RCRA-CN-01_DOE/RL-2009-69_R2

Interim Status Change Number 1: Interim Status Groundwater Monitoring Plan for the LLBG WMA-4

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
Richland, Washington 99352

Approved for Public Release;
Further Dissemination Unlimited

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Date Published
April 2020

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APPROVED
By Sarah Harrison at 7:09 am, Jun 10, 2020

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RCRA INTERIM STATUS GROUNDWATER MONITORING PLAN INTERIM CHANGE FORM

Change Number: *(Obtain Change Number From Interim Change Custodian)*		Date:
RCRA-CN-01_DOE/RL-2009-69_R2		04/30/2020
Document Number: DOE/RL-2009-69	Title: Interim Status Change Number 1: Interim Status Groundwater Monitoring Plan for the LLBG WMA-4	Rev: 2
Originator: Tessa Clark		Phone: 3605203189

Description of Change: This form is used only for RCRA interim status groundwater monitoring plans *(i.e., shall not be used for final status groundwater monitoring plans)*. Describe the interim changes made to the RCRA interim status groundwater monitoring plan; consider any previous interim changes made to the plan. Changes cannot be made to the plan that conflict with the requirements of 40 CFR 265, Subpart F.

-Previous Appendix A included the Quality Assurance Project Plan and Sampling Protocols in a single appendix. Replace Appendix A in its entirety with the most current version of the Quality Assurance Project Plan (Appendix A). Added Appendix B, Sampling Protocols, using the most current version.
-Change appendix references to Appendix A and/or Appendix B in Table of Contents, Chapter 1 on page 1-1, Table 2-1 on pg. 2-10, Chapter 3 on pg. 3-1, and Section 3.3 on pg. 3-6, of main text, as applicable.
-Clarify that well 299-W18-21 became rewetted and was added to the network as an upgradient well in 2016 per TPA-CN-718, in: Section 2.5 on pg. 2-6, Section 3.2 on pg. 3-1, and Section 3.4 on pg. 3-6, as applicable. Change well designation of well 299-W18-21 to "Rewetted Well" in Figure 3-1.
-Added upgradient well 299-W18-21 to well network in Table 3-1 and Table 3-2.
-Replace Table 3-1 with new Table 3-1 on pg. 3-3a, and adjust reference in Table of Contents (Tables).
-Add Table 3-1a, "Phenols Analyzed as Groundwater Quality Constituents" to pg. 3-3c and Table of Contents (Tables).
-In Table 3-2, add footnote "a" to clarify wells 299-W15-17 and 299-W18-22 are deep wells and will be used for information only, and footnote "b" to clarify April 2019 groundwater elevation information used for well 299-W18-21.
-Replace reference to annual groundwater monitoring report with reference to annual RCRA groundwater monitoring report in Sections 4.4 and 4.5 in main text, and include March 1 reporting due date in Section 4.5.
-Update Chapter 5 to reflect TPA change notice and annual RCRA groundwater monitoring report reference.

NOTE: For form use see CHPRC-03210, *Review of RCRA Groundwater Data and Management Plans.* Identify page(s), section(s), and table(s) that changed. Attach redline/strikeout of entire groundwater monitoring plan. Post interim change form(s) and redline/strikeout of entire groundwater monitoring plan on the S&GRP webpage as the current plan and place in Facility Operating Record.

Justification and Impacts of Change: State the reason and justification for the change(s) to the issued groundwater monitoring plans. Identify any impacts or actions that may result from this change.

-Appendix A is replaced in its entirety to separate the Quality Assurance Project Plan (Appendix A) and Sampling Protocols (Appendix B) due to multiple updates since issuance of the monitoring plan.
-Changes in the main text reflect the revised Appendix A and new Appendix B.
-Update well network in the main text to add rewetted well 299-W18-21 as an upgradient well due to an increase in groundwater elevation, and classify wells 299-W15-17 and 299-W18-22 as deep wells to be used for information purposes only, per TPA-CN-718.
-Table 3-1 updated to separate parameters required in 40 CFR 265.92 from supporting constituents, and to include corrosion constituents added to assess well integrity.
-Table 3-1a added to clarify what phenols will be analyzed as groundwater quality constituents.
-Clarified that data and reporting occur in the annual RCRA groundwater monitoring

RCRA INTERIM STATUS GROUNDWATER MONITORING PLAN
INTERIM CHANGE FORM (Continued)

Justification and Impacts of Change: State the reason and justification for the change(s) to the issued groundwater monitoring plans. Identify any impacts or actions that may result from this change.

report. March 1 reporting due date added to comply with regulations.

Approvals: Include "Other" approvals as appropriate *(e.g., Obtain SMR approvals on changes to "Field and Laboratory Quality Control Elements and Acceptance Criteria" table).*

Other:

Print First and Last Name	Signature	Date
Kelly Whitley	email approval attached -	06/08/2020

S&GRP Environmental Compliance Officer:

Print First and Last Name	Signature	Date
Sean Sexton	email approval attached -	06/08/2020

CHPRC RCRA Groundwater Manager:

Print First and Last Name	Signature	Date
Bill Faught	email approval attached -	06/08/2020

DOE Subject Matter Expert:

Print First and Last Name	Signature	Date
Doug Hildebrand	email approval attached -	06/08/2020

From: PRC SharePoint
To: Clark, Tessa J
Cc: Clark, Tessa J
Subject: Electronic Approval has completed for document: RCRA-CN-01_DOE_RL-2009-69_R2.
Date: Monday, June 8, 2020 3:03:28 PM

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Electronic Approval for document: RCRA-CN-01_DOE_RL-2009-69_R2 has successfully COMPLETED.

Electronic Approval started by Clark, Tessa J on 6/8/2020 1:14 PM
Comment: To comply with CHPRC's electronic signature directive, we are resending the RCRA groundwater monitoring plan redlines for secondary approval. This is required to process the plans in clearance.

Approved by Whitley, Kelly M on 6/8/2020 1:17 PM
Comment:

Approved by Faught, William R on 6/8/2020 2:35 PM
Comment:

Approved by Sexton, Sean M on 6/8/2020 2:58 PM
Comment:

Approved by Hildebrand, R D (Doug) on 6/8/2020 3:03 PM
Comment:

Change History of Interim Status Monitoring Plan DOE/RL-2009-69, Rev. 2, for Low Level Burial Ground Waste Management Area 4

Title	Document Number	Revision Number	Interim Change Number	Effective Date
Interim Status Groundwater Monitoring Plan for the LLBG WMA-4*	DOE/RL-2009-69	2	N/A	10/29/2012
Interim Status Groundwater Monitoring Plan for the LLBG WMA-4	DOE/RL-2009-69	2	RCRA-CN-01_DOE/RL-2009-69_R2	4/30/2020

*Groundwater monitoring plan was also modified by TPA-CN-718, 2016, *Tri-Party Agreement Change Notice Form: DOE/RL-2009-69, Interim Status Groundwater Monitoring Plan for the LLBG WMA-4, Revision 2*, dated May 12, U.S. Department of Energy, Richland Operations Office, and Washington State Department of Ecology, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/pdf.cfm?accession=0076959H.

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Executive Summary

Low-Level Waste Management Area 4 (LLWMA-4) consists of the 218-W-4B and 218-W-4C Burial Grounds and is regulated via Washington State's RCW 70.105[1] and the implementing requirements in WAC 173-303-400.[2] The Washington State Department of Ecology has been authorized by the U.S. Environmental Protection Agency[3] to conduct its hazardous waste regulatory program in lieu of the *Resource Conservation and Recovery Act of 1976*.[4]

This document supersedes PNNL-14859[5], as revised in interim change notices PNNL-14859-ICN-1[6] and PNNL-14859-ICN-2,[7] to incorporate changes that have occurred at LLWMA-4 since the previous plan was written.

This document describes the groundwater monitoring plan for LLWMA-4. The plan addresses the following:

- Number, locations, and depths of wells in the LLWMA-4 groundwater monitoring network
- Sampling and analytical methods for groundwater parameters and hazardous wastes or hazardous waste constituents
- Procedures for evaluating groundwater quality information
- Schedule for groundwater monitoring at the LLWMA

This indicator monitoring plan is the principal controlling document for conducting groundwater monitoring at LLWMA-4.

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[1] RCW 70.105, "Hazardous Waste Management Act," *Revised Code of Washington*.
[2] WAC 173-303-400, "Dangerous Waste Regulations," "Interim Status Facility Standards," *Washington Administrative Code*, Olympia, Washington.
[3] *Authorized State Hazardous Waste Programs*, 42 USC 6926, et seq.
[4] *Resource Conservation and Recovery Act of 1976*, 42 USC 6901, et seq.
[5] PNNL-14859, 2004, *Interim Status Groundwater Monitoring Plan for Low-Level Waste Management Areas 1 to 4, RCRA Facilities, Hanford, Washington*, Pacific Northwest National Laboratory, Richland, Washington.
[6] PNNL-14859-ICN-1, 2006, *Interim Status Groundwater Monitoring Plan for Low-Level Waste Management Areas 1 to 4, RCRA Facilities, Hanford, Washington*, Interim Change Notice 1, Pacific Northwest National Laboratory, Richland, Washington.
[7] PNNL-14859-ICN-2, 2007, *Interim Status Groundwater Monitoring Plan for Low-Level Waste Management Areas 1 to 4, RCRA Facilities, Hanford, Washington*, Interim Change Notice 2, Pacific Northwest National Laboratory, Richland, Washington.

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Terms

amsl	above mean sea level
CCU	Cold Creek unit
DOE	U.S. Department of Energy
DQO	data quality objective
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
LLW	low-level waste
LLWMA	low-level waste management area
NAVD88	North American Vertical Datum of 1988
OU	operable unit
PCB	polychlorinated biphenyl
PFP	Plutonium Finishing Plant
QAPjP	quality assurance project plan
RCRA	*Resource Conservation and Recovery Act of 1976*
SVOC	semivolatile organic compound
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order*
TOC	total organic carbon
TOX	total organic halides
TPH	total petroleum hydrocarbon
TRU	transuranic
VOC	volatile organic compound

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1 Introduction

Low-Level Waste Management Area 4 (LLWMA-4) is located in the 200 West Area of the Hanford Site (Figure 1-1). The LLWMA-4 consists of the 218-W-4B and 218-W-4C Burial Grounds, which contain 28 unlined trenches that were used for waste disposal. The 218-W-4B Burial Ground also contains 12 below-grade caissons at the southern end of the facility. The LLWMA-4 was used for disposal of low-level radioactive and low-level mixed wastes beginning in 1967. The caissons in the 218-W-4B Burial Ground contain remote-handled, low-level waste (LLW) and retrievable transuranic (TRU) waste. The dangerous chemicals in the low-level mixed waste portions of LLWMA-4 are regulated under the *Resource Conservation and Recovery Act of 1976* (RCRA), as modified in 40 CFR 265 ("Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities") and RCW 70.105 ("Public Health and Safety," "Hazardous Waste Management") and its implementing requirements in Washington State's dangerous waste regulations (WAC 173-303-400, "Dangerous Waste Regulations," "Interim Status Facility Standards").

The objectives for indicator evaluation monitoring, as required by 40 CFR 265.92(d), "Sampling and Analysis," are to determine the following:

- Concentrations of specified groundwater quality parameters annually
- Concentrations of groundwater contamination indicator parameters semiannually
- Annual elevation of the water table

The scope of this plan is to obtain the necessary groundwater data to reach these objectives. This document replaces the previous groundwater monitoring plan (PNNL-14859, *Interim Status Groundwater Monitoring Plan for Low-Level Waste Management Areas 1 to 4, RCRA Facilities, Hanford, Washington*, as revised in interim change notices PNNL-14859-ICN-1 and PNNL-14859-ICN-2) to include several activities that have occurred at LLWMA-4 since that plan was written. Chapter 2 summarizes background information, with reference to additional documents for more detail. Chapter 2 also describes the LLWMA and the types of waste present, provides a brief history of groundwater monitoring, and describes the geology and hydrology pertinent to LLWMA-4. This information is summarized as a site conceptual model to aid in development of the groundwater monitoring program.

Chapter 3 describes the RCRA groundwater monitoring program, including the wells in the monitoring network, constituents analyzed, sampling frequency, and sampling protocols. Chapter 4 describes data evaluation and reporting, and Chapter 5 contains references. Appendix A provides the quality assurance project plan (QAPjP). Appendix B provides the sampling protocols.

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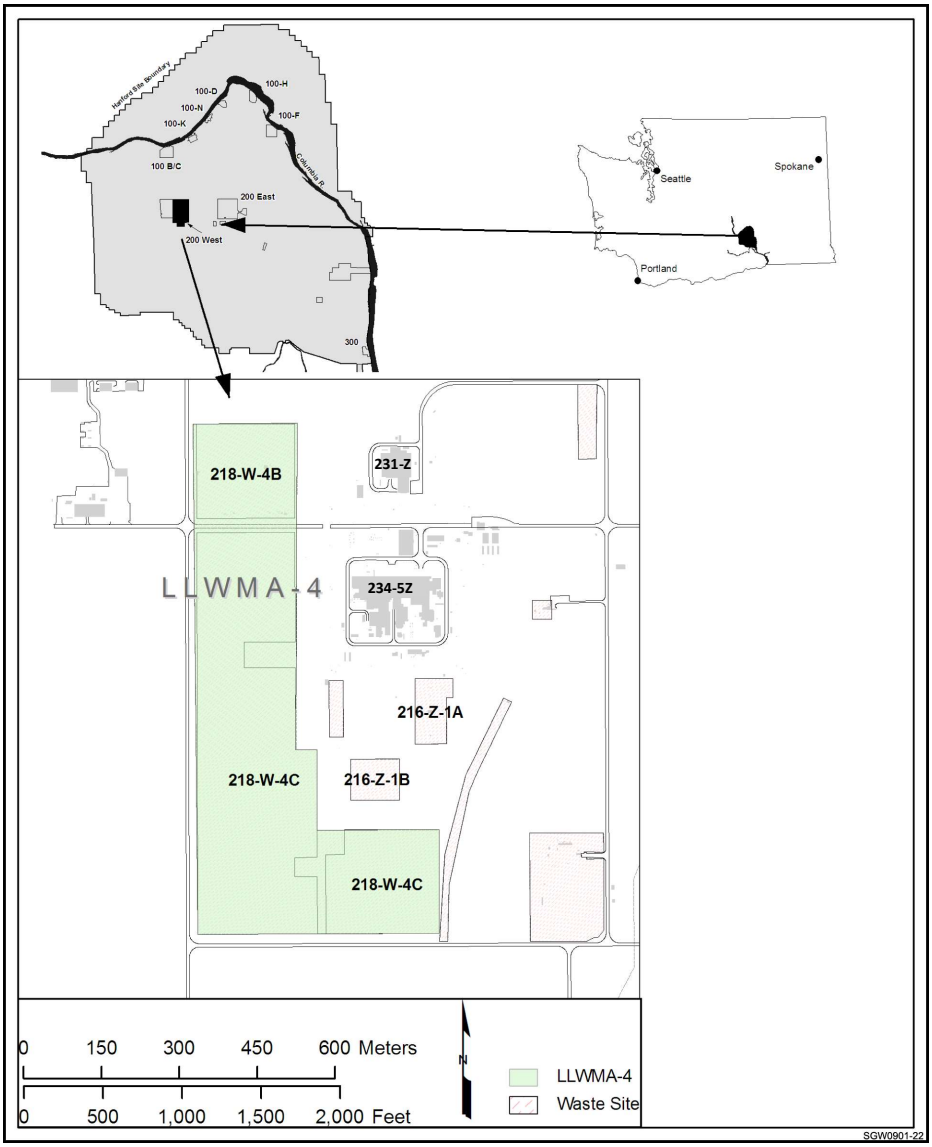

Figure 1-1. Location Map for LLWMA-4

2 Background

This chapter describes the LLWMA-4 facility and operating history, the waste and waste characteristics associated with the LLWMA, the local geology and hydrology, a summary of previous monitoring, the groundwater and vadose zone contamination at the LLWMA, and a conceptual model for the LLWMA. The discussion in this chapter is summarized from previous documents.

2.1 Facility Description and Operating History

The LLWMA-4 is located in the western portion of 200 West Area, west of the Plutonium Finishing Plant (PFP) and Waste Management Area U. The LLWMA-4 consists of the 218-W-4B and 218-W-4C Burial Grounds.

2.1.1 218-W-4B Burial Ground

The 218-W-4B Burial Ground began receiving waste in 1967. After August 19, 1987, RCRA and state-only designated mixed LLW was not disposed to the 218-W-4B Burial Ground. The burial ground covers 4 ha (10 ac) and contains TRU and TRU mixed waste, some of which is contained in caissons (DOE/RL-2004-60, *200-SW-1 Nonradioactive Landfills Group Operable Unit and 200-SW-2 Radioactive Landfills Group Operable Unit Remedial Investigation/Feasibility Study Work Plan*).

The 218-W-4B Burial Ground is located in the central portion of the 200 West Area, about 150 m (500 ft) northwest of the 234-5Z Building and directly west of the 231-Z Building (Figure 1-1). It consists of 14 trenches (one trench contains 12 caissons, of which 4 caissons contain suspect TRU waste). The trenches are approximately 490 m (1,600 ft) long and 3.7 m (12 ft) deep.[8] The burial ground received miscellaneous radioactive waste from the 100, 200, and 300 Areas, as well as offsite waste shipments from 1967 to 1990 (a total of approximately 10,461 m^3 [13,682 yd^3] of waste). Solid waste disposed at the site consisted of rags, paper, cardboard, plastic, pumps, tanks, process equipment, and other miscellaneous high-dose-rate and TRU dry waste. The last waste trench at the 218-W-4B Burial Ground was closed in 1990 (DOE/RL-2004-60).

2.1.2 218-W-4C Burial Ground

The 218-W-4C Burial Ground began receiving waste in 1978. The 218-W-4C Burial Ground contains post-August 19, 1987, RCRA- and state-regulated mixed waste. The burial ground covers approximately 20 ha (50 ac) and contains TRU (some combustible) and test reactor fuel waste. The largest portion of the 218-W-4C Burial Ground is located west and southwest of the PFP, east of Dayton Avenue. A smaller section of the burial ground is located directly south of the PFP and north of 16th Street (DOE/RL-2004-60).

The 281-W-4C Burial Ground is designed to contain up to 65 trenches (each about 3.7 m [12 ft] deep[9]), including the following:

- Forty-eight trenches run east-west:
  - Twenty-four trenches are 184 m (602 ft) long
  - Nineteen trenches are 220 m (719 ft) long

[8] Based on Hanford Site drawing H-2-33055, *Dry Waste Burial Ground 218-W-4B*.

[9] Based on Hanford Site drawing H-2-34762, *Dry Waste Burial Ground 218-W-4C* (RHO-CD-673, 1979, *Handbook 200 Areas Waste Sites,* Volume 2 of 3, Rockwell Hanford Operations, Richland, WA).

  - Four trenches are 180 m (594 ft) long
  - One trench is 91 m (300 ft) long

- Seventeen trenches run north-south:
  - Fourteen trenches are 200 m (665 ft) long
  - Three trenches are 155 m (508 ft) long

Only 15 trenches, ranging from 91 to 219 m (300 to 719 ft) long, have been used for waste storage and/or disposal.

The 218-W-4C Burial Ground began accepting packaged waste materials from 200 West Area operations, other Hanford Site areas, and offsite sources in 1974. According to records, the 218-W-4C Burial Ground contains approximately 20,473 m^3 (26,777 yd^3) of LLW, TRU, and mixed waste. The TRU waste has been segregated from other burial ground waste since 1970 and was placed in separate burial trenches and/or areas of burial trenches where the packages are retrievably stored. In 2004, the last open trench at the 218-W-4B Burial Ground was closed (DOE/RL-2004-60).

2.2 Regulatory Basis

In May 1987, the U.S. Department of Energy (DOE) issued a final rule (10 CFR 962, "Byproduct Material"), stating that the hazardous waste components of mixed waste are subject to RCRA regulations. In November 1987, the U.S. Environmental Protection Agency (EPA) authorized the Washington State Department of Ecology (Ecology) to regulate these hazardous waste components within the state of Washington (51 FR 24504, "EPA Clarification of Regulatory Authority Over Radioactive Mixed Waste"). In 1996, the Washington State Attorney General determined that the effective date of mixed waste in Washington State was August 19, 1987.

In May 1989, DOE, EPA, and Ecology signed the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al., 1989). This agreement established the roles and responsibilities of the agencies involved in regulating and controlling remedial restoration of the Hanford Site, which includes LLWMA-4. Groundwater monitoring is conducted at LLWMA-4 in accordance with WAC 173-303-400(3) (and by reference, 40 CFR 265, Subpart F, "Ground-Water Monitoring"), which requires monitoring to determine whether dangerous waste or dangerous waste constituents from the waste site have entered the groundwater. A RCRA groundwater monitoring program for LLWMA-4 was initiated in 1987 (WHC-SD-EN-AP-015, *Revised Ground-Water Monitoring Plan for the 200 Areas Low-Level Burial Grounds*) based on the interim status monitoring requirements of 40 CFR 265, Subpart F and WAC 173-303-400 and continues today.

Between 1989 and January 2009, groundwater monitoring was conducted under an indicator evaluation monitoring program. In January 2009, a groundwater quality assessment program was initiated at LLWMA-4 (SGW-40211, *First Determination RCRA Groundwater Quality Assessment Plan for the Low-Level Burial Grounds Low-Level Waste Management Area–4*) due to elevated total organic carbon (TOC) in one downgradient well (299-W15-224). In March 2009, groundwater was sampled from wells 299-W15-224, 299-W15-30, and 299-W15-83 and analyzed for coliform bacteria, oil and grease, chemical oxygen demand, total petroleum hydrocarbons (TPHs) (gasoline, diesel, and kerosene), pesticides, herbicides, dioxins, and polychlorinated biphenyls (PCBs), as well as the 40 CFR 264, Appendix IX ("Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," "Ground-Water Monitoring List") list of volatile organic analyses and semivolatile organic analyses. In July 2009, the results of the March sampling did not find dangerous waste in the groundwater at LLWMA-4, and monitoring at the LLWMA returned to indicator evaluation monitoring.

2.3 Waste Characteristics

The waste characteristics for the 218-W-4B and 218-W-4C Burial Grounds are discussed below.

2.3.1 218-W-4B Burial Ground

The 218-W-4B Burial Ground received shipments described as miscellaneous, solid, radioactive mixed waste from several sources on the Hanford Site, including the 100-C, 100-N, 200 West, and 300 Areas. The waste disposed in the burial ground included rags, paper, rubber gloves, disposable supplies, and broken tools. The 12 caissons at the south end of the facility contain remote-handled, retrievable TRU and alpha LLW. Two trenches were also filled with retrievable TRU and TRU mixed waste. The 218-W-4B Burial Ground did not receive any post-August 19, 1987, RCRA- and state-only designated mixed LLW.

2.3.2 218-W-4C Burial Ground

The 218-W-4C Burial Ground started receiving waste in 1978. The burial ground covers approximately 23 ha (57 ac) and contains TRU (some combustible) and test reactor fuel waste (DOE REG-0271, *Low-Level Burial Grounds Fact Sheet*).

The 218-W-4C Burial Ground began accepting packaged waste materials from 200 West Area operations, other Hanford Site areas, and offsite sources in 1974 (based on information from the Waste Information Data System database). According to burial records, the 218-W-4C Burial Ground contained approximately 21,916 m^3 (28,665 yd^3) of LLW, TRU, and mixed waste. The TRU waste has been segregated from other landfill waste since 1970 and placed in separate burial trenches and/or areas of burial trenches, where the packages were retrievably stored.

Trenches 1, 4, 7, 20, and 29 and the east end of Trench 24 contained retrievably stored suspect TRU waste. Trenches NC, 14, 19, 23, 28, 33, 48, 53, and 58 and the remainder of Trench 24 received buried LLW. In addition, some of the waste in Trenches NC, 14, and 58 is currently identified as mixed LLW and was disposed after the effective date of mixed waste regulation at the Hanford Site (August 19, 1987).

The northernmost trench (Trench NC) contains a number of core barrels originating from the U.S. Department of the Navy. Trench 1 contains drums generated from mining the 216-Z-9 Crib/Trench and approximately 500 cans of ash received in the early 1980s. The ash was generated by the 232-Z Waste Incinerator Facility, which incinerated miscellaneous waste (e.g. rubber gloves, rags, paper, spent solvent, and cutting oils).

Trench 7 is at the location of a former waste site. The Z Plant Burn Pit was a disposal site for combustible nonradioactive construction, office, and nonhazardous laboratory waste, including unnamed chemicals. The burn pit is reported to have received 2,000 m^3 (2,600 yd^3) of waste for burning, including less than 1,000 m^3 (1,300 yd^3) of laboratory chemicals. The burn pit was 15 m (50 ft) long, 12 m (40 ft) wide, and 3 m (10 ft) deep, and it was used from 1950 to 1960.

The waste in the 218-W-4C Burial Ground is mainly from the 200 West Area (24 percent by volume), the 100 Area (12 percent), the 300 Area (9 percent), and offsite generators (47 percent). The remaining 8 percent is from miscellaneous Hanford Site areas and the tank farms. The eastern annex portion of this unit never received waste (DOE/RL-2004-60).

2.4 Geology and Hydrogeology

The geology and hydrology of the 200 West Area, including the area of LLWMA-4, has been described in detail in the following documents:

- PNL-6820, *Hydrogeology of the 200 Areas Low-Level Burial Grounds – An Interim Report*
- PNNL-13858, *Revised Hydrogeology for the Suprabasalt Aquifer System, 200-West Area and Vicinity, Hanford Site, Washington*
- PNNL-16887, *Geologic Descriptions for the Solid Waste Low-Level Burial Grounds*
- WHC-SD-EN-AP-015, *Revised Ground-Water Monitoring Plan for the 200 Areas Low-Level Burial Grounds*
- WHC-SD-EN-TI-290, *Geologic Setting of the Low-Level Burial Grounds*

The following discussion summarizes descriptions from these documents. The uppermost aquifer and aquifers hydraulically interconnected beneath the LLWMA are also discussed.

The LLWMA-4 is underlain from the ground surface to the top of the basalt by the Hanford formation, the Cold Creek unit (CCU), and the Ringold Formation. The vadose zone beneath LLWMA-4 is approximately 68 to 76 m (223 to 249 ft) thick and consists of the Hanford formation, the CCU, the Taylor Flats member of the Ringold Formation, and the upper portion of unit E of the Wooded Island member of the Ringold Formation. The water table is at approximately 136 to 137 m (446 to 449 ft) in elevation and is entirely within the Ringold Unit E. The Ringold lower mud unit is present everywhere beneath LLWMA-4 and forms the bottom of the unconfined aquifer. The saturated thickness of the unconfined aquifer is approximately 69 m (226 ft) in the south (at well 299-W18-22) and 59 m (194 ft) in the north (at well 299-W15-17). The thickness of the aquifer, as well as the groundwater flow direction and flow rate, are influenced by the 200-ZP-1 Operable Unit (OU) pump-and-treat system injection wells to the west of the LLWMA and the extraction wells located northeast of the LLWMA.

Water levels in the unconfined aquifer increased as much as approximately 25 m (82 ft) above the pre-Hanford natural water table in the area of U Pond (about 325 m [1,066 ft] south of LLWMA-4) due to artificial recharge from liquid waste disposal operations active between the mid-1940s and 1995. The height of the water table mound beneath LLWMA-4 was at least 18 m (59 ft) above the pre-Hanford elevation, as indicated by water levels from well 699-39-79 (located just west of the LLWMA).

Discharges to U Pond and other disposal facilities from the 1940s through the 1970s changed the groundwater flow direction beneath the LLWMA from eastward (the pre-Hanford direction) to a north or northwest direction. The groundwater flow direction has more recently returned to the pre-Hanford eastward direction, which can be attributed to (1) the groundwater mound beneath U Pond dissipating as a result of cessation of discharges to U Pond, (2) the influence of the 200-ZP-1 OU pump-and-treat system extraction wells east of LLWMA-4, and (3) the injection wells west of the LLWMA reinforcing eastward movement of groundwater in the area.

The hydraulic conductivity in the unconfined aquifer beneath LLWMA-4 is on the order of 2.5 to 10 m/d (8.2 to 32.8 ft/d), and the hydraulic gradient is approximately 0.0032. Using these values and assuming an average effective porosity of aquifer materials between 0.1 and 0.3, the groundwater flow rate is calculated at 0.08 to 0.32 m/d (0.26 to 1.05 ft/d). Figure 2-1 provides a current water table map for LLWMA-4.

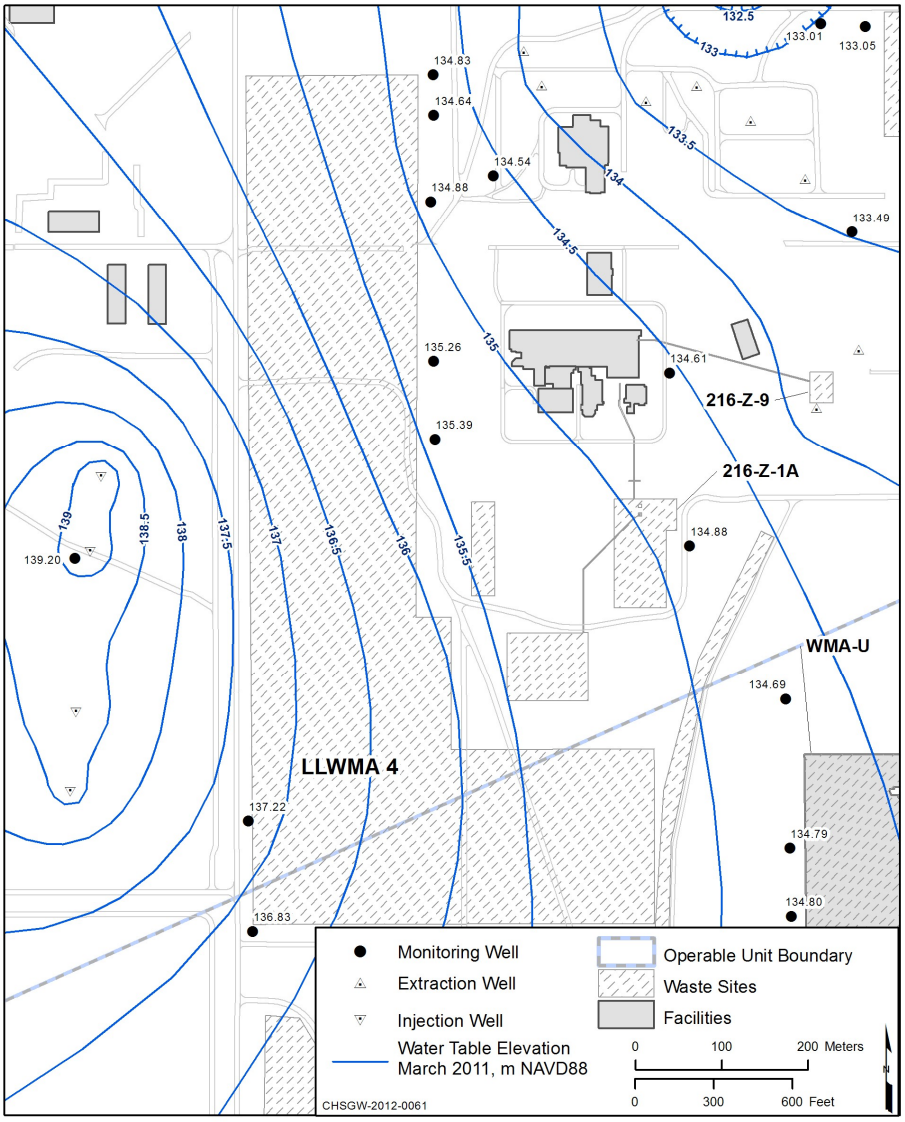

Figure 2-1. Water Table Map for LLWMA-4, March 2011

2.5 Summary of Previous Groundwater Monitoring

Monitoring wells were installed at LLWMA-4 between 1987 and 1992. The original monitoring network included 17 wells. One well, 299-W18-29, was completed in a perched aquifer but went dry soon after it was drilled. Sampling at LLWMA-4 was suspended for a period of time during fiscal years 1990 and 1991. Groundwater flow was toward the west at the beginning of RCRA monitoring, but the hydraulic gradient altered dramatically with termination of discharges to U Pond and other facilities. The initiation of the 200-ZP-1 OU pump-and-treat groundwater remediation also impacted groundwater flow and quality at LLWMA-4. The monitoring network was updated in 1998 to redefine the upgradient and downgradient wells. Four shallow wells and one deep well were chosen to monitor upgradient conditions, and three shallow wells were chosen to monitor downgradient of the burial ground. Since that time, three upgradient wells have gone dry (299-W15-15, 299-W18-21[10], and 299-W18-23); one deep and one shallow upgradient well remain in the monitoring network. After the monitoring network was updated in 1998 to reflect the changing flow directions, newly designated downgradient well 299-W15-16 exceeded the statistical comparison value for total organic halides (TOX). The exceedance was attributed to the regional carbon tetrachloride plume that moved into the area under previous flow conditions. This exceedance was first reported to Ecology in August 1999. The TOX values continue to exceed the critical mean value at LLWMA-4.

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The LLWMA-4 is affected by regional volatile organic compound (VOC) contamination, and the northern portion is within the capture zone of the 200-ZP-1 OU interim action pump-and-treat system. Carbon tetrachloride is the major contaminant in the plume, but chloroform, trichloroethene, tetrachloroethene, and nitrate are also present.

Total organic carbon concentrations between 1,090 and 1,300 µg/L in well 299-W15-224 exceeded the 790 µg/L critical mean in August 2008. This was the first time that the well had exceeded the critical mean for TOC. The well was sampled again and the results available in November 2008 were 2,100 and 2,200 µg/L, again exceeding the critical mean. A request was then submitted to resample the well and analyze for an extensive list of VOCs, semivolatile organic compounds (SVOCs), and TPHs to identify the cause of elevated TOC. The resampling event occurred in December 2008, and the results received in January 2009 indicted that no organic compounds were identified that would account for the elevated TOC.

In January 2009, the Soil and Groundwater Remediation Project notified DOE and other CH2M HILL Plateau Remediation Company organizations regarding the elevated TOC concentration at LLWMA-4, and DOE then notified Ecology. The project also prepared a groundwater quality assessment plan to evaluate the elevated TOC, which proposed sampling wells 299-W15-224, 299-W15-30, and 299-W15-83 for analysis of 40 CFR 264, Appendix IX organic constituents and other constituents potentially responsible for elevated TOC.

Prior to assessment sampling, the pump was removed from well 299-W15-224 and a camera survey was completed to determine if any anomalies were present in the well. Nothing out of the ordinary was noted during the camera survey, the pump was replaced, and samples were collected on March 15 and 16, 2009. The samples were analyzed for the 40 CFR 264, Appendix IX list of VOCs and SVOCs, TOX, chemical oxygen demand, oil and grease, phenols, pesticides, herbicides, PCBs, dioxans, dissolved oxygen, TPH (diesel, gasoline, and kerosene), and coliform bacteria. In July 2009, the results of the first determination

[10]Due to the groundwater elevation increase from 2012 to 2016, well 299-W18-21 became rewetted and, thus, added back into the monitoring network as an upgradient well in May 2016 (TPA-CN-718).

did not find dangerous waste in the groundwater at LLWMA-4, and monitoring at the LLWMA returned to indicator evaluation monitoring.

2.6 Conceptual Model

This section describes the LLWMA-4 conceptual model for potential contaminant transport to guide future groundwater monitoring. The conceptual model for contaminant release and transport is based on the following assumptions:

- Engineered barriers are not taken into account, so the model is applicable to unlined trenches but is highly conservative for the newest (lined) mixed waste trenches.
- Average precipitation and net infiltration (5 to 10 cm/yr [2 to 3.9 in./yr]) prevail over the time frame of interest.
- Net infiltration is assumed to occur under gravity drainage.
- Maximum vertical hydraulic conductivity in the vadose zone is assumed to be significantly larger than the net infiltration rate.
- The effective saturated porosity in the vadose zone is equal to the moisture content.
- Leaching of mobile contaminants from buried waste in unsealed containers, or contaminated soils in direct contact with the trench are assumed to be the major potential sources for contamination.
- There are no artificial sources of water (e.g., leaking potable or raw water lines) based on Hanford Site drawings.
- Extreme conditions or accidental releases are recognized as factors but would be addressed under emergency response/corrective actions.

2.6.1 Geochemical Considerations

The solubility and subsequent mobility of waste constituents in pore fluid depend on the container, chemical nature of the waste constituents, and natural subsurface geochemical conditions.

Pore fluid in the unsaturated and saturated zones beneath LLWMA-4 is slightly alkaline (>7 pH <8), with appreciable amounts of bicarbonate and very little natural organic material. The lack of organic matter means that conditions are generally oxidizing. Calcium carbonate is also abundant in vadose zone sediment. These general conditions favor sorption or retardation of many heavy metals (e.g., uranium) and favor formation of anionic species, which enhances mobility for other metals (e.g., hexavalent chromium). Laboratory sorption studies have documented these effects and related mobility issues in Hanford Site media (e.g., WHC-EP-0645, *Performance Assessment of the Disposal of Low-Level Waste in the 200 West Area Burial Grounds*; and PNNL-11800, *Composite Analysis for Low-Level Waste Disposal in the 200 Area Plateau of the Hanford Site*).

2.6.2 Soil Moisture Factors

With the exception of waste in sealed metal or concrete containers (e.g., retrievable waste), direct precipitation is the primary driver for hypothetical leaching of waste constituents from the burial trenches and subsequent transport to groundwater. Contaminants in the soil disposed to the trench or waste in degradable containers (e.g., cardboard boxes or wooden boxes) subject to collapse are assumed to be leachable.

The amount of natural infiltration that can pass through the leachable buried waste and drain to the water table is controlled by the texture of the cover and backfill and by the amount of vegetative cover. Stratigraphic features in the soil column beneath the buried waste can also influence or retard downward migration by spreading soil moisture laterally. Direct observational evidence to assess this effect at LLWMA-4 is lacking. Under the gravity drainage assumption, only a small horizontal gradient component is likely to be available to produce lateral spreading of infiltrating water.

Most of the burial ground trenches are backfilled with natural excavation materials (Hanford formation) consisting of coarse gravel, cobbles, and some interstitial sand. Some amount of vegetation exists on the established backfilled areas and on unused portions of the LLWMA. A coarse, nonvegetated cover material allows a major fraction of the precipitation to infiltrate and potentially drain to groundwater. In "Hanford Site Vadose Zone Studies: An Overview" (Gee et al., 2007), it is estimated that recharge rates at the Hanford Site range from near zero at highly vegetated sites to greater than 50 mm/yr at gravel-covered, nonvegetated sites.

2.6.3 Hydrogeologic Considerations

The vadose zone beneath LLWMA-4 is between 68 and 76 m (223 and 249 ft) thick and consists of (from top to bottom) the Hanford formation, the CCU, and the Ringold Formation. The CCU is likely to retard downward movement of moisture and contaminants due to the finer textured sediment and cementing that characterize this stratigraphic feature in the vadose zone.

If contaminants do break through to groundwater beneath LLWMA-4, contaminants would move toward the east-northeast. The flow direction has shifted from nearly north to northeast and is slowly changing eastward as the influence of the groundwater mound subsides. Also, because of the low permeability of the aquifer in this area, groundwater flow rate is estimated to be between about 29 to 117 m/yr (96 to 383 ft/yr).

As the 200-ZP-1 OU groundwater pump-and-treat system is expanded to add extraction and injection wells to provide greater capacity, the pump-and-treat system may impact groundwater levels and gradients beneath LLWMA-4. After the system becomes fully operational, groundwater level data will be evaluated. Any hydrologic and hydrogeologic impacts that occur based on the operation of the pump and treat will be reported and incorporated into the monitoring program.

2.7 Data Quality Objectives

To define the required information for groundwater indicator evaluation monitoring, the data quality objective (DQO) process is used to ensure that data gathered are of appropriate quantity and quality to meet specific objectives. The DQO parameters, regulatory interim status requirements, and associated reports supporting the regulatory requirements are outlined in Table 2-1.

Table 2-1. DQOs at RCRA Sites Monitoring for Indicator Parameters

DQO Parameter	Related Requirements	Plan Criteria and Associated Historical Documentation
Scope	RCRA interim status ground-water monitoring at sites where no impact to ground-water has been identified. Related requirements are found in WAC 173-303-400(3) and 40 CFR 265.90 through 40 CFR 265.94, as modified by WAC 173-303-400(3)(b) and WAC 173-303-400(3)(c)(v).	
Number and location of wells Point(s) of compliance	**40 CFR 265.91, "Ground-Water Monitoring System."** (a) A ground-water monitoring system must be capable of yielding ground-water samples for analysis and must consist of: (1) Monitoring wells (at least one) installed hydraulically upgradient (i.e., in the direction of increasing static head) from the limit of the waste management area. Their number, locations, and depths must be sufficient to yield ground-water samples that are: (i) Representative of background ground-water quality in the uppermost aquifer near the facility; and (ii) Not affected by the facility; and (2) Monitoring wells (at least three) installed hydraulically downgradient (i.e. in the direction of decreasing static head) at the limit of the waste management area. Their number, locations, and depths must ensure that they immediately detect any statistically significant amounts of dangerous waste or dangerous waste constituents that migrate from the waste management area to the uppermost aquifer.	This plan, Section 3.2 PNNL-14859, *Interim Status Groundwater Monitoring Plan for Low-Level Waste Management Areas 1 to 4, RCRA Facilities, Hanford, Washington* PNNL-14859-ICN-1 PNNL-14859-ICN-2
Well configuration (depth and length of screened interval; well construction)	**40 CFR 265.91, "Ground-Water Monitoring System," as modified by WAC 173-303-400.** (c) All monitoring wells must be cased in a manner that maintains the integrity of the monitoring well borehole. This casing must be screened or perforated, and packed with gravel or sand where necessary; to enable sample collection at depths where appropriate aquifer flow zones exist. The annular space (i.e., the space between the borehole and well casing) above the sampling depth must be sealed with a suitable material (e.g., cement grout or bentonite slurry) to prevent contamination of samples and the ground-water.	This plan, Section 3.2 PNNL-14859, *Interim Status Groundwater Monitoring Plan for Low-Level Waste Management Areas 1 to 4, RCRA Facilities, Hanford, Washington* PNNL-14859-ICN-1 PNNL-14859-ICN-2

Table 2-1. DQOs at RCRA Sites Monitoring for Indicator Parameters

DQO Parameter	Related Requirements	Plan Criteria and Associated Historical Documentation
	Additional Requirements from WAC 173-303-400(3)(c)(v)(C). Ground-water monitoring wells must be designed, constructed, and operated so as to prevent ground-water contamination. WAC 173-160 may be used as guidance in the installation of wells.	
Frequency of sampling Types of analysis or measurement Method detection limits or accuracy and precision	**40 CFR 265.92, "Sampling and Analysis."** (b) The owner or operator must determine the concentration or value of the following parameters in ground-water samples in accordance with paragraphs (c) and (d) of this section: (1) Parameters characterizing the suitability of the ground-water as a drinking water supply, as specified in Appendix III. *[NOTE: Have not listed these because, in accordance with 40 CFR 265.92(c)(1), these analyses are only conducted for the first year, and this site is not in the first year of monitoring.]* (2) Parameters establishing ground-water quality: (i) Chloride (ii) Iron (iii) Manganese (iv) Phenols (v) Sodium (vi) Sulfate *[COMMENT: These parameters are to be used as a basis for comparison in the event a groundwater quality assessment is required under 40 CFR 265.93(d).]*	This plan, Section 3.1 ~~and~~ Appendix A, and Appendix B PNNL-14859, *Interim Status Groundwater Monitoring Plan for Low-Level Waste Management Areas 1 to 4, RCRA Facilities, Hanford, Washington* PNNL-14859-ICN-1 PNNL-14859-ICN-2

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Table 2-1. DQOs at RCRA Sites Monitoring for Indicator Parameters

DQO Parameter	Related Requirements	Plan Criteria and Associated Historical Documentation
	40 CFR 265.92, "Sampling and Analysis." (cont'd) (3) Parameters used as indicators of ground-water contamination: (i) pH (ii) Specific conductance (iii) Total organic carbon (iv) Total organic halogen (c)(1) For all monitoring wells, the owner or operator must establish initial background concentrations or values of all parameters specified in paragraph (b) of this section. The owner or operator must do this quarterly for one year. (c)(2) For each of the indicator parameters specified in paragraph (b)(3) of this section, at least four replicate measurements must be obtained for each sample and the initial background arithmetic mean and variance must be determined by pooling the replicate measurements for the respective parameter concentrations or values in samples obtained from upgradient wells during the first year. (d) After the first year, all monitoring wells must be sampled and the samples analyzed with the following frequencies: (1) Samples collected to establish ground-water quality must be obtained and analyzed for the parameters specified in paragraph (b)(2) of this section at least annually. (2) Samples collected to indicate ground-water contamination must be obtained and analyzed for the parameters specified in paragraph (b)(3) of this section at least semiannually. (e) Elevation of the ground-water surface at each monitoring well must be determined each time a sample is obtained.	

Table 2-1. DQOs at RCRA Sites Monitoring for Indicator Parameters

DQO Parameter	Related Requirements	Plan Criteria and Associated Historical Documentation
Methods used to evaluate the collected data	**40 CFR 265.93, "Preparation, Evaluation, and Response."** (b) For each indicator parameter specified in 40 CFR 265.92(b)(3), the owner or operator must calculate the arithmetic mean and variance, based on at least four replicate measurements on each sample, for each well monitored in accordance with 40 CFR 265.92(d)(2) and compare these results with the initial background arithmetic mean. The comparison must consider individually each of the wells in the monitoring system, and must use the Student's t-test at the 0.01 level of significance (see Appendix IV) to determine statistically significant increases (and decreases, in the case of pH) over initial background.	This plan, Section 4.2 and Appendix A PNNL-14859, *Interim Status Groundwater Monitoring Plan for Low-Level Waste Management Areas 1 to 4, RCRA Facilities, Hanford, Washington* PNNL-14859-ICN-1 PNNL-14859-ICN-2

Notes: The references cited in this table are listed in the reference list (Chapter 5) of this plan.

DQO = data quality objective

RCRA = *Resource Conservation and Recovery Act of 1976*

3 Groundwater Monitoring Program

This chapter lists the wells monitored, constituents analyzed, and sampling frequency. ~~Protocols for sampling and analysis~~ Analytical methods are provided in the QAPjP in Appendix A. Sampling protocols are provided in Appendix B.

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3.1 Constituent List and Sampling Frequency

Table 3-1 lists the constituents to be analyzed for RCRA. Wells are sampled semiannually and constituents are monitored semiannually or annually, as indicated in Table 3-1. Maintenance problems and sampling logistics sometimes delay scheduled sampling events. If sampling at a well is delayed more than 3 months, that event will be cancelled, as it would be nearly time for the next scheduled sampling event. Missed sampling events are reported in the annual groundwater report.

3.2 Monitoring Well Network

Figure 3-1 shows the groundwater monitoring well network for LLWMA-4. Table 3-1 lists the wells in the groundwater monitoring network, their constituents, and sampling frequencies. Some of the wells in the LLWMA-4 monitoring network are also sampled for the 200-ZP-1 OU. Sampling for LLWMA-4 and the 200-ZP-1 OU is coordinated to eliminate duplicate analyses and well trips.

Table 3-2 summarizes well construction information and provides the current water table elevation in each well. All of the wells in the LLWMA-4 monitoring network are constructed to meet the requirements of WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells." These wells have stainless-steel casing and screen, sand pack in the screened interval, and full annular seal above.

Four new downgradient wells were drilled in 2005 and 2006. Several alternatives are currently being considered regarding upgradient well compliance issues:

- **Deepen existing wells upgradient of LLWMA-4:** Four dry monitoring wells that have not yet been decommissioned are located along the western (upgradient) edge of LLWMA-4 and are candidates for deepening. The March 2009 depth to water was between approximately 77 m (252 ft) below ground surface at well 299-W15-15 and 68 m (223 ft) below ground surface at well 299-W18-21 prior to the wells going dry. Thus, the dry wells located west of LLWMA-4 would need to be deepened as much as 7.6 m (25 ft) from original drilled depth to have about 6.1 m (20 ft) of water in the new screened interval.
- **Identify one existing useable well upgradient:** Only well 699-39-79 is a potential candidate for use as an upgradient well. The well is an old, perforated, carbon-steel well that is currently used for water-level measurements. There is no documentation regarding the surface casing, surface seals, or annual seals; therefore, the well is not WAC 173-160-compliant but it might be usable as a monitoring well after further evaluation and extensive well maintenance.
- Due to groundwater elevation changes from 2012 to 2016, well 299-W18-21 is able to be sampled as an upgradient monitoring well, and was added back into the monitoring network as an upgradient monitoring well in May 2016 (TPA-CN-718).

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Table 3-1. Monitoring Network, Constituent List, and Sampling Frequency for LLWMA-4

Well Name	Purpose	WAC Compliant	RCRA Required[a] Contaminant Indicator Parameters					Groundwater Quality Parameters							Supporting Constituents[b]			
								Anions[d]			Metals (Unfiltered)[d]							
			Water Level[c]	pH[c]	Specific Conductance[c]	TOC	TOX	Chloride	Nitrate	Sulfate	Sodium	Iron	Manganese	Phenols[d]	Temperature[c]	Turbidity[c]	Dissolved Oxygen[c]	Alkalinity
299-W15-17	Downgradient	Y	S	S	S	S	S	A	A	A	A	A	A	A	S	S	S	A
299-W15-30	Downgradient	Y	S	S4	S4	S4	S4	A	A	A	A	A	A	A	S	S	S	A
299-W15-83	Downgradient	Y	S	S4	S4	S4	S4	A	A	A	A	A	A	A	S	S	S	A
299-W15-94	Downgradient	Y	S	S4	S4	S4	S4	A	A	A	A	A	A	A	S	S	S	A
299-W15-152	Downgradient	Y	S	S4	S4	S4	S4	A	A	A	A	A	A	A	S	S	S	A
299-W15-224	Downgradient	Y	S	S4	S4	S4	S4	A	A	A	A	A	A	A	S	S	S	A
299-W18-22	Upgradient	Y	S	S	S	S	S	A	A	A	A	A	A	A	S	S	S	A

a. Constituents and parameters required by 40 CFR 265.92, "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," "Sampling and Analysis."

b. Constituents are not required by RCRA but are needed to support interpretation.

c. Field measurement.

d. For anions, analytes include, but are not limited to, chloride, fluoride, nitrate, nitrite, and sulfate. For cations/metals, analytes include, but are not limited to, calcium, chromium, iron, magnesium, manganese, potassium, and sodium.

~~Table 3-1. Monitoring Network, Constituent List, and Sampling Frequency for LLWMA-4~~

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Well Name	Purpose	WAC Compliant	RCRA Required[a] Contaminant Indicator Parameters					Groundwater Quality Parameters							Supporting Constituents[b]			
								Anions[d]			Metals (Unfiltered)[d]							
			Water Level[e]	pH[e]	Specific Conductance[e]	TOC	TOX	Chloride	Nitrate	Sulfate	Sodium	Iron	Manganese	Phenols[d]	Temperature[e]	Turbidity[e]	Dissolved Oxygen[e]	Alkalinity

A = sampled annually
RCRA = *Resource Conservation and Recovery Act of 1976*
S = sampled semiannually
S4 = sampled semiannually, with quadruplicate samples taken
TOC = total organic carbon
TOX = total organic halides
Y = well is constructed to the resource protection well standards of WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells"

Table 3-1. Monitoring Network, Constituent List, and Sampling Frequency for LLWMA-4

Well Name	Purpose	WAC Compliant	RCRA Required Parameters[a]											Supporting Constituents[b]			
				Contaminant Indicator Parameters				Groundwater Quality Parameters									
			Water Level[f]	pH[c]	Specific Conductance[c]	TOC	TOX	Chloride	Sulfate	Sodium[d]	Iron[d]	Manganese[d]	Phenols[e]	Anions[f]	Field Measurements[g]	Metals[d,h]	Alkalinity
299-W15-17[i]	Downgradient	Y	S	S	S	S	S	A	A	A	A	A	A	S	S	S	A
299-W15-30	Downgradient	Y	S	S4	S4	S4	S4	A	A	A	A	A	A	S	S	S	A
299-W15-83	Downgradient	Y	S	S4	S4	S4	S4	A	A	A	A	A	A	S	S	S	A
299-W15-94	Downgradient	Y	S	S4	S4	S4	S4	A	A	A	A	A	A	S	S	S	A
299-W15-152	Downgradient	Y	S	S4	S4	S4	S4	A	A	A	A	A	A	S	S	S	A
299-W15-224	Downgradient	Y	S	S4	S4	S4	S4	A	A	A	A	A	A	S	S	S	A
299-W18-21	Upgradient	Y	S	S4	S4	S4	S4	A	A	A	A	A	A	S	S	S	A
299-W18-22[i]	Upgradient	Y	S	S	S	S	S	A	A	A	A	A	A	S	S	S	A

a. Constituents and parameters required by 40 CFR 265.92, "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," "Sampling and Analysis."

b. Supporting constituents are used to support interpretation of the required groundwater monitoring results and provide a better understanding of the potential condition of the network wells. Some constituents (chloride, iron, manganese, sodium, and sulfate) are also collected as groundwater quality parameters and are subject to collection requirements under RCRA. The remaining supporting constituents are not required, or subject to requirements, under RCRA.

c. Field measurement.

d. Unfiltered samples will be collected in conjunction with filtered samples for select analysis to determine if metal constituents being monitored occur as both suspended and dissolved phases or in only one state. The evaluation of suspended and dissolved metals provides supporting information for groundwater geochemical characteristics, as well as indication of well integrity such as the presence of dislodged well encrustation, well corrosion products, or failure of the well screen filter pack.

e. The specific phenols to be analyzed as groundwater quality parameters are identified in Table 3-1a.

f. For anions, analytes include chloride, fluoride, nitrate, nitrite, and sulfate.

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Table 3-1. Monitoring Network, Constituent List, and Sampling Frequency for LLWMA-4

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Well Name	Purpose	WAC Compliant	RCRA Required Parameters[a]												Supporting Constituents[b]			
				Contaminant Indicator Parameters				Groundwater Quality Parameters										
			Water Level[f]	pH[c]	Specific Conductance[c]	TOC	TOX	Chloride	Sulfate	Sodium[d]	Iron[d]	Manganese[d]	Phenols[e]	Anions[f]	Field Measurements[g]	Metals[d,h]	Alkalinity

g. Field measurements include dissolved oxygen, temperature, and turbidity.

h. Metals (filtered and unfiltered) include calcium, magnesium, potassium, and sodium for groundwater chemistry and charge balance calculations, and chromium, iron, manganese, molybdenum, and nickel for identification of well casing corrosion.

i. Deep monitoring well used for information purposes only and not required to satisfy regulatory requirements. Because the sample results from deep wells are used for information only and are not used to satisfy regulatory requirements, this well is specified for annual sampling and the indicator parameters are not collected in quadruplicate.

A = sampled annually
RCRA = *Resource Conservation and Recovery Act of 1976*
S = sampled semiannually
S4 = sampled semiannually, with quadruplicate samples taken
TOC = total organic carbon
TOX = total organic halides
Y = well is constructed to the resource protection well standards of WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells"

Table 3-1a. Phenols Analyzed as Groundwater Quality Constituents

Constituent	CAS Number
2-Chlorophenol	95-57-8
2-Methylphenol (o-Cresol)	95-48-7
2-Nitrophenol (o-Nitrophenol)	88-75-5
2,3,4,6-Tetrachlorophenol	58-90-2
2,4-Dichlorophenol	120-83-2
2,4-Dimethylphenol (2,4-Xylenol)	105-67-9
2,4-Dinitrophenol	51-28-5
2,4,5-Trichlorophenol	95-95-4
2,4,6-Trichlorophenol	88-06-2
2,6-Dichlorophenol	87-65-0
3-Methylphenol (m-Cresol)	108-39-4*
4-Chloro-3-methylphenol (p-Chloro-m-cresol)	59-50-7
4-Methylphenol (p-Cresol)	106-44-5*
4,6-Dinitro-O-cresol (4,6-Dinitro-2-methyl phenol)	534-52-1
Dinoseb (2-sec-Butyl-4,6-dinitrophenol)	88-85-7
p-Nitrophenol (4-Nitrophenol)	100-02-7
Pentachlorophenol	87-86-5
Phenol	108-95-2

This table provides the specific phenols to be included for analysis as groundwater quality parameters under this monitoring plan.

*Analyzed and reported as 3 & 4 Methylphenol (CAS number 65794-96-9)

CAS = Chemical Abstracts Service

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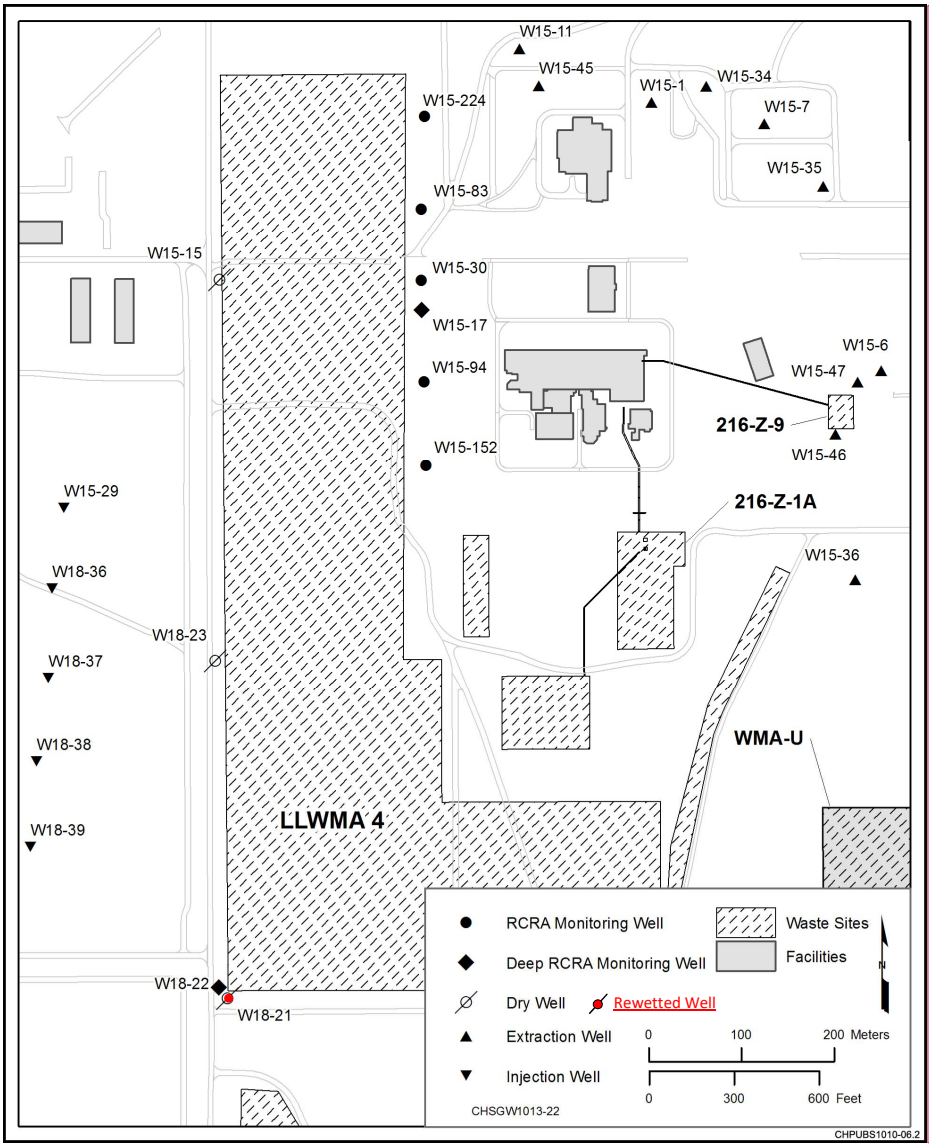

Figure 3-1. Groundwater Monitoring Network for LLWMA-4

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Table 3-2. Attributes for Wells in LLWMA-4 Groundwater Monitoring Network

Well Name	Completion Date	Easting (m)	Northing (m)	Top of Casing Elevation (m NAVD88)	Water Table Elevation (m amsl)*	Screened Interval Top (m amsl)	Screened Interval Bottom (m amsl)	Water Remaining (m)
299-W15-17[a]	October 1987	566306.891	135718.958	209.78	135.14	80.98	77.98	57.16
299-W15-30	May 1995	588304.617	135748.936	210.13	135.08	143.67	131.49	3.59
299-W15-83	September 2005	566304.52	135826.24	209.32	134.88	137.69	127.02	7.86
299-W15-94	September 2005	566307.58	135640.34	209.86	135.26	137.90	126.23	9.03
299-W15-152	September 2005	566309.40	135550.00	209.87	135.39	137.93	126.26	9.13
299-W15-224	April 2006	566307.89	135926.08	209.19	134.64	137.41	126.74	7.90
299-W18-21	July 1987	566097.70	134978.692	204.90	137.252[b]	144.21	135.06	2.19[b]
299-W18-22[a]	September 1987	566088.632	134990.157	204.86	136.33	77.91	68.46	67.87

* March 2011 water levels.

a. Deep monitoring wells used for information only and not to satisfy regulatory requirements.

b. April 2019 water data.

amsl = above mean sea level

NAVD88 = North American Vertical Datum of 1988

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- **Alternative statistics that do not require upgradient wells:** The RCRA allows application of intrawell statistical methods for analysis of groundwater monitoring data at permitted facilities. These methods, allowable in accordance with WAC 173-303-645(8) ("Releases from Regulated Units"), include the use of a tolerance or prediction interval procedure (in WAC 173-303-645[8][h][ii]) and a control-chart approach (in WAC 173-303-645[8][h][iv]). These approaches may be applied without the use of upgradient wells because each new analytical result from a downgradient well is compared to previously obtained results from the same well. For groundwater applications, procedures for both methods are discussed in EPA guidance (EPA/530-R-93-003, *Statistical Training Course for Ground-Water Monitoring Data Analysis*; EPA 530/R-09-007, *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities Unified Guidance*) and in *Guide for Developing Appropriate Statistical Approaches for Ground-Water Detection Monitoring Programs* (ASTM D6312-98).

- **Temporary use of a new 200 West Area pump-and-treat injection well:** New injection well IW-7 is scheduled for installation in fiscal year 2013 or 2014 and is located on the west (upgradient) side of LLWMA-4. It may be feasible that the well could be used as an upgradient monitoring well until such time that it is needed as an injection well.

3.3 Sampling and Analysis Protocol

Groundwater monitoring activities at LLWMA-4 follow the conventions of the project and are described in Chapter 4 and Appendix B.

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3.4 Differences Between This Plan and Previous Plan

There are several differences between the wells and analytes monitored by this plan and the wells and analytes measured by the previous plan (PNNL-14859-ICN-2), including the following:

- Three wells that ~~recently~~ went dry (299-W15-15, 299-W18-21, and 299-W18-23) ~~have been~~ were dropped from the network described in the previous plan. Between 2012 and 2016, well 299-W18-21 became rewetted and was added back into the monitoring network as an upgradient monitoring well in May 2016 (TPA-CN-718).

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- Two analytes, mercury and lead, have been dropped from the LLWMA-4 analyte list. Twenty years of monitoring for these constituents has shown that neither is a problem at the LLWMA.

- The sampling frequency for groundwater quality parameters has been changed from semiannual to annual, which is still in compliance with 40 CFR 265.92(d)(1).

4 Data Evaluation and Reporting

This chapter discusses data evaluation and reporting for LLWMA-4.

4.1 Data Review

Data review, validation, and verification activities are discussed in the QAPjP (Appendix A).

4.2 Statistical Evaluation

Statistical upgradient and downgradient comparisons are required to test for potential impact to the groundwater at RCRA interim status facilities in accordance with 40 CFR 265.93, "Preparation, Evaluation, and Response." For each of the four indicator parameters, the owner or operator must calculate the arithmetic mean and variance based on at least four replicate measurements on each sample for each well monitored and compare these results with the initial background arithmetic mean. The comparison must consider each of the individual wells in the monitoring system and must use the Student's t-test at the 0.01 level of significance to determine statistically significant increases (and decreases, in the case of pH) over initial background. Implementation of the statistical test method at the Hanford Site, including at LLWMA-4, is described in further detail in *Hanford Site Groundwater Monitoring: Setting, Sources and Methods* (PNNL-13080); *Statistical Approach on RCRA Groundwater Monitoring Projects at the Hanford Site* (WHC-SA-1124-FP); and EPA 530/R-09-007.

If a comparison for an upgradient well shows a significant increase (or pH decrease), then the information must be submitted in the Hanford Site annual groundwater report. If a comparison for a downgradient well show a significant increase (or pH decrease), then the well is resampled and split samples are sent to different laboratories to determine if the exceedance of the comparison value was the result of laboratory error. In addition, the original samples may be re-analyzed if laboratory error is suspected.

If the exceedance of the statistical comparison value is confirmed by resampling, written notice is then provided to the regional administrator within 7 days that the facility may be affecting groundwater quality. Within 15 days after the notification, a groundwater quality assessment program must be developed and submitted. In some instances, it is possible to immediately determine that the statistical finding is not the result of contamination from the facility. In that case, the regional administrator is notified and an assessment program is not instituted.

4.3 Interpretation

After data are validated and verified, acceptable data are used to interpret groundwater conditions at LLWMA-4. Interpretive techniques include the following:

- **Hydrographs:** Graph water levels versus time to determine decreases, increases, seasonal, or manmade fluctuations in groundwater levels.
- **Water table maps:** Use water table elevations from multiple wells to construct contour maps and to estimate flow directions. Groundwater flow is assumed to be perpendicular to lines of equal potential on the maps.
- **Trend plots:** Graph concentrations of constituents versus time to determine increases, decreases, and fluctuations. May be used in tandem with hydrographs and/or water table maps to determine if concentrations are related to changes in water level or in groundwater flow directions.

- **Plume maps:** Map distributions of chemical or radiological constituent concentrations in the aquifer to determine the extent of contamination. Changes in plume distribution over time assist in determining plume movement and the direction of groundwater flow.
- **Contaminant ratios:** Can sometimes be used to distinguish among different sources of contamination.

4.4 Annual Determination of Monitoring Network

The RCRA groundwater monitoring requirements include an annual evaluation of the groundwater monitoring network to determine if it remains adequate to monitor the LLWMA. The network must include upgradient and downgradient wells in the uppermost aquifer.

The groundwater flow direction beneath LLWMA-4 may change in the future due to increases or decreases in groundwater extraction and injection associated with the 200 West pump and treat. The 200 West Area pump and treat was installed in 2011 and began operations in 2012. The installation of the system has delayed proposing new monitoring well construction until after the effects of the pump and treat are measured. Any new RCRA wells needed at LLWMA-4 will be negotiated and prioritized by Ecology, DOE, and EPA and approved in accordance with Tri-Party Agreement Milestone M-24-00.

Water-level measurements will continue to be collected before each sampling event. A more comprehensive set of water-level measurements is made in the 200 West Area in March of each year. The resulting data are presented in the annual Hanford Site RCRA groundwater monitoring report (e.g., ~~DOE/RL-2011-118*Hanford Site Groundwater Monitoring for 2011*~~ DOE/RL-2018-65, *Hanford Site RCRA Groundwater Monitoring Report for 2018*).

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4.5 Reporting and Notification

The results of indicator evaluation monitoring are reported annually in accordance with the requirements of 40 CFR 265.94, "Recordkeeping and Reporting." Reporting will be made in the annual Hanford Site RCRA groundwater monitoring report (e.g., DOE/RL-2018-65) by March 1 ~~groundwater monitoring report (e.g., DOE/RL-2011-118~~).

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Appendix A

Quality Assurance Project Plan

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Terms

DOE	U.S. Department of Energy
DQI	data quality indicator
DUP	duplicate (laboratory)
DWMU	dangerous waste management unit
EB	equipment blank
ECO	Environmental Compliance Officer
EPA	U.S. Environmental Protection Agency
FSO	Field Sample Operations
FTB	full trip blank
FWS	Field Work Supervisor
HEIS	Hanford Environmental Information System
LCS	laboratory control sample
MB	method blank
MS	matrix spike
MSD	matrix spike duplicate
QA	quality assurance
QAPjP	quality assurance project plan
QC	quality control
RCRA	*Resource Conservation and Recovery Act of 1976*
SMR	Sample Management and Reporting
SPLIT	field split
SUR	surrogate

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A1 Introduction

A quality assurance project plan (QAPjP) establishes the quality requirements for environmental data collection. This QAPjP includes planning, implementation, and assessment of sampling tasks, field measurements, laboratory analysis, and data review. This chapter describes the applicable environmental data collection quality assurance (QA) elements for this groundwater monitoring plan. This QAPjP is intended to supplement the contractor's environmental QA program plan.

This QAPjP is divided into the following four chapters that describe the quality requirements and controls applicable to the dangerous waste management unit (DWMU) groundwater monitoring activities:

- Chapter A2, Project Management
- Chapter A3, Data Generation and Acquisition
- Chapter A4, Data Review and Usability
- Chapter A5, References

A2 Project Management

This chapter addresses the management approaches planned, project goals, and planned documentation.

A2.1 Project/Task Organization

Project organization (regarding groundwater monitoring) is described in the following sections and illustrated in Figure A-1. Titles used in the project organization are for the purposes of discussing the role of the individual in the performance of the work scope. Individuals with different titles but similar/equivalent positions may fulfill these roles.

A2.1.1 U.S. Department of Energy Manager

Hanford Site operation is the responsibility of the U.S. Department of Energy (DOE). The DOE Manager is responsible for authorizing the contractor to perform activities at the Hanford Site under the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*; *Resource Conservation and Recovery Act of 1976* (RCRA); *Atomic Energy Act of 1954*; and Ecology et al., 1989, *Hanford Federal Facility Agreement and Consent Order*.

A2.1.2 U.S. Department of Energy Project Lead

The DOE Project Lead is responsible for providing day-to-day oversight of the contractor's performance of the work scope, working with the contractor to identify and work through issues, and providing technical input to DOE management.

A2.1.3 U.S. Department of Energy Primary Contractor Management for Groundwater Science

The DOE Primary Contractor Management for Groundwater Science provides oversight and coordinates with DOE in support of sampling and reporting activities. The DOE Primary Contractor Management for Groundwater Science also provides support to the Project Delivery Manager for Groundwater Science to ensure that work is performed safely and cost effectively.

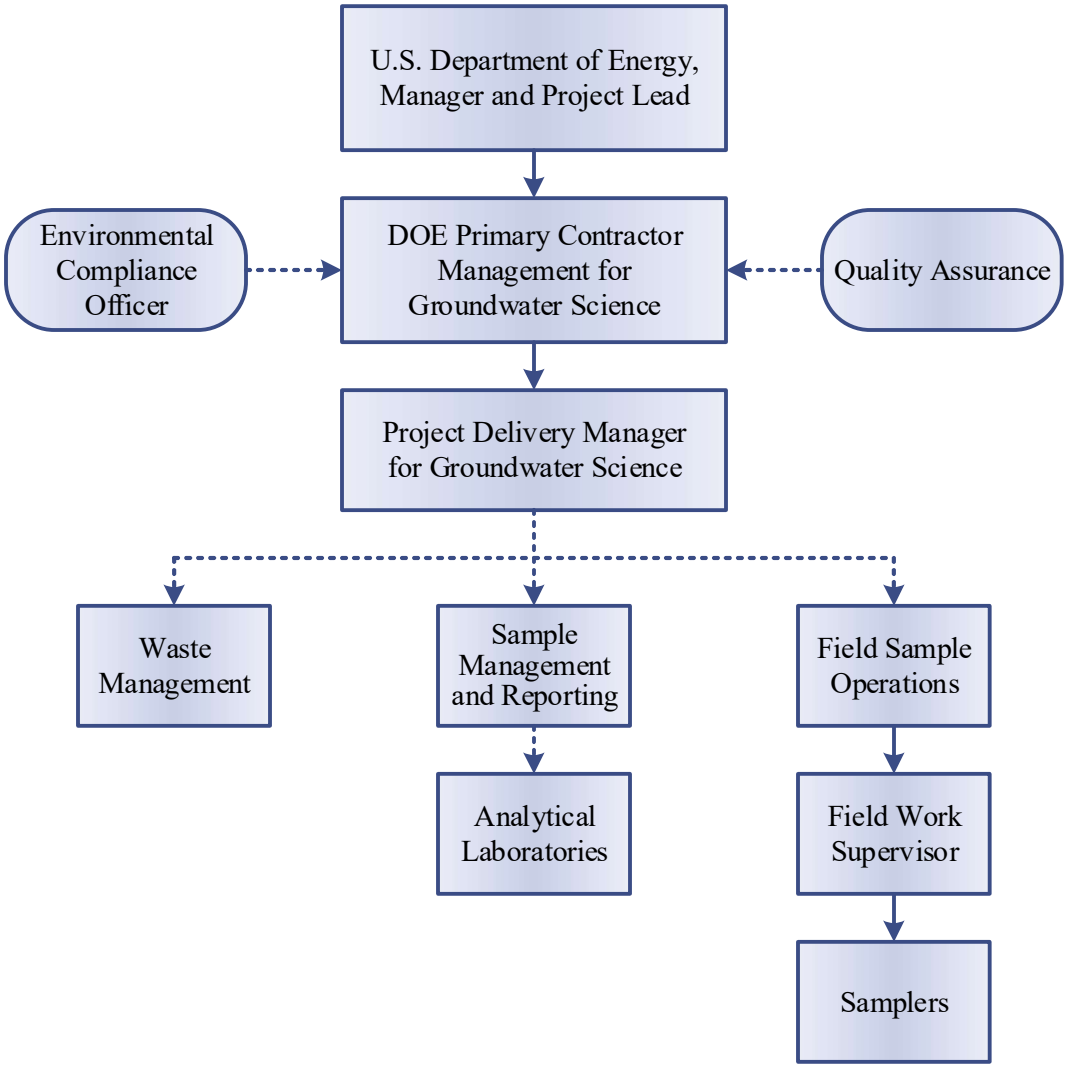

Figure A-1. Project Organization

A2.1.4 Project Delivery Manager for Groundwater Science

The Project Delivery Manager for Groundwater Science is responsible for direct management of activities performed to meet DWMU groundwater monitoring requirements. The Project Delivery Manager for Groundwater Science coordinates with, and reports to, DOE and DOE Primary Contractor Management for Groundwater Science regarding DWMU groundwater monitoring requirements. The Project Delivery Manager for Groundwater Science (or designee) works closely with the Environmental Compliance Officer (ECO), QA, and Sample Management and Reporting (SMR) group to integrate these and other technical disciplines in planning and implementing the work scope. The Project Delivery Manager for Groundwater Science assigns staff to provide technical expertise.

A2.1.5 Sample Management and Reporting Group

The SMR group oversees offsite analytical laboratories, coordinates laboratory analytical work with this plan, and verifies that laboratories are qualified for performing Hanford Site analytical work. They generate field sampling documents, labels, and instructions for field sampling personnel and develop sample authorization forms, which provide information and instruction to the analytical laboratories. The SMR group revises field sampling documents to reflect approved changes. This group's

responsibilities include receiving analytical data from the laboratories, performing data entry into the Hanford Environmental Information System (HEIS) database, arranging for data validation and recordkeeping. The SMR group is responsible for resolving sample documentation deficiencies or issues associated with Field Sample Operations (FSO), laboratories, or other entities. They are responsible for informing the Project Delivery Manager for Groundwater Science (or designee) of any issues reported by the analytical laboratories.

A2.1.6 Field Sample Operations

FSO is responsible for planning and coordinating field sampling resources and provides the Field Work Supervisor (FWS) for routine groundwater sampling operations. The FWS directs the samplers who collect groundwater samples for this groundwater monitoring plan. Samplers collect samples, complete field logbooks, data forms, and chain-of-custody forms, including any shipping paperwork, and assist sample delivery to the analytical laboratory.

A2.1.7 Quality Assurance

The QA point of contact provides independent oversight, is responsible for addressing QA issues on the project, and overseeing implementation of the project QA program.

A2.1.8 Environmental Compliance Officer

ECOs provide technical oversight, direction, and acceptance of project and subcontracted environmental work, with the goal of minimizing adverse environmental impacts.

A2.1.9 Waste Management

Waste Management identifies waste management sampling/characterization activities for regulatory compliance and is responsible for data interpretation to determine waste designations and profiles. Waste Management communicates policies and practices for project compliance for waste storage, transportation, disposal, and tracking in a safe and cost-effective manner.

A2.1.10 Analytical Laboratories

The laboratories maintain custody and analyze samples in accordance with established quality systems and provide data packages containing sample and quality control (QC) results. Laboratories provide explanations of results to support data review and resolve analytical issues.

A2.2 Problem Definition/Background

The purpose of this groundwater monitoring plan is to satisfy *Washington Administrative Code* and *Code of Federal Regulations* requirements (WAC 173-303-400, “Dangerous Waste Regulations,” “Interim Status Facility Standards,” and 40 CFR 265, “Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities,” Subpart F, “Ground-Water Monitoring”) for indicator parameter evaluation. Additional information on the activities to satisfy these requirements and background information on monitoring is provided in the main text of this monitoring plan.

A2.3 Project/Task Description

The focus of this plan is to monitor the parameters used as indicators of groundwater contamination and for parameters establishing groundwater quality in accordance with 40 CFR 265.92, “Sampling and Analysis;” evaluate the well network; and interpret analytical results. The indicator parameters to be monitored, along with the monitoring wells and frequency of sampling, are provided in the main text (Chapter 3). Information on the collection and analyses of groundwater from the monitoring network is provided in this appendix and in Appendix B.

A2.4 Quality Assurance Objectives and Criteria

The QA objective of this plan is the generation of analytical data of known and appropriate quality. In support of this objective, the process to assess data usability may include data verification, data validation, or a data quality indicator (DQI) evaluation. Principal DQIs are precision, accuracy, representativeness, comparability, completeness, bias, and sensitivity. These DQIs are defined for the purposes of this document in Table A-1.

The applicable QC guidelines, DQI acceptance criteria, and levels of effort for assessing data quality are dictated by the intended use of the data and the requirements of the analytical method. The process to assess data usability is further discussed in Section A4.

Table A-1. Data Quality Indicators

Data Quality Indicator (QC Element)[a]	Definition	Determination Methodologies	Possible Corrective Actions
Precision (field duplicates, laboratory sample duplicates, and matrix spike duplicates)	Precision measures the agreement among a set of replicate measurements. Field precision is assessed through the collection and analysis of field duplicates. Analytical precision is estimated by duplicate/replicate analyses, usually on laboratory control samples, spiked samples, and/or field samples. The most commonly used estimates of precision are the relative standard deviation and, when only two samples are available, the relative percent difference.	Use the same analytical instrument to make repeated analyses on the same sample. Use the same method to make repeated measurements of the same sample within a single laboratory. Acquire replicate field samples for information on sample acquisition, handling, shipping, storage, preparation, and analytical processes and measurements.	If duplicate data do not meet objective: • Evaluate apparent cause (e.g., sample heterogeneity). • Request reanalysis or remeasurement. • Qualify the data before use.
Accuracy (laboratory control samples, matrix spikes, and surrogates)	Accuracy is the closeness of a measured result to an accepted reference value. Accuracy is usually measured as a percent recovery. QC analyses used to measure accuracy include laboratory control samples, spiked samples, and surrogates.	Analyze a reference material or reanalyze a sample to which a material of known concentration or amount of pollutant has been added (a spiked sample).	If recovery does not meet objective: • Qualify the data before use. • Request reanalysis or remeasurement. • Determine if follow-up evaluation is needed. • Evaluate instrumentation and re-calibrate, if necessary
Representativeness (field duplicates)	Sample representativeness expresses the degree to which data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, a process condition, or an environmental condition. It is dependent on the proper design of the sampling program and will be satisfied by ensuring that the approved plans were followed during sampling and analysis.	Evaluate whether measurements are made and physical samples collected in such a manner that the resulting data appropriately reflect the environment or condition being measured or studied.	If results are not representative of the system sampled: • Identify the reason for results not being representative. • Flag for further review. • Review data for usability. • If data are usable, qualify the data for limited use and define the portion of the system that the data represent. • If data are not usable, flag as appropriate. • Redefine sampling and measurement requirements and protocols. • Resample and reanalyze, as appropriate.

Table A-1. Data Quality Indicators

Data Quality Indicator (QC Element)[a]	Definition	Determination Methodologies	Possible Corrective Actions
Comparability (field duplicate, field splits, laboratory control samples, matrix spikes, and matrix spike duplicates)	Comparability expresses the degree of confidence with which one dataset can be compared to another. It is dependent upon the proper design of the sampling program and will be satisfied by ensuring that the approved plans are followed and that proper sampling and analysis techniques are applied.	Use identical or similar sample collection and handling methods, sample preparation and analytical methods, holding times, and quality assurance protocols.	If data are not comparable to other datasets: • Identify appropriate changes to data collection and/or analysis methods. • Identify quantifiable bias, if applicable. • Qualify the data as appropriate. • Resample and/or reanalyze if needed. • Revise sampling/analysis protocols to ensure future comparability.
Completeness (no QC element; addressed in data usability assessment)	Completeness is a measure of the amount of valid data collected compared to the amount of data planned. Measurements are considered valid if they are unqualified or qualified as estimated data during validation. Field completeness is a measure of the number of samples collected versus the number of samples planned. Laboratory completeness is a measure of the number of valid measurements compared to the total number of measurements planned.	Compare the number of valid measurements completed (samples collected or samples analyzed) with those established by the project's quality criteria (data quality objectives or performance/acceptance criteria).	If dataset does not meet the completeness objective: • Identify appropriate changes to data collection and/or analysis methods. • Identify quantifiable bias, if applicable. • Resample and/or reanalyze if needed. • Revise sampling/analysis protocols to ensure future completeness.
Bias (equipment blanks, full trip blanks, laboratory control samples, matrix spikes, and method blanks)	Bias is the systematic or persistent distortion of a measurement process that causes error in one direction (e.g., the sample measurement is consistently lower than the sample's true value). Bias can be introduced during sampling, analysis, and data evaluation. Analytical bias refers to deviation in one direction (i.e., high, low, or unknown) of the measured value from a known spiked amount.	Sampling bias may be revealed by analysis of replicate samples. Analytical bias may be assessed by comparing a measured value in a sample of known concentration to an accepted reference value or by determining the recovery of a known amount of contaminant spiked into a sample (matrix spike).	For sampling bias: • Properly select and use sampling tools. • Institute correct sampling and subsampling processes to limit preferential selection or loss of sample media. • Use sample handling processes, including proper sample preservation, that limit the loss or gain of constituents to the sample media. • Analytical data that are known to be affected by either sampling or analytical bias are flagged to indicate possible bias. • Laboratories that are known to generate biased data for a specific analyte are asked to correct

Table A-1. Data Quality Indicators

Data Quality Indicator (QC Element)[a]	Definition	Determination Methodologies	Possible Corrective Actions
			their methods to remove the bias as practicable. Otherwise, samples are sent to other laboratories for analysis.
Sensitivity (method detection limit, practical quantitation limit, and relative percent difference)	Sensitivity is an instrument's or method's minimum concentration that can be reliably measured (i.e., instrument detection limit or limit of quantitation).	Determine the minimum concentration or attribute to be measured by an instrument (instrument detection limit) or by a laboratory (limit of quantitation). The lower limit of quantitation[b] is the lowest level that can be routinely quantified and reported by a laboratory.	If detection limits do not meet objective: • Request reanalysis or remeasurement using methods or analytical conditions that will meet required detection or limit of quantitation. • Qualify/reject the data before use.

Based on SW-846 Compendium (July 2014). Available at: https://www.epa.gov/hw-sw846/sw-846-compendium.

a. Acceptance criteria for QC elements are provided in Table A-5.

b. For purposes of this groundwater monitoring plan, the lower limit of quantitation is interchangeable with the practical quantitation limit.

QC = quality control

A2.5 Documents and Records

The Project Delivery Manager for Groundwater Science (or designee) is responsible for ensuring that the current version of the groundwater monitoring plan is used and providing any updates to field personnel. Table A-2 defines the types of changes that may impact the groundwater monitoring plan and the associated approvals, notifications, and documentation requirements. Elements of the monitoring plan that are required by 40 CFR 265 Subpart F cannot be changed.

Table A-2. Change Control for Monitoring Plans

Type of Change	Action	Documentation
Unintentional impact to groundwater monitoring plan that impacts the groundwater quality assessment program requirements of 40 CFR 265, Subpart F, including one-time missed well sampling due to operational constraints, delayed sample collection, broken pump, lost bottle set, missed sampling of groundwater constituents or parameters, or loss of samples in transit.	Project Delivery Manager for Groundwater Science provides informal notification to DOE-RL. DOE-RL provides informal notification to Ecology as appropriate.	Copy of informal notification to Ecology is placed in the facility operating record. Annual Hanford Site RCRA groundwater monitoring report.
Planned change to groundwater monitoring activities, including addition or deletion of constituents analyzed for, change of sampling frequency, or changes to well network.	Project Delivery Manager for Groundwater Science obtains DOE-RL approval; revise monitoring plan as appropriate.	Annual Hanford Site RCRA groundwater monitoring report and revised groundwater monitoring plan as appropriate.

40 CFR 265, Subpart F, "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," "Ground-Water Monitoring."

DOE-RL = U.S. Department of Energy, Richland Operations Office

Ecology = Washington State Department of Ecology

RCRA = *Resource Conservation and Recovery Act of 1976*

Logbooks and data forms are used to document field activities. The logbooks are identified with a unique project name and number. Individuals responsible for the logbooks are identified in the front of the logbook, and only authorized individuals may make entries into the logbooks. Logbooks will be controlled documents. Data forms are also identified with a unique project name and number, may be used to record the same field information as logbooks, and are referenced in the logbooks.

The FWS, SMR group, and field crew supervisors are responsible for alignment of field instructions with the groundwater monitoring plan.

Convenience copies of laboratory analytical results are maintained in the HEIS database. Records may be stored in either electronic (e.g., in the managed records area of the Integrated Document Management System) or hardcopy format (e.g., DOE Records Holding Area). Records of analyses required by 40 CFR 265.94, "Recordkeeping and Reporting," are to be maintained throughout the active life of a facility and post-closure care period (if any).

By March 1, groundwater monitoring results are reported in the Hanford Site RCRA groundwater monitoring report (e.g., DOE/RL-2018-65, *Hanford Site RCRA Groundwater Monitoring Report for 2018*).

A3 Data Generation and Acquisition

This chapter addresses data generation and acquisition so that the project's methods for sampling, measurement and analysis, data collection or generation, data handling, and QC activities are appropriate and documented. Instrument calibration and maintenance, supply inspections, and data management are also discussed.

A3.1 Analytical Method Requirements

Sample analytical methods are presented in Table A-3. Equivalent (e.g., U.S. Environmental Protection Agency [EPA] Method 300 and SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods,* Method 9056) or updated (e.g., updates to SW-846 methods) Washington State Department of Ecology-accredited methods may be substituted for the methods identified in Table A-3.

Table A-3. Analytical Methods for the DWMU

CAS Number	Waste Constituent (Alternate Name)	Analytical Method[a]	Practical Quantitation Limit (µg/L)
General Chemistry			
ALKALINITY	Alkalinity, total as CaCO3	310.1, Standard Method 2320, Standard Method 4500	5250
TOC	Total organic carbon	415.1, 9060	1050
59473-04-0	Total organic halogen	9020	31.5
Anions[b]			
16887-00-6	Chloride	300, 9056	400
16984-48-8	Fluoride	300, 9056	525
14797-55-8	Nitrate, as NO3	300, 9056	250
14797-65-0	Nitrite, as NO2	300, 9056	250
14808-79-8	Sulfate	300, 9056	1050
Field Measurements			
--	pH	150.1, 9040, Standard Method 4500 H+	N/A
--	Dissolved oxygen	360.1, Standard Method 4500 O	N/A
--	Specific conductance	120.1, 9050, Standard Method 2520 B-97	N/A
--	Temperature	170.1	N/A
--	Turbidity	180.1, Standard Method 2130 B	N/A
Metals			
7440-70-2	Calcium	6010	1050
7440-47-3	Chromium	6020	10.5

Table A-3. Analytical Methods for the DWMU

CAS Number	Waste Constituent (Alternate Name)	Analytical Method[a]	Practical Quantitation Limit (µg/L)
7439-89-6	Iron	6010	105
7439-95-4	Magnesium	6010	1050
7439-96-5	Manganese	6020	5.25
7439-98-7	Molybdenum	6020	5.25
7440-02-0	Nickel	6020	21
7440-09-7	Potassium	6010	5250
7440-23-5	Sodium	6010	1050
Semivolatile Organic Compounds			
95-57-8	2-Chlorophenol	8270	10.5
95-48-7	2-Methylphenol (o-Cresol)	8270	10.5
88-75-5	2-Nitrophenol (o-Nitrophenol)	8270	10.5
58-90-2	2,3,4,6-Tetrachlorophenol	8270	52.5
120-83-2	2,4-Dichlorophenol	8270	10.5
105-67-9	2,4-Dimethylphenol (2,4-Xylenol)	8270	10.5
51-28-5	2,4-Dinitrophenol	8270	50
95-95-4	2,4,5-Trichlorophenol	8270	10.5
88-06-2	2,4,6-Trichlorophenol	8270	10.5
87-65-0	2,6-Dichlorophenol	8270	10.5
108-39-4[c]	3-Methylphenol (m-Cresol)	8270	--
59-50-7	4-Chloro-3-methylphenol (p-Chloro-m-cresol)	8270	10.5
106-44-5[c]	4-Methylphenol (p-Cresol)	8270	--
534-52-1	4,6-Dinitro-O-cresol (4,6-Dinitro-2-methyl phenol)	8270	52.5
88-85-7	Dinoseb (2-sec-Butyl-4,6-dinitrophenol)	8270	21
100-02-7	p-Nitrophenol (4-Nitrophenol)	8270	21
87-86-5	Pentachlorophenol	8270	52.5
108-95-2	Phenol	8270	10.5

Table A-3. Analytical Methods for the DWMU

CAS Number	Waste Constituent (Alternate Name)	Analytical Method[a]	Practical Quantitation Limit (µg/L)

Note: Analytical methods and practical quantitation limits provided in this table do not represent EPA nor Washington State Department of Ecology requirements but are intended solely as guidance.

a. For EPA Methods 180.1 and 300, see EPA/600/R-93/100, *Methods for the Determination of Inorganic Substances in Environmental Samples.* For EPA Methods 120.1, 150.1, 170.1, 310.1, 360.1, 376.1 and 415.1, see EPA/600/4-79/020, *Methods for Chemical Analysis of Water and Wastes*. For four-digit EPA methods, see the SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Compendium*. For Standard Methods, see APHA/AWWA/WEF, 2017, *Standard Methods for the Examination of Water and Wastewater*.

b. Dilutions for certain ion chromatography constituents may be necessary, potentially raising the practical quantitation limit above the limits provided.

c. Analyzed and reported as 3 & 4 Methylphenol (CAS number 65794-96-9). The PQL for 3 & 4 Methylphenol is 20 µg/L.

CAS = Chemical Abstracts Service
DWMU = dangerous waste management unit
Ecology = Washington State Department of Ecology
EPA = U.S. Environmental Protection Agency
N/A = not applicable
PQL = practical quantitation limit

A3.2 Field Analytical Methods

Field screening and survey data will be measured in accordance with applicable work practices. Field analytical methods may also be performed in accordance with manufacturer manuals. Appendix B provides further discussion on field measurements.

A3.3 Quality Control

Field QC samples will be collected to evaluate the potential for cross-contamination and to provide information pertinent to sampling variability. Laboratory QC samples estimate the precision, bias, and matrix effects on the analytical data. Field and laboratory QC samples, and their typical frequencies, are summarized in Table A-4. Acceptance criteria for field and laboratory QC are shown in Table A-5. Data will be qualified and flagged in the HEIS database, as appropriate.

Table A-4. QC Samples

Sample Type	Frequency	Characteristics Evaluated
Field QC		
Equipment blanks	1 in 20 samples when nondedicated equipment is used[a]	Contamination from nondedicated sampling equipment
Field duplicates	1 in 20 well trips[b]	Reproducibility/sampling precision
Field splits	As needed	Interlaboratory comparability
Full trip blanks	1 in 20 well trips[b]	Contamination from containers preservative reagents, storage, or transportation

Table A-4. QC Samples

Sample Type	Frequency	Characteristics Evaluated
Analytical QC[c]		
Laboratory control samples	One per analytical batch[d]	Method accuracy
Laboratory sample duplicates	One per analytical batch[d]	Laboratory reproducibility and precision
Matrix spikes	One per analytical batch[d]	Matrix effect/laboratory accuracy
Matrix spike duplicates	One per analytical batch[d]	Laboratory reproducibility, and method accuracy and precision
Method blanks	One per analytical batch[d]	Laboratory contamination
Surrogates	Added to each sample and QC sample	Recovery/yield for organic compounds

Note: The information in this table does not create U.S. Environmental Protection Agency or Washington State Department of Ecology requirements; it is intended solely as guidance.

a. For portable pumps, equipment blanks are collected (1 for every 20 well trips). Whenever a new type of nondedicated equipment is used, an equipment blank will be collected each time sampling occurs until it can be shown that less frequent collection of equipment blanks is adequate to monitor the decontamination methods for the nondedicated equipment.

b. For groundwater, a sample is collected any time a well is accessed for sampling; this is also known as a well trip. Field duplicates and full trip blanks are run at a frequency of 1 in 20 well trips (i.e., 5% of the well trips) for all groundwater monitoring wells sampled within any given month and drilling campaign (for all groundwater monitoring programs).

c. A batch is a group of up to 20 samples that behave similarly with respect to the sampling or testing procedures being employed and which are processed as a unit. Batching across projects is allowed for similar matrices (e.g., Hanford Site groundwater).

d. Unless not required by, or different frequency is called out, in laboratory analysis method.

QC = quality control

Table A-5. Field and Laboratory QC Elements and Acceptance Criteria

Analyte[a]	QC Element	Acceptance Criteria	Corrective Action
General Chemistry			
Alkalinity	MB	<MDL <5% sample concentration	Flag with “C”
	LCS	80% to 120% recovery	Flag with “o”[b]
	DUP[c] or MS/MSD[d]	≤20% RPD	Review data[e]
	MS/MSD[d]	75% to 125% recovery	Flag with “N”
	EB, FTB	<MDL <5% sample concentration	Flag with “Q”
	Field duplicate[c]	≤20% RPD	Review data[e]

Table A-5. Field and Laboratory QC Elements and Acceptance Criteria

Analyte[a]	QC Element	Acceptance Criteria	Corrective Action
Total organic carbon	MB	<MDL <5% sample concentration	Flag with "C"
	LCS	80% to 120% recovery	Flag with "o"[b]
	DUP[c] or MS/MSD[d]	≤20% RPD	Review data[e]
	MS/MSD[d]	75% to 125% recovery	Flag with "N"
	EB, FTB	<MDL <5% sample concentration	Flag with "Q"
	Field duplicate[c]	≤20% RPD	Review data[e]
Total organic halogen	MB	<MDL <5% sample concentration	Flag with "C"
	LCS	80% to 120% recovery	Flag with "o"[b]
	DUP[c] or MS/MSD[d]	≤20% RPD	Review data[e]
	MS/MSD[d]	75% to 125% recovery	Flag with "N"
	EB, FTB	<MDL <5% sample concentration	Flag with "Q"
	Field duplicate[c]	≤20% RPD	Review data[e]
Anions			
Anions by ion chromatography	MB	<MDL <5% sample concentration	Flag with "C"
	LCS	80% to 120% recovery	Flag with "o"[b]
	DUP[c] or MS/MSD[d]	≤20% RPD	Review data[e]
	MS/MSD[d]	75% to 125% recovery	Flag with "N"
	EB, FTB	<MDL <5% sample concentration	Flag with "Q"
	Field duplicate[c]	≤20% RPD	Review data[e]
Metals			
Metals by inductively coupled plasma/atomic emission spectrometry	MB	<MDL <5% sample concentration	Flag with "C"
	LCS	80% to 120% recovery	Flag with "o"[b]
	DUP[c] or MS/MSD[d]	≤20% RPD	Review data[e]
	MS/MSD[d]	75% to 125% recovery	Flag with "N"
	EB, FTB	<MDL <5% sample concentration	Flag with "Q"
	Field duplicate[c]	≤20% RPD	Review data[e]
Metals by inductively coupled plasma/mass spectrometry	MB	<MDL <5% sample concentration	Flag with "C"

Table A-5. Field and Laboratory QC Elements and Acceptance Criteria

Analyte[a]	QC Element	Acceptance Criteria	Corrective Action
	LCS	80% to 120% recovery	Flag with "o"[b]
	DUP[c] or MS/MSD[d]	≤20% RPD	Review data[e]
	MS/MSD[d]	75% to 125% recovery	Flag with "N"
	EB, FTB	<MDL <5% sample concentration	Flag with "Q"
	Field duplicate[c]	≤20% RPD	Review data[e]
Semivolatile Organic Compounds			
Phenols gas chromatography/mass spectrometry	MB	<MDL <5% sample concentration	Flag with "B"
	LCS	70% to 130% recovery or % recovery statistically derived[f]	Flag with "o"[b]
	DUP[c] or MS/MSD[d]	≤20% RPD	Review data[e]
	MS/MSD[d]	% recovery statistically derived[f]	Flag with "T"
	SUR	% recovery statistically derived[f]	Review data[e]
	EB, FTB	<MDL <5% sample concentration	Flag with "Q"
	Field duplicate[c]	≤20% RPD	Review data[e]

Notes: The information in this table does not create U.S. Environmental Protection Agency or Washington State Department of Ecology requirements; it is intended solely as guidance.

This table applies only to laboratory analyses. Field measurements (e.g., specific conductance, dissolved oxygen, pH, temperature, and turbidity) are not listed because they are measured in the field.

a. See Table A-3 for constituent list and analytical methods.
b. The reporting laboratory will apply the "o" flag with SMR group concurrence.
c. Applies when at least one result is greater than the laboratory PQL.
d. Either a DUP or an MS/MSD is to be analyzed to determine measurement precision (if there is insufficient sample volume, a laboratory control sample duplicate is analyzed with the acceptance criteria defaulting to the ≤20% RPD criteria).
e. After review, corrective actions are determined on a case-by-case basis. Corrective actions may include a laboratory recheck or flagging the data.
f. Laboratory-determined, statistically derived control limits based on historical data are used here. Control limits are reported with the data.

DUP = laboratory sample duplicate
EB = equipment blank
FTB = full trip blank
LCS = laboratory control sample
MB = method blank
MDL = method detection limit
MS = matrix spike
MSD = matrix spike duplicate
PQL = practical quantitation limit
QC = quality control
RPD = relative percent difference
SMR = Sample Management and Reporting
SUR = surrogate

Table A-5. Field and Laboratory QC Elements and Acceptance Criteria

Analyte[a]	QC Element	Acceptance Criteria	Corrective Action

Data Flags

B, C	=	possible laboratory contamination: analyte was detected in the associated method blank – laboratory applied. The B flag is used for organic analytes. The C flag is used for general chemical and inorganic analytes.
N	=	result may be biased: associated matrix spike result was outside the acceptance limits (except gas chromatograph/mass spectrometry) – laboratory applied.
o	=	result may be biased: associated laboratory control sample result was outside the acceptance limits – laboratory applied.
Q	=	problem with associated field QC blank: results were out of limits – SMR review.
T	=	result may be biased: associated matrix spike result was outside the acceptance limits (gas chromatograph/mass spectrometry only) – laboratory applied.

A3.3.1 Field Quality Control Samples

Field QC samples are used to monitor the integrity of field samples during sample collection, transportation, storage, and laboratory analysis. Field QC samples are submitted to the analyzing laboratories as field samples. Field QC samples are analyzed for the same set of analytes as their corresponding field samples. Field QC samples include field duplicates, field split (SPLIT) samples, and field blanks (equipment blanks [EBs], and full trip blanks [FTBs]). Field blanks are typically prepared to match the sample matrix as closely as possible using high-purity water[1]. The following describe the QC samples in more detail:

- **Equipment blanks:** EBs are used to monitor the effectiveness of the decontamination process for reusable sampling equipment. They are samples of high-purity water contacted with the sampling surfaces of equipment used to collect samples prior to using that equipment for field sampling. EBs are collected from each type of reusable sampling equipment to ensure that the decontamination procedures are effective for the specific equipment types. EBs will be analyzed for the same analytes as samples collected using that equipment. EB samples are not required for disposable sampling equipment.

- **Field duplicates:** Field duplicates provide information regarding the homogeneity of the sample matrix and the precision of the sampling and analysis processes. Field duplicates are two samples that are intended to be identical and are collected as close as possible in time and location. Each sample in the sample-duplicate pair receives its own unique sample number.

- **Field splits:** SPLITs are two samples that are intended to be identical and are collected as close as possible in time and location. SPLITs will be stored in separate containers and analyzed by different laboratories for the same analytes. SPLITs are interlaboratory comparison samples used to evaluate comparability between laboratories.

- **Full trip blanks:** FTBs are used to monitor for potential sample contamination from the sampling container, preservation reagents, or storage conditions. FTBs are prepared high-purity water and sealed prior to traveling to the sampling site, transported to the sampling site (not opened in the field), and then shipped as part of the sample set to the laboratory. The bottle set is either for volatile organic

[1] High-purity water is generally defined as water that has been distilled, deionized, or any combination of distillation, deionization, reverse osmosis, activated carbon filtration, ion exchange, particulate filtration, or other polishing techniques.

analysis only or identical to the set that will be collected in the field. Collected FTBs are typically analyzed for the same constituents as the samples from the associated sampling event.

A3.3.2 Laboratory Quality Control Samples

Internal QA/QC programs are maintained by laboratories used by the project and include the use of laboratory control samples (LCSs), laboratory sample duplicates (DUPs), matrix spikes (MSs), matrix spike duplicates (MSDs), method blanks (MBs), and surrogates (SURs). These QC analyses follow EPA methods (e.g., those in the SW-846 Compendium). QC checks outside of control limits are documented in analytical laboratory reports and during a DQI evaluation. Descriptions of the various types of laboratory QC samples are as follows:

- **Laboratory control sample:** A control matrix (e.g., reagent water) spiked with analytes representative of the target analytes or a certified reference material that is used to evaluate laboratory accuracy.
- **Laboratory sample duplicate:** A second aliquot of a sample that is taken through the entire sample preparation and analytical process. DUPs are used to evaluate the precision of a method in a given sample matrix.
- **Matrix spike:** An aliquot of a sample spiked with a known concentration of target analyte(s) that is then taken through the entire sample preparation and analytical process. An MS is used to assess the bias of a method in a given sample matrix. Thus, MS results are an indicator of the effect the sample matrix has on the accuracy of measurement of the target analytes.
- **Matrix spike duplicate:** A replicate spiked aliquot of a sample that is subjected to the entire sample preparation and analytical process. MSD results are used to determine the bias and precision of a method in a given sample matrix.
- **Method blank:** An analyte-free matrix to which the same reagents are added in the same volumes or proportions as used in the sample processing. The MB is carried through the complete sample preparations and analytical process. The MB is used to quantify contamination resulting from the sample preparation and analysis.
- **Surrogate:** Used only in organic analyses, a compound added to every sample in the analysis batch (field samples and QC samples) prior to preparation. SURs are typically similar in chemical composition to the analyte being determined, but they are not normally encountered. SURs are expected to respond to the preparation and analytical process in a manner similar to the analytes of interest. Because SURs are added to every sample and QC sample, they are used to evaluate overall method performance in a given matrix.

Samples are analyzed within the holding time guidelines provided in Table A-6. In some instances, constituents in the samples not analyzed within the holding times may be compromised by volatilization, decomposition, or other chemical changes. Data from samples analyzed outside of the holding times are flagged in the HEIS database with an “H.”

Table A-6. Preservation and Holding Time Guidelines for Laboratory Analyses

Constituent[a]	Preservation[b]	Holding Time
General Chemistry		

Table A-6. Preservation and Holding Time Guidelines for Laboratory Analyses

Constituent[a]	Preservation[b]	Holding Time
Alkalinity	Store ≤6°C	14 days
Total organic carbon	Store <6°C, adjust pH to <2 with sulfuric acid or hydrochloric acid	28 days
Total organic halogen	Store <6°C, adjust pH to <2 with sulfuric acid	28 days
Anions		
Chloride, Fluoride, Sulfate	Store ≤6°C	28 days
Nitrate, Nitrite	Store ≤6°C	48 hours
Metals		
Metals by inductively coupled plasma-atomic emission spectrometry	Adjust pH to <2 with nitric acid	6 months
Metals by inductively coupled plasma/mass spectrometry	Adjust pH to <2 with nitric acid	6 months
Semivolatile Organic Compounds		
Phenols by gas chromatography/mass spectrometry	Store ≤6°C	7 days before extraction 40 days after extraction

Notes: Holding times and preservation methods are dependent on the constituent and are consistent with EPA guidance and approved analytical methods. Information in this table does not create EPA or Washington State Department of Ecology requirements but is intended solely as guidance.

The container type for a sample is available on the chain-of-custody documentation.

This table applies only to laboratory analyses. Field measurements (e.g., specific conductance, dissolved oxygen, pH, temperature, and turbidity) are not listed because they are measured in the field.

a. See Table A-3 for constituent list and analytical methods.

b. For preservation identified as stored at ≤6°C, the sample should be protected against freezing unless it is known that freezing will not impact the sample integrity.

EPA = U.S. Environmental Protection Agency

A3.4 Measurement Equipment

Each measuring equipment user will ensure that equipment is functioning as expected, properly handled, and properly calibrated per methods governing control of the measuring equipment. Onsite environmental instrument testing, inspection, calibration, and maintenance will be recorded according to approved methods. Field screening instruments will be used, maintained, and calibrated as provided in manufacturer specifications and other approved methods.

A3.5 Instrument and Equipment Testing, Inspection, and Maintenance

Collection, measurement, and testing equipment will meet applicable standards (e.g., ASTM International, formerly the American Society for Testing and Materials) or have been evaluated as acceptable and valid according to instrument-specific methods and specifications. Software applications will be acceptance tested prior to use in the field. Measurement and testing equipment used in the field will be subject to preventive maintenance measures to minimize downtime.

A3.6 Instrument/Equipment Calibration and Frequency

Field equipment calibration is discussed in Appendix B.

A3.7 Inspection/Acceptance of Supplies and Consumables

Consumables, supplies, and reagents will be reviewed per test methods in the SW-846 Compendium and EPA/600 Method series (e.g., EPA/600/4-79/020, *Methods for Chemical Analysis of Water and Wastes*) and will be appropriate for their use. Supplies and consumables used in sampling and analysis activities are procured under internal work processes. Supplies and consumables are checked and accepted by users prior to use.

A3.8 Nondirect Measurements

Data obtained from sources such as computer databases, programs, literature files, and historical records will be evaluated by the staff member assigned by the Project Delivery Manager for Groundwater Science. Data used in evaluations will be identified by source. Historical data obtained from the HEIS database are usable for comparison to data collected by this groundwater monitoring plan.

A3.9 Data Management

Records of data analyses and groundwater surface elevations are maintained as required by 40 CFR 265.94.

Electronic data access will be through a Hanford Site database (e.g., HEIS). Where electronic data are not available, hard copies will be provided.

A4 Data Review and Usability

This chapter addresses QA activities that occur after data collection. Implementation of these activities determines whether the data conform to the specified criteria, thus satisfying the project objectives.

A4.1 Data Review and Verification

Data review and verification are performed to confirm that field and field QC sampling and chain-of-custody documentation are complete. This review includes linking sample numbers to specific sampling locations, and reviewing sample collection dates and sample preparation and analysis dates to determine if holding times were met.

The criteria for verification include, but are not limited to, review for contractual compliance (samples were analyzed as requested), use of the correct analytical method, transcription errors, correct application of dilution factors, and the correct application of conversion factors. Data verification is typically conducted on a portion of multi-media samples collected across projects.

The staff member, assigned by the Project Delivery Manager for Groundwater Science, will also perform a data review to determine if observed changes reflect improved/degraded groundwater quality or potential data errors, which may result in a request for data review on questionable data. The laboratory may be asked to check calculations, reanalyze samples, or the well may be resampled. Results of the request for data review process are used to flag data in the HEIS database and to add comments.

A4.2 Data Validation

Data validation is performed at the discretion of the Project Delivery Manager for Groundwater Science, under the direction of the SMR group. The decision to perform validation is based on the results of QC

samples for individual well networks and discussions with the staff member assigned by the Project Delivery Manager for Groundwater Science. If conducted, data validation (third-party) will be performed at a minimum frequency of 5% per method. Data validation evaluates the analytical quality of data from samples specifically collected for this plan.

A4.3 Reconciliation with User Requirements

The purpose of reconciliation with user requirements is to determine if quantitative data are of the correct type and are of adequate quality and quantity to meet the project data needs. For routine groundwater monitoring undertaken by projects, DQIs such as precision, accuracy, representativeness, comparability, completeness, bias, and sensitivity for the specific datasets (individual data packages) will typically be evaluated on an annual basis. A DQI evaluation specific to data quality requirements specified in this plan may be performed at the discretion of the Project Delivery Manager for Groundwater Science. Results of the DQI evaluation(s) will be used by the Project Delivery Manager for Groundwater Science to interpret the data and determine if the data quality objectives for this activity have been met.

A5 References

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Appendix B

Sampling Protocol

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Terms

DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
IATA	International Air Transport Association
QA	quality assurance
QC	quality control
RCRA	*Resource Conservation and Recovery Act of 1976*

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B1 Introduction

Groundwater monitoring at the Hanford Site, as defined by the *Resource Conservation and Recovery Act of 1976* (RCRA) and implemented in WAC 173-303, "Dangerous Waste Regulations," has been conducted since the mid-1980s. Hanford Site groundwater sampling methods contain sampling precautions to be taken; identify equipment and its use; cleaning and decontamination practices; records and documentation; and sample collection, management, and control activities. Together, Appendices A and B discuss the sampling and analysis elements for the groundwater monitoring plan: sample collection, sample preservation and holding times, chain–of-custody control, analytical methods, and field and laboratory quality assurance (QA)/quality control (QC).

This appendix provides elements of the sampling protocols and techniques used for the groundwater monitoring plan. The main text of the groundwater monitoring plan identifies the monitoring wells that will be sampled, constituents to be analyzed, and sampling frequency for the groundwater monitoring at the dangerous waste management unit.

B2 Sampling Methods

Sampling may include, but is not limited to, the following methods:

- Field screening measurements
- Groundwater sampling
- Water-level measurements

Groundwater samples will be collected according to the current revision of applicable operating methods. Groundwater samples are collected after field measurements of purged groundwater have stabilized:

- **pH** – two consecutive measurements agree within 0.2 pH units
- **Temperature** – two consecutive measurements agree within 0.2°C (0.36°F)
- **Conductivity** – two consecutive measurements agree within 10% of each other
- **Turbidity** – less than 5 nephelometric turbidity units prior to sampling (or the staff assigned by the Project Delivery Manager for Groundwater Science's recommendation at the time of collection)

Dissolved oxygen if included in the main text of the groundwater monitoring plan will also be measured in the field. Dissolved oxygen is not required to be stable prior to sample collection.

Unless special directions are provided by the staff assigned by the Project Delivery Manager for Groundwater Science at the time of sample collection, wells are typically purged at a flow rate not to exceed 7.6 L/min (2 gal/min). Purging will continue until stable readings of selected field water quality parameters are achieved (as described above).

Field measurements (except for turbidity) are typically obtained using an instrumented flow-through cell located at the well head. Groundwater is pumped directly from the well to the flow-through cell. At the beginning of the sample event, field crews attach a clean stainless steel sampling manifold to the riser discharge. The manifold has two valves and two ports: one port is used only for purgewater, and the other port is used to supply water to the flow-through cell. Probes are inserted into the flow-through cell to measure pH, temperature, specific conductance, and dissolved oxygen, if required by the main text. Turbidity is measured by collecting an aliquot of water from the purgewater valve and inserting the

sample vial into a turbidimeter. Purgewater, including the water passing through the flow-through cell, is then discharged to a tank on the purgewater truck.

Collection of the field measurement data will commence when a volume of water equal to the volume of the pump riser pipe has been extracted and discharged to the purgewater truck. Once field measurements have stabilized, the hose supplying water to the flow-through cell is disconnected and a clean stainless steel drop leg is attached for sampling collection. The flow rate does not exceed 7.6 L/min (2 gal/min) during sampling to minimize loss of volatiles (if any) and prevent overfilling the bottles. Sample bottles are filled in a sequence designed to minimize loss of volatiles (if any). If both filtered and unfiltered samples are required (see Table 3-1 in main text), filtered samples are collected after collection of the unfiltered samples.

Samples may be filtered in the field using a 0.45 µm filter as noted on the chain-of-custody form. Unfiltered samples are collected in conjunction with filtered samples for select analysis to determine if metal constituents being monitored (excluding hexavalent chromium, if one of the monitored constituents) occur as both suspended and dissolved phases, or in only one state. The evaluation of suspended and dissolved metals provide supporting information for groundwater geochemical characteristics, as well as indication of well integrity such as the presence of dislodged well encrustation, well corrosion products, or failure of the well screen filter pack.

Environmental-grade electric submersible pumps will typically be used for well purging and sample collection. In the event a well exhibits insufficient productivity to support purging and sampling using the electric submersible pumps, adjustable-rate bladder pumps with typical flow rates of 0.1 to 0.5 L/min (0.26 to 0.13 gal/min) may be employed. The same purge protocol described above will be used for these pumps.

For certain types of samples, preservatives are required. Preservatives, based on the analytical methods used, are generally added to the collection bottles before their use in the field. Sample preservation and holding times for groundwater samples are provided in Appendix A (Table A-6) and are based on the analytical method identified in Appendix A (Table A-3). Container types, preservatives, and volumes will be identified on the chain-of-custody form. This groundwater monitoring plan defines a sample as a filled sample bottle for purposes of starting the clock for holding time restrictions.

Holding time is the maximum allowable period between sample collection and analysis. Exceeding holding times could result in changes in constituent concentrations due to volatilization, decomposition, or other chemical alterations. Holding times depend on the constituent and are listed in analytical method compilations such as APHA/AWWA/WEF, 2017, *Standard Methods for the Examination of Water and Wastewater*; SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods*; and the EPA/600 Method series (e.g., EPA/600/4-79/020, *Methods for Chemical Analysis of Water and Wastes*).

B2.1 Decontamination of Drilling and Sampling Equipment

Drilling of wells is not addressed by this groundwater monitoring plan. Therefore, a discussion of the decontamination of drilling equipment is not included.

Sampling equipment will be decontaminated in accordance with sampling equipment decontamination methods. To prevent potential contamination of the samples, care should be taken to use decontaminated equipment for each specific sampling activity.

Special care should be taken to avoid the following common ways in which cross-contamination or background contamination may compromise the samples:

- Improperly storing or transporting sampling equipment and sample containers
- Contaminating the equipment or sample bottles by setting the equipment/sample bottle on or near potential contamination sources (e.g., uncovered ground)
- Handling bottles or equipment with dirty hands or gloves
- Improperly decontaminating equipment before sampling or between sampling events

Decontamination of sampling equipment and pumps is typically performed using high-purity water[1] in each step. In general, three rinse cycles are performed to decontaminate sampling equipment: detergent rinse, acid rinse, and water rinse. During the detergent rinse, equipment is washed in a phosphate-free detergent solution, followed by rinsing with water in three sequential containers. After the third water rinse, equipment that is stainless steel or glass is rinsed in a 1 M nitric acid solution (pH less than 2). Equipment is then rinsed with water in three sequential containers (the water rinses following the acid rinse are conducted in separate water containers that are not used for detergent rinse). Following the final water rinse, equipment is rinsed in hexane and then placed on a rack to dry. Dry equipment is loaded into a drying oven. The oven is set at approximately 50°C (122°F) for items that are not metal or glass or at approximately 100°C (212°F) for metal or glass. Once reaching temperature, equipment is baked for approximately 20 minutes and then cooled. Equipment is then removed from the oven and enclosed in clean, unused aluminum foil using surgical gloves. The wrapped equipment is stored in a custody locked, controlled access area. Water-level measurement tapes (portion that came in contact with groundwater) are decontaminated using a high-purity water rinse and dried with disposable towels.

To decontaminate sampling pumps that are not permanently installed, the pump cowling is first removed, washed (if needed) in phosphate-free detergent solution, and then reinstalled on the pump. Typically, the pump is then submerged in phosphate-free detergent solution, and 11.4 L (3 gal) of solution is pumped through the unit and disposed. Detergent solution is then circulated through the submerged pump for 5 minutes. The pump is removed from solution and rinsed with water. The pump is submerged in water, and 30.3 L (8 gal) of water is pumped through the unit and disposed. The pump is removed from the water, and the intake and housing are covered with plastic sleeving. Cleaning is documented on a tag that is affixed to the pump with the following information:

- Date of pump cleaning
- Pump identification
- Comments (if any)
- Signature of person performing decontamination

B2.2 Water Levels

Each time a sample is obtained, measurement of the groundwater surface elevation at each monitoring well is required by 40 CFR 265.92(e), "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," "Sampling and Analysis." Using a calibrated depth measurement tape, the depth to water is recorded in each well prior to sampling. When two consecutive measurements are taken that agree within 6 mm (0.24 in.), the final determined measurement is recorded, along with the date and time for the specific event. The depth to groundwater is subtracted from the

[1] High-purity water that is generally defined as water that has been distilled, deionized, or any combination of distillation, deionization, reverse osmosis, activated carbon filtration, ion exchange, particulate filtration, or other polishing techniques.

elevation of a reference point (usually the top of the casing) to obtain the water-level elevation. The top of the casing is a known elevation reference point because it has been surveyed to local reference data.

B3 Documentation of Field Activities

Logbooks for field activities are identified with a unique project name and number. The individual(s) responsible for logbooks will be identified in the front of the logbook, and only authorized persons may make entries in logbooks. Logbook entries will be reviewed by the sampling Field Work Supervisor, cognizant scientist/engineer, or other responsible manager; the review will be documented with a signature and date. Logbooks will be permanently bound, waterproof, and ruled with sequentially numbered pages. Pages will not be removed from logbooks for any reason. Entries will be made in indelible ink. Corrections will be made by marking through the erroneous data with a single line, entering the correct data, and initialing and dating the changes.

Data forms for field activities are also identified with a unique project name and number. Data forms may be used to collect field information; information recorded on data forms is the same as for logbooks. The data forms are referenced in the logbooks.

The following information is recorded in logbooks or on data forms:

- Day and date; time task started; weather conditions; and names, titles, and organizations of personnel performing the task
- Purpose of visit to the task area
- Details of field tests that were conducted, and references to forms that were used and methods followed in conducting the activity
- Details of field calibrations and surveys that were conducted, and references to forms that were used, other data records, and methods followed in conducting the calibrations and surveys
- Details of samples collected and the preparation (if any) of splits, duplicates, or blanks
- Time, equipment type, serial or identification number, and methods followed for decontaminations and equipment maintenance performed (reference the page number[s] of any logbook where detailed information is recorded)
- Equipment failures or breakdowns that occurred, with a brief description of replacements

B4 Calibration of Field Equipment

Onsite environmental instruments are calibrated in accordance with the manufacturer's operating instructions, internal work processes, and/or field instructions that provide direction for equipment calibration or verification of accuracy by analytical methods. Calibration records will include the raw calibration data, identification of the standards used, associated reports, date of analysis, and analyst's name or initials. Results from instrument calibration activities are recorded.

Field instrumentation calibration and QA checks will be performed as follows:

- Prior to initial use of a field analytical measurement system
- At a minimum, at the frequency recommended by the manufacturer or methods, or as required by regulations

- Upon failure to meet specified QC criteria
- Daily calibration checks will be performed and documented for each instrument used (these checks will be made on standard materials sufficiently like the matrix under consideration for direct comparison of data; analysis times will be sufficient to establish detection efficiency and resolution)
- Using standards for calibration that are traceable to a nationally recognized standard agency source or measurement system (manufacturer's recommendations for storage and handling of standards, if any, will be followed)

B5 Sample Handling

Sample handling and transfer methods preclude loss of identity, damage, deterioration, and loss of sample. Custody seals or custody tape will be used to verify that sample integrity has been maintained during sample transport. The custody seal will be inscribed with the sampler's initials and date.

A sampling and analytical database is used to track samples from the point of collection through the laboratory analysis process.

B5.1 Containers

Samples will be collected, where and when appropriate, in break-resistant containers. The field sample collection record will indicate the lot number of the bottles used in sample collection. When commercially precleaned containers are used in the field, the name of the manufacturer, lot identification, and certification will be retained for documentation.

Containers will be capped and stored in an environment that minimizes the possibility of sample container contamination. If contamination of the stored sample containers occurs, corrective actions will be implemented to prevent reoccurrences. Contaminated sample containers cannot be used for a sampling event. Container sizes may vary depending on laboratory-specific volumes/requirements for meeting analytical detection limits. Container types and sample amounts/volumes are identified on the chain-of-custody form.

B5.2 Container Labeling

Each sample is identified by affixing a standardized label or tag to the container. This label or tag will contain the sample identification number. The label will identify or provide reference to associate the sample with the date and time of collection, preservative used (if applicable), analysis requested, and collector's name or initials. Sample labels may be either preprinted or handwritten in indelible or waterproof ink.

B5.3 Sample Custody

Sample custody protocols maintain sample integrity throughout the analytical process. Chain-of-custody protocols will be followed throughout sample collection, transfer, analysis, and disposal to ensure that sample integrity is maintained. A chain-of-custody record will be initiated in the field at the time of sampling and will accompany each set of samples shipped to any laboratory.

Shipping requirements will determine how sample shipping containers are prepared for shipment. The analyses requested for each sample will be indicated on the accompanying chain-of-custody form. Each time the responsibility for custody of the sample changes, new and previous custodians will sign the record and note the date and time.

The following minimum information is provided on a completed chain-of-custody form:

- Project name
- Collectors' names
- Unique sample number
- Date, time, and location (or traceable reference thereto) of sample collection
- Matrix
- Preservatives
- Chain-of-possession information (i.e., signatures and printed names of each individual involved in the transfer of sample custody and storage locations, and dates/times of receipt and relinquishment)
- Requested analyses (or reference thereto)
- Shipped to information (i.e., analytical laboratory performing the analysis)

B5.4 Sample Transportation

Packaging and transportation instructions will comply with applicable transportation regulations and U.S. Department of Energy (DOE) requirements. Regulations for classifying, describing, packaging, marking, labeling, and transporting hazardous materials, hazardous substances, and hazardous wastes are enforced by the U.S. Department of Transportation (DOT). Carrier specific requirements, defined in the current edition of International Air Transport Association (IATA) *Dangerous Goods Regulations*, will also be considered when preparing sample shipments conveyed by air freight providers.

Samples containing hazardous constituents will be considered hazardous material in transportation and transported according to DOT/IATA requirements. If the sample material is known or can be identified, then it will be classified, described, packaged, marked, labeled, and shipped according to the specific instructions for that material.

B6 Management of Waste

Waste materials generated during sample activities, including purgewater and decontamination fluids, will be collected and managed in accordance with the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* as authorized under Ecology et al., 1989, *Hanford Federal Facility Agreement and Consent Order Action Plan* Milestone M-024.

For waste designation purposes, wells listed in the main text of the monitoring plan may be surveyed in the Hanford Environmental Information System, and the maximum concentration for each analyte within the most recent 5 years will be evaluated for use in creating a waste profile, if necessary.

Packaging and labeling during waste storage and transportation will meet WAC 173-303, DOE, and DOT requirements, as appropriate.

Offsite analytical laboratories are responsible for the disposal of unused sample quantities and wastes generated during analytical processes.

B7 References

40 CFR 265.92, "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," "Sampling and Analysis," *Code of Federal Regulations*. Available at: http://www.ecfr.gov/cgi-bin/text-idx?SID=2cd7465519114fb3472b4864a0e3c42b&node=pt40.26.265&rgn=div5.

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