DOE/RL-2009-75
REV. 1

Interim Status Groundwater Monitoring Plan for the LLBG WMA-1

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

U.S. DEPARTMENT OF ENERGY | Richland Operations Office

P.O. Box 550
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August 2015

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APPROVED
By Julia Raymer at 11:01 am, Aug 08, 2016

Release Approval Date

Executive Summary

This document presents a revision to the Low Level Waste Management Area 1 (LLWMA-1) groundwater monitoring plan[1] previously published in 2009. This revised monitoring plan is based on the requirements for interim status facilities, as defined by the *Resource Conservation and Recovery Act of 1976*[2] (RCRA) and the implementing requirements in WAC 173-303-400,[3] which in turn, specifies groundwater monitoring regulations under 40 CFR 265.[4] The U.S. Department of Energy (DOE), Richland Operations Office (DOE-RL), is revising this groundwater monitoring plan due to the age of the plan and to ensure that the plan contains the most current Hanford Site groundwater monitoring information for the treatment, storage, and disposal (TSD) unit (e.g., changes in groundwater flow direction and changes to the monitoring network). This indicator evaluation program groundwater monitoring plan is the principal controlling document for conducting groundwater monitoring at LLWMA-1.

The LLWMA-1 is an inactive interim status TSD unit in the 200-SW-2 Groundwater Operable Unit (OU). LLWMA-1 is located in the northwestern corner of the 200 East Area (Figure ES-1). LLWMA-1 consists of the 218-E-10 Burial Ground, which contains 14 excavated trenches, one of which (Trench 9) received mixed waste regulated under RCRA consisting of di-octyl phthalate, and lead. From 1955 to 2000, the 218-E-10 Burial Ground received shipments of industrial waste from the Plutonium-Uranium Extraction (PUREX) Plant, B Plant, T Plant, offsite (mainly Formerly Utilized Sites Remedial Action Program waste), and the 100 Areas (mainly N Reactor waste). Operating records indicate that mixed waste was disposed of only into portions of Trench 9 from 1987 to 1993.

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[1] DOE/RL-2009-75, 2009, *Interim Status Groundwater Monitoring Plan for the LLBG WMA-1* Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0084331. .

[2] *Resource Conservation and Recovery Act of 1976*, 42 USC 6901, et seq. Available at: http://www.epw.senate.gov/rcra.pdf

[3] WAC 173-303-400, "Dangerous Waste Regulations," "Interim Status Facility Standards," *Washington Administrative Code*, Olympia, Washington, Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173+303-400.

[4] 40 CFR 265, "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," *Code of Federal Regulations*. Available at: http://www.ecfr.gov/cgi-bin/text-idx?SID=2cd7465519114fb3472b4864a0e3c42b&node=pt40.26.265&rgn=div5.
265.92, "Sampling and Analysis."
265.93, "Preparation, Evaluation, and Response."

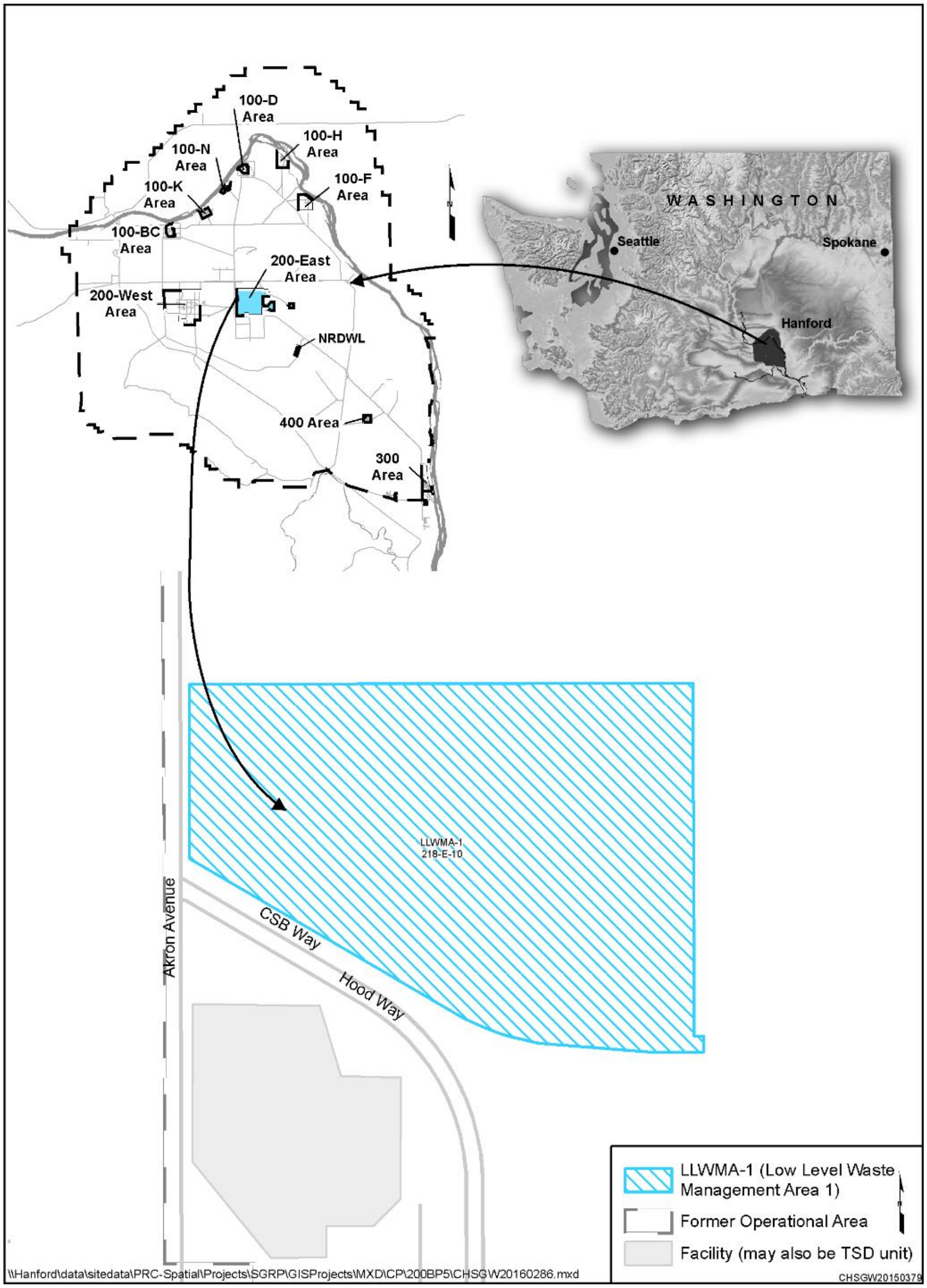

Figure ES-1. LLWMA-1 the 200 East Area

The mixed waste was from PUREX, B Plant, 225B Waste Encapsulation and Storage Facility, and 271B Support Building. The trenches were backfilled on a daily or weekly basis.

As LLWMA-1 received industrial waste contaminated with dangerous waste or dangerous waste constituents, a groundwater monitoring program in accordance with 40 CFR 265 was implemented in 1986. Historically, three exceedances (1989, 1998, and 2012) of the background indicator parameters within downgradient wells have been verified. In each case, the groundwater quality assessment program concluded there was no dangerous waste, or dangerous waste constituents, entering groundwater associated with LLWMA-1. In 1989, statistical evaluation of specific conductance showed that concentrations in one downgradient well were statistically greater than background levels. Verification sampling confirmed the specific conductance exceedance. An interim status groundwater quality assessment plan for LLWMA-1 was prepared and initiated in 1990.[5] Indicator evaluation monitoring was resumed in 1994 after results of the groundwater quality assessment program concluded the initial estimate of groundwater flow was incorrect and that the increased concentration of specific conductance was likely due to northward migration of liquid waste from past practice waste sites to the south and not related to releases of dangerous waste constituents from LLWMA-1.[6]

Concentrations of specific conductance were exceeded in 1998 for downgradient well 299-E33-34. A notification letter and an assessment report[7] were submitted to the Washington State Department of Ecology in March 1999; the notification letter reported that the elevated specific conductance was associated with nitrate contamination from the area of the BY Cribs.

In early 2012, total organic carbon was verified as exceeding background levels. A groundwater quality assessment program plan[8] was submitted to the Regional Administrator in 2012. The plan was implemented in July 2012, and a subsequent first

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[5] WHC-SD-EN-AP-021, 1990, *Interim-Status Groundwater Quality Assessment Plan for Waste Management Area 1 of the 200 Areas Low-Level Burial Grounds,* Rev. 0, Westinghouse Hanford Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=E0006975.

[6] WHC-SD-EN-EV-025, 1994, *Results of Groundwater Quality Assessment Program at Low-Level Waste Management Area 1 of the Low-Level Burial Grounds*, Rev. 0, Westinghouse Hanford Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D196097452.

[7] Furman, M.J., 1999, "Notification of Specific Conductance Exceedance at Low-Level Waste Management Area 1 (218-E-10)" (letter to S. Leja, Acting Perimeter Areas Manager, Nuclear Waste Program, State of Washington Department of Ecology, from M.J. Furman), U.S. Department of Energy, Richland Operations Office, Richland, Washington, March 18. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D199152613.

[8] DOE/RL-2012-35, 2012, *First Determination RCRA Groundwater Quality Assessment Plan for Low-Level Burial Grounds Low-Level Waste Management Area-1,* Rev. 0, U.S. Department of Energy, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0091456.

determination report[9] concluded there was no dangerous waste, or dangerous waste constituents entering groundwater associated with LLWMA-1. The indicator evaluation program was reinstated based on 40 CFR 265.93(d)(6).

This revised groundwater monitoring plan presents an updated indicator evaluation program for detection monitoring of the uppermost aquifer beneath LLWMA-1. This plan addresses the following:

- Number, locations, and depths of wells in the LLWMA-1 groundwater monitoring network
- Sampling and analytical methods of parameters required for groundwater contamination detection monitoring
- Methods for evaluating groundwater quality information
- Schedule for groundwater monitoring at LLWMA-1

This revised plan updates the existing groundwater monitoring well network as identified in the previous groundwater monitoring plan (DOE/RL-2009-75, Rev. 0, *Interim Status Groundwater Monitoring Plan for the LLBG WMA-1*) and addresses the well network changes needed to accommodate the 2011 groundwater flow reversal. From mid-2011 to mid-2015, groundwater flow direction determinations continue to indicate a southward groundwater flow direction beneath LLWMA-1. As a result an eight well network has been devised to evaluate groundwater quality, including a new downgradient well that will monitor the southeast corner of LLWMA. Future groundwater flow changes are possible as a result of the 200-BP-5 treatability test (DOE/RL-2010-74, *Treatability Test Plan for the 200-BP-5 Groundwater Operable Unit*).[10] The 200-BP-5 treatability test will be completed at a well located east of LLWMA-1 and will use varying groundwater extraction rates to determine hydraulic parameters and existence of nearby hydrogeologic boundary conditions.

[9] DOE/RL-2013-25, 2013, *First Determination RCRA Groundwater Quality Assessment Report for Low-Level Burial Grounds Low-Level Waste Management Area-1*, Rev. 0, U.S. Department of Energy, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0088747.

[10] DOE/RL-2010-74, 2015, *Treatability Test Plan for the 200-BP-5 Groundwater Operable Unit*, Rev. 2, U.S. Department of Energy, Richland Operations Office, Richland, Washington, Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0081243H.

Groundwater in LLWMA-1 monitoring wells will be sampled and analyzed semiannually for the parameters used as indicators of groundwater contamination (pH, specific conductance, total organic carbon, and total organic halogen) and annually for parameters establishing groundwater quality (chloride, iron, manganese, phenols, sodium, and sulfate) in accordance with 40 CFR 265.92(b)(2)&(3) and (d). The newly installed well will be sampled quarterly as a best practice activity to provide additional scientific and technical information. Additional site-specific constituents (calcium, magnesium, potassium, fluoride, nitrate, and nitrite) and field measurements (dissolved oxygen, temperature, and turbidity) will also be collected for general groundwater chemistry to support the evaluation of upgradient and downgradient water chemistry variations. Water-level measurements will be taken each time that a sample is collected to satisfy the requirements of 40 CFR 265.92(e).

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Terms

AEA	*Atomic Energy Act of 1954*
CCU	Cold Creek Unit
CCU$_f$ (lam-msv)	CCU fine-grained, laminated to massive; (the early Palouse soil)
CCU$_g$	CCU – gravel dominated
CCU$_z$	CCU – silt dominated
CSM	conceptual site model
DOE	U.S. Department of Energy
DOE-RL	DOE Richland Operations Office
Ecology	Washington State Department of Ecology
EMM	Elephant Mountain Member
EPA	U.S. Environmental Protection Agency
FWS	Field Work Supervisor
H1	Hanford formation unit 1
H2	Hanford formation unit 2
HEPA	high-efficiency particulate arrestance
LLWMA	Low-Level Waste Management Area
NAD83	*North American Datum of 1983*
NAVD88	*North American Vertical Datum of 1988*
OU	operable unit
PUREX	Plutonium-Uranium Extraction
QAPjP	quality assurance project plan
RCRA	*Resource Conservation and Recovery Act of 1976*
TBD	to be determined
TEDF	Treated Effluent Disposal Facility
TOC	total organic carbon
TOX	total organic halogen
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order* (Ecology et al., 1989a)
TRU	transuranic

TSD	treatment, storage, and disposal
UPR	unplanned release
WMA	waste management area

1 Introduction

This document presents the revised groundwater monitoring plan for the Low-Level Waste Management Area 1 (LLWMA-1) and supersedes the previous plan (DOE/RL-2009-75, Rev. 0, *Interim Status Groundwater Monitoring Plan for the LLBG WMA-1*) (Figure 1-1). The U.S. Department of Energy (DOE), Richland Operations Office (DOE-RL), is revising this groundwater monitoring plan due to the age of the plan and to ensure that the plan contains the most current Hanford Site groundwater monitoring information for the treatment, storage, and disposal (TSD) unit (changes in groundwater flow direction and changes to the monitoring network). This groundwater monitoring plan is based on the requirements for interim status facilities, as defined by the *Resource Conservation and Recovery Act of 1976* (RCRA), with regulations promulgated by the Washington State Department of Ecology (Ecology) in the *Washington Administrative Code* , and the *Code of Federal Regulations* by reference (WAC 173-303-400, "Dangerous Waste Regulations," "Interim Status Facility Standards;" 40 CFR 265, "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," Subpart F, "Ground-Water Monitoring"). This plan is used to monitor the indicator parameters in groundwater samples that are used to determine whether dangerous waste or dangerous waste constituents have entered the groundwater. This plan is also used for monitoring the parameters used to establish groundwater quality.

LLWMA-1 is an inactive interim status TSD unit regulated as a landfill, as defined in WAC 173-303-040, "Definitions." In accordance with Section I.A of WA7890008967, *Hanford Facility Resource Conservation and Recovery Act (RCRA) Permit*, *Dangerous Waste Portion for the Treatment*, *Storage, and Disposal of Dangerous Waste* (hereafter referred to as the Hanford Facility RCRA Permit), LLWMA-1 will continue to be considered an interim status unit until is it incorporated into Part III, V, and/or VI of the Hanford Facility RCRA Permit, or until interim status is terminated. Therefore, groundwater monitoring for LLWMA-1 continues under interim status requirements. For regulatory purposes, the TSD unit boundary of the LLWMA-1 is identified on the current Hanford Facility RCRA Permit Part A Form.

LLWMA-1 is located at the northwestern corner of the 200 East Area within the 200-SW-2 OU (Figure 1-1). LLWMA-1 consists of the 218-E-10 Burial Ground, originally planned for 19 trenches; however, only 14 trenches were excavated for waste disposal (Figure 1-2). Operating records indicate that LLWMA-1 received industrial waste from 1955 to 2000 and mixed waste from 1987 to 1993. The industrial waste shipments were from the Plutonium-Uranium Extraction (PUREX) Plant, B Plant, T Plant, offsite (mainly Formerly Utilized Sites Remedial Action Program waste), and the 100 Areas (mainly N Reactor waste). Only portions of Trench 9 received mixed waste regulated under RCRA (Figure 1-2). The regulated RCRA mixed waste consists of di-octyl phthalate[11] and lead.

[11] Chemical Abstract Service number 117-84-0.

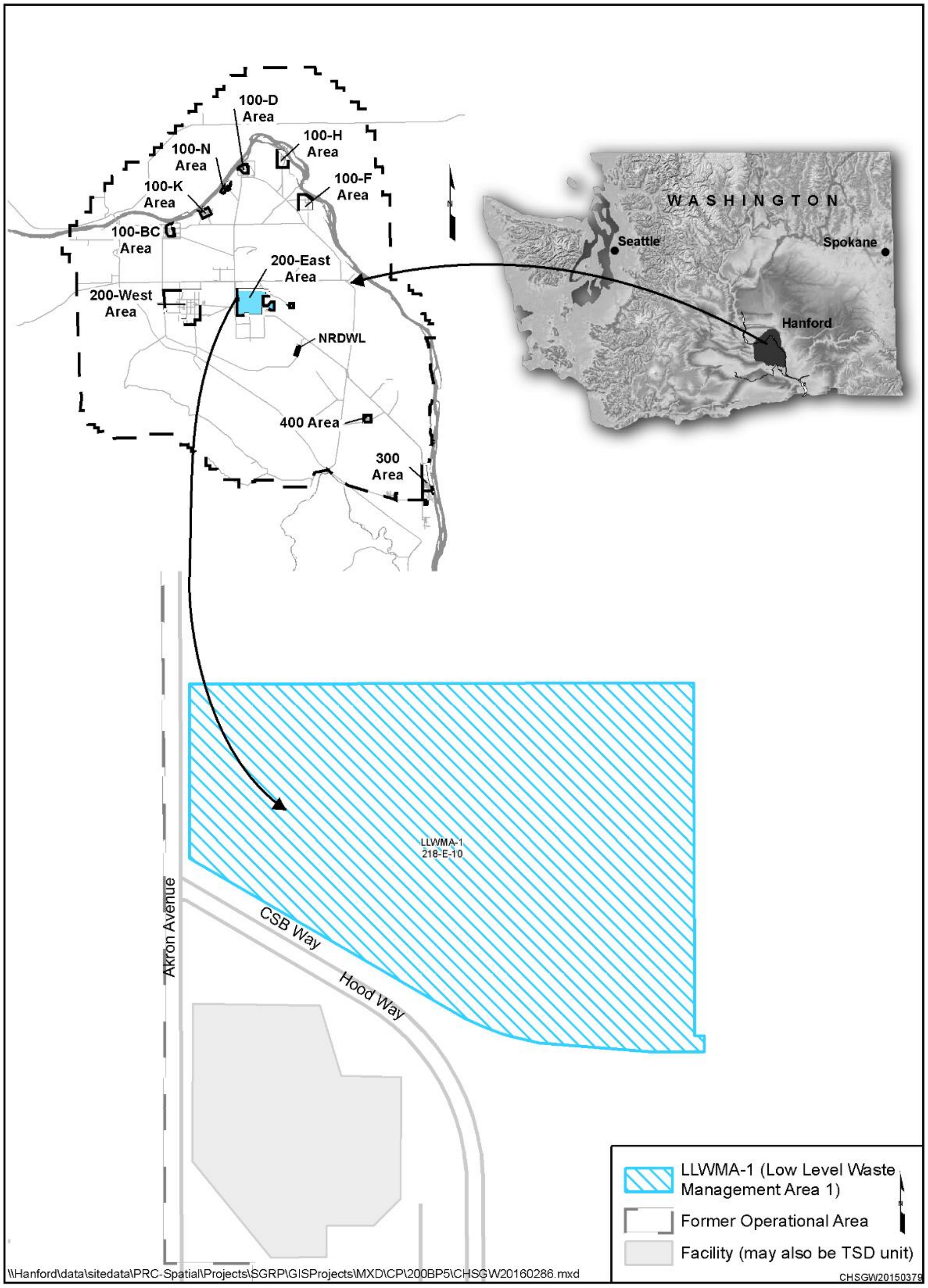


Figure 1-1. LLWMA-1 in the 200 East Area

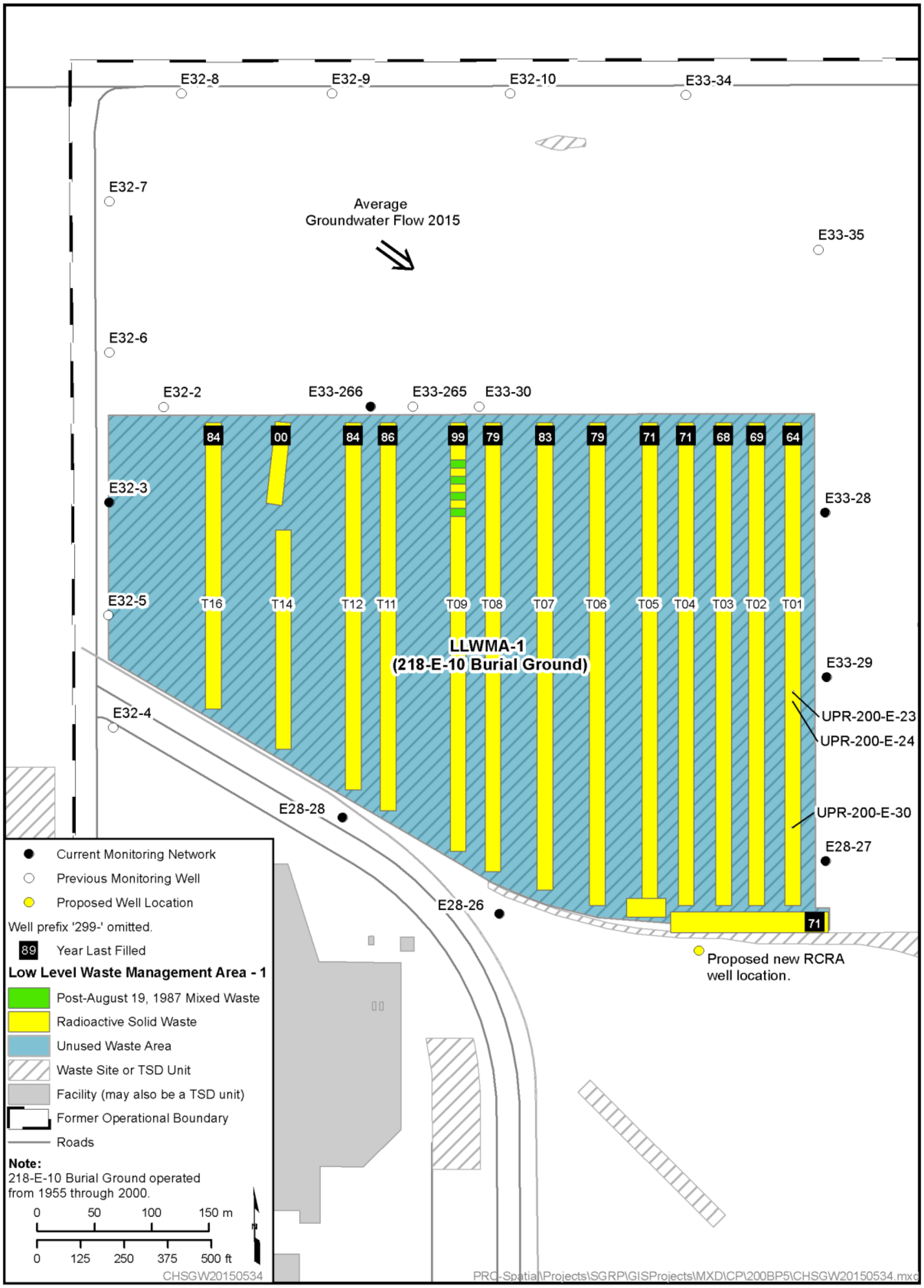


Figure 1-2. 218-E-10 Burial Ground at LLWMA-1

The purpose of this groundwater monitoring plan is to present an updated groundwater monitoring program for the parameters used as indicators of groundwater contamination and groundwater quality from LLWMA-1, commonly referred to as an indicator evaluation program under interim status. This plan is required by 40 CFR 265.90(a) and (b) and is intended specifically to satisfy monitoring requirements for interim status TSD units, as required by WAC 173-303-400(3) and 40 CFR 265.92, “Sampling and Analysis.” This monitoring plan is the principal controlling document for conducting groundwater monitoring at the LLWMA-1. The indicator evaluation program detailed in this plan requires semiannual sampling for parameters used as indicators of groundwater contamination, as well as and annual sampling for parameters establishing groundwater quality for the two upgradient and six downgradient wells. One of the six downgradient wells will be a new well installed to monitor the southeast corner of LLWMA and will be sampled quarterly for one year. Water level measurements are also required each time a sample is collected in accordance with 40 CFR 265.92(e).

This revised plan uses seven existing groundwater monitoring wells from the previous monitoring network and proposes a new well be added to the well network for the total of eight wells to address the groundwater flow direction change. Future groundwater flow changes are possible as a result of the 200-BP-5 treatability test (DOE/RL-2010-74, *Treatability Test Plan for the 200-BP-5 Groundwater Operable Unit*). The 200-BP-5 treatability test will be completed at a well located east of LLWMA-1 and will use varying groundwater extraction rates to determine hydraulic parameters and existence of nearby hydrogeologic boundary conditions.

This groundwater monitoring plan addresses the operational history, current hydrogeology, and conceptual site model (CSM) for the TSD unit and incorporates knowledge about the potential for contamination originating from the LLWMA-1 and includes the following chapters and appendices:

- Chapter 2 summarizes background information and references other documents that contain more detailed or additional information. It also describes LLWMA-1 and the regulatory basis, types of waste present, the pertinent geology and hydrogeology beneath LLWMA-1; and it presents a brief history of groundwater monitoring. This information is summarized as a CSM to aid in development of the groundwater monitoring program.
- Chapter 3 describes the groundwater monitoring program, including the wells in the monitoring network, constituents analyzed, sampling frequency, and sampling protocols.
- Chapter 4 describes data evaluation and reporting.
- Chapter 5 provides an updated outline for a groundwater quality assessment plan.
- Chapter 6 contains the references cited in this plan.
- Appendix A provides the quality assurance project plan (QAPjP).
- Appendix B contains sampling protocols.
- Appendix C provides information for the wells within the groundwater monitoring network.

2 Background

This chapter describes LLWMA-1 and its operating history, regulatory basis, waste and waste characteristics associated with LLWMA-1, local subsurface geology and hydrogeology, a summary of previous groundwater monitoring, and the CSM for LLWMA-1.

The information contained in this chapter was obtained from several sources including previous groundwater monitoring plans listed in Section 2.5, documents listed in Section 2.4, and the following documents:

- Furman, 1999, "Notification of Specific Conductance Exceedance at Low-Level Waste Management Area 1 (218-E-10)"
- DOE/RL-2004-60, *200-SW-2 Radioactive Landfills Group Operable Unit RCRA Facility Investigation/Corrective Measures Study/Remedial Investigation/Feasibility Study Work Plan*
- DOE/RL-2012-35, *First Determination RCRA Groundwater Quality Assessment Plan for Low-Level Burial Grounds Low-Level Waste Management Area-1*
- DOE/RL-2013-25, *First Determination RCRA Groundwater Quality Assessment Report for Low-Level Burial Grounds Low-Level Waste Management Area-1*
- DOE/RL-2014-43, *Mixed Waste Disposed of in the Low-Level Burial Grounds*
- PNNL-13404, *Hanford Site Groundwater Monitoring for Fiscal Year 2000*

2.1 Facility Description and Operational History

Most of the information conveyed in this section is from DOE/RL-2004-60, which provides details regarding the beginning of disposal, site dimensions, types of waste disposed of, and disposal operating procedures. These are summarized as follows.

LLWMA-1 consists of the 218-E-10 Burial Ground and covers approximately 36.5 ha (90.2 ac), including a northern annexed portion. The 14 unlined trenches vary in length from 165 to 433 m (541 to 1,421 ft), as shown in Figure 1-2. The trenches are located in the southern portion of LLWMA-1, occupying approximately 23 ha (57 ac). All trenches are 4.6 m (15 ft) deep except Trench 1, which is 7.3 m (24 ft) deep (DOE/RL-2004-60). The northern annexed portion of LLWMA-1 was not used for disposal of waste (DOE/RL-2004-60 and SGW-48278, *Investigation of Unused Landfill Areas: 218-W-4C, 218-W-6, 218-E-10 and 218-E-12B*). The existing trenches received approximately 26,900 m^3 (950,000 ft^3) of waste. Based on the waste disposal depths, there is 73.4 to 82.8 m (241 to 272 ft) of vadose zone between the base of the trenches and groundwater. Solid waste received at the 218-E-10 Burial Ground was generally from the 200 East Area but also included 100 and 300 Areas material. A detailed listing of wastes disposed of to the 218-E-10 Burial Ground is provided in Appendix D of DOE/RL-2004-60. Most of the low-level waste appeared to have been associated with used 200 Area separation plant equipment (scrubbers, connectors, resin tanks, filters, pumps, tube bundles, columns, and centrifuges) but also included building demolition waste and debris. The building demolition waste and debris included concrete, roofing material, insulation, wood and other associated building items. Asphalt also was listed as part of the waste. Metals identified included aluminum, lead, stainless steel, and steel. Other miscellaneous materials included soil, dewatered sludge, and absorbent materials. Trench 9 (shown as T09 in Figure 1-2) is the only trench identified with mixed waste disposed after the effective date of mixed waste regulations. Based on the research conveyed in DOE/RL-2014-43 (Appendix G), di-octyl phthalate and lead are the only dangerous waste constituents associated with waste storage at LLWMA-1.

