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Revision 0

Annual Status Report (FY 2020): Performance Assessment for the Disposal of Low Level Waste in the 200 East Area Burial Grounds

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 annual review provides the projected dose estimates of radionuclide inventories disposed in the 200 East 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-SD-WM-TI-730[1]). The estimates are compared with requirements of DOE O 435.1 Chg 1[2] and performance objectives defined in companion documents DOE M 435.1-1 Chg 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 Chg 1 is expected.

A new PA study was initiated in fiscal year (FY) 2019 for evaluation of active disposal sites within the 200 East and 200 West Areas (Trench 94 in 200 East; Trenches 31 and 34 in 200 West) due to extended time elapsing between the current annual status report and the original PA for the active disposal sites. The new PA for the active disposal sites is expected to be completed in FY 2021.

Within the active burial grounds in the 200 East Area, low-level waste and mixed low-level waste will continue to be disposed of in the dedicated U.S. Navy reactor compartment trench at the 218-E-12B Burial Ground (Trench 94). During this reporting

[1] WHC-SD-WM-TI-730, 1996, *Performance Assessment for the Disposal of Low-Level Waste in the 200 East Area Burial Grounds*, Rev. 0, Westinghouse Hanford Company, Richland, Washington. Available at: https://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0071840H.

[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, 2019, *Hanford Site Solid Waste Acceptance Criteria*, Rev. 18, CH2M HILL Plateau Remediation Company, Richland, Washington. Available at: https://pdw.hanford.gov/document/AR-03163.

period (FY 2020, from October 1, 2019 through September 30, 2020), two reactor compartments were disposed in Trench 94.

Results from sorption experiments are summarized for this reporting period to quantify the efficacy of concrete waste forms in retaining key radionuclides (e.g., technetium-99 and iodine-129). The test durations ranged from 1 to 3 months.

Continued groundwater monitoring of the 200 East Area LLBGs indicates no groundwater contamination due to LLBG waste. Current assumptions about future land use at the Hanford Site are consistent with PA analysis[1] assumptions of a post-closure facility that will not be degraded by human activity. The LLBGs are located in an area identified for waste management and containment of residual contamination. This area will remain after final environmental remediation and the proposed shrinkage of Hanford Site boundaries to small sections within the 200 East and 200 West Areas in the Central Plateau (DOE/EIS-0391[6]). The current closure plan for the LLBGs (DOE/RL-2000-70[7]) estimates that the 200 East 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 Chg 1. Overall, there are no substantive changes to primary PA assumptions nor the PA analysis conclusion; therefore, compliance with DOE O 435.1 Chg 1 and the Disposal Authorization Statement is maintained.

[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, *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.

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Terms

AEA	*Atomic Energy Act of 1954*
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CY	calendar year
DWS	drinking water standard
EA	environmental assessment
FY	fiscal year
K_d	partition coefficient
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*

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1 Changes Potentially Affecting the Performance Assessment

This chapter outlines all potential or actual changes, discoveries, proposed actions, and new information identified during the reporting period of fiscal year (FY) 2020 (from October 1, 2019 to September 30, 2020) for the 200 East Area Low-Level Burial Grounds (LLBGs) with the potential to impact the performance assessment (PA) (WHC-SD-WM-TI-730, *Performance Assessment for the Disposal of Low-Level Waste in the 200 East Area Burial Grounds*; HNF-2005, *Addendum to the Performance Assessment Analysis for Low-Level Waste Disposal in the 200 East Area Active Burial Grounds*). While considerable information and data have been acquired in the 200 East 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 Impacts
216-E-10	None	None	N/A	N/A	None
216-E-12B	None	None	N/A	N/A	None

N/A = not applicable
PA = performance assessment
UCAQE = unreviewed composite analysis question evaluation
UDQE = unreviewed disposal question evaluation

A new PA study was initiated in FY 2019 for evaluation of active disposal sites within the 200 East and 200 West Areas (Trench 94 in 200 East; Trenches 31 and 34 in 200 West) because extended time has elapsed between the current annual status report and the original PA for the active disposal sites.

2 Cumulative Effects of Changes

In accordance with DOE M 435.1-1 Chg 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. 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 waste form degradation and release processes. These changes/updates will not result in any significant or adverse changes to the conclusions of the 1996 PA. These new datasets and information will, however, be incorporated into the ongoing PA for active disposal sites.

Chapter 1 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 referred to as the Hanford Site Composite Analysis). The 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 composite analysis is provided in DOE/RL-2019-49, *Annual Status Report (FY 2019): Composite Analysis for Low-Level Waste Disposal in the Central Plateau of the Hanford Site*.

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 towards satisfying PA conditional approval requirements (Section 3.5)
- Summary statement of conclusions about compliance with performance objectives (Section 3.6)

3.1 Facility Overview

Figure 1 shows the location of the 200 East Area LLBGs in relation to the 200 West Area LLBGs, the Central Plateau, and the Hanford Site. Two LLBGs in the 200 East Area (218-E-10 and 218-E-12B) (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 Chg 1, *Radioactive Waste Management*.

WHC-SD-WM-TI-730 notes that, in the 200 East Area, the general type of disposal facility is a shallow, unlined trench of variable width (approximately 3 to 10 m [10 to 33 ft]), length (50 to 100 m [165 to 330 ft]), and depth (5 to 10 m [17 to 33 ft]). Waste is typically packaged in containers (metal drums or boxes; box materials include cardboard, wood, metal, and concrete) 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. Types of waste include paper, plastic, wood, concrete rubble, activated metal, and sludge.

Trenches, except for the reactor compartments, are typically arranged in parallel alignment, with the long axis running due north and south. The reactor compartments, which contained defueled compartments from decommissioned U.S. Navy vessels, are typically large, cylindrical waste packages ranging from about 9 to 13 m (30 to 42 ft) in diameter and 11 to 17 m (37 to 55 ft) in length. Trench 94 in the 218-E-12B Burial Ground is dedicated for disposal of the naval reactor compartments. To accommodate these large waste packages, the trench is about 15 m (50 ft) deep, 490 m (1,600 ft) long, and 120 m (400 ft) wide. Other than the naval reactor compartment waste, the majority of waste received in the 200 East Area LLBGs is from Hanford Site generators, including the Plutonium-Uranium Extraction Plant, B Plant, and tank farm operations.

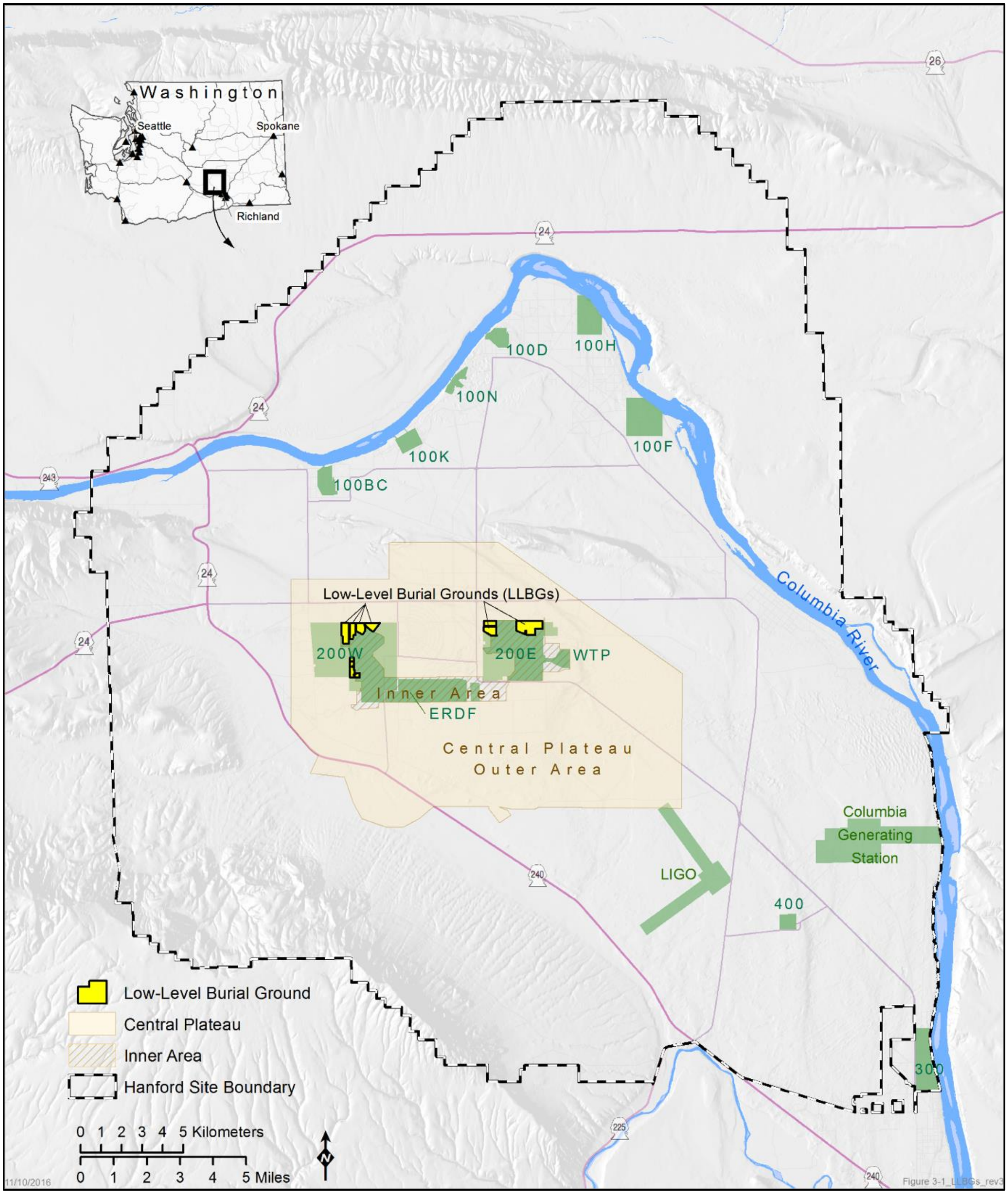


Figure 1. Location of the 200 East Area LLBGs

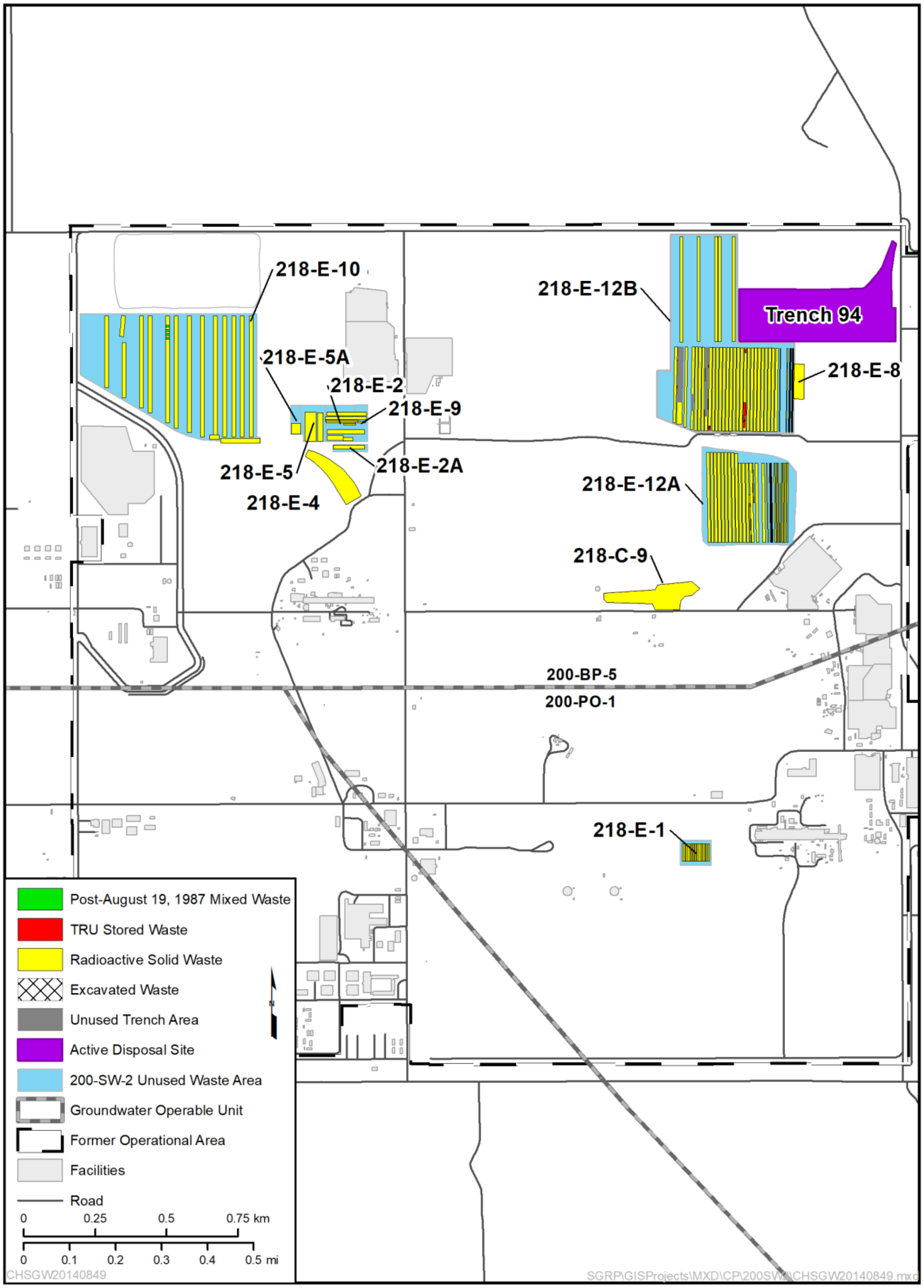


Figure 2. LLBGs and Other Solid Waste Burial Sites in the 200 East Area

Currently, LLW and MLLW may be disposed in the dedicated naval reactor compartment trench in the 218-E-12B Burial Ground (Trench 94). There are no plans for additional disposal in the inactive portions of the 200 East burial grounds.

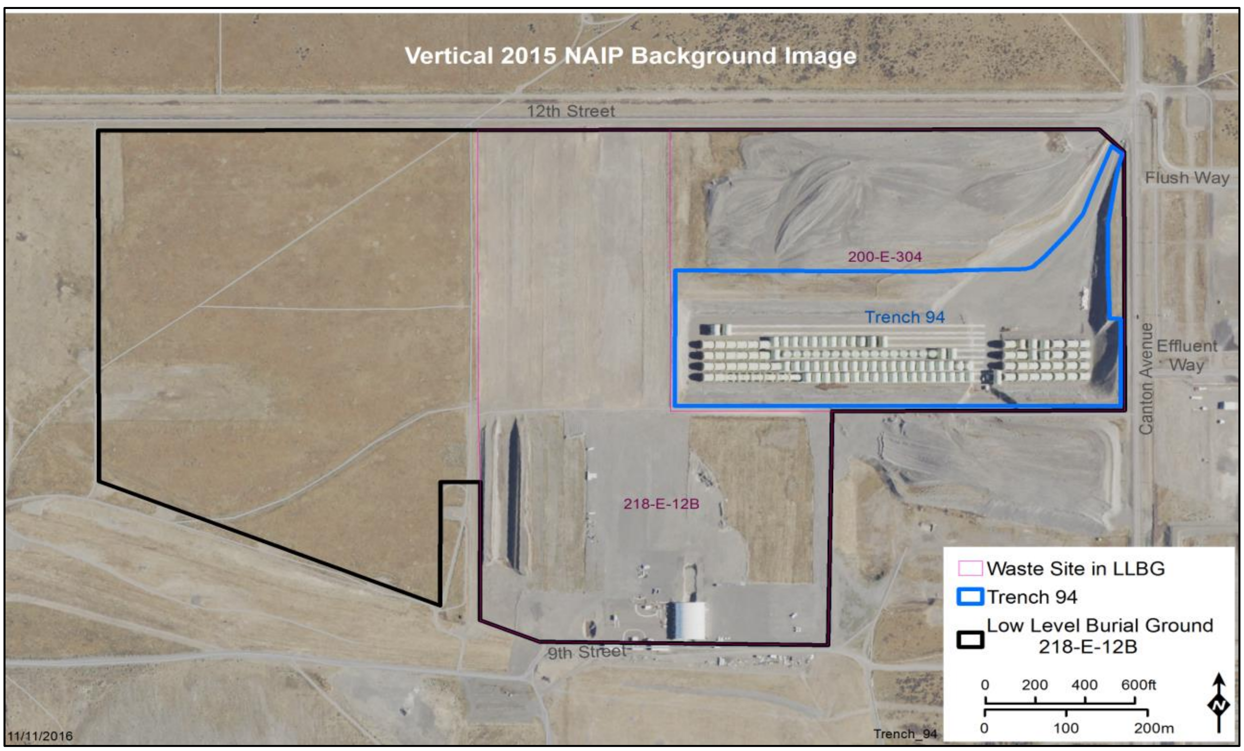
An environmental assessment (EA) was completed by the U.S. Navy to allow disposal of defueled aircraft carrier reactors from the USS Enterprise (USN, 2012, *Final Environmental Assessment on the Disposal of Decommissioned, Defueled Naval Reactor Plants from USS Enterprise (CVN 65)*). Naval reactor compartment disposal at Trench 94 will continue until the waste stream is completely exhausted. The results of the EA indicated that the metal reactor compartments provide a robust engineered barrier to the release of radionuclides. Due to their thickness and very slow corrosion rates, the compartments are likely to remain intact for periods well beyond the compliance period. As a result, the Trench 94 is designed for expansion on an as-needed basis and has no estimated disposal capacity. Under the "no migration clause" in RCRA, the disposal capacity is not calculated. The ongoing PA for Trench 94 will review the EA conducted by the U.S. Navy before developing the basis to exclude the possibility of release of radionuclides over the timescales evaluated in the PA. It is anticipated that no releases from the reactor compartments will occur during the compliance period and no aquifer contamination is envisioned for several thousands of years.

