DOE/RL-2009-76
Revision 1

Interim Status Groundwater Monitoring Plan for the LLBG WMA-2

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

U.S. DEPARTMENT OF ENERGY | Richland Operations Office

P.O. Box 550
Richland, Washington 99352

Approved for Public Release;
Further Dissemination Unlimited

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Terms

AEA	*Atomic Energy Act of 1954*
CCUg	Cold Creek unit gravel
DOE	U.S. Department of Energy
DWMU	dangerous waste management unit
Ecology	Washington State Department of Ecology
ECN	engineering change notice
EPA	U.S. Environmental Protection Agency
FWS	Field Work Supervisor
Hf1	Hanford formation unit 1
Hf2	Hanford formation unit 2
Hf3	Hanford formation unit 3
LLBG	Low-Level Burial Grounds
QAPjP	quality assurance project plan
PCB	polychlorinated biphenyl
RCRA	*Resource Conservation and Recovery Act of 1976*
SVOC	semivolatile organic compound
TOC	total organic carbon
TOX	total organic halogen
TPH	total petroleum hydrocarbons
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order*
UPR	unplanned release
VOC	volatile organic compound
WMA	waste management area

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1 Introduction

This document presents a groundwater monitoring program for Low-Level Burial Grounds (LLBG) Waste Management Area (WMA)-2, and when issued into the operating record, becomes the principal controlling document for conducting groundwater monitoring under the dangerous waste regulations (WAC 173-303, "Dangerous Waste Regulations") at LLBG WMA-2, superseding the previous plan (RCRA-CN-01_DOE/RL-2009-76_R0, *Interim Status Change Number 1: Interim Status Groundwater Monitoring Plan for the LLBG WMA-2*).

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, "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 required by 40 CFR 265.90(a) and (b), "Applicability," and is intended to satisfy groundwater monitoring requirements applicable to interim status treatment, storage, and disposal units (referred to as dangerous waste management units [DWMUs] in this plan), and monitors for indicator parameters in groundwater samples that are used to determine whether dangerous waste or dangerous waste constituents have entered the groundwater. This plan also monitors parameters used in establishing groundwater quality.

Revision 0 of this groundwater monitoring plan was issued in 2010. The U.S. Department of Energy (DOE) is revising the plan for LLBG WMA-2 to provide updated information on the geology, hydrology, contamination migration conceptual model, and monitoring results since Rev. 0 was issued, and revise the well network, monitoring constituents, and sampling frequency.

LLBG WMA-2 overlies the 200-BP-5 Groundwater Operable Unit in the northeastern corner of the 200 East Area (Figure 1-1) of the Hanford Site and consists of the 218-E-12B Burial Ground, which contains 39 unlined trenches and Trench 94. LLBG WMA-2 began receiving waste in 1967 and continues to receive U.S. Navy vessel reactor compartments in Trench 94. The other trenches contain nondangerous, unsegregated, low-level waste that have been covered with soil. Trench 94 is the only portion of the burial ground that actively receives waste.

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* (hereinafter referred to as the Hanford Facility RCRA Permit), LLBG WMA-2 will continue under interim status until it is incorporated into Part III, V, and/or VI of the Hanford Facility RCRA Permit (or its successor) or until interim status is terminated. Therefore, groundwater monitoring for LLBG WMA-2 continues under interim status requirements. For regulatory purposes, the boundary of LLBG WMA-2 is identified on the Hanford Facility RCRA Permit Part A Form.

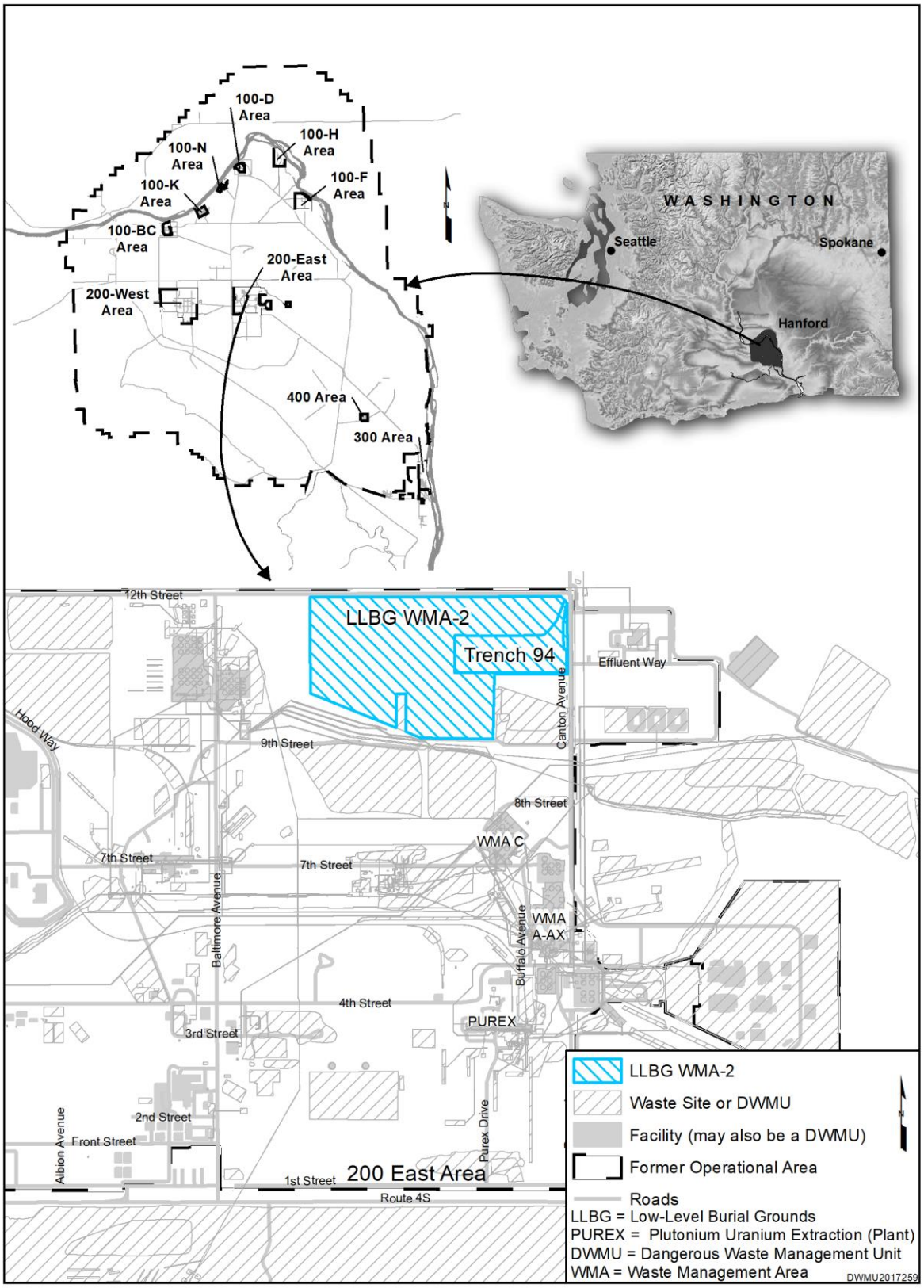

Figure 1-1. Location Map for LLBG WMA-2

This groundwater monitoring plan 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 LLBG WMA-2 and the regulatory basis, types of waste present, and pertinent geology and hydrogeology beneath LLBG WMA-2, and it presents a brief history of groundwater monitoring. This information is summarized as a contaminant migration conceptual model to support development of the groundwater monitoring program.
- Chapter 3 describes the groundwater monitoring program, including the wells in the monitoring network, constituents analyzed, and sampling frequency.
- Chapter 4 describes data evaluation and reporting.
- Chapter 5 provides an 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) and the analytical methods for LLBG WMA-2 sampling constituents.
- Appendix B contains sampling protocols.
- Appendix C provides information for the wells within the groundwater monitoring network.

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2 Background

This chapter describes LLBG WMA-2 and its operating history, regulatory basis, wastes and waste characteristics associated with the unit, local subsurface geology and hydrogeology, a summary of previous groundwater monitoring, and the contaminant migration conceptual model.

2.1 Facility Description and Operational History

LLBG WMA-2 comprises 39 trenches that received nondangerous waste and Trench 94. LLBG WMA-2 covers 70 ha (173 ac), including the western annexed portion that was never used (Figure 2-1).

The 39 trenches at the 218-E-12B Burial Ground, which are oriented north-south, were placed into service in 1967 and received waste until 2004. Trench 94 is an open trench used for receipt and disposal of offsite defueled U.S. Navy reactor compartments. Trench 94 began receiving reactor compartments in 1986 and still actively receives these units.

The reactor compartments within Trench 94 are stored aboveground on concrete blocks and comprise the reactor vessel, steam generator, main coolant pump, and associated valves and piping. Each reactor compartment contains approximately 200 tons of lead that was used for shielding protection of the vessel crew while the reactor was in use; during decommissioning and disposal of the vessel; and during the preparation, transportation, and disposal of the reactor compartments (Section 6.10 in WHC-EP-0912, *The History of the 200 Area Burial Ground Facilities*).

In 1995, an unplanned release (UPR) of diesel fuel was reported in Trench 94 (e.g., waste site 200-E-8). Analytical results confirmed that the spill was number 2 diesel fuel (38 to 57 L [10 to 15 gal]). The impacted soil was excavated and disposed.

West-southwest of LLBG WMA-2, two UPRs of crude product occurred (Figure 2-2). Neither UPR, which are described as follows, originated from LLBG WMA-2:

- UPR-200-E-32 occurred in November 1963, when the 207-B Retention Basin was contaminated with the cesium-rare earth fraction of the fission product stream, primarily cerium-144, after a coil leak developed in the 221-B Building tank 6-1 (Section 10.1 in BHI-00179, *B Plant Aggregate Area Management Study Technical Baseline Report*). After damming the 216-B-2-1 Ditch at a location 305 m (1,000 ft) from its head, the contaminated basin water was flushed into the ditch. The total volume of liquid discharged to the ditch during this incident was estimated to be 4,900,000 L (1,300,000 gal), 4,200,000 L (1,100,000 gal) of which was low-activity level cooling water.
- UPR-200-E-138 occurred in March 1970, when an estimated release of 1,000 Ci of strontium-90 occurred during an attempt to measure the liquid level of product storage tank 8-1 (located in the 221-B Building). Several small water hoses were used to spray down the waste to the B Plant floor drain and chemical sewer that led to the 216-B-2-2 Ditch (Section 10.2 in BHI-00179).