Packaging requirements were designed to prevent the spread of contamination to the environment, and are discussed as follows. Initial disposal procedures were directed by HW-25457, *Manual of Radiation Protection Standards*. The manual specifically provided packaging, handling, transport, and burial procedures in order to minimize personnel exposure and prevent the spread of radioactivity to the environment. These waste disposal procedures were more detailed and restrictive than earlier procedures because of the increasing concern for contaminant releases to groundwater. By 1970, ARH-1842, *Specification and Standards for the Burial of ARHCO Solid Wastes*, was implemented, which required the segregation of transuranic (TRU) waste from non-TRU waste for retrieval within 20 years. Other notable preventative packaging requirements included the following (DOE/RL-2004-60):

- Solid wastes were to be dry
- Damp wastes were to be packaged in an inner waterproof container
- Wood, cardboard, and fiberboard containers were to be banded for TRU waste
- Containers of waste containing easily airborne contaminants were to have an inner container such as sheet plastic.

In 1977, two barriers for waste packages were imposed by RHO-CD-138, *Containment Barrier Criteria*. TRU packaging was further refined in 1980 under the requirements of RHO-MA-222, *Hanford Radioactive Solid Waste Packaging, Storage, and Disposal Requirements*, which required no loss of containment for 25 years instead of the 20 years required by ARH-1842. Packing requirements continued to increase throughout the years for protection of human health and the environment as discussed further in DOE/RL-2004-60.

Liquid waste disposal at LLWMA burial grounds was considered minimal because bulk liquids could be disposed to cribs, trenches, and underground storage tanks until 1973 (DOE/RL-2004-60). Damp wastes were packaged in an inner waterproof container that was typically packaged with absorbent material (DOE/RL-2004-60).

Because the nature of the material disposed was predominantly dry or sorbed onto media to reduce mobility, the likelihood of contaminant migration below the trenches is expected to be low. Consideration of the low annual precipitation and recharge rates further reduces the likelihood for contaminant migration because infiltration is the driving mechanism (DOE/RL-2004-60).

Two unplanned releases (UPRs) occurred in the early 1960s (UPR-200-E-23 and UPR-200-E-30) in Trench 1 (shown as T01 in Figure 1-2). The UPRs occurred due to the collapse of two wooden burial boxes releasing high-level contamination. Dose levels were reported in supporting release documents (HW-65935, *Chemical Processing Department Monthly Report For June, 1960*, page K-2, HW-84619, *Summary of Environmental Contamination Incidents At Hanford, 1958-1964*, page 6, HW-69443, *Chemical Processing Department Monthly Report April, 1961* pages B-3 and E-2) with maximum dose readings of 60 and 500 mrem/hr, respectively. When UPR-200-E-23 was identified, the contamination was fixed by spraying water or road oil over the affected area (UPR-200-E-24). One document (HW-65935, page E-2) indicated that a conventional agricultural sprinkler system consisting of 366 m (1,200 ft) of 10.3 cm (4 in.) irrigation pipe was installed in an effort to stabilize the ground contamination. Rye seed was inferred to have been sown to form a root mat for preventing wind erosion. UPR-200-E-30 occurred during soil coverage, which was used to mitigate airborne contamination.

2.2 Regulatory Basis

In May 1987, DOE issued a final rule (10 CFR 962, "Byproduct Material") stating that the hazardous waste components of mixed waste are subject to RCRA regulations. The hazardous waste components of mixed waste were determined to be subject to Ecology authority to regulate these waste since August 19, 1987.

In May 1989, DOE, the U.S. Environmental Protection Agency (EPA), and Ecology signed the Ecology et al., 1989, *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement). This agreement established the roles and responsibilities of the agencies involved in regulating and controlling remedial restoration of the Hanford Site, which includes LLWMA-1. Groundwater monitoring is conducted at LLWMA-1 in accordance with WAC 173-303-400(3) (and by reference, 40 CFR 265, Subpart F), which requires monitoring to determine whether the dangerous waste constituents from the TSD unit have entered the groundwater in the uppermost aquifer underlying the TSD unit.

Dangerous waste is regulated under RCW 70.105, "Hazardous Waste Management," and its implementing requirements in the Washington State dangerous waste regulations (WAC 173-303-400). Radionuclides in mixed waste may include source, special nuclear, and byproduct materials as defined in the *Atomic Energy Act of 1954* (AEA). AEA states that these radionuclide materials are regulated at DOE facilities, exclusively by the DOE, acting pursuant to its AEA authority. Radionuclide materials are not hazardous/dangerous wastes and, therefore, are not subject to regulation by the state of Washington under RCRA or RCW 70.105.

Groundwater monitoring at LLWMA-1 was initiated in 1986 (PNL-6772, *A Detection-Level Hazardous Waste Ground-Water Monitoring Compliance Plan for the 200 Areas Low-Level Burial Grounds and Retrievable Storage Units*) based on the interim status indicator evaluation program requirements of 40 CFR 265, Subpart F, and WAC 173-303-400. The groundwater monitoring plan was revised in 1989 (WHC-SD-EN-AP-015, *Revised Ground-Water Monitoring Plan for the 200 Areas Low-Level Burial Grounds*), in 2004 (PNNL-14859, *Interim Status Groundwater Monitoring Plan for Low-Level Waste Management Areas 1 to 4, RCRA Facilities, Hanford, Washington*), and again in 2009 (DOE/RL-2009-75, Rev. 0). A summary of the monitoring history is provided in Section 2.5 of this report, which explains the details behind the various monitoring performed over the past three decades. An indicator evaluation program that monitors parameters required for groundwater contamination detection continues to this day.

2.3 Waste Characteristics

The LLWMA-1 trenches began receiving shipments of industrial waste in 1955. The waste included low-level radiological waste, mixed low-level waste, and unsegregated remote-handled waste from PUREX, B Plant, T Plant, offsite (mainly Formerly Utilized Sites Remedial Action Program waste), and the 100 Areas (mainly N Reactor waste). The trenches received large items, often packaged in drag-off boxes (DOE/RL-2004-60). Radiological waste is not regulated under RCRA and is discussed herein for informational purposes only. The mixed industrial waste regulated under RCRA was disposed of into portions of Trench 9 from 1987 to 1993. Burial records for the mixed waste include approximately 13 kg (30 lbs) of di-octyl phthalate impregnated high-efficiency particulate arrestance (HEPA) filters and approximately 550 kg (1,200 lbs) of lead (DOE/RL-2014-43). The mixed waste was contained in either concrete or plastic and fiberboard burial boxes. The plastic and fiberboard burial boxes were grouted. The trenches were backfilled on a daily or weekly basis, and LLWMA-1 stopped receiving waste in 2000.

2.4 Geology and Hydrogeology

The geology and hydrogeology of the 200 East Area, including the region of LLWMA-1, are described in detail in the following documents:

- DOE/RL-2002-39, *Standardized Stratigraphic Nomenclature for Post-Ringold-Formation Sediments Within the Central Pasco Basin*
- PNL-6820, *Hydrogeology of the 200 Areas Low-Level Burial Grounds-An Interim Report*
- PNL-8889, *Solid-Waste Leach Characteristics and Contaminant-Sediment Interactions*
- PNNL-11800, *Composite Analysis for Low-Level Waste Disposal in the 200 Area Plateau of the Hanford Site*)
- PNNL-12261, *Revised Hydrogeology for the Suprabasalt Aquifer System, 200-East Area and Vicinity, Hanford Site, Washington*
- PNNL-19277, *Conceptual Models for Migration of Key Groundwater Contaminants Through the Vadose Zone and Into the Unconfined Aquifer Below the B-Complex*
- PNNL-19702, *Hydrogeologic Model for the Gable Gap Area, Hanford Site*
- RHO-BW-SA-318 P, *Paleodrainage of the Columbia River System on the Columbia Plateau of Washington State: A Summary*
- RHO-BWI-ST-4, *Geologic Studies of the Columbia Plateau, A Status Report*
- WHC-MR-0204, *200-East and 200-West Areas Low-Level Burial Grounds Borehole Summary Report*
- WHC-MR-0205, *Borehole Completion Data Package for the Low-Level Burial Gounds-1990*
- WHC-SD-EN-DP-044, *1991 Borehole Completion Data Package for the Low-Level Burial Grounds*
- WHC-SD-EN-DP-049, *1992 Borehole Completion Data Package for the Low-Level Burial Grounds*
- WHC-SD-EN-EV-024, *Site Characterization Report for the Liquid Effluent Retention Facility*
- WHC-SD-WM-TI-730, *Performance Assessment for the Disposal of Low-Level Waste in the 200 East Area Burial Grounds*

2.4.1 Stratigraphy

The suprabasalt sediment of the northwest corner of the 200 East Area, specifically the area of LLWMA-1, was initially investigated and reported in detail in PNL-6820 and supporting documents WHC-MR-0204, WHC-MR-0205, WHC-SD-EN-DP-044, and WHC-SD-EN-DP-049. Since the time of these reports, the stratigraphic terminology for the suprabasalt sediments has evolved, including a new lithologic unit, the Cold Creek Unit (CCU) as described in Section 2.4.1.3. The following subsections describe the stratigraphic units present beneath LLWMA-1, from deepest to shallowest.

2.4.1.1 Elephant Mountain Member Basalt

The Columbia Plateau is recognized as the Earth's youngest flood-basalt province, formed between 6 and 16.5 million years ago (RHO-BW-SA-318P). Several individual flows occurred over the 10 plus million years, and the uppermost flow in the area of LLWMA-1 is the Elephant Mountain Member (EMM) of the Saddle Mountains Basalt units. The EMM has been characterized as consisting of two flows that erupted approximately 10.5 million years ago. In the region near LLWMA-1, the younger EMM flow is not present (RHO-BWI-ST-4); however, the oldest EMM flow (Elephant Mountain I) is continuous throughout the area.

Regionally, Elephant Mountain I has been reported to range in thickness from approximately 12 m (39 ft), where partially eroded, to greater than 35.1 m (115 ft) north of the eastern part of the 200 East Area (WHC-SD-EN-EV-024). Closer to LLWMA-1, four wells (299-E33-12, 299-E33-40, 299-E33-50, and 299-E33-340) have extended through Elephant Mountain I with an average thickness of 15.3 m (50 ft). The reason Elephant Mountain I was eroded in this area is the meandering nature of the ancestral Columbia River across the Pasco Basin, including the southern flank of the Gable Butte/Gable Mountain anticlinal first-order fold. Beneath the 218-E-10 Burial Ground, the basalt dips predominantly to the southwest as shown in Figure 2-1.

2.4.1.2 Ringold Formation

The Ringold Formation beneath LLWMA-1 comprises only the relict basal Ringold fluvial sediments, unit A. PNNL-12261 refined the hydrostratigraphic conceptual model for the 200 East Area Ringold Formation through visual depictions and definition of three Ringold unit A subunits. Only the oldest subunit, 9C, has been defined near LLWMA-1 (PNNL-12261). Younger Ringold Formation units were also deposited at LLWMA-1; however, a Columbia River course change in the Columbia River Gorge about 2 to 3.4 million years ago began a headward erosion of the Ringold Formation (RHO-BW-SA-318-P), leaving only a thin remnant of the low hydraulic conductive Ringold unit 9C in the southwest portion of the LLWMA-1 network (Figure 2-1).

The primary characteristic used to differentiate Ringold Formation basal gravel from the overlying Cold Creek gravel-dominated facies is its significantly lower hydraulic conductivity and slower drilling rate when hard tooling with a cable tool drill rig. The consolidated condition of the Ringold Formation gravels stems from the millions of years of in situ weathering and groundwater contact (PNNL-19702). As a result, granitic and gneissic clasts, which are friable in such environments, can be transformed into low to moderate binding cements through diagenesis.

Geologist observations and hydraulic data confirm Ringold Formation gravels only in the lower portions of the southwestern wells (PNNL-6820 and PNNL-12261). Because of the elevation and location of these sediments, they do not play a role in groundwater monitoring at LLWMA-1. This is shown in Figure 2-1, where the Ringold Formation sediments are located within the deeper part of the aquifer and below the well screens in this area.

2.4.1.3 Cold Creek Unit

The suprabasalt CCU sediments disconformably overlie both Ringold unit 9C and the Elephant Mountain basalt and contain two facies: the lower gravel-dominated and upper silt-dominated units. These sediments were formerly referred to as the “Plio-Pleistocene unit” and “pre-Missoula Gravels,” as well as the “early Palouse soil.” The nomenclature was derived in order to define sediments generally confined to the boundaries of the Cold Creek syncline (DOE/RL-2002-39). The lower gravel unit extends generally from the basalt interface to 10 or more meters above the water table. The exception is in the southwest corner, where the Ringold unit 9C gravels exist.

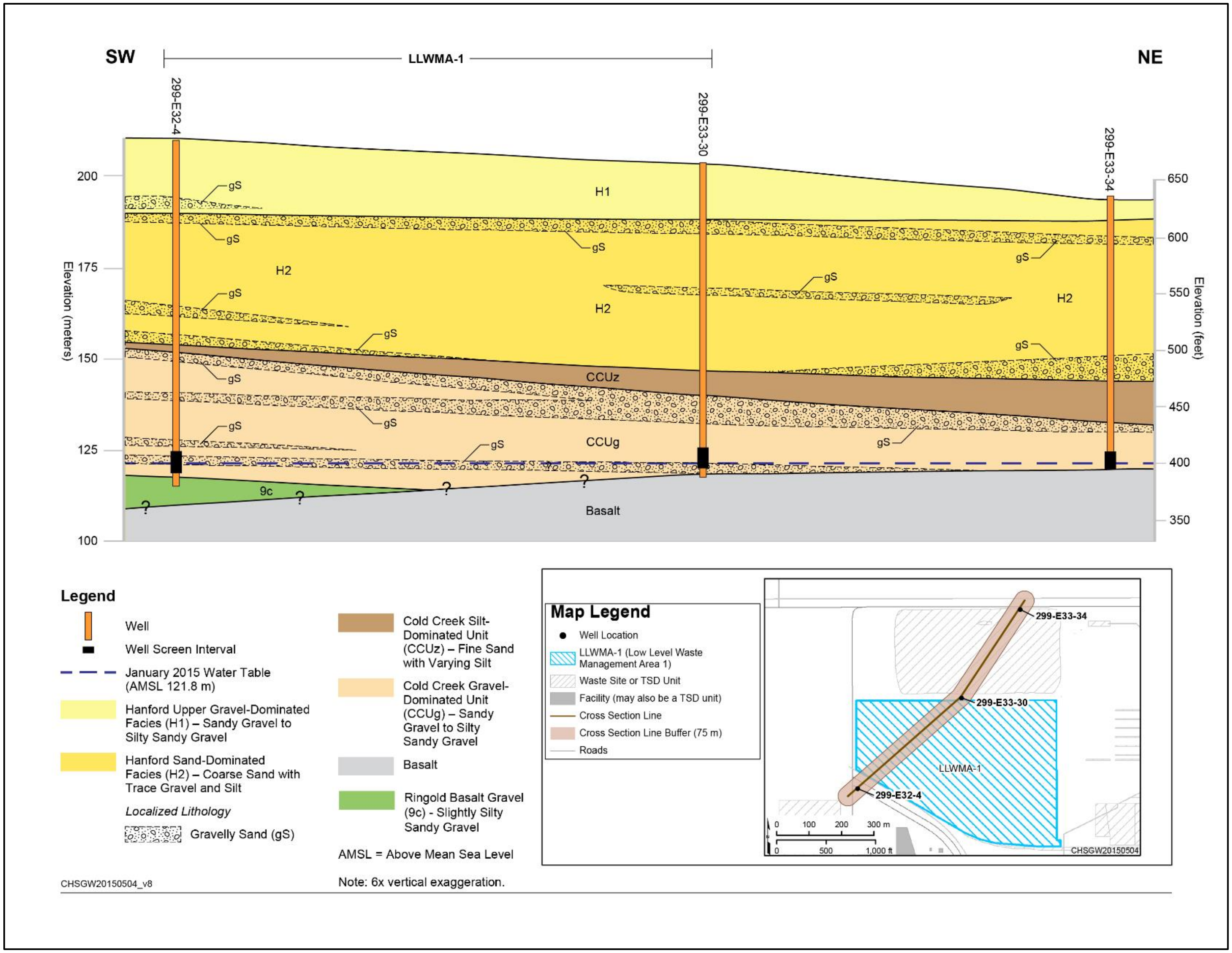


Figure 2-1. Geologic Cross-Section of Suprabasalt Sediments and Underlying EMM Extending from the Northeast to the Southwest Corner of LLWMA-1

2.4.1.3.1 Cold Creek Unit - Gravel Dominated

The CCU - gravel-dominated (CCU_g) deposition began between 2 and 3.4 million years ago, as the ancestral Columbia River neared the basal incision depth through possibly 200 m (600 ft) of Ringold Formation sediments in the central portion of the Pasco Basin. Near and beneath the 218-E-10 Burial Ground, a gravel train of Cold Creek sediments marks one interpreted ancestral Columbia River pathway through the Gable Butte/Gable Mountain Gap and into the 200 East Area (Figure 2-2).

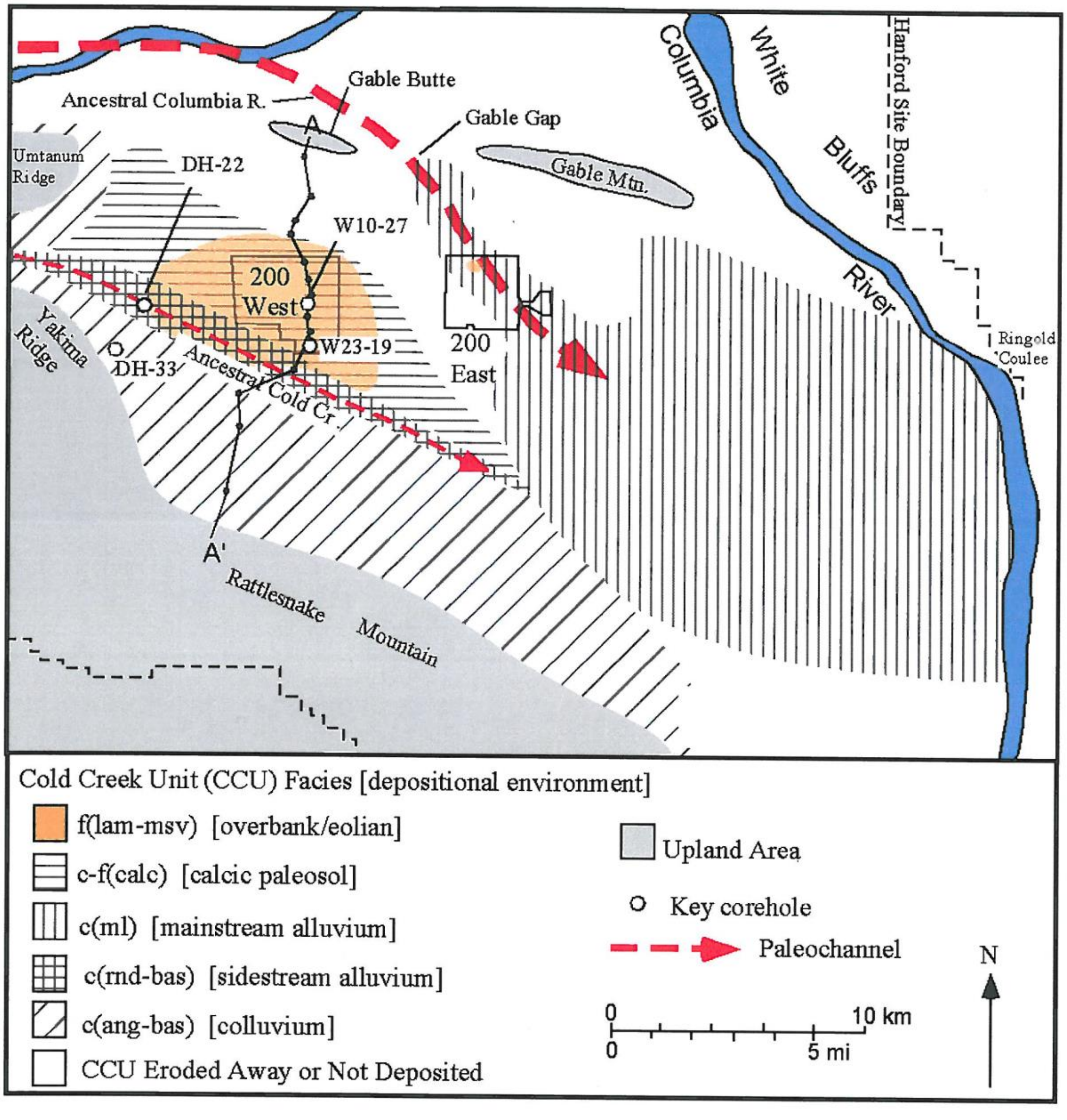


Figure 2-2. 2002 Interpretation of Cold Creek Depositional Extent

The Cold Creek gravels are best distinguished from the underlying Ringold unit 9C sediments by the significantly higher hydraulic conductivity and higher drilling rate. In addition, the CCU_g generally lacks significant weathering and consolidation, due to its younger age.

The Cold Creek gravels beneath LLWMA-1 range from silty sand to sandy gravel and increase in thickness to the west (Figures 2-3 through 2-5). The facies' upper boundary was based primarily on the sieve analysis completed during drilling of the initial eight monitoring wells. Sieve analyses were not performed as thoroughly during drilling of the more recent monitoring wells, and when comparing geologist observations to the sieve analysis, there is usually a 5 to 10 percent difference in the sediment composition. There are a various number of fining-upward sequences within the CCU_g, ranging from three to seven identifiable layers, based on sieve analyses.

Wells to the west have gravel content ranging from 40 to 70 percent, while wells to the east have gravel content ranging from nearly zero to 30 percent. Thus, it appears that dispersive effects within the groundwater will be greater along the east side of LLWMA-1 than along the west side.

2.4.1.3.2 Cold Creek Unit - Silt-Dominated

The CCU - silt-dominated (CCU_z) facies is continuous beneath the 218-E-10 Burial Ground and is known to extend to the east beneath WMA B-BX-BY. DOE/RL-2002-39 indicates that this unit can grade from fluvial to alluvial overbank and eolian deposits laterally (e.g., CCU_f [lam-msv] CCU_z [early Palouse soil]). The structure of the sediments during this gradation is described as transitioning from laminated to massive.

The CCU_z facies beneath the 218-E-10 Burial Ground ranges from a fine-grained sand to sandy silt based on sieve analyses. The unit thickness is consistent across the site but increases in elevation to the west (Figures 2-3 through 2-5). The silt content generally ranges from 2.4 to 17 percent; however, the silt range at wells 299-E28-26 and 299-E33-30 is up to 47.6 and 65.8 percent, respectively. The highest silt content is found in the base of the unit, and sediment size increases with elevation. The sand content ranges from 75 to 97 percent, except where the higher silt content is observed. Calcium carbonate content ranges from none to a few percent. Where higher calcium carbonate content is found, clumps of silt and sand were generally reported.

2.4.1.4 Hanford Formation

The Hanford formation is the informal name for the glacio-fluvial deposits from cataclysmic Ice Age floods. Sources for floodwaters included Glacial Lake Missoula, pluvial Lake Bonneville, and ice-margin lakes that formed around the margins of the Columbia Plateau (Baker et al., 1991, "Quaternary Geology of the Columbia Plateau"). The last Ice Age floods occurred about 15,000 years ago; the earliest may have been 1 to 2 million years ago (Bjornstad, 2006, *On the Trail of the Ice Age Floods: A Geological Field Guide to the Mid-Columbia Basin)*. The Hanford formation consists of mostly unconsolidated sediments that cover a wide range in grain size, from pebble to boulder-size gravel, fine- to coarse-grained sand, silty sand, and silt. The Hanford formation is subdivided further into gravel and sand-dominated facies, which transition into one another laterally with distance from the main, high-energy flood currents (PNNL-19277).

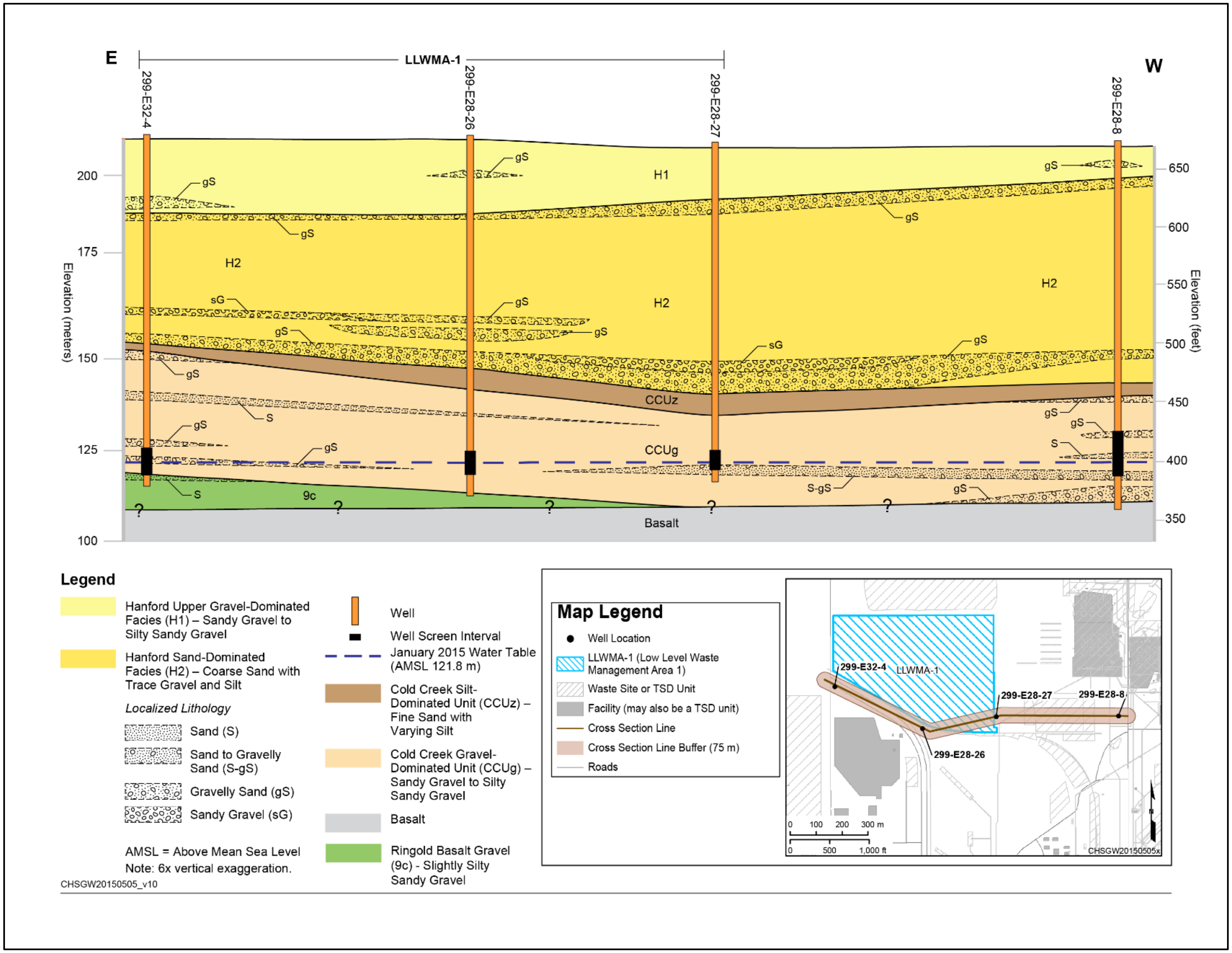


Figure 2-3. Geologic Cross-Section of Suprabasalt Sediments and Underlying EMM Extending from West to East along the LLWMA-1 Southern Boundary

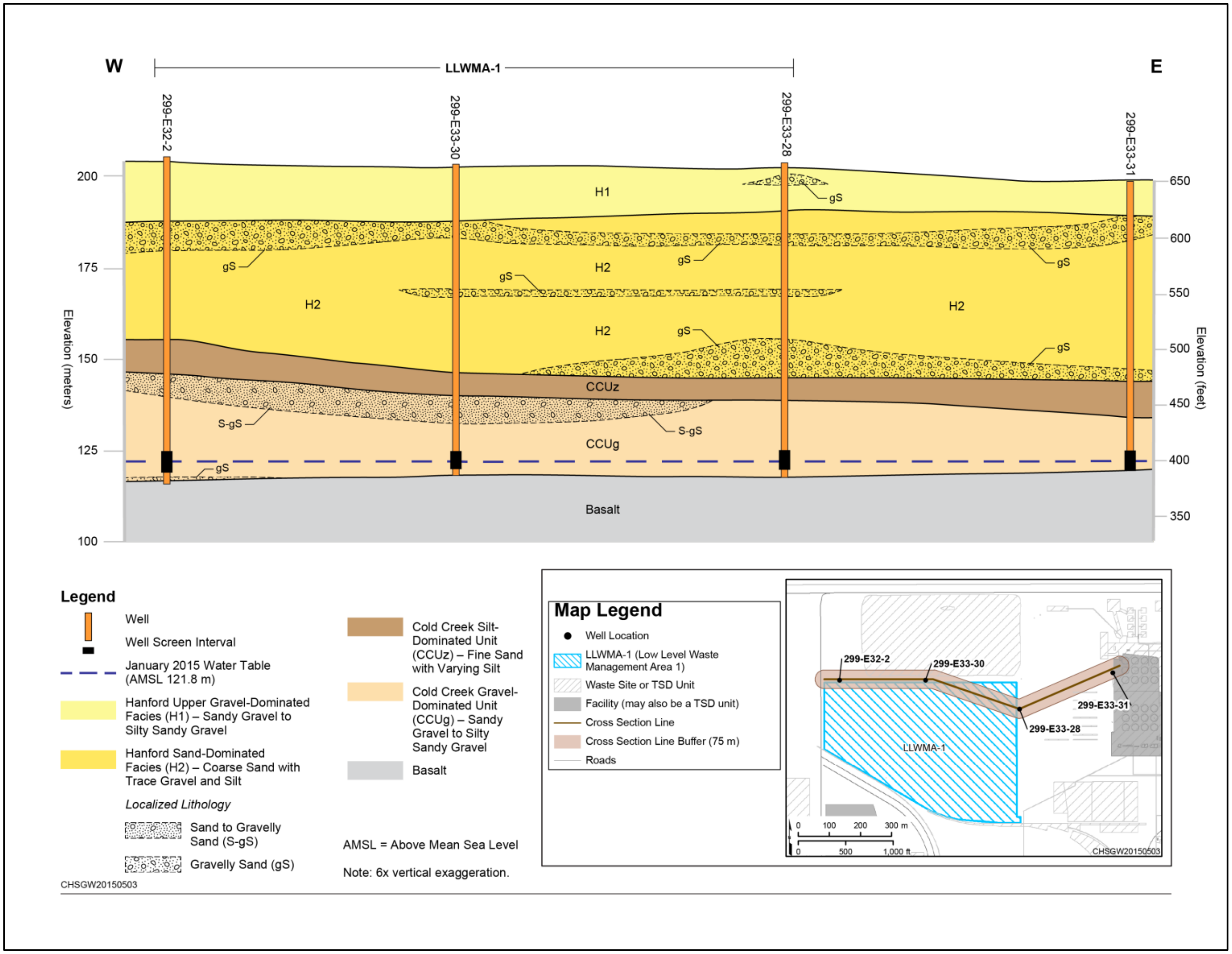


Figure 2-4. Geologic Cross-Section of Suprabasalt Sediments and Underlying EMM Extending from West to East within the Central Portion of LLWMA-1

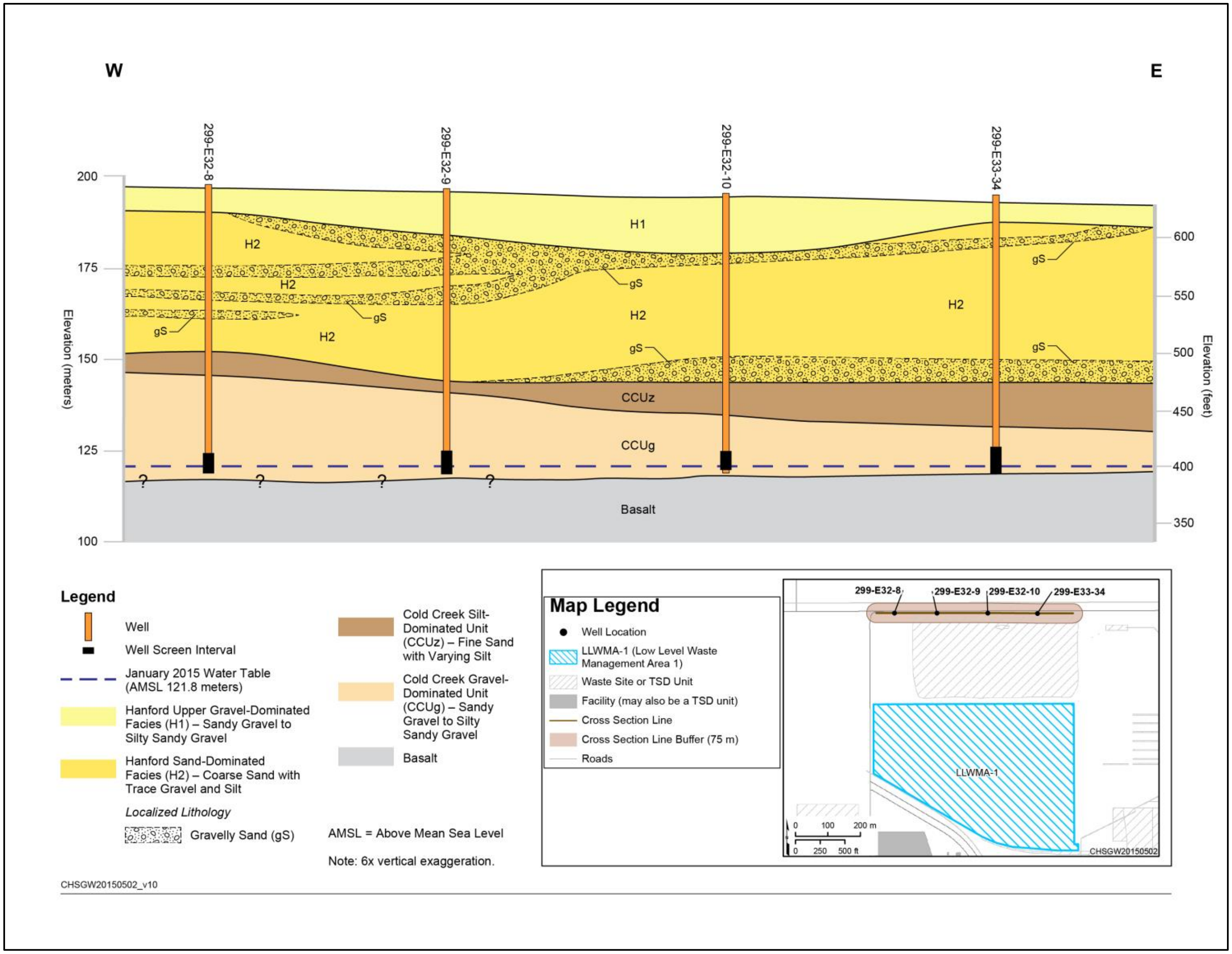


Figure 2-5. Geologic Cross-Section of Suprabasalt Sediments and Underlying EMM Extending from West to East along the LLWMA-1 Northern Boundary

2.4.1.4.1 Hanford Formation Sand-Dominated Unit

The Hanford formation unit 2 (H2) sand-dominated sequence deposition is considered the result of slowing flood currents south of Gable Gap (PNNL-19702). The buildup of the sand facies beneath the 218-E-10 Burial Ground was associated conceptually with aggregation of a significant suspended sediment load within the flood currents that exceeded the preflood river banks. As the sediment-loaded floodwaters diverged from the primary channel, the flow slowed, resulting in vertical accretion. Figure 2-6 shows the relationship of the various flood channels, the deposition of gravel-dominated main channel flood deposits, and the areas of sand-dominated aggregation. Figure 2-7 provides the extent of the sand-dominated facies in relation to the 200 East Area, including LLWMA-1.

The H2 sand-dominated sequence overlies the CCU_z at LLWMA-1. Silty sand or silt is occasionally observed near the top of the graded sand to gravelly sand sequences. Cementation is minor or absent in the H2, and total calcium carbonate content is generally a few weight percent or less.

The H2 sand-dominated facies under the 218-E-10 Burial Ground thickens slightly from west to east, ranging from 35 to 47 m (115 to 155 ft), respectively. Locally fine-grained lenses are apparent; however, based on sieve analysis, the lenses do not appear to be continuous beneath the site.

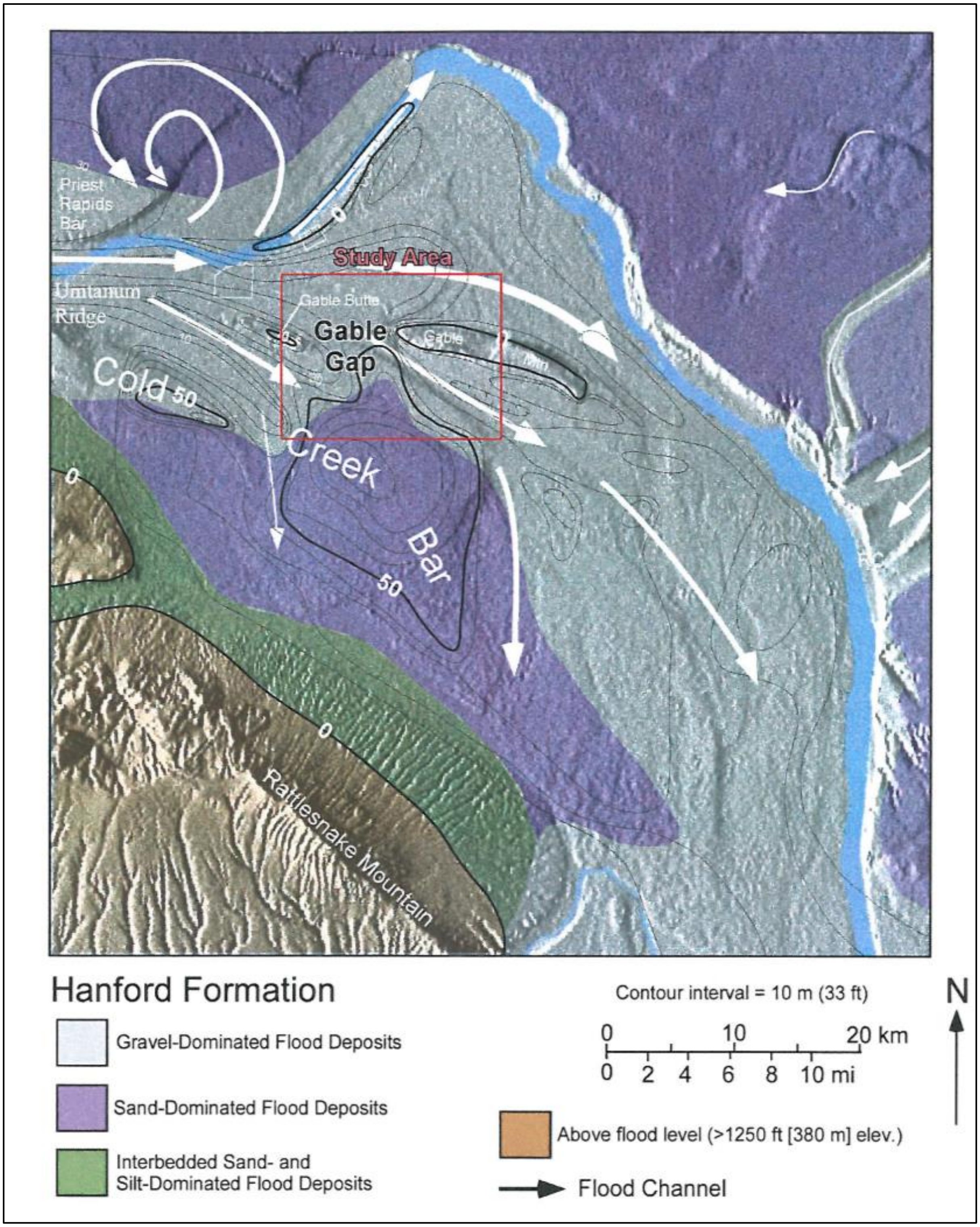
Regionally, PNNL-19277 defined the mean bulk density, porosity, and effective porosity of the H2 sand-dominated facies as 1.77 g/cm^3, 0.2515 cm^3/cm^3, and 0.2207 cm^3/cm^3, respectively. The field capacity result provided in PNNL-19277 was 0.0842 cm^3/cm^3. The longitudinal and transverse dispersivity was also provided, and the ratio was 0.1.

2.4.1.4.2 Hanford Formation Gravel-Dominated Unit

The Hanford formation unit 1 (H1) gravel-dominated sequence overlies the H2 sand-dominated sequence. The H1 gravel-dominated sequence consists of the high-energy gravels with subordinate lenticular and discontinuous layers of the sand and silt. The maximum thickness of the H1 reflects a northeast-southwest-trending trough (i.e., channel) through LLWMA-1 (Figures 2-3 through 2-5). The maximum thickness of the H1 in this trough is about 23 m (75 ft) (Figure 2-4). Regionally, PNNL-19277 defined the mean bulk density, porosity, and effective porosity of this unit as 2.07 g/cm^3, 0.1207 cm^3/cm^3, and 0.1027 cm^3/cm^3, respectively. Field capacity and longitudinal to transverse dispersivity was also provided in PNNL-19277 at 0.0741 cm^3/cm^3, with a ratio of 0.1.

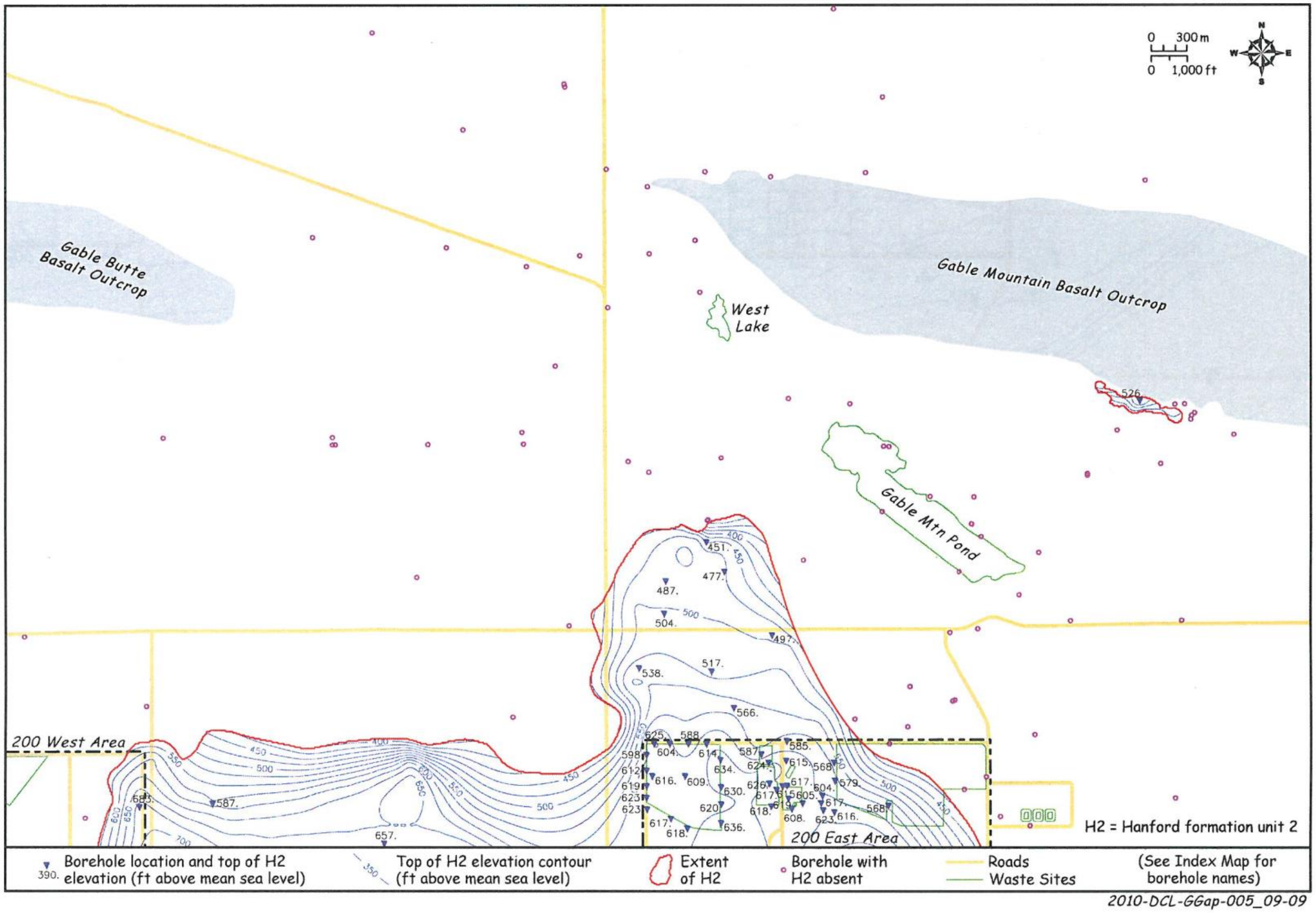
2.4.2 Hydrogeology

The vadose zone beneath LLWMA-1 consists of Hanford formation and Cold Creek suprabasalt sediments. The Hanford formation consists of the upper gravel-dominated (H1) and lower sand-dominated (H2) facies (Section 2.4.1). Neither of these facies appears to contain sufficient silt layers to establish a perched water horizon beneath LLWMA-1. However, underlying the H2 sand-dominated facies is the CCU_z, which is associated with a perched water horizon to the east of LLWMA-1. As discussed in Section 2.4.1, the CCU_z facies beneath LLWMA-1 dips from west to east and, at the base of the unit, is a continuous silty sand to sandy silt layer. The silt content at the base of the unit, according to sieve analysis, ranges from 10 to more than 50 percent silt or finer sediments. The highest measured silt percentage was at wells 299-E28-26 and 299-E33-30, with 48 and 64 present, respectively. Perched water conditions were not seen during drilling of the boreholes used to set the LLWMA-1 monitoring well network. Historical review of the area indicates that waste disposal was dry. Even if a large number of 208 L (55 gal) drums (e.g., 48) storing liquid waste were stored in a 9.3 m^2 (100 ft^2) area of one of the trenches and all the content were released to the underlying soils, the total liquid released would be less than 1 percent of the effective porosity to the basal silt unit of the CCU_z. Thus, it appears that a perched water horizon should not develop beneath this site.



Source: PNNL-19702, *Hydrogeologic Model for the Gable Gap Area, Hanford Site.*

Figure 2-6. Distribution of Cataclysmic Hanford Formation Flood Deposits within the Central Pasco Basin



Source: PNNL-19702, *Hydrogeologic Model for the Gable Gap Area, Hanford Site*.
Note: Contour intervals = 25 ft (7.6 m)

Figure 2-7. Top of the (Sand-Dominated) H2 Unit

The unconfined aquifer directly beneath LLWMA-1 ranges in thickness from 1.7 m (5.6 ft) at the northeast corner to an estimated 15 m (49.2 ft) at the southwest corner (Figure 2-1). The water table was approximately 3 m (10 ft) higher in elevation in 1988 than in January 2015 but did not reach the bottom of the CCU_z. Thus, residual moisture from previous elevated anthropogenic groundwater mounds only affected the CCU_g.

The unconfined aquifer is primarily contained within the CCU_g as discussed in Section 2.4.1. The sediments are transmissive, as determined from previous hydraulic testing, in which the hydraulic conductivity ranged from greater than 400 m/day (1,300 ft/d) (PNL-6820).

The general groundwater chemistry beneath LLWMA-1 displays calcium bicarbonate-dominated composition. However, the chemical composition varies where past plumes from the south and east have migrated beneath LLWMA-1. The most affected wells, 299-E32-5 to the southeast and 299-E32-10, 299-E33-34, and 299-E33-35 to the northwest, display a calcium bicarbonate-sulfate chemical composition. The sulfate signature dissipates with distance from these wells. This chemical signature indicates that all the wells are hydraulically connected, and that the dispersive effects of migrating plumes are laterally sufficient to be observed in neighboring wells. Based on these observations it appears the monitoring network is sufficient to detect contaminant infiltration into the aquifer beneath LLWMA-1, with the exception of the southeast corner between wells 299-E28-26 and 299-E28-27. Chapter 3 discusses the resolution of this deficiency.

2.4.3 Groundwater Flow Interpretation

In the northwest corner of the 200 East Area, including the area of LLWMA-1, the direction of groundwater flow has varied due to changes in liquid waste discharges. During the operational period of the Hanford Site, recharge mounds from Gable Mountain Pond and B Pond caused groundwater to flow to the northwest. The mounds began to dissipate in the late 1980s, when Hanford Site actions were curtailed, and cooling water discharges to Gable Mountain Pond ceased. As discharges to B Pond were also curtailed and eventually terminated, the groundwater mound within the 200 East Area dissipated in elevation, as shown in Figure 2-8, for LLWMA-1 wells 299-E28-27, 299-E32-6, and 299-E33-28. Initially, groundwater levels dropped rapidly, and contaminant plumes within the 200 East Area migrated northwest toward the northwest corner of the 200 East Area and into the Gable Gap and beyond. As the water table in the 200 East Area continued to decline, the groundwater gradient and direction became increasingly difficult to determine. Between 2008 and 2011, the determination of groundwater flow direction and magnitude was generally uncertain. Occasionally, the propagation of Columbia River spring runoff was transmitted through the permeable Cold Creek gravel train (Section 2.4.1), extending into the 200 East Area through the Gable Gap, causing a statistically significant gradient and flow direction to the south. From mid-2011 to early 2015, a perpetual southward flow direction has been maintained. Even in 2014, when five separate months of significant discharges ($>10^8$ L/month) of cooling water at the Treated Effluent Disposal Facility (TEDF) (located southeast of the 200 East Area) occurred, a statistically significant southward flow direction was maintained (Figure 2-9). The average groundwater flow direction in 2014 at LLWMA-1 was to the southeast, with an azimuth from north of 159°. Further details of the calculation of flow direction are provided in ECF-200E-12-0086, *Calculations in Support of the Low Hydraulic Gradient Evaluation Study for the 200 East Area Unconfined Aquifer*. Although the water table has declined significantly in the past, from January 2012 to January 2015, the water table has not shown a significant decline at LLWMA-1 wells 299-E28-27, 299-E32-6, and 299-E33-28 (Figure 2-8).

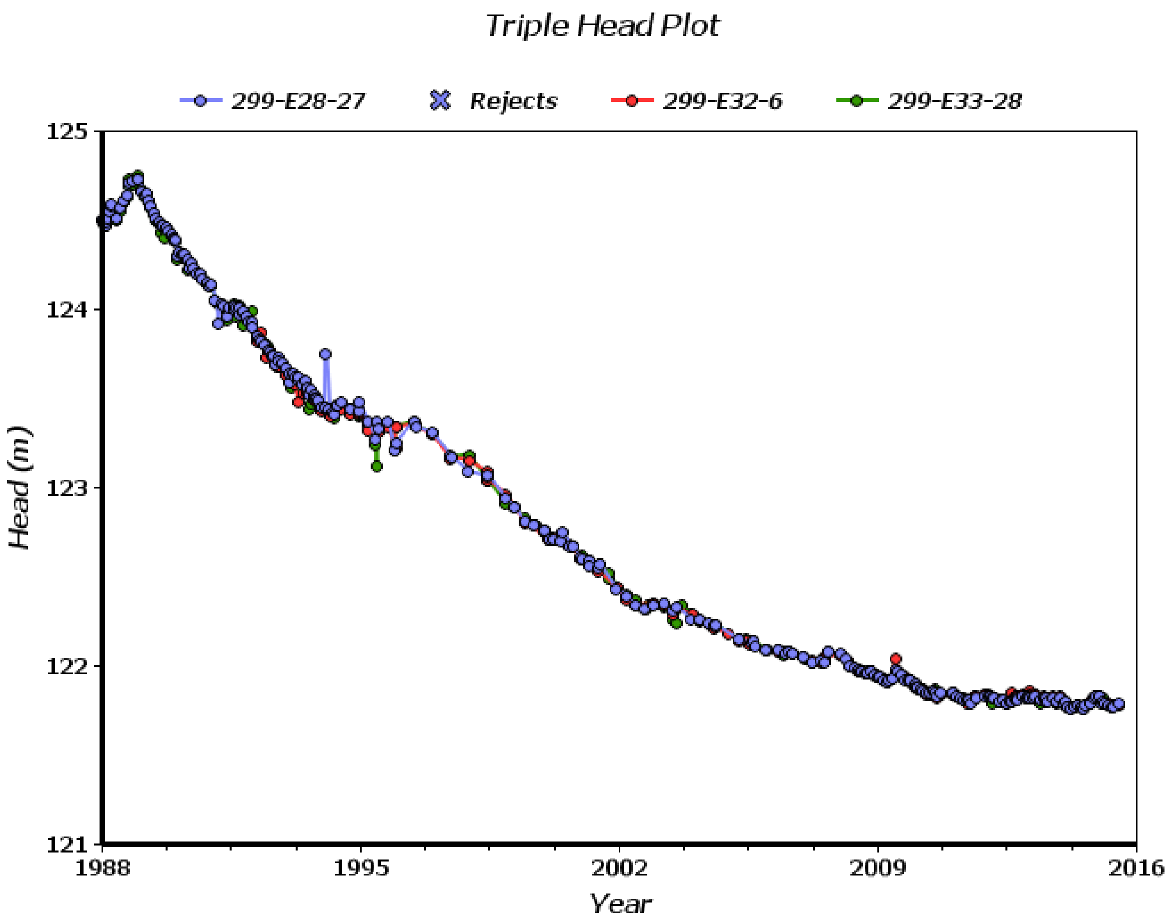


Figure 2-8. Water Table Elevations at LLWMA-1 Wells 299-E28-27, 299-E32-6, and 299-E33-28

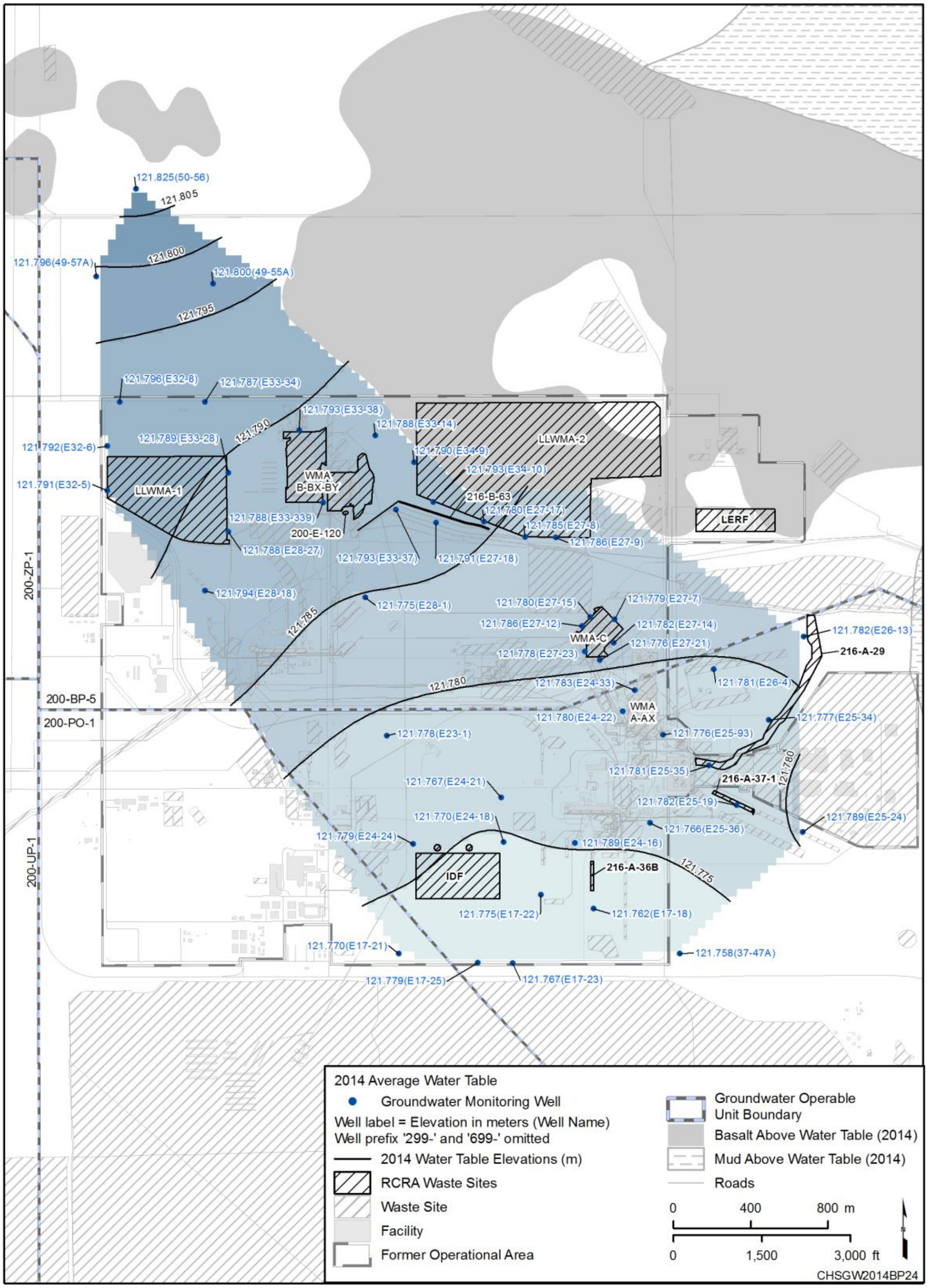


Figure 2-9. 2014 Annual Average 200 East Water Table Elevations and Interpreted Water Table Isopleths

2.5 Summary of Previous Groundwater Monitoring

Table 2-1 lists the previous groundwater monitoring plans implemented at LLWMA-1.

Table 2-1. Previous Monitoring Plans

Document	Date Issued	Monitoring Program[a]
PNL-6772, *A Detection-Level Hazardous Waste Ground-Water Monitoring Compliance Plan for the 200 Areas Low-Level Burial Grounds and Retrievable Storage Units*	February 1987	Indicator Evaluation Program
WHC-SD-EN-AP-015, *Revised Ground-Water Monitoring Plan for the 200 Areas Low-Level Burial Grounds*	August 1989	Indicator Evaluation Program
WHC-SD-EN-AP-021, *Interim-Status Ground-Water Quality Assessment Program Plan for Waste Management Area 1 of the 200 Areas Low-Level Burial Grounds*	January 1990	Interim-Status Groundwater Quality Assessment Program
DOE/RL-2009-75, *Interim Status Groundwater Monitoring Plan for the LLBG WMA-1*	December 2009	Indicator Evaluation Program
DOE/RL-2012-35, Rev. 0, *First Determination RCRA Groundwater Quality Assessment Plan for Low-Level Burial Grounds Low-Level Waste Management Area-1*	September 2012	First Determination Plan implementing Groundwater Quality Assessment Program
DOE/RL-2009-75, Rev. 0, *Interim Status Groundwater Monitoring Plan for the LLBG WMA-1*	Reinstated in 2013[b]	Indicator Evaluation Program

a. The Indicator Evaluation Program satisfies the requirements of 40 CFR 265.92(b)(2), (b)(3), (d)(1), (d)(2), and (e), "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," "Sampling and Analysis." The groundwater quality assessment program's first determination satisfies the requirements of 40 CFR 265.93(d)(4) and (d)(6), "Preparation, Evaluation, and Response."

b. DOE/RL-2009-75, Rev. 0, reinstated in 2013 when LLWMA-1 returned to an indicator evaluation program as reported in DOE/RL-2013-25, First *Determination RCRA Groundwater Quality Assessment Report for Low-Level Burial Grounds Low-Level Waste Management Area-1*.

LLWMA = Low-Level Waste Management Area

A detection-level groundwater monitoring well construction plan was initiated at LLWMA-1 in 1986 in accordance with PNL-6772 (WHC-SD-EN-AP-015). PNL-6772 established the construction criteria of eight initial monitoring wells at LLWMA-1. The well configuration was initially designed to reflect long-term groundwater flow directions (e.g., east to west or east to northwest) (PNL-6772 and WHC-SD-EN-EV-AP-015). The well screens for LLWMA-1 were designed to monitor the top portion of the uppermost aquifer (WHC-SD-EN-AP-015), extending from above the unconfined aquifer to 2 to 3 m (7 to 10 ft) into the unconfined aquifer. All eight of the wells that were in place at the 1987 time period were constructed in compliance with WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells."

Detection monitoring for initial background indicator parameters (e.g., total organic carbon, total organic halides, pH, and specific conductivity) began at the initial eight wells in September/October 1988

(WHC-SD-EN-AP-021). The delay between well completion and background sampling was because of mechanical problems with pump installation and personnel limitations (PNL-6675, *Ground-Water Monitoring Compliance Projects for Hanford Site Facilities: Progress Report for the Period April 1 to June 30, 1988*). From September/October 1988 to September/October 1989, quarterly background groundwater quality and indicator parameter samples were collected. The year of background indicator parameter results was used to develop a 0.01 level of significance, critical mean, for each indicator parameter from the upgradient monitoring wells (299-E28-27, 299-E33-28, and 299-E33-29), as directed by 40 CFR 265.93(b), “Preparation, Evaluation, and Response.”

An indicator evaluation monitoring plan, WHC-SD-EN-AP-015, was developed in 1989 to provide direction for commencement of detection monitoring and improvement of the spatial coverage of the groundwater monitoring network. Four additional wells were defined to improve the spatial coverage at LLWMA-1: one well in 1989 and three wells in 1990 (WHC-SD-EN-EV-AP-015). Two of the four wells were located along the boundary of a north expansion area for future disposal. However, the north expansion area was never used.

The derived background comparison value, critical mean, for specific conductance was exceeded in well 299-E28-26 (located along the south boundary of LLWMA-1) in September 1989. Verification sampling confirmed the exceedance, and an interim status groundwater quality assessment program was initiated as outlined in WHC-SD-EN-AP-021. The quarterly assessment monitoring extended until April 1994, except between June 1990 and June 1991, when laboratory services were unavailable. Quarterly assessment sampling results provided evidence that LLWMA-1 did not contribute to the elevated specific conductance (WHC-SD-EN-EV-025, *Results of Groundwater Quality Assessment Program at Low-Level Waste Management Area 1 of the Low-Level Burial Grounds*); rather, liquid waste disposal facilities to the south were identified as the most probable sources. The sampling frequency changed to semiannual in 1994 and remained semiannual until 2000.

Five additional wells were added to the network: four wells in 1991 and one well in 1992. The additional wells installed in 1991 and 1992 were designed to encompass the LLWMA-1 boundary, which included the northern expansion area, and to provide sufficient coverage for potential groundwater flow direction changes. Another specific conductance exceedance was found; encountered in the northeast well 299-E33-34 in December 1998. A notification letter and an assessment report were submitted to Ecology in March 1999 (Furman, 1999). The letter report determined the exceeded specific conductance critical mean was associated with migration of increased nitrate concentrations from the BY Cribs source. Based on the determination, no further actions were required per 40 CFR 265.93(d). The determination was also reported in the annual report (PNNL-13404).

Two additional monitoring wells (299-E33-265 and 299-E33-266) were added in 2010 to provide downgradient detection monitoring for the northern portion of Trench 9 (Figure 1-2).

The most recent indicator parameter exceedance was total organic carbon at well 299-E33-265 from a January 25, 2012, semiannual detection monitoring sample. Split verification samples were collected on April 5, 2012, to determine if a laboratory error may have occurred. Upon confirmation of the exceedance, DOE transmitted DOE/RL-2012-35 to Ecology in May 2012. DOE and Ecology agreed on the plan in June 2012, and DOE began assessment sampling in July 2012 for well 299-E33-265 and two neighboring wells (299-E33-30 and 299-E33-266). In October 2012 the entire LLWMA-1 monitoring network was sampled to complete the assessment. After evaluation of the assessment results, a determination was made that no dangerous waste or dangerous waste constituents were associated with LLWMA-1. The determination was reported in DOE/RL-2013-25. As a result, the site returned to indicator detection monitoring in January 2013.

The groundwater monitoring activities at LLWMA-1 under this groundwater monitoring plan currently sample from a network of eight wells. Samples are analyzed semiannually for parameters used as indicators of groundwater contamination and annually for parameters establishing groundwater quality. Water-level measurements are collected each time that a sample is obtained from a network well. The network wells are also included in the annual comprehensive March water-level measurement campaign (SGW-38815, *Water-Level Monitoring Plan for the Hanford Site Soil and Groundwater Remediation Project*). Groundwater monitoring results are summarized for the LLWMA-1 in the annual Hanford Site RCRA groundwater monitoring report (e.g., DOE/RL-2016-12, *Hanford Site RCRA Groundwater Monitoring Report for 2015*).

2.6 Conceptual Site Model

This section describes the LLWMA-1 CSM for potential contaminant transport to guide future groundwater monitoring. The CSM is shown in Figure 2-10. The CSM describes the current understanding of the contaminant release and transport and includes the following assumptions (DOE/RL-2009-75, Rev. 0):

- Engineering barriers are not taken into account, so the model is applicable to unlined trenches.
- Average precipitation and net infiltration (5 to 10 cm/yr [2 to 3.9 in./yr]) prevail over the timeframe 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.
- 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).

As of the writing of this plan no groundwater dangerous wastes or dangerous waste constituents have been attributed to releases associated with the 218-E-10 Burial Ground even though groundwater quality has been affected. Direct precipitation is the primary driver for hypothetical leaching of waste constituents from the burial ground trenches and subsequent transport to groundwater. Contaminants from degradable containers (e.g., cardboard boxes) subject to collapse are assumed to be leachable. Conservative calculations suggest recharge rates for LLWMA-1 could be as high as 10 cm/year (4 in./year) at gravel-covered nonvegetated sites (WHC-SD-WM-TI-730). However, solid waste leaching tests associated with Hanford formation sediments and natural waters found most metals are not mobile when contacted by natural waters (PNL-8889). Tests also found that oxidizing and calcium carbonate present in vadose zone sediments promotes sorption or retardation of many heavy metals (PNL-8889). 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 deposited sediments within the vadose zone. Stratigraphic features in the soil column, such as the CCU_z can retard downward migration by capillary retentive forces. Based on the information, provided in the following subsections, it appears unlikely that leached wastes could migrate to the groundwater in the near future. Current conservative calculations suggest that leached waste from the 218-E-10 Burial Ground is probably still within the trench or the adjacent sediments beneath the burial trench.

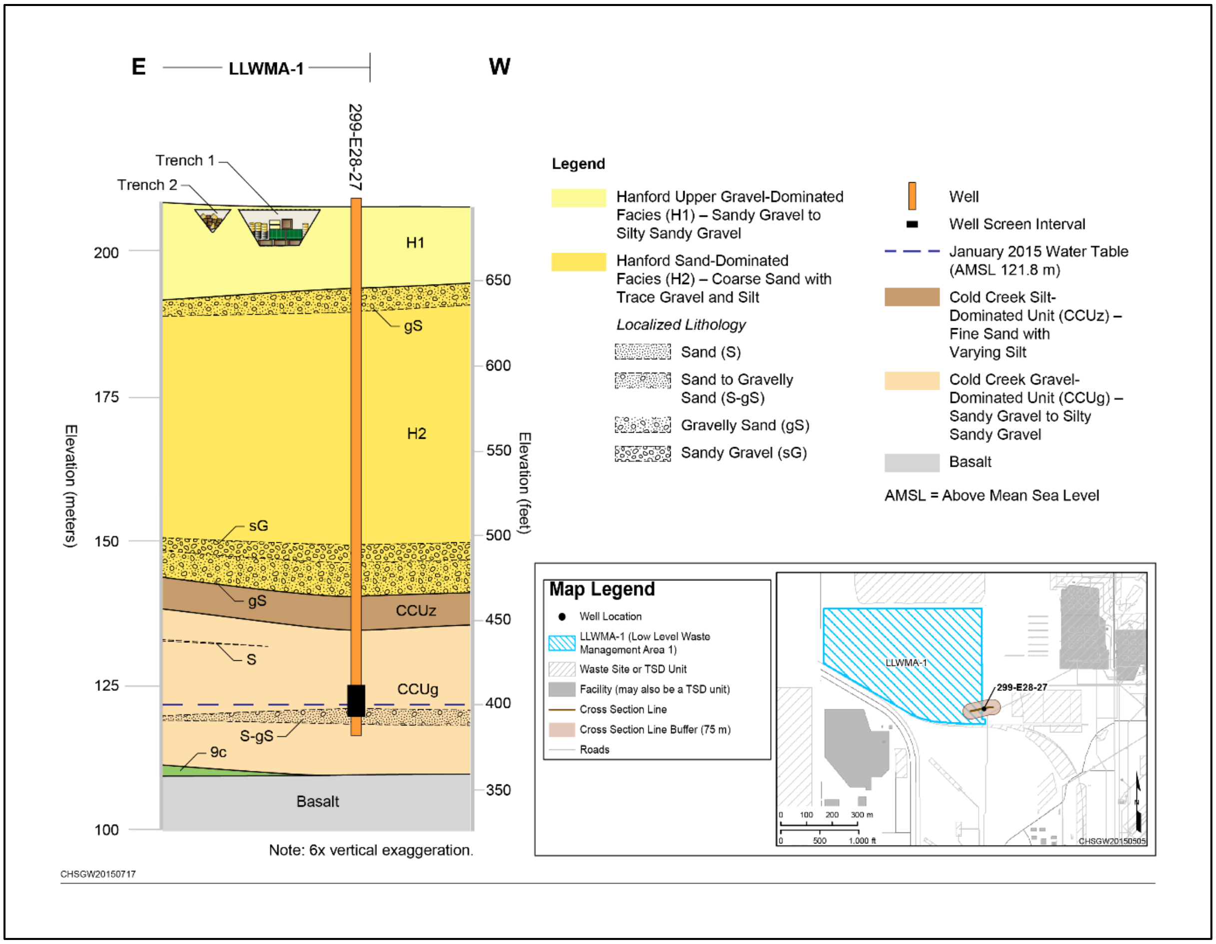


Figure 2-10. General Representation of Hydrogeologic Characteristics Underlying the LLWMA-1

2.6.1 Geochemical Considerations

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

Pore fluid in the unsaturated and saturated zones beneath LLWMA-1 is slightly alkaline (7 < pH < 8), with appreciable amounts of bicarbonate and very little natural organic material. The lack of organic matter indicates that conditions generally are oxidizing. Calcium carbonate is also present in vadose zone sediment. These general conditions favor sorption or retardation of many heavy metals and favor the mobilization of anionic species. Laboratory sorption studies have documented these effects and related mobility issues in Hanford Site media (e.g., PNNL-11800).

Based on the general geochemical conditions in the vadose zone and nonradiological waste constituents disposed at LLWMA-1, significant contaminant migration appears unlikely (Figure 2-10). It is possible that large volumes of water were applied to the region of a UPR (e.g., UPR-200-E-23), but gross-gamma logging results from 1987 at proximal wells 299-E28-27 and 299-E33-29 (approximately 87 and 118 m [285 and 387 ft], respectively) showed no elevated sign of gamma. Cesium-137, which would be the most logical gamma emitter detected in gross-gamma logging, was not detected. Because cesium-137 has mobility similar to lead, as defined in PNNL-11800, it is a good surrogate for the mobility of lead. Note that neither lead nor cesium-137 are very mobile in Hanford formation sediments. For example, cesium-137 is mainly found directly beneath cribs that have released significant quantities (>1 million L

[264,172 gal]) of liquid waste. Cesium-137 is generally not detected beyond 15.2 m (50 ft) below the base of the crib because of the absorptive attraction to Hanford Site vadose zone sediments. Thus, with 73.4 to 82.8 m (241 to 272 ft) of vadose zone, migration of lead to groundwater is considered unlikely.

Ecological information on di-octyl phthalate indicates this constituent binds to soils and sediments. In addition, disposal records indicate this constituent was initially absorbed to HEPA filters. It is also expected to biodegrade in aerobic conditions with a photochemical estimated half-life of 18 hours. Thus, it appears that this constituent should not migrate much farther than the bottom of the trench in which it was disposed. Figure 2-10 provides a generalized visual depiction of the expected state of dangerous waste contaminant migration from the bottom of Burial Trench 9 (note Figure 2-10 identifies Trenches 1 and 2 as surrogates for cesium-137 migration as discussed earlier in this section, but also is used for the conceptual migration of Trench 9 for dangerous waste components, lead and di-octyl phthalate).

2.6.2 Soil Moisture Factors

Except for 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 the subsequent transport to groundwater. Contaminants in soil disposed to the trench or waste in degradable containers (e.g., cardboard boxes or wooden boxes) subject to collapse are 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 the degree of vegetative cover. Most of the burial ground trenches are backfilled with natural excavation materials (Hanford formation) consisting of coarse gravel, cobbles, and some interstitial sand. Some amounts of vegetation exist on the established backfilled areas and on unused portions of LLWMA-1. Therefore, the coarse, sparsely vegetated cover material allows a fraction of the precipitation to infiltrate and potentially drain to the groundwater.

Two different documented studies of pore water migration within Hanford Site sediments are used to provide a conceptual model of the expected vertical transport of gravity drained precipitation within the vadose zone. PNNL-8889 used moisture retention and saturated hydraulic conductivity of the Hanford Site sediments to calculate the vadose zone hydraulic conductivity versus natural pore water content. Using a 4 to 7 percent moisture content, the rate of vertical transport of pore water was calculated at 0.3 to 3 cm/yr (0.1 to 1 in./yr). Alternatively, WHC-SD-WM-TI-730 determined the maximum infiltration rate for unvegetated coarse-grained soils ranged between 5 and 10 cm/yr (2 and 4 in./yr). Using the more conservative infiltration rate (5 cm/yr [2 in./yr]) and ignoring less permeable silt-dominated horizons such as the CCU_z, a conceptual model of pore water vertical transport is provided in the next paragraph below. Note the use of 5 cm/yr (2 in./yr) converges with the rate of recharge condition developed for DOE/EIS-0391, *Draft Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington*.

Using the more conservative precipitation infiltration rate estimate (e.g., 5 cm/yr [2 in./yr]) and a minimum depth to groundwater of 73.4 m (241 ft), model results suggest a range between 115 and 129 years are required for gravity-drained, precipitation-driven pore water to first reach groundwater from the bottom of the burial trench (DOE/EIS-0391, Table N-2 and WHC-SD-WM-TI-730, Figure 4-19). The migration of leached contaminant pore water in the model result is based on fixed boundary conditions of the site to groundwater, constant infiltration rate (precipitation), and three hydraulic conductivity values for three vadose zone layers as a function of moisture content. Using an average moisture content of 0.087 yields travel time similar to the 129 year travel time result by the model for the arrival of the peak concentration at the groundwater (WHC-SD-WM-TI-730, Figure 4-19). Considering that the initial buried waste has currently been in contact with natural pore water for up to 60 years, possibility of additional moisture added to the site, and variability of geologic sediments, uninhibited contaminant migration may reach groundwater sooner than expected.

2.6.3 Hydrogeologic Considerations

The hydrogeology beneath LLWMA-1 is discussed in Section 2.4.2. The vadose zone (e.g., ground surface to water table) beneath the trench bottoms of LLWMA-1 ranges from 73.4 to 82.8 m (234 to 272 ft) below ground surface. The lithology of the vadose zone consists of the Hanford formation (i.e., H1 upper gravel-dominated sequence and, H2 lower sand-dominated sequence) and CCUs (i.e., upper CCU_z facies and CCU_g facies). The continuous silty sand to sandy silt layer of the CCU_z facies beneath the 218-E-10 Burial Ground, based on sieve analyses, ranges from 10 to 65.8 percent and is likely to retard downward movement of moisture and contaminants because of the finer textured sediment (Figures 2-1 and 2-3 through 2-5).

If contaminants break through to the groundwater beneath LLWMA-1, contaminants would move toward the southeast, based on 2014 and early to mid-2015 groundwater flow determinations. The five wells 299-E28-26, 299-E28-27, 299-E28-28, 299-E33-28, and 299-E33-29 would detect possible LLWMA-1 releases while groundwater flows to the southeast, with the exception of the section between wells 299-E28-26 and 299-E28-27. However, installation of a new monitoring well is proposed in this area through Tri-Party Agreement (Ecology et al., 1989) Milestone M-24.

2.7 Monitoring Objectives

The groundwater monitoring program at LLWMA-1 is conducted with the objective of determining the facility's impact, if any, on the quality of the underlying groundwater. This groundwater monitoring plan addresses specifically those applicable dangerous waste requirements for interim status TSD units where no impact to groundwater has been identified. The regulatory requirements applicable to this groundwater monitoring plan are found in WAC 173-303-400(3) and 40 CFR 265.90, "Applicability," through 265.94, "Recordkeeping and Reporting." Table 2-2 identifies where each groundwater monitoring element of the pertinent regulations is addressed within this plan. Site-specific constituents are not required by 40 CFR 265.92, but used to support interpretation, are included in Table 2-3.

Table 2-2. Pertinent Interim Status Facility Groundwater Monitoring Requirements

Groundwater Monitoring Element	Pertinent Requirement[a]	Section Where Requirement is Addressed in Monitoring Plan
Applicability	40 CFR 265.90, “Applicability” (a) Within one year after the effective date of these regulations, the owner or operator of a surface impoundment, landfill, or land treatment facility which is used to manage hazardous waste must implement a ground-water monitoring program capable of determining the facility’s impact on the quality of ground water in the uppermost aquifer underlying the facility, except as §265.1 and paragraph (c) of this section provide otherwise. (b) Except as paragraphs (c) and (d) of this section provide otherwise, the owner or operator must install, operate, and maintain a ground-water monitoring system which meets the requirements of §265.91, and must comply with §§265.92 through 265.94. This ground-water monitoring program must be carried out during the active life of the facility, and for disposal facilities, during the post-closure care period as well.	Chapter 1
Number and Location of Wells	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 numbers, 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.	Section 3.2
Well Configuration	40 CFR 265.91: (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. Additional requirements from WAC 173-303-400(3)(c)(v)(C), “Dangerous Waste Regulations,” “Interim Status Facility Standards”:	Section 3.2 and Appendix C

Table 2-2. Pertinent Interim Status Facility Groundwater Monitoring Requirements

Groundwater Monitoring Element	Pertinent Requirement[a]	Section Where Requirement is Addressed in Monitoring Plan
	Ground water monitoring wells must be designed, constructed, and operated so as to prevent ground water contamination. Chapter 173-160 WAC may be used as guidance in the installation of wells.	
Sample Protocols Analytical Methods	40 CFR 265.92: (a) The owner or operator must obtain and analyze samples from the installed ground-water monitoring system. The owner or operator must develop and follow a ground-water sampling and analysis plan. He must keep this plan at the facility. The plan must include procedures and techniques for: (1) Sample collection; (2) Sample preservation and shipment; (3) Analytical procedures; and (4) Chain of custody control.	Appendix A, Section A3 and Appendix B, Sections B2 though B5
Parameters to be Sampled Frequency of Sampling Water-Level Measurements	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[b]. (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 ground-water quality assessment is required under §265.93(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. He must do this quarterly for one year. (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	Section 3.1 and Appendix B, Section B2.2

Table 2-2. Pertinent Interim Status Facility Groundwater Monitoring Requirements

Groundwater Monitoring Element	Pertinent Requirement[a]	Section Where Requirement is Addressed in Monitoring Plan
	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 semi-annually. (e) Elevation of the ground-water surface at each monitoring well must be determined each time a sample is obtained.	
Groundwater Quality Assessment Program Plan Outline	40 CFR 265.93, "Preparation, Evaluation, and Response": (a) Within one year after the effective date of these regulations, the owner or operator must prepare an outline of a ground-water quality assessment program. The outline must describe a more comprehensive ground-water monitoring program (than that described in §§265.91 and 265.92) capable of determining: (1) Whether hazardous waste or hazardous waste constituents have entered the ground water; (2) The rate and extent of migration of hazardous waste or hazardous waste constituents in the ground water; and (3) The concentrations of hazardous waste or hazardous waste constituents in the ground water.	Chapter 5
Methods Used to Evaluate the Collected Data and Responses	40 CFR 265.93: (b) For each indicator parameter specified in §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 §265.92(d)(2), and compare these results with its 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.(c)(2) If the comparison for downgradient wells made under paragraph (b) of this section show a significant increase (or pH decrease), the owner or operator must then immediately obtain additional ground-water samples from those downgradient wells where a significant difference was detected, split the samples in two, and obtain analyses of all additional samples to determine whether the significant difference was a result of laboratory error. (d)(1) If the analyses performed under paragraph (c)(2) of this section confirm the significant increase (or pH decrease), the owner or operator	Section 4.1, 4.2, 4.3 and Appendix A

Table 2-2. Pertinent Interim Status Facility Groundwater Monitoring Requirements

Groundwater Monitoring Element	Pertinent Requirement[a]	Section Where Requirement is Addressed in Monitoring Plan
	must provide written notice to the department-within seven days of the date of such confirmation-that the facility may be affecting ground-water quality. (d)(2) Within 15 days after the notification under paragraph (d)(1) of this section, the owner or operator must develop a specific plan, based on the outline required under paragraph (a) of this section and certified by a qualified geologist or geotechnical engineer, for a ground-water quality assessment at the facility.	
Recordkeeping and Reporting	40 CFR 265.93: (c)(1) If the comparisons for the *upgradient* wells made under paragraph (b) of this section show a significant increase or (pH decrease), the owner or operator must submit this information in accordance with §265.94(a)(2)(ii). 40 CFR 265.94, "Recordkeeping and Reporting": (a)(1) Keep records of the analyses required in §265.92(c) and (d), the associated ground-water surface elevations required in §265.92(e), and the evaluation required in §265.93(b) throughout the active life of the facility. (a)(2) Report the following ground-water monitoring information to the department: (ii) Annually: Concentrations or values of the parameters listed in §265.92(b)(3) for each ground-water monitoring well, along with the required evaluations for these parameters under §265.93(b). The owner or operator must separately identify any significant differences from the initial background found in the upgradient wells, in accordance with §265.93(c)(1). (iii) No later than March 1 following each calendar year: Results of the evaluations of ground-water surface elevations under §265.93(f), and a description of the response to that evaluation, where applicable.	Section 4.5 Appendix A, Sections A2.6 and A3.9

Notes: The references cited in this table are listed in the reference section (Chapter 6) of this plan.

In accordance with WAC 173-303-400(3)(b), "Dangerous Waste Regulations," "Interim Status Facility Standards", for the purposes of applying the interim status standards of 40 CFR 265, Subpart F, the federal terms "Regional Administrator" means the "Department" and "Hazardous" means "Dangerous".

In accordance with Section I.A of the WA7890008967, *Hanford Facility Resource Conservation and Recovery Act (RCRA) Permit, Dangerous Waste Portion for the Treatment, Storage, and Disposal of Dangerous Waste* (Hanford Facility RCRA Permit), this unit will continue to be considered an interim status unit until is it incorporated into Part III, V, and/or VI of the Hanford Facility RCRA Permit, or until interim status is terminated. Therefore, groundwater monitoring continues under interim status requirements.

Table 2-2. Pertinent Interim Status Facility Groundwater Monitoring Requirements

Groundwater Monitoring Element	Pertinent Requirement[a]	Section Where Requirement is Addressed in Monitoring Plan

a. Regulatory requirements for interim status TSD units, where no impact to groundwater has been identified, are found in WAC 173-303-400(3) and 40 CFR 265.90, “Applicability,” through 40 CFR 265.94, “Recordkeeping and Reporting,” which are applicable to this groundwater monitoring plan.

b. The parameters characterizing the suitability of the groundwater as a drinking water supply, as specified in 40 CFR 265, Appendix III, “EPA Interim Primary Drinking Water Standards,” are conducted only during the first year of monitoring in accordance with 40 CFR 265.92(c)(1), “Sampling and Analysis”. For this TSD unit, the Appendix III parameters are included for monitoring at well(s) specified in Section 3.1 as a best practice activity to obtain additional scientific and technical information..

RCRA = *Resource Conservation and Recovery Act of 1976*

TSD = treatment, storage, and disposal

Table 2-3. Additional Monitoring Objectives

Monitoring Objective	TSD Unit-Specific Constituent/Field Measurements*
Metals-additional metals used in ion balance and to support water chemistry analysis	Calcium, magnesium, and potassium
Anions-additional anions used in ion balance and to support water chemistry analysis	Fluoride, nitrate, and nitrite,
Field measurements provided information on water properties at the time of sampling.	Dissolved oxygen, temperature, and turbidity

* Sampling for TSD unit-specific constituents/field measurements is not required by WAC 173-303-400, “Dangerous Waste Regulations,” “Interim Status Facility Standards” nor 40 CFR 265, Subpart F, “Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities,” “Ground Water Monitoring.”

TSD = treatment, storage, and disposal

3 Groundwater Monitoring Program

This chapter describes the groundwater monitoring indicator evaluation program for LLWMA-1 consisting of parameters used as indicators of groundwater contamination, parameters establishing groundwater quality, a monitoring well network, and sampling and analysis protocols. The monitoring program presented herein has been revised from that presented in the previous plan (DOE/RL-2009-75, Rev. 0), and supersedes the monitoring program of the previous plan.

3.1 Constituents List and Sampling Frequency

Table 3-1 presents the wells in the groundwater monitoring network, parameters analyzed, and sampling frequency for monitoring of LLWMA-1. Parameters used as indicators of groundwater contamination (pH, specific conductance, total organic carbon (TOC), and total organic halogen (TOX)) will be sampled and analyzed semiannually (40 CFR 265.92(b)(3) and (d)(2)). Parameters establishing groundwater quality (chloride, iron, manganese, phenols, sodium, and sulfate) will be sampled and analyzed annually (40 CFR 265.92(b)(2) and (d)(1)). Water-level measurements at each monitoring well will be determined each time that a sample is obtained (40 CFR 265.92). Site-specific constituents (calcium, magnesium, potassium, fluoride, nitrate, nitrite, dissolved oxygen, temperature, and turbidity) not required by 40 CFR 265.92, but used to support interpretation, are included in Table 3-1.

The newly installed well will be sampled quarterly during the first year of monitoring as a best practice activity to provide additional scientific and technical information. The quarterly monitoring will include the parameters used for indicators of groundwater contamination and parameters establishing groundwater quality (Table 3-2). In addition, the new well will be sampled quarterly for one year for the drinking water suitability parameters included in Appendix III to 40 CFR 265 (Table 3-2). At the end of the first year, monitoring will thereafter be conducted along the same frequency as other established wells and as provided in Table 3-1.

Maintenance problems and sampling logistics resulting from multiple factors including environmental (i.e., inclement weather) and access restrictions (i.e., heightened fire danger, area access restriction due to work by other Hanford contractors such as in the tank farms) sometimes delay scheduled sampling events. Sampling events are scheduled by month. The Field Work Supervisor (FWS) determines the specific times within a given month that a well will be sampled. If a well cannot be sampled at the times determined by the FWS, then the FWS and Sampling Management and Reporting group, along with the project scientist, will consult on how to best recover or reschedule the sampling event as close to the original sampling date as possible. If it is observed during the pre-sampling walkdown that one or more network wells cannot be sampled, then sampling of the well network will not begin and management will be notified. Depending on the situation, the network sampling will be rescheduled within a short time frame (such as 3 to 4 weeks). In some cases, it may not be obvious that sampling cannot be performed until a well is accessed (e.g., an issue with a pump).

Missed sampling events that are not rescheduled within the same month are given top priority when rescheduling sampling for the following month. In the event that a sampling delay has occurred and the representativeness of the samples is in question, DOE-RL and Ecology may agree to resampling wells. DOE-RL will provide informal notification to Ecology if sampling of the network is expected to be delayed for longer than 4 weeks. Ecology may provide input in a timely fashion to DOE-RL on how to proceed. Missed or cancelled sampling events are reported to DOE-RL and are documented in the annual Hanford Site RCRA groundwater monitoring report (e.g., DOE/RL-2016-12).

Table 3-1. Monitoring Well Network for LLWMA-1

Well Name	Purpose	WAC Compliant	RCRA-Required Parameters[a]											Site-Specific Constituents		
				Contamination Indicator Parameters				Groundwater Quality Parameters								
			Water Level	pH	Specific Conductance	Total Organic Carbon	Total Organic Halogen	Chloride	Iron (Filtered and Unfiltered)[b]	Manganese (Filtered and Unfiltered)[b]	Phenols	Sodium	Sulfate	Metals (Filtered and Unfiltered)[b,c]	Anions[d]	Field Measurements[e]
299-E28-26	Downgradient	Y	S	S4	S4	S4	S4	A	A	A	A	A	A	A	A	S
299-E28-27	Downgradient	Y	S	S4	S4	S4	S4	A	A	A	A	A	A	A	A	S
299-E28-28	Downgradient	Y	S	S4	S4	S4	S4	A	A	A	A	A	A	A	A	S
299-E32-3	Upgradient	Y	S	S4	S4	S4	S4	A	A	A	A	A	A	A	A	S
299-E33-28	Downgradient	Y	S	S4	S4	S4	S4	A	A	A	A	A	A	A	A	S
299-E33-29	Downgradient	Y	S	S4	S4	S4	S4	A	A	A	A	A	A	A	A	S
299-E33-266	Upgradient	Y	S	S4	S4	S4	S4	A	A	A	A	A	A	A	A	S
Proposed Well	Downgradient	Y	S	S4	S4	S4	S4	A	A	A	A	A	A	A	A	S

Table 3-1. Monitoring Well Network for LLWMA-1

a. Parameters are 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. Unfiltered samples will be collected in conjunction with filtered samples for select analyses 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 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.

c. Includes analysis of calcium, magnesium, and potassium.

d. Includes analysis of fluoride, nitrate, and nitrite.

e. Includes measurement of dissolved oxygen, temperature, and turbidity.

A	=	to be sampled annually
CFR	=	*Code of Federal Regulations*
LLWMA	=	Low-Level Waste Management Area
N	=	well is not constructed as a resource protection well (WAC 173-160)
RCRA	=	*Resource Conservation and Recovery Act of 1976*
S	=	to be sampled semiannually
S4	=	to be sampled semiannually, with quadruplicate samples collected during each event
WAC	=	*Washington Administrative Code*
Y	=	well is constructed as a resource protection well (WAC 173-160)

Table 3-2. Constituents and Sampling Frequency for Proposed Well during Initial Year after Implementation of Groundwater Monitoring Plan

		Parameters[a]																														
		40 CFR 265 Appendix III Parameters																					Groundwater Contamination Indicator Parameters				Groundwater Quality Parameters					
Well Name	Water Level	Arsenic (Filtered and Unfiltered)[b]	Barium (Filtered and Unfiltered)[b]	Cadmium (Filtered and Unfiltered)[b]	Chromium (Filtered and Unfiltered)[b]	Fluoride	Lead (Filtered and Unfiltered)[b]	Mercury	Nitrate (as N)	Selenium (Filtered and Unfiltered)[b]	Silver (Filtered and Unfiltered)[b]	Endrin	Lindane	Methoxychlor	Toxaphene	2,4,-D	2,4,5-TP Silvex	Radium	Gross Alpha	Gross Beta	Coliform Bacteria	Turbidity	pH	Specific Conductance	Total Organic Carbon	Total Organic Halogen	Chloride	Iron (Filtered and Unfiltered)[b]	Manganese (Filtered and Unfiltered)[b]	Phenols	Sodium (Filtered and Unfiltered)[b]	Sulfate
Proposed Well	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q4	Q4	Q4	Q4	Q	Q	Q	Q	Q	Q

Reference: 40 CFR 265.92, "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," "Sampling and Analysis."

Appendix III, "EPA Interim Primary Drinking Water Standards."

a. Sampling for the Appendix III drinking water parameters (40 CFR 265.92(b)(1)) for one year at wells added to the groundwater monitoring network after the initial year of interim status monitoring at the treatment, storage, and disposal unit is not required by the regulations. Such monitoring is performed as a best practice activity to provide additional scientific and technical information.

b. Unfiltered samples will be collected in conjunction with filtered samples for select analyses 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 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.

CFR = *Code of Federal Regulations*

Q = to be sampled quarterly

Q4 = to be sampled quarterly, with quadruplicate samples collected during each event

3.2 Monitoring Well Network

The current LLWMA-1 monitoring network consists of two upgradient and five downgradient wells, as shown in Table 3-1. An additional downgradient well is proposed at the northing and easting coordinates, 136992 and 573116, respectively. Figure 3-1 shows the groundwater monitoring network, including the proposed new well, and information for the wells is summarized in Table 3-3. The proposed well location is based on the current flow direction with respect to Trench 9, as shown in Figure 1-2. This location also provides sufficient coverage for the flow direction variability over the past 4 years, since the flow direction change. Past indicator parameter results from the two upgradient wells (299-E32-3 and 299-E33-266) will be used to establish background levels for the revised LLWMA-1 groundwater monitoring program. The two upgradient wells are considered hydraulically upgradient based on groundwater flow determinations from July 2011 to mid-2015. The five wells to the south and east of LLWMA-1 will be used to monitor whether a 0.01 level of significant increase (and decrease, in the case of pH) over background is observed. One additional downgradient well is required to monitor the southeast corner of LLWMA-1 to ensure that a statistically significant increase can be observed.

If a well is within approximately 2 years of going dry, a replacement well will be proposed; such wells are negotiated annually by Ecology, DOE, and EPA under Tri-Party Agreement (Ecology et. al., 1989a) Milestone M-24-00.

Construction details and pertinent information for the wells are provided in Appendix C.

3.3 Differences Between This Plan and Previous Plan

Table 3-4 identifies the main differences between this plan and the previous groundwater monitoring plan. Monitoring well network changes from the previous plan include number and location of upgradient wells, number and location of downgradient wells, and addition of one new downgradient well. Changes to the number and location of network wells was based on a groundwater flow change. The flow direction was previously north-northwest. However, groundwater mounding in the 200 East Area has dissipated since the 1980s, and since mid-2011, groundwater elevations to the north have been higher, causing the groundwater to flow to the south-southeast. The current arrangement of the two upgradient wells provides a sufficient spatial relationship for incorporating spatial variability of background parameters.
The addition of the new downgradient well provides a more uniform distance between downgradient wells.

3.4 Sampling and Analysis Protocol

The groundwater protection regulations of WAC 173-303-400 dictate the groundwater sampling and analysis requirements applicable to interim status TSD units. The QAPjP outlining the project management structure, data generation and acquisition, analytical procedures, and quality control is provided in Appendix A. Appendix B provides the sampling protocols (e.g., sampling methods, sample handling and custody, management of waste and health and safety considerations).

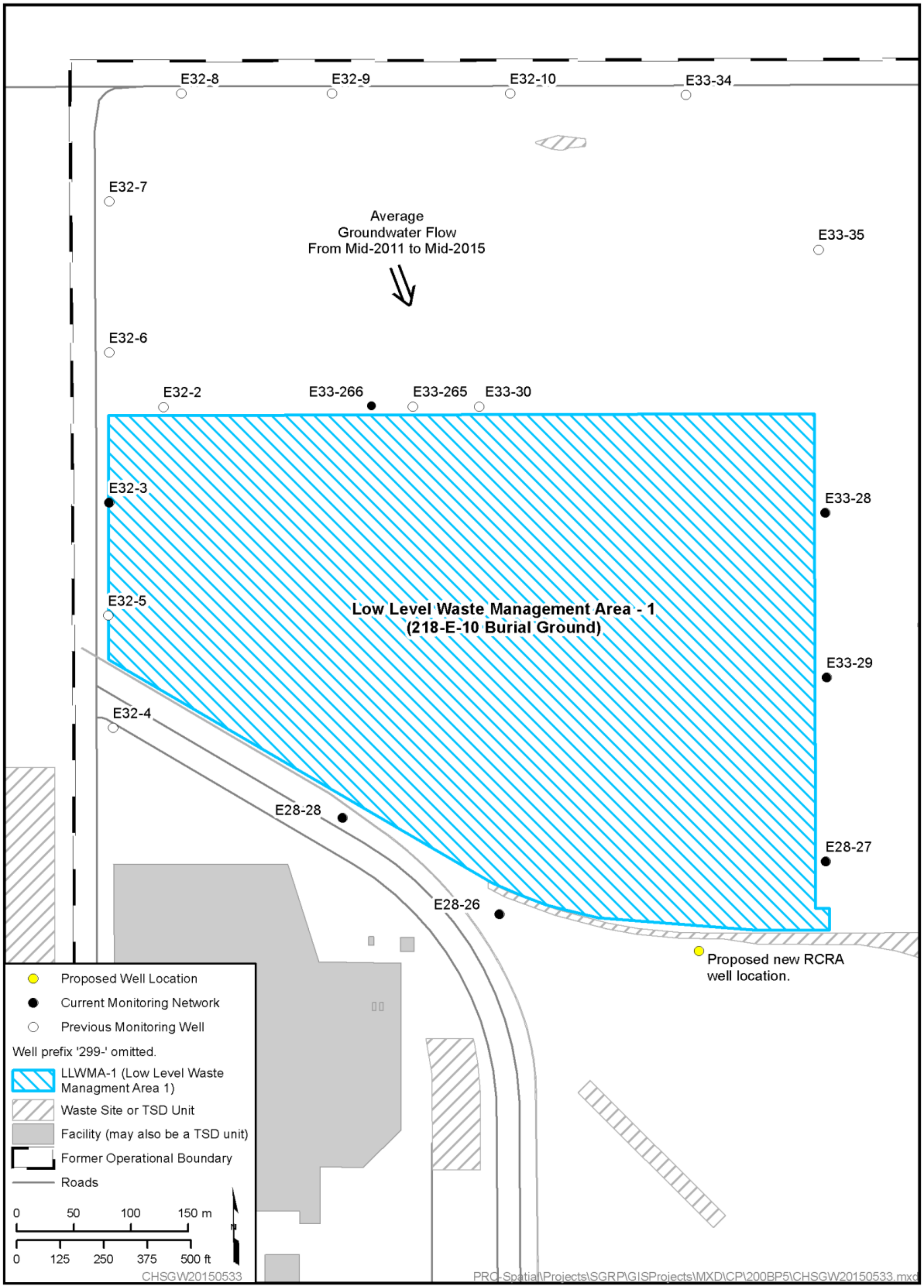


Figure 3-1. Groundwater Monitoring Well Network at LLWMA-1

Table 3-3. Attributes for Wells in the LLWMA-1 Groundwater Monitoring Network

Well Name	Completion Date	Easting[a] (m)	Northing[a] (m)	Groundwater Elevation[b] (m [ft])	Groundwater Thickness across Screen Interval (m [ft])	Measured Groundwater Level Date
299-E28-26	11/06/1987	572941.553	137024.016	121.8 (399.6)	3.0 (9.96)	January 2015
299-E28-27	09/29/1987	573226.784	137070.063	121.8 (399.6)	2.3 (7.7)	January 2015
299-E28-28	04/17/1990	572804.351	137108.259	121.8 (399.6)	2.3 (7.5)	January 2015
299-E32-3	09/30/1987	572600.614	137383.996	121.8 (399.6)	2.1 (6.9)	January 2015
299-E33-28	10/15/1987	573226.365	137375.019	121.8 (399.6)	2.8 (9.1)	January 2015
299-E33-29	09/30/1987	573227.858	137231.193	121.8 (399.6)	2.2 (7.4)	January 2015
299-E33-266	10/06/2010	57282.95	137467.95	121.8 (399.6)	4.5 (14.8)	January 2015
Proposed Well	TBD	573116	136992	TBD	TBD	N/A

a. Coordinates are in NAD83, *North American Datum of 1983*.

b. Elevations are in NAVD88, *North American Vertical Datum of 1988*.

N/A = not applicable

TBD = to be determined

Table 3-4. Main Differences between This Plan and Previous Plan

Type of Change	Previous Plan*	Current Plan	Justification Summary
Constituents	40 CFR 265.92(b)(2) and (b)(3) and alkalinity, dissolved oxygen, temperature, and turbidity as a site-specific constituent	Alkalinity discontinued	Alkalinity is not required per 40 CFR 265.92(b)(2) and (b)(3). Cation balances can be completed using specific conductance instead of against anions.
Sampling Frequency	Annual sampling frequency for phenols Semiannual sampling frequency for indicator parameters, dissolved oxygen, temperature, and turbidity. Semiannual sampling frequency for iron, manganese, sodium, chloride, and sulfate	Annual sampling frequency for phenols Semiannual sampling frequency for, indicator parameters, dissolved oxygen, temperature, and turbidity Reduced sampling frequency to annual iron, manganese, sodium, chloride, and sulfate	Historical data indicates only annual sampling, consistent with 40 CFR 265.92 requirements, is necessary to determine well quality.
Well Network	Downgradient wells 299-E32-2 through 299-E32-10, 299-E33-34, 299-E33-265, and 299-E33-266 Upgradient wells 299-E28-26, 299-E28-27, 299-E28-28, 299-E33-28, 299-E33-29, and 299-E33-35	Downgradient wells 299-E28-26, 299-E28-27, 299-E28-28, 299-E33-28, 299-E33-29, and proposed well Upgradient wells 299-E32-3 and 299-E33-266	Both upgradient and downgradient wells were changed based on groundwater flow direction changes.
Groundwater Flow Direction	Northwest	South-southeast	Decline of 200 East Area groundwater mounds has created a continuing south-southeast flow direction.
Type of Groundwater Monitoring Program	Indicator Evaluation Program	Indicator Evaluation Program	No change
Background Arithmetic Mean, a concentration derived from upgradient wells at the	Calculated approximately yearly for changing	Calculate yearly to ensure representative background groundwater quality as	Calculated annually using EPA 530/R-09-007, *Statistical Analysis of Groundwater*

Table 3-4. Main Differences between This Plan and Previous Plan

Type of Change	Previous Plan*	Current Plan	Justification Summary
0.01 level of significance per 40 CFR 265.93 for comparison with downgradient indicator concentrations, is recalculated approximately every year to ensure representativeness of upgradient comparison values.	groundwater conditions.	required in 40 CFR 265.91 and recommended in the unified guidance.	*Monitoring Data at RCRA Facilities Unified Guidance*.
Groundwater Quality Assessment Plan Outline	Not applicable as groundwater quality assessment plan outline was provided in WHC-SD-EN-AP-015, Table 4.1	Chapter 5	Update outline to current norms.

References: 40 CFR 265, "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities."

265.91, "Ground-Water Monitoring System."

265.92, "Sampling and Analysis."

265.93, "Preparation, Evaluation, and Response."

WHC-SD-EN-AP-015, *Interim-Status Ground-Water Quality Assessment Plan for Waste Management Area 1 of the 200 Areas Low-Level Burial Grounds*.

* DOE/RL-2009-75, Rev. 0, *Interim Status Groundwater Monitoring Plan for the LLBG WMA-1*.

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4 Data Evaluation and Reporting

This chapter discusses the evaluation and interpretation of data.

4.1 Data Review

The data review and verification tasks are discussed in the QAPjP (Appendix A).

4.2 Statistical Evaluation

The goal of the groundwater monitoring indicator evaluation program is to determine if LLWMA-1 operations have affected groundwater quality beneath the TSD unit, which is determined based on the results of specified statistical tests. Under this plan, sampling activities and statistical evaluation methods are based on 40 CFR 265, Subpart F (incorporated by reference into WAC 173-303-400). These interim status regulations require the use of a statistical method that compares mean concentrations of the four general groundwater contamination indicator parameters (pH, specific conductance, TOC, and TOX) to background levels to test for potential impact to groundwater. Each time that a monitoring well is sampled, four replicate samples for TOC and TOX are collected, and four replicate field measurements are made for pH and specific conductance.

The basic procedure for statistical comparisons is as follows. Twice each year, monitoring data from downgradient wells are compared to the upgradient (background) results for each of the four indicator parameters. The arithmetic mean and variance must be calculated based on at least four replicate measurements on each sample, for each well monitored, and then compared with the background arithmetic mean obtained (40 CFR 265.92(c)(2)) and updated as discussed in Chapter 5 of EPA 530/R-09-007, *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities Unified Guidance*. 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 background (40 CFR 265.93(b) and Appendix IV to 40 CFR 265). Implementation of the statistical test method at the Hanford Site, including at LLWMA-1, is generally consistent with EPA 530/R-09-007. The background statistical analysis is updated annually to establish comparative values for indicator parameters. A rolling mean is used because of changing upgradient concentrations and groundwater flow conditions.

If a downgradient well comparison shows a significant increase (or pH decrease), then the well is resampled. For TOC and TOX, split samples are sent to different laboratories to determine if the exceedance of the comparison value was the result of laboratory error.

If the exceedance of the statistical comparison value is confirmed by resampling, then written notifications are made as detailed in Section 4.5 and in accordance with 40 CFR 265.93(d)(1).

4.3 Interpretation

Data are used to interpret groundwater conditions at LLWMA-1. Interpretive techniques include the following:

- **Hydrographs:** Graph water levels versus time to determine decreases and increases and seasonal or manmade fluctuations in groundwater levels.

- **Water table maps:** Use water table elevations from multiple wells to construct contour maps and estimate flow directions. Groundwater flow is assumed to be perpendicular to the equal potential lines 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 relate to changes in water level or groundwater flow directions.
- **Plume maps:** Map distributions of chemical constituent concentrations in the aquifer to determine the extent of contamination. Changes in plume distribution over time assist in determining plume movement and direction of groundwater flow.
- **Contaminant ratios:** Illustrate the relative abundances of contaminants from previously characterized Hanford Site-related processes and sources. Comparison of these ratios in groundwater can sometimes be used to distinguish among different sources of contamination (e.g., a specific process and its associated facility). Ratios may provide evidence of continuing source contamination, thereby linking contamination with a specific facility under monitoring. Evaluation of contaminant ratios in concentration trends may be used to demonstrate when facility-specific contamination no longer affects underlying groundwater.

4.4 Annual Determination of Monitoring Network

Groundwater monitoring requirements include an annual evaluation of the network to determine if it remains adequate to monitor the facility's impact on the quality of the groundwater in the uppermost aquifer underlying the facility (40 CFR 265.93(f)). The network must include at least one upgradient and at least three downgradient wells in the uppermost aquifer (40 CFR 265.91(a)(1) and (2)).

The current groundwater monitoring network will continue to be re-evaluated to ensure that it is adequate to monitor any changing hydrogeologic conditions beneath the unit. If flow changes are observed, the LLWMA-1 CSM and groundwater constituents will be re-evaluated to determine network efficiency and any necessary modifications required for the network.

Water-level measurements will continue to be collected during each sampling event. An additional and more comprehensive set of water-level measurements is made annually for selected wells on the Hanford Site, and the data are presented in the annual Hanford Site RCRA groundwater monitoring reports (e.g., DOE/RL-2016-12).

4.5 Reporting and Notification

Groundwater monitoring and evaluation of groundwater surface elevation results are reported annually in accordance with the requirements of 40 CFR 265.94(a)(2). Reporting will be made in the annual Hanford Site RCRA groundwater monitoring reports (e.g., DOE/RL-2016-12).

If a comparison for an upgradient well shows a significant increase (or pH decrease) relative to the statistical comparison value, that information is also reported in the annual Hanford Site RCRA groundwater monitoring report (e.g., DOE/RL-2016-12).

If the exceedance of the statistical comparison value is confirmed, written notice is then provided to Ecology within 7 days (40 CFR 265.93(d)(1)) stating that the facility may be affecting groundwater quality. Within 15 days after the notification, a groundwater quality assessment program must be developed and placed in the facility operating record (40 CFR 265.93(d)(2). This plan must be submitted to Ecology (WAC 173-303-400(3)(c)(v)D)).

5 Outline for Groundwater Quality Assessment Plan

If a groundwater contamination indicator parameter at a downgradient well significantly exceeds the background value or if pH decreases and is confirmed by verification sampling, a groundwater quality assessment plan will be prepared and submitted to Ecology and the facility monitoring will be elevated to assessment monitoring status. The assessment program must be capable of determining whether dangerous waste or dangerous waste constituents from the facility have entered the groundwater, their rate and extent of migration and their concentration. This chapter presents a revision of the groundwater quality assessment monitoring plan outline required by 40 CFR 265.93(a). A crosswalk to information that is still pertinent (e.g., the facility description, geology and hydrogeology, or sampling protocols) within the indicator parameter program groundwater monitoring plan that precedes the groundwater quality assessment plan may be included. An outline for the assessment plan is presented in Table 5-1. Changes may be made to this outline based on the information identified on the crosswalk, if used. The groundwater quality assessment program may include the following elements:

- Description of the hydrogeologic conditions and identification of potential contaminant pathways
- Description of the investigative approach for making first determination to decide if dangerous waste or dangerous waste constituents from the facility have entered the groundwater or if the exceedance was caused by other sources (false-positive rationale)
- Description of the approach to fully characterize rate and extent of contaminant migration
- Number, locations, and depths of wells in the monitoring network
- Sampling and analytical methods used
- Data evaluation methods
- An implementation schedule

The results of assessment determinations will be made as soon as technically feasible and a report of the findings will be sent to Ecology. The results of the groundwater quality assessment program will then be reported annually as required by 40 CFR 265.94(b).

Table 5-1. Suggested Groundwater Quality Assessment Plan Outline

- Introduction
- Background
  - Facility Description and Operational History
  - Regulatory Basis
  - Waste Characteristics
  - Geology and Hydrogeology
  - Summary of Previous Groundwater Monitoring and Results
  - Conceptual Site Model
  - Monitoring Objectives
- Groundwater Monitoring
  - Constituent List and Sampling Frequency
  - Well Network
  - Sampling and Analysis Protocol
- Data Evaluation and Reporting
  - Data Evaluation
  - Interpretation
  - Annual Determination of Monitoring Network
  - Reporting and Notification
- Implementation Schedule
- References
- Appendix A – Quality Assurance Project Plan
- Appendix B –As-Built Drawings of Wells in Well Network

Note: A crosswalk to information that is still pertinent (e.g., the facility description, geology and hydrogeology, or sampling protocols) within the indicator parameter program groundwater monitoring plan that precedes the groundwater quality assessment plan may be included. Changes may be made to this outline based on the information identified on the crosswalk, if used.

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Appendix A

Quality Assurance Project Plan

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Contents

Tables

Figure

1 # Terms

CAS	Chemical Abstract Service
DOE	U.S. Department of Energy
DOE-RL	U.S. Department of Energy, Richland Operations Office
DQA	data quality assessment
DQI	data quality indicator
DUP	duplicate (laboratory)
EB	equipment blank
ECO	Environmental Compliance Officer
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
FSO	Field Sample Operations
FTB	full trip blank
FWS	Field Work Supervisor
GC	gas chromatography
GC/MS	gas chromatography/mass spectrometry
HASQARD	*Hanford Analytical Services Quality Assurance Requirements Document* (DOE/RL-96-68)
HEIS	Hanford Environmental Information System
LCS	laboratory control sample
LLWMA-1	Low-Level Waste Management Area 1
MB	method blank
MDC	minimum detectable activity
MDL	method detection limit
MS	matrix spike
MSD	matrix spike duplicate
N/A	not applicable
PQL	practical quantitation limit
QA	quality assurance
QAPjP	quality assurance project plan

QC	quality control
RCRA	*Resource Conservation and Recovery Act of 1976*
RPD	relative percent difference
SAF	Sampling Authorization Form
S&GRP	Soil and Groundwater Remediation Project
SMR	Sample Management and Reporting
SPLIT	field split
SUR	surrogate
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order* (Ecology et al., 1989a)
TSD	treatment, storage, and disposal

A1 Introduction

A quality assurance project plan (QAPjP) establishes the quality requirements for environmental data collection. It includes planning, implementation, and assessment of sampling tasks, field measurements, laboratory analysis, and data review. This chapter describes the applicable environmental data collection requirements and controls based on the quality assurance (QA) elements found in EPA/240/B-01/003, *EPA Requirements for Quality Assurance Project Plans* (EPA QA/R-5), and DOE/RL-96-68, *Hanford Analytical Services Quality Assurance Requirements Document* (HASQARD). Sections 6.5 and 7.8 of the Ecology et al., 1989b, *Hanford Federal Facility Agreement and Consent Order Action Plan* (Tri-Party Agreement Action Plan) require the QA/quality control (QC) and sampling and analysis activities to specify QA requirements for treatment, storage, and disposal (TSD) units, as well as for past practice processes. This QAPjP also describes the applicable requirements and controls based on guidance provided in Ecology Publication No. 04-03-030, *Guidelines for Preparing Quality Assurance Project Plans for Environmental Studies*, and EPA/240/R-02/009, *Guidance for Quality Assurance Project Plans* (EPA QA/G-5). This QAPjP is intended to supplement the contractor's environmental QA program plan.

This QAPjP is divided into the following five chapters, which describe the quality requirements and controls applicable to Low-Level Waste Management Area 1 (LLWMA-1) groundwater monitoring activities:

- Chapter A2, Project Management
- Chapter A3, Data Generation and Acquisition
- Chapter A4, Assessment and Oversight
- Chapter A5, Data Review and Usability
- Chapter A6, References

A2 Project Management

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

A2.1 Project/Task Organization

Project organization (regarding routine groundwater monitoring) is described in the following subsections and illustrated in Figure A-1.

A2.1.1 DOE-RL Manager

Hanford Site cleanup is the responsibility of U.S. Department of Energy (DOE)-Richland Operations Office (RL). The DOE-RLManager 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., 1989a, *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement).

A2.1.2 DOE-RL Project Lead

The DOE-RL 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 the DOE-RL management.

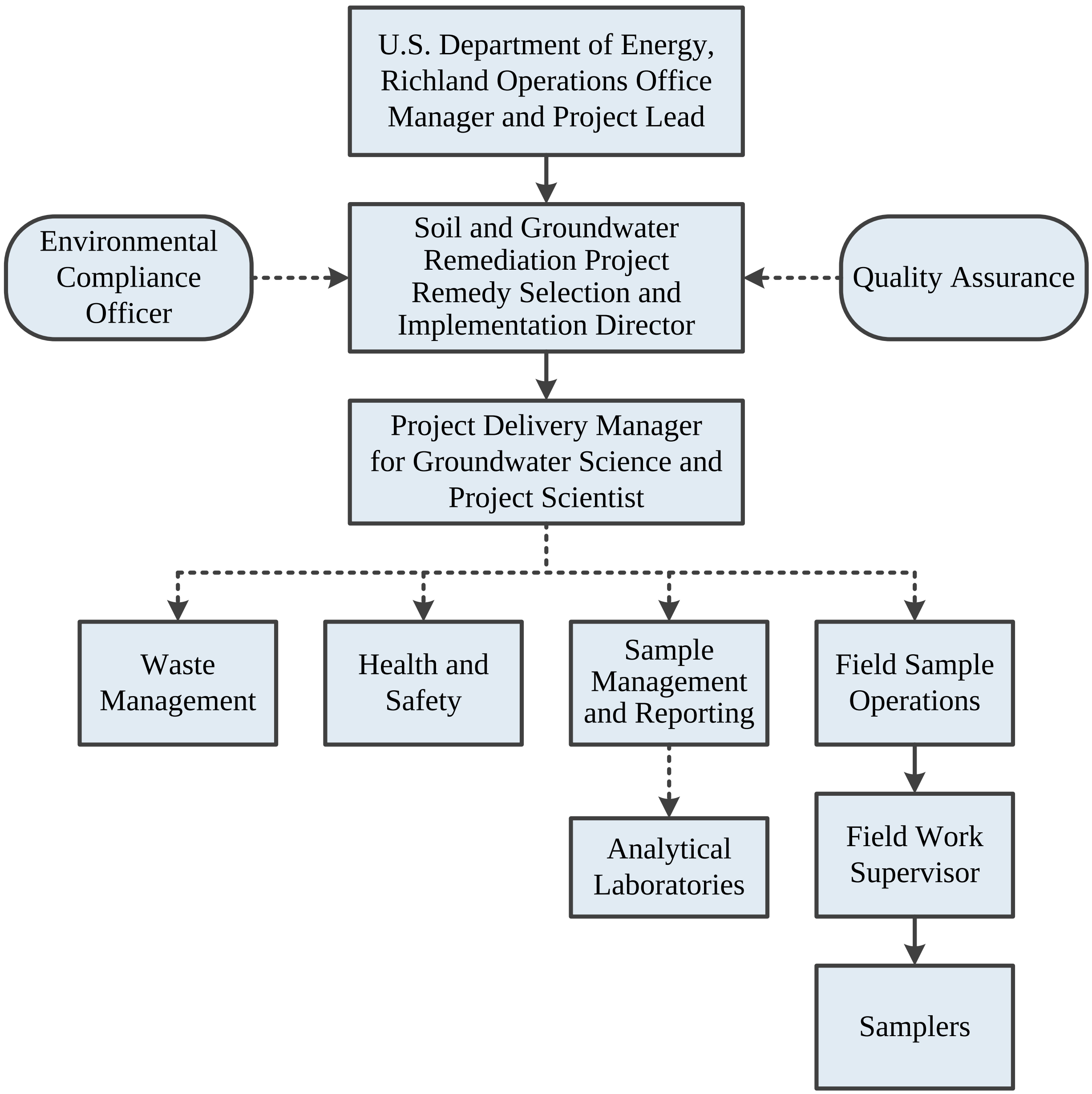

Figure A-1. Project Organization

A2.1.3 Soil and Groundwater Remediation Project Remedy Selection and Implementation Director

The Soil and Groundwater Remediation Project (S&GRP) Remedy Selection and Implementation Director provides oversight and coordinates with DOE-RL and primary contractor management in support of sampling and reporting activities. The Remedy Selection and Implementation Director also provides support to the Project Delivery Manager for Groundwater Science to ensure that work is performed safely and cost effectively.

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 TSD unit groundwater monitoring requirements. The Project Delivery Manager for Groundwater Science coordinates with, and reports to, DOE-RL and primary contractor management regarding TSD unit groundwater monitoring requirements. The Project Delivery Manager for Groundwater Science (or designee) works closely with the Environmental Compliance Officer (ECO), QA, Health and Safety, 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 scientists to provide technical expertise.

A2.1.5 Sample Management and Reporting Group

The SMR group oversees offsite analytical laboratories, coordinates laboratory analytical work to ensure that laboratories conform to the requirements of this plan, and verifies that laboratories are qualified for performing Hanford Site analytical work. The SMR group generates field sampling documents, labels, and instructions for field sampling personnel and develops the Sampling Authorization Form (SAF), which provides information and instruction to the analytical laboratories. The SMR group ensures that field sampling documents are revised to reflect approved changes. The SMR group receives analytical data from the laboratories, ensures it is appropriately reviewed, performs data entry into the Hanford Environmental Information System (HEIS) database, and arranges 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. The SMR group is responsible for informing the Project Delivery Manager for Groundwater Science 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 nuclear chemical operators (samplers), who collect groundwater samples in accordance with this groundwater monitoring plan and corresponding standard procedures and work packages. The FWS ensures that deviations from field sampling documents or issues encountered in the field are documented appropriately (e.g., in the field logbook). The FWS ensures that samplers are appropriately trained and available. Samplers collect samples in accordance with sampling documentation. Samplers also complete field logbooks, data forms, and chain-of-custody forms, including any shipping paperwork, and enable delivery of the samples to the analytical laboratory.

Pre-job briefings are conducted by FSO, in accordance with work management and work release requirements, to evaluate activities and associated hazards by considering the following factors:

- Objective of the activities
- Individual tasks to be performed
- Hazards associated with the planned tasks
- Controls applied to mitigate the hazards
- Environment in which the job will be performed
- Facility where the job will be performed
- Equipment and material required

A2.1.7 Quality Assurance

The QA point of contact provides independent oversight and is responsible for addressing QA issues on the project and overseeing implementation of the project QA requirements. Responsibilities include reviewing project documents, including the QAPjP, and participating in QA assessments on sample collection and analysis activities, as appropriate.

A2.1.8 Environmental Compliance Officer

The ECO provides technical oversight, direction, and acceptance of project and subcontracted environmental work and also develops appropriate mitigation measures with the goal of minimizing adverse environmental impacts.

A2.1.9 Health and Safety

The Health and Safety organization is responsible for coordinating industrial safety and health support within the project as carried out through health and safety plans, job hazard analyses, and other pertinent safety documents required by federal regulations or internal primary contractor work requirements.

A2.1.10 Waste Management

Waste Management is responsible for identifying waste management sampling/characterization requirements to ensure regulatory compliance and for interpreting data to determine waste designations and profiles. Waste Management communicates policies and procedures and ensures project compliance for storage, transportation, disposal, and waste tracking in a safe and cost-effective manner.

A2.1.11 Analytical Laboratories

The analytical laboratories analyze samples, in accordance with established procedures and the requirements of this plan, and provide necessary data packages containing analytical and QC results. Laboratories provide explanations of results to support data review and in response to resolution of analytical issues. Statements of work flow down quality requirements consistent with the HASQARD (DOE/RL-98-68). The laboratories are evaluated under the DOE Consolidated Audit Program and must be accredited by the Washington State Department of Ecology (Ecology) for the analyses performed for S&GRP.

A2.2 Problem Definition/Background

The purpose of this groundwater monitoring plan is to satisfy *Washington Administrative Code* (WAC) and *Code of Federal Regulations* (CFR) 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 evaluation program monitoring. More specific information on the activities to satisfy these requirements is provided in the main text of this monitoring plan in Chapter 1 and Sections 2.7, 3.1, 3.2, and 4.2. Background information on monitoring is also provided in the main text (Sections 2.2, 2.5, and 3.3).

A2.3 Project/Task Description

The focus of this plan is to monitor parameters used as indicators of groundwater contamination and for parameters establishing groundwater quality in accordance with 40 CFR 265.92(b)(2)&(3) and (d), "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. In addition to the required parameter indicators of 40 CFR 265.92, a selection of site specific constituents to be monitored is included in Chapter 3.

A2.4 Quality Assurance Objectives and Criteria

The QA objective of this plan is to ensure that the generation of analytical data of known and appropriate quality is acceptable and useful in order to meet the evaluation requirements stated in the monitoring plan.

In support of this objective, data descriptors known as data quality indicators (DQIs) are used to help determine the acceptability and usefullness of the data to the user. 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.

Data quality is defined by the degree of rigor in the acceptance criteria assigned to the DQIs. 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. DQIs are evaluated during the data quality assessment (DQA) process (Section A5.3).

A2.5 Special Training/Certification

Workers receive a level of training that is commensurate with their responsibility for collecting and transporting groundwater samples according to the dangerous waste training plan maintained for the TSD unit to meet the requirements of WAC 173-303-330, “Personnel Training.” The FWS, in coordination with line management, will ensure that special training requirements for field personnel are met.

Training has been instituted by the contractor management team to meet training and qualification programs that satisfy multiple training drivers imposed by applicable *Code of Federal Regulations* and *Washington Administrative Code* requirements. Training records are maintained for each employee in an electronic training record database. The contractor’s training organization maintains the training records system. Line management confirms that an employee’s training is appropriate and up-to-date prior to performing any field-work.

A2.6 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. Version control is maintained by the administrative document control process. 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 265.92 (e.g., water-level measurements will be collected each time a sample is obtained) cannot be changed.

Logbooks and data forms are required for field activities. The logbook must be identified with a unique project name and number. Individuals responsible for the logbooks shall be identified in the front of the logbook, and only authorized individuals may make entries into the logbooks. Logbooks will be controlled in accordance with internal work requirements and processes.

The FWS, SMR group, and any field crew supervisors are responsible for ensuring that field instructions are maintained and aligned with any revisions or approved changes to the groundwater monitoring plan. The SMR group will ensure that any deviations from the plan are reflected in revised field sampling documents for the samplers and analytical laboratory. The FWS or appropriate field crew supervisors will ensure that deviations from the plan or problems encountered in the field are document appropriately (e.g., in the field logbook).

Table A-1. Data Quality Indicators

Data Quality Indicator (QC Element) [a]	Definition	Determination Methodologies	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 re-measurement. • 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 standard recoveries, 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 re-measurement.
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	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 data set 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 data sets: • 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 quality assessment)	Completeness is a measure of the amount of valid data collected compared to the amount of data planned. Measurements are considered to be 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 data set 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.

Table A-1. Data Quality Indicators

Data Quality Indicator (QC Element) [a]	Definition	Determination Methodologies	Corrective Actions
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 procedures to limit preferential selection or loss of sample media. • Use sample handling procedures, 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 their methods to remove the bias as best 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 re-measurement using methods or analytical conditions that will meet required detection or limit of quantitation. • Qualify/reject the data before use.

Source: SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update V, as amended*.

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

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

QC = quality control

Table A-2. Change Control for Monitoring Plans

Type of Change*	Action	Documentation
Temporary addition of wells or site-specific constituents, or increased sampling frequency that does not impact the requirements of 40 CFR 265.92.	Project Delivery Manager for Groundwater Science approves temporary change; provides informal notification to DOE-RL.	SMR group's integrated groundwater monitoring schedule
Unintentional impact to groundwater monitoring plan that impacts the indicactor parameter 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 indicator 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.	Annual Handford Site RCRA groundwater monitoring report
Planned change to groundwater monitoring activities, including addition or deletion of site-specific constituents, change of sampling frequency for site-specific constituents, 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 RCRA groundwater monitoring plan as appropriate
Anticipated unavoidable changes	Project Delivery Manager for Groundwater Science provides informal notification to DOE-RL; revise monitoring plan as appropriate.	Annual Hanford Site RCRA groundwater monitoring report and revised RCRA groundwater monitoring plan as appropriate

Notes:

40 CFR 265.93, "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," "Preparation, Evaluation, and Response," contains additional sampling and notification requirements should indicator parameter results demonstrate a significant increase (or pH decrease).

40 CFR 265, Subpart F, "Ground-Water Monitoring."

* "Site-specific constituents" are any constituents that may be included in this monitoring plan as additional analytes that are not required by 40 CFR 265.92, "Sampling and Analysis."

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

Ecology = Washington State Department of Ecology

RCRA = *Resource Conservation and Recovery Act of 1976*

SMR = Sample Management and Reporting

The Project Delivery Manager for Groundwater Science, FWS, or designee is responsible for communicating field corrective action requirements and ensuring that immediate corrective actions are applied to field activities. The Project Delivery Manager for Groundwater Science is also responsible for ensuring that project files are set up, as appropriate, and/or maintained. The project files will contain project records or references to their storage locations. Project files generally include, as appropriate, the following information:

- Operational records and logbooks
- Data forms

- Global positioning system data (a copy will be provided to the SMR group)
- Inspection or assessment reports and corrective action reports
- Field summary reports
- Interim progress reports
- Final reports
- Forms required by WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells," and the master drilling contract

The following records are managed and maintained by SMR personnel:

- Completed field sampling logbooks
- Groundwater sample reports and field sample reports
- Completed chain-of-custody forms
- Sample receipt records
- Laboratory data packages
- Analytical data verification and validation reports
- Analytical data case file purges (i.e., raw data purged from laboratory files) provided by offsite analytical laboratories

The laboratory is responsible for maintaining, and having available upon request, the following items:

- Analytical logbooks
- Raw data and QC sample records
- Standard reference material and/or proficiency test sample data
- Instrument calibration information
- Training records for employees, as they relate to analytical methods.
- Laboratory state accredation records
- Laboratory audit records

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 hard copy format (e.g., DOE Records Holding Area). Documentation and records, regardless of medium or format, are controlled in accordance with internal work requirements and processes that ensure accuracy and retrievability of stored records. Records required by the Tri-Party Agreement (Ecology et al., 1989a) will be managed in accordance with the requirements therein. Records of analyses required by 40 CFR 265.92(c) and (d), as well as associated groundwater surface elevations required by 40 CFR 265.92(e) are to be maintained throughout the active life of a facility and post-closure care period.

The results of groundwater 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 reports (e.g., DOE/RL-2016-12, *Hanford Site RCRA Groundwater Monitoring Report for 2015*).

A3 Data Generation and Acquisition

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

A3.1 Analytical Method Requirements

Analytical method requirements for samples collected are presented in Table A-3. Updated U.S. Environmental Protection Agency (EPA) methods may be substituted for the analytical methods identified in Table A-3.

Table A-3. Analytical Requirements for Groundwater Analysis

Constituent	Analytical Method[a]	Highest Allowable Practical Quantitation Limit[b] (µg/L unless otherwise noted)
Drinking Water Suitability Parameters[c]		
Arsenic	SW-846 Method 6010B/C	10
Barium		100
Cadmium		5
Chromium		10
Fluoride[d]	EPA/600 Method 300.0	500
Lead	SW-846 Method 6010B/C	15
Mercury	SW-846 Method 7470	0.5
Nitrate (as N)[d]	EPA/600 Method 300.0	100
Selenium	SW-846 Method 6010B/C	50
Silver		10
Endrin	SW-846 Method 8081	0.1
Lindane		0.05
Methoxychlor		0.5
Toxaphene		2
2,4-D	SW-846 Method 8150	20
2,4,5-TP Silvex		1

Table A-3. Analytical Requirements for Groundwater Analysis

Constituent	Analytical Method[a]	Highest Allowable Practical Quantitation Limit[b] (µg/L unless otherwise noted)
Radium	Gamma Energy Analysis	1 pCi/L (Radium-226) 3 pCi/L (Radium-228)
Gross Alpha	Gas Proportional Counting	3 pCi/L
Gross Beta		4 pCi/L
Coliform Bacteria	Standard Method 9223	N/A
Turbidity	Field measurement Instrument/meter	N/A
Groundwater Quality Parameters (40 CFR 265.92(b)(2))		
Chloride[d]	EPA/600 Method 300.0	400
Sulfate[d]		550
Iron	SW-846 Method 6010B/C	100
Manganese		15
Sodium		1,000
Phenols	SW-846 Method 8270D	10[e]
Contamination Indicator Parameters (40 CFR 265.92(b)(3))		
pH	Field measurement Instrument/meter	N/A
Specific Conductance		N/A
Total Organic Carbon	SW-846 Method 9060	1,000
Total Organic Halogen	SW-846 Method 9020	10
Site-Specific Constituents/Measurements[f]		
Fluoride[d]	EPA/600 Method 300.0	500
Nitrate[d]		250
Nitrite[d]		250
Calcium	SW-846 Method 6010B/C	1,000
Magnesium		1,000
Potassium		5,000

Table A-3. Analytical Requirements for Groundwater Analysis

Constituent	Analytical Method[a]	Highest Allowable Practical Quantitation Limit[b] (µg/L unless otherwise noted)
Dissolved Oxygen	Field measurement Instrument/meter	N/A
Temperature		N/A
Turbidity		N/A

Reference: 40 CFR 265.92, "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," "Sampling and Analysis."

Appendix III, "EPA Interim Primary Drinking Water Standards."

Note: Analytical methods and highest allowable PQLs provided in this table do not represent EPA requirements but are intended solely as guidance.

a. For EPA Method 300.0, see EPA/600/R-93/100, *Methods for the Determination of Inorganic Substances in Environmental Samples*. For four-digit EPA methods, see SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update V*. Equivalent methods may be substituted.

b. For purposes of this groundwater monitoring plan, the highest allowable PQL is interchangeable with the lower limit of quantitation, which is the lowest level that can be routinely quantified and reported by a laboratory. The highest allowable PQLs are not to be exceeded and are specified in contracts with analytical laboratories. Actual quantitation limits vary by laboratory and may be lower than required contractually. MDLs are three to five times lower than quantitation limits.

c. Parameters characterizing the suitability of groundwater as a drinking water supply as presented in Appendix III to 40 CFR 265 will be monitored for one year at the wells identified in Table 3-2 of the main text as a best practice activity.

d. General Chemistry Analyses: Dilutions for certain ion chromatography constituents may be necessary, potentially raising the PQL above the limits established in this table. In circumstances where the PQL, is critical to a project, SMR will negotiate with the project scientist regarding project specific requirements.

e. PQL provided for phenol (CAS No. 108-95-2). Other PQL values may apply to other phenolic compounds.

f. Site-specific constituents/measurements are not required by RCRA but are used to support interpretation.

CAS = Chemical Abstracts Service
CFR = *Code of Federal Regulations*
EPA = U.S. Environmental Protection Agency
MDL = method detection limit
N/A = not applicable
PQL = practical quantitation limits
RCRA = *Resource Conservation and Recovery Act of 1976*
SMR = Sample Management and Reporting

A3.2 Field Analytical Methods

Field screening and survey data will be measured in accordance with HASQARD (DOE/RL-96-68) requirements (as applicable). Field analytical methods may also be performed in accordance with manufacturer manuals. Table A-3 provides the parameters (if any) identified for field measurements. Appendix B provides further discussion on field measurements.

A3.3 Quality Control

QC requirements specified in the plan must be followed in the field and analytical laboratory to ensure that reliable data are obtained. 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 of the analytical data. Field and laboratory QC samples 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 HEIS, as appropriate.

Table A-4. QC Samples

Sample Type	Frequency	Characteristics Evaluated
Field QC		
Field Duplicates	One in 20 well trips	Precision, including sampling and analytical variability
Field Splits	As needed When needed, the minimum is one for every analytical method, for analyses performed	Precision, including sampling, analytical, and interlaboratory
Full Trip Blanks	One in 20 well trips	Cross-contamination from containers or transportation
Equipment Blanks	As needed If only disposable equipment is used or equipment is dedicated to a particular well, then an equipment blankis not required; one for every 20 samples[a]	Adequacy of sampling equipment decontamination and contamination from nondedicated equipment
Analytical QC[b]		
Laboratory Duplicates	One per analytical batch[c]	Laboratory reproducibility and precision
Matrix Spikes	One per analytical batch[c]	Matrix effect/laboratory accuracy
Matrix Spike Duplicates	One per analytical batch[c]	Laboratory accuracy and precision
Laboratory Control Samples	One per analytical batch[c]	Laboratory accuracy
Method Blanks	One per analytical batch[c]	Laboratory contamination
Surrogates	Added to each sample and QC sample[c]	Recovery/yield
Carriers	Added to each sample and quality control sample [c]	Recovery/yield

Note: The information in this table does not represent EPA requirements but is intended solely as guidance.

a. For portable pumps, equipment blanks are collected one for every 10 well trips. Whenever a new type of nondedicated equipment is used, an equipment blank will be collected every 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. Batching across projects is allowed for similar matrices (e.g., all Hanford groundwater).

c. Unless not required by, or different frequency is called out in, laboratory analysis methods.

EPA = U.S. Environmental Protection Agency

QC = quality control

Table A-5. Field and Laboratory Quality Control and Acceptance Criteria

Analysis	QC Element	Acceptance Criteria	Corrective Action
Coliform	MB	Pass/Fail[a]	Review Data[b]
	LCS	Pass/Fail[a]	Review Data[b]
	DUP[c]	Pass/Fail[a]	Review Data[b]
Total organic carbon	MB	<MDL <5% Sample Concentration	Flag with "C"
	LCS	80 to 120% Recovery	Review Data[b]
	DUP[c]/MSD[d]	≤20% RPD[c]	Review Data[b]
	MS/MSD[d]	75 to 125% Recovery	Flag with "N"
	EB, FTB	<2 times MDL	Flag with "Q"
	Field Duplicate/SPLIT	≤20% RPD[c]	Review Data[b]
Total organic halogen	MB	<MDL <5% Sample Concentration	Flag with "C"
	LCS	80 to 120% Recovery	Review Data[b]
	DUP[c]/MSD[d]	≤20% RPD[c]	Review Data[b]
	MS/MSD[d]	75 to 125% Recovery	Flag with "N"
	EB, FTB	<2 times MDL	Flag with "Q"
	Field Duplicate/SPLIT	≤20% RPD[c]	Review Data[b]
Anions			
Anions by ion chromatography (chloride, fluoride, nitrate, nitrite, and sulfate)	MB	<MDL <5% Sample Concentration	Flag with "C"
	LCS	80 to 120% Recovery	Review Data[b]
	DUP[c]/MSD[d]	≤20% RPD[c]	Review Data[b]
	MS/MSD[d]	75 to 125% Recovery	Flag with "N"
	EB, FTB	<2 times MDL	Flag with "Q"
	Field Duplicate/SPLIT	≤20% RPD[c]	Review Data[b]

Table A-5. Field and Laboratory Quality Control and Acceptance Criteria

Analysis	QC Element	Acceptance Criteria	Corrective Action
Metals			
Inductively coupled plasma/atomic emission spectrometry metals (arsenic, barium, cadmium, calcium, chromium, iron, lead, magnesium, manganese, potassium, selenium, silver, and sodium)	MB	<MDL <5% Sample Concentration	Flag with "C"
	LCS	80 to 120% Recovery	Review Data[b]
	DUP[c]/MSD[d]	≤20% RPD	Review Data[b]
	MS/MSD[d]	75 to 125% Recovery	Flag with "N"
	EB, FTB	<2 times MDL	Flag with "Q"
	Field Duplicate/SPLIT	≤20% RPD[c]	Review Data[b]
Mercury by cold-vapor atomic absorption	MB	<MDL <5% Sample Concentration	Flag with "C"
	LCS	80 to 120% Recovery	Review Data[b]
	DUP[c]/MSD[d]	≤20% RPD	Review Data[b]
	MS/MSD[d]	75 to 125% Recovery	Flag with "N"
	EB, FTB	<2 times MDL	Flag with "Q"
	Field Duplicate/SPLIT	≤20% RPD[c]	Review Data[b]
Semivolatile Organic Compounds			
Herbicides by gas chromatography (2,4-D and 2,4,5,-TP silvex)	MB	<MDL <5% Sample Concentration	Flag with "B"
	LCS	70 to 130% Recovery	Review Data[b]
	DUP[c]/MSD[d]	≤20% RPD	Review Data[b]
	MS/MSD[d]	% Recovery Statistically Derived[e]	Flag with "N"
	SUR	70 to 130% Recovery	Review Data[b]
	EB, FTB	<2 times MDL	Flag with "Q"
	Field Duplicate/SPLIT	≤20% RPD[c]	Review Data[b]
Pesticides by gas chromatography (endrin, lindane, methoxychlor, and toxaphene)	MB	<MDL <5% Sample Concentration	Flag with "B"
	LCS	70 to 130% Recovery	Review Data[b]
	DUP[c]/MSD[d]	≤20% RPD	Review Data[b]

Table A-5. Field and Laboratory Quality Control and Acceptance Criteria

Analysis	QC Element	Acceptance Criteria	Corrective Action
	MS/MSD[d]	% Recovery Statistically Derived[e]	Flag with “N”
	SUR	70 to 130% Recovery	Review Data[b]
	EB, FTB	<2 times MDL	Flag with “Q”
	Field Duplicate/SPLIT	≤20% RPD[c]	Review Data[b]
Phenols by gas chromatography/mass spectrometry	MB	<MDL <5% Sample Concentration	Flag with “B”
	LCS	70 to 130% Recovery	Review data[b]
	DUP[c]/MSD[d]	≤20% RPD	Review data[b]
	MS/MSD[d]	% Recovery Statistically Derived[e]	Flag with “T”
	SUR	70 to 130% Recovery	Review data[b]
	EB, FTB	<2 times MDL	Flag with “Q”
	Field Duplicate/SPLIT	≤20% RPD[c]	Review data[b]
Radiological			
Gross alpha	MB	<MDC <5% Sample Activity Concentration	Flag with “B”
	LCS	80 to 120% Recovery	Review Data[b]
	DUP	≤20% RPD[f]	Review Data[b]
	EB, FTB	<2 times MDC	Flag with “Q”
	Field Duplicate/SPLIT	≤20% RPD[f]	Review Data[b]
Gross beta	MB	<MDC <5% Sample Activity Concentration	Flag with “B”
	LCS	80 to 120% Recovery	Review Data[b]
	DUP	≤20% RPD[f]	Review Data[b]
	EB, FTB	<2 times MDC	Flag with “Q”
	Field Duplicate/SPLIT	≤20% RPD[f]	Review Data[b]
Radium by gamma energy analysis	MB	<MDC <5% Sample Activity Concentration	Flag with “B”

Table A-5. Field and Laboratory Quality Control and Acceptance Criteria

Analysis	QC Element	Acceptance Criteria	Corrective Action
	LCS	80 to 120% Recovery	Review Data[b]
	DUP	≤20% RPD[f]	Review Data[b]
	Carrier	30 to 105% Recovery	Review Data[b]
	EB, FTB	<2 times MDC	Flag with "Q"
	Field Duplicate/SPLIT	20% RPD[f]	Review Data[b]

Notes:

The information in this table does not represent EPA requirements but is intended solely as guidance. The table is consistent with SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update V*; and DOE/RL-96-68, *Hanford Analytical Services Quality Assurance Requirements Document*.

This table only applies to laboratory analyses. Dissolved oxygen, specific conductance, pH, temperature, and turbidity are not listed as they are measured in the field.

a. Passing QC; MB = no colonies detected, LCS = appropriate colonies detected, DUP = colonies detected/undetected are consistent with sample.

b. After review, corrective actions are determined on a case-by-case basis. Corrective actions may include a laboratory recheck or flagging the data as suspect (Y flag), failed field QC (Q flag), or rejected (R flag).

c. Applies when at least one result is greater than the laboratory PQL (chemical analyses).

d. Either a DUP or a MSD is to be analyzed to determine measurement precision.

e. Laboratory-determined, statistically derived control limits based on historical data are used here. Control limits are reported with the data.

f. Applies only in cases where both results are greater than 5 times the MDC.

Data Flags

B, C = possible laboratory contamination: analyte was detected in the associated method blank

N = result may be biased: associated matrix spike result was outside the acceptance limits (except gas chromatograph/mass spectrometry).

Q = problem with associated field QC blank: results were out of limits

T = result may be biased: associated matrix spike result was outside the acceptance limits (gas chromatograph/mass spectrometry only).

DUP = laboratory sample duplicate
EB = equipment blank
EPA = U.S. Environmental Protection Agency
FTB = full trip blank
LCS = laboratory control sample
MB = method blank
MDC = minimum detectable activity
MDL = method detection limit
MS = matrix spike
MSD = matrix spike duplicate
PQL = practical quantitation limit
QC = quality control
RPD = relative percent difference
SPLIT = field split
SUR = surrogate

A3.3.1 Field Quality Control Samples

Field QC samples are collected to evaluate the potential for cross-contamination and provide information pertinent to field sampling variability and laboratory performance to help ensure that reliable data are obtained. Field QC samples include field duplicates, field split (SPLIT) samples, and two types of field blanks (full trip blanks [FTBs] and equipment blanks [EBs]). Field blanks are typically prepared using high-purity reagent water. QC sample definitions and their required frequency for collection are described below:

Field duplicate: independent samples collected as close as possible to the same time and same location as the scheduled sample, and intended to be identical. Field duplicates are placed in separate sample containers and analyzed independently. Field duplicates are used to determine precision for both sampling and laboratory measurements.

Field splits (SPLITs): two samples collected as close as possible to the same time and same location and intended to be identical. 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): bottles prepared by the sampling team before travel to the sampling site. The preserved bottle set is either for volatile organic analysis only or identical to the set that will be collected in the field. It is filled with high-purity reagent water,[1] and the bottles are sealed and transported (unopened) to the field in the same storage containers used for samples collected that day. Collected FTBs are typically analyzed for the same constituents as the samples from the associated sampling event. FTBs are used to evaluate potential contamination of the samples attributable to the sample bottles, preservative, handling, storage, and transportation.

Equipment blanks (EBs): Reagent water passed through or poured over the decontaminated sampling equipment identical to the sample set collected and placed in sample containers, as identified on the SAF. EB sample bottles are placed in the same storage containers with samples from the associated sampling event. EB samples will be analyzed for the same constituents as samples from the associated sampling event. EBs are used to evaluate the effectiveness of the decontamination process and these samples are not required for disposable sampling equipment.

A3.3.2 Laboratory Quality Control Samples

Internal QA/QC programs are maintained by laboratories used by the project. Laboratory QA includes a comprehensive QC program that includes the use of laboratory sample duplicates (DUPs), matrix spikes (MSs), matrix spike duplicates (MSDs), laboratory control samples (LCSs), method blanks (MBs), surrogates (SURs), and carriers. These QC analyses are required by EPA methods (e.g., those in SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update V*), and will be run at the frequency specified in the respective references unless superseded by agreement. QC checks outside of control limits are documented in analytical laboratory reports during DQAs, if performed. Laboratory QC checks and their typical frequencies are listed in Table A-4. Acceptance criteria are shown in Table A-5. Descriptions of the various types of laboratory QC samples are as follows:

Carrier: a known quantity of non-radioactive isotope that is expected to behave similarly and is added to an aliquot of sample. Sample results are generally corrected based on carrier recovery.

Laboratory sample duplicate (DUP): an intralaboratory replicate sample that is used to evaluate the precision of a method in a given sample matrix.

[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 (DOE/RL-96-68).

Matrix spike (MS): an aliquot of a sample spiked with a known concentration of target analyte(s). MS is used to assess the bias of a method in a given sample matrix. Spiking occurs prior to sample preparation and analysis.

Matrix spike duplicate (MSD): 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.

Laboratory control sample (LCS): 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.

Method blank (MB): 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 procedure and is used to quantify contamination resulting from the analytical process.

Surrogate (SUR): 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 measurement systems in a manner similar to the analytes of interest. Because SURs are added to every standard, sample, and QC sample, they are used to evaluate overall method performance in a given matrix. SURs are used only in organic analyses.

Laboratories are required to analyze samples within the holding time specified 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. Holding Time Guidelines for Laboratory Analyses

Constituent/Parameter	Holding Time
Coliform	6 hours
Total organic carbon	28 days
Total organic halogen	28 days
Anions by ion chromatography (chloride, fluoride, nitrate, nitrite, and sulfate)	48 hours
Herbicides by GC (2,4-D, 2,4,5-TP and silvex)	7 days before extraction 40 days after extraction
Pesticides by GC (endrin, lindane, methoxychlor, and toxaphene)	7 days before extraction 40 days after extraction
Inductively coupled plasma metals (arsenic, barium, cadmium, calcium, chromium, iron, lead, magnesium, manganese, potassium, selenium, silver, and sodium)	6 months
Mercury by cold-vapor atomic absorption	28 days

Table A-6. Holding Time Guidelines for Laboratory Analyses

Constituent/Parameter	Holding Time
Phenols by GC/MS	7 days before extraction 40 days after extraction
Gross alpha/beta by gas proportional counting	180 days
Radium by gamma energy analysis	180 days

Notes:

Information in this table does not represent EPA requirements but is intended solely as guidance.

This table only applies to laboratory analyses. Specific conductance, pH, dissolved oxygen, temperature, and turbidity are not listed as they are measured in the field

EPA = U.S. Environmental Protection Agency

GC = gas chromatography

GC/MS = gas chromatography/mass spectrometry

A3.4 Measurement Equipment

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

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

Collection, measurement, and testing equipment should meet applicable standards (e.g., ASTM International, formerly the American Society for Testing and Materials) or should have been evaluated as acceptable and valid in accordance with instrument-specific methods, requirements, and specifications. Software applications will be acceptance tested prior to use in the field.

Measurement and testing equipment used in the field or in the laboratory will be subject to preventive maintenance measures to ensure minimization of downtime. Laboratories must maintain and calibrate their equipment. Maintenance requirements (e.g., documentation of routine maintenance) will be included in the individual laboratory and onsite organization's QA plan or operating protocols, as appropriate. Maintenance of laboratory instruments will be performed in a manner consistent with applicable Hanford Site requirements.

A3.6 Instrument/Equipment Calibration and Frequency

Field equipment calibration is discussed in Appendix B. Analytical laboratory instruments are calibrated in accordance with the laboratory's QA plan and applicable Hanford Site requirements.

A3.7 Inspection/Acceptance of Supplies and Consumables

Consumables, supplies, and reagents will be reviewed in accordance with test methods in SW-846 and will be appropriate for their use. Supplies and consumables used in support of sampling and analysis activities are procured in accordance with internal work requirements and processes. Responsibilities and interfaces necessary to ensure that items procured/acquired for the contractor meet the specific technical and quality requirements must be in place. The procurement system ensures that purchased items comply with applicable procurement specifications. 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 databases, will be technically reviewed to the same extent as data generated as part of any sampling and analysis QA/QC effort. Data used in evaluations will be identified by source.

A3.9 Data Management

The SMR group, in coordination with the Project Delivery Manager for Groundwater Science, is responsible for ensuring that analytical data are appropriately reviewed, managed, and stored in accordance with applicable programmatic requirements governing data management methods. Records of data analyses and groundwater surface elevations are kept as required by 40 CFR 265.94(a)(1).

Electronic data access, when appropriate, will be through a Hanford Site database (e.g., HEIS). Where electronic data are not available, hard copies will be provided in accordance with Section 9.6 of the Tri-Party Agreement Action Plan (Ecology et al., 1989b).

Laboratory errors are reported to the SMR group through an established process. For reported laboratory errors, a sample issue resolution form will be initiated in accordance with applicable methods. This process is used to document analytical errors and establish their resolution with the Project Delivery Manager for Groundwater Science. The sample issue resolution forms become a permanent part of the analytical data package for future reference and records management.

A4 Assessment and Oversight

Assessment and oversight activities address the effectiveness of project implementation and associated QA/QC activities. The purpose of assessment is to ensure that the QAPjP is implemented as prescribed.

A4.1 Assessments and Response Actions

Random surveillances and assessments verify compliance with the requirements outlined in this plan, project field instructions, the QAPjP, methods, and regulatory requirements. Deficiencies identified by these assessments will be reported in accordance with existing programmatic requirements. The project line management chain coordinates the corrective actions/deficiency resolutions in accordance with the QA program, corrective action management program, and associated methods implementing these programs. When appropriate, corrective actions will be taken by the Project Delivery Manager for Groundwater Science.

Oversight activities in the analytical laboratories, including corrective action management, are conducted in accordance with laboratory QA plans. The SMR group oversees offsite analytical laboratories and verifies that laboratories are qualified to perform Hanford Site analytical work.

A4.2 Reports to Management

Program and project management (as appropriate) will be made aware of deficiencies identified by self-assessments, corrective actions from ECOs, and findings from QA assessments and surveillances.

Issues reported by the laboratories are communicated to the SMR group, which then initiates a sample issue resolution form. This process is used to document analytical or sample issues and establish resolution with the Project Delivery Manager for Groundwater Science.

A5 Data Review and Usability

This section 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.

A5.1 Data Review and Verification

Data review and verification are performed to confirm that sampling and chain-of-custody documentation are complete. This review includes linking sample numbers to specific sampling locations, reviewing sample collection dates and sample preparation and analysis dates to assess whether holding times, if any, have been met. Furthermore, a review of QC data is used to determine whether analyses have met the data quality requirements specified in this plan.

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, appropriate reporting of dry weight versus wet weight, and correct application of conversion factors. Field QA/QC results also will be reviewed to ensure that they are usable.

The project scientist, assigned by the Project Delivery Manager for Groundwater Science, will perform a data review to help determine if observed changes reflect improved/degraded groundwater quality or potential data errors and may result in submittal of a request for data review on questionable data. The laboratory may be asked to check calculations or re-analyze the sample, or the well may be resampled. Results of the request for data reviewprocess are used to flag the data appropriately in the HEIS database and/or to add comments.

A5.2 Data Validation

Data validation is performed at the discretion of the Project Delivery Manager for Groundwater Science and under the direction of the SMR group. It is based on the results of the QC samples for an individual network, discussions with the project scientist, and discussions with the laboratory services manager. If defined as appropriate, data validation (third party) will be performed at a minimum frequency of 5 percent and be based on EPA functional guidelines.

A5.3 Reconciliation with User Requirements

The DQA process compares completed field sampling activities to those proposed in corresponding sampling documents and provides an evaluation of the resulting data. The purpose of the DQA is to determine whether quantitative data are of the correct type and are of adequate quality and quantity to meet the project data quality needs. For routine groundwater monitoring performed through this groundwater monitoring plan, the DQA is captured in the DQA appendix associated with the annual Hanford Site RCRA groundwater report (e.g., DOE/RL-2016-12), which evaluates field and laboratory QC and the usability of data. Further DQAs will be performed at the discretion of the S&GRP RCRA groundwater manager and documented in a report overseen by the SMR group.

A6 References

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Appendix B

Sampling Protocol

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Contents

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Terms

DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
FWS	Field Work Supervisor
gpm	gallons per minute
HASQARD	*Hanford Analytical Services Quality Assurance Requirements Document* (DOE/RL-96-68)
IATA	International Air Transport Association
LLWMA-1	Low-Level Waste Management Area 1
NTU	nephelometric turbidity unit
QA	quality assurance
QC	quality control
SMR	Sample Management and Reporting

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B1 Introduction

Groundwater monitoring at the Hanford Site, as defined by the *Resource Conservation and Recovery Act of 1976* and implemented in WAC 173-303-400, “Dangerous Waste Regulations,” “Interim Status Facility Standards,” has been conducted since the mid-1980’s. Hanford Site groundwater sampling methods contain extensive requirements for sampling precautions to be taken; equipment and its use; cleaning and decontamination; records and documentation; and sample collection, management, and control activities. Together, Appendices A and B, provide the sampling and analysis essentials necessary for the groundwater monitoring plan: sample collection, sample holding times, chain-of-custody control, analytical procedures, and field and laboratory quality assurance (QA)/quality control (QC).

This appendix provides more specific elements of the sampling protocols and techniques used for the groundwater monitoring plan. Chapter 3 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 Low-Level Waste Management Area 1 (LLWMA-1).

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 in accordance with 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 (32.3°F)
- **Conductivity** – two consecutive measurements agree within 10 percent of each other
- **Turbidity** – less than 5 nephelometric turbidity units (NTUs) prior to sampling (or project scientist’s recommendation)

Dissolved oxygen will also be measured in the field in this groundwater monitoring plan. Dissolved oxygen is not an indicator parameter nor a groundwater quality parameter and is not required to be stable prior to sample collection.

Unless special requirements are requested from project scientists, wells are typically purged using the equivalent volume as that of three borehole diameters mutipled by the length of the saturated portion of the well screen. Stable field readings are also required as specified above. The default pumping rate is 7.6 to 45.4 L/min (2 to 12 gallons per minute [gpm]) depending on the pump, although this is not practical at every well. On occasions when the purge volume is extraordinarily large, wells are purged for a minimum of 1 hour and are then sampled once stable field readings are obtained.

Field measurements (except for turbidity) are obtained using a flow-through cell. 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, conductivity, and dissolved oxygen. Turbidity is measured by inserting a sample vial into a turbidimeter. The purgewater is then 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. The flow rate is reduced during sampling to minimize loss of volatiles (if any) and prevent over filling thebottles. Sample bottles are filled in a sequence designed to minimize loss of volatiles, if any. Filtered samples are collected after collection of the unfiltered samples. For some constituents (e.g. metals) both filtered and unfiltered samples are collected. If additional samples require filtration (e.g., at turbidity greater than 5 NTUs), an inline disposable 0.45 µm filter is used.

Typically, three traditional types (i.e., Grundfos,[1] Hydrostar,[2] and submersible electrical pumps) of environmental-grade sampling pumps are used for groundwater sampling at Hanford Site monitoring wells. In addition, low-purge-volume, adjustable-rate bladder pumps may be used. Individual pumps are selected based on the unique characteristics of the well and the sampling requirements.

A small number of wells will not support pumping of samples because of yield or the physical characteristics of the well. In these cases, a grab sample may be obtained. In cases where there is not sufficient yield, purgewater activities are not performed

Low-purge-volume sampling methodology for the collection of groundwater samples is also being implemented at the Hanford Site. Low-flow purging and sampling uses a low-purge-volume, adjustable-rate bladder pump with flow rates typically on the order of 0.1 to 0.5 L/min (0.26 to 0.13 gpm). This methodology is intended to minimize excessive movement of water from the soil formation into the well. The objective is to pump in a manner that minimizes stress (drawdown) to the system. Purge volumes for wells using low purge bladder pumps are determined on a well-specific basis based on drawdown, pumping rate, pump and sample line volume, and volume required to obtain stable field conditions prior to collecting samples.

For certain types of samples, preservatives are required. Preservatives, based on analytical methods used, are added to the collection bottles before their use in the field. Samples may require filtering in the field, as noted on the chain-of-custody form.

To ensure sample and data usability, sampling associated with this groundwater monitoring plan will be performed in accordance with the requirements of DOE/RL-96-68, *Hanford Analytical Services Quality Assurance Requirements Document* (HASQARD), pertaining to sample collection, collection equipment, and sample handling.

Sample holding time requirements are specified for groundwater samples in Appendix A, Table A-6. These requirements are in accordance with the analytical methods specified in Appendix A, Table A-3. The 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 on holding time restrictions.

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[1] Grundfos® is a registered trademark of Grundfos Holding A/S Corporation, Bjerringbro, Denmark.
[2] Hydrostar® is a registered trademark of KYB Corporation, Tokyo, Japan.

Holding time is the maximum allowable period between sample collection and analysis. Exceeding required holding times could result in changes in constituent concentrations due to volatilization, decomposition, or other chemical alterations. Required holding times depend on the constituent and are listed in analytical method compilations such as APHA/AWWA/WEF, 2012, *Standard Methods for the Examination of Water and Wastewater*; and SW-846, *Test Methods for Evaluating Solid Waste, Physical/ Chemical Methods, Third Edition; Final Update V*. Recommended holding times are also provided in HASQARD (DOE/RL-96-68) and in applicable laboratory contracts.

B2.1 Decontamination of Sampling Equipment

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 performed using high-purity water[3] in each step. In general, three rinse cycles are performed to decontaminate sampling equipment: a detergent rinse, an acid rinse, and a water rinse. During the detergent rinse, the 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 1M 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 50 degrees C (122 degrees Fahrenheit) for items that are not metal or glass or at 100 degrees C (212 degrees Fahrenheit) for metal or glass. Once reaching temperature, equipment is baked for 20 minutes and then cooled. The equipment is then removed from the oven, and the equipment is enclosed in clean, unused aluminum foil using surgeon's gloves. The wrapped equipment is stored in a custody-locked, controlled-access area.

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. 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.

[3] 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 (DOE/RL-96-68).

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. The cleaning is documented on a tag that is affixed to the pump, and the tag will include the following information:

- Date pump cleaned
- Pump identification
- Comments
- Signature of person performing decontamination

B2.2 Water Levels

Each time a sample is obtained, measurement of the ground water 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 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 or data forms are required for field activities and will be used in accordance with HASQARD (DOE/RL-96-68) requirements. A logbook must be 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 (FWS), 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 may be used to collect field information; however, information recorded on data forms must follow the same requirements as those for logbooks. The data forms must be referenced in the logbooks.

A summary of information to be recorded in logbooks or on data forms is as follows:

- 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.
- Site activities in specific detail (e.g., maps and drawings) or the forms used to record such information (e.g., soil boring log or well completion log). Also, details of any field tests that were conducted; reference to any forms that were used, other data records, and methods followed in conducting the activity.
- Details of any field calibrations and surveys that were conducted. Reference any forms that were used, other data records, and the methods followed in conducting the calibrations and surveys.

- Details of any samples collected and the preparation (if any) of splits, duplicates, matrix spikes, or blanks. Reference the methods followed in sample collection or preparation; list location of sample collected, sample type, each label or tag numbers, sample identification, sample containers and volume, preservation method, packaging, chain-of-custody form number, and analytical request form number pertinent to each sample or sample set; and note the time and the name of the individual to whom custody of samples was transferred.
- 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.
- Any equipment failures or breakdowns that occurred, with a brief description of repairs or replacements.

B3.1 Corrective Actions and Deviations for Sampling Activities

The Project Delivery Manager for Groundwater Science, FWS, appropriate field crew supervisors, and Sample Management and Reporting (SMR) personnel must document deviations from protocols, issues pertaining to sample collection, chain-of-custody forms, target analytes, contaminants, sample transport, or noncompliant monitoring. Examples of deviations include samples not collected due to field conditions.

As appropriate, such deviations or issues will be documented (e.g., in the field logbook) in accordance with internal corrective action methods. The Project Delivery Manager for Groundwater Science, FWS, field crew supervisors, or SMR personnel will be responsible for communicating field corrective action requirements and ensuring that immediate corrective actions are applied to field activities.

Changes in sample activities that require notification, approval, and documentation will be performed as specified in Appendix A, Table A-2.

B4 Calibration of Field Equipment

Onsite environmental instruments are calibrated in accordance with the manufacturer’s operating instructions, internal work requirements and processes, and/or field instructions that provide direction for equipment calibration or verification of accuracy by analytical methods. Calibration records shall include the raw calibration data, identification of the standards used, associated reports, date of analysis, and analyst’s name or initials. The results from all instrument calibration activities are recorded in accordance with the HASQARD requirements (DOE/RL-96-68).

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

- Prior to initial use of a field analytical measurement system.
- 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 will be in accordance with established methods to 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 shall be collected, where and when appropriate, in break-resistant containers. The field sample collection record shall indicate the laboratory lot number of the bottles used in sample collection. When commercially pre-cleaned containers are used in the field, the name of the manufacturer, lot identification, and certification shall be retained for documentation.

Containers shall 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 shall 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. Recommended 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 shall contain the sample identification number. The label shall identify or provide reference to associate the sample with the date and time of collection, preservative used (if applicable), analysis required, 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 will be maintained in accordance with existing protocols to ensure that sample integrity is maintained 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 field sampling team will make a copy of the signed record before sample shipment and transmit the copy to the SMR group.

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

- Project name
- Collector's names
- Unique sample number
- Date and time of 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)

Samplers should note any anomalies with the samples. If anomalies are found, samplers should inform the SMR group; so special direction for analysis can be provided to the laboratory if deemed necessary.

B5.4 Sample Transportation

Packaging and transportation instructions shall 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) as described in 49 CFR 171, "Transportation," "General Information, Regulations, and Definitions," through 49 CFR 177, "Carriage by Public Highway."[4] Carrier-specific requirements, defined in the current edition of International Air Transport Association (IATA) *Dangerous Goods Regulations*, shall also be used when preparing sample shipments conveyed by air freight providers.

Samples containing hazardous constituents shall 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. Appropriate laboratory notifications will be made, if necessary, through the SMR project coordinator.

B6 Management of Waste

Waste materials are generated during sample collection, processing, and subsampling activities. Waste will be managed in accordance with DOE/RL-2003-30, *Waste Control Plan for the 200-BP-5 Operable Unit.* For waste designation purposes, wells listed in Table 3-2 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 required.

[4] Transportation regulations 49 CFR 174, "Carriage by Rail," and 49 CFR 176, "Carriage by Vessel," are not applicable, as these two transportation methods are not used.

Miscellaneous solid waste that has contacted suspect dangerous waste will be managed as dangerous waste. Purgewater and decontamination fluids will be collected and managed in accordance with DOE/RL-2011-41, *Hanford Site Strategy for Management of Investigation Derived Waste*; and DOE/RL-2009-80, *Investigation Derived Waste Purgewater Management Work Plan*. Waste materials requiring collection will be placed in containers appropriate for the material and the receiving facility in accordance with the applicable waste management or waste control plan and applicable substantive federal and/or state requirements.

Packaging and labeling during waste storage and transportation will meet WAC 173-303 and DOT requirements, as appropriate. Packaging exceptions to DOT requirements may be used for onsite waste shipments if documented as such and if the packaging provides an equivalent degree of safety during transportation.

Offsite analytical laboratories are responsible for the disposal of unused sample quantities.

B7 Health and Safety

DOE established the hazardous waste operations safety and health program pursuant to the *Price-Anderson Amendments Act of 1988* to ensure the safety and health of workers involved in mixed-waste site activities. The program was developed to comply with the requirements of 10 CFR 851, “Worker Safety and Health Program,” which incorporates the standards of 29 CFR 1910.120, “Occupational Safety and Health Standards,” “Hazardous Waste Operations and Emergency Response”; 10 CFR 830, “Nuclear Safety Management”; and 10 CFR 835, “Occupational Radiation Protection.” The health and safety program defines the chemical, radiological, and physical hazards and specifies the controls and requirements for daily work activities on the overall Hanford Site. Personnel training; control of industrial safety and radiological hazards; personal protective equipment; site control; and general emergency response to spills, fire, accidents, injury, site visitors, and incident reporting are governed by the health and safety program.

B8 References

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Appendix C

Well Construction

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Contents

Figures

Tables

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C1 Introduction

This appendix provides the following information for the Low-Level Waste Management Area 1 (LLWMA-1) groundwater monitoring wells:

- Well name
- Hydrogeologic unit to be monitored (the portion of the aquifer that is located at the well screen or perforated casing) (Table C-1)
- The following sampling interval information, as shown in Table C-2:
  - Elevation at top of the screen or perforated interval
  - Elevation at the bottom of the screen or perforated interval
  - Open interval length (i.e., difference between elevations of top and bottom of the screen or perforated interval)

Figures C-1 through C-7 provide the well construction and completion summary for the LLWMA-1 monitoring network.

Table C-1. Hydrogeologic Monitoring Unit Classification Scheme

Unit	Description
TU	**Top of Unconfined.** Screened across the water table or the top of the open interval is within 1.5 m (5 ft) of the water table, and the bottom of the open interval is no more than 10.7 m (35 ft) below the water table.

Table C-2. Sampling Interval Information for Wells within the LLWMA-1 Network

Well or Aquifer Tube Name	Hydrogeologic Unit Monitored	Elevation Top of Open Interval (m [ft] NAVD88)	Elevation Bottom of Open Interval (m [ft] NAVD88)	Open Interval Length (m [ft])
299-E28-26	TU	125.1 (410.4)	118.8 (389.8)	6.1 (20.0)
299-E28-27	TU	125.6 (412.1)	119.5 (392)	6.1 (20.0)
299-E28-28	TU	125.6 (412.1)	119.5 (392)	6.2 (20.3)
299-E32-3	TU	125.8 (412.7)	119.7 (392.7)	6.1 (20.0)
299-E33-28	TU	125.1 (410.4)	119.0 (390.4)	6.1 (20.0)
299-E33-29	TU	125.7 (412.4)	119.6 (392.4)	6.1 (20.0)
299-E33-266	TU	123.4 (404.8)	117.3 (384.8)	6.1 (20.0)

Reference: NAVD88, *North American Vertical Datum of 1988*.

Note: See Table 3-3 in main text for depth of remaining water column.

TU = Top of Unconfined, as described in Table C-1

WELL CONSTRUCTION AND COMPLETION SUMMARY

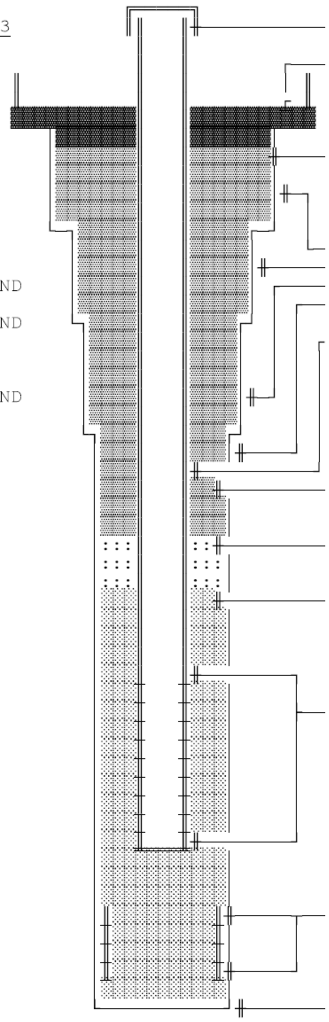
Drilling Method: Cable tool
Sample Method: Drive barrel Hard tool
Drilling Fluid Used: 200 E Water Supply
Additives Used: Not documented
Driller's Name: C. Walmsley
WA State Lic Nr:
Drilling Company: Kaiser Engineers
Company Location: Hanford
Date Started: 17Sep87
Date Complete: 06Nov87

WELL NUMBER: 299-E28-26
TEMPORARY WELL NO:
Hanford Coordinates: N/S N 44,446 E/W W 55,606
State Coordinates: N 449,605 E 2,239,605
Start Card #: Not documented T____ R____ S________
Elevation Ground surface: 684.84-ft (Brass cap)

Depth to water: 279.3-ft Oct87
(Ground surface) 283.0-ft 25Jun93

GENERALIZED STRATIGRAPHY
Geologist's Log
Sl = Slightly

0-25 Silty, sandy GRAVEL
25-30: Sandy GRAVEL
30-35: Sl silty sl gravelly SAND
35-70: Silty sandy GRAVEL
70-75: Sl silty gravelly SAND
75-80: SAND
80-85: Sl gravelly SAND
85-100: Sl silty SAND
100-110: Sl silty sl gravelly SAND
110-135: Sl silty SAND
135-145: Sl silty sl gravelly SAND
145-160: SAND
160-165: Sl silty SAND
165-170: SAND
170-175: Sl silty sl gravelly SAND
175-180: Silty sandy GRAVEL
180-190: SAND
190-200: Silty sandy GRAVEL
200-205: Sandy GRAVEL
205-210: Sl silty SAND
210-215: SAND
215-220: Sl silty SANDd GRAVEL
220-225: Silty SAND
225-247: Silty sandy GRAVEL
247-255: No sample
255-290: Silty sandy GRAVEL
290-295: No sample
295-315: Silty sandy GRAVEL
315-320: Sl silty gravelly SAND
320-326: Silty sandy GRAVEL
326-328.5: BASALT



Elevation of reference point: [687.26-ft]
(top of casing)
Height of reference point above [2.4-ft]
ground surface

Depth of surface seal [3-271.1-ft]
Type of surface seal:
Bentonite crumbles to 271.1-ft
4-ft x 4-ft x 6-in surface pad to 3-ft

Hole diameter,
0-79.8-ft, 17-in nominal
79.8-163.8-ft, 13-in nominal
163.8-238.1-ft, 11-in nominal
238.1-328.5-ft, 9-in nominal

4-in ID stainless steel casing,
+2.4-278.8-ft

Bentonite crumbles,
3-271.1-ft

Volclay pellets,
271.1-276.2-ft

Silica sand pack,
276.2-293-ft, 20-30-mesh
293-299-ft, 10-30-mesh
299-328.5-ft, 20-30-mesh

4-in stainless steel screen,
278.8-298.8-ft, #20-slot

8-in stainless steel
telescoping screen,
315.1-325.1-ft, #30-slot

Borehole drilled depth: [328.5-ft]

Drawing By: RKL/2E28-26.ASB
Date : 10Sep93
Reference : HANFORD WELLS

Figure C-1. Well 299-E28-26 Construction and Completion Summary

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                    SUMMARY OF CONSTRUCTION DATA AND FIELD OBSERVATIONS
                           RESOURCE PROTECTION WELL - 299-E28-26

WELL DESIGNATION     :    299-E28-26
RCRA FACILITY        :    Low Level WMA-1
CERCLA UNIT          :    200 Aggregate Area Management Study
HANFORD COORDINATES  :    N  44,446  W    55,606
LAMBERT COORDINATES  :    N 449,605  E 2,239,605 [HANCONV]
DATE DRILLED         :    Nov87
DEPTH DRILLED  (GS)  :    328.5-ft
MEASURED DEPTH (GS)  :    299.3-ft, 10Aug93
DEPTH TO WATER (GS)  :    280.5-ft, 20Oct87;
                          283.0-ft, 25Jun93
CASING DIAMETER      :    4-in, stainless steel, +2.4-278.8-ft.
ELEV TOP CASING      :    687.26-ft,           [07Dec87-200E]
ELEV GROUND SURFACE  :    684.84-ft, Brass cap [07Dec87-200E]
PERFORATED INTERVAL  :    Not applicable
SCREENED INTERVAL    :    278.8-299.0-ft, 4-in, stainless steel, #20-slot,
                          315.1-325.1-ft, 8-in, stainless steel, #30-slot,
COMMENTS             :    FIELD INSPECTION, 10Aug93;
                          4 and 6-in stainless steel casing.
                          4-ft by 4-ft concrete pad, 4 posts, 1 removable.
                          Capped and locked, brass cap in pad with well ID.
                          Not in radiation zone.
AVAILABLE LOGS       :    Geologist, Driller
TV SCAN COMMENTS     :    Not applicable
DATE EVALUATED       :    Not applicable
EVAL RECOMMENDATION  :    Not applicable
LISTED USE           :    LLBG-WMA-1 monthly water level measurement, 01Dec87-25Jun93;
CURRENT USER         :    WHC ES&M w/l monitoring and RCRA sampling,
                          PNL sitewide sampling 93
PUMP TYPE            :    Hydrostar
MAINTENANCE          :
```

Figure C-1. Well 299-E28-26 Construction and Completion Summary (continued)

WELL CONSTRUCTION AND COMPLETION SUMMARY

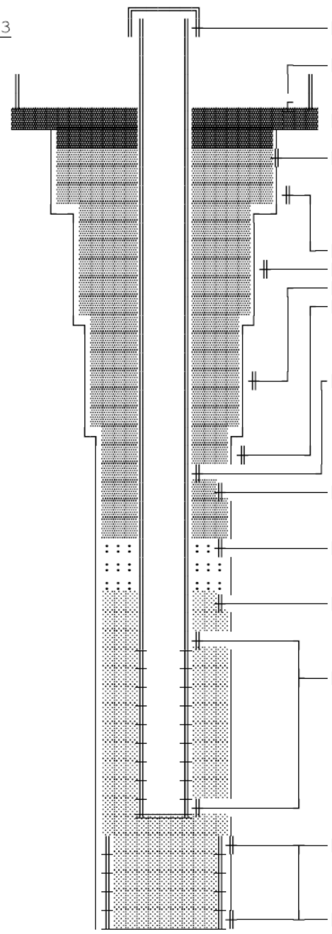
Drilling Method: Cable tool
Sample Method: Drive barrel Hard tool
Drilling Fluid Used: 200 E Water Supply
Additives Used: Not documented
Driller's Name: Murphy/Robinson
WA State Lic Nr:
Drilling Company: Kaiser Engineers
Company Location: Hanford
Date Started: 02Sep87
Date Complete: 29Sep87

WELL NUMBER: 299-E28-27
TEMPORARY WELL NO:
Hanford Coordinates: N/S N 44,595 E/W W 54,670
State Coordinates: N 449,756 E 2,240,541
Start Card #: Not documented T R S
Elevation Ground surface: 678.18-ft (Brass cap)

Depth to water: 273.2-ft Sep87
(Ground surface) 276.4-ft 25Jun93

GENERALIZED STRATIGRAPHY
Geologist's Log

0-10 Silty, sandy GRAVEL
10-15: Sandy GRAVEL
15-55: Silty sandy GRAVEL
55-60: Sandy GRAVEL
60-65: Silty gravelly SAND
65-70: SAND
70-80: Gravelly SAND
80-90: Silty SAND
90-95: Silty gravelly SAND
95-100: SAND
100-110: Gravelly SAND
110-115: Silty gravelly sand
115-120: Gravelly SAND
120-125: SAND
125-140: Gravelly SAND
140-145: SAND
145-150: Gravelly SAND
150-185: SAND
185-190: Silty gravelly SAND
190-195: Silty SAND and GRAVEL
195-210: Sandy GRAVEL
210-220: SILT, SAND and GRAVEL
220-225: Gravelly SAND
225-230: Silty SAND
230-240: Gravelly SAND
240-290: GRAVEL, SAND and SILT
290-295: SAND
295-300: Silty sandy GRAVEL
300-301: Gravelly SAND



Drawing By: RKL/2E28-27.ASB
Date : 10Sep93
Reference : HANFORD WELLS

Figure C-2. Well 299-E28-27 Construction and Completion Summary

```
                    SUMMARY OF CONSTRUCTION DATA AND FIELD OBSERVATIONS
                           RESOURCE PROTECTION WELL - 299-E28-27

WELL DESIGNATION     :    299-E28-27
RCRA FACILITY        :    Low Level Burial Grounds, 218-E-10
CERCLA UNIT          :    200 Aggregate Area Management Study
HANFORD COORDINATES :     N  44,595  W    54,670 [07Dec87-200E]
LAMBERT COORDINATES :     N 449,756  E 2,240,541 [HANCONV]
DATE DRILLED         :    Sep87
DEPTH DRILLED  (GS) :     301.5-ft
MEASURED DEPTH (GS) :     Not documented
DEPTH TO WATER (GS) :     273.2-ft, Sep87
                          276.4-ft, 25Jun93
CASING DIAMETER      :    4-in, stainless steel, +2.2-289.9-ft.
ELEV TOP CASING      :    680.37-ft            [07Dec87-200E]
ELEV GROUND SURFACE :     678.18-ft, Brass cap [07Dec87-200E]
PERFORATED INTERVAL :     Not applicable
SCREENED INTERVAL    :    4-in, 269.9-289.9-ft;
                          8-in, 291.2-301.5-ft
COMMENTS             :    FIELD INSPECTION, 06Feb90,
                          4-in stainless steel casing, no protective casing.  Capped and locked.
                          4-ft by 4-ft concrete pad, 4 posts, brass marker with stamped ID.
                          OTHER;
AVAILABLE LOGS       :    Geologist, Driller
TV SCAN COMMENTS     :    Not applicable
DATE EVALUATED       :    Not applicable
EVAL RECOMMENDATION :     Not applicable
LISTED USE           :    LLBG monthly water level measurement, 01Dec87-25Jun93,
CURRENT USER         :    WHC ES&M w/l monitoring and RCRA sampling,
                          PNL sitewide sampling and w/l monitoring 93
PUMP TYPE            :    Hydrostar
MAINTENANCE          :
```

Figure C-2. Well 299-E28-27 Construction and Completion Summary (continued)

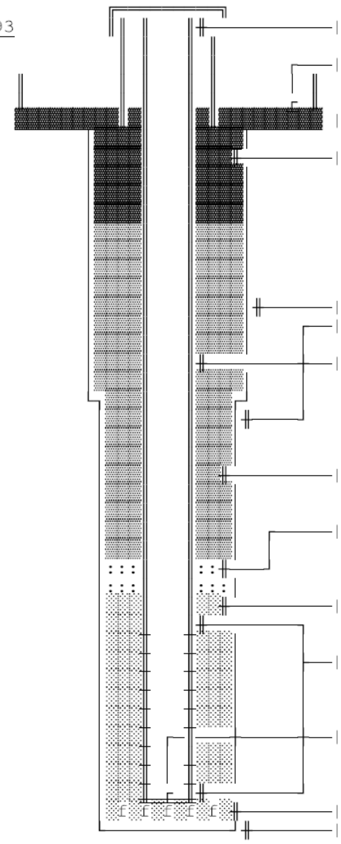
WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method: Cable tool	Sample Method: Drive barrel Hard tool	WELL NUMBER: 299-E28-28
Drilling Fluid Used: 200E Area Water	Additives Used: None	TEMPORARY WELL NO: E10-MW1
Driller's Name: L. Watkins	WA State Lic Nr: Not documented	Hanford Coordinates: N/S N 44,724 E/W W 56,056
Drilling Company: Kaiser Engineers	Company Location: Hanford	State Coordinates: N 449,882 E 2,239,154
Date Started: 02Jan90	Date Complete: 17Apr90	Start Card #: T R S
		Elevation Ground surface: 683.55-ft (Brass cap)

Depth to water: 279.7-ft Feb90
(Ground surface) 281.8-ft 25Jun93

GENERALIZED Geologist's
STRATIGRAPHY Log

0-10: Sandy GRAVEL
10-25: Muddy sandy GRAVEL
25-35: Sandy GRAVEL
35-40: Gravelly SAND
40-45: Sandy GRAVEL
45-60: Gravelly SAND
60-70: Sandy GRAVEL
70-85: Slightly gravelly SAND
85-95: SAND
95-100: Slightly gravelly SAND
100-105: Gravelly SAND
105-120: Slightly gravelly SAND
120-130: SAND
130-135: Slightly gravelly SAND
135-145: Slightly muddy SAND
145-160: SAND
160-170: Sandy GRAVEL
170-175: Gravelly SAND
175-190: Gravelly SAND
190-200: Slightly gravelly slightly muddy SAND
200-205: SAND
205-215: Sandy GRAVEL
215-220: Silty muddy GRAVEL
220-235: Sandy GRAVEL
235-275: Muddy sandy GRAVEL
275-280: No recovery
280-285: Muddy sandy GRAVEL
285-290: Gravelly SAND
290-296: Slightly gravelly SAND



Elevation of reference point: [686.55-ft]
(top of 4-in casing)
Height of reference point above [3.0-ft]
ground surface

Depth of surface seal [2.5-20.0-ft]
Type of surface seal:
Cement grout to 20.0-ft
4 x 4-ft x 6-in surface pad
4 equidistant protective posts
Pad extends 2.5-ft into annulus

Hole diameter,
0-128-ft, 11-in nominal
128-296.0-ft, 9-in nominal

4-in ID T304 stainless steel casing,
+ND-275.0-ft

Bentonite crumbles,
20.0-267.0-ft, 8-20-mesh

- -in Volclay tablets,
267.0-271.5-ft

Silica sand pack,
271.5-294.8-ft, 20-40-mesh

4-in stainless steel screen,
275.0-295.0-ft, #10-slot
w/channel pack

Depth to bottom,
295.9-ft, 06Nov91

Backfill,
294.8-296.0-ft
Borehole drilled depth: [296.0-ft]

Drawing By: RKL/2E28-28.ASB
Date : 10Sep93
Reference : HANFORD WELLS

Figure C-3. Well 299-E28-28 Construction and Completion Summary

SUMMARY OF CONSTRUCTION DATA AND FIELD OBSERVATIONS
RESOURCE PROTECTION WELL - 299-E28-28

WELL DESIGNATION :	299-E28-28
RCRA FACILITY :	218-E10 LLWMA-1
CERCLA UNIT :	200 Aggregate Area Management Study
HANFORD COORDINATES :	N 44,724 W 56,056 [19Apr90-200E]
LAMBERT COORDINATES :	N 449,882 E 2,239,154 [HANCONV] N 137,108.51m E 572,804.49m [19Apr90-NAD83]
DATE DRILLED :	Jan-Apr90
DEPTH DRILLED (GS) :	296-ft
MEASURED DEPTH (GS) :	295.9-ft, Nov91
DEPTH TO WATER (GS) :	279.7-ft, Feb90; 281.8-ft, 25Jun93
CASING DIAMETER :	4-in, stainless steel, ND-275.0-ft 6-in stainless steel +3.0-~0.5-ft
ELEV TOP CASING :	686.55-ft (19Apr90)
ELEV GROUND SURFACE :	683.55 (Brass cap)
PERFORATED INTERVAL :	Not applicable
SCREENED INTERVAL :	275.0-295.0-ft, 4-in stainless steel w/channel pack, #10-slot
COMMENTS :	Field Inspection, 06Nov91; 6-in stainless steel outer casing. Capped and locked. 4x4-ft concrete pad. 4 protective posts, 1 removable. Identification stamped on brass cap in pad. Not in radiation zone. OTHER;
AVAILABLE LOGS :	Drillers; Geologists
TV SCAN COMMENTS :	Not applicable
DATE EVALUATED :	Not applicable
EVAL RECOMMENDATION :	Not applicable
LISTED USE :	LLBG monthly water level measurement, 24Apr90-25Jun93,
CURRENT USER :	WHC ES&M w/l monitoring and RCRA sampling
PUMP TYPE :	Hydrostar, intake at 290.74-ft below top-of-casing
MAINTENANCE :	

Figure C-3. Well 299-E28-28 Construction and Completion Summary (continued)

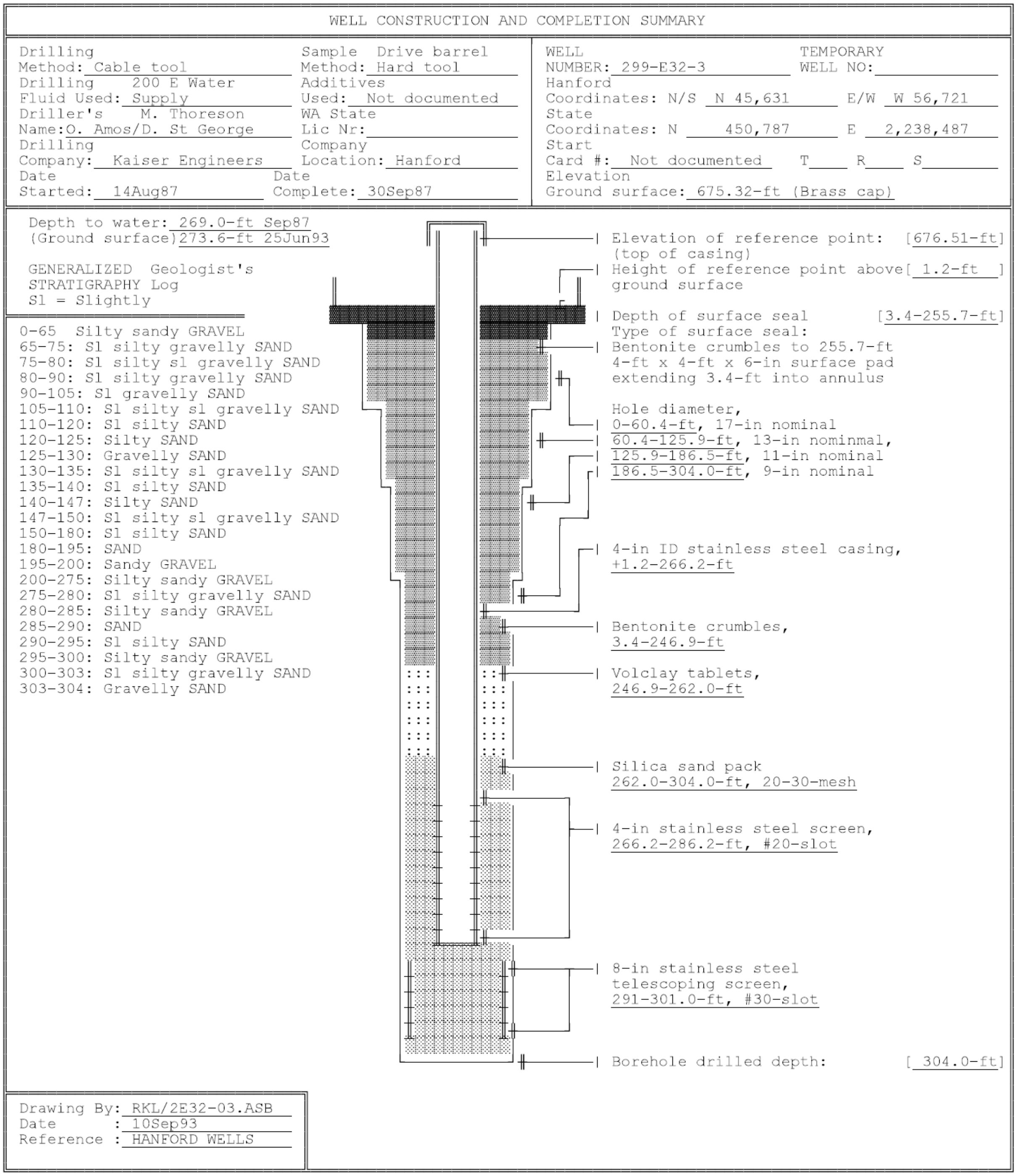


Figure C-4. Well 299-E32-3 Construction and Completion Summary

```
                    SUMMARY OF CONSTRUCTION DATA AND FIELD OBSERVATIONS
                          RESOURCE PROTECTION WELL - 299-E32-3

WELL DESIGNATION    :    299-E32-3
RCRA FACILITY       :    Low Level Burial Grounds, WMA-1
CERCLA UNIT         :    200 Aggregate Area Management Study
HANFORD COORDINATES :    N   45,631  W   56,721
LAMBERT COORDINATES :    N  450,787  E 2,238,487
DATE DRILLED        :    Sep87
DEPTH DRILLED  (GS) :    304.0-ft
MEASURED DEPTH (GS) :    Not documented
DEPTH TO WATER (GS) :    269.0-ft, 04Sep87;
                         273.6-ft, 25Jun93
CASING DIAMETER     :    4-in, stainless steel, +1.2-266.2-ft.
ELEV TOP CASING     :    676.51-ft
ELEV GROUND SURFACE :    675.32-ft (Brass cap)
PERFORATED INTERVAL :    Not applicable
SCREENED INTERVAL   :    4-in, stainless steel, #20-slot, 266.2-286.2-ft;
                         8-in, stainless steel, #30-slot, 291.0-301.0-ft
COMMENTS            :    FIELD INSPECTION, 07Feb90;
                         4-in stainless steel casing.  4-ft by 4-ft concrete pad, 4 posts, 1 removable
                         capped and locked, brass cap in pad with well ID.
                         Not in radiation zone.
AVAILABLE LOGS      :    Geologist, Driller
TV SCAN COMMENTS    :    Not applicable
DATE EVALUATED      :    Not applicable
EVAL RECOMMENDATION :    Not applicable
LISTED USE          :    LLBG monthly water level measurement, 01Dec87-25Jun93;
CURRENT USER        :    WHC ES&M w/l monitoring and RCRA sampling
PUMP TYPE           :    Hydrostar
MAINTENANCE         :
```

Figure C-4. Well 299-E32-3 Construction and Completion Summary (continued)

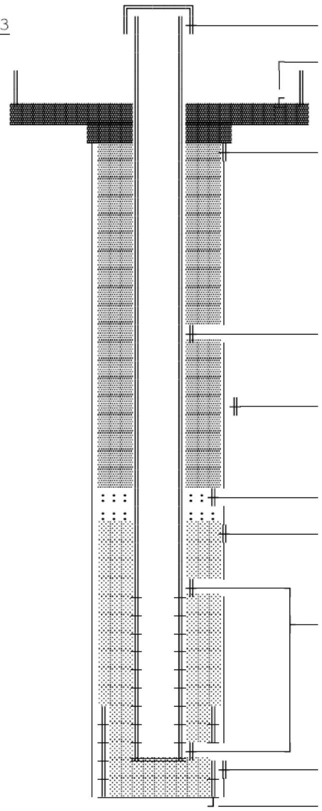
WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method: Cable tool	Sample Method: Drive barrel	WELL NUMBER: 299-E33-28 — TEMPORARY WELL NO:
Drilling Fluid Used: 200 E Water Supply	Additives Used: Not documented	Hanford Coordinates: N/S N 45,596 — E/W W 54,668
Driller's Name: Watkins/Cordon	WA State Lic Nr: 1271/0079	State Coordinates: N 450,758 — E 2,240,540
Drilling Company: Kaiser Engineers	Company Location: Hanford	Start Card #: Not documented — T ___ R ___ S ___
Date Started: 24Sep87	Date Complete: 15Oct87	Elevation Ground surface: 662.66-ft (Brass cap)

Depth to water: 257-ft Oct87
(Ground surface) 260.8-ft 25Jun93

GENERALIZED Geologist's
STRATIGRAPHY Log
(Sl=Slightly)

5-40: Silty sandy GRAVEL
40-50: Gravelly SAND
50-60: Sl gravelly, sl silty SAND
60-75: Sl silty gravelly SAND
75-80: Sl gravelly SAND
80-85: Gravelly SAND
85-90: SAND
95-105: Sl gravelly SAND
105-110: SAND
110-115: Silty SAND
115-120: Sl gravelly silty SAND
120-130: Sl GRAVELLY, sl silty SAND
130-135: Sl silty gravelly SAND
135-160: SAND
160-165: Sl silty gravelly SAND
165-170: Sl gravelly, sl silty SAND
170-175: Sl silty gravelly SAND
175-185: Silty sandy GRAVEL
185-210: SAND
210-245: Silty sandy GRAVEL
245-250: Sl silty gravelly SAND
250-265: Silty sandy GRAVEL
265-270: Sl silty gravelly SAND
270-275: Silty sandy GRAVEL



Elevation of reference point: [664.23 ft]
(top of casing)
Height of reference point above [1.6-ft]
ground surface

Depth of surface seal [3.8-241.5-ft]
Type of surface seal:
Bentonite crumbles,
3.8-241.5-ft
Has 4-ft x 4-ft x 6-in
concrete pad extending
3.8-ft into annulus

4-in ID stainless steel casing,
+1.6-255.7-ft

Hole diameter, 9-in nominal
3.8-278.3-ft

Volclay pellets
241.5-247.8-ft

Silica sand pack,
247.8-278.3-ft, 20-30-mesh

4-in stainless steel screen,
255.7-275.7-ft, #20-slot

8-in stainless steel telescoping screen,
268.0-278-ft, #30-slot

Borehole drilled depth: [278.3-ft]

Drawing By: RKL/2E33-28.ASB
Date : 13Sep93
Reference : HANFORD WELLS

Figure C-5. Well 299-E33-28 Construction and Completion Summary

```
                      SUMMARY OF CONSTRUCTION DATA AND FIELD OBSERVATIONS
                             RESOURCE PROTECTION WELL - 299-E33-28

WELL DESIGNATION     :    299-E33-28
RCRA FACILITY        :    Low Level Burial Grounds - WMA-1
CERCLA UNIT          :    200 Aggregate Area Management Study (200-BP-1)
HANFORD COORDINATES  :    N  45,596   W    54,668 [07Dec87-200E]
LAMBERT COORDINATES  :    N 450,758   E 2,240,540 [HANCONV]
DATE DRILLED         :    Nov87
DEPTH DRILLED  (GS)  :    278-ft
MEASURED DEPTH (GS)  :    275-ft, Nov89 TV
DEPTH TO WATER (GS)  :    257-ft, Oct87;
                          260.8-ft, 25Jun93
CASING DIAMETER      :    4-in, stainless steel, +1.6-255.7-ft
ELEV TOP OF CASING   :    664.23-ft,          [07Dec87-200E]
ELEV GROUND SURFACE  :    662.66, Brass cap [07Dec87-200E]
PERFORATED INTERVAL  :    Not applicable
SCREENED INTERVAL    :    255.7-275.7-ft, 4-in, #20-slot stainless steel
COMMENTS             :    FIELD INSPECTION, 06Feb90
                          4-in stainless steel casing. 4x4-ft concrete pad.  4 posts.
                          Well identification stamped on brass cap in pad.
                          Not in radiation zone.
                          OTHER:
AVAILABLE LOGS       :    Geologist
TV SCAN COMMENTS     :    19Nov89, depths referenced to ground surface;
                          Depth to bottom: 275-ft
                          Bottom of casing: 275-ft
                          Depth to water: 259.9-ft
                          Screen: 256-275-ft
                          Clean, ready for sampling.
DATE EVALUATED       :    13Nov90
EVAL RECOMMENDATION  :    1.  No remediation required.  Surface seal is 3 3/4-ft, not >18-ft per WAC 173-160.
LISTED USE           :    LLBG monthly water level measurement, 02Dec87-25Jun93;
CURRENT USER         :    WHC ES&M w/1 monitoring and RCRA sampling,
                          WHC ER monitoring
PUMP TYPE            :    Hydrostar, intake at 274.9-ft, (top-of-casing).
MAINTENANCE          :    12Oct89; Removed hydrostar pump for camera survey.
                          19Oct89; TV camera survey.
                          02Nov89; TV camera survey.
                          28Nov89; Reinstalled hydrostar pump.
```

Figure C-5. Well 299-E33-28 Construction and Completion Summary (continued)

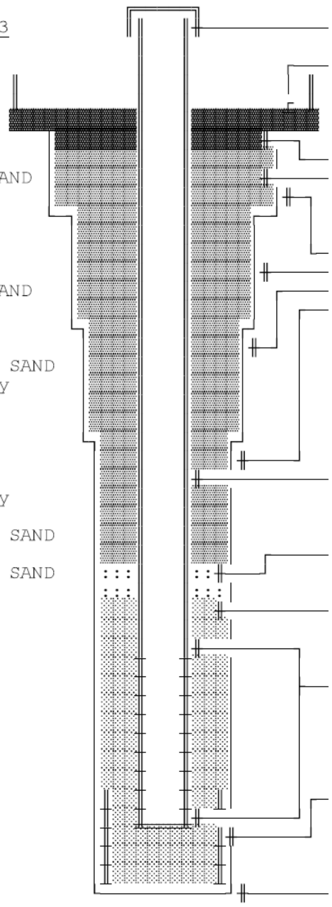
WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method: Cable tool	Sample Method: Drive barrel Hard tool	WELL NUMBER: 299-E33-29
Drilling Fluid Used: 200 E Water Supply	Additives Used: Not documented	TEMPORARY WELL NO:
Driller's Name: Murphy/Robinson	WA State Lic Nr:	Hanford Coordinates: N/S N 45,124 E/W W 54,665
Drilling Company: Kaiser Engineers	Company Location: Hanford	State Coordinates: N 450,285 E 2,240,544
Date Started: 17Aug87	Date Complete: 30Sep87	Start Card #: Not documented T____ R____ S________
		Elevation Ground surface: 671.53-ft (Brass cap)

Depth to water: 265.7-ft Sep87
(Ground surface) 269.7-ft 25Jun93

GENERALIZED Geologist's
STRATIGRAPHY Log

0-5: GRAVEL
5-55: Silty sandy GRAVEL
55-60: Slightly silty gravelly SAND
60-70: Slightly silty, slightly gravelly SAND
70-75: Slightly silty SAND
75-80: Slightly gravelly SAND
80-85: Gravelly SAND
85-90: Slightly silty gravelly SAND
90-95: SAND
95-105: Slightly gravelly SAND
105-120: SAND
120-125: Slightly silty gravelly SAND
125-130: Slightly silty, slightly gravelly SAND
130-135: Slightly silty SAND
135-140: SAND
140-145: Slightly silty SAND
145-150: Slightly gravelly SAND
150-160: Slightly silty, slightly gravelly SAND
160-165: Slightly silty gravelly SAND
165-180: Slightly gravelly SAND
180-185: Slightly silty gravelly SAND
185-205: SAND
205-215: Sandy SILT
215-250: Silty sandy GRAVEL
250-255: Sandy GRAVEL
255-280: Silty sandy GRAVEL
280-285: SAND
285-290: GRAVEL
290 : BASALT



Elevation of reference point: [673.77-ft]
(top of casing)
Height of reference point above [2.2-ft]
ground surface
Depth of surface seal [0-252.2-ft]
Type of surface seal
Portland cement to 5.0-ft
Bentonite crumbles,
5-252.2-ft

Hole diameter
0-57.4-ft, 17-in nominal
57.4-134.5-ft, 13-in nominal
134.5-204.2-ft, 11-in nominal
204.2-290.5-ft, 9-in nominal

4-in ID stainless steel casing,
+2.2-252.2-ft

Bentonite pellets,
252.2-257.0-ft

Silica sand pack,
257.0-290.5-ft, 20-30 mesh

4-in stainless steel screen,
262.8-282.8-ft, #20-slot

8-in stainless steel telescoping screen,
279.5-289.5-ft, #30-slot

Borehole drilled depth: [290.5-ft]

Drawing By: RKL/2E33-29.ASB
Date : 13Sep93
Reference : HANFORD WELLS

Figure C-6. Well 299-E33-29 Construction and Completion Summary

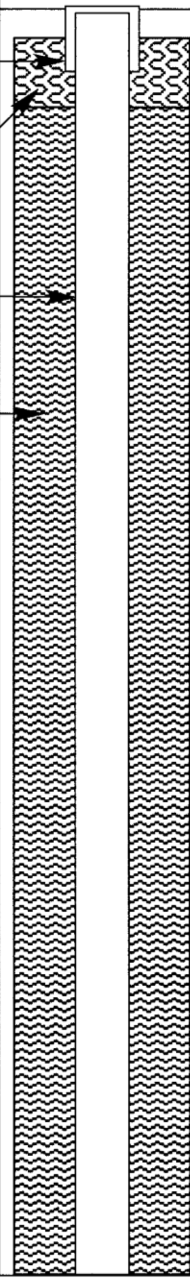
```
                    SUMMARY OF CONSTRUCTION DATA AND FIELD OBSERVATIONS
                           RESOURCE PROTECTION WELL - 299-E33-29

WELL DESIGNATION     :    299-E33-29
RCRA FACILITY        :    Low Level Burial Grounds, 218-E-10
CERCLA UNIT          :    200 Aggregate Area Management Study (200-BP-5)
HANFORD COORDINATES :     N  45,124   W    54,665 [07Dec87]
LAMBERT COORDINATES :     N 450,285   E 2,240,544 [HANCONV]
DATE DRILLED         :    Sep87
DEPTH DRILLED  (GS) :     290.0-ft
MEASURED DEPTH (GS) :     Not documented
DEPTH TO WATER (GS) :     265.7-ft, Sep87,
                          269.7-ft, 25Jun93
CASING DIAMETER      :    4-in, stainless steel, +2.2-262.8-ft.
ELEV TOP CASING      :    673.77-ft,           [07Dec87]
ELEV GROUND SURFACE :     671.53-ft, Brass cap [07Dec87]
PERFORATED INTERVAL :     Not applicable
SCREENED INTERVAL    :    4-in, 262.8-282.8-ft;
                          8-in, 279.5-289.5-ft
COMMENTS             :    FIELD INSPECTION, 02Jun90,
                          4-in stainless steel casing, no protective casing.  Capped and locked.
                          4-ft by 4-ft concrete pad, 4 posts, brass marker with stamped ID.
                          OTHER;
AVAILABLE LOGS       :    Geologist, Driller
TV SCAN COMMENTS     :    Not applicable
DATE EVALUATED       :    Not applicable
EVAL RECOMMENDATION :     Not applicable
LISTED USE           :    LLBG monthly water level measurement, 01Dec87-25Jun93;
CURRENT USER         :    WHC ES&M w/l monitoring and RCRA sampling,
                          WHC ER characterization
PUMP TYPE            :    Hydrostar
MAINTENANCE          :
```

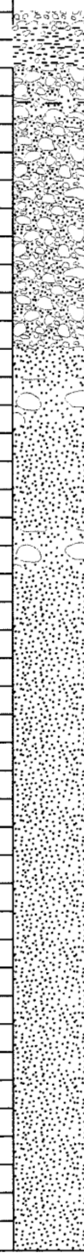
Figure C-6. Well 299-E33-29 Construction and Completion Summary (continued)

WELL SUMMARY SHEET		Start Date: 4/9/10 Finish Date: 4/26/10	Page 1 of 2
Well ID: C7565		Well Name: 299-E33-266	
Location: 100 m W of 299-E33-30		Project: 5 M-24 RCRA Monitoring Wells	
Prepared By: Ryan W. Brauchla	Date: 4/28/10	Reviewed By: L.D. Walker	Date: 8/9/10
Signature: [signature]		Signature: [signature]	

CONSTRUCTION DATA

Description	Diagram
Stainless Steel Protective Casing: 3.0 ft above ground surface Portland Cement Type I/II: 0 - 10.2 ft bgs 4-in I.D. Stainless Steel Type 304, Permanent Blank Casing: + 2.06 - 263.05 ft bgs Granular Bentonite Crumbles: 10.2 - 252.3 ft bgs All temporary drill casing was removed from the ground. All depths are in feet below ground surface. Borehole drilled with 9-inch O.D. casing. 0.0 - 286.06 ft bgs	

GEOLOGIC/HYDROLOGIC DATA



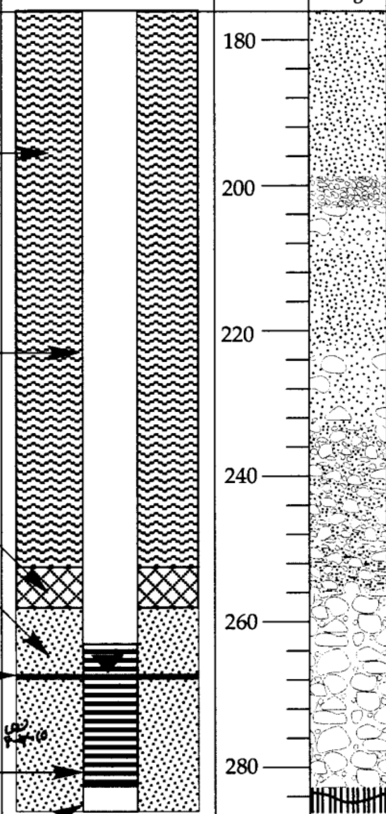
Depth in Feet	Lithologic Description/Groundwater Sample Depths (ft bgs)
0	0-1 Gravel (G)
	1-8 Gravelly Silt (gM)
	8-12 Sandy Gravel (sG)
	12-15 Silty Sandy Gravel (msG)
	15-48 Sandy Gravel (sG)
20	
40	
	48-52 Sand (S)
	52-59 Gravelly Sand (gS)
60	59-74 Sand (S)
	74-79 Gravelly Sand (gS)
80	79-199 Sand (S)
100	
120	
140	
160	

Figure C-7. Well 299-E33-266 Well Summary Sheet

WELL SUMMARY SHEET		Start Date: 4/9/10 Finish Date: 4/26/10	Page 2 of 2
Well ID: C7565		Well Name: 299-E33-266	
Location: 100 m W of 299-E33-30		Project: 5 M-24 RCRA Monitoring Wells	
Prepared By: Ryan W. Brauchla	Date: 4/28/10	Reviewed By: L.D. Walker	Date: 8-9-10
Signature: [signature]		Signature: [signature]	

CONSTRUCTION DATA

Description
Granular Bentonite Crumbles: 10.2 - 252.3 ft bgs
4-in I.D. Stainless Steel Type 304, Permanent Blank Casing: + 2.06 - 263.05 ft bgs
1/4-in Bentonite Pellets: 252.3 - 258.2 ft bgs
Primary Filter Pack 10-20 Mesh Colorado Silica Sand: 258.2 - 286.06 ft bgs
Static Water Level 267.72 ft bgs (4/26/10)
4-in I.D. Stainless Steel Type ~~304,~~ 316 20 Slot (0.020-in) Screen: 263.05- 283.07 ft bgs
4-in, I.D. Stainless Steel Sump/End Cap: 283.07 - 286.06 ft bgs
All temporary drill casing was removed from the ground.
All depths are in feet below ground surface.
Borehole drilled with 9-inch O.D. casing. 0.0 - 286.06 ft bgs



GEOLOGIC/HYDROLOGIC DATA

Lithologic Description/Groundwater Sample Depths (ft bgs)
79-199 Sand (S)
199-203 Gravel (G)
203-209 Gravelly Sand (gS)
209-222 Sand (S)
222-233 Gravelly Sand (gS)
233-251 Sandy Gravel (sG)
251-256 Silty Sandy Gravel (msG)
256-283 Gravel (G)
283-286.06 Basalt
Total Depth Drilled: 286.06 ft bgs (4/23/10)

Figure C-7. Well 299-E33-266 Well Summary Sheet (continued)

C2 Reference

NAVD88, 1988, *North American Vertical Datum of 1988*, National Geodetic Survey, Federal Geodetic Control Committee, Silver Spring, Maryland. Available at: http://www.ngs.noaa.gov/.