Same as Figure 2-42 in DOE/RL-2021-26, *Performance Assessment of Active Trenches in 200 East and West Low-Level Burial Grounds at the Hanford Site*.

Figure 5-2. Surface Water Features on the Hanford Site, Washington



Source: Figure 3-11 in DOE/EIS-0391, *Final Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington*. Same as Figure 2-43 in DOE/RL-2021-26, *Performance Assessment of Active Trenches in 200 East and West Low-Level Burial Grounds at the Hanford Site*.

Figure 5-3. Probable Maximum Flood Area in Hanford Site

5.2 Characteristics of Trenches 31, 34, and 94

Trenches 31 and 34 are lined trenches, with a primary and secondary liner system, while Trench 94 is an unlined trench that receives naval reactor compartments. Figure 1-1 shows the Hanford Site boundaries and the location of active trenches 31 and 34 of the 218-W-5 Burial Ground in the 200 West Area LLBGs and Trench 94 of the 218-E-12B Burial Ground in the 200 East Area LLBGs. Figure 5-1 provides a location map for the facilities around the 200 West Area LLBGs. Figure 2-1 and Figure 2-3 provide site maps showing the specific waste trench configuration for the 200 West Area LLBGs, including active Trenches 31 and 34. Figure 2-2 and Figure 2-4 provide site maps showing the specific waste trench configuration for the 200 East Area LLBGs, including active Trench 94. Design drawings with boundaries for the trenches are provided in Section 2.2 of Trench 31, 34, and 94 PA document (DOE/RL-2021-26).

5.2.1 Trenches 31 and 34 Leachate Collection and Removal Systems

As described in Addendum C, Section C4.4 of DOE/RL-2015-74, the purpose of the LCRS is to provide sufficient permeability and storage volume to collect, retain, and dispose, in a timely manner, fluids falling on or moving through the waste. The LCRS includes the piping required to move leachate to a storage unit. The primary LCRS provides the preferential path along which the leachate flows into the primary LCRS sump. The secondary LCRS (also called the leak detection system) is located between the primary and secondary geomembranes and provides the preferential path along which any fluids leaking through the primary liner system flow to the secondary LCRS sump. The primary and secondary LCRSs are described in the following sections in the sequence in which liquids and leachate would flow through the liner system (i.e., from top to bottom).

5.2.2 Closure Cap

The plans for closure of Trenches 31 and 34 summarized in DOE/RL-2015-74 include the use of a modified RCRA Subtitle C surface barrier closure cap. The barrier is designed to act as a barrier to intrusion and provide hydrologic protection and containment for a performance period of 500 years. The specific choice of barrier materials, barrier thickness, and degree of capping barrier slope will be tailored to the function and performance requirements for these uppermost layers as the design of the surface cap progresses. Figure 3-1 shows the initial choice of barrier materials, barrier thickness, and degree of capping barrier slope for the active trenches. The modified RCRA Subtitle C surface barrier will be constructed over the trenches to ensure a minimum depth below the surface of at least 5 m (16.4 ft) to provide shielding from radioactive material and to deter intrusion. The cover includes a vegetated surface layer of fine-grained soils to retain moisture and encourage ET, thereby minimizing infiltration and vadose zone transport of contaminants to groundwater. The basis for cover design criteria is summarized in Table 3-3 (Table 25 in DOE/RL-93-33).

The closure cap for Trench 94 has the similar performance requirements as the Trenches 31 and 34 based on Addendum H of WA7890008967.

5.2.2.1 Erosion Protection

Water and wind erosion can impact the integrity of a surface cover. The low precipitation, the low intensity of precipitation events, the absence of surface run-on features at the Hanford Site, and stability monitoring of the PHB (PNNL-18845) all support the assumption that water erosion will not be a significant factor for the planned covers for the active trenches of the LLBGs.

Although wind erosion has been observed at the Hanford Site, primarily in exposed sandy areas, analysis of the potential effects of wind erosion presented in DOE/RL-99-11, *200-BP-1 Prototype Barrier*

Treatability Test Report indicate that the worst-case wind erosion rate would be to lose 15 cm (6 in.) of silt loam in 500 years. The analysis method was derived for agricultural soils and did not consider the benefits of the pea gravel admix. Extensive wind tunnel studies performed at the Hanford Site show that a mixture of fine-grained soil and pea gravel significantly reduced erosion due to wind forces. Soil/pea gravel armoring can reduce erosion rates from 96.5% to more than 99% at wind speeds of 72, 90, and 108 km/hr (45, 56, and 67 mi/hr) (PNL-8478, *Soil Erosion Rates Caused by Wind and Saltating Sand Stresses in a Wind Tunnel*; WHC-EP-0673, *Permanent Isolation Surface Barrier Development Plan*). With the lower reduction value (96%), the wind erosion potential would be 15 cm (6 in.) in 12,500 years. The experience at the PHB (PNNL-18845) suggests that wind erosion will be negligible within months after the barrier surface is vegetated. As a result, wind erosion of the silt loam is assumed to be insignificant for the planned vegetated, closure surface barrier.

The engineered cover system surface will be seeded and fertilized to promote plant growth. Vegetation will minimize erosion and accelerate removal of water from the water storage layer through transpiration. The vegetation will consist of local plant species based on vegetation studies performed for Hanford Site disturbed areas.

5.2.2.2 Postclosure Inadvertent Intrusion Protection

DOE/RL-93-33 included design criteria 4 and 7 listed in Table 3-3 as part of the design of the modified RCRA Subtitle C surface barrier to meet the requirements of 10 CFR 61.42, “Licensing Requirements for Land Disposal of Radioactive Waste,” “Protection of Individuals from Inadvertent Intrusion”; and 10 CFR 61.52, “Land Disposal Facility Operation and Disposal Site Closure,” for the protection of the inadvertent intruder. Additionally, to further deter the inadvertent intrusion of humans into the waste, a marker system will be used to warn future generations of the dangers of the buried waste. Permanent markers that identify the potential exposure hazards will be installed at all corner boundaries of the closed facility. The DOE is expected to maintain active control of the Hanford Site (using fences, patrols, alarms, and monitoring instruments). Site information will be provided on an Internet website, U.S. Geological Survey maps, libraries, and other information repositories that would be readily available to the public. Land-use restrictions and institutional controls will be placed on the closed active trenches and the adjacent buffer zone to permanently preclude development until unacceptable risk no longer remains at the site.

The engineered surface cover system also contains a bio-intrusion layer consisting of gravel. The function of this layer is to prevent small burrowing animals and rodents from penetrating the underlying cover components and the waste material. Barrier studies at the Hanford Site have shown that a thin layer of gravel is effective in preventing animals and rodents from penetrating underlying waste materials (WHC-EP-0673). The bio-intrusion material will consist of gravel screened from the local available alluvium at the Hanford Site. The alluvium gravels at the site are composed of granite, quartz, and other durable minerals that make it ideally suited for long-term applications.

5.3 Waste Characteristics

Trenches 31 and 34 are dedicated to the disposal of containerized LLW and MLLW from the Hanford Site and offsite generators that meet the LDR requirements of the waste acceptance criteria (WAC 173-303-140). The source of waste includes compactable and non-compactable debris and non-debris solid waste from different Hanford Site locations. The types of waste include paper, plastic, wood, concrete rubble, activated metal, and sludge. Commonly observed radionuclides in these wastes include strontium-90, cesium-137, and uranium. Lesser but significant activities of carbon-14, iodine-129, and technetium-99 are also present.

The waste characterization and categorization are used to determine the completeness of the reported radionuclide inventory and the categorization of that inventory into different waste streams and container configurations that were used in Trenches 31, 34, and 94 PA to model the release of radionuclides from the waste forms to the natural system.

Specifically, the waste must meet the waste acceptance criteria specified in HNF-EP-0063. The criteria for waste acceptance to Trenches 31 and 34 of the LLBGs include the current requirements for the radiological characterization of the waste (Section 2.5 of HNF-EP-0063), for radiological concentration limits (Section 3.4 and Appendix A of HNF-EP-0063), and radiological treatment and segregation (Section 2.6 of HNF-EP-0063).

Trenches 31 and 34 may manage any of the dangerous wastes identified in Table 2-2 of SGW-59564. The dangerous wastes managed at Trenches 31 and 34 are described, and managed, in accordance with DOE/RL-2015-74.

Trench 94 of the 200 East Area LLBGs is designed and has been used for disposal of defueled naval reactor compartments. Trench 94 was excavated in 1984 and began receiving naval reactor compartments in 1986. The naval reactor compartments disposed in Trench 94 are comprised of corrosion-resistant carbon steel (HY80) and highly corrosion-resistant stainless steel 304 or an ICONEL alloy 600. The corrosion-resistant carbon steel is used for the nuclear reactor plant and the associated bulkheads, as well as the reactor pressure vessel and tank structure. The highly corrosion resistant stainless steel or ICONEL alloy 600 are used for the reactor vessel internal structure.

This section presents descriptions and characteristics of the different waste categories and containers disposed in Trenches 31 and 34. The estimated waste volumes at closure are listed in Table 3-1. The inventory expected to be disposed at closure in Trenches 31, 34, and 94 is listed in Table 2-7 of the PA document (DOE/RL-2021-26).

5.3.1 CAT1 Waste

CAT1 waste has no stability requirement but has waste concentration limit for each radionuclide in each waste package. Mobile radionuclides are subject to additional limits. These are specified in the Waste Acceptance Criteria in HNF-EP-0063). The CAT1 waste packages are surrounded by backfill that is the excavated soil with properties similar to Hanford formation unit. The PA assumes no credit for the waste containers and that the waste properties are same as the backfill properties. The release of dissolved radionuclides from CAT1 waste is assumed by primarily advection controlled by the net infiltration rate. Release of volatile radionuclides is assumed to occur by gaseous diffusion with diffusivity proportional to the soil moisture content.

In the hypothetical inadvertent intruder scenarios, intrusion occurs at 243 years, the assumed end of institutional control.

5.3.2 CAT3 Waste

CAT3 waste must not exceed the specified waste concentration limit for each radionuclide in a waste package (HNF-EP-0063). The mobile radionuclides must also be lower than the additional limits specified in HNF-EP-0063. In addition, HNF-EP-0063 requires stability of CAT3 waste packages against intruders for at least 500 years. The stability process involves grouting of the waste and containing the grouted waste in high-integrity containers (HICs) with a prefabricated layer of concrete. The waste packages that are not stabilized within the containers are grouted together to form a monolith. The monolith is further encased with concrete blocks. There is one such encasement in Trench 31 and multiple encasements in Trench 34 (ECF-HANFORD-19-0069). Uranium billets are a special, one-time CAT3 waste encasement containing unirradiated reactor fuels and are disposed in Trench 34.

In the hypothetical inadvertent intruder scenarios, intrusion occurs at 500 years postclosure, the expected lifetime of the intruder barrier.

Most Trench 94 waste is categorized as CAT3. Since more than 10 years ago, all waste accepted in Trench 94 is categorized as CAT3.

5.3.3 Inventory and Volume Data at Closure

The waste inventory and volume data are based on the SWITS (HNF-58315) data records. For each waste package, SWITS records radionuclide activity at the acceptance date for all radionuclides in the waste package, the container dimension and weights, disposal date, waste categorization (CAT1 or CAT3 wastes), generator, profile, disposal trench, etc., starting as early as 1977. This information was used to calculate radionuclide activities and the waste volume in each category and trench for the disposed waste packages.

Using the activity and volume information from 2009 – 2018, and excluding one-time disposal packages, the average radionuclide concentration for each category and trench can be calculated. Using the total volume capacity for each trench, disposed volume, total and remaining operating floor areas, the remaining disposal volume for each category and trench was estimated. The average concentration and the remaining disposal volume were used to project future (from 2019 to the closure date assumed to be 2035) annual disposal activities and volumes.

The total inventory of a radionuclide is the sum of disposed and projected activity decayed/ingrown up to the closure date. The radionuclide activities at the closure date are listed in Section 2.3 of the PA document (DOE/RL-2021-26) for each category and trench. Because release of CAT3 waste radionuclide is dependent on the container configuration and dimension, the CAT3 waste container information in the SWITS database was analyzed, which results in a couple of container and encasement groups. The inventory fractions for each container group were estimated and are listed in Section 2.3 of the PA document (DOE/RL-2021-26).

The total waste volume at closure has been presented in Table 3-1. The currently disposed inventory derived from SWITS database and decayed/ingrown up to the closure date is given in Table 13 in ECF-HANFORD-19-0069. The forecasted inventory decayed/ingrown up to the closure date is given in Table 14 of ECF-HANFORD-19-0069. The 120-radionuclides’ activities at closure including both the currently disposed and forecasted are presented in Table 2-7 of the PA document (DOE/RL-2021-26). Additional details associated with the development of the inventory projection for the active trenches of the active trenches is presented in ECF-HANFORD-19-0069.

6 Approach to Closure

After operations are concluded at Trenches 31 and 34, they will enter into a process of closure consistent with requirements identified in DOE O 435.1 or subsequent orders or regulations. The objective of this order is to ensure that radioactive waste is managed in a manner that protects workers, public health and safety, and the environment. The documented closure approach in this chapter applies to Trenches 31 and 34. Trench 94 is currently assumed to complete the disposal at January 1, 2035, and will go through the same closure process as Trenches 31 and 34 with similar cover design.

This chapter describes the conceptual technical approach for specific activities that will be conducted to close the trenches in a manner that will meet the requirements of DOE O 435.1, DOE M 435.1-1, DOE O 458.1, *Radiation Protection of the Public and the Environment*, and applicable EPA and Washington State requirements and Nuclear Regulatory Commission guidance.

6.1 Detailed Closure Actions

During an initial period (termed Interim Closure), below ground modification methods will be applied to concentrate and stabilize waste and operational cover soil within individual trenches. These measures will be necessary to prepare each trench for construction of an engineered surface barrier, which is the anticipated final remedial action. Construction of surface barriers will occur during the Final Closure period. Information is presented in this section regarding the anticipated scope and extent of activities to be performed during Interim Closure (Section 6.3), and Final Closure (Section 6.4).

6.2 Closure Schedule and Timeframe

The source of information presented in this section is primarily from DOE/RL-2015-74. Interim Closure involves subgrade modification to stabilize the disposed waste areas to support the soil cover overburden. The interim closure should occur within two years following the completion of the last waste disposal. The final closure cover will require the placement of massive amounts of material. Construction of the final covers will be completed approximately 150 weeks (1,050 days) after the start of each closure period as shown in Table 6-1 (DOE/RL-2015-74). Due to extensive requirements inherent in the design and construction of a landfill cover, an extended closure period greater than the allowable 180 days identified in WAC 173-303-610(4)(c) is required.

Approval of this closure plan by Ecology (under WAC 173-303-610) will grant the Hanford Facility an extended closure period for construction of the final covers, and a separate extension request will not be filed. During closure periods, all steps to prevent threats to human health and the environment, including compliance with all applicable permit requirements, will be demonstrated. Closure certification will be submitted to Ecology within 60 days following completion of closure activities at Trenches 31, 34, and/or 94, as outlined in Section H-A3.8 in DOE/RL-2015-74 and Figure 6-1.

Table 6-1. Trenches 31, 34, and 94 Closure Activities

Closure Activity Description		Expected Duration
Primary Activity	**Secondary Activity**	
Monitoring of groundwater	Not applicable	Continuous
Inspections and maintenance of the leachate collection system (Trenches 31 and 34) Inspections and maintenance of the run-on/run-off* control systems	Not applicable	Continuous
Closure Activities		
General mobilization	Water sources, construction trailers, heavy equipment	4 weeks (week 4)
	Provide Ecology with 30-day notification of construction work	
Cover installation preparation	Fill voids	24 weeks (week 28)
	Prepare subgrade (filling of low areas, compacting, and regrading)	
	Excavate run-on/run-off* controls	
Modifications to the abovegrade portion of the trench	Relocate leachate monitoring system (Trenches 31 and 34 only)	26 weeks (week 54)
	Fill voids	
	Place silt	
Installation of the final cover, including vegetation	Stabilize barrier base	96 weeks (week 150)
	Construct barrier layers	
	Install vegetation	
Closure Activities Complete		
Owner/Operators and IQRPE Submit Closure Certification	In accordance with WAC 173-303-610(6), within 60 days of completion of closure of each DWMU; certification that the DWMU has been closed in accordance with the specifications in the approved closure plan (see Section H-A3.8 DOE/RL-2015-74 for more details on the closure certification)	60 days
Beginning of Postclosure Activities		

Source: Tables H-A2 and H-C2 in DOE/RL-2015-74, *Hanford Facility Dangerous Waste Part B Permit Application; Low-Level Burial Grounds Trenches 31, -34, -94, T Plant Complex, and Central Waste Complex-Waste Receiving and Processing Facility*.

Reference: WAC 173-303-610, "Dangerous Waste Regulations," "Closure and Post-Closure."

*Run-on/run-off control system is installed around the perimeter of each trench to prevent contamination to groundwater resources (Addendum I in DOE/RL-2015-74).

DWMU = dangerous waste management unit

Ecology = Washington State Department of Ecology

IQRPE = independent, qualified, registered professional engineer

6.3 Operational/Interim Closure

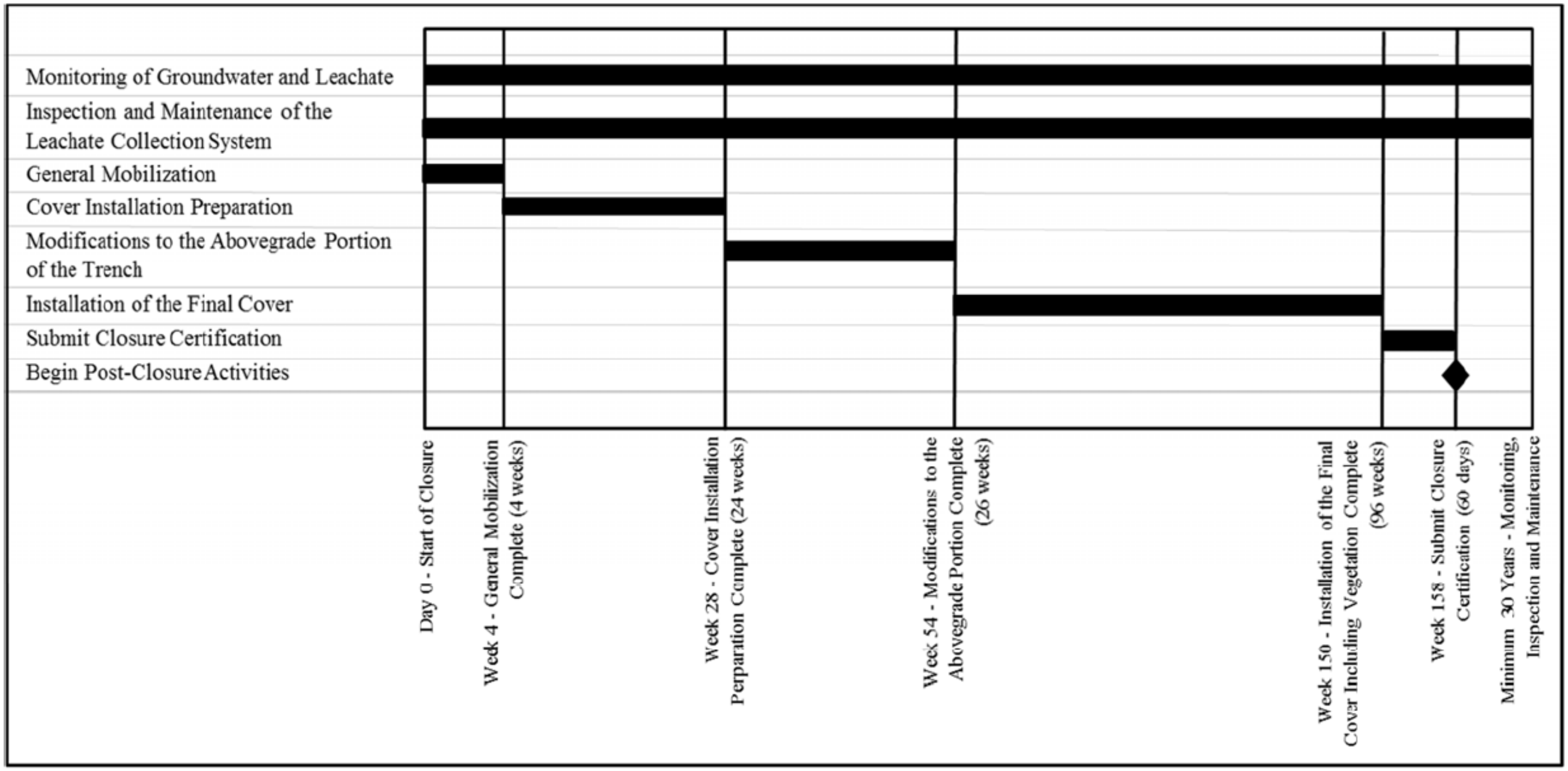
This section describes the interim closure activities. The source of information is primarily from the previous closure plan: DOE/RL-2000-70. DOE/RL-2000-70 supports the previous PAs for the 200 West and 200 East LLBGs (WHC-EP-0645 and WHC-SD-WM-TI-730, respectively). Despite of the differences in key assumptions (summarized in Section 1.5 in DOE/RL-2021-26) of the Trenches 31, 34, and 94 PA and the previous LLBG PA, there are similarities between the two closure plans because both closures involve use the modified RCRA Subtitle C surface barrier to some, if not all, of the disposal units.

6.3.1 Subgrade Modification

The following principal objectives of subgrade modification activities performed during the Interim Closure Period will be to:

1. Densify and stabilize trench fill materials to minimize or eliminate sources of long-term settlement and subsidence.

2. Develop sufficient bearing capacity to support the weight of an engineered surface barrier over the site (i.e., the anticipated final remedial action).



Source: Figures H-A3 and H-C3 in DOE/RL-2015-74, *Hanford Facility Dangerous Waste Part B Permit Application; Low-Level Burial Grounds Trenches 31, -34, -94, T Plant Complex, and Central Waste Complex-Waste Receiving and Processing Facility*.