3.2 Disposed Waste Receipt Description

During the reporting period (FY 2020, from October 1, 2019 to September 30, 2020), two new naval reactor vessels were disposed in the 218-E-12B Burial Ground (Trench 94) (Figure 3). The radiological inventory in the previously received naval reactor compartments is primarily from nickel-63 and cobalt-60 present as activated metals (Appendix B of this document). The total volume of naval reactor compartments disposed to date is 123.1×10^3 m^3 (greater than 4.3 million ft^3). Two additional naval reactor vessels were disposed in the 218-E-10 Burial Ground during FY 2020. Table 2 summarizes the total waste receipt inventory for the 200 East Area LLBGs.

3.3 Projected Dose Estimates from the Disposed Waste to Evaluate Compliance with DOE O 435.1 Chg 1

Among the performance objectives defined in DOE M 435.1-1 Chg 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-SD-WM-TI-730), 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, the 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.



Source: U.S. Department of Agriculture National Agriculture Imagery Program.

Figure 3. Images of Burial Ground 218-E-12B (Trench 94), CY 2019 (Top) and CY 2015 (Bottom)

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	PA Impacts
218-E-10 (Trenches 9 and 14)	4,677	56,000[a]	8.3	1.29E-04[b]	None
218-E-E12B (Trenches 32, 36, 38, 42, 48, and 53)	27,309	168,000[a]	16	3.15E-04[b]	None
218-E-E12B (Trench 94)	123,094.3	N/A[c]	N/A[c]	N/A[c]	None

a. Based on rough estimates of trench sizes (approximately 7 m deep, 8 m wide, and 500 m in length) in WHC-SD-WM-TI-730, *Performance Assessment for the Disposal of Low-Level Waste in the 200 East Area Burial Grounds*, pp. 2-20.

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

c. Trench 94 is designed for expansion on an as needed basis and has no estimated disposal capacity. Under the "no migration clause" in RCRA, the disposal capacity is not calculated. Additionally, the reactor compartments are expected to be intact well beyond the compliance period.

N/A = not applicable

PA = performance assessment

RCRA = *Resource Conservation and Recovery Act of 1976*

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 (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. In the 200 East Area, inventories disposed in the two LLBGs (218-E-10 and 218-E-12B) were considered independently because they are geographically separated, and previous analyses suggest that future contaminant plumes from each burial ground should not commingle. For this reporting period, other than the activated metal inventory from two naval reactor vessels, no other reportable waste was disposed in the 200 East Area LLBGs. The contribution from reactor compartments is negligibly small and not explicitly counted due to very slow corrosion rates of the activated metal waste (Appendix B of this document). As a result, the dose estimates from the previous analysis (being cumulative) have been repeated.

The next most significant compliance requirement in DOE O 435.1 Chg 1 is the inadvertent intruder limit. A dose limit of 100 mrem/yr from chronic exposure or 500 mrem/yr from acute exposure was defined for an inadvertent intruder who might be exposed to waste in the disposal facility. In the PA analysis (WHC-SD-WM-TI-730), it was shown that the 100 mrem/yr chronic dose limit was the more limiting alternative. 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 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 the 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.

3.3.1 Groundwater Dose Estimates

In the PA analysis (WHC-SD-WM-TI-730), a methodology was developed to evaluate groundwater dose for any size disposal facility of interest within the boundaries of the collective burial grounds (Section 3.2.1.2 in WHC-SD-WM-TI-730). 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.

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 3.2.3.1 of WHC-SD-WM-TI-730) 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 the majority 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 3, the drinking water dose estimates are divided into two LLBG groups (the 218-E-10 and 218-E-12B) and by two different periods and major contributors (uranium dose versus other radionuclides dose). The two different periods distinguish between inventory disposed from facility inception (September 27, 1988) through FY 2019 (September 30, 2015; prepared in the previous annual report, DOE/RL-2019-51, *Annual Status Report (FY 2019): Performance Assessment for the Disposal of*

Low-Level Waste in the 200 East Area Burial Grounds) versus the inventory disposed in FY 2019 (this reporting period). Summing the dose estimates from these two periods yields the total dose estimate for the LLBG groups that are also reported in Table 3. The contribution from reactor compartments is not explicitly counted in the dose estimate for the 218-E-12B Burial Ground because it is calculated to be small (less than 0.0001 mrem/yr) relative to the 4 mrem/yr dose requirement, primarily due to very slow corrosion rates of the activated metal waste.

Table 3. 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 2019 (September 27, 1988–September 30, 2019)				
218-E-10	1.31E-03	0.00E+00	5.58E-03	6.89E-03
218-E-12B	5.27E-03	4.95E-05	6.79E-04	5.99E-03
Dose from Waste Disposal During FY 2020 (October 1, 2019–September 30, 2020)				
218-E-10	0.00E+00	0.00E+00	0.00E+00	0.00E+00
218-E-12B	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Dose from Total Waste Disposal from Inception through FY 2020 (September 27, 1988–September 30, 2020)				
218-E-10	1.31E-03	0.00E+00	5.58E-03	6.89E-03
218-E-12B	5.27E-03	4.95E-05	6.79E-04	5.99E-03

Notes:

Values are reported in mrem/yr.

Drinking water dose values are reported in mrem/yr.

a. Peak doses were reported for 10,000 years post-closure 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 Chg 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-SD-WM-TI-730, *Performance Assessment for the Disposal of Low-Level Waste in the 200 East 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

Dose estimates from waste disposed during this reporting period are zero because no reportable waste was disposed during the period. The largest total dose (about 6.89×10^{-3} mrem/yr) results from the disposal of mobile radionuclides. The estimated dose values for mobile radionuclides listed in Table 3 were generated with the inclusion of estimates of mobile radionuclide inventory (not including uranium) for radionuclides that may be present in disposed waste at trace levels but have not been reported or measured. In the 200 East Area PA, a scaling factor was derived from reactor production ratios of cesium-137concentrations to other contaminants (Appendix A in WHC-SD-WM-TI-730). The concept is that in lieu of direct characterization information, the unknown mobile radionuclide inventory can be reasonably estimated by assuming that reactor production ratios are maintained in waste. Using these scaling factors and disposed cesium-137 inventories during this reporting period, estimated inventories of mobile contaminants and associated doses were calculated. Dose contribution from disposed uranium has frequently been larger than that from disposed mobile radionuclides; however, during this reporting period, low disposal inventory reduced the estimated uranium dose to incidental levels.

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. Groundwater drinking dose estimates were unchanged from FY 2019 (October 1, 2018 through September 30, 2019) because no reportable waste was disposed in the current reporting period (FY 2020).

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 25 mrem/yr and 4 mrem/yr, respectively. Table 3 shows the drinking water doses for comparison to the 4 mrem/yr limit.

3.3.2 Inadvertent Intruder Dose Estimates

Compliance with the inadvertent intruder waste acceptance limits is determined by comparing projected intruder dose from the 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 a particular waste package with 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, Category 3 conditions are assumed to exist in the post-closure period. Separate periods are not considered for these estimates because the calculated doses apply to cumulative inventories and waste volumes.

Table 4 provides the trench volumes, activities of the largest contributors, and dose fractions for the inadvertent intruder dose estimates. The intruder dose from other radionuclides is negligibly small. 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. In the 200 East Area trenches, cesium-137 and/or strontium-90 provide the largest dose.

The projected total burial ground inadvertent intruder doses provided in Table 4 are consistent with those provided in the PA analysis (WHC-SD-WM-TI-730) and are similar to individual trench dose estimates. On this scale of waste-volume averaging, the estimated doses for each burial ground are well below the compliance limit.

Table 4. Estimated Intruder Dose Fraction by Trench for Waste Disposed September 27, 1988, Through September 30, 2020

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-E-10	9	1,062	4.00E+02	6.18E+02	1.96E-02	3.77E-01	5.82E-01	1.85E-05	3.14E-05	1.08E-05	3.69E-05	7.91E-05
	14	3,615	2.15E-02	2.14E-02	9.02E-02	5.94E-06	5.91E-06	2.49E-05	4.95E-10	1.10E-10	4.99E-05	4.99E-05
218-E-12B	32	12,446	1.47E-02	1.14E-04	2.27E-02	1.18E-06	9.17E-09	1.83E-06	9.84E-11	1.70E-13	3.65E-06	3.65E-06
	36	1,741	1.04E-02	3.92E-03	1.03E-02	5.96E-06	2.25E-06	5.90E-06	4.97E-10	4.17E-11	1.18E-05	1.18E-05
	38	2,017	9.45E-03	3.32E-01	0.00E+00	4.69E-06	1.65E-04	0.00E+00	3.90E-10	3.05E-09	0.00E+00	3.44E-09
	42	8,146	3.83E+00	3.32E+00	2.15E-02	4.71E-04	4.08E-04	2.64E-06	3.92E-08	7.55E-09	5.28E-06	5.32E-06
	48	374	8.17E-01	1.36E+00	0.00E+00	2.18E-03	3.64E-03	0.00E+00	1.82E-07	6.73E-08	0.00E+00	2.49E-07
	53	2,585	1.01E+01	1.54E+01	3.79E-01	3.90E-03	5.96E-03	1.47E-04	3.25E-07	1.10E-07	2.93E-04	2.94E-04

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

3.4 Other Performance Objectives

Two other limits were considered in the PA analysis: air emissions dose (10 mrem/yr) and radon flux (20 pCi/m^2/s) (WHC-SD-WM-TI-730). Table 5 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, potential sources of air contamination were concluded to be carbon-14 and hydrogen-3 (tritium). 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 tritium would have decayed to trivial amounts (Section 4.3.1 of WHC-SD-WM-TI-730). Therefore, no dose from an atmospheric release was projected.

Table 5. Comparison of Dose or Flux Estimates with Performance Objectives

Performance Objective	Exposure Pathway	Estimated Peak Dose or Flux[a,b] 200 East Area	
		218-E-10	218-E-12B
25 mrem/yr	Groundwater, all pathways	0.02	0.01
4 mrem/yr	Groundwater, drinking	0.007	0.006
100 mrem/yr at 500 years	Post-drilling intruder	0.006	0.003
20 pCi/m^2/s at 10,000 years	Radon emission	0.001	0.00009
10 mrem/yr	Air contaminant	0	0

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. Units of measure of dose/flux values are the same as the corresponding performance objective.

b. Peak doses were reported for 10,000 years post-closure 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; 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, “Disposal Authorization for the Hanford Site Low-Level Waste Disposal Facilities – Revision 2”).

3.6 Conclusions

This review concludes that as of September 30, 2020, 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 Chg 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-SD-WM-TI-730); 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 East Area LLBGs and are routinely monitored for contaminants as part of the Hanford Sitewide monitoring program. With respect to the requirements of DOE O 435.1 Chg 1, particular attention is paid to the following mobile contaminants: technetium-99, uranium, iodine-129, and tritium. In this program, the 200 East Area LLBGs are divided into two monitoring groups or low-level waste management areas (LLWMAs): LLWMA-1 (218-E-10) and LLWMA-2 (218-E-12B). Summary documents are issued annually that describe and interpret the collected information.

The latest summary of groundwater monitoring information (DOE/RL-2019-66, *Hanford Site Groundwater Monitoring Report for 2019*) describes data collected during calendar year (CY) 2019 (from January 1 through December 31, 2019). It represents the latest available information for purpose of this annual summary report. Trend plots of the indicator parameters did not indicate groundwater quality effects associated with LLWMA-1 (218-E-10) or LLWMA-2 (218-E-12B). Tables 6 and 7 summarize the compliance monitoring and performance monitoring evaluations. Additional monitoring details are presented in Section 4.1 for LLWMA-1 and Section 4.2 for LLWMA-2. Air monitoring results for CY 2019 are summarized in DOE/RL-2020-26, *Hanford Annual Site Environmental Report for Calendar Year 2019*, specifically Section 6.0, “Air Monitoring.” The information discussed in Section 4.3 was drawn from that report.

Table 6. Compliance Monitoring

Disposal Facility and Unit	Monitoring Type	Monitoring Results and Trends	Performance Objective Measure or Other Regulatory Limit	Action Level[a]	Action Taken	PA/CA Impacts
218-E-10	Groundwater[b]	No indication of contamination from the LLBGs	DWS	DWS	None	None
218-E-12B	Groundwater[b]	No indication of contamination from the LLBGs	DWS	DWS	None	None

Table 6. Compliance Monitoring

Disposal Facility and Unit	Monitoring Type	Monitoring Results and Trends	Performance Objective Measure or Other Regulatory Limit	Action Level[a]	Action Taken	PA/CA Impacts
200 East Area	Air[c]	Stable; comparable to widespread background concentrations	--	--	None	None

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 LLBGs*.

b. DOE/RL-2019-66, *Hanford Site Groundwater Monitoring Report for 2019*.

c. DOE/RL-2020-26, *Hanford Annual Site Environmental Report for Calendar Year 2019*.

CA = composite analysis
DWS = drinking water standard
PA = performance assessment
LLBG = low-level burial ground

Table 7. Performance Monitoring

Disposal Facility and Unit	Monitoring Purpose	Monitoring Results and Trends	PA Expected Behavior	Action Taken	PA/CA Impacts
216-E-10	Radionuclide transport	Compliant	Compliant	None	None
216-E-12B	Radionuclide transport	Compliant	Compliant	None	None

Reference:

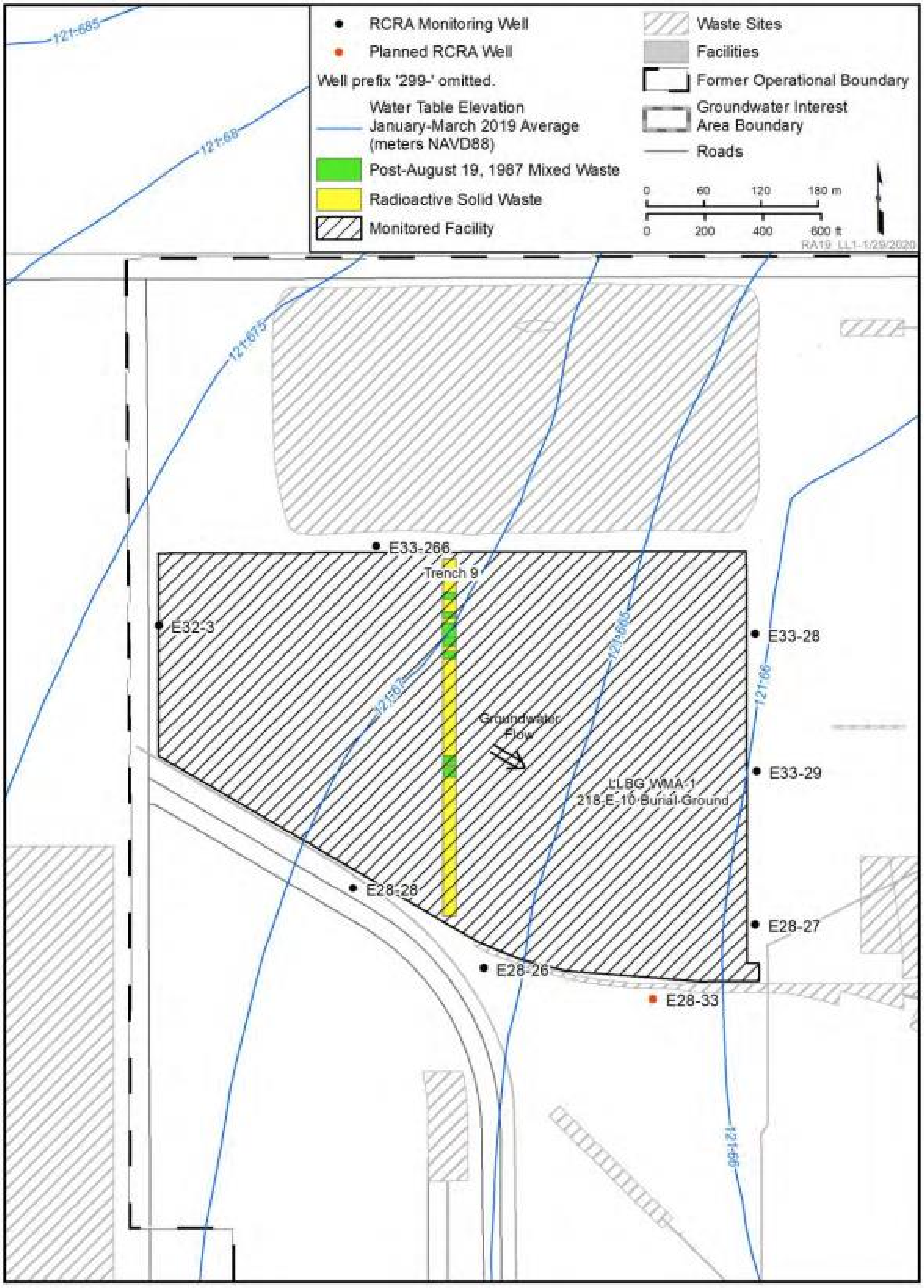
DOE/RL-2019-66, *Hanford Site Groundwater Monitoring Report for 2019*.

CA = composite analysis
PA = performance assessment

4.1 Low-Level Waste Management Area 1

Groundwater monitoring of the well network at LLWMA-1 (Figure 4) in CY 2019 continued under *Resource Conservation and Recovery Act of 1976* (RCRA) and *Atomic Energy Act of 1954* (AEA) requirements. The monitoring network encompasses the LLWMA-1 boundary to provide coverage for potential groundwater flow direction changes. The LLWMA-1 monitoring network consists of seven wells screened in the upper portion of the aquifer at the water table. PA monitoring of radionuclides at LLWMA-1 complements the RCRA detection monitoring program. The current monitoring plan (DOE/RL-2000-72, *Performance Assessment Monitoring Plan for the Hanford Site Low-Level Burial Grounds*) includes groundwater monitoring of technetium-99, iodine-129, tritium, and uranium, which are deemed performance-related constituents of interest. These are co-sampled with the RCRA groundwater sampling schedule for the LLBG.

Groundwater gradient magnitudes and flow directions were determined using the 200 East Area low-gradient monitoring network for the northwest corner of 200 East Area. Based on the low-gradient water table map, the estimated hydraulic gradient beneath LLWMA-1 in 2019 was 3.3×10^{-5} m/m, sloping to the east-southeast (Figure 4), with an associated flow rate of 2.3 m/d (7.6 ft/d).



Source: Figure 9-28 in DOE/RL-2019-66, *Hanford Site Groundwater Monitoring Report for 2019*.

Figure 4. Groundwater Monitoring Well Locations at LLWMA-1

During 2019, the LLWMA-1 monitoring wells were sampled semiannually for indicator parameters as scheduled. Specific conductance, pH, total organic carbon, and total organic halides did not exceed critical mean values. The nitrate concentrations were greater than 45 mg/L in three wells due to a regional nitrate plume. In 2019, the tritium concentrations in some upgradient LLWMA-1 wells decreased or remained stable, though all were below 50% of the drinking water standard (DWS). Uranium concentrations did not exceed the DWS for any of the monitoring wells.

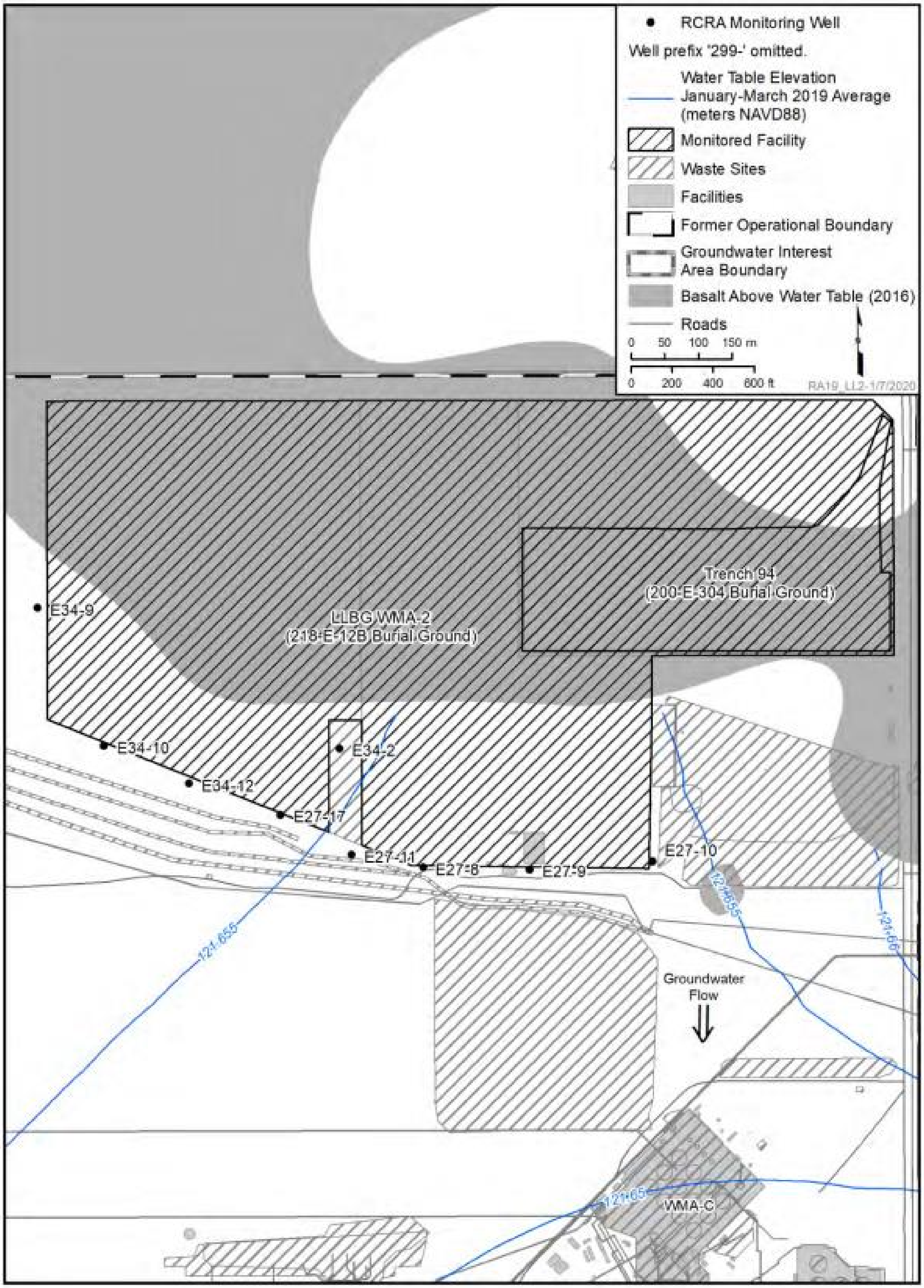
The elevated concentrations of iodine-129 exceeded the DWS in six LLWMA-1 wells while elevated concentrations of technetium-99 exceeded the DWS in one well from plume migration from the northwest following the south-southeast groundwater gradient in the 200-BP-5 groundwater interest area (see Chapter 9 of DOE/RL-2018-66, *Hanford Site Groundwater Monitoring Report for 2018*, for additional details). The elevated concentrations are associated with wells along the north and northeast boundaries of the burial ground considered upgradient or cross gradient relative to the regional plume orientation. The corresponding downgradient wells continue to trend with upgradient wells but with lower concentrations. The trend analyses between upgradient and downgradient wells did not show any indication of contribution from the 218-E-10 Burial Ground. In summary, the performance assessment indicator parameters for LLWMA-1 did not indicate groundwater quality effects associated with 218-E-10 in 2019.

4.2 Low-Level Waste Management Area 2

Groundwater monitoring of the well network at LLWMA-2 (Figure 5) in CY 2019 continued under RCRA and AEA requirements. PA monitoring of radionuclides at LLWMA-2 complements the RCRA detection monitoring program. The current monitoring plan (DOE/RL-2000-72) includes technetium-99, iodine-129, tritium, and uranium. All wells were successfully sampled semiannually or annually during CY 2018. There were several confirmed critical mean exceedances in 2018 due to regional plume movement.

Groundwater gradient magnitudes and flow directions were determined using the low-gradient monitoring network for the northwest corner of 200 East Area. The average gradient of the monitoring network was 5.4×10^{-6} m/m, dipping to the south (Figure 5). As with other LLWMAs, DOE monitors for AEA radionuclides as described in DOE/RL-2000-72. Iodine-129 concentrations exceeded the DWS in three LLWMA-2 wells during 2019 while technetium-99 concentrations exceeded DWS in two LLWMA-2 wells. The concentration trend is associated with migration of a contaminant plume following the regional groundwater gradient to the south-southeast. Tritium and uranium concentrations were below DWS in wells at LLWMA-2.

The trend analyses between upgradient and downgradient wells did not show any indication of contribution from the 218-E-12B Burial Ground. In summary, the performance assessment indicator parameters for LLWMA-2 did not indicate groundwater quality effects associated with the 218-E-12B Burial Ground in 2019.



Source: Figure 9-29 in DOE/RL-2019-66, *Hanford Site Groundwater Monitoring Report for 2019*.

Figure 5. Groundwater Monitoring Well Locations at LLWMA-2

4.3 Air Monitoring for Radionuclides for 200 East 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 2019 to monitor radioactive airborne materials in air near Hanford Site facilities and operations (details are reported in Table 6-4 of DOE/RL-2020-26). 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 with respect to the 200 East Area (focus of the 200 East LLBGs) were reported in DOE/RL-2020-26 as follows:

> Air sampling was conducted at 28 locations in the 200-East Area during 2019. Generally, radionuclide levels measured were similar to those in previous years. Cesium-137 was detected in approximately 10% of the samples. Uranium-234 and uranium-238 were detected in approximately 20% of the samples.

5 Research and Development

PNNL-30756, *FY 2020 Radionuclide Migration Project Status*, presents results from a set of sorption experiments completed in FY 2020 to evaluate partition coefficients for iodine and technetium-99 using intact concrete monoliths. These experiments are an extension of work conducted FY 2019 (PNNL-29445, *FY2019 Radionuclide Migration Tests*) and FY 2018 (PNNL-28317, *Radionuclide Migration Tests*). Experiments conducted in FY 2020 focused on smaller sets utilizing each of the two matrix solutions, only one monolith size, and the same concentration range as FY 2019. The two test solutions included saturated calcium hydroxide [$Ca(OH)_2$] solution and a modified solution with a composition more representative of Hanford Site groundwater.

Partition coefficients (K_ds) calculated for iodine range from 9.201 mL/g for a 1-month test duration to 23.221 mL/g for 3-month tests with modified $Ca(OH)_2$ saturated solution with simulated groundwater. The K_ds resulting in FY 2020 tests were comparable to FY 2018 testing. When comparing FY 2020 K_d results with FY 2019, there is an approximate decrease in value by 50%. Measurement of pH prior to and after testing ranged from 12.23 to 12.49 and indicated no change in pH as a result of the experimental conditions. Some precipitate was observed in experiment containers such that higher K_d values may be due to precipitation as a result of simulated groundwater components.

Technetium-99 K_ds calculated for FY 2020 ranged from 0.0719 mL/g for the 1-month tests using the modified $Ca(OH)_2$ saturated solution with simulated groundwater to 0.2448 mL/g for the 3-month test with saturated $Ca(OH)_2$. All three target spiking concentrations were 10 times lower than intended as a result of incorrect calculations. As a result, the data are limited to the single 1 ppb starting concentration for FY 2020 that can be compared to the same concentration in FY 2019 and FY 2018 experiments. Comparison of the three datasets show a decrease in K_d value for FY 2020 1-month tests and an increase in K_d for 3-month tests. The results are inconclusive and should be repeated with comparable concentrations to better evaluate between sorption experiments.

Additional analysis is needed to confirm the cause for the observed increase in K_d values for iodine and to obtain reliable data for technetium-99 for calculations. Suggested future work includes more detailed surface analysis (i.e., scanning electron microscopy) to better understand the changes in surface interactions in addition to longer test durations to confirm steady state and the extent of iodine incorporation.

The results of R&D work performed over the last few years are summarized in Table 8. In addition to those reported in PNNL-23841, *Radionuclide Migration through Sediment and Concrete: 16 Years of Investigation*, and PNNL-26938, *Radionuclide Migration through Concrete: Carbonation and Tracer Tests*, these results will be evaluated either as part of the PA update or as part of the PA maintenance activities.

Table 8. R&D Activities

<table>
<tr><th>Document Number</th><th>Results</th><th>PA or CA Impacts</th></tr>
<tr><td>PNNL-28317</td><td>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.</td><td rowspan="3">No impact.
Support assessment of uncertainty in PA inputs.</td></tr>
<tr><td>PNNL-29445</td><td>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.</td></tr>
<tr><td>PNNL-30756</td><td>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.</td></tr>
</table>

References:

PNNL-28317, *Radionuclide Migration Tests*.

PNNL-29445, *FY2019 Radionuclide Migration Tests*.

PNNL-30756, *FY 2020 Radionuclide Migration Project Status*.

CA = composite analysis

PA = performance assessment

FY = fiscal year

6 Planned or Contemplated Changes

In accordance with DOE M 435.1-1 Chg 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 2020), no changes have occurred to cause substantive changes in disposal facility operations, disposal facility performance, and PA assumptions or results. However, a new PA study was initiated in FY 2019 for evaluation of active disposal sites within the 200 East and 200 West Areas (Trench 94 in 200 East; Trenches 31 and 34 in 200 West) based on the recommendations from the Office of Enterprise Assessments.

In February 2018, the Office of Enterprise Assessments issued DOE, 2018, *Office of Enterprise Assessments Assessment of Low-Level Radioactive Waste Disposal Practices at the Hanford Site*, which 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 CH2M HILL Plateau Remediation Company to commence development of a new PA to cover the active LLBGs in the 200 East and 200 West Areas (i.e., Trenches 31, 34, and 94). Work has started on this active LLBG PA in FY 2019. It is planned that a closure PA will be developed later to cover the balance of LLBGs in the 200 East and 200 West Areas.

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 (WHC-SD-WM-TI-730). 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 Chg 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 Chg 1 closure actions can be identified, and the maintenance, PA monitoring and closure plans will be updated as necessary.

During this reporting period (FY 2019), there are no outstanding information needs (e.g., data gaps and uncertainties) identified in the 200 East Area PA, subsequent addendum, or previous annual reviews. Table 9 summarizes the planned or contemplated changes.

Table 9. Planned or Contemplated Changes

Planned or Contemplated Changes	Change Basis	PA Impacts	Schedule
Develop a PA for evaluation of active disposal sites	Extended time has elapsed between the current annual status report and the original PA for the active disposal sites (Trenches 31 and 34 in 200 West; Trench 94 in 200 East).	Because of several conservative assumptions used in the original PA, any embedded uncertainty in PA inputs will be reduced.	Ongoing
Maintenance and closure updates	Extended time between current annual status report and 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*
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 is now applied to clarify the objective performance period of the original PAs and addendums for the LLBG PAs. The new active LLBG PA will report to DOE O 435.1 standards, including a comparison of performance objectives and measures to the 1,000-year compliance and post-compliance time periods.

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

As indicated in Table 10, there are no outstanding issues for the 216-E-10 and 216-E-12B LLBGs.

Table 10. Status of DAS 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
216-E-10	None	N/A	N/A	N/A	N/A	None
216-E-12B	None	N/A	N/A	N/A	N/A	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 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 the 216-E-10 and 216-E-12B Burial Grounds.

As mentioned in Table 9, a new PA study has been initiated in FY 2020 for evaluation of active disposal sites within the 200 East and 200 West Areas.

Appendix C 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 East Area Low-Level Burial Grounds provide a reasonable expectation that the performance objectives/measures identified in DOE O 435.1 Chg 1 will be met.

____ ______________________

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 Chg 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 East 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 Chg 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 East Area Low-Level Burial Grounds Performance Assessment

Reporting Period*	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)"

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

Reporting Period*	Document
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 Summary of the Integrated Disposal Facility Performance Assessment 2012*
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	DOE/RL-2015-68, *Annual Status Report (FY 2015): Performance Assessment for the Disposal of Low-Level Waste in the 200East Area Burial Grounds*
FY 2016	DOE/RL-2016-64, *Annual Status Report (FY 2016): 200 West and 200 East Performance Assessments*
FY 2017	DOE/RL-2017-57, *Annual Status Report (FY2017): Performance Assessment for the Disposal of Low-Level Waste in the 200 East Area Burial Grounds*
FY 2018	DOE/RL-2018-62, *Annual Status Report (FY2018): Performance Assessment for the Disposal of Low-Level Waste in the 200 East Area Burial Grounds*
FY 2019	DOE/RL-2019-51, *Annual Status Report (FY 2019): Performance Assessment for the Disposal of Low Level Waste in the 200 East Area Burial Grounds*

*Reporting period has changed from FY to CY and back to 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.

CY = calendar year

FY = fiscal year

A2 References

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Appendix B

Trench 94 (Naval Reactor Compartments) Inventory in the 200 East Area Low-Level Burial Grounds Performance Assessment

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Contents

Table

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B1 Trench 94 (Naval Reactor Compartments) Inventory in the 200 East Area Low-Level Burial Grounds Performance Assessment

This appendix provides further comparison of the waste inventory received to date in Trench 94 in the 200 East Area Low-Level Burial Grounds to the inventory analyzed in the 200 East Area performance assessment (PA) (WHC-SD-WM-TI-730, *Performance Assessment for the Disposal of Low-Level Waste in the 200 East Area Burial Grounds*). The Solid Waste Information and Tracking System database was queried for total disposed inventory to date for each radionuclide listed in Table 2-5 of WHC-SD-WM-TI-730. After evaluating the relevant radionuclides, several inventories exceed PA inventory, including americium-241, curium-243, curium-244, cesium-137, plutonium-238, plutonium-239, plutonium-240, plutonium-241, and strontium-90 (Table B-1).

Table B-1. Trench 94 Inventory Comparison to Performance Assessment

Radionuclide	Estimated Inventory Analyzed in the PA (Ci)[a]	Inventory Disposed from Inception to 9/30/2020 (Ci)[b]	Fraction of PA Inventory Disposed to Date
Americium-241	6.50E-01	2.42E+00	372%
Americium-243	4.80E-05	4.32E-06	9%
Beryllium-10	1.30E-06	#N/A	--
Carbon-14	6.40E+02	1.31E+02	20%
Carbon-14 ACTIV. METAL	--	2.20E+02	--
Chlorine-36	6.00E-03	5.71E-03	95%
Curium-242	1.90E-06	2.94E-03	154737%
Curium-243	2.20E-08	5.11E-07	2323%
Curium-244	8.50E-06	3.12E-04	3671%
Cobalt-60	3.00E+06	1.03E+06	34%
Cobalt-60 ACTIV. METAL	--	1.95E+05	--
Cesium-137	1.30E+01	5.26E+01	405%
Tritium	2.50E+03	1.12E+03	45%
Iodine-129	6.30E-03	2.94E-03	47%
Molybdenum-93	1.50E-01	6.90E-02	46%
Niobium-93m	1.20E+00	5.61E-01	47%
Niobium-94	9.90E+01	1.50E+01	15%
Niobium-94 ACTIV. METAL	--	3.37E+01	--
Nickel-59	2.90E+04	5.12E+03	18%
Nickel-59 ACTIV. METAL	--	2.35E+02	--
Neptunium-237	4.80E-05	1.56E-08	0%
Plutonium-238	1.30E+00	2.03E+00	156%
Plutonium-239	3.40E-04	1.95E-01	57353%

Table B-1. Trench 94 Inventory Comparison to Performance Assessment

Radionuclide	Estimated Inventory Analyzed in the PA (Ci)[a]	Inventory Disposed from Inception to 9/30/2020 (Ci)[b]	Fraction of PA Inventory Disposed to Date
Plutonium-240	3.60E-04	1.08E-01	30000%
Plutonium-241	2.20E+01	6.36E+01	289%
Plutonium-242	8.50E-07	4.05E-07	48%
Selenium-79	3.00E-03	2.31E-05	1%
Strontium-90	8.50E+00	2.14E+01	252%
Technetium-99	4.10E+00	8.08E-01	20%
Zirconium-93	1.20E+00	5.61E-01	47%

a. The PA does not indicate the assumed closure date. It is also unclear if Table 2-5 of WHC-SD-WM-TI-730, *Performance Assessment for the Disposal of Low-Level Waste in the 200 East Area Burial Grounds*, is decay-corrected to an assumed closure date.

b. The sum of annual waste receipts as queried from the Solid Waste Information and Tracking System database without decay correction.

PA = performance assessment

B2 Trench 94 Dose Estimate Summary

Both the intruder scenario and groundwater contamination pathways were deemed significant projected dose pathways in PA evaluations, as described in Section 3.3 in the main text of this annual status report. Primary radionuclides contributing to the intruder scenario include cesium-137 and strontium-90, both of which have disposed inventories greater than PA analyzed inventory (Table B-1). Although the PA calculated drilling through the naval reactor compartments, it is not viewed as a credible scenario due to the extreme hardness of the vessel metal. Furthermore, it is highly unlikely for a drill used for wells in sandy soil to penetrate the reactor material. Regarding the groundwater contamination pathway, the radionuclides contributing to projected dose in the PA include iodine-129, uranium, technetium-99, and selenium-99. There were no primary radionuclides contributing to groundwater contamination with an inventory exceeding the estimated PA inventory. Furthermore, none of the radionuclides exceeding estimated PA inventories was evaluated to be significant dose contributors.

B3 Reference

WHC-SD-WM-TI-730, 1996, *Performance Assessment for the Disposal of Low-Level Waste in the 200 East Area Burial Grounds*, Rev. 0, Westinghouse Hanford Company, Richland, Washington. Available at: https://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0071840H.

Appendix C

Crosswalk of LFRG Review Criteria to Annual Status Report Content

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C1 Introduction

This appendix provides a crosswalk (Table C-1) to support review of this annual status report by identifying where the review criteria specified in DOE-STD-5002-2017, *Disposal Authorization Statement and Tank Closure Documentation*, are met in the content of this report.

Table C-1. Crosswalk of LFRG Review Criteria to Annual Status Report Content

ID	Review Criteria*	Where Criteria are Met
ASR-1	**9.2.1 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 PA, CA, DAS, other DAS technical basis documents, and the RWMB to meet the DOE Order (O) 435.1 performance objectives/measures?	The Executive Summary includes mention of the PA, closure plan, and DAS. The maintenance plan and composite analysis are mentioned in Chapter 2. Monitoring plan summaries and the performance assessment monitoring plan are covered in Sections 4.1 and 4.2. Performance objectives are discussed in Table 5 in Section 3.4.
1.2	If the ASR indicates that these documents need revision, has a corrective action plan been developed and implemented?	Chapter 2, paragraph 1 states the following: Numerous data-gathering and research efforts over the past 25 years have improved our knowledge base since the last PA was completed. For example, we have improved inventory estimates, have a better understanding of the waste form degradation and release processes, and developed more sophisticated tools for evaluating contaminant fate and transport. It is our expert opinion that these changes/updates will not result in any significant or adverse changes to the conclusions of the 1996 PA. These new datasets and information will, however, be incorporated into the ongoing PA for active disposal sites. Chapter 6 (pages 19 and 20) elaborates on plans for the inactive trenches as follows: 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 Chg 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 Chg 1 closure actions can be identified, and the maintenance, PA monitoring and closure plans will be updated as necessary.

Table C-1. Crosswalk of LFRG 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) 6) PA, CA, DAS, and RWMB impact	There were no Unreviewed questions as explained in Chapter 1.and the 2 shipments received and shown in Table 2 of Section 3.2 are within the *Washington Administrative Code* limits. See responses to ASR 1.2 above regarding additional information and lack of changes. A new PA has been initiated in FY2019 that incorporates data gathered within the past 25 years and is ongoing. Impact to PA is addressed in Table 2.
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. Section 2 states that 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. Section 2 states that 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	During the reporting period (FY 2020, from October 1, 2019 to September 30, 2020) two new navel reactor vessels were disposed of in the 218-E-12B Burial Ground (Trench 94), Figure 3. The total volumes, disposed waste to date and Sum of Fractions as well as PA impacts are shown in the Table 2. The results of the Navy EA (USN, 2012) indicated that the metal reactor compartments provide a robust engineered barrier to the release of radionuclides. The total volume and due to their thickness and very slow corrosion rates they are likely to remain intact for periods well beyond the compliance period. As a result, the Trench 94 is designed for expansion on as needed basis and has no estimated disposal capacity. Under the “no migration clause” in RCRA, the disposal capacity is not calculated. The ongoing PA for

Table C-1. Crosswalk of LFRG Review Criteria to Annual Status Report Content

ID	Review Criteria*	Where Criteria are Met
		Trench 94 will review the EA conducted by the U.S. Navy before developing the basis to exclude the possibility of release of radionuclides over the timescales evaluated in the PA. It is anticipated that no releases from the reactor compartments will occur during the compliance period and no aquifer contamination is envisioned for several thousands of years.
4.2	Was a discussion regarding waste receipts included?	Two waste shipments (naval reactors) were received during the reporting period and a discussion was included in Section 3.2.
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 *7)* PA/CA impacts	The latest summary of groundwater monitoring information (DOE/RL-2019-66, *Hanford Site Groundwater Monitoring Report for 2019*) describes data collected during CY 2019 (from January 1, 2019, through December 31, 2019). Compliance Monitoring information is described in Chapter 4 and Table 6 addresses The disposal facility and unit, Monitoring type, results and trends, Performance Measures or Objectives, action levels and PA/CA impacts. Table 5 gives a comparison of Dose or Flux estimates with Performance Objectives. Action levels - to insure consistency with DOE/RL-2000-72, *Performance Assessment Monitoring Plan for the Hanford Site LLBGs,* Rev.1, action levels are being considered as the standards given in Table 4.1 of (DOE/RL-2000-72 Rev.1).
5.2	Was a discussion regarding monitoring results included?	Section 4. Discussed monitoring for water and air for contaminants (including radiological). LLWMA-2 monitoring plan DOE/RL-2000-72, Rev. 1 describes the monitoring basis. Performance objectives are summarized in Table 5. Comparison of Dose or Flux Estimates with Performance Objectives.

Table C-1. Crosswalk of LFRG Review Criteria to Annual Status Report Content

ID	Review Criteria*	Where Criteria are Met
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) PA/CA impacts	Table 7 summarizes the performance monitoring evaluations. Additional monitoring details are presented in Section 4.1 for LLWMA-1 and Section 4.2 for LLWMA-2. Hanford is complicated by contamination from upgradient sources. This is discussed on page 14 last paragraph as follows: The elevated concentrations of I-129 exceeded the DWS in seven LLWMA-1 wells while elevated concentrations of Tc-99 exceeded the DWS in three wells from plume migration from the northwest following the south-southeast groundwater gradient in the 200-BP groundwater interest area (see Section 9 of DOE/RL-2019-66 for additional details). The elevated concentrations are associated with wells along the north and northeast boundaries of the burial ground considered upgradient or cross gradient relative to the regional plume orientation. The corresponding downgradient wells continue to trend with upgradient wells but with lower concentrations. The trend analyses between upgradient and downgradient wells did not show any indication of contribution from the 218-E-10 Burial Ground. In summary, the performance assessment indicator parameters for LLWMA-1 did not indicate groundwater quality effects associated with 218-E-10 in 2018. Performance is further assured by calculating annual disposal volumes and concentrations against the WAC.
5.4	Were results differing from expected behavior documented and discussed with any corrective actions?	Results were as expected as noted in Chapter 1 and Table 1. All data were within expected ranges. No corrective actions were required. For the Active Trench 94. CERCLA actions have the potential to affect closure of inactive trenches.

Table C-1. Crosswalk of LFRG 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 R&D, field studies, etc. results provided and discussed? 1) Document number 2) Results 3) PA/CA results	Chapter 5 provides a summary of diffusion and distribution coefficient experiments. This has reduced the uncertainty of some of the PA model inputs. Table 8 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, CP, Waste Acceptance Criteria, MonP, and change control process) discussed? The following information should be provided: 1) Planned or contemplated change 2) Change basis 3) PA/CA impact 4) Schedule	Chapter 6 addresses planned or contemplated changes, including updates to the PAs and other DAS documentation and currently planned closure dates. There is also a discussion of potential changes to the dimensions of the landfills. Table 9 discusses planned or contemplated changes including Change Basis, PA impacts and schedule. Also 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 6) PA, CA, and DAS impact	The ASR Chapter 6, provides a status of the Office of Enterprise Assessments, *Assessment of Low-Level Radioactive Waste Disposal Practices at the Hanford Site.* There were no DAS Key or Secondary issues. See responses to ASR-1.2.

Table C-1. Crosswalk of LFRG Review Criteria to Annual Status Report Content

ID	Review Criteria*	Where Criteria are Met
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.*	Section 8, on page 21 contains the certification.

Complete reference citations are provided in the Chapter C2 in this appendix.

*Source: DOE-STD-5002-2017, *Disposal Authorization Statement and Tank Closure Documentation*.

ASR	=	Annual Status Report
CA	=	composite analysis
CERCLA	=	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CP	=	closure plan
CY	=	calendar year
DAS	=	disposal authorization statement
DOE	=	U.S. Department of Energy
DWS	=	drinking water standard
EA	=	environmental assessment
LFRG	=	Low-Level Waste Disposal Facility Federal Review Group
LLWMA	=	low-level waste management area
MonP	=	monitoring plan
R&D	=	research and development
RCRA	=	*Resource Conservation and Recovery Act of 1976*
RWMB	=	radioactive waste management basis

C2 References

Comprehensive Environmental Response, Compensation, and Liability Act of 1980, 42 USC 9601, et seq., Pub. L. 107-377, December 31, 2002. Available at: https://www.csu.edu/cerc/researchreports/documents/CERCLASummary1980.pdf.

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DOE/RL-2000-72, 2006, *Performance Assessment Monitoring Plan for the Hanford Site Low-Level Burial Grounds*, Rev. 1, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: https://pdw.hanford.gov/document/AR-04023.

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