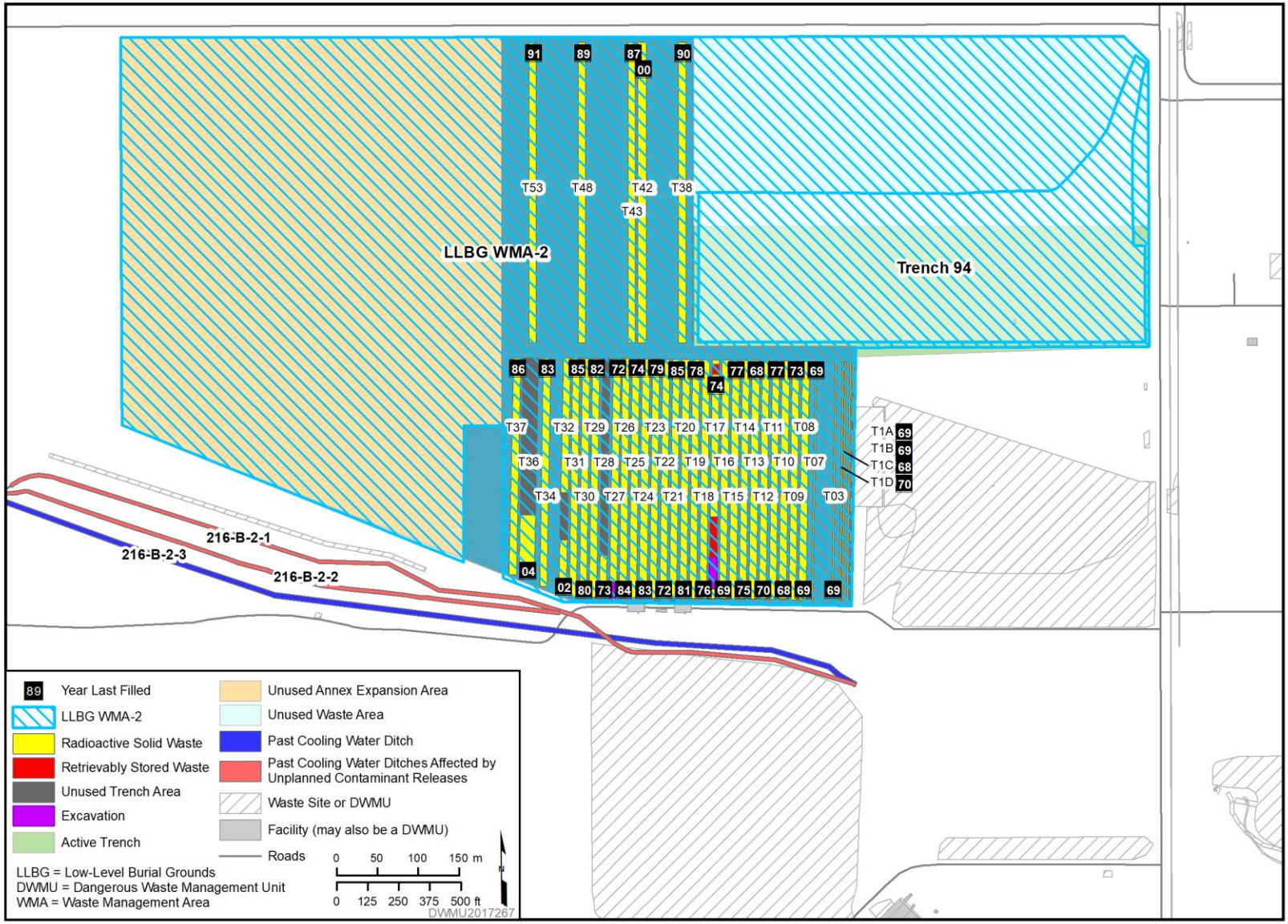


Figure 2-1. Schematic for LLBG WMA-2

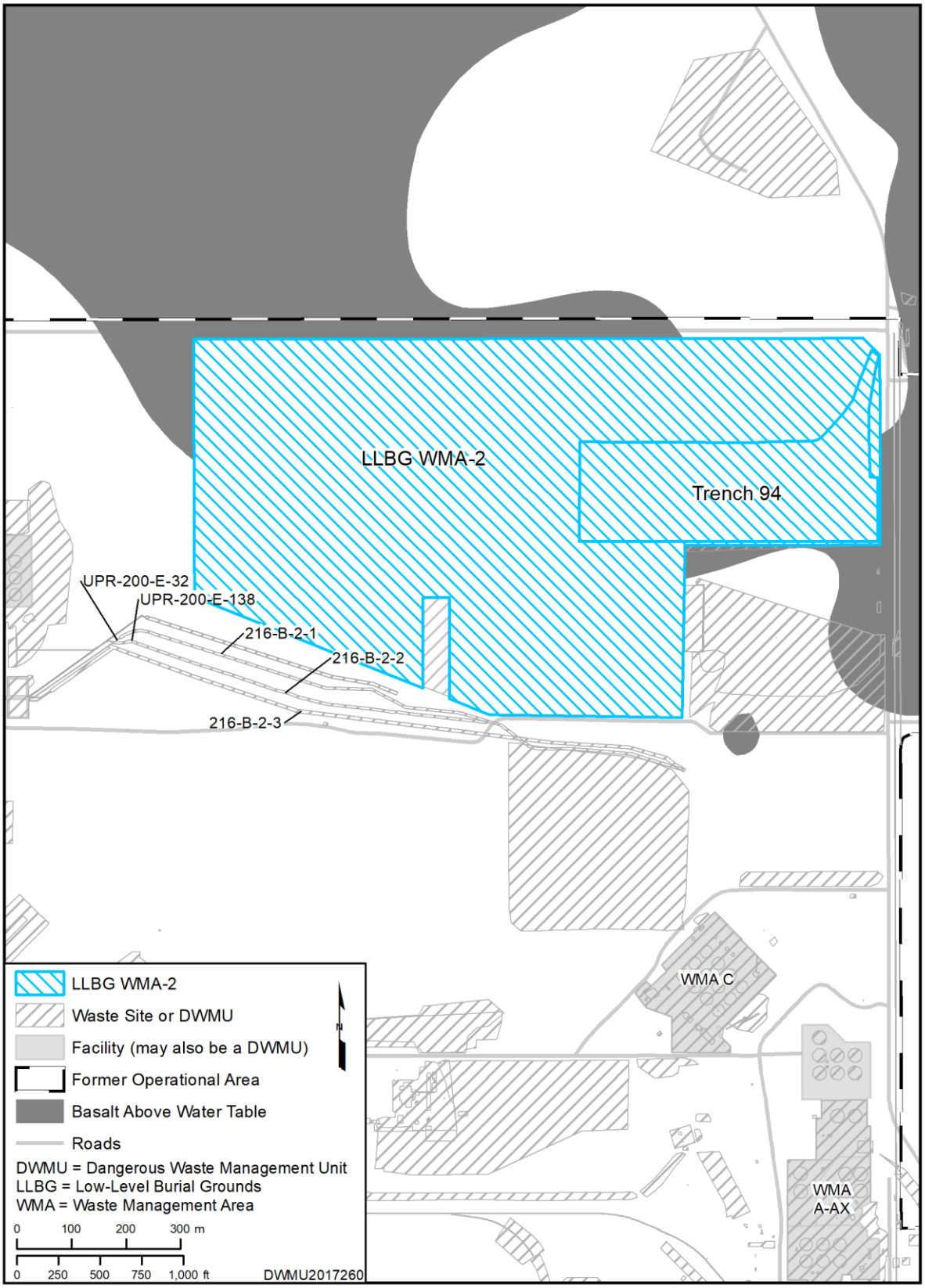


Figure 2-2. LLBG WMA-2 and 216-B-2 Ditches

In 1986, a wetting front was observed in Trench 36 of LLBG WMA-2, which was subsequently determined to be associated with plugging of the unlined 216-B-2-3 Ditch. Based on the investigation results, cooling water was determined to have migrated laterally from the 216-B-2-3 Ditch northeast to Trench 36 (Chapter 7.0 in WHC-SD-WM-TI-260, *Water Inflow Investigation at the 218-E12A and 218-E-12B Burial Grounds*). Although the liquid release volumes from UPR-200-E-32 and UPR-200-E-138 were insignificant, the later wetting front from the infiltrating cooling water of the plugged 216-B-2-3 Ditch appeared to have mobilized contaminants from these earlier releases, thereby affecting groundwater quality (Chapter 5.0 in WHC-SD-WM-TI-260).

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. Ecology gained regulatory authority over the hazardous waste components of mixed waste on August 19, 1987.

In May 1989, DOE, the U.S. Environmental Protection Agency (EPA), and Ecology signed 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 LLBG WMA-2. Groundwater monitoring is conducted at LLBG WMA-2 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 DWMU have entered the groundwater in the uppermost aquifer underlying the unit.

Dangerous waste is regulated under RCW 70.105, "Hazardous Waste Management," and its Washington State implementing regulations (WAC 173-303). Radionuclides in mixed waste may include "source, special nuclear, and byproduct materials" as defined in the *Atomic Energy Act of 1954* (AEA). The AEA states that these radionuclide materials are regulated at DOE facilities, exclusively by 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.

An interim status indicator parameter groundwater monitoring program (PNL-6772, *A Detection-Level Hazardous Waste Ground-Water Monitoring Compliance Plan for the 200 Areas Low-Level Burial Grounds and Retrievable Storage Units*) was initiated in 1987 at LLBG WMA-2 in accordance with 40 CFR 265, Subpart F (as referenced by WAC 173-303-400[3]). The indicator parameter monitoring program since continued with the most recent plan (DOE/RL-2009-76, *Interim Status Groundwater Monitoring Plan for the LLBG WMA-2*) issued in 2010 and modified in 2020 by change notice (RCRA-CN-01_DOE/RL-2009-76_R0).

2.3 Waste Characteristics

Within LLBG WMA-2, Trench 94 is actively used for receipt and disposal of offsite, defueled U.S. Navy reactor compartments. Approximately 200 tons of lead is integrated as shielding into, and surrounding, each reactor compartment (WHC-EP-0912). The reactor compartments are unique integrated and welded steel structures that form a sealed containment barrier for the internal material. The minimum thickness of the containment barrier is typically 1.9 cm (0.75 in).

The reactor compartments contain polychlorinated biphenyl (PCBs) in solid form, tightly bound within the matrix of industrial materials (e.g., rubber, thermal insulation) (Section 4.3.3.3.3 in EIS-0259, *Final Environmental Impact Statement on the Disposal of Decommissioned, Defueled Cruiser, Ohio Class, and Los Angeles Class Naval Reactor Plants*). The PCB-bearing materials are sealed within the welded steel containment barriers of the reactor compartments. PCBs at LLBG Trench 94 are exempt under

WAC 173-303-071(k)(i)(B), "Excluded Categories of Waste." PCBs are regulated under the *Toxic Substances Control Act of 1976*.

Other than Trench 94, the 218-E-12B Burial Ground trenches contain nondangerous, solid, low-level radiological waste.

2.4 Geology and Hydrogeology

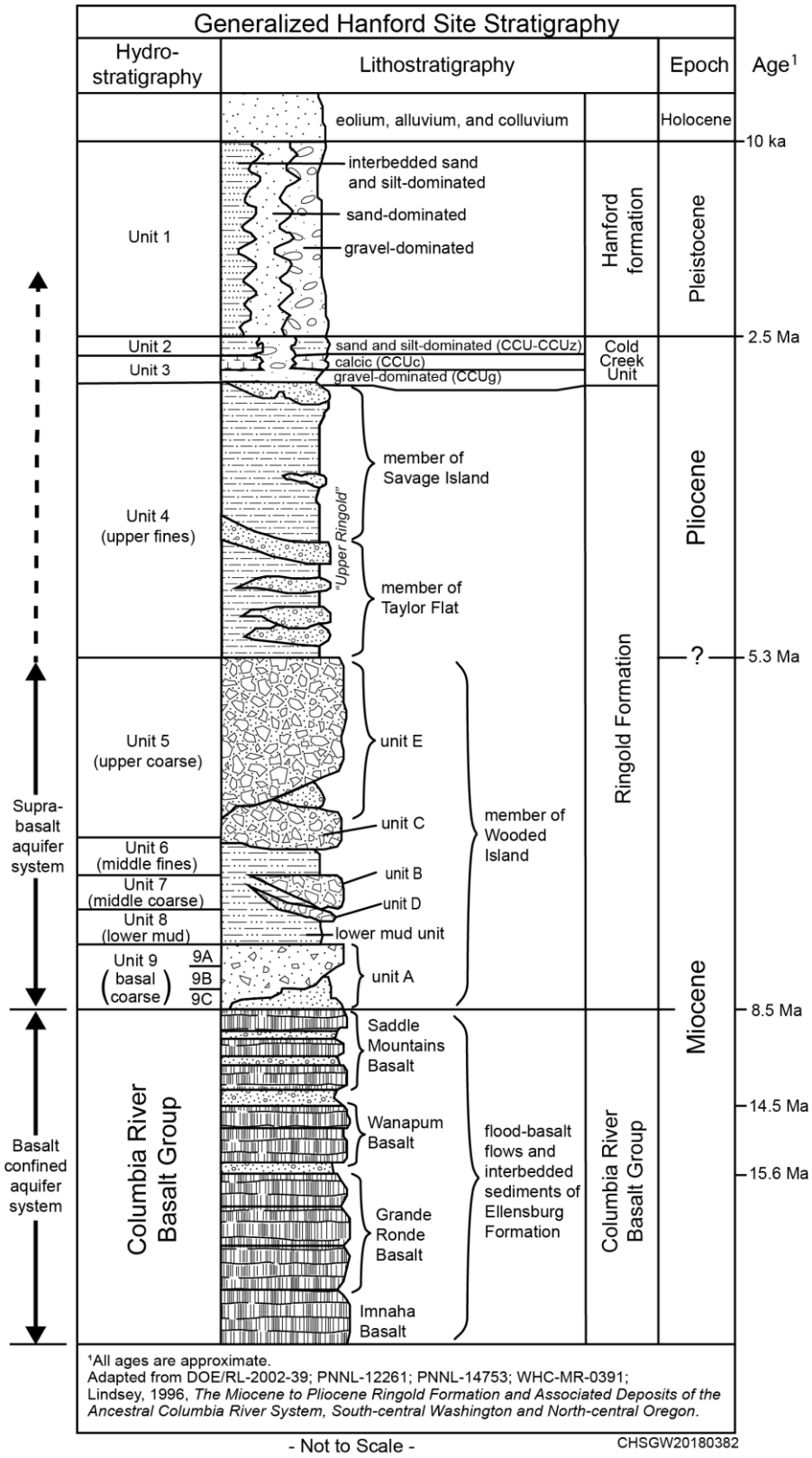
This section describes the local geology and hydrogeology beneath LLBG WMA-2 and is intended to provide a brief overview of the current understanding of the site. This section focuses on the area at Trench 94 where the regulated dangerous waste in LLBG WMA-2 is located. The information provided is summarized from several sources, including: Section 3.1.3 in WHC-SD-EN-TI-012, *Geologic Setting of the 200 East Area; An Update*; Section 5.4.1.1 in WHC-SD-EN-TI-019, *Hydrogeologic Model for the 200 East Groundwater Aggregate Area*; Section 2.5 in PNNL-19277, *Conceptual Models for Migration of Key Groundwater Contaminants Through the Vadose Zone and Into the Unconfined Aquifer Below the B-Complex*); and Section 4.3.1 in supporting document WHC-MR-0204, *200-East and 200-West Areas Low-Level Burial Grounds Borehole Summary Report*. PNL-6820, *Hydrogeology of the 200 Areas Low-Level Burial Grounds -- An Interim Report: Volume 1: Text*, and PNL-6820, *Hydrogeology of the 200 Areas Low Level Burial Grounds -- An Interim Report: Volume 2: Appendixes*, provide analytical, geophysical, hydrogeological, and lithological results used to differentiate various geologic facies at Trench 94 during installation of the initial monitoring network. The information provided in the following sections provides the most updated geologic information and is in alignment with ECF-HANFORD-13-0029, *Development of the Hanford South Geologic Framework Model, Hanford Site, Washington*, and ECF-HANFORD-18-0035, *Central Plateau Vadose Zone Geoframework*.

In addition, Chapter 3 in PNNL-12261, *Revised Hydrogeology for the Suprabasalt Aquifer System, 200-East Area and Vicinity, Hanford Site, Washington*; Section 2.2 in SGW-54165, *Evaluation of the Unconfined Aquifer Hydraulic Gradient Beneath the 200 East Area, Hanford Site*; Sections 4.1 and 4.2 in SGW-52467, *Integrated Surface Geophysical Investigation Results at Liquid Effluent Retention Facility, 200 East Area, Hanford, Washington*, and Chapter 4.0 in WHC-SD-EN-TI-012 provide information on the hydrogeology of the 200 East Area and vicinity.

2.4.1 Stratigraphy

The generalized stratigraphy of the Hanford Site is shown in Figure 2-3. Geologic cross sections show the units underlying the area (Figures 2-4 through 2-6). The stratigraphy beneath the LLBG WMA-2 area consists of approximately 76 m (250 ft) of unconsolidated to semiconsolidated sediments overlying basalt bedrock of the Columbia River Basalt Group. The sedimentary units present beneath Trench 94 are (from youngest to oldest) as follows:

- Sand and gravel backfill, and scattered amounts of eolian silty sand
- Sand and gravel of the Hanford formation:
  - Upper gravel-dominated facies (Hanford formation unit 1 [Hf1])
  - Middle sand-dominated facies (Hanford formation unit 2 [Hf2])
  - Lower gravel-dominated facies (Hanford formation unit 3 [Hf3])
  - Gravel deposits of the Cold Creek unit (CCUg)



Note: Complete reference citations are provided in Chapter 6.

Figure 2-3. General Stratigraphy at the Hanford Site

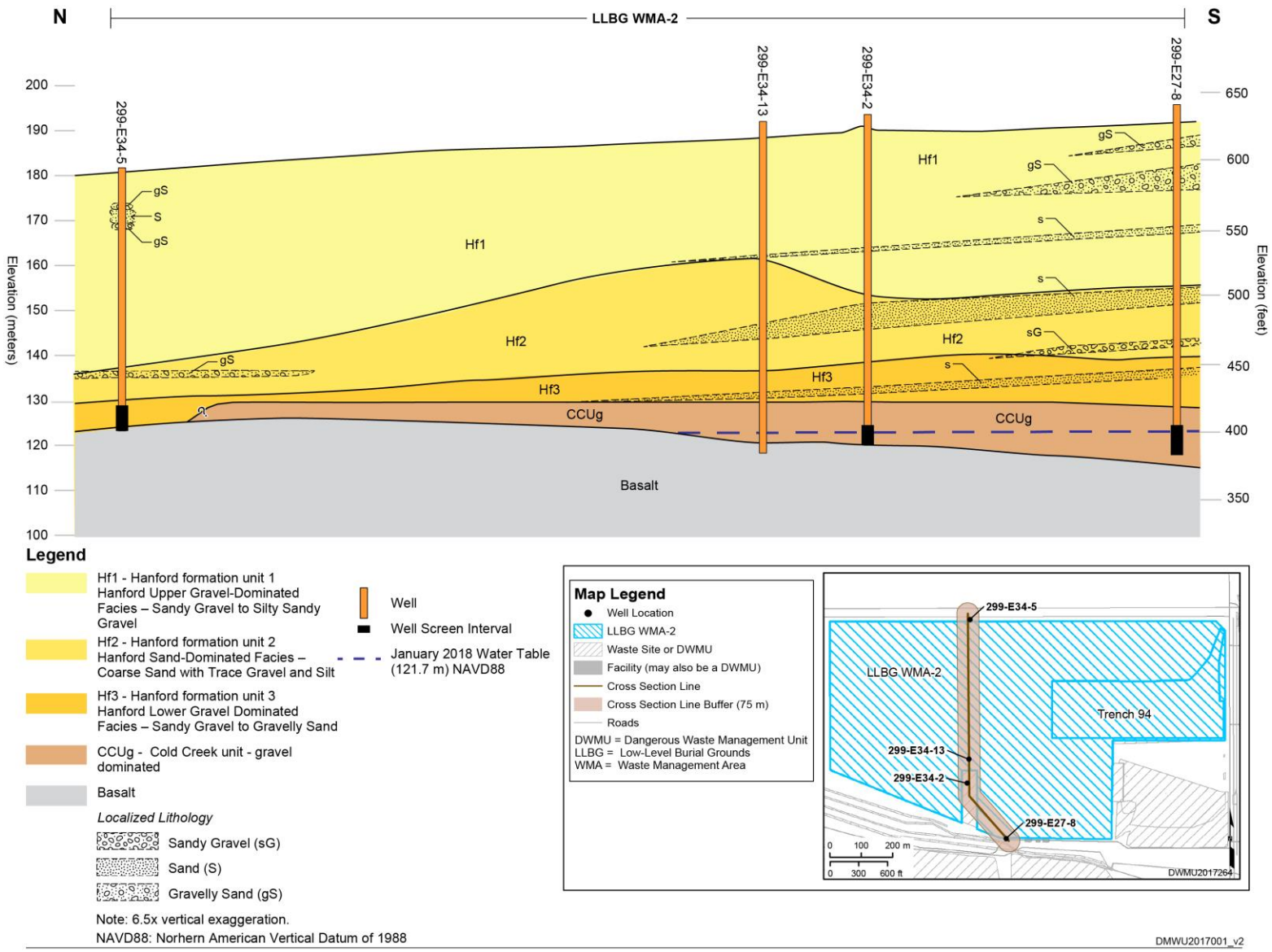


Figure 2-4. North to South Geologic Cross Section of LLBG WMA-2

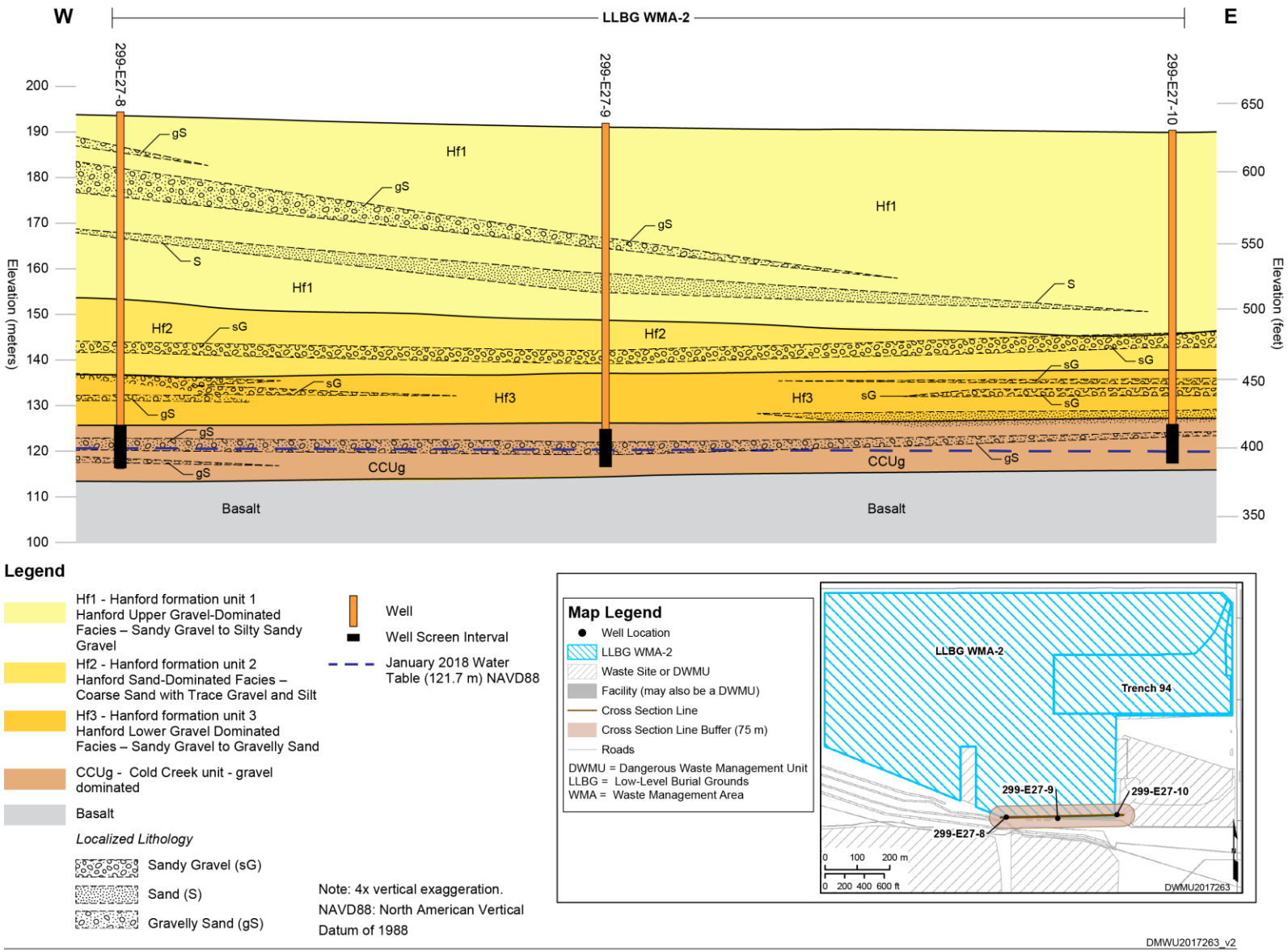


Figure 2-5. West to East Geologic Cross Section of LLBG WMA-2

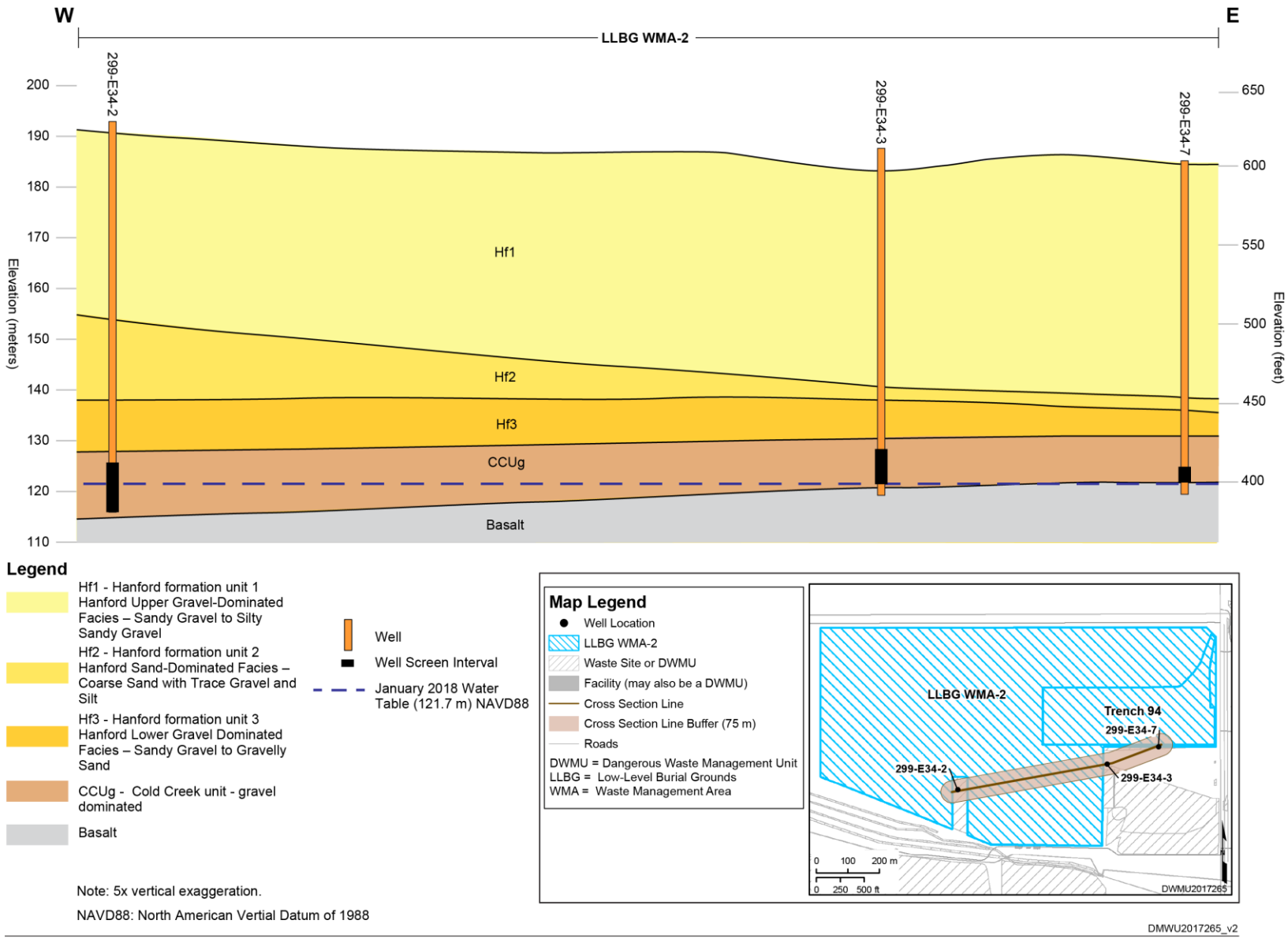


Figure 2-6. Southwest to Northeast Cross Section of LLBG WMA-2

The Hanford formation (equivalent to hydrostratgraphic unit 1) is an informal stratigraphic unit consisting of uncemented gravel, sand, and silt deposited by the late Pleistoscene Missoula cataclysmic glacial floods (Section 3.1.3.3 in WHC-SD-EN-TI-012). The Hanford formation consists of three facies subunits (e.g., silt dominated, sand dominated, and gravel dominated), which grade into one another both vertically and laterally with distance from the main, high-energy flood currents (Section 2.5.2 in PNNL-19277). On the Central Plateau, the Hanford formation is sometimes further delineated into Hf1, Hf2, and Hf3 lithostratigraphic sequences. Hf1 and Hf3 gravel sequences are sometimes difficult to differentiate in those areas where the intervening sandy Hf2 sequence is absent. Units Hf1 and Hf3 consist of coarse-grained, basalt-rich, sandy gravels with varying amounts of silt/clay. The Hf2 sequence is dominated by sand to gravelly sand, with minor sandy gravel or silt/clay interbeds. Both the sand-dominated and gravel-dominated sequences are present (Figures 2-4 through 2-6).

The Hanford formation upper gravel-dominated sequence (Hf1) is the shallowest stratigraphic unit present and overlies the Hanford formation sand-dominated sequence (Hf2) (Figures 2-4 through 2-6). Based on observations of outcrop and intact core samples, the Hanford formation gravel sequence is interpreted to consist of the high-energy, gravel-dominated facies interbedded with lenticular and discontinuous layers of the sand-dominated facies. Silt-dominated facies may also be present, although they probably constitute a relatively small percentage of the total. Cementation was not observed in the Hf1 unit, and total calcium carbonate content is generally a few weight percent or less. The poorly sorted Hf1 sequence consists of uncemented, matrix-poor, cross-stratified, coarse-grained sands and pebble to boulder-sized gravel.

The Hanford formation sand-dominated facies (Hf2) overlies the lower gravel-dominated facies (Hf3) beneath the central and western part of Trench 94 and thickens from east to west (Figures 2-4 through 2-6). Fine- to coarse-grained sand dominates the Hf2 sequence with lenses of silty sand to sandy gravel. Cementation is very minor or absent in the Hf2 unit, and total calcium carbonate ($CaCO_3$) content is generally a few weight percent or less. The silt content of Hf2 is generally below 8%; however, 10% to 12% silt is occasionally observed near the top of the graded gravelly sand and sand sequences (Figure 2-7). These finer-grained lenses can be continuous to distances of several hundred meters and are capable of generating temporary perched water horizons (Sections 2.1 and 2.2 in WHC-SD-WM-TI-260, and Section 2.1.8.1 in WHC-SD-WM-TI-730, *Performance Assessment for the Disposal of Low-Level Waste in the 200 East Area Burial Grounds*) (Figures 2-4 through 2-6). In the northeast part of Trench 94, the Hf2 appears to have been incised by high-energy ice age floods associated with the Hanford upper gravel-dominated facies (Figure 2-1). The Hf2 unit is predominantly a gravelly sand and dips to the east-northeast.

The unconsolidated lower gravel-dominated facies of the Hanford formation (Hf3) overlies the CCUg (Figures 2-4 through 2-6) and generally consists of poorly sorted pebble to boulder gravel, fine- to coarse-grained basaltic sand, and variable amounts of silt. Discontinuous sand and silt beds may be interbedded throughout sequences of gravel-dominated facies. Gravel clasts are predominantly basalt, which range from 60% to 80% (Section 3.2.3.1 in DOE/RL-2002-39, *Standardized Stratigraphic Nomenclature for Post-Ringold-Formation Sediments Within the Central Pasco Basin*), with lesser amounts of granite, quartzite, and gneiss clasts (Section 3.1.3.3 in WHC-SD-EN-TI-012). The unconfined aquifer is contained within this facies and the CCUg. It can be difficult to distinguish the difference between the Hf3 and CCUg in areas where the intervening silt-dominated CCU is absent. The CCUg resembles the Hf3 in grain-size distribution but with a greater proportion of felsic gravel and sand and fewer basalt clasts (Section 3.1.3 in DOE/RL-2002-39).

Reference: Section 2.5.2 in PNNL-19277, *Conceptual Models for Migration of Key Groundwater Contaminants Through the Vadose Zone and Into the Unconfined Aquifer Below the B-Complex*.

Figure 2-7. Cross Section of Various Hanford Sands in the 200 East Area

The uppermost basalt unit is the Elephant Mountain Member of the Saddle Mountains Basalt Formation, at an elevation of 122 to 123.4 m (400 to 405 ft). In general, the elevation of the top of the Elephant Mountain Member basalt declines to the south toward the axis of the Cold Creek syncline.

2.4.2 Hydrogeology

Groundwater beneath LLBG WMA-2 occurs as an unconfined aquifer in glaciofluvial sediments and deeper confined aquifers within the Columbia River Basalt Group. The uppermost unconfined aquifer beneath Trench 94 occurs at approximately 125 m (410 ft) NAVD88, *North American Vertical Datum of 1988*, within the gravel-dominated facies of the Hanford formation (Hf3) and CCUg and is limited to the southern part of Trench 94 (Figures 2-4 through 2-6). The Hf3 and CCUg facies are composed of sandy gravel and silty-sandy gravel. The silt content increases to the east, which may explain the higher hydraulic conductivity at well 299-E27-8 (>730 m/d [>2,400 ft/d]) versus wells 299-E27-9 and 299-E27-10 (460 m/d [1,500 ft/d]). For the eastern portion of LLBG WMA-2, the hydraulic conductivity ranges from 1,500 to 6,700 m/d (4,920 to 21,980 ft/d) (pump test results from PNL-6820).

In the vicinity of Trench 94, the unconfined aquifer is ranging in thickness from 0 to 2.4 m (0 to 8 ft), increasing in thickness toward the southeast (Figures 2-5 and 2-6). The top of the basalt extends above the water table beneath the northern portion of Trench 94 (Figure 2-4). The base of the unconfined aquifer is conceptualized as the top of the Elephant Mountain Member of the Saddle Mountains Basalt Formation (Columbia River Basalt Group) or the top of the dense, unfractured portion of the basalt.

A seismic study in 2009 indicated the basalt surface might be either heavily weathered or fractured (SGW-52162, *Seismic Reflection Investigation at the Liquid Effluent Retention Facility, 200 East Area, Hanford Site Richland, Washington*). Based on the interpretations and basalt chip observations during a groundwater evaluation investigation near the Liquid Effluent Retention Facility (LERF) (SGW-41072, *Liquid Effluent Retention Facility Characterization Report*), it appears that the upper part of the basalt may be hydraulically connected to, or included in, the suprabasalt aquifer. Subsequent hydrologic and groundwater chemistry characterizations of the uppermost aquifer conducted during this investigation suggest that the permeable basalt flow top comprises much of the unconfined aquifer in the vicinity of the LERF basins and LLBG WMA-2 (Chapter 4 and Figure 2-1 in SGW-41702). A 2012 study that employed a suite of geophysical methods indicated the presence of the potentially permeable basalt zones in the vicinity of LERF and Trench 94 (SGW-52467).

The dense, interior portion of the basalt acts as a confining unit for underlying sedimentary interbeds, which form confined aquifers. The Rattlesnake Ridge interbed forms the uppermost, regionally extensive, confined aquifer within the Saddle Mountains Basalt Formation (Figure 2-3) (Section 6.1.1 in RHO-RE-ST-12P, *An Assessment of Aquifer Intercommunication in the B Pond-Gable Mountain Pond Area of the Hanford Site*). Groundwater flow rates within the Rattlesnake Ridge interbed have been estimated between 0.7 and 2 m/yr (2.3 and 6.6 ft/yr), which is a considerably lower flow rate than most estimates for the overlying unconfined aquifer system. The sediment comprising the interbed consists mostly of sandstone (with silts and clays) and is much less permeable than the sediment in the unconfined aquifer. In addition, the magnitude of the hydraulic gradient is generally lower than in the unconfined aquifer (Section D3.1 in DOE/RL-2017-66, *Hanford Site Groundwater Monitoring Report for 2017*). During drilling of well 699-47-50 to the northwest of Trench 94, the Rattlesnake Ridge interbed was encountered at 94 m (308 ft) elevation; it is estimated to be 17 m (56 ft) below the top of the basalt at Trench 94 and 80 m (262 ft) below ground surface.

Possible interconnection between the unconfined aquifer and confined Rattlesnake Ridge aquifer near LLBG WMA-2 does exist. A large erosional window in the Elephant Mountain Member basalt flow is located to the north and northeast of the 200 East Area in the Gable Gap area and near West Lake (Figures 15 and 16 in RHO-RE-ST-12P) and may provide a pathway for groundwater movement between the two aquifers. Additionally, two other erosional "windows" have been identified through the Elephant Mountain Member basalt (Section 6.1.3 in RHO-RE-ST-12P). This interconnection is further exemplified by the indication of upward potential movement of water determined from water-level elevation measurements conducted in 1983 (Section 6.2.2.3 in RHO-RE-ST-12P); the low barometric efficiencies in wells located near known or suspected areas of basalt erosion (Section 6.3 in RHO-RE-ST-12P); and hydrogeochemical data that indicates a pattern of mixing of unconfined waters to the Rattlesnake Ridge aquifer (Chapter 7.0 in RHO-RE-ST-12P).

2.4.3 Groundwater Flow System

During the defense operational efforts at the Hanford Site (1943 to 1995), the groundwater elevation and flow direction throughout most of the 200 East Area was influenced by the persistent hydraulic mounding associated with planned discharges in the 200 West Area and with planned discharges within and near the 200 East Area. These include large volume discharges to the 216-B-3 Pond (B Pond) system (located on the east side of the 200 East Area) and Gable Mountain Pond system (i.e., 216-A-25 Pond system, located

to the north of the 200 East Area). This groundwater mounding is evident in hydrographs and water-table maps up to, through, and in some locations beyond the 1990s. Along the east and east-central portion of the 200 East Area, the mounding generated a local hydraulic gradient to the southwest (Figures 5 through 10 in SGW-60338, *Historic Changes in Water Table Elevation and Groundwater Flow Direction at Hanford: 1944 to 2014*).

Water-table elevations in the 200 East Area were at their highest during the Hanford Site's peak operating years (the 1960s through 1990s; Figure 2 in SGW-60338). The termination of discharges to the Gable Mountain Pond system in 1985 and subsequent termination of discharges to the B Pond system in 1993 resulted in the gradual dissipation of the 200 East Area groundwater mound. As groundwater elevations continued to decline, the water table became extremely flat throughout the 200 East Area. Because of the flat water table, it became difficult to estimate the direction of groundwater flow by measuring water levels and mapping the water table. Changes in groundwater elevations and associated hydraulic gradients and flow directions have become less discernible from year to year subsequent to the cessation of operational discharges. The changes in gradient magnitude have been accompanied by changes in groundwater flow direction, with most of the 200 East Area presently exhibiting a northwest to southeast flow direction. This flow direction suggests that the groundwater elevations and hydraulic gradients are approaching preoperational conditions at the Hanford Site.

Efforts have been made to obtain more accurate well survey elevations and measurements of the deviation from vertical for key monitoring wells in the 200 East Area. In 2019, there were 65 wells in what is termed the low-gradient monitoring network. The water-level measurements obtained from the low-gradient monitoring network were evaluated by generating digital grids of the mapped water table and performing trend surface analyses.

LLBG WMA-2 is located in the northeastern part of the 200 East Area and overlies a hydrogeologic boundary between two aquifers that exhibit substantially different hydrogeological properties. Basalts of the Elephant Mountain Member of the Saddle Mountains Basalt Formation underlie the majority of Trench 94. However, southern portions of Trench 94 overlie or are located slightly north of the northern extent of the unconfined Hanford formation unconsolidated sediments that are typical of the 200 East Area. The exact location where the basalts subcrop, and may locally contain, the water table is not precisely known.

2.5 Summary of Previous Groundwater Monitoring and Results

Table 2-1 identifies the interim status groundwater monitoring plans that have been implemented at LLBG WMA-2. Figure 2-8 provides the locations of wells discussed in this section.

Table 2-1. Interim Status Monitoring Plans

Document	Date Issued	Monitoring Program*
PNL-6772, *A Detection-Level Hazardous Waste Ground-Water Monitoring Compliance Plan for the 200 Areas Low-Level Burial Grounds and Retrievable Storage Units*	1987	Indicator evaluation program
WHC-SD-EN-AP-015, *Revised Ground-Water Monitoring Plan for the 200 Areas Low-Level Burial Grounds*	1989	Indicator evaluation program
ECN 113805	1991	
ECN 144234	1991	

Table 2-1. Interim Status Monitoring Plans

Document	Date Issued	Monitoring Program*
ECN 618165 ECN 618180	1994 1995	
PNNL-14859, *Interim Status Groundwater Monitoring Plan for Low-Level Waste Management Areas 1 to 4, RCRA Facilities, Hanford, Washington* PNNL-14859-ICN-1	2004 2006	Indicator evaluation program
DOE/RL-2009-76, *Interim Status Groundwater Monitoring Plan for the LLBG WMA-2* RCRA-CN-01_DOE/RL-2009-76_R0	2010 2020	Indicator evaluation program

* 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."

In 1987, DOE initiated an indicator parameter groundwater monitoring program at the LLBG unit (which includes LLBG WMA-2) in accordance with PNL-6772, based on the requirements of 40 CFR 265, Subpart F, and WAC 173-303-400. PNNL-6772 included installation of 8 new wells to monitor the LLBG WMA-2 area (Figure 18 in PNNL-6772). Monitoring constituents included the contamination indicator parameters, groundwater quality parameters, and drinking water parameters required by 40 CFR 265.92(b), "Sampling and Analysis." Ammonium, calcium, magnesium, potassium, and total dissolved solids were also included for sampling. The wells that were installed in 1987 include 299-E27-8, 299-E27-9, 299-E27-10, 299-E34-2, 299-E34-3, 299-E34-4, 299-E34-5, and 299-E34-6.

In 1989, a new groundwater monitoring plan for LLBG was issued (WHC-SD-EN-AP-015, *Revised Ground-Water Monitoring Plan for the 200 Areas Low-Level Burial Grounds*) and included a revised network for LLBG WMA-2. Recently drilled wells 299-E27-10 and 299-E34-3 were identified as upgradient. Existing well 299-E26-1 was added as an upgradient well, and a new upgradient well was planned. Wells 299-E27-8, 299-E27-9, 299-E34-2, 299-E34-4, 299-E34-5, and 299-E34-6 were identified as downgradient, and two new downgradient wells were planned. Well 299-E34-4, drilled in 1987, was included as a downgradient well, although it had not reached the unconfined aquifer before entering the basalt, and thus was a dry well (Section 3.3.4.2 in WHC-SD-EN-AP-015). Monitoring constituents included the contamination indicator parameters, groundwater quality parameters, and drinking water parameters required by 40 CFR 265.92(b), ammonium, uranium, tritium, and volatile organic compounds (VOCs) (Section 3.5 in WHC-SD-EN-AP-015). The dangerous wastes listed in Appendix IX of 0, "Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," Appendix IX, "Ground-Water Monitoring List," were included for the first sample from each well, followed by annual sampling at selected wells (these wells were not identified in the plan) (Section 3.5 in WHC-SD-EN-AP-015). Groundwater at LLBG WMA-2 was considered to flow to the west and southwest (Section 2.3.3.2 in WHC-SD-EN-AP-015). Although upgradient well 299-E26-1 was included as a network well in the 1989 monitoring plan, a review of subsequent annual reports found that it was not used as part of the LLBG WMA-2 network. Well 299-E26-1 was decommissioned in 2004.

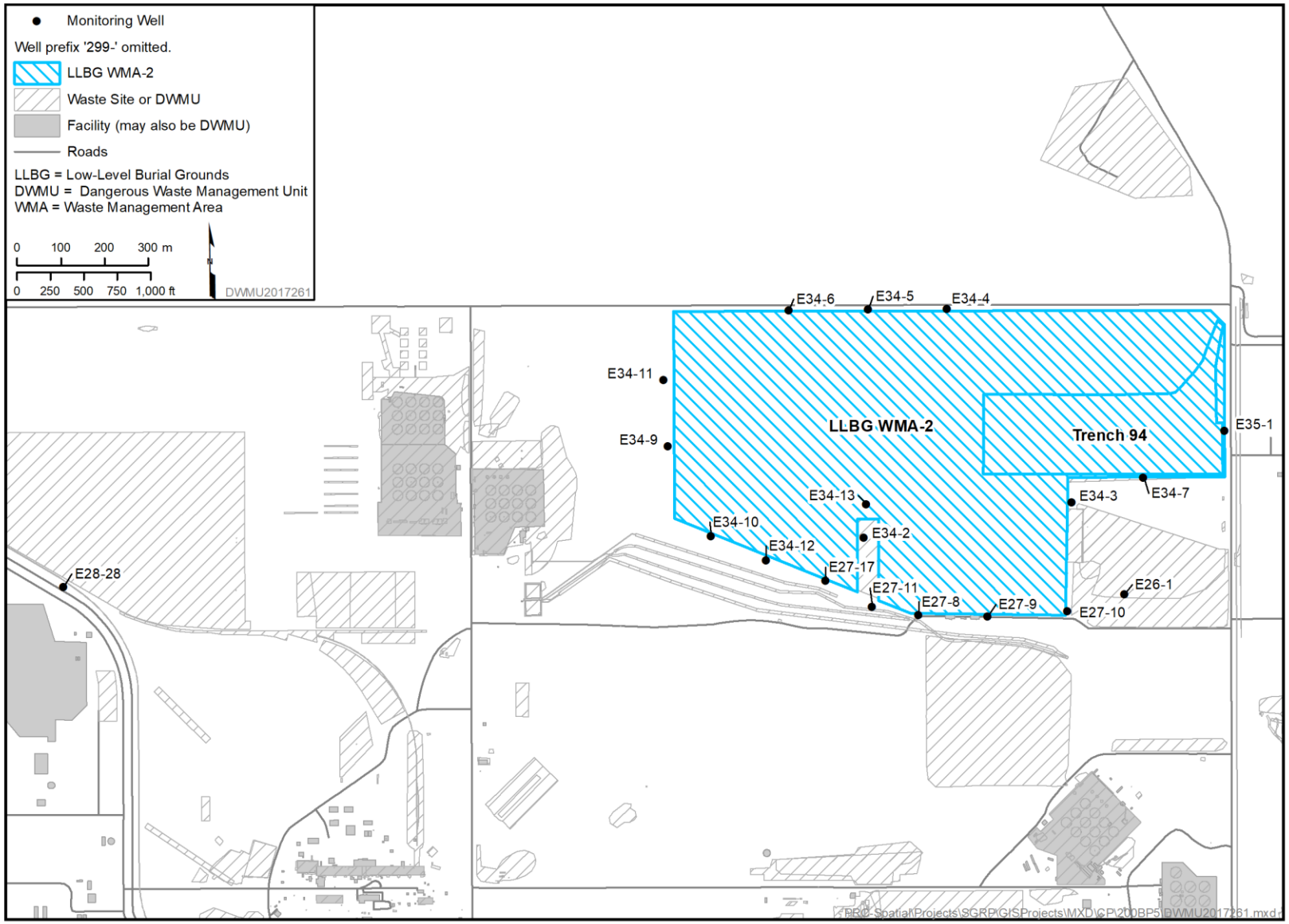


Figure 2-8. Wells Used During Interim Status Monitoring of LLBG WMA-2

In 1989, upgradient well 299-E35-1 and downgradient wells 299-E34-7 and 299-E27-11 were installed. In 1990, the interpretation of groundwater flow direction at LLBG WMA-2 was modified. The designation of well 299-E34-3 changed to downgradient and wells 299-E34-4 (dry), 299-E34-5, and 299-E34-6 were redesignated as upgradient (Section 14.2.4.3 in DOE/RL-91-03, *Annual Report for RCRA Groundwater Monitoring Projects at Hanford Site Facilities for 1990*). The hydraulic gradient of the area was very low at 0.0004 (Section 14.2.4.1 in DOE/RL-91-03). The groundwater flow direction for LLBG WMA-2 was not reported as the water-level data did not provide an accurate picture of the flow (Section 14.2.4.1 in DOE/RL-91-03). The groundwater flow direction at LLBG WMA-2 was not determined for the RCRA annual reports from 1991 through 1995.

Groundwater sampling was temporarily discontinued in June 1990 due to cancelation of the analytical laboratory contract. The Hanford Site sampling program resumed in June 1991 (Introduction in DOE/RL-92-03, *Annual Report for RCRA Groundwater Monitoring Projects at Hanford Site Facilities for 1991*). Samples at LLBG WMA-2 were not collected until after the sampling program resumed in June 1991 (Introduction in DOE/RL-92-03).

In 1991, ECN 113805, *Engineering Change Notice to WHC-SD-EN-AP-015, Rev. 0 Revised Groundwater Monitoring Plan for Low-Level Burial Grounds*, to WHC-SD-EN-AP-015 was issued and included seven new monitoring wells for LLBG WMA-2. Six new wells were installed between 1990 and 1992. Upgradient well 299-E28-28 was installed in 1990 and downgradient wells 299-E27-17, 299-E34-9, and 299-E34-10 were installed in 1991, followed by wells 299-E34-11 and 299-E34-12 in 1992. ECN 144234, *Engineering Change Notice to WHC-SD-EN-AP-015, Rev. 0 Revised Groundwater Monitoring Plan for Low-Level Burial Grounds*, was also issued in 1991 but was specific to a LLBG WMA-4 well change and did not affect LLBG WMA-2.

By 1991, the water-level in well 299-E35-1 had declined to the point that sample collection was no longer possible (Section 15.2.2.1 in DOE/RL-92-03). In 1991, upgradient well 299-E27-10 was not included in the monitoring network, while wells 299-E27-17, 299-E34-9, and 299-E34-10 were added as downgradient wells (Table 15-3 in DOE/RL-92-03). The reported network comprised 14 wells (upgradient 299-E28-28, 299-E34-4 [dry], 299-E34-5, 299-E34-6, and 299-E35-1 [going dry], and downgradient 299-E27-8, 299-E27-9, 299-E27-11, 299-E27-17, 299-E34-2, 299-E34-3, 299-E34-7, 299-E34-9, and 299-E34-10) (Table 15-3 in DOE/RL-92-03).

By 1992, the water level in well 299-E34-6 had declined to the point that sample collection was no longer possible (Section 15.2.2.1 in DOE/RL-93-09, *Annual Report for RCRA Groundwater Monitoring Projects at Hanford Site Facilities for 1992*). The reported network for 1992 was expanded to include two new downgradient wells (299-E34-11 and 299-E24-12), bringing the network total to 16 wells (upgradient wells 299-E28-28, 299-E34-4 [dry], 299-E34-5, 299-E34-6 [going dry], and 299-E35-1 [going dry], and downgradient wells 299-E27-8, 299-E27-9, 299-E27-11, 299-E27-17, 299-E34-2, 299-E34-3, 299-E34-7, 299-E34-9, 299-E34-10, 299-E34-11, and 299-E34-12) (Table 15-3 in DOE/RL-93-09).

The 1993 monitoring network was modified to again include upgradient well 299-E27-10 (which had not been included in the network in the 1991 and 1992 annual RCRA reports) and remove upgradient well 299-E28-28 (Table 4.12-3 in DOE/RL-93-88, *Annual Report for RCRA Groundwater Monitoring Projects at Hanford Site Facilities for 1993*). The reason for the network change was not reported.

ECN 618165, *Engineering Change Notice to WHC-SD-EN-AP-015, Rev. 0 Revised Groundwater Monitoring Plan For Low-Level Burial Grounds* (1994), and ECN 618180, *Engineering Change Notice to WHC-SD-EN-AP-015, Rev. 0 Revised Groundwater Monitoring Plan for Low-Level Burial Grounds* (1995), revised the constituents required for sampling after the first year of monitoring. The revised sampling list for LLBG WMA-2 included the contamination indicator parameters and groundwater

quality parameters required by 40 CFR 265.92(b), gross alpha, gross beta, tritium, anion, metals, lead, mercury, PCBs, turbidity, and alkalinity.

In 1997, the designations for wells 299-E34-3 and 299-E34-7, previously identified as downgradient, were changed to upgradient (Table A.14 in PNNL-11793, *Hanford Site Groundwater Monitoring for Fiscal Year 1997*). Groundwater flow was reported toward the west (Section 2.9.1.11 in PNNL-13116, *Hanford Site Groundwater Monitoring for Fiscal Year 1999*), consistent with previous annual reports.

Upgradient well 299-E34-5 was identified as used for information only (not statistical evaluation) beginning with the 2000 annual groundwater monitoring report (Table A.39 in PNNL-13404, *Hanford Site Groundwater Monitoring for Fiscal Year 2000*). No explanation for the change was presented in this or subsequent annual reports; however, the 2004 groundwater monitoring plan states that well 299-E34-5 was hydraulically isolated from the WMA by basalt (Section 3.2 in PNNL-14859, *Interim Status Groundwater Monitoring Plan for Low-Level Waste Management Areas 1 to 4, RCRA Facilities, Hanford, Washington*).

In 2000, specific conductance exceedances were reported at upgradient well 299-E34-7. The elevated results were attributed to nitrate, sulfate, and calcium but the source was unknown because there were no apparent sources of nitrate and sulfate in LLBG WMA-2 near the well (Section 2.9.1.12 in PNNL-13404).

In 2002, downgradient well 299-E34-11 went dry (Section 2.9.1.13 in PNNL-14187, *Hanford Site Groundwater Monitoring for Fiscal Year 2002*) and no further sampling was performed at this well. In 2003, upgradient well 299-E34-3 was declared sample dry due to declining water levels and was removed from the network (Section 2.10.3.4 in PNNL-14548, *Hanford Site Groundwater Monitoring for Fiscal Year 2003*). In 2003, downgradient well 299-E34-2 was also identified as dry, but the well continued to be reported as part of the network (Table B.23 in PNNL-14548).

In 2004, a revised monitoring plan was issued (PNNL-14859) that included two upgradient wells (299-E27-10 and 299-E34-7), one information-only upgradient well (299-E34-5), and eight downgradient wells (299-E27-8, 299-E27-9, 299-E27-11, 299-E27-17, 299-E34-2, 299-E34-9, 299-E34-10, and 299-E34-12) (Table A.8 in PNNL-14859). Upgradient well 299-E34-5 was retained as a supplemental upgradient well (information only) because it was believed to be hydraulically isolated from the rest of the WMA by basalt (Section 3.2 in PNNL-14859). The plan identified that recently measured exceedances of specific conductance in upgradient well 299-E34-7 were related to increases in sulfate, chloride, nitrate, sodium, and calcium concentrations (Section 2.3.2.1 in PNNL-14859). Increases in total organic carbon (TOC) and total organic halogen (TOX) at well 299-E34-7 were also reported, but the source of the increase was unknown because LLBG WMA-2 did not contain organic dangerous waste (Section 2.3.2.1 in PNNL-14859). The revised monitoring parameters included the contamination indicator parameters and groundwater quality parameters required by 40 CFR 265.92(b), lead, mercury, PCBs, temperature, turbidity, and alkalinity. Due to increases in TOC and TOX concentrations, additional monitoring was performed annually at well 299-E34-7 for the VOCs and semivolatile organic compounds (SVOCs) identified in Appendix IX of 40 CFR 264, oil and grease, total petroleum hydrocarbons (TPH), and coliform (Table A.8 in PNNL-14859).

In 2006, PNNL-14859-ICN-1, *Interim Status Groundwater Monitoring Plan for Low-Level Waste Management Areas 1 to 4, RCRA Facilities, Hanford, Washington*, Interim Change Notice 1, identified the LLBG WMA-2 wells that had become dry and revised the LLBG WMA-2 monitoring network to remove upgradient well 299-E34-7 and supplemental upgradient well 299-E34-5. The monitoring constituents remained the same, except that the single remaining upgradient well (299-E27-10) was to have additional monitoring for the VOCs and SVOCs in Appendix IX of 40 CFR 264, oil and grease, TPH, and coliform during fiscal year 2007 only (Table A.8 in PNNL-14859-ICN-1).

The monitoring network remained unchanged until the groundwater monitoring plan was revised in 2010 (DOE/RL-2009-76). The 2010 plan identified previously upgradient well 299-E27-10 as crossgradient and proposed a new downgradient well (299-E34-13) to investigate water availability in the basalt. Information obtained from the drilling of well 299-E34-13 would be used to determine if proposed downgradient well 299-E34-14 and proposed upgradient well 299-E34-15 would be drilled (Section 2.7 in DOE/RL-2009-76). An additional proposed upgradient well (299-E34-16) was also identified (Section 3.1 and Table 3-1 in DOE/RL-2009-76). The revised monitoring parameters included the contamination indicator parameters and groundwater quality parameters required by 40 CFR 265.92(b), anions (fluoride, nitrate, and nitrite), metals (calcium, chromium, potassium), alkalinity, dissolved oxygen, temperature, and turbidity.

Well 299-E34-13 was drilled in 2010; however, groundwater was not encountered above the basalt (Section 9.3.2.1 in DOE/RL-2011-01, *Hanford Site Groundwater Monitoring Report for 2010*). Drilling continued 3.1 m (10 ft) into the basalt, and groundwater was eventually encountered; however, the infiltration rate was low at 13.2 L/hr (3.5 gal/hr). The groundwater chemistry showed sulfate (244 mg/L) and elevated nitrate (40.3 mg/L) (Section 9.3.2.1 in DOE/RL-2011-01). Because well 299-E34-13 produced insufficient groundwater and the groundwater that was present was not associated with the upper unconfined aquifer, the well was decommissioned. The other three new wells proposed in DOE/RL-2009-76 were not drilled.

In 2011, the groundwater flow direction reported for LLBG WMA-2 changed from “undefined” due to the flat nature of the water table in 2011 (Section 3.4.13.6 in DOE/RL-2011-118, *Hanford Site Groundwater Monitoring for 2011*) to southeast in 2012 (DOE/RL-2013-22, *Hanford Site Groundwater Monitoring for 2012*). Groundwater flow direction was further refined for 2014 in DOE/RL-2015-07, *Hanford Site Groundwater Monitoring Report for 2014*, based on contaminant migration into the area. The flow along the west side of the facility was to the southeast, and the flow along the east side was to the south (Section 9.10.6 in DOE/RL-2015-07). The designations for the well network in 2013 included one upgradient well (299-E34-2), three downgradient wells (299-E27-8, 299-E27-9, and 299-E27-10), and five crossgradient wells (299-E27-11, 299-E27-17, 299-E34-9, 299-E34-10, and 299-E34-12) (DOE/RL-2014-32, *Hanford Site Groundwater Monitoring Report for 2013*).

In 2013 and 2014, specific conductance exceeded the critical mean[1] at well 299-E34-9. DOE/RL-2014-32 and Section 9.10.6 in DOE/RL-2015-07 reported that elevated specific conductance was associated with the migration of nitrate primarily from the BY Cribs, as described in 13-AMRP-0192, “Notification of Resource Conservation and Recovery Act Indicator Parameter Exceedance at Low-Level Waste Management Area 2.” The BY Cribs were considered an upgradient source because the direction of groundwater flow had changed to southeast in 2011. Meetings with DOE, Ecology, and CH2M HILL Plateau Remediation Company were held. It was determined that LLBG WMA-2 was not associated with the elevated specific conductance; therefore, LLBG WMA-2 did not go into assessment monitoring. Specific conductance at well 299-E34-9 did not exceed the critical mean in 2015 (Table B-48 in DOE/RL-2016-09, *Hanford Site Groundwater Monitoring Report for 2015*).

The 2016 Hanford Site RCRA groundwater monitoring report identified a south to southeast flow direction (Table 2-43 in DOE/RL-2016-66, *Hanford Site RCRA Groundwater Monitoring Report for 2016*). The 2016 well network included one upgradient (299-E34-2), three downgradient (299-E27-8,

[1]The critical mean is a statistically determined background value that is calculated as specified under 40 CFR 265.93(b) and is used to determine if indicator parameters exhibit a significant increase (or pH decrease) in downgradient wells.

299-E27-9, and 299-E27-10), and five crossgradient (299-E27-11, 299-E27-17, 299-E34-9, 299-E34-10, and 299-E34-12) (Table 2-42 in DOE/RL-2016-66).

In 2016, one unfiltered chromium result exceeded WAC 173-340-705, "Model Toxics Control Act—Cleanup," "Use of Method B," cleanup standard in well 299-E27-17 (Section 2.12 in DOE/RL-2016-66). Nitrate concentrations were elevated in wells 299-E27-9, 299-E27-10, 299-E34-9, 299-E34-10, and 299-E34-12. Elevated nitrate in wells 299-E34-9, 299-E34-10, and 299-E34-12 appeared to be associated with southeast migration from sources to the northwest, primarily the BY Cribs, while elevated nitrate and sulfate in wells 299-E27-9 and 299-E27-10 appeared to be associated with the previous UPRs at the 216-B-2 Ditches (Section 2.12 in DOE/RL-2016-66).

In 2018, the reported flow direction at LLBG WMA-2 varied from south along the east side of the unit to southeast at the west side. The gradient designations for the network wells (Table 2-44 in DOE/RL-2018-65, *Hanford Site RCRA Groundwater Monitoring Report for 2018*) reflect the network as presented in the 2010 groundwater monitoring plan (DOE/RL-2009-76). However, while well 299-E34-9 was identified as downgradient in Table 2-44 of DOE/RL-2018-65, the direction of groundwater flow had changed and the well location was now considered upgradient of the unit based on 2018 water-table map interpretations and the migration of nitrate and sulfate plumes (Section 2.12 in DOE/RL-2018-65).

In early 2018, TOC exceedances were confirmed in downgradient well 299-E27-9 and crossgradient well 299-E27-10. DOE notified Ecology of the exceedance and because TOC was elevated in both the crossgradient and downgradient wells, DOE recommended that future TOC results be used for information purposes only (Section 2.12 in DOE/RL-2018-65). However, statistical comparisons were made for the second semiannual sample, with exceedances confirmed again in both wells.

Also in 2018, a confirmed exceedance of the specific conductance critical mean and TOC occurred at well 299-E34-9 (Section 2.12 and Table 2-46 in DOE/RL-2018-65). The specific conductance trend in well 299-E34-9 was similar to that in well 299-E33-14, located 243 m (797 ft) to the northwest, indicating a southeast flow direction that reflected contamination from a source other than LLBG WMA-2.

In 2019, the reported groundwater flow direction ranged from southeast to southwest, with an average hydraulic gradient sloping to the south (Section 2.9 in DOE/RL-2019-65, *Hanford Site RCRA Groundwater Monitoring Report for 2019*). The average flow rate was 0.37 m/d (1.2 ft/d) (Table 1-2 in DOE/RL-2019-65). Due to basalt above the water table in the northern portion of the unit, no upgradient well was identified for the unit and sample results from well 299-E34-2 were used to calculate background comparison values (critical means) (Section 2.9 in DOE/RL-2019-65).

2.6 Contaminant Migration Conceptual Model

The conceptual model for contaminant release and transport through the vadose zone to groundwater at LLBG WMA-2 primarily focuses on the area at Trench 94, which is the only location of regulated dangerous waste within the unit. The conceptual model is summarized in the following sections and based on the following assumptions:

- Average precipitation of about 17.2 cm/yr (6.8 in/yr) and recharge in the B Pond area has been estimated to be between 1.5 and 17 mm (0.06 and 0.67 in) annually, depending on soil texture and vegetation (Table 4.15 in PNNL-14702, *Vadose Zone Hydrogeology Data Package for Hanford Assessments*).
- Net infiltration is assumed to occur under gravity drainage of precipitation on the soil surface.

- Leaching of mobile contaminants from buried waste in unsealed containers, or contaminated soils in direct contact with the trench, is assumed the major potential source for contamination to the vadose zone.
- Local, artificial sources of water (e.g., leaking potable or raw water lines) are not present based on Hanford Site drawings.
- Extreme conditions or accidental releases are recognized as factors but would be addressed under emergency response/corrective actions.

2.6.1 Vadose Zone

The vadose zone beneath LLBG WMA-2 consists of approximately 51 m (167 ft) of Hanford formation sand and gravel (Figures 2-4 through 2-6). The lithology of the vadose zone beneath WMA-2 consists of the Hanford formation (e.g., upper gravel-dominated sequence, intermediate sand sequence, and a lower gravel-dominated sequence). The unsaturated sediments above the water table affect how waste solutions move through the soil, how much is retained in the sediment column, and how much liquid waste eventually reaches the water table. Interbeds of sand and silt facies are present in each of the Hanford formation sequences and have the potential for generating perched aquifer conditions (Section 5.6.1 in WHC-SD-EN-TI-290, G*eologic Setting of the Low-Level Burial Grounds*). Varying percentages of fine-grained sediments are present beneath the south and central part of LLBG WMA-2 (Figures 2-4 through 2-6). Outcrop observations show that fine-grained interbeds are present and are normally a few to tens of centimeters thick (Section 5.6.1 in WHC-SD-EN-TI-290) (example shown in Figure 2-7). The contact between Hf1 and underlying strata generally is irregular as a result of the interfingering nature of the Hanford formation deposits; this results in the absence of a distinct bounding surface (Section 5.6.1 in WHC-SD-EN-TI-290).

The potential for migration of contamination from the vadose zone to groundwater is unlikely due to the lack of artificial recharge. Infiltration of natural precipitation is the only potential force capable of moving contaminants to the groundwater. Based on records from the Hanford Meteorological Station, the average annual precipitation at the Hanford Site between 1950 and 2015 has been 172 mm/yr (6.78 in/yr). Annual recharge in the LLBG WMA-2 area has been estimated to be between 1.5 mm/yr (0.06 in/yr) in a shrub-steppe vegetated area to 17 mm/yr (0.67 in/yr) at a gravel-covered, nonvegetated area based on Table 4.15 in PNNL-14702. The risk of infiltration by snowmelt and the potential for vertical migration of contaminants, however, is considered low because of low annual precipitation.

2.6.2 Soil Moisture Factors

As presented in Section 4.2 in PNNL-12261, based on hydrogeologic data, groundwater within the Hanford formation unconfined aquifer does not flow vertically through the lower mud unit (where present). Thus, the unconfined aquifer is the only aquifer that could be potentially impacted by releases from LLBG WMA-2.

External sources of water or other liquid may drive any contamination downward. Infiltration of fresh water (as well as precipitation and unintentional, manmade releases such as leaking water lines) may move potential waste in the soil downward to the groundwater, however, no water lines exist at LLBG WMA-2. The potential contributor to moisture detected in the Hanford formation below LLBG WMA-2 is B Pond (Section 4.2.1 in PNNL-12261).

2.6.3 Hydrogeologic Considerations

Previous liquid waste disposal practices at B Pond, Gable Mountain Pond, Plutonium Uranium Extraction Plant Cribs, and other facilities established localized water-table mounds that elevated the water-table

throughout the 200 East Area. An artificial groundwater mound east of the 200 East Area that was created by past effluent disposal activities at the B Pond complex persisted for many years into the late 1990s.

From 2013 to 2018, the water-table elevation declined at LLBG WMA-2 monitoring wells, from 1.3 to 19.2 cm (0.5 to 7.6 in), and the average decline among six wells with consistent declining averages is 1.9 cm/yr (0.75 in/yr) (Section 2.12 in DOE/RL-2018-65). Hydrochemistry data indicates that wastewater discharge to the Treated Effluent Disposal Facility does not impact water quality of the uppermost unconfined aquifer within the 200 East Area, but no wells currently monitor the uppermost unconfined aquifer downgradient of the Treated Effluent Disposal Facility (Section 4.2.1 in PNNL-12261).

Accompanying the historical changes in water level were changes in groundwater flow direction. Pre-Hanford Site groundwater flow direction in the 200 East Area was generally toward the east or southeast (Table 1 in SGW-60338). Since that time, the liquid disposal to B Pond, Gable Mountain pond, and other disposal facilities have impacted local flow directions in the 200 East Area several times during Hanford Site operations. Figures 2-4 through 2-6 show that the groundwater flow direction at LLBG WMA-2 has been relatively consistent and toward the south-southwest since 2013, which is consistent with the current determination of flow direction (southeast to south-southwest) and historical plume migration characteristics.

2.6.4 Groundwater Chemistry

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

Many analyses of the unconfined aquifer groundwater have been completed at the Hanford Site. Pore fluid and groundwater in the unsaturated and saturated zones beneath the LLBG WMA-2 is slightly alkaline ($7.8<pH<8.4$) (Section 2.1.9 in WHC-SD-WM-TI-730), with appreciable amounts of bicarbonate and very little natural organic material. Vadose soil and groundwater are generally well aerated. The dissolved oxygen concentrations fall into the higher range for groundwater (7 to 10 mg/L). These general conditions favor sorption or retardation of many heavy metals (e.g., lead), and also favor stability of oxy anionic species, which enhance mobility for other metals (e.g., hexavalent chromium). Laboratory sorption studies have documented these effects and related mobility issues in Hanford Site media. These conditions tend to allow chlorinated solvents (e.g., carbon tetrachloride) to remain persistent, as these compounds normally degrade more rapidly in reduced groundwater environments.

Past releases of liquid waste from nearby facilities may have contributed to increased concentrations of numerous dissolved inorganic constituents and TOC in some monitoring wells adjacent to Trench 94. Of particular interest to groundwater monitoring at Trench 94 is the historical presence of elevated concentrations of numerous constituents observed in the shallow unconfined aquifer at well 299-E34-7, located immediately adjacent to the south side of the Trench 94 excavation (Figure 2-9). This well was originally an active monitoring well for LLBG WMA 2 and exhibited substantial elevated concentrations of inorganic ions, TOC, and TOX at various times until sampling could no longer be performed and the well was removed from service after 2006. The maximum concentrations (and minimum in the case of alkalinity) of selected constituents observed in well 299-E34-7 are summarized in Table 2-2.

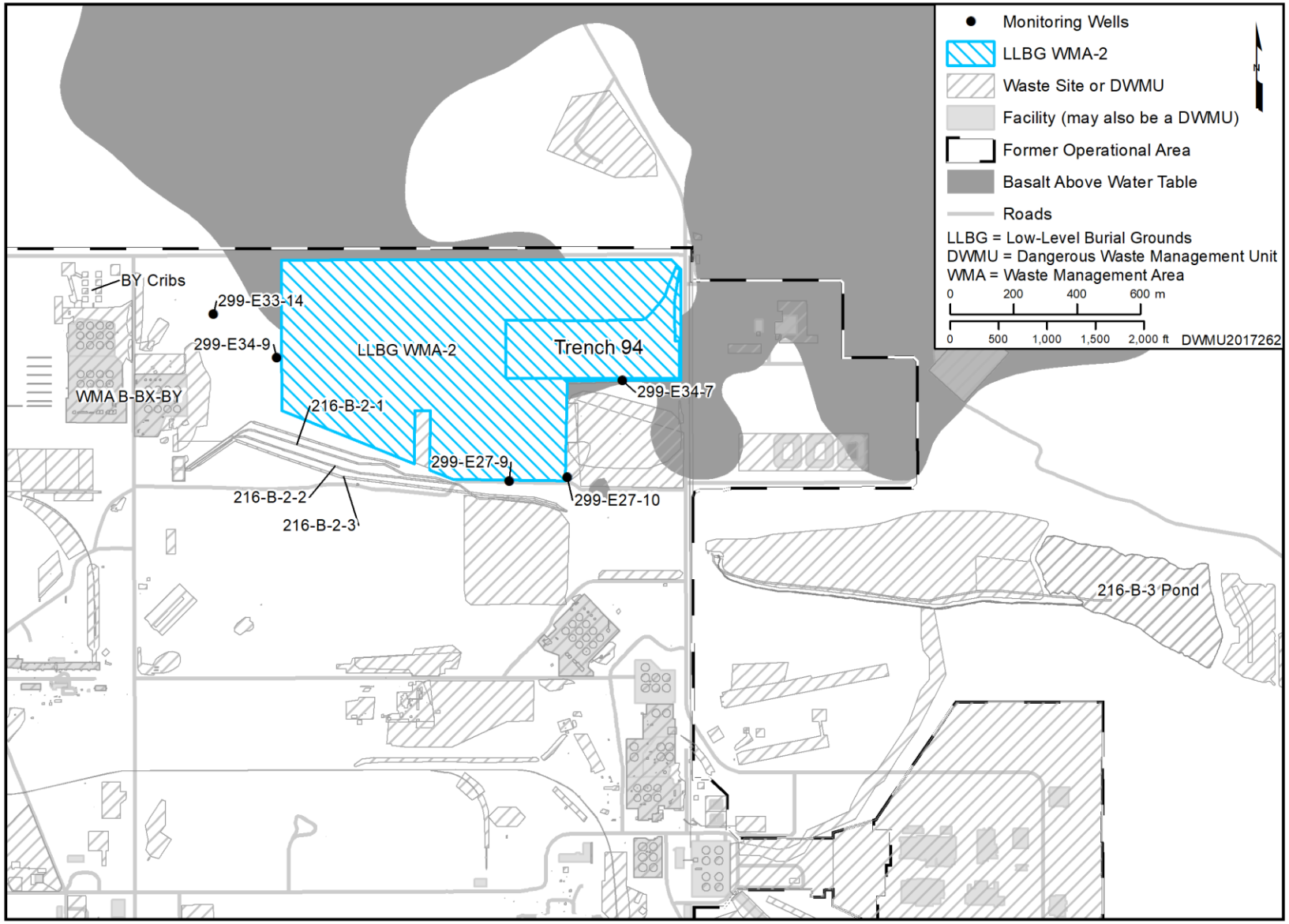


Figure 2-9. Location of Well 299-E34-7 and Other Wells with Elevated Specific Conductance

Table 2-2. Summary of Selected Constituent Concentrations in Groundwater at Well 299-E34-7, Adjacent to Trench 94

Constituent	Concentration (Year Observed)	Remarks
Total organic carbon	6.5 mg/L (2002)	Source of TOC not identified
Total organic halides	0.058 mg/L (2005)	Source of TOX not identified
Alkalinity	44 mg/L (2001)	Substantially lower than nearby wells. Declined from 110 mg/L in 1995 to 44 mg/L in 2001
pH	7.6 (2000)	Decrease from pH = 8.8 in 1994
Specific conductance	2,458 µS/cm (2002)	Derived peak TDS in well was 1,598 mg/L*
Nitrate	145 mg/L (2002)	None
Sulfate	671 mg/L (2003)	None
Chloride	356 mg/L (2002)	None

* Estimated TDS is derived from empirical relationship: Estimated TDS in mg/L = specific conductance (µS/cm) x 0.65.

TDS = total dissolved solids TOC = total organic carbon TOX = total organic halides

Time-series of conditions at well 299-E34-7 are discussed below. The observed concentration time series for alkalinity, chloride, sulfate, and nitrate are illustrated in Figure 2-10. Each of these constituents increased steadily, reaching peak concentrations around 2002-2003. The TOC time series for well 299-E34-7 is illustrated in Figure 2-11; TOC exhibited a peak concentration of over 6 mg/L in groundwater. The TOX concentration exhibited a similar pattern but at a substantially lower magnitude (Figure 2-12). The substantial decline in groundwater pH of over 1 pH unit between 1994 and 2000 is shown in Figure 2-13. Specific conductance exhibited a transient parallel to that observed for the dissolved ions in general (Figure 2-14).

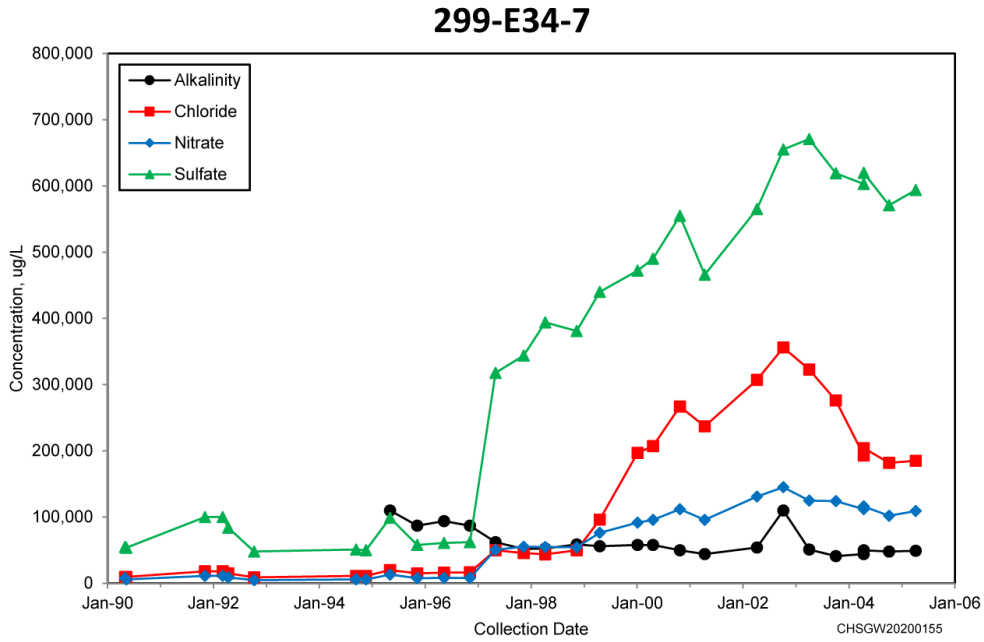


Figure 2-10. Time Series of Inorganic Ion Constituents Exhibiting Increases in Groundwater at Well 299-E34-7

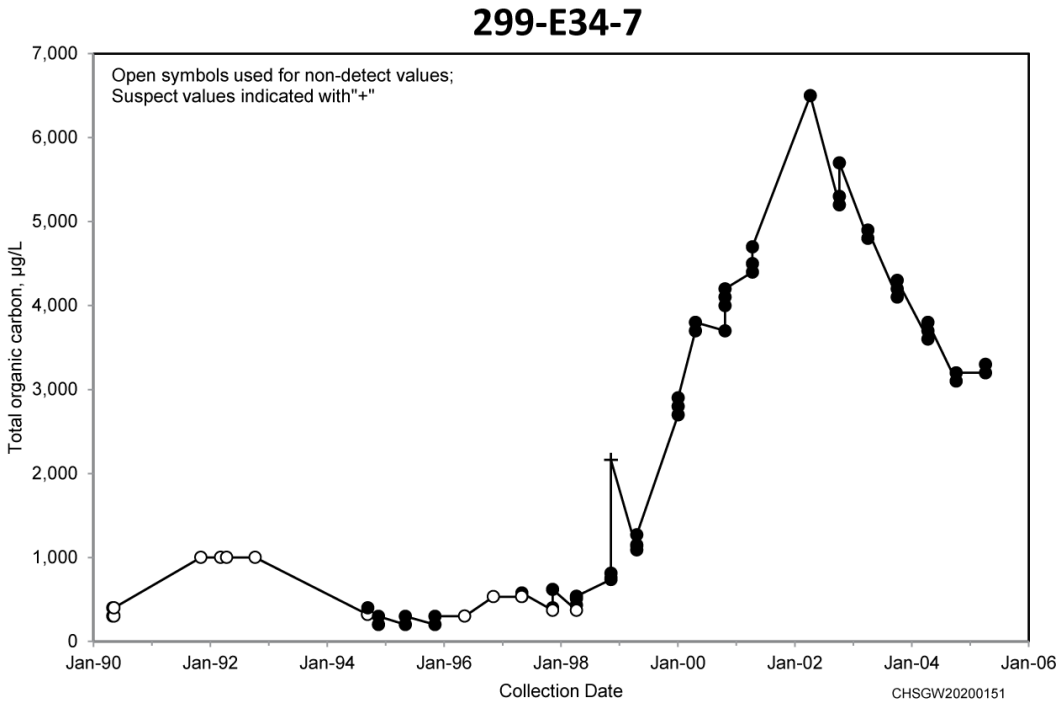


Figure 2-11. Time Series of Total Organic Carbon Concentration Exhibiting Increase in Groundwater at Well 299-E34-7

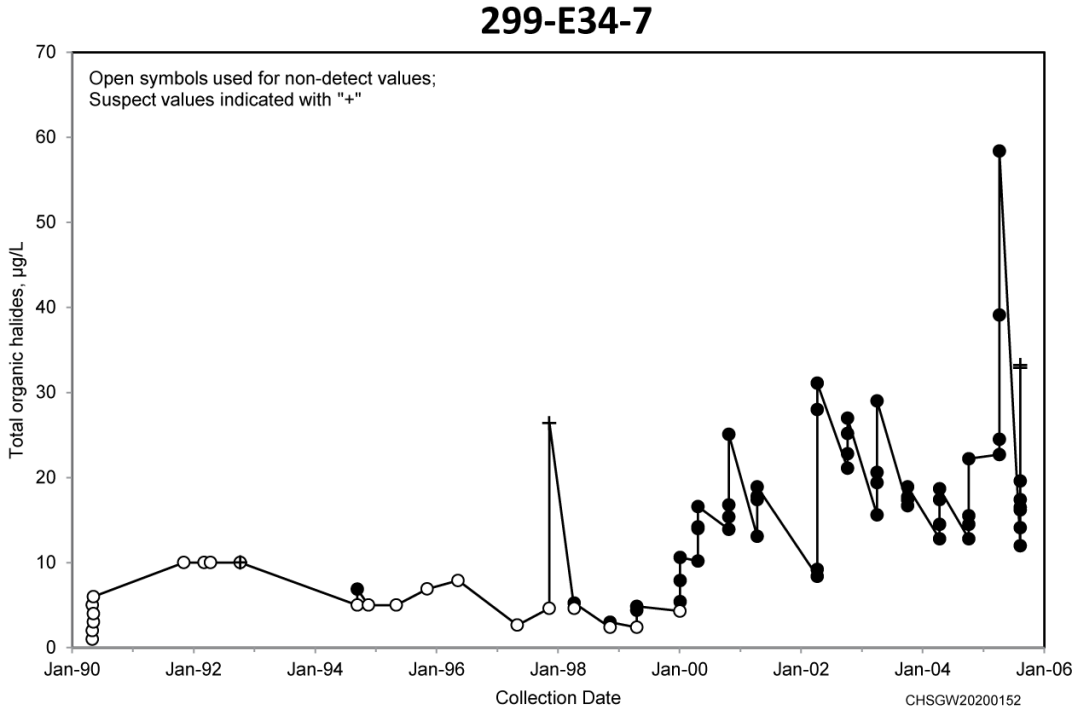


Figure 2-12. Time Series of Total Organic Halides Concentration Exhibiting Increase in Groundwater at Well 299-E34-7

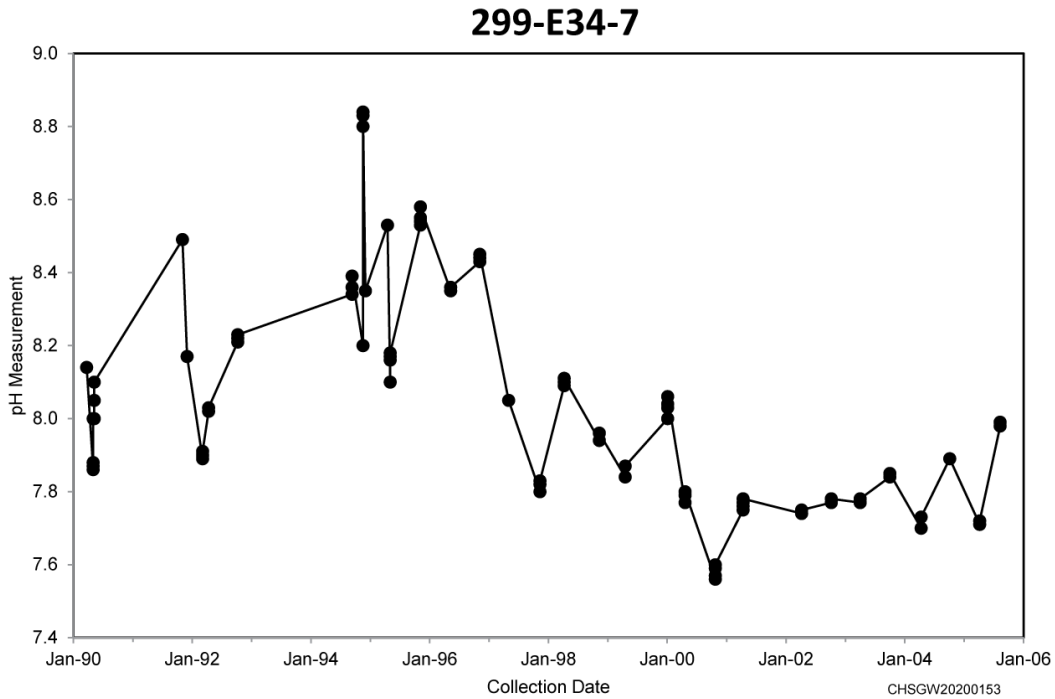


Figure 2-13. Time Series of Groundwater pH Exhibiting Decrease at Well 299-E34-7

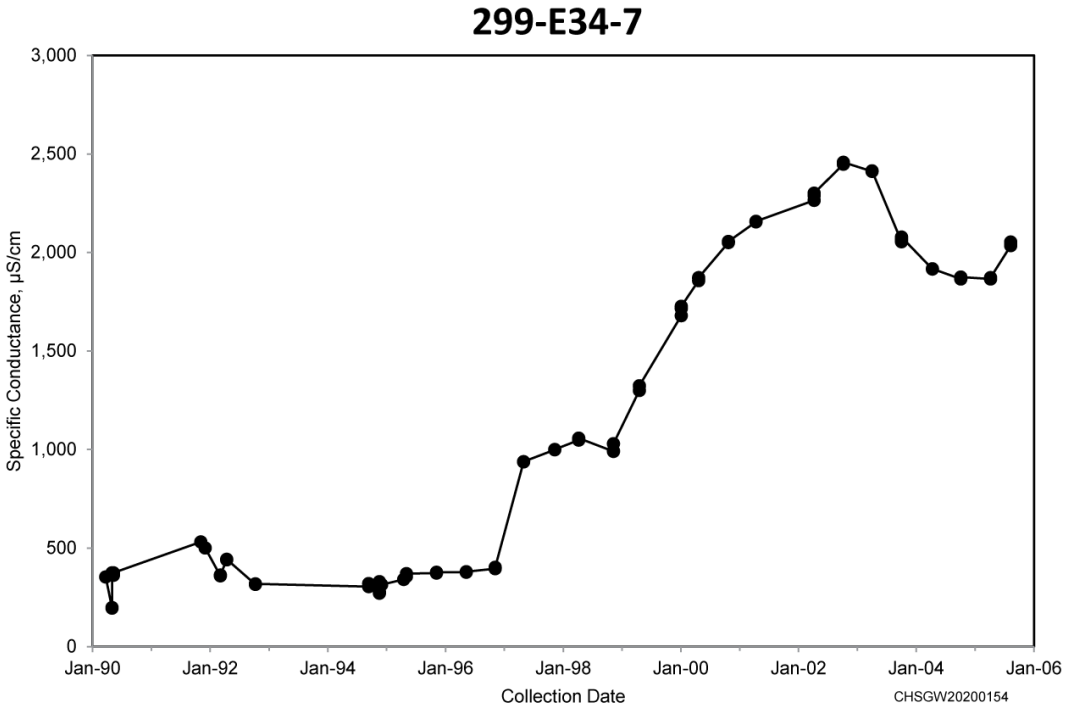


Figure 2-14. Time Series of Groundwater Specific Conductance Substantial Increase at Well 299-E34-7

Past elevated specific conductance in groundwater is associated with parallel increases in concentration of sulfate, nitrate, chloride, and alkalinity. The source of these high ion concentrations has not been clearly identified but may be associated with the migration of constituents from the BY Cribs, or the B ditch system (including the 216-B-2-1 and 216-B-2-2 Ditches) to the south and southwest of Trench 94. In April 2018, TOC exceedances were confirmed in downgradient well 299-E27-9 and crossgradient well 299-E27-10. Also in 2018, a confirmed exceedance of the specific conductance critical mean and TOC occurred at well 299-E34-9 (Section 2.12 and Table 2-46 in DOE/RL-2018-65). The specific conductance trend in well 299-E34-9 was similar to that in well 299-E33-14, located 243 m (797 ft) to the northwest (Figure 2-13 in DOE/RL-2018-65), and indicating a southeast flow direction which reflected contamination from a source other than LLBG WMA-2. Both wells are downgradient of WMA B-BX-BY (Figure 2-9), which is monitored under an interim status groundwater quality assessment program and has had past detections of nitrate and sulfate in downgradient monitoring wells. The current and historical detections of elevated inorganic ions, organic carbon, and organic halides complicates the plans for future groundwater monitoring at Trench 94.

Additionally in 2018, iron concentrations were above the secondary drinking water standard of 300 µg/L (40 CFR 143.3, "National Secondary Drinking Water Regulations," "Secondary Maximum Contaminant Levels") in unfiltered samples from well 299-E27-10. Previous video surveys of the well show moderate encrustation of apparent amorphous ferric hydroxide (orange in color). Other metals associated with stainless steel corrosion (i.e., chromium and nickel) are also detected in this well at elevated levels. It is likely that corrosion in this well affected the sample. Well 299-E27-10 was added to the well maintenance priority list for cleaning (Section 2.12 and in DOE/RL-2018-65).

2.7 Monitoring Objectives

The objective of the groundwater monitoring program at LLBG WMA-2 is to determine the facility's impact, if any, on the quality of the underlying groundwater. This groundwater monitoring plan addresses specifically those applicable RCRA requirements for interim status DWMUs 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 40 CFR 265.94, "Recordkeeping and Reporting." Table 2-3 identifies where each groundwater monitoring element of the pertinent regulations is addressed within this plan.

Table 2-3. 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	Chapter 1

Table 2-3. Pertinent Interim Status Facility Groundwater Monitoring Requirements

Groundwater Monitoring Element	Pertinent Requirement[a]	Section Where Requirement is Addressed in Monitoring Plan
	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.	
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 and Table 3-3
Well configuration	40 CFR 265.91: (c) All monitoring wells must be cased in a manner that maintains the integrity of the monitoring well bore hole. 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 bore hole 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:" 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.	Section 3.2 and Appendix C

Table 2-3. Pertinent Interim Status Facility Groundwater Monitoring Requirements

Groundwater Monitoring Element	Pertinent Requirement[a]	Section Where Requirement is Addressed in Monitoring Plan
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 through 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 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.	Section 3.1 and Appendix B, Section B2.2

Table 2-3. Pertinent Interim Status Facility Groundwater Monitoring Requirements

Groundwater Monitoring Element	Pertinent Requirement[a]	Section Where Requirement is Addressed in Monitoring Plan
	(d) After the first year, all monitoring wells must be sampled and the samples analyzed with the following frequencies: (1) Samples collected to establish ground-water quality must be obtained and analyzed for the parameters specified in paragraph (b)(2) of this section at least annually. (2) Samples collected to indicate ground-water contamination must be obtained and analyzed for the parameters specified in paragraph (b)(3) of this section at least semiannually. (e) Elevation of the ground-water surface at each monitoring well must be determined each time a sample is obtained.	
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 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.	Sections 4.1, 4.2, and 4.3 and Appendix A

Table 2-3. Pertinent Interim Status Facility Groundwater Monitoring Requirements

Groundwater Monitoring Element	Pertinent Requirement[a]	Section Where Requirement is Addressed in Monitoring Plan
	(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, Section A2.5

Notes: Complete reference citations are provided in Chapter 6.

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, "Interim Status Standards for Owners and Operations of Hazardous Waste Treatment, Storage, and Disposal Facilities," Subpart F, "Ground-Water Monitoring," the federal terms "Regional Administrator" means the "Department" and "Hazardous" means "Dangerous."

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* (Hanford Facility RCRA Permit), this unit will continue to be considered an interim status unit until it is 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.

a. Regulatory requirements for interim status 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 of a unit in accordance with 40 CFR 265.92(c)(1), "Sampling and Analysis." Because the first year of monitoring at this unit has been completed, Appendix III sampling is not applicable under this plan.

Sampling for site-specific and supporting constituents (Table 2-4) is not required under 40 CFR 265 but provides additional information supporting data interpretation.

In addition to the parameters required by 40 CFR 265.92, supporting constituents are monitored at LLBG WMA-2 (Table 2-4). Sampling will be performed to support charge balance calculation (alkalinity, anions [chloride, nitrate, and sulfate] and metals [calcium, magnesium, potassium, and sodium]); identify corrosion in stainless steel well casing (chromium, iron, manganese, molybdenum, and nickel); monitor influence of upgradient releases that impact specific conductance measurements (nitrate and sulfate); and provide information on water properties at the time of sampling (dissolved oxygen, temperature, and turbidity).

Table 2-4. Additional Monitoring Objectives

Monitoring Objective/Rationale	Supporting Constituents*
Charge balance calculations	• Alkalinity • Anions (chloride, nitrate, and sulfate) • Metals (calcium, magnesium, potassium, and sodium)
Monitoring for influence from upgradient releases (i.e., 216-B-2 Ditches) that can affect specific conductance measurements in network wells	Anions (nitrate and sulfate)
Monitoring for stainless steel well casing corrosion constituents	Metals (chromium, iron, manganese, molybdenum, and nickel)
Information on groundwater properties at the time of sampling	Field measurements (dissolved oxygen, temperature, and turbidity)

*Sampling for supporting constituents is not required by WAC 173-303-400, “Dangerous Waste Regulations,” “Interim Status Facility Standards,” or 40 CFR 265, Subpart F, “Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities,” “Ground-Water Monitoring.”

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3 Groundwater Monitoring Program

This chapter describes the groundwater monitoring indicator evaluation program for LLBG WMA-2, consisting of parameters used as indicators of groundwater contamination, parameters establishing groundwater quality, site-specific and supporting constituents, sampling frequency, monitoring well network, and sampling and analysis protocols; and summarizes the differences between this plan and the previous groundwater monitoring plan (RCRA-CN-01_DOE/RL-2009-76_R0).

3.1 Constituent List and Sampling Frequency

Table 3-1 presents the wells in the groundwater monitoring network, parameters and constituents to be analyzed, and the sampling frequency for monitoring of LLBG WMA-2. Parameters used as indicators of groundwater contamination (pH, specific conductance, TOC, and 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)). The specific phenols to be analyzed as groundwater quality parameters are identified in Table 3-2.

Although not required to be collected under 40 CFR 265, supporting constituents will be sampled and analyzed semiannually to support interpretation of the required groundwater monitoring results and monitor the condition of the network wells[2]. Supporting constituents are collected as follows:

- Charge balance calculation: alkalinity, anions (chloride, nitrate, and sulfate), and metals (calcium, magnesium, potassium, and sodium)
- Monitoring for influence of upgradient releases that can affect specific conductance measurements in network wells: nitrate and sulfate
- