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Revision 0

Annual Status Report (FY 2022): Performance Assessment for the Disposal of Low-Level Waste in the 200 West Area Burial Grounds

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

P.O. Box 550
Richland, Washington 99352

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Executive Summary

This annual review provides the projected dose estimates of radionuclide inventories disposed in the active 200 West Area Low-Level Waste Burial Grounds (LLBGs) since September 26, 1988. These estimates are calculated using the original dose methodology developed in the performance assessment (PA) analysis (WHC-EP-0645[1]). The estimates are compared with the performance objectives defined in U.S. Department of Energy requirements (DOE O 435.1[2] and its companion documents DOE M 435.1-1[3] and DOE-STD-5002-2017[4]). All performance objectives are currently satisfied, and operational waste acceptance criteria (HNF-EP-0063[5]) and waste acceptance practices continue to be sufficient to maintain compliance with performance objectives. Inventory estimates and associated dose estimates from future waste disposal actions are unchanged from previous years' evaluations that indicate potential impacts well below performance objectives; therefore, future compliance with DOE O 435.1 is expected.

Within the active burial grounds, low-level and mixed low-level waste currently may be disposed only in two lined trenches in the 218-W-5 Burial Ground (Trenches 31 and 34) until they are either filled or a decision is made to close these trenches. Some mixed low-level waste is also disposed at the Environmental Restoration Disposal Facility in the 200 West Area (which is covered under a separate PA). During this (fiscal year 2022) reporting period (October 1, 2021, through September 30, 2022), waste was disposed to the 200 West Area LLBGs.

Continued groundwater monitoring of the 200 West Area LLBGs indicates no groundwater contamination due to LLBG waste. Current assumptions about future land

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[1] WHC-EP-0645, 1995, *Performance Assessment for the Disposal of Low-Level Waste in the 200 West Area Burial Grounds*, Westinghouse Hanford Company, Richland, Washington. Available at: https://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0075582H.

[2] DOE O 435.1 Chg 1 (PgChg), 2007, *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.

[3] DOE M 435.1-1 Chg 1, 2001, *Radioactive Waste Management Manual*, U.S. Department of Energy, Washington, D.C. Available at: https://www.directives.doe.gov/directives-documents/400-series/0435.1-DManual-1-chg1.

[4] DOE-STD-5002-2017, 2017, *Disposal Authorization Statement and Tank Closure Documentation*, U.S. Department of Energy, Washington, D.C. Available at: https://www.energy.gov/sites/prod/files/2018/09/f55/DOE-STD-5002-2017-DAS-and-Tank-Closure-Documentation-May2017.pdf.

[5] HNF-EP-0063, 2021, *Hanford Site Solid Waste Acceptance Criteria*, Rev. 20, Central Plateau Cleanup Company, Richland, Washington. Available at: https://www.hanford.gov/files.cfm/HNF-EP-0063_Rev-20.pdf.

use at the Hanford Site are consistent with PA analysis[1] assumptions of a postclosure facility that will not be degraded by human activity. The LLBGs are in an area identified for waste management and containment of residual contamination (DOE/EIS-0391[6]). The current closure plan for the LLBGs (DOE/RL-2000-70[7]) estimates that the 200 West LLBGs will be closed in the 2050 timeframe. The Disposal Authorization Statement, other technical basis documents, and the radioactive waste management basis are of continued adequacy to meet the performance objectives of DOE O 435.1. Overall, there are no substantive changes to primary PA assumptions and no changes to the PA analysis conclusion; therefore, compliance with DOE O 435.1 and the Disposal Authorization Statement is maintained.

A new PA to evaluate the long-term impacts of three disposal trenches that are currently active within the 200 East and 200 West Areas (Trench 94 in the 200 East Area and Trenches 31 and 34 in the 200 West Area) was initiated in fiscal year 2019 and completed in fiscal year 2022. Corrective actions addressing 3 key issues and 31 secondary issues identified during the review process were developed and submitted to the Low-Level Waste Disposal Facility Federal Review Group Co-Chairs for review and approval. This PA provides additional technical basis for the continued adequacy of the existing Operating Disposal Authorization Statement.

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[6] DOE/EIS-0391, 2012, *Final Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington (TC & WM EIS)*, U.S. Department of Energy, Office of River Protection, Richland, Washington. Available at: http://energy.gov/nepa/downloads/eis-0391-final-environmental-impact-statement.

[7] DOE/RL-2000-70, 2000, *Closure Plan for Active Low-Level Burial Grounds*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D8532666.

Contents

Appendices

Figures

Tables

Terms

AEA	*Atomic Energy Act of 1954*
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CY	calendar year
DOE-RL	U.S. Department of Energy, Richland Operations Office
DWS	drinking water standard
FY	fiscal year
LFRG	Low-Level Waste Disposal Facility Federal Review Group
LLBG	low-level burial ground
LLW	low-level waste
LLWMA	low-level waste management area
MLLW	mixed low-level waste
PA	performance assessment
R&D	research and development
RCRA	*Resource Conservation and Recovery Act of 1976*
RWMB	radioactive waste management basis
TOC	total organic carbon
TOX	total organic halides

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1 Changes Potentially Affecting the Performance Assessment

This document outlines all potential or actual changes, discoveries, proposed actions, and new information identified during this reporting period (fiscal year [FY] 2022) (October 1, 2021, through September 30, 2022) for the 200 West Area Low-Level Burial Grounds (LLBGs) with potential to impact the performance assessment (PA) (WHC-EP-0645, *Performance Assessment for the Disposal of Low-Level Waste in the 200 West Area Burial Grounds*; HNF-SD-WM-TI-798, *Addendum to the Performance Assessment Analysis for Low-Level Waste Disposal in the 200 West Area Active Burial Grounds*). While considerable information and data have been acquired in the 200 West Area since the last PA, no significant changes were found during the reporting period that would adversely affect the PA conclusions, as summarized in Table 1.

Table 1. Potential Changes Affecting the Performance Assessment

Disposal Facility or Unit	UDQE/UCAQE or Change Control Process Identification Number	Change, Discovery, Proposed Action, New Information Description	Evaluation Results	Special Analysis Number (If Applicable)	PA, CA, DAS or RWMB Impacts
218-W-3A	None	None	N/A	N/A	None
218-W-3AE	None	None	N/A	N/A	None
218-W4C	None	None	N/A	N/A	None
218-W-5	None	None	N/A	N/A	None

CA = composite analysis
DAS = disposal authorization basis
N/A = not applicable
PA = performance assessment
RWMB = radioactive waste management basis
UCAQE = unreviewed composite analysis question evaluation
UDQE = unreviewed disposal question evaluation

A new PA to evaluate the long-term impacts of three disposal trenches that are currently active within the 200 East Area (Trench 94) and 200 West Area (Trenches 31 and 34) was initiated in FY 2019 and completed in FY 2022. Corrective actions were developed to address 3 key issues and 31 secondary issues identified by the Low-Level Waste Disposal Facility Federal Review Group (LFRG), which have been submitted to the LFRG Co-Chairs for review and approval. This PA provides additional technical basis for the continued adequacy of the existing Operating Disposal Authorization Statement (Scott, 2001, "Disposal Authorization for the Hanford Site Low-Level Waste Disposal Facilities – Revision 2").

2 Cumulative Effects of Changes

In accordance with DOE M 435.1-1, *Radioactive Waste Management Manual*, the purpose of this chapter is to identify any cumulative effects of changes in facility operations, waste receipts, waste form behavior, monitoring data, research and development (R&D) data, or land-use decisions during the reporting period that have affected PA assumptions and conclusions, collectively representing the radioactive waste management basis (RWMB).

The RWMB for LLBGs is provided in CPCC-MP-WM-52872, *Waste Management Basis*. Appendix E of CPCC-MP-WM-52872 provides the facility specific information and documents.

Numerous data-gathering and research efforts over the past 25 years have improved the knowledge base since the last PA was completed. For example, new information has resulted in better understanding of

the inventory and waste form degradation and release processes. These changes/updates will not result in any significant or adverse changes to the conclusions of the 1995 PA.

This chapter outlines that no substantive changes have occurred in disposal facility operations, disposal facility performance, and PA assumptions or results (Table 1), therefore resulting in no additional cumulative effects. Appendix A provides maintenance history for this PA since its approval.

The composite analysis supporting this PA is reported in PNNL-11800, *Composite Analysis for Low-Level Waste Disposal in the 200 Area Plateau of the Hanford Site*, and PNNL-11800 Addendum 1, *Addendum to Composite Analysis for Low-Level Waste Disposal in the 200 Area Plateau of the Hanford Site* (hereinafter collectively called the Hanford Site Composite Analysis). The Hanford Site Composite Analysis is maintained separately under its own maintenance plan (DOE/RL-2000-29, *Maintenance Plan for the Composite Analysis of the Hanford Site, Southeast Washington*), and the concurrent annual status report for the Hanford Site Composite Analysis is provided in DOE/RL-2021-57, *Annual Status Report (FY 2021): Performance Assessment for the Disposal of Low-Level Waste in the 200 West Area Burial Grounds*. A new composite analysis has recently been conducted and is currently under review by the LFRG chair.

3 Waste Receipts

This chapter includes the following sections:

- Facility overview (Section 3.1)
- Description of disposed inventory (Section 3.2)
- Summary of groundwater and inadvertent intruder dose estimates associated with disposed inventory (Section 3.3)
- Evaluation of compliance with other performance objectives (Section 3.4)
- Statement of progress toward satisfying PA conditional approval requirements (Section 3.5)
- Summary statement of conclusions about compliance with performance objectives (Section 3.6)

Table 2 presents a summary of the compiled waste receipts and shows that no additional changes are outlined to continue the adequacy of the PA.

Table 2. Waste Receipts

Disposal Facility or Unit	Waste Disposed to Date (m^3)	PA Estimated Disposal Capacity (m^3)	Percent Filled Volume (%)	Sum of Fractions or Total Curie Versus PA Curie Limit	PA Impacts
218-W-5 (Trench 31)	6,704	25,080[a]	26.7	7.60E-04[b]	None
218-W-5 (Trench 34)	7,703	25,080[a]	30.7	1.78E-01[b]	None

a. Based on measurements of trench sizes (~76 by 30 m and an average depth of 11 m) provided in DOE/RL-2017-24, *Hanford Site Environmental Report for Calendar Year 2016*.

b. Total fraction based on intruder dose fraction of Category 3 limit for cesium-137, strontium-90, and uranium.

PA = performance assessment

3.1 Facility Overview

Figure 1 shows the location of the 200 West Area LLBGs in relation to the 200 East Area LLBGs, the Central Plateau, and the Hanford Site. Four LLBGs in the 200 West Area (218-W-5, 218-W-3A, 218-W-3AE, and 218-W-4C) (Figure 2) received low-level waste (LLW) and mixed low-level waste (MLLW) after September 26, 1988, and therefore are subject to the requirements of DOE O 435.1, *Radioactive Waste Management*. Figure 3 provides a site map showing the specific waste trench configuration for the 218-W-5 Burial Ground (including active Trenches 31 and 34), and Figure 4 provides a corresponding aerial image.

WHC-EP-0645 notes that, in the 200 West Area, the general type of disposal facility is a shallow, unlined trench of variable width of approximately 3 to 10 m (10 to 33 ft), length of 50 to 100 m (165 to 330 ft), and depth of 5 to 10 m (17 to 33 ft). Waste is typically packaged in containers (metal drums or wooden boxes) and placed in trenches up to 2 to 3 m (7 to 10 ft) from the surface. When a trench is filled, a soil cover is placed over the waste. Trenches are typically arranged in parallel to each other, with the long axis running due east-west. The following two types of disposal facilities are present:

- **Category 1 waste facility**: Assumed to have no functional surface barrier and intended to contain very low concentrations and quantities of radionuclides in the inventory.
- **Category 3 waste facility**: Planned to have a surface barrier (cover) that controls infiltration to the same degree as the natural soil and vegetation system, with the option to use waste form physical and chemical properties to control radionuclide release from wastes containing high concentrations of long-lived mobile radionuclides (i.e., technetium-99 and carbon-14).

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.

Currently, LLW and MLLW may be disposed in two active lined trenches in the 218-W-5 Burial Ground (Trenches 31 and 34) until they are either filled or a decision is made to close the trenches. During this reporting period, waste was disposed in Trenches 31 and 34. There are no plans to increase disposal capacity at the current burial grounds. Some MLLW is also disposed at the Environmental Restoration Disposal Facility in the 200 West Area, which is covered under a separate PA. Long-term needs for disposal of LLW and MLLW at the Hanford Site are evaluated in DOE/EIS-0391, *Final Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington (TC & WM EIS)*, which identifies three waste management alternatives for the proposed actions. The preferred action is Alternative 2: continued treatment of onsite LLW and MLLW in a single facility (i.e., the Integrated Disposal Facility-east).

3.2 Disposed Inventory Description

During this reporting period (FY 2022) (October 1, 2021 to September 30, 2022), waste was disposed in Trenches 31 and 34 of the 218-W-5 LLBG.

Performance-sensitive radionuclides disposed during this review period are summarized in Table 3 for uranium isotopes and in Table 4 for mobile radionuclides. Both are reported in this manner to support evaluation of the all-pathways performance objective, wherein waste acceptance criteria are defined for mobile radionuclides as specific inventory limits.

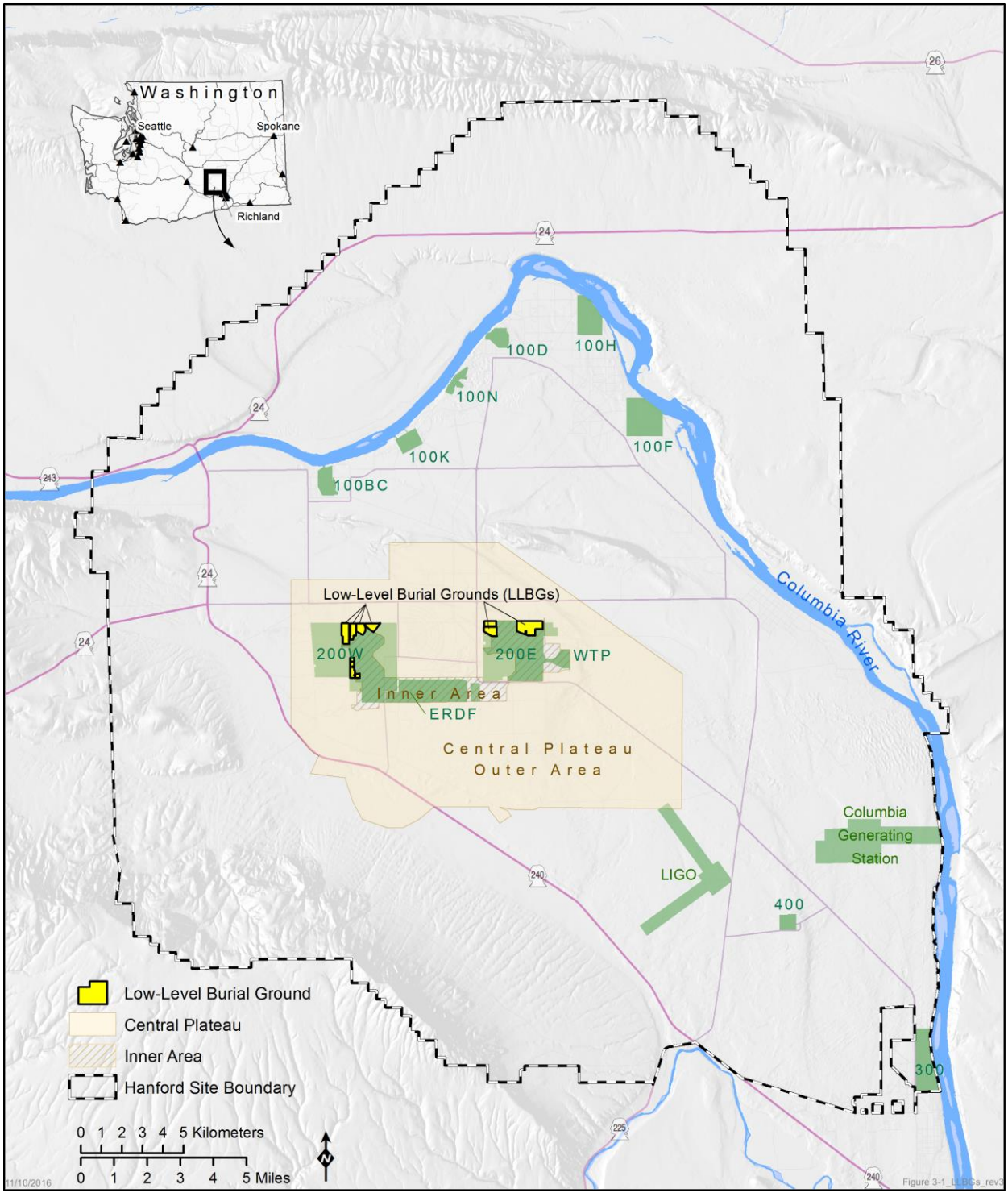


Figure 1. Location of the LLBGs

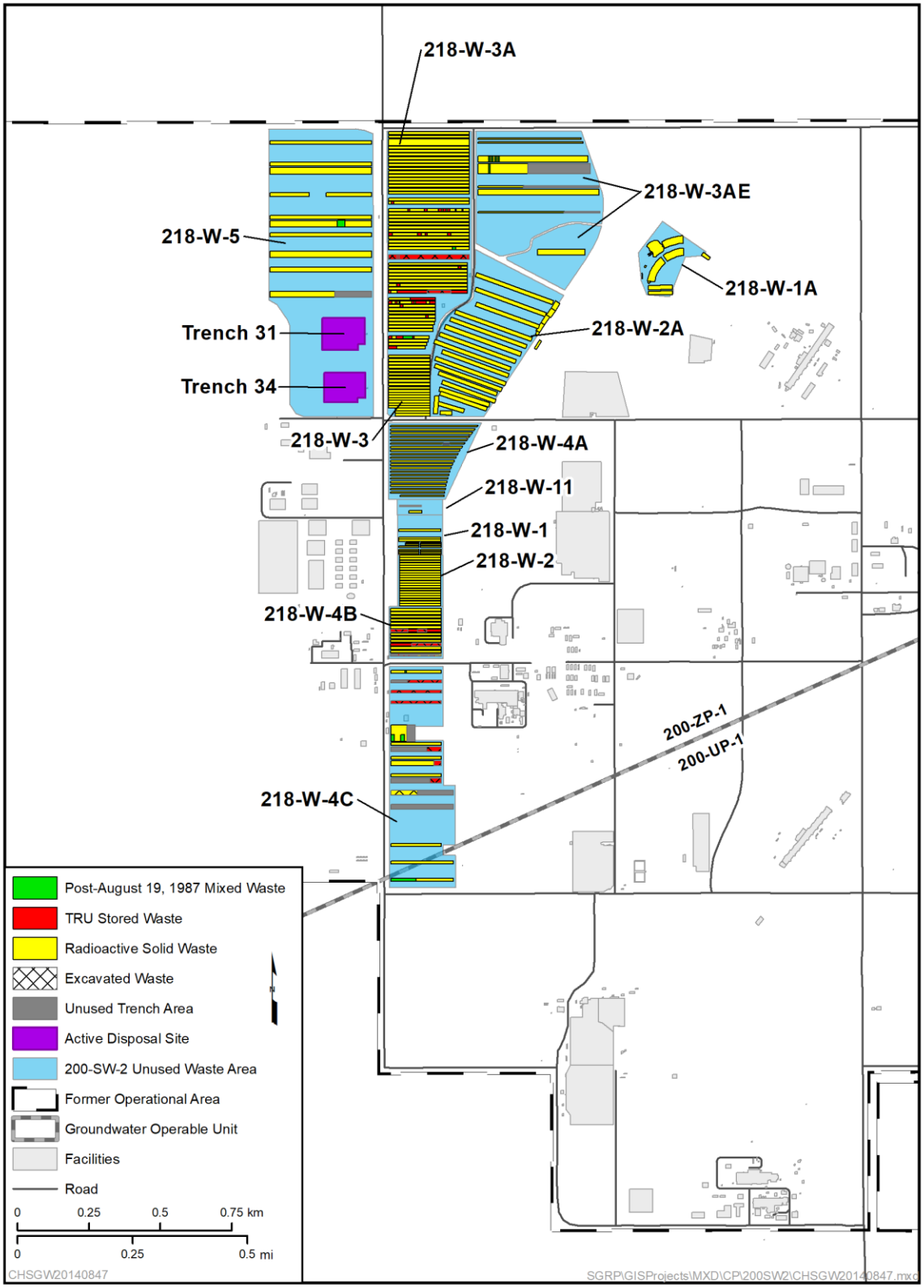


Figure 2. LLBGs and Other Solid Waste Disposal Sites in the 200 West Area

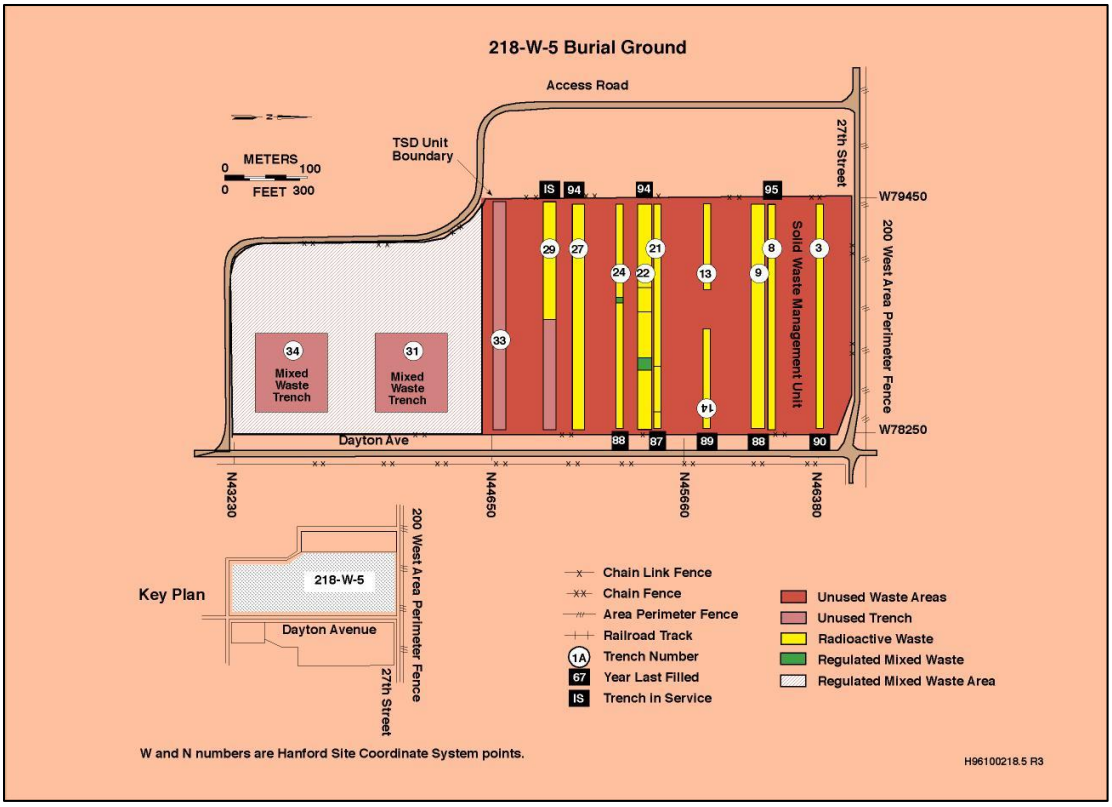


Figure 3. 218-W-5 Burial Ground Site Map

Source: DOE/RL-2017-24, *Hanford Site Environmental Report for Calendar Year 2016*.

Figure 4. Aerial Image of Trenches 31 (Bottom Left) and 34 (Upper Right)

Table 3. Uranium Waste Mass and Activity Disposed During FY 2022 (October 1, 2021 Through September 30, 2022) at the 218-W-5 Burial Ground

Trench	Uranium-232	Uranium-233	Uranium-234	Uranium-235	Uranium-236	Uranium-238	Total Uranium
Mass (g) of Disposed Uranium Waste							
31 (HIC)	1.00E-08	4.02E-03	6.43E-02	2.12E+00	5.58E-02	2.70E+02	2.72E+02
31 (no HIC)	0.00E+00	7.15E-06	7.35E-06	5.58E-03	2.64E-05	1.90E+00	1.91E+00
34 (HIC)	2.60E-07	2.23E-02	3.13E-01	1.05E+01	2.55E-01	1.35E+03	1.36E+03
34 (no HIC)	0.00E+00	3.76E-03	1.26E-01	1.83E+01	4.09E-02	3.58E+03	3.60E+03
Total	2.70E-07	3.00E-02	5.04E-01	3.09E+01	3.52E-01	5.21E+03	5.24E+03
Activity (Ci) of Disposed Uranium Waste							
31 (HIC)	1.80E-07	3.88E-05	3.99E-04	4.59E-06	3.60E-06	9.08E-05	5.37E-04
31 (no HIC)	2.00E-08	7.00E-08	4.00E-08	1.00E-08	0.00E+00	6.40E-07	7.80E-07
34 (HIC)	5.92E-06	2.14E-04	1.95E-03	2.28E-05	1.65E-05	4.55E-04	2.66E-03
34 (no HIC)	2.40E-07	3.62E-05	7.84E-04	3.94E-05	2.62E-06	1.20E-03	2.07E-03
Total	6.36E-06	2.89E-04	3.13E-03	6.68E-05	2.28E-05	1.75E-03	5.27E-03

HIC = high-integrity container

Table 4. Mobile Radionuclides Activity Disposed During FY 2021 (October 1, 2020, Through September 30, 2021) at the 218-W-5 Burial Ground

Trench	Tritium	Carbon-14	Chlorine-36	Selenium-79	Technetium-99	Iodine-129	Neptunium-237
Activity (Ci) of Disposed Mobile Radionuclide Waste							
31 (HIC)	2.30E-05	4.91E-06	0.00E+00	2.46E-05	9.70E-05	1.50E-07	2.25E-05
31 (no HIC)	2.22E-06	4.60E-07	0.00E+00	9.00E-08	3.42E-06	1.00E-08	2.00E-08
34 (HIC)	8.08E-04	1.73E-04	0.00E+00	1.55E-04	8.51E-02	7.44E-06	1.18E-04
34 (no HIC)	2.17E-04	1.04E-04	0.00E+00	6.80E-07	3.29E-02	1.71E-06	1.13E-04
Total	1.05E-03	2.82E-04	0.00E+00	1.80E-04	1.18E-01	9.31E-06	2.54E-04

HIC = high-integrity container

3.3 Projected Dose Estimates from the Disposed Waste to Evaluate Compliance with DOE O 435.1

Among the performance objectives defined in DOE M 435.1-1 and DOE-STD-5002-2017, *Disposal Authorization Statement and Tank Closure Documentation*, the primary objective is the all-pathways dose limit of 25 mrem/yr to an individual residing 100 m (328 ft) downgradient of the disposal facility. In the PA analysis (WHC-EP-0645), a multiple-exposure pathway agriculture scenario was used to generate dose estimates that were compared to the 25 mrem/yr limit. A single exposure groundwater consumption pathway was compared to a 4 mrem/yr drinking water limit. For all radionuclides (except chlorine-36), calculations showed higher doses with respect to the 4 mrem/yr drinking water limit for the same inventory, making that limit more stringent; therefore, drinking water dose results are presented in this report. Collective dose estimates for uranium and the combined inventories of mobile radionuclides are provided in Section 3.3.1 for comparison with the 25 mrem/yr all-pathways limit and the 4 mrem/yr drinking water limit.

The analyses also show that requirements in HNF-EP-0063, *Hanford Site Solid Waste Acceptance Criteria*, are satisfied; consequently, no special analyses or reviews were needed. For the all-pathways performance objective, waste acceptance criteria are defined for mobile radionuclides as specific inventory limits that correspond to inventory estimated to provide the maximum allowable dose when leached from the facility and transported to a 100 m (328 ft) downgradient well. The limits are expressed indirectly in the LLBG waste acceptance criteria (Table A-2 in HNF-EP-0063) as trigger values (radionuclide-specific concentrations) calculated on a package-by-package basis. If a package contains any radionuclides exceeding this value, a review of the disposal criteria is initiated to determine if additional disposal requirements beyond normal are needed. Annual summaries (such as this one) are then completed to show that the performance objective and inventory limits have not been exceeded. Compliance demonstration is based on dose estimates for the entire facility, as it now exists. Cumulative groundwater drinking dose estimates are provided for the 200 West Area LLBGs and for individual trenches in the 200 West Area LLBGs in Section 3.3.1.

The next most significant compliance requirement in DOE M 435.1-1 is the inadvertent intruder limit. A dose limit of 100 mrem/yr from chronic exposure or 500 mrem from acute exposure was defined for an inadvertent intruder who might be exposed to waste in the disposal facility. In the PA analysis, it was shown that the 100 mrem/yr chronic dose limit was the more limiting alternative (WHC-EP-0645). Therefore, the chronic exposure standard was adopted for comparing dose results and establishing waste acceptance criteria that are quantified in the LLBG waste acceptance criteria (Table A-2 in HNF-EP-0063) as radionuclide-specific concentration limits (Ci/m^3) for two categories of waste (Categories 1 and 3). The waste acceptance criteria also specify that Category 3 waste, which contains radionuclides at higher concentrations, must be grouted or placed in high-integrity containers or equivalent. The trench-by-trench breakdown was not included in the PA, but a total burial ground dose was provided in which radionuclide concentrations were calculated based on total burial ground inventory and total waste volume disposed.

Dose estimates from the inventory listed in Table 5 and Table 6 are summarized and explained in the following sections for each of the primary criteria. The dose estimates assume that Category 3 conditions will ultimately be the end-state condition (e.g., a final burial ground cap is placed over the disposal trenches to create a 5 m [16.4 ft] layer over waste and limit infiltration to no more than 0.5 cm/yr [0.2 in./yr]). Waste disposal configurations that have enhanced isolation from the hydrogeologic environment (primarily placement in high-integrity containers or equivalent) have also been incorporated into the calculations.

Table 5. Category 3 Groundwater Peak Dose Estimates by Burial Ground for Disposed Inventory

Burial Ground	Uranium Dose	Mobile Radionuclide Peak[a] Dose		Estimated Peak[a] Total Dose[d]
		Reported[b]	Estimated[c]	
Dose from Waste Disposal from Inception Through FY 2021 (September 27, 1988–September 30, 2021)				
200 West Area	1.37E-01	5.51E-02	2.54E-02	2.18E-01
Dose from Waste Disposal During FY 2022 (October 1, 2021–September 30, 2022)				
200 West Area	1.24E-05	6.97E-04	1.78E-05	7.27E-04
Dose from Total Waste Disposal from Inception Through FY 2022 (September 27, 1988–September 30, 2022)				
200 West Area	1.37E-01	5.58E-02	2.54E-02	2.19E-01

Note: Groundwater dose values are reported in mrem/yr.

a. Peak doses were reported for 10,000 years postclosure in the performance assessment prepared under DOE Order 5820.2A, *Radioactive Waste Management*. The updated estimates reported in this table are for 10,000 years as well, which differs from the 1,000-year performance objective evaluation period presently required under DOE O 435.1, *Radioactive Waste Management*; a 1,000-year dose estimate is not available.

b. Reported dose is calculated for the reported inventory of mobile radionuclides.

c. Estimated dose is calculated for estimates of the mobile radionuclide inventory that may be present in disposed waste at trace levels but has not been reported or measured, using a scaling factor derived from reactor production ratios of cesium-137 concentrations to other contaminants (Appendix B in WHC-EP-0645, *Performance Assessment for the Disposal of Low-Level Waste in the 200 West Area Burial Grounds*). The concept is that in lieu of direct characterization information, the unknown mobile radionuclide inventory can be conservatively estimated by assuming that reactor production ratios are maintained in waste.

d. Estimated total dose is the sum of uranium dose, reported mobile radionuclide dose, and estimated radionuclide dose.

FY = fiscal year

Table 6. Category 3 Groundwater Peak Dose Estimates by Trench for Disposed Inventory, September 27, 1988 Through September 30, 2022

Burial Ground	Trench[a]	Uranium Dose (mrem/yr)		Mobile Radionuclide Dose (mrem/yr)				Total Peak[c] Dose (mrem/yr)
		09/27/1988–09/30/2021	10/01/2021–09/30/2022	09/27/1988–09/30/2021	Key Radionuclides[b]	10/01/2021–09/30/2022	Key Radionuclides[b]	
218-W-3A	19	3.39E+00	—	4.50E-02	Carbon-14	—	—	3.44E+00
	3S	1.50E-01	—	5.60E-04	Technetium-99	—	—	1.51E-01
	46	2.20E-01	—	5.30E-14	Carbon-14	—	—	2.20E-01
	49	5.00E-01	—	4.29E-02	Technetium-99	—	—	5.43E-01
	6S	1.50E-03	—	2.20E-04	Iodine-129	—	—	1.72E-03
218-W-3AE	3	2.23E-02	—	2.90E-03	Technetium-99	—	—	2.52E-02
	8[d]	1.26E-01	—	6.03E-01	Technetium-99, carbon-14	—	—	7.30E-01
	13	1.38E-03	—	3.72E-04	Technetium-99, carbon-14	—	—	1.75E-03
	16	2.61E+00	—	2.27E-02	Technetium-99, carbon-14	—	—	2.63E+00
	26	1.10E+00	—	1.69E-02	Technetium-99	—	—	1.12E+00
218-W-4C	14[d]	5.25E-01	—	1.61E-01	Carbon-14, technetium-99	—	—	6.88E-01
	20	2.12E-04	—	4.60E-02	Technetium-99	—	—	4.62E-02
	33	5.63E-02	—	1.58E-02	Carbon-14, technetium-99, iodine-129	—	—	7.21E-02
	48	7.00E-04	—	1.10E-09	Technetium-99	—	—	7.00E-04
	53	2.00E-03	—	7.80E-04	Technetium-99	—	—	2.78E-03
	NC	1.10E-02	—	6.95E-01	Carbon-14	—	—	7.06E-01

Table 6. Category 3 Groundwater Peak Dose Estimates by Trench for Disposed Inventory, September 27, 1988 Through September 30, 2022

Burial Ground	Trench[a]	Uranium Dose (mrem/yr)		Mobile Radionuclide Dose (mrem/yr)				Total Peak[c] Dose (mrem/yr)
		09/27/1988–09/30/2021	10/01/2021–09/30/2022	09/27/1988–09/30/2021	Key Radionuclides[b]	10/01/2021–09/30/2022	Key Radionuclides[b]	
218-W-5	3	1.00E-04	—	5.40E-03	Carbon-14, iodine-129	—	—	5.50E-03
	8	3.80E-01	—	8.80E-05	Technetium-99	—	—	3.80E-01
	13	3.00E-03	—	1.53E-01	Iodine-129, carbon-14	—	—	1.56E-01
	14	5.40E-01	—	8.00E-03	Carbon-14	—	—	5.48E-01
	22	1.08E+00	—	4.41E-01	Iodine-129, technetium-99	—	—	1.52E+00
	24	8.47E-04	—	3.00E-03	Carbon-14	—	—	3.85E-03
	27	1.32E+0	—	1.11E-01	Iodine-129, carbon-14	—	—	1.43E+00
	29	8.52E-01	—	1.83E-01	Carbon-14, technetium-99	—	—	1.04E+00
	31[d]	3.15E-03	1.78E-07	1.29E-01	Technetium-99, iodine-129, carbon-14	2.90E-05	Technetium-99	1.32E-01
	33	3.00E-02	—	1.04E-01	Carbon-14, technetium-99	—	—	1.34E-01
	34[d]	6.32E-02	2.14E-04	8.20E-02	Technetium-99, iodine-129	1.20E-02	Technetium-99	1.57E-01

Notes:

a. All trenches are inactive, except for Trenches 31 and 34 in the 200-W-5 Burial Ground.

b. Key radionuclides are those that contribute substantially to the mobile radionuclide dose; other contributors comprise less than 1% of total radiological dose.

c. Peak doses were reported for 10,000 years postclosure in the performance assessment prepared under DOE Order 5820.2A, *Radioactive Waste Management*. The updated estimates reported in this table are for 10,000 years as well, which differs from the 1,000-year performance objective evaluation period that is presently required under DOE O 435.1, *Radioactive Waste Management*; a 1,000-year dose estimate is not available.

d. Trench contains high-integrity containers or stabilized waste.

3.3.1 Groundwater Dose Estimates

In the PA analysis, a methodology was developed to evaluate groundwater dose for any size disposal facility of interest within the boundaries of the collective burial grounds (Section 3.2.3.1 in WHC-EP-0645). An assumption was made that any trench or set of trenches could be divided into a series of waste volume slices parallel to groundwater flow. Dose estimates from the waste configuration of interest were then derived from an average slice evaluation. This approach was taken to facilitate evaluating future changes in disposal facility size that cannot be predicted. All aspects of the disposal configuration continue to be represented adequately. In addition to the burial ground dose estimates used to determine compliance with DOE O 435.1, the methodology has been used to evaluate doses on a trench-by-trench basis in the 200 West Area LLBGs as an aid to the routine day-to-day waste acceptance process.

3.3.1.1 Burial Ground Drinking Water Dose Estimates

When calculating contaminant release and transport, it is necessary to make numerous averaging and simplifying assumptions because much of the environmental heterogeneity present cannot be characterized or modeled realistically. To calculate the groundwater drinking or all-pathways dose, a simplifying assumption of uniform radionuclide distribution across the disposal facility axis perpendicular to the general direction of groundwater flow was made, although it is acknowledged that specific waste volumes with much higher contaminant concentrations exist.

This approach does not explicitly model the current period in which the LLBGs are only covered with an interim cover that likely permits greater average recharge than that assumed for Category 3 conditions. Qualitative arguments have been made in the PA analysis (Section 3.2.2.1 of WHC-EP-0645) that conservative assumptions used in the model accommodate this potentially nonconservative condition. Most waste packages used since September 26, 1988, are sufficiently sturdy to delay contact of infiltrating water with radionuclides through the operational period, so minimal release is expected before placement of the final cover several decades from now. This scenario is particularly the case with Category 3 waste that is placed in sealed or grouted concrete boxes and contains most of the PA-sensitive inventory. In the Hanford Site Composite Analysis (PNNL-11800; PNNL-11800 Addendum 1), a sensitivity case was considered in which an enhanced recharge rate of 7.5 cm/yr (3 in./yr) through the LLBGs was assumed during the operating period (approximately 40 years), followed by infiltration rates controlled by a final cover (0.5 cm/yr [0.2 in./yr]). It was concluded that the brief period of increased infiltration did not have a significant effect on estimated downstream groundwater concentrations and therefore dose estimates.

In Table 5, the drinking water dose estimates are divided into two different periods by major contributors (uranium isotopes versus other mobile radionuclides). The two different periods distinguish between inventory disposed from facility inception (September 27, 1988) through FY 2021 (September 30, 2021; prepared in the previous annual report, DOE/RL-2021-57) and from inventory disposed in FY 2022 (this reporting period). Summing the dose estimates from these two periods yields the total dose estimates that are reported in Table 5.

Compared to a 4 mrem/yr limit, the total dose for each burial ground group shows that compliance with the performance goal has been maintained.

Dose estimates for the less-stringent all-pathways scenario (not reported) show the same trends as the groundwater drinking scenario; in both cases, the total estimates fall below performance objective values of 4 mrem/yr and 25 mrem/yr, respectively. Table 5 shows the drinking water doses for comparison to the 4 mrem/yr limit.

3.3.1.2 Trench-by-Trench Dose Calculations for the 200 West Area Low-Level Burial Grounds

Dose estimates are also divided by trench for the 200 West Area LLBGs, with the goal of preventing potential dose estimates more than the 4 mrem/yr limit for any trench. The trench-by-trench calculations are completed as part of the waste acceptance process. The calculations are not a part of compliance demonstration, but they are a means of ensuring that day-to-day waste disposal will not cause a cumulative disposal that exceeds the overall LLBG limit. This strategy works because dose calculations are proportional to inventory distribution assumptions and become larger as the assumed inventory distribution becomes more restrictive (e.g., when the trench-by-trench analysis is performed, rather than all trenches considered as one large unit).

It is noted that the dose estimates in the PA were based on trench alignment and general groundwater flow direction for contemporary groundwater flow conditions (1990s). Currently, the groundwater gradients are different due to the strong local perturbation effects of the 200 West pump and treat system. However, the PA predicts that releases from the 200 West Area LLBGs will reach groundwater thousands of years in the future, long after the perturbation of local groundwater direction changes due to pump and treat operations that will end in about a century under current remedial plans. Thus, changes in groundwater flow direction at present are not impactful to the PA.

Table 6 summarizes the trench-by-trench groundwater dose projections. The dose calculation methodology is identical to the whole burial ground calculations discussed previously, except the trench-specific waste inventories, waste volumes, and waste areas are considered one trench at a time. Doses are provided for each trench for the two periods that include all disposed waste, and a total dose is also provided. Uranium doses are provided separately from other mobile radionuclides.

All trenches have projected dose estimates that fall below the 4 mrem/yr goal, and most of the trenches are full. Overall, the LLBG groundwater-related dose estimates are dominated by uranium, technetium-99, and carbon-14.

3.3.2 Inadvertent Intruder Dose Estimates

Compliance with the inadvertent intruder waste acceptance limits is determined by comparing projected intruder dose from a trench waste volume and inventory with a 100 mrem/yr chronic dose limit. Occasionally, individual waste packages are received that approach or exceed the Category 3 limits. In these cases, written justification for alternative waste concentration averaging is provided to the waste disposal organization by the PA contact. The likelihood that an inadvertent intruder would exhume the package with the high concentration inventory is considered very small; therefore, averaging based on trench volume is a reasonable approach to compliance evaluation. As with the groundwater dose evaluation, the Category 3 conditions are assumed to exist in the postclosure period. Separate periods are not considered for these estimates because the calculated doses apply to cumulative inventories and waste volumes.

In Table 7, trench volumes, activities of the largest contributors, and dose fractions for the inadvertent intruder dose estimates are provided. Dose estimates are 100 times the sum of fractions dose. In most trenches, dose estimates are less than 1 mrem/yr, far below the 100 mrem/yr limit. Where uranium is present in significant quantities, it usually provides the largest projected dose. The clearest examples of uranium waste influence on the intruder dose estimate are found in Trench 8 (218-W-3AE Burial Ground), Trench 14 (218-W-4C Burial Ground), and Trench 34 (218-W-5 Burial Ground); otherwise, cesium-137 and/or strontium-90 provide the largest dose.

Table 7. Estimated Intruder Dose Fraction by Trench for Waste Disposed September 27, 1988 Through September 30, 2022

Burial Ground	Trench	Volume (m^3)	Inventory (Ci)			Concentration (Ci/m^3)			Fraction of Category 3 Limit			Total Dose Fraction
			Cesium-137	Strontium-90	Uranium	Cesium-137	Strontium-90	Uranium	Cesium-137	Strontium-90	Uranium	
218-W-3A	19	1616	1.91E+01	1.27E+00	1.70E-02	1.18E-02	7.86E-04	1.05E-05	9.84E-07	1.46E-08	2.10E-05	2.20E-05
	3S	138	5.83E+01	1.04E+02	9.18E-02	4.22E-01	7.50E-01	6.66E-04	3.52E-05	1.39E-05	1.33E-03	1.38E-03
	46	98	2.60E-03	2.90E-03	1.10E-03	2.65E-05	2.96E-05	1.12E-05	2.21E-09	5.48E-10	2.24E-05	2.25E-05
	49	2522	1.05E+03	2.75E+02	1.34E-01	4.16E-01	1.09E-01	5.30E-05	3.47E-05	2.02E-06	1.06E-04	1.43E-04
	6S	63	1.01E-01	5.00E-06	8.76E-04	1.60E-03	7.94E-08	1.39E-05	1.34E-07	1.47E-12	2.78E-05	2.79E-05
218-W-3AE	3	397	2.29E+04	2.26E+04	7.68E-01	5.76E+01	5.69E+01	1.94E-03	4.80E-03	1.05E-03	3.87E-03	9.72E-03
	5	30	2.65E-02	0.00E+00	0.00E+00	8.83E-04	0.00E+00	0.00E+00	7.36E-08	0.00E+00	0.00E+00	7.36E-08
	8	8301	3.37E+03	2.01E+03	2.30E+02	4.05E-01	2.43E-01	2.77E-02	3.38E-05	4.49E-06	5.55E-02	5.55E-02
	13	2143	9.12E+04	1.46E+04	1.47E-02	4.26E+01	6.81E+00	6.88E-06	3.55E-03	1.26E-04	1.38E-05	3.69E-03
	16	852	3.40E+04	2.23E+04	4.75E+00	3.99E+01	2.62E+01	5.58E-03	3.33E-03	4.84E-04	1.12E-02	1.50E-02
	26	2985	7.36E+02	3.76E+02	7.55E-02	2.47E-01	1.26E-01	2.53E-05	2.05E-05	2.33E-06	5.06E-05	7.35E-05
218-W-4C	14	22154	3.86E+01	1.31E+02	8.63E+01	1.74E-03	5.91E-03	3.89E-03	1.45E-07	1.09E-07	7.79E-03	7.79E-03
	20	15	3.68E-01	3.62E-01	1.00E-04	2.45E-02	2.42E-02	6.67E-06	2.05E-06	4.47E-07	1.33E-05	1.58E-05
	33	621	1.09E-01	1.09E-01	1.23E-02	1.76E-04	1.76E-04	1.98E-05	1.46E-08	3.25E-09	3.96E-05	3.96E-05
	48	526	4.40E-03	7.50E-02	8.61E-04	8.37E-06	1.43E-04	1.64E-06	6.97E-10	2.64E-09	3.27E-06	3.28E-06
	53	1034	2.15E+02	8.32E+01	1.34E-03	2.08E-01	8.05E-02	1.30E-06	1.73E-05	1.49E-06	2.60E-06	2.14E-05
	58	292	2.15E+02	2.13E+02	0.00E+00	7.36E-01	7.30E-01	0.00E+00	6.14E-05	1.35E-05	0.00E+00	7.49E-05
	NC	905	2.40E-01	3.10E-02	1.30E-02	2.65E-04	3.43E-05	1.44E-05	2.21E-08	6.34E-10	2.88E-05	2.88E-05

Table 7. Estimated Intruder Dose Fraction by Trench for Waste Disposed September 27, 1988 Through September 30, 2022

Burial Ground	Trench	Volume (m^3)	Inventory (Ci)			Concentration (Ci/m^3)			Fraction of Category 3 Limit			Total Dose Fraction
			Cesium-137	Strontium-90	Uranium	Cesium-137	Strontium-90	Uranium	Cesium-137	Strontium-90	Uranium	
218-W-5	3	608	1.58E+02	1.86E+02	7.21E-03	2.60E-01	3.06E-01	1.19E-05	2.17E-05	5.67E-06	2.37E-05	5.10E-05
	8	1892	2.03E+03	8.33E+02	3.34E-03	1.07E+00	4.40E-01	1.76E-06	8.92E-05	8.16E-06	3.53E-06	1.01E-04
	13	839	8.18E-01	1.85E-01	4.82E-03	9.75E-04	2.21E-04	5.74E-06	8.12E-08	4.08E-09	1.15E-05	1.16E-05
	14	412	2.50E-01	3.24E-01	8.90E-01	6.07E-04	7.86E-04	2.16E-03	5.06E-08	1.46E-08	4.32E-03	4.32E-03
	22	6972	5.80E+01	3.45E+01	7.70E+01	8.32E-03	4.95E-03	1.11E-02	6.93E-07	9.16E-08	2.21E-02	2.21E-02
	24	153	1.10E-02	0.00E+00	4.00E-04	7.19E-05	0.00E+00	2.61E-06	5.99E-09	0.00E+00	5.23E-06	5.23E-06
	27	11788	7.20E+01	1.79E+02	1.70E+01	6.11E-03	1.51E-02	1.44E-03	5.09E-07	2.81E-07	2.88E-03	2.88E-03
	29	19671	1.71E+02	8.55E+01	5.35E+00	8.70E-03	4.35E-03	2.72E-04	7.25E-07	8.05E-08	5.44E-04	5.45E-04
	31*	6704	5.22E+03	5.46E+02	2.32E+00	7.79E-01	8.14E-02	3.47E-04	6.49E-05	1.51E-06	6.93E-04	7.60E-04
	33	25406	1.56E+00	1.44E+00	7.64E-02	6.15E-05	5.66E-05	3.01E-06	5.12E-09	1.05E-09	6.01E-06	6.02E-06
	34	7703	1.20E+02	1.03E+05	6.85E+02	1.55E-02	1.33E+01	8.89E-02	1.29E-06	2.47E-04	1.78E-01	1.78E-01

Notes:

The Category 3 limits are from Table A-2 in HNF-EP-0063, *Hanford Site Solid Waste Acceptance Criteria*.

*Trench 31 contains 2.04 Ci of radium-226, giving a current concentration of 3.06E-04 Ci/m^3, which is 0.7 mrem (a total fraction of 7E-03).

The projected total burial ground inadvertent intruder doses provided in Table 7 are consistent with the doses provided in the PA analysis (WHC-EP-0645) and are like individual trench dose estimates. On this scale of waste-volume averaging, the estimated doses for each burial ground are well below the compliance limit.

3.4 Other Performance Objectives

Two other limits were considered in the PA analysis: the air emissions dose (10 mrem/yr) and radon flux (20 pCi/m^2/s; WHC-EP-0645). Table 8 provides the estimated doses for comparison to these two limits as well as a summary of the groundwater contamination and inadvertent intruder doses. In the PA analysis, the potential sources of air contamination were concluded to be carbon-14 and tritium. Given the limited inventory of carbon-14, decay of tritium, and partitioning of both elements between liquid and gas, it was shown that dose estimates would be very small (Section 4.3.1 of WHC-EP-0645). In the case of a Category 3 closure condition assumption (exposure at 500 years), it was concluded that the conditions needed for carbon-14 to provide an atmospheric dose (e.g., delayed beyond 100 years followed by complete and instantaneous release) were unrealistic, and hydrogen-3 (tritium) would have decayed to trivial amounts; therefore, no dose from an atmospheric release was projected. Negligible increases in estimated radon flux were calculated from parent isotopes of uranium disposed in this reporting period. All increases in dose and flux during this period are negligible with respect to those from the previous reporting period.

Table 8. Comparison of Dose or Flux Estimates with Performance Objectives

Performance Objective	Exposure Pathway	Estimated Peak Dose or Flux[a,b] 200 West Area
25 mrem/yr	Groundwater, all pathways	0.4
4 mrem/yr	Groundwater, drinking	0.2
100 mrem/yr	Chronic inadvertent intruder	1.8
20 pCi/m^2/s at 10,000 years	Radon emission	0.3
10 mrem yr	Air contaminant	Nil

a. All estimates are made assuming Category 3 conditions as the final state of the low-level burial grounds. Potential doses from current and projected inventory are summed. All projected inventory and associated dose are assumed to go into the 200 West Area Low-Level Burial Grounds. Units of measure of dose/flux values are the same as the corresponding performance objective.

b. Peak doses were reported for 10,000 years postclosure in the performance assessment prepared under DOE Order 5820.2A, *Radioactive Waste Management*. The updated estimates reported in this table are for 10,000 years as well, which differs from the 1,000-year performance objective evaluation period presently required under DOE O 435.1, *Radioactive Waste Management*; a 1,000-year dose estimate is not available.

Other criteria in the LLBG waste acceptance criteria (HNF-EP-0063) address disposal in a physically stable configuration with minimal void space, minimal gas emission, and elimination of pyrophoric characteristics. These criteria are also used to minimize long-term subsidence, and these requirements are being administered by LLBG operations and typically involve solidification or void-fill processes. As necessary, waste packages are grouted or placed in concrete boxes that are high-integrity containers or equivalent. Surveillance for local subsidence is performed routinely by LLBG staff, and any cavities that form are filled in with dirt or grout.

3.5 Conditional Approval Requirements

All conditional approval requirements have been completed (Scott, 2001).

3.6 Conclusions

This review concludes that as of September 30, 2022, disposal practices and waste inventories disposed in the active LLBGs comply with performance objectives. The current waste disposal procedures and waste management practices are sufficient to maintain compliance with the performance objectives. None of the information presented in this report indicates that the PA must be changed to demonstrate compliance with DOE O 435.1. Information collected across the Hanford Site on key assumptions affecting performance estimates (e.g., engineered barrier control of infiltration, and rates and sorption of key radionuclides) over the past two decades suggests some substantially conservative assumptions in the currently approved version of the PA analysis (WHC-EP-0645); thus, improved facility performance is expected.

4 Monitoring

Monitoring of water and air for contaminants (both radiological and chemical) is an ongoing program across the Hanford Site. In certain locations, vadose zone characterization is also being conducted, primarily at remediation sites and soil columns contaminated by tank leaks. Groundwater monitoring wells and air sampling stations are located near the 200 West Area LLBGs and are routinely monitored for contaminants as part of the Hanford sitewide monitoring program. With respect to the requirements of DOE M 435.1-1, particular attention is paid to the following mobile contaminants: technetium-99, uranium, iodine-129, and tritium. In this program, the 200 West Area LLBGs are divided into two monitoring groups or low-level waste management areas (LLWMAs): LLWMA-3 (218-W-3A, 218-W-3AE, and 218-W-5) and LLWMA-4 (218-W-4C). Summary documents are issued annually that describe and interpret the collected information. The latest summary of groundwater monitoring information (DOE/RL-2021-51, *Hanford Site Groundwater Monitoring Report for 2021*) describes data collected through calendar year (CY) 2021. Data from these sources are summarized in the following sections: LLWMA 3 (Section 4.1) and LLWMA 4 (Section 4.2). It represents the latest available information for purpose of this annual summary report.

Table 9 and Table 10 summarize the compliance monitoring and performance monitoring evaluation, respectively. Trend plots from the groundwater monitoring wells do not indicate any groundwater quality impacts influenced by the waste disposed at the LLBGs (see discussion in Sections 4.1 and 4.2). In addition, based on operation of leachate collection system and leachate sampling at Trench 31 and 34 along with daily maintenance of the disposal facility all engineering systems appear to be performing as expected. No leakage from the lined disposal facility have been reported till date. The performance monitoring for the unlined trenches is not feasible due to lack of active monitoring of the vadose zone in and around the disposed waste.

Air monitoring results for CY 2021 are summarized in DOE/RL-2022-08*, Hanford Annual Site Environmental Report for Calendar Year 2021*, specifically Section 6.0, “Air Monitoring.” The information discussed in Section 4.3 was drawn from that report.

Table 9. Compliance Monitoring

Disposal Facility or Unit	Monitoring Type	Monitoring Results and Trends	Performance Objective Measure or Other Regulatory Limit	Action Level[a]	Action Taken	PA Impacts
LLWMA-3/218-W-3A, 218-W-3AE, and 218-W-5	Groundwater[b]	No indication of contamination from LLBGs	DWS	DWS	None	None
LLWMA-4/218-W-4C	Groundwater[b]	No indication of contamination from LLBGs	DWS	DWS	None	None
200 West Area	Air[c]	Stable; comparable to widespread background concentrations	10 mrem/yr (40 CFR 61)	--	None	None

Reference: 40 CFR 61, "National Emission Standards for Hazardous Air Pollutants."

a. To ensure consistency, action levels are being considered as the standards given in Table 4.1 of DOE/RL-2000-72, *Performance Assessment Monitoring Plan for the Hanford Site Low-Level Burial Grounds*.

b. DOE/RL-2021-51, *Hanford Site Groundwater Monitoring Report for 2021*.

c. DOE/RL-2022-08, *Hanford Annual Site Environmental Report for Calendar Year 2021*.

DWS = drinking water standard
LLBG = low-level burial ground
LLWMA = low-level waste management area
PA = performance assessment

Table 10. Performance Monitoring

Disposal Facility/Unit	Monitoring Purpose	Monitoring Results and Trends	PA Expected Behavior	Action Taken	PA Impacts
LLWMA-3/218-W-3A, 218-W-3AE, and 218-W-5	Radionuclide transport	No indication of leak from the lined facility All containers in Trench 31 and 34 are intact	No transport expected from the lined facility and limited transport from the unlined trenches	None	None
LLWMA-4/218-W-4C	Radionuclide transport	None available for the vadose zone			

LLWMA = low-level waste management area
PA = performance assessment

4.1 Low-Level Waste Management Area 3

Groundwater monitoring of the well network at LLWMA-3 (Figure 5) within the 200-ZP-1 Operable Unit in the 200 West Area continued during CY 2022 under *Resource Conservation and Recovery Act of 1976* (RCRA) and *Atomic Energy Act of 1954* (AEA) requirements (DOE/RL-2009-68, *Interim Status Groundwater Monitoring Plan for the LLBG WMA-3*). Additional monitoring wells will be added in the near future to the monitoring network.

Due to water-level declines, the only previous upgradient well on the western side of the LLWMA (299-W9-1) went dry in 2000. In 2011, the U.S. Department of Energy, Richland Operations Office (DOE-RL) drilled and installed new upgradient well 299-W9-2. Water levels are measured each time a groundwater sample is collected, and sitewide water-level measurements are collected annually in March. The water table increased in this region in 2012 through 2015 in response to groundwater injection. Three

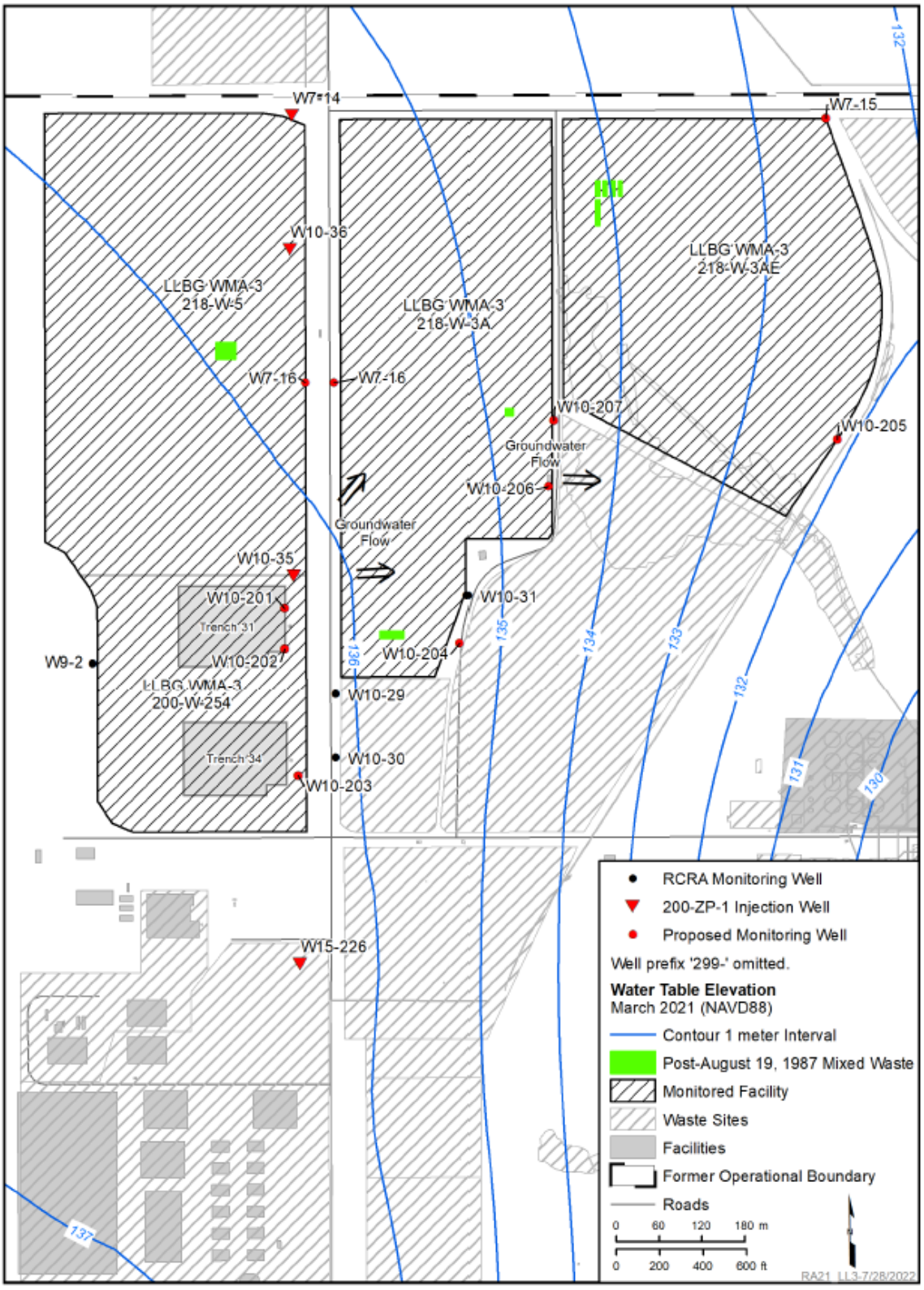
200 West Area injection wells (W7-14, W10-35, and W10-36) are located within the boundaries of LLWMA-3 (Figure 5) and another injection well is located east of LLWMA. The groundwater flow direction across LLWMA-3 is eastward, and the average gradient was 3.0×10^{-3} m/m, with an estimated velocity of 0.24 m/d (0.79 ft/d) (Table B-2 in DOE/RL-2020-60). Beneath Trenches 31 and 34, the average gradient is 4.5×10^{-3} m/m, and the estimated velocity is 0.35 m/d (1.1 ft/d).

During the reporting period, all wells were sampled as scheduled for indicator parameters (pH, specific conductance, total organic carbon [TOC], and total organic halides [TOX]) (Table B-43 in DOE/RL-2021-51). Carbon tetrachloride was observed above the primary drinking water standard (DWS) of 5 µg/L in downgradient wells 299-W10-29, 299-W10-30, and 299-W10-31. Nitrate (not a dangerous waste constituent) was observed above the DWS of 45 mg/L in downgradient well 299-W10-31. The 2021 results were consistent with previous data and indicate that the well is within the regional nitrate plume (DOE/RL-2021-51). Due to the 2019 critical mean exceedances, DOE-RL prepared and interim status groundwater assessment plan (DOE/RL-2019-32, *Interim Status Groundwater Quality Assessment Plan for the Low-Level Burial Grounds Waste Management Area-3*), and the plan was revised in June 2021 to update the monitoring well network, sampling frequency for the new wells, and constituents for the proposed new wells (DOE/RL-2019-32). As reported in previous Hanford Site groundwater monitoring reports, the specific conductance trend at well 299-W10-31 may be related to increasing nitrate concentrations at this well (likely caused by movement of the regional nitrate plume affected by ongoing pump and treat remediation).

As with other LLWMAs, DOE monitors for AEA radionuclides as described in DOE/RL-2000-72, *Performance Assessment Monitoring Plan for the Hanford Site Low-Level Burial Grounds*, iodine-129, technetium-99, uranium, and tritium were monitored semiannually in the upgradient and three downgradient RCRA monitoring wells. The concentrations for these analytes were below DWSs for all wells during 2021. Uranium concentrations were consistently less than 2 µg/L. Iodine-129 and technetium-99 in the LLBG WMA-3 monitoring wells were below the detection limits (DOE/RL-2021-51). The 2021 groundwater data do not indicate a release associated with 218-W-5 Burial Ground Trenches 31 and 34.

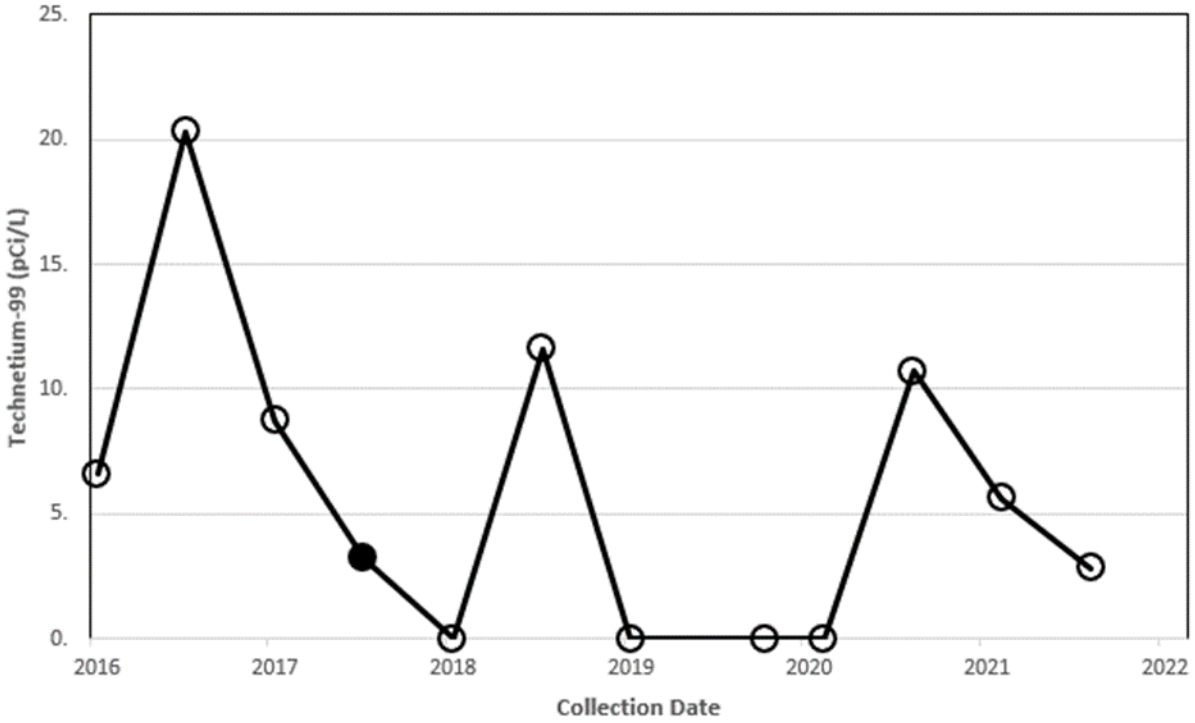
Figure 6 presents the monitored groundwater concentrations between 2016 and 2022 for technetium-99 at well 299-W9-2, which is located upgradient of LLWMA-3 (see Figure 5). Figure 7 shows the groundwater concentrations of technetium-99 for the same period at well 299-W10-30, which is located downgradient of LLWMA-3.

When comparing the monitoring concentrations for technetium-99 for the two wells (Figure 6 and Figure 7), it is observed that the monitored technetium-99 concentrations in the upgradient well were either nondetect or less than 5 pCi/L. Similarly, the monitored concentrations for technetium-99 for the downgradient well 299-W10-30 were either nondetect or below 15 pCi/L (Figure 7). These results demonstrate that there is no observable impact from LLWMA-3 on the monitored groundwater concentrations.



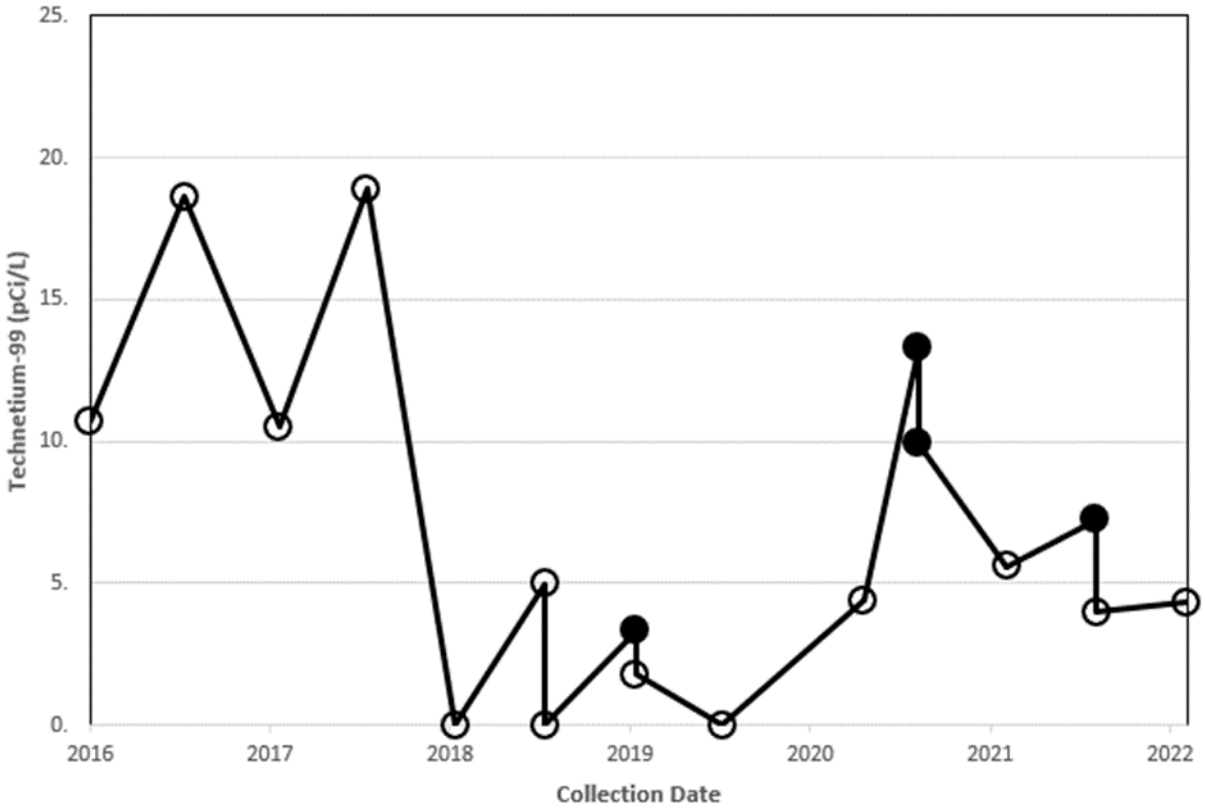
Sources: NAVD88, *North American Vertical Datum of 1988*; Figure 12-24 in DOE/RL-2021-51, *Hanford Site Groundwater Monitoring Report for 2021*.

Figure 5. Groundwater Monitoring Well Locations at LLWMA-3



Note: Open circle indicates nondetects.

Figure 6. Groundwater Monitoring Concentration Trend for Technetium-99 at Well 299-W9-2



Note: Open circle indicates nondetects.

Figure 7. Groundwater Monitoring Concentration Trend for Technetium-99 at Well 299-W10-30

4.2 Low-Level Waste Management Area 4

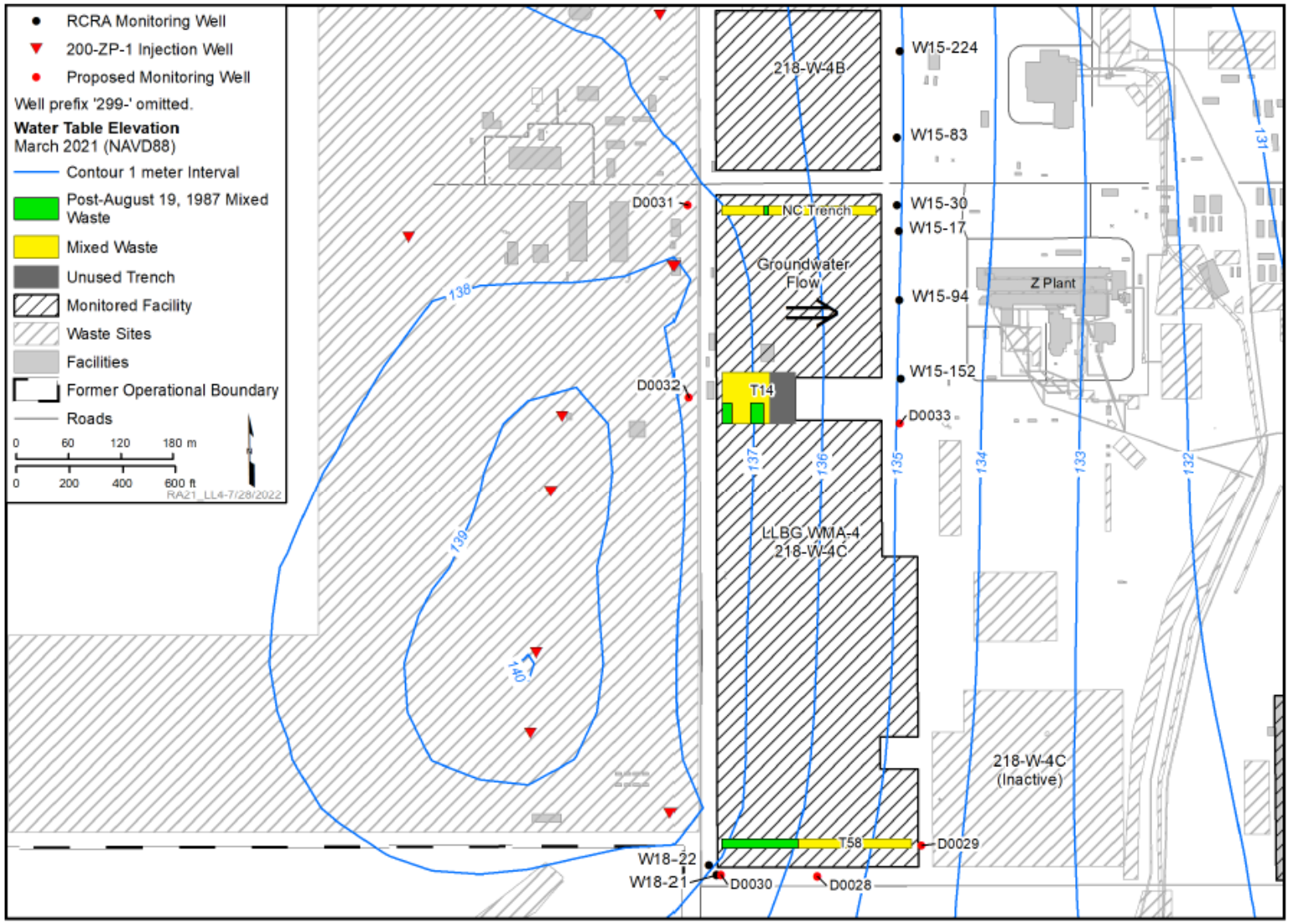
Groundwater monitoring of the well network at LLWMA-4 (Figure 8) within the 200-ZP-1 Operable Unit in the 200 West Area continued during CY 2020 under RCRA and AEA requirements (DOE/RL-2009-69, *Interim Status Groundwater Monitoring Plan for the LLBG WMA-4*). The monitoring network at LLWMA-4 includes six downgradient wells and one upgradient well (299-W18-22). The well network complies with RCRA groundwater monitoring requirements. Upgradient wells 299-W15-15 and 299-W18-23 went dry in 2008. The water level in upgradient well 299-W18-21 varies in response to changes in operation of nearby injection wells. As a result, insufficient water was available for collection during July 2016 sampling, and the pump was removed. Well 299-W18-21, screened at the top of the aquifer, varies in response to changes in operation of nearby injection wells. In 2021, the well was sampled with a bailer because it did not contain sufficient water to sample with a pump . An engineering evaluation report published in 2018 in support of final status monitoring recommended a modified network that includes several new wells (SGW-60584, *Engineering Evaluation Report for Low-Level Burial Grounds Waste Management Area-4 Green Islands Groundwater Monitoring*).

The pump and treat injection wells located west (upgradient) of LLWMA-4 have caused the water table to rise and increased the hydraulic gradient since injection began in 2012. The general direction of groundwater flow is east, the gradient magnitude in 2021 was 9.8×10^{-3} m/m, and the estimated average groundwater flow velocity was 0.66 m/d (2.2 ft/d) beneath the LLWMA (Table B-2 in DOE/RL-2021-51).

The well network was sampled in 2021 for indicator and site-specific parameters, including pH, specific conductance, TOC, and TOX (Table B-45 in DOE/RL-2021-51). During the January 2021 sampling event, TOC exceeded the critical mean in all but one of the monitoring wells. Confirmation split samples to verify the exceedance, collected in March 2021, returned irregular and inconclusive TOC results. A second confirmation sampling event, conducted in July 2021, returned TOC results below the critical mean value (1,640 µg/L) (Table B-46 in DOE/RL-2021-51). Nitrate concentrations were above the 45 mg/L DWS in one upgradient and five downgradient wells in 2021 (Table B-46 in DOE/RL-2021-51).

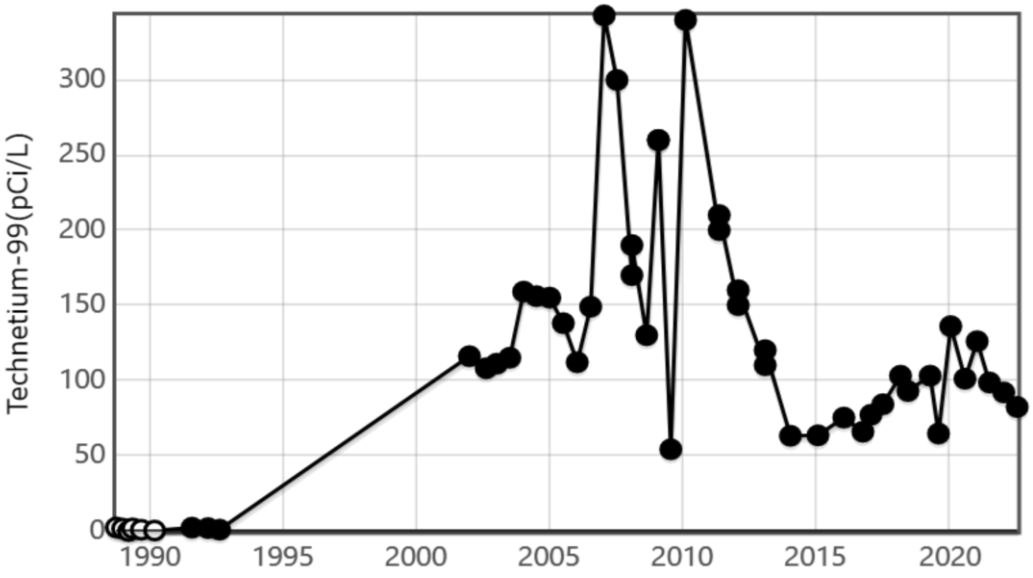
As with other LLWMAs, DOE monitors for AEA radionuclides (DOE/RL-2000-72). For LLBG WMA-4, technetium-99 concentrations remained well below 50% of the DWS. Uranium concentrations in upgradient well 299-W18-21 continued to decrease and are below the 30 µg/L DWS. Monitoring data for all AEA radionuclides indicate all contaminants of concern were below DWSs at LLWMA-4.

Figure 9 presents the long-term groundwater monitoring data for technetium-99 for well 299-W18-21 in LLWMA-4. Though well 299-W18-21 is not directly upgradient of LLWMA-4, but due to the locations of injection wells, it is the best available upgradient well. Figure 10 shows the technetium-99 groundwater concentrations collected from a downgradient well 299-W15-30. Both wells show influence of regional scale contamination from surrounding waste sources. However, over the past few years (2018-2021), the technetium-99 concentration in both wells has remained low (around 100 pCi/L) and the trends are similar indicating that there is no discernable impact from LLWMA-4 sources.



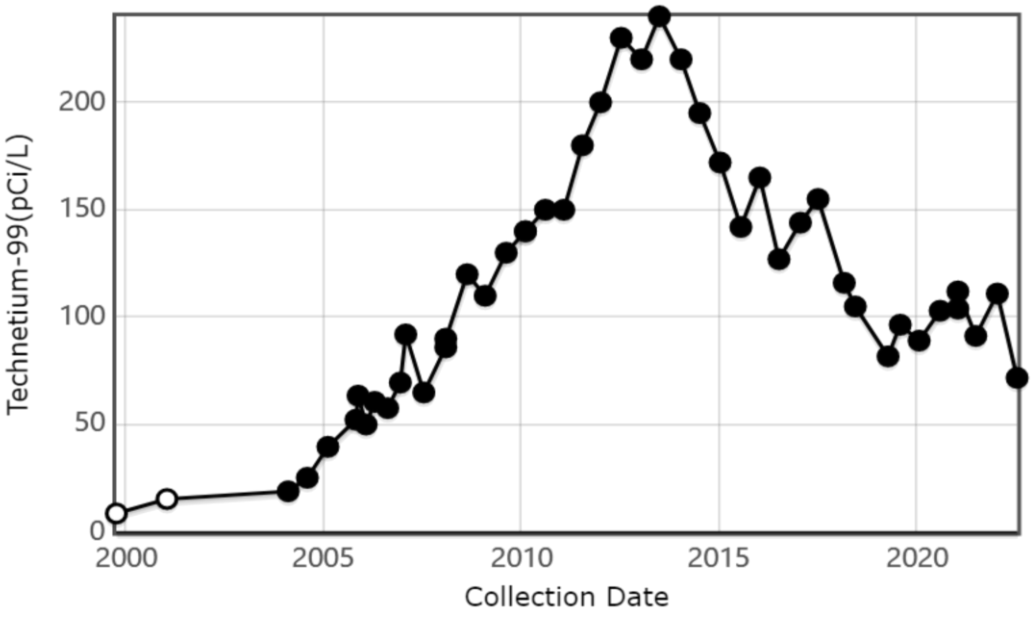
Sources: NAVD88, *North American Vertical Datum of 1988*; Figure 12-25 in DOE/RL-2021-51, *Hanford Site Groundwater Monitoring Report for 2021*.

Figure 8. Groundwater Monitoring Well Locations at LLWMA-4



Note: Open circle indicates nondetects.

Figure 9. Monitoring Concentration Trend for Technetium-99 at Well 299-W18-21



Note: Open circle indicates nondetects.

Figure 10. Groundwater Monitoring Concentration Trend for Technetium-99 at Well 299-W15-30

4.3 Air Monitoring for Radionuclides for 200 West Area

Atmospheric releases of radioactive materials from Hanford Site facilities and operations to the surrounding region are potential sources of exposure to humans. Radioactive constituents in air are monitored at Hanford Site facilities and operations at locations away from site facilities, offsite around the perimeter, and in nearby and distant communities. Information about these ambient air monitoring

efforts, including detailed descriptions of air sampling and analysis techniques, is provided in the DOE/RL-91-50, *Hanford Site Environmental Monitoring Plan*.

A network of continuously operating samplers at 78 locations across the Hanford Site was used during 2021 to monitor radioactive airborne materials in air near Hanford Site facilities and operations (details are reported in Table 6-4 in DOE/RL-2022-08). The samplers were primarily located at or within approximately 500 m (1,640 ft) of sites and facilities that have the potential for or a history of environmental releases. The samplers were primarily located in the prevailing downwind direction. Samples were collected according to a schedule established before the 2019 monitoring year.

Airborne particle samples were collected at each location by drawing air through a cellulose filter. The filters were collected bi-weekly, field-surveyed for gross radioactivity, held for at least 5 days, and then analyzed for gross alpha and beta activity. The 5-day holding period is necessary to allow for the decay of naturally occurring, short-lived radionuclides that would otherwise obscure the detection of longer-lived radionuclides associated with emissions from nuclear facilities. The gross radioactivity measurements were used to indicate changes in trends in the onsite facility environment.

The results of this monitoring program were reported in DOE/RL-2022-08 as follows:

> Air sampling was conducted at 23 locations in the 200-West Area during 2021. Radionuclide levels measured were similar to results for previous years. Cesium-137 and plutonium-239/240 were detected in less than 5% of the samples. All other radionuclides of concern were below analytical detection limits.

5 Research and Development

Sorption experiments were completed in FY 2021 to evaluate partition coefficients for technetium-99 for intact concrete monoliths. The partition coefficient parameter included processes such as surface complexation, ion exchange, and potential precipitation. For a given monolith size, the testing used two sets utilizing each of the two matrix solutions [a saturated $Ca(OH)_2$ solution and a $Ca(OH)_2$ saturated solution with simulated groundwater]. The test conditions were chosen to provide comparison to testing in prior years; four technetium-99 concentrations and three time periods were chosen to overlap with prior test conditions (PNNL-32601, *Radionuclide Migration Project Status FY2021 – FY2022*).

For FY 2021, the calculated technetium-99 partition coefficients ranged from 0.0514 mL/g for the 6-month tests using the saturated $Ca(OH)_2$ solution to 0.3634 mL/g for the 4-month tests with the modified $Ca(OH)_2$ saturated solution with simulated groundwater. A decrease in the calculated values for the 6-month tests from the 4-month tests was not expected. Nitrate concentration increased and the sulfate concentration decreased over the course of testing. These changes potentially impacted the matrix dissolution process within the monolith which may have led to reintroduction of the technetium-99 to the solution in the 6-month tests. There was no indication of experimental issues for the 6-month tests.

The FY 2020 testing included medium sized monoliths; FY 2020 partition coefficients are comparable to FY 2021 results at the 3-month timepoint. The FY 2021 partition coefficients for all test concentrations at 3 months are within ±5% of those for FY 2020 values. A comparison of the results for the saturated $Ca(OH)_2$ and modified groundwater solutions indicates that effects from the added constituents in the modified groundwater were minimal.

The results of R&D work performed over the last few years are summarized in Table 11. Additional information from past studies can be found in PNNL-23841, *Radionuclide Migration through Sediment and Concrete: 16 Years of Investigation* and PNNL-26938, *Radionuclide Migration through Concrete: Carbonation and Tracer Tests*.

The R&D work may reduce uncertainty and highlight those existing assumptions in the PA that would be expected to overstate the release rates. Although the PA demonstrates compliance, the research may still be helpful for understanding the realistic impact from the individual radionuclides.

Table 11. R&D Activities

Document Number	Results	PA or CA Impacts
PNNL-28317	For sorption experiments conducted in FY 2018 for large, intact concrete monoliths, sorption coefficients for iodine ranged from 6.7 mL/g with a 1-month test to 22 mL/g for small monoliths with a 6-month test. Technetium-99 sorption coefficients ranged from 0.28 mL/g for large monoliths with a 1-month test to 1.1 mL/g for medium monoliths with a 6-month test.	No impact. Support assessment of uncertainty in PA inputs.
PNNL-29445	Technetium-99 and iodine-129 sorption experiments were conducted in FY 2019 using a range of starting solution compositions over 1- and 3-month test durations. Iodine-129 sorption coefficients (K_d) values ranged from 19.51 mL/g for a large monolith 1-month test duration to 52.70 mL/g in small monoliths during a 3-month duration. Technetium-99 sorption coefficients ranged from 0.3778 mL/g for medium monoliths to 0.5535 mL/g for large monoliths within the 1-month test duration.	
PNNL-30756	Technetium-99 and iodine-129 sorption experiments were conducted in FY 2020 using a single monolith size and a range of starting solution compositions over 1- and 3-month test durations. Iodine-129 sorption coefficients (K_d) values ranged from 9.201 mL/g for a 1-month test duration to 23.221 mL/g for a 3-month test duration. Measurements of pH prior to and after test durations indicate significant change staying in the range of 12.23 to 12.49. Technetium-99 sorption coefficients ranged from 0.0719 mL/g for 1-month tests to 0.2448 mL/g for 3-month tests. Spiked technetium-99 concentrations were 10x lower than intended resulting in limited results to compare against previously conducted experiments.	
PNNL-32601	Sorption experiments were completed in FY 2021 to evaluate partition coefficients for technetium-99 for intact concrete monoliths. The partition coefficient parameter included processes such as surface complexation, ion exchange, and potential precipitation. For FY 2021, the calculated technetium-99 partition coefficients ranged from 0.0514 mL/g for the 6-month tests using the saturated $Ca(OH)_2$ solution to 0.3634 mL/g for the 4-month tests with the modified $Ca(OH)_2$ saturated solution with simulated groundwater. A decrease in the calculated values for the 6-month tests from the 4-month tests was not expected. Nitrate concentration increased and the sulfate concentration decreased over the course of testing.	

Note: Complete reference citations are provided in Chapter 9 of this document.

CA = composite analysis

FY = fiscal year

PA = performance assessment

6 Planned or Contemplated Changes

In accordance with DOE M 435.1-1, the purpose of this chapter is to identify any changes in facility operations, waste receipts, waste form behavior, monitoring data, R&D data, or land-use decisions during the reporting period that have affected PA assumptions and conclusions. If such changes exist, potential impacts are to be assessed, and recommended changes to address the impact of the reported changes are to be identified.

For this reporting period (FY 2022), no changes have occurred to cause substantive changes in disposal facility operations, disposal facility performance, and PA assumptions or results.

DOE, 2018, *Office of Enterprise Assessments Assessment of Low-Level Radioactive Waste Disposal Practices at the Hanford Site* (issued in February 2018), noted that:

> The computational methods and some assumed parameters and conditions for the PAs for both 200 West Area and 200 East Area LLBGs have become outdated. The software used for both LLBG PAs can be executed only on obsolete computer operating systems. Section 5.3.3 lists several reasons for the rebuilding and reanalysis of the CA, which is currently under way. The PAs for the LLBG provide crucial source input to the CA. With the rebuilding of the CA, it is important to rebuild the LLBG PAs to maintain the required and expected QA standards of the analyses. (**OFI-CHPRC-1**) (emphasis included)

The report further observed:

> The PA criteria for the 200 East and West Area LLBGs are currently satisfied. However, the 200 West Area PA will require rebuilding and reanalysis to support the reanalysis for the CA expected to be completed over the next three years.

In response, DOE-RL directed the prime contractor responsible at the time for Central Plateau remediation (CH2M HILL Plateau Remediation Company) to commence development of a new PA for the three trenches that are currently active in the 200 East Area (i.e., Trench 94) and 200 West Area\s (i.e., Trench 94). Work started in FY 2019 and the draft PA was completed in FY 2022. Corrective actions addressing 3 key issues and 31 secondary issues identified during the review process were developed and submitted to the LFRG Co-Chairs for review and approval. This PA provides additional technical basis for the continued adequacy of the existing Operating Disposal Authorization Statement (Scott, 2001) for the LLW disposal facilities at the Hanford Site. Planning is underway to develop a separate PA to cover the balance of LLBGs in the 200 East and 200 West Areas (for the inactive trenches).

Additionally, three documents (RFSH, 1997, *Program Plan for Maintenance of Hanford Burial Ground Performance Assessment [PA] Analyses*; DOE/RL-2000-70, *Closure Plan for Active Low-Level Burial Grounds;* DOE/RL-2000-72) may also require updates given the length of time that has elapsed since completion and acceptance of the initial PA analysis. Both maintenance and closure activities will be strongly affected by *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) remediation efforts for past-practice burial grounds and trenches, particularly for the unlined trenches that received DOE O 435.1 waste. Development of the CERCLA remediation process is ongoing. Once the development process has matured and the effects of remediation decisions for past-practice units on unlined trench closure actions have been clarified, any necessary additional DOE O 435.1 closure actions can be identified, and the maintenance and closure plans will be updated as necessary. Table 12 summarizes the planned or contemplated changes.

Table 12. Planned or Contemplated Changes

Planned or Contemplated Changes	Change Basis	PA Impacts	Schedule
New PA has been completed to evaluate dose impacts from waste disposal at active disposal trenches (Trenches 31 and 34 in 200 West; Trench 94 in 200 East).	Extended time has elapsed since the original PA was completed.	Because of several assumptions used in the original PA regarding disposed inventory and natural system the updates may result in differences in PA dose impacts.	Under review by LFRG Co-Chair.
Develop and update the PA for the balance of LLBGs (containing inactive trenches)	Extended time has elapsed between the current annual status report and the original PA for the inactive disposal trenches	Because of several conservative assumptions used in the original PA, any embedded uncertainty in PA inputs will be reduced.	PA update for the inactive trenches in 200 West LLBGs will initiate in FY 2023.
Maintenance and closure updates	Extended time between current annual status report and the original PA.	Impacted by CERCLA remediation efforts for past-practice burial grounds and trenches.	Ongoing

CERCLA = *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
FY = fiscal year
LFRG = Low-Level Waste Disposal Facility Federal Review Group
PA = performance assessment

An important overlooked consideration in the maintenance reports for the LLBG PAs is that these regulations were developed to meet DOE Order 5820.2A, *Radioactive Waste Management*, which preceded DOE O 435.1. These PAs were developed to report a peak dose for a 10,000-year rather than 1,000-year performance objective period. Thus, the small doses resulting from these PAs updated in the scaling methodology used for annual maintenance for over 20 years have not been explicitly presented as pertaining to a longer performance objective period than readers familiar with DOE O 435.1 requirements might presume. Starting with the FY 2018 annual status reports, appropriate language and footnotes for tabulated doses in maintenance documents are now applied to clarify the objective performance period of the original PAs and addenda for the LLBG PAs.

7 Status of Disposal Authorization Statement Conditions and Key and Secondary Issues

All trenches in the 218-W-5, 218-W-3A, 218-W-3AE, and 218-W-4C Burial Grounds are inactive (interim closed), except for Trenches 31 and 34 in the 218-W-5 Burial Ground. As shown in Table 13, there are no outstanding issues that need resolution for 218-W-5 Burial Ground Trenches 31 and 34.

Table 13. Status of Disposal Authorization Statement Conditions and Key and Secondary Issues

Disposal Facility and Unit	Key, Secondary Issue, or DAS Condition Number	Issue Description	Initial Resolutions Schedule Date	Projected Resolution Scheduled Date	Disposition Documentation and Date Completed	PA Impact
218-W-5 (Trench 31)	None	N/A	N/A	N/A	None	None
218-W-5 (Trench 34)	None	N/A	N/A	N/A	None	None

DAS = disposal authorization statement
N/A = not applicable
PA = performance assessment

8 Certification of the Continued Adequacy of the Performance Assessment

Chapter 1 of this annual status report outlines that no changes have occurred to cause substantive changes in disposal facility operations, disposal facility performance, and PA assumptions or results (Table 1), effecting cumulative effects. In summary, the information reviewed in this annual status report resulted in no change to the PA or the disposal authorization statement for 218-W-5 Burial Ground Trenches 31 and 34. All trenches in the 218-W-5, 218-W-3A, 218-W-3AE, and 218-W-4C Burial Grounds are closed, except for Trenches 31 and 34 in the 218-W-5 Burial Ground.

Appendix B is included to support the adequacy review, which provides a crosswalk between the review criteria and where the criteria are met in this report.

Certification by the Field Element Manager or Designee

I certify, to the best of my knowledge, that information in this annual status report is true, accurate, and complete and that any proposed or implemented changes associated with the 200 West Area Low-Level Burial Grounds provide a reasonable expectation that the performance objectives/measures identified in DOE O 435.1 will be met.

1 May 23

B.T. Vance, Manager
U.S. Department of Energy, Richland Operations Office

Date

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Appendix A

History of Performance Assessment Maintenance

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Contents

Table

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A1 History of Performance Assessment Maintenance

Two guidance documents (DOE M 435.1-1, *Radioactive Waste Management Manual*; DOE, 1999, *Maintenance Guide for U.S. Department of Energy Low-Level Waste Disposal Facility Performance Assessments and Composite Analyses*) define the primary components of performance assessment (PA) maintenance. A primary component of the PA maintenance effort is an annual review of the PA analysis. This annual review of the 200 West Area PA analysis is the latest in a series of annual reviews prepared and issued since 1997 (Table A-1) to maintain these PAs. In accordance with U.S. Department of Energy guidance (DOE M 435.1-1), the primary function of this review is to evaluate the continued compliance of disposal actions during the previous year with the performance objectives and continued relevance of critical PA assumptions. A discussion of supporting research and development and monitoring results relevant to the PA analysis and disposal facility performance is also required.

Table A-1. Maintenance Documents for the 200 West Area Low-Level Burial Grounds Performance Assessment

Reporting Period[a]	Document
FY 1997	RFSH, 1997, *Program Plan for Maintenance of Hanford Burial Ground Performance Assessment (PA) Analyses*, transmitted in RFSH-9755566, "Transmittal of Program Plan for Maintenance of Hanford Burial Ground Performance Assessment (PA) Analyses, that Fulfills Performance Agreement WM 1.8.1"
	HNF-1561, *1996-1997 Annual Review of the 200 West and 200 East Area Performance Assessments*
FY 1998	HNF-3762, *1997-1998 Annual Review of the 200 West and 200 East Area Performance Assessments*
FY 1999	HNF-7561, *1998-1999 Annual Review of the 200 West and 200 East Area Performance Assessments*
FY 2000	HNF-7562, *1999-2000 Annual Review of the 200 West and 200 East Area Performance Assessments*
FY 2001	FH-0105097, "Performance Assessment Review Report, 2000-2001 Annual Review of the 200 West and 200 East Area Performance Assessments"
FY 2002	FH-0204558, "Performance Assessment Review Report, 2001-2002 Annual Review of the 200 West and 200 East Area Performance Assessments"
FY 2003	FH-0304003, "Performance Assessment Review Report, 2002-2003 Annual Review of the 200 West and 200 East Area Performance Assessments"
FY 2004	FH-0501152, "Performance Assessment Review Report, 2003-2004 Annual Review of the 200 West and 200 East Area Performance Assessments"
FY 2005	FH-0600899, "Performance Assessment Review Report, 2004-2005 Annual Review of the 200 West and 200 East Area Performance Assessments"
CY 2005 (partial); CY 2006	FH-0700959, "Performance Assessment Review Report, Annual Review of the 200 West and 200 East Area Performance Assessments (12/1/2005-12/31/2006)"
CY 2007	FH-0802190, "Performance Assessment Review Report, Annual Review of the 200 West and 200 East Area Performance Assessments (1/1/2007-12/31/2007)"
CY 2008	DOE/RL-2009-99, *Annual Review of the 200 West and 200 East Area Performance Assessments (January 1, 2008 – December 31, 2008)*
CY 2009 (partial)	DOE/RL-2009-134, *Annual Review of the 200 West and 200 East Performance Assessments (January 1, 2009 – September 30, 2009)*
FY 2010	DOE/RL-2010-120, *Annual Review of the 200 West and 200 East Performance Assessments (FY 2010)*
FY 2011	DOE/RL-2011-110, *Annual Review of the 200 West and 200 East Performance Assessments (FY 2011)*
FY 2012	DOE/RL-2012-57, *Annual Review of the 200 West and 200 East Performance Assessments (FY 2012)*

Table A-1. Maintenance Documents for the 200 West Area Low-Level Burial Grounds Performance Assessment

Reporting Period[a]	Document
FY 2013	DOE/RL-2013-41, *Annual Status Report (FY 2013): 200 West and 200 East Performance Assessments*
FY 2014	DOE/RL-2014-47, *Annual Status Report (FY 2014): 200 West and 200 East Performance Assessments*
FY 2015[b]	DOE/RL-2015-67, *Annual Status Report (FY 2015): Performance Assessment for the Disposal of Low-Level Waste in the 200 West Area Burial Grounds*
FY 2016	DOE/RL-2016-63, *Annual Status Report (FY 2016): Performance Assessment for the Disposal of Low-Level Waste in the 200 West Area Burial Grounds*
FY 2017	DOE/RL-2017-56, *Annual Status Report (FY 2017): Performance Assessment for the Disposal of Low-Level Waste in the 200 West Area Burial Grounds*
FY 2018	DOE/RL-2018-61, *Annual Status Report (FY 2018): Performance Assessment for the Disposal of Low-Level Waste in the 200 West Area Burial Grounds*
FY 2019	DOE/RL-2019-50, *Annual Status Report (FY 2019): Performance Assessment for the Disposal of Low-Level Waste in the 200 West Area Burial Grounds*
FY2020	DOE/RL-2020-49, *Annual Status Report (FY 2020): Performance Assessment for the Disposal of Low Level Waste in the 200 West Area Burial Grounds*
FY2021	DOE/RL-2021-57, *Annual Status Report (FY 2021): Performance Assessment for the Disposal of Low Level Waste in the 200 West Area Burial Grounds*

a. Reporting period has changed from FY to CY, and then back to an FY basis during the maintenance history of these performance assessments in response to U.S. Department of Energy direction, which is reflected by the maintenance documents listed in this table.

b. The 200 East Area and 200 West Area Low-Level Burial Grounds were maintained in joint annual status reports until FY 2015 and separately thereafter.

CY = calendar year

FY = fiscal year

A2 References

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Appendix B

Crosswalk of Review Criteria to Annual Status Report Content

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Crosswalk of Review Criteria to Annual Status Report Content

ID	Review Criteria	Where Criteria are Met
ASR-1	*9.21 Executive Summary*	
1.1	Does the ASR provide an overview of the documents and data used to make the certification of the continued adequacy of the performance assessment (PA), composite analysis (CA), disposal authorization statement (DAS), other DAS technical basis documents, and the radioactive waste management basis (RWMB) to meet the Department of Energy (DOE) Order (O) 435.1 performance objectives/measures?	Executive Summary has been revised to include mention of the PA, Closure Plan and Disposal Authorization Statement. Maintenance Plan and Composite Analysis are mentioned in Chapter 2, "Cumulative Effects of Changes." Monitoring Plan summaries and the Performance Assessment Monitoring Plan are covered in Sections 4.1 and 4.2. Performance Objectives are discussed in Table 8 in Section 3.4.
1.2	If the ASR indicates that these documents need revision, has a corrective action plan been developed and implemented?	The following text was added to Chapter 2 as the third paragraph: "Numerous data-gathering and research efforts over the past 25 years have improved the knowledge base since the last PA was completed. For example, new information has resulted in better understanding of the inventory and waste form degradation and release processes. These changes/updates will not result in any significant or adverse changes to the conclusions of the 1995 PA." Chapter 6 elaborates on plans for the inactive trenches as follows: Both maintenance and closure activities will be strongly affected by CERCLA remediation efforts for past-practice burial grounds and trenches, particularly for the unlined trenches that received DOE O 435.1 waste. Development of the CERCLA remediation process is ongoing. Once the development process has matured and the effects of remediation decisions for past-practice units on unlined trench closure actions have been clarified, any necessary additional DOE O 435.1 closure actions can be identified, and the maintenance, PA monitoring and closure plans will be updated as necessary.

Crosswalk of Review Criteria to Annual Status Report Content

ID	Review Criteria	Where Criteria are Met
ASR-2	*Chapter 8 Change Control Process Guide and 9.2.2 Changes Potentially Affecting the PA, CA, DAS or RWMB*	
2.1	Are all change control process evaluations (called Unreviewed Disposal Question Evaluation/Unreviewed Composite Analysis Question Evaluation) or other change control processes (e.g., non-conformances and corrective actions) used to evaluate proposed actions, changes, and new information to determine if these activities are within the boundaries analyzed in the approved PA and CA listed and explained? Specific information for each identified change should include the following: 1) disposal facility/unit name; 2) change control process identification number; 3) change description; 4) evaluation results; 5) special analysis number if appropriate); and 6) PA, CA, DAS, and RWMB impact.	There were no unreviewed disposal questions and the waste receipts are within the waste acceptance criteria limits. See responses to ASR 1.2 above regarding additional information and lack of changes. Impact to PA is addressed.
2.2	Are their potential effect on the continued adequacy of the DAS, PA, CA, and RWMB provided?	See Response to Comment 1.2 above. Compliance is assumed based on measured parameter changes and expert judgment that there will be little if any effect on the results of the new CA, new PA, or DAS.
ASR-3	*9.2.3 Cumulative Effects of Changes*	
3.1	Does the ASR provide an evaluation and discussion of the cumulative effects of all the changes that have been identified in "Changes Potentially Affecting the PA, CA, DAS or RWMB" during the year?	See Response to Comment 1.2 above. Compliance is assumed based on measured parameter changes and expert judgment that there will be little if any effect on the results of the new CA, new PA, or DAS.
ASR-4	*9.2.4 Waste Receipts*	
4.1	Is the following information regarding waste receipts provided and adequately discussed? 1) disposal facility/unit name; 2) disposed volumes; 3) PA estimated disposal capacity; 4) percent filled – volume; 5) Sum of fractions or total curie vs PA curie limit; 6) PA/CA impacts	Waste shipments were received during the reporting period were evaluated. See information in Tables 2 through 6 in Chapter 3.
4.2	Was a discussion regarding waste receipts included?	Yes, in Sections 3.1 and 3.2.

Crosswalk of Review Criteria to Annual Status Report Content

ID	Review Criteria	Where Criteria are Met
ASR-5	*9.2.5 Monitoring*	
5.1	Was the following compliance monitoring information provided?) 1) disposal facility/unit name; 2) monitoring type; 3) monitoring results and trends: 4) performance objective, measure, or other regulatory limit; 5) action level; 6) action taken; and 7) PA/CA impacts.	The latest summary of groundwater monitoring information (DOE/RL-2021-51) describes data collected during CY 2021 (from January 1, 2021, through December 31, 2021). It represents the latest available information for purpose of this annual summary report. Compliance monitoring information is provided in Chapter 4 as follows: The groundwater monitoring did not indicate groundwater quality effects associated with LLWMA-3 (Figure 5) or LLWMA-4 (Figure 8) both within the 200-ZP-1 Operable Unit. Tables 9 and 10 summarize the compliance monitoring and performance monitoring evaluations. Additional monitoring details are presented in Section 4.1 for LLWMA-3 and Section 4.2 for LLWMA-4. Action levels - to ensure consistency with DOE/RL-2000-72 action levels are being considered as the standards are given in Table 4.1 of DOE/RL-2000-72. They are footnoted in Table 9 of DOE-RL-2019-50 ASR.
5.2	Was a discussion regarding monitoring results included?	Chapter 4 discusses monitoring for water and air for contaminants (including radiological). LLWMA-2 monitoring plan DOE/RL-2000-72 describes the monitoring basis. Performance objectives are summarized in Table 8, "Comparison of Dose or Flux Estimates with Performance Objectives."
5.3	Was the following performance monitoring information provided? 1) disposal facility/unit name; 2) monitoring purpose; 3) monitoring results and trends; 4) PA expected behavior; 5) action taken; 6) and PA/CA impacts.	For LLWMA-3: During the reporting period, all wells were sampled as scheduled for indicator parameters (pH, specific conductance, TOC, and TOX), and there were no confirmed critical mean exceedances (Table B-46 in DOE/RL-2021-51). For LLWMA-4, see text in Section 4.2. Also, see Tables 9 and 10. Performance is further assured by calculating annual disposal volumes and concentrations against the waste acceptance criteria.
5.4	Were results differing from expected behavior documented and discussed with any corrective actions?	Results were as expected. Monitoring reports are documented and referenced. All data were within expected ranges. No corrective actions were required. CERCLA actions have the potential to affect closure of inactive trenches.

Crosswalk of Review Criteria to Annual Status Report Content

ID	Review Criteria	Where Criteria are Met
ASR-6	*9.2.6 Research and Development*	
6.1	Was the following information for research and development (R&D), field studies, etc. results provided and discussed? 1) document number; 2) results; and 3) PA/CA results.	Chapter 5 provides a summary of diffusion and K_d experiments. This has reduced the uncertainty of some of the PA model inputs. Table 11 summarizes the findings. The research reduces uncertainty and highlights that existing assumptions in the PA would be expected to overstate the release rates.
ASR-7	*9.2.7 Planned or Contemplated Changes*	
7.1	Were planned or contemplated changes (including completion schedules) in disposal facility design, construction, operations, closure, R&D, land use, or in technical basis documents (Maintenance Plan, Closure Plan (CP), Waste Acceptance Criteria, Monitoring Plan (MonP), and change control process) discussed? The following information should be provided: 1) planned or contemplated change; 2) change basis; 3) PA/CA impact; and 4) schedule.	Chapter 6 addresses planned or contemplated changes, including updates to the PAs and other DAS documentation and currently planned closure dates. See responses to ASR 1.2
ASR-8	*9.2.8 Status of DAS Conditions, Key and Secondary Issues*	
8.1	Did the ASR provide a status update on any DAS conditions and key or secondary issues resulting from a LFRG review of the facility's PA and CA and other technical basis documents (e.g., MonP, CP, etc.)? The following information should be provided: 1) disposal facility/unit name; 2) key/secondary issue or DAS condition number; 3) issue description; initial resolution schedule date; 4) projected resolution scheduled date; 5) disposition documentation and date completed; and 6) PA, CA, and DAS impact.	The ASR provides a status of DOE (2018). There were no DAS Key or Secondary issues. See responses to ASR-1.2.
ASR-9	*9.2.9 Certifications of the Continued of the Adequacy of the PA, CA, DAS, and RWMB*	
9.1	Does the ASR or transmittal memo contain the following statement signed by the Field Element Manager or designee? *I certify to the best of my knowledge that information in this ASR is true, accurate and complete and that any proposed or implemented changes associated with the PA or other technical basis documents provide a reasonable expectation that the performance objectives/measures identified in DOE O 435.1 will be met.*	Chapter 8 contains the certification. The signature is found on page 31.

Note: Terms are provided in the front matter and complete reference citations are provided in Chapter 9 of the main text.