Figure 6-1. Trenches 31, 34, and 94 Closure Schedule Activities

Potential subgrade modification methods are listed and briefly described below. Implementation of these methods is 14 years in the future and new ground-modification technologies may become available within this time frame. However, the necessary objectives could be met using methods and equipment that are available now.

- Deep Dynamic Compaction: The technique involves dropping heavy (e.g., 4.5 to 18.1 metric ton, 5 to 20 ton) steel or concrete blocks onto 6 to 30 m (20 to 100 ft) the ground surface. A grid pattern is marked off over the surface area to be treated. Each grid point receives several (two to ten) blows in one or several passes. The drop block typically is raised and dropped by a crane with appropriate capacity and rigging for the activity. Limited performance tests at the Hanford Site (Phillips and Gilbert, 1985, *Near-Field Evaluation of Compliance for Radioactive Material Package*) have shown that multiple blows with impact energies of 4.0×10^5 J/m^2 (or about 27,000 lb ft/ft^2) give adequate compaction of waste fills to a depth of 3.0 m (10 ft).

- Vibroflotation: This technique has been in use since the 1930s for compacting granular soils to considerable depths (6 m [20 ft] or more). A tool string is vibrated into the ground, with or without assistance of a water spray jet. Soil is compacted in a radial direction outward from the centerline of the tool string. Effective compaction of soil is achieved to a radial distance of about 1.5 m (5 ft).

- Compaction Grouting: This technique is included as an alternative to mechanical methods and involves injecting a very stiff mortar-like grout into the soil mass. The grout is designed to stay together in a homogeneous mass that displaces and compacts the surrounding soil (Bandimere, 1993, *Grouting; Engineers and Contractors Working Together*). Displacement of the soil increases its in-place density and bearing capacity. Specially designed equipment is required for mixing and pumping the stiff and abrasive grout mix used in this method.

- Permeation Grouting: A highly flowable grout material is injected into the soil mass under low pressure, displacing air and filling the void volume in the soil. Chemical grouts or micro-fine cement grouts with moderate to high water to cement ratios typically are used (Bandimere, 1993). When the cement hardens, the soil mass is bonded together into a monolith with improved bearing capacity. This technique is envisioned to be advantageous for limited situations such as improving bearing capacity of backfill soil around HICs.

- Void-Fill Grouting: For certain types of waste containers (such as large heavy-gauge steel boxes) that may retain structural integrity in trench fills for many years and may be difficult to compact effectively by dynamic methods, a useful alternative is to drill into the container and displace the air volume with a flowable, self-leveling grout formulation. This technique already is used, to a limited extent, in LLBG operations.

6.3.2 Supporting Geophysical Monitoring/Investigation Methods

It is envisioned that subgrade modification operations will be monitored and evaluated principally by geophysical survey methods. The primary objectives of geophysical surveys over solid waste landfill trenches are as follows:

1. Accurately delineate the lateral boundaries of individual trenches, the locations of various disposed materials and void spaces within the trenches, and the thickness of overburden (i.e., operational soil cover)

2. Evaluate the density of trench fill materials

Geophysical surveys will be used to plan and administer trench fill densification work and to provide confirmation of the effectiveness of densification efforts. Electromagnetic induction, ground-penetrating radar, and micro-gravity surveys are proposed investigative methods for making these assessments. Shallow reflection seismic surveys could also be performed as an alternative to micro-gravity surveys or as a supplemental method for obtaining in-place density data. These methods are all noninvasive techniques.

6.3.3 Implementation of Subgrade Modification Methods to Trench Fills

The goal of subgrade modification is to densify and/or stabilize trench fill materials so that adequate bearing capacity can be developed to support the weight of an engineered surface barrier over the site. The actual bearing capacity requirement is traceable to specific attributes of the surface barrier design. The key determinants from the design are the combined weight per unit area of materials in the various barrier layers and the amount of differential settlement that can be tolerated by the barrier without compromising any essential performance functions or design attributes.

Trench-specific remedial designs will be developed that take into consideration the original waste inventory information, the results from geophysical investigations, and the final cover design. Remedial designs will provide specifications for the types of subgrade modification methods to be implemented for trench fills and remedial action goals (corresponding to acceptable bearing capacity and settlement values).

Among currently available methods, deep dynamic compaction is envisioned to be the method of choice for densifying trench fills containing bulk waste, drummed waste, and small boxes. Deep dynamic compaction may also be unsuitable for compacting boxes with large air voids or large boxes with reinforced concrete or heavy steel construction. Alternative methods (e.g., vibroflotation, permeation grouting, or compaction grouting) can be used to densify soil in the vicinity of HICs. Large boxes could be filled with grout. In fact, the interior of CAT3 waste containers and encasements is grouted per the stability requirements.

Trench fills will be periodically resurveyed by geophysical methods during and after subgrade modification to assess progress toward site improvement goals and to identify areas that require additional remedial attention. The geophysical survey reports generated during the work will provide an effective means of documenting the extent of remedial activities at the conclusion of the work.

An implementation-testing program will be required to develop and evaluate performance attributes of various candidate subgrade modification methods. This testing is needed to:

- Evaluate performance attributes (e.g., hole spacings, number of passes, drop weights and heights, grout formulations)
- Develop correlations between geophysical measurements and target bearing capacity values (e.g., correlations between seismic velocity data and/or micro-gravity readings and in-place bulk density and bearing capacity)
- Evaluate the overall suitability and effectiveness of various proposed methods
- Acquire cost and schedule data for devising appropriate procurement strategies for contracting of geotechnical services and equipment

All of these types of information are needed to prepare effective trench-specific remedial action plans and designs.

6.3.4 Inspection, Monitoring and Maintenance during Interim Closure

As shown in Table 6-1, the current inspection, monitoring, and maintenance activities performed in support of facility operations will continue into and through the Final Closure period including the Interim Closure period. Inspections of burial grounds surfaces for newly formed subsidence features will continue to be performed on a regular schedule. Leachate collection systems for lined mixed-waste Trenches 31 and 34 will be inspected, monitored, and maintained until leachate generation is eliminated. Trench 94 is not lined and is exempted from leachate collection. Site access controls also will be inspected at regular intervals. Maintenance activities will be scheduled as needed to address deficiencies noted on inspection logs.

The regimen of inspection, monitoring, and maintenance practices carried over from the trench Operations into the Interim Closure period will be revised (downgraded) as specific inspection and monitoring requirements can cease. As subgrade modification of individual trench fills is completed, there will be no further need to include these areas in periodic inspections. Groundwater monitoring will continue through the Interim Closure period, consistent with requirements and commitments described in DOE/RL-91-50, *Hanford Site Environmental Monitoring Plan* and WHC-SD-EN-AP-015, *Revised Groundwater Monitoring Plan for the 200 Areas Burial Grounds* and/or successor documents (see PA monitoring plan DOE/RL-2021-39). Currently, groundwater monitoring of LLBGs involves semiannual sampling and analysis of a total of 57 wells. Groundwater sampling procedures, laboratory analytical procedures, statistical evaluation procedures, data quality objectives and quality assurance requirements for the current near-facility groundwater monitoring program are provided in WHC-SD-EN-AP-015. Changes to the groundwater monitoring program for the active trenches will be documented as revisions to that document or successor documents.

Monitoring wells are inspected at each scheduled sampling event. An inspection log is prepared to document any maintenance issues (e.g., repairs to casing, screen, pump, or locking cap) identified.

6.4 Final Closure

Historically, CAT1 and CAT3 wastes have not been segregated. All active burial grounds have received CAT1 and CAT3 LLW, and the two waste classes are commingled in the trenches. In addition, all active burial grounds have received some quantities of waste containing constituents that are currently regulated by the State of Washington as dangerous waste under provisions of WAC 173-303.

Consequently, closure requirements pertaining to CAT3 waste facilities in the PAs likely will apply to all active trenches. Closure requirements for State regulated dangerous waste also will apply as applicable or relevant and appropriate requirements during final remedy selection under CERCLA.

In accordance with WAC 173-303-665, “Landfills,” final landfill covers will be designed and constructed with the following objectives:

- Minimize migration of liquids through closed landfills
- Require minimal maintenance
- Promote drainage and minimize cover erosion or abrasion
- Maintain cover integrity despite settling and subsidence
- Provide permeability less than or equal to that of any bottom liner system or natural subsoil present

In 1996, a focused feasibility study (FFS) (DOE/RL-93-33) of engineered barriers (covers) was prepared for the 200 Area of the Hanford Facility. The FFS provided four generic conceptual cover designs that evaluated federal and state regulatory requirements and drew upon experience with cover designs for

Hanford Facility applications. The modified RCRA Subtitle C surface barrier defined in the FFS is designed to meet or exceed regulatory requirements for applications at CAT1 and CAT3 LLW sites and is the baseline for Hanford Facility areas containing dangerous waste, CAT3 LLW, CAT3, and CAT1 MLLW. The modified RCRA subtitle C surface barrier is designed to provide long-term containment, hydrologic protection, and provision to control biointrusion and human intrusion for a performance period of 500 years (key PA assumptions listed in Table 4-1).

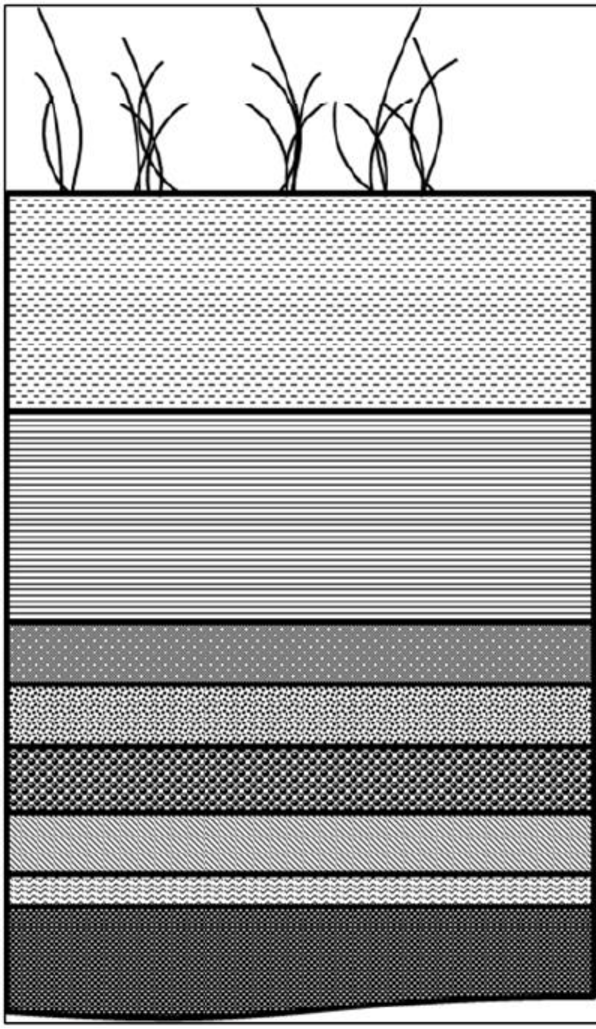
Until the final volume of waste is disposed into Trenches 31 and 34, the definitive design for the cover for each trench cannot be specified. Once the final volume of waste is disposed into a disposal cell, a definitive final cover design for that cell based on the modified RCRA Subtitle C surface barrier will be completed and submitted as a permit modification in accordance with WAC 173-303-610 requirements.

Figure 6-2 describes the modified RCRA Subtitle C surface barrier layers.

6.4.1 Description of Final Cover Design

Based on the decision logic and selection rationale elaborated in the FFS, the modified RCRA Subtitle C surface barrier design has been designated as the current planning basis for final closure of active Trenches 31 and 34. The logic and rationale supporting this design are consistent with the current out-year planning and long-range implementation planning of the DOE. This barrier treatment also is assumed in the SW-EIS (DOE/EIS-0286F) as an element of the Baseline Alternative and the Regional Alternative for purposes of evaluating closure of Trenches 31 and 34. The planning basis may change in the future to reflect developments and/or modifications to barrier technology for Hanford Site applications. Any changes to the planning basis will be documented in revisions to this document.

Design descriptions of the individual layers in the modified RCRA Subtitle C surface barrier and their respective functions are provided in the following sections, which are excerpted from DOE/RL-93-33. Figure 6-2 shows a profile view through the barrier.



Reference: Adapted from DOE/RL-2015-74, *Hanford Facility Dangerous Waste Part B Permit Application; Low-Level Burial Grounds Trenches 31-34-94, T Plant Complex, and Central Waste Complex-Waste Receiving and Processing Facility*, Appendices H-A and H-C. Same as Figure 2-60 in DOE/RL-2021-26, *Performance Assessment of Active Trenches in 200 East and West Low-Level Burial Grounds at the Hanford Site*.

Figure 6-2. Modified RCRA Subtitle C Surface Barrier

6.4.1.1 Layer 1 (Topsoil with Pea Gravel Admixture) and Layer 2 (Compacted Topsoil Without Pea Gravel)

Layer 1 consists of 50 cm (20 in.) of sandy silt-to-silt loam soil containing 15% (by weight) pea gravel. Layer 1 will be placed in a relatively loose condition, with a bulk density value of about 1.46 g/cc (91 to 92 lb/ft^3). Layer 2 consists of 50 cm (20 in.) of the same silt loam soil, without pea gravel, placed in a relatively densified state, approximately 1.76 g/cc (110 lb/ft^3). The topsoil component (i.e., Layers 1 and 2) is designed to perform as a storage medium for soil moisture, and to support cover vegetation. The purpose of the pea gravel in Layer 1 is to improve the soil's resistance to wind erosion (PNL-7435, *Soil Erosion Rates from Mixed Soil and Gravel Surfaces in a Wind Tunnel*). The surface slope will be limited to 2% (after allowances for settlement and subsidence). This value is steep enough to provide for coherent drainage of runoff from the covered area, yet shallow enough to limit exposure of the surface to wind erosion.

Compaction of Layer 2 during construction will decrease its saturated hydraulic conductivity by three to four orders of magnitude (i.e., from values in the range of 10^{-3} to 10^{-4} cm/s down to values between 10^{-6} to 10^{-7} cm/s based on DOE/RL-2000-70). The indicated reduction in conductivity is readily achievable by compacting the silt loam soil to densities in the range of 1.68 to 1.84 g/cc (105 to 115 lb/ft^3). Laboratory testing indicates that these results can be accomplished with moderate compactive effort (WHC-SD-EN-TI-218, *Material Properties Data and Volume Estimate of Silt Loam at NRDWL Reserve, McGee Ranch*). Compaction will retard moisture migration through Layer 2. A capillary barrier at the base of Layer 2 will enhance moisture retention and ET within Layers 1 and 2. Numerical performance simulations using the Hydrologic Evaluation of Landfill Performance (HELP) model predict that essentially 100% of average annual precipitation will be removed from the barrier by ET (Appendix C of DOE/RL-93-33).

Cover vegetation will consist of a mixture of perennial grass species. Specifications for the seed mix, and the methods of seed application, fertilizing, and mulching will be developed during definitive design. Planting of cover vegetation will meet or exceed recommendations in the U.S. Environmental Protection Agency's technical guidance for final covers (EPA, 1989, *Technical Guidance Document: Final Covers on Hazardous Waste Landfills and Surface Impoundments*).

6.4.1.2 Layer 3 (Sand Filter) and Layer 4 (Gravel Filter)

These layers are components of a two-layer graded filter designed to prevent topsoil particles from moving downward and accumulating in the lateral drainage layer (Layer 5). Both layers are 15 cm (6 in.) thick. These materials will be clean, screened aggregate materials obtained from a local borrow site. The design of the graded filter conforms to the criteria published in Cedergre, 1989, *Seepage, Drainage, and Flow Nets*, and Ecology, 1987, *Solid Waste Landfill Design Manual*.

6.4.1.3 Layer 5 (Lateral Drainage Layer)

This layer will facilitate the removal of any moisture that moves completely through the topsoil component of the barrier (Layers 1 and 2). This layer represents a contingency scheme to remove soil moisture in response to extreme climatic events, such as the design storm. Layer 5 will be sloped at 2% to move water to the edge of the cover where it will be collected and/or diverted in an appropriate manner. Layer 5 will be 15 cm (6 in.) thick and will be constructed of clean, screened aggregate material with a hydraulic conductivity of at least 1 cm/s (DOE/RL-2000-70). An effective particle size (D_{10}) of 1 mm or greater is needed for the drainage media to achieve the desired permeability value. Layer 5 will be situated approximately 1.3 m (4.3 ft) below final grade, which satisfies the design criterion for frost protection. Performance simulations with the HELP model indicate that little (if any) lateral drainage will occur (Appendix C of DOE/RL-93-33).

6.4.1.4 Layer 6 (Asphalt Layer)

This layer will function as a low-permeability barrier layer and as a biointrusion barrier. Layer 6 will be constructed of a durable asphaltic concrete mixture consisting of double-tar asphalt (i.e., twice the tar content of normal highway asphalt) with added sand as binder material. Based on the study of the PHB (PNNL-18845), the horizontal neutron-probe measurements above and below the asphalt shows no evidence of deep percolation of water. Lateral movement of water under the asphalt layer was quite limited.

The low-permeability asphalt layer is expected to be a highly effective deterrent to intrusion by plant roots and burrowing animals. As necessary, it will also function as a human intrusion barrier. The strength of the asphaltic concrete material, the thickness of Layer 6, and its deliberate construction should serve to advise inadvertent intruders that this layer is an intentional barrier. Layer 6 can be breached with mechanical excavation equipment, but intrusion scenarios involving the use of heavy equipment probably would be considered advertent rather than inadvertent.

6.4.1.5 Layer 7 (Asphalt Base Course)

This layer will provide a stable base for placement of the overlying asphalt layer. The base course will consist of screened, crushed-surfacing material, with 100% passing the 32 mm (1.25 in.) sieve.

6.4.1.6 Layer 8 (Grading Fill)

Grading fill will be placed, as necessary, to establish a smooth, planar base surface for construction of the overlying layers. The preexisting site surface will be contoured and graded to create uniform surfaces sloped at 2%, as needed for internal lateral drainage and surface runoff control. Grading the site before construction will facilitate accurate and controlled placement of soil lifts and layers. Grading fill will consist of a well-graded granular soil mixture, which may include as much as 20% by volume of cobbles measuring no more than 75 mm (3 in.) in the greatest dimension.

6.4.1.7 Total Thickness of the Cover

The total thickness of the cover must be 5 m to satisfy the design criteria listed in Table 3-3 (also key PA assumption No. 6 in listed in Table 4-1).

6.4.2 Sources of Cover Materials

Specifications and performance predictions for topsoil in Layers 1 and 2 of the modified RCRA Subtitle C surface barrier’s design in DOE/RL-93-33 are based on field and laboratory characterization tests of soil samples obtained from the McGee Ranch site, located north and west of the Yakima Barricade on the Hanford Site. That site is within the portion of the Hanford Site land area that acquired National Monument status earlier in 2000. The SW-EIS (DOE/EIS-0286F) proposes to obtain silt loam soil for construction of engineered surface barriers over LLBGs from two areas north of State Route 240 and southwest of the 200 West Area. The EIS indicates that approximately 727,000 m^3 (950,000 yd^3) of silt loam soil will be required for construction of covers over the eight active burial grounds.

Sand and gravel will be obtained from pit 30 (an existing borrow pit) on the Hanford Site. This pit is located midway between the 200 East and 200 West Areas. The EIS indicates that approximately 1.5 million m^3 (2.0 million yd^3) of screened and unscreened sand and gravel materials will be required for cover construction.

Additionally, the EIS estimates that cover construction will require 377,000 m^3 (493,000 yd^3) of asphalt from commercial off-site sources.

6.4.3 Cover Performance

PAs for Trenches 31, 34, and 94 indicate that long-term performance goals can be achieved if engineered surface barriers over burial grounds limit deep infiltration into/through the waste layer to 0.5 mm/yr (0.02 in./yr) or less for 500 years (key PA assumptions in Table 4-1).

Results from the PHB study (PNNL-18845) provided evidence that supports the expected performance of Trenches 31 and 34 cover. Performance monitoring of the PHB indicates that with the total precipitation received from October 1994 through August 2008 of 3,311 mm on the northern half (formerly irrigated), and 2,638 mm on the southern (nonirrigated half), water storage in the fine-soil layer shows a cyclic pattern, increasing in the winter and decreasing in the spring and summer to a lower limit of around 100 mm, regardless of precipitation, in response to ET. Total percolation ranged from near zero amounts under the soil-covered plots to over 600 mm under the side slopes. The asphaltic concrete prevented any of this water from reaching the buried waste thereby eliminating the driving force for the contaminant remobilization. Topographic surveys conducted to the PHB study show the barrier and side slopes to be stable and the pea-gravel admix has proven effective in minimizing erosion through the creation of a desert pavement during deflationary periods (key PA assumption No.4 in Table 4-1).

6.4.4 Inspection, Monitoring and Maintenance during Final Closure

Inspection, monitoring, and maintenance practices in place at the time of transition from Interim Closure to Final Closure will be continued. Regularly scheduled inspections of surfaces over filled trenches for evidence of subsidence will have been phased out as a result of subgrade modification measures implemented during Interim Closure. As lined mixed-waste trenches are covered and cease to generate leachate for Trenches 31 and 34, inspection, monitoring and maintenance of leachate collection systems can be eliminated.

Groundwater monitoring is planned to continue through the Final Closure period, consistent with requirements and commitments described in DOE/RL-91-50, WHC-SD-EN-AP-015, and/or successor documents. Changes to the groundwater monitoring program for active trenches will be documented as revisions to WHC-SD-EN-AP-015 or successor documents.

6.4.5 Records Management Plan for Documents and Records Generated During Final Closure

Records concerning the disposal-product receipt acceptance and the total inventory of waste placed in the active trenches will be maintained as a part of the permanent closure documentation (DOE O 435.1 and WAC 246-247, “Radiation Protection—Air Emissions”). Records must also include 40 CFR 268 and WAC 173-303-801, “Types of Dangerous Waste Management Facility Permits,” and disposal restriction certification and records supporting waste verification and confirmation through the operating life of the trenches.

Before final closure of the Trenches 31, 34, and 94, records of the final inventory of waste placed in the facility will be made available for additional updating of the PA and the closure plan.

7 Compliance

Closure of Trenches 31, 34, and 94 is predicated on the ability to meet the performance objectives defined in DOE M 435.1-1. The Trenches 31, 34, and 94 PA (DOE/RL-2021-26) describes the basis of the models and parameter used in the prediction of the postclosure performance and the associated assumptions. This section provides a summary of the compliance of Trenches 31, 34, and 94 with the performance objectives with a focus on the key assumptions related to the closure of the facility.

7.1 Compliance with Performance Objectives

The PA modeling and calculation documented in DOE/RL-2021-26 were conducted for Trenches 31 and 34. For Trench 94, review of the initial PA (WHC-SD-WM-TI-730) and the latest corrosion rate of the corrosion-resistant steel concluded that the initial PA results are still valid due to bounding assumptions and robust performance of the corrosion-resistant steel used by the naval reactor compartments (see Appendix A of DOE/RL-2021-26). The maximum dose for drinking water is 0.0005 mrem/yr while for the inadvertent intruder scenario, the maximum dose is 0.7 mrem/yr (WHC-SD-WM-TI-730).

The maximum results evaluated at the points of assessment of Trenches 31 and 34 include all-pathway effective annual doses, radon fluxes, intruder doses, groundwater concentrations, and equivalent dose of water ingestion for water-resource protection. The deterministic base case assessment results for the compliance period (from closure to 1,000 years after) and the mean probabilistic assessment results for postcompliance period (1,000 to 10,000 years postclosure) are presented in Table ES-1 of DOE/RL-2021-26. The time-histories of the results are presented in Chapters 5, 6, and 7 of DOE/RL-2021-26. The results are summarized as follows:

1. The deterministic base case results are presented for the compliance period to demonstrate compliance. During the compliance period, the peak dose is 1.7E-03 mrem/yr contributed by carbon-14 through air pathway. No radionuclides arrive at the point of assessment through groundwater pathway during the compliance period, yielding zero doses and concentrations.

2. The mean peak results from uncertainty analysis are presented for the postcompliance period. The maximum mean peak dose is 2.4 mrem/yr contributed primarily by technetium-99 through groundwater pathway. The maximum mean dose for air pathway is less than 1E-05 mrem/yr.

3. During the postcompliance period, the mean peak beta-gamma (40 CFR 141.66, "National Primary Drinking Water Regulations," "Maximum Contaminant Levels for Radionuclides") dose for water resource protection is 3 mrem/yr. The mean peak dose based on DOE dosimetry (DOE-STD-1196-2011, *Derived Concentration Technical Standard*) is 1.5 mrem/yr. The mean peak concentrations for gross alpha, combined radium-226 and 228, total uranium, strongtium-90, and tritium are all zero.

4. The peak radon flux is 0.82 pCi/m^2/s during the compliance period. The mean peak radon flux is 0.45 pCi/m^2/s during the postcompliance period.

5. The maximum acute exposure dose is 2.4 mrem. The maximum chronic exposure dose is 1.8 mrem/yr. The inadvertent intrusion assessment period for CAT1 waste is from 243 years postclosure (CY 2278) to 1,000 years postclosure. For CAT3 waste with intruder barriers, the intrusion assessment period is from 500 to 1,000 years postclosure.

These results demonstrate the compliance of Trenches 31 and 34 with DOE O 435.1 requirements by meeting all performance objectives and measures. Some “what-if” type of sensitivity cases were also conducted to evaluate the consequences associated with the loss of part or entirety of a safety function. These stylized sensitivity cases provide additional insights on the system behavior and complement uncertainty analyses in demonstrating long-term safety of the disposal system.

7.2 Compliance with Other Requirements

This section briefly describes the requirements imposed by the PA, RCRA regulations, and DOE O 458.1.

7.2.1 Requirements from Performance Assessment

The Trenches 31, 34, and 94 PA impose no specific constraints on the waste loading or configuration of the closed disposal facility.

7.2.2 RCRA-Based Requirements

Trenches 31, 34, and 94 will be permitted for closure.

7.2.3 RCRA Corrective Action

The longest institutional control period will be that identified in existing CERCLA and RCRA decision documents, and the latest version of DOE/RL-2001-41.

7.2.4 DOE O 458.1 Requirements

Institutional controls shall continue until the facility can be released (DOE O 435.1) pursuant to DOE O 458.1.

7.2.5 Long-Term Site Stewardship

After trench loading and backfilling are completed, the top of active trenches will receive a modified RCRA Subtitle C surface barrier to provide appropriate protection from the weather and other types of intrusion. Postclosure activities will be initiated on completion of closure cap construction. The length of time required for postclosure care will depend on the results of postclosure monitoring. The need and duration of monitoring will be assessed at each permit review and renewal. Additional information is provided in Trenches 31, 34, and 94 PA maintenance plan (DOE/RL-2021-38) and monitoring plan (DOE/RL-2021-39).

8 Institutional Controls

An engineered barrier cover will be installed in accordance with RCRA regulatory requirements to minimize infiltration of precipitation into the trenches and hinder the inadvertent intruder from accessing the waste packages. Once the trenches are closed, operations are reduced to site access control, inspection, continuance of monitoring and maintenance of security systems for this facility; the waste is safeguarded and monitored by institutional control. Institutional control shall continue until the facility can be released (DOE O 435.1) pursuant to DOE O 458.1.

8.1 Inspection Plan

Inspections will be conducted on prescribed schedules to ensure continued integrity of the closed facilities and the cover systems during the institutional control period. Inspections will be conducted in accordance with controlled procedures, and permanent logs of inspection results will be maintained. An inspection plan and procedures will be prepared that will address the following issues and concerns. The primary information source is DOE/RL-2000-70. The proposed plan in this document, however, is subject to change based on new available technologies, such as web-based security cameras, drone, etc.

8.1.1 Site Access Control

Trenches 31, 34, and 94 are located within controlled access areas of the Hanford Site, which cannot be accessed by the general public. Physical access controls will be inspected at regular intervals. Any deficiencies will be noted in inspection logs.

8.1.2 Erosion Damage

Damage to closure cover surfaces may occur either from wind or water erosion. Visual inspections will be performed at regular intervals (e.g., quarterly) to identify localized areas where significant soil losses have occurred. Inspectors will check for conditions such as sheet or rill erosion (gully formation), sand deposition, uniformity of vegetative cover, and the integrity of run-off and run-on control measures. Observations will be recorded in an inspection logbook.

If soil losses occur over larger areas of the cover, they will be detected by surveys of monuments laid out on a regular grid spacing. Cover surfaces will be most susceptible to wind erosion during the first year after construction, before a mature vegetative cover has been established, or periods following reduction of vegetation by range fires.

8.1.3 Cover Settlement, Subsidence, and Displacement

Localized subsidence features will be identified in periodic visual inspections of cover surfaces. Settlement over larger areas will be detected by surveys of surface monuments (also used to detect soil losses from wind erosion). Covers will be reinspected for settlement/subsidence damage following seismic events producing surface accelerations above a predetermined threshold. Accelerometers in the 200 Areas will record the amplitude and frequency of surface accelerations during seismic events. The threshold for significant acceleration will be determined based on a seismic evaluation of the final cover design. Inspectors will check for ground fractures and surface displacements of cover materials.

8.1.4 Vegetative Cover Condition

Frequent (e.g., monthly) visual inspections of cover vegetation may be performed beginning with seeding of the cover surface and continuing until vegetation becomes well established. Inspectors will record quantitative measures of the condition and density of the vegetative cover and note colonization of covers by deep-rooted plants and/or other invasive species. More frequent inspections would be implemented (as necessary) to monitor recovery of vegetation after range fires.

8.1.5 Burrowing Animal Activity

During visual inspections, any evidence of destructive activity by burrowing animals will be noted. Observations will be recorded in an inspection logbook.

8.1.6 Cover Drainage System

Accessible drainage components of the cover system will be inspected at regular intervals for evidence of sedimentation or blockage.

8.1.7 Leachate Collection/Detection System

If some cover systems over regulated mixed waste trenches will need to include leachate collection/detection and removal systems, then visual inspections of these systems will be performed. The tubing, pumps, and holding tanks will be inspected for leaks, damage, corrosion, or blockage. Observations will be recorded in an inspection logbook.

8.1.8 Monitoring Well Condition

Monitoring wells will be examined on each occasion that groundwater samples are withdrawn. Locking caps, vehicle guard posts and pump connectors will be inspected semiannually for damage. Any damage or other problems will be noted in an inspection logbook.

8.1.9 Benchmark Integrity

Benchmarks and survey monuments will be inspected as an aspect of erosion and settlement surveys. Any indication that a benchmark has been damaged or misaligned will be noted in an inspection logbook.

8.2 Monitoring Plan

Monitoring plan contents are discussed in the following subsections. The primary information source is DOE/RL-2000-70. For more details and the latest updates, see the PA monitoring plan (DOE/RL-2021-39).

8.2.1 Groundwater Monitoring

It is anticipated that groundwater monitoring will continue during the Institutional Control Period, consistent with requirements and commitments described in the environmental monitoring plan (DOE/RL-91-50), the revised groundwater monitoring plan (WHC-SD-EN-AP-015); and/or successor documents. Trenches 31, 34, and 94 are undergoing detection-level monitoring at the present time. It is also anticipated that detection-level monitoring will continue into the institutional control period unless dangerous waste constituents from Trenches 31, 34, and 94 are detected at a designated point of compliance at some time in the future. In that event, more stringent sampling and analysis requirements may be imposed (e.g., assessment- or compliance-level monitoring requirements), or it may be necessary to implement a corrective action program.

Currently, groundwater monitoring of Trenches 31, 34, and 94 involves semiannual sampling and analysis of a total of 57 wells. Several active monitoring wells are situated inside areas that will be covered during Final Closure. Consequently, some wells will have to be modified or capped and abandoned and replaced in order to maintain current monitoring capabilities during the institutional control period.

Groundwater sampling procedures, laboratory analytical procedures, statistical evaluation procedures, data quality objectives and quality assurance requirements for the current near-facility groundwater monitoring program are provided in WHC-SD-EN-AP-015. Program changes will be documented as revisions to that document or to successor documents.

8.2.2 Leachate Collection/Detection and Removal

For facilities with leachate collection systems (Trenches 31 and 34), operation of the leachate collection/detection and removal system will be continued (if necessary) into the institutional control period to monitor leachate generation after closure. Leachate production should attenuate over time during or after cover construction, enabling monitoring and maintenance requirements for this system to be incrementally reduced and eventually eliminated.

8.3 Maintenance Plan

The cover, groundwater monitoring, and leachate collection systems will be regularly maintained to ensure their continued integrity during the Institutional Control Period. Maintenance activities generally will be triggered by inspection reports. Maintenance reports will be prepared to document all maintenance activities. Maintenance reports will reference the initiating inspection report and the follow-up maintenance record to provide comprehensive documentation of all maintenance activities. Maintenance reports and records will be maintained available for inspection at a designated location. The primary information source is DOE/RL-2000-70. For more details and the latest updates, see the PA maintenance plan (DOE/RL-2021-38).

8.3.1 Security Controls

Security controls, consisting of perimeter fences, locked gates, and warning signs, will be inspected at regular intervals, and maintained as necessary to prevent unauthorized access to closed facilities.

8.3.2 Erosion Damage

Depending on the areal extent of the damage and the specific cause (e.g., wind or water erosion), maintenance may simply take the form of replacing lost topsoil to restore the surface to the original grade, or it might also involve revegetation efforts (e.g., mulching and reseeding). Maintenance might also involve removal of soil (silt loam topsoil or windblown sand) from areas of accumulation. Criteria for initiating maintenance (repair) of the cover surface will be developed during definitive design of the cover system.

8.3.3 Cover Settlement and Subsidence

Minor settlement or subsidence may be difficult to distinguish from localized topsoil losses due to wind erosion in visual inspections of cover surfaces. Settlement and subsidence affect all cover layers, whereas wind erosion affects the condition of the topsoil layer only. In cases where settlement and/or subsidence are suspected, more detailed inspections must be performed which would involve probing downward through the upper layers of the cover to determine the elevation of the low-permeability asphalt layer. Criteria for initiating maintenance (repair) of the cover surface will be developed during definitive design of the cover system.

Minor settlement over a broad area may not significantly affect long-term performance of the cover system and may be corrected by adding topsoil to restore the surface to design grade. Localized settlement or subsidence is a relatively more serious problem which could produce closed depressions (i.e., ponding conditions) on top of the asphalt layer. Extreme localized subsidence or differential settlement could lead to rupture of the asphalt layer, depending on the severity of the event. Contingency corrective action plans will be developed to address the range of appropriate remedial responses that can be anticipated.

8.3.4 Vegetative Cover Condition

Active maintenance of cover vegetation will be performed in cases where vegetation fails to become sufficiently well-established within 6 months to 1 year after planting to limit erosion damage. As experience is acquired over time, more suitable mixes of shallow-rooted perennial species may be identified and substituted. Revegetation of entire cover areas may be necessary following range fires.

8.3.5 Animal Activity

Large burrows identified within covered areas will be filled in and the animals involved in the activity will be trapped and removed from the site.

8.3.6 Cover Drainage Components

Components of the cover design that are provided to control or collect drainage will be maintained so that they remain functional for the duration of active institutional control. Blockages will be eliminated using methods that minimize disturbance to the cover system.

8.3.7 Leachate Collection/Detection and Removal System

Maintenance activities will be performed (as needed) on tubing, pumps, and holding tanks of any leachate collection/detection and removal systems included in covered areas as long as these systems are required to remain functional.

8.3.8 Groundwater Monitoring Wells.

Maintenance will be performed as needed on groundwater monitoring wells, including locking caps, down-hole casing, screens, and pumps. Damaged equipment will be repaired or replaced, as necessary.

8.3.9 Benchmark Integrity.

A benchmark that is found to be damaged or out of alignment will be replaced as necessary and its location will be resurveyed.

8.4 Contingency Corrective Action Plans

Contingency plans and procedures will be developed describing detailed responses for foreseeable types of major problems with the cover system and/or facility monitoring systems during the institutional control period. Corrective action plans will be developed in conjunction with the inspection, monitoring, and maintenance plans described above. Specific threshold values and conditions will be identified to enable inspectors to distinguish situations requiring maintenance from situations requiring corrective action. Any of the following types of problems may require a corrective action response:

- Excessive settlement or subsidence of portions of the cover system
- Excessive infiltration through the cover, resulting in detectable contaminant migration
- Damage to the cover as the result of natural phenomena (e.g., earthquakes or severe storm events)
- Failure of monitoring systems/equipment
- Loss of cover vegetation (e.g., by range fires) or replacement by undesirable plant species
- Excessive erosion (e.g., formation of deep gullies through the topsoil layers of the cover)
- Uncontrolled site access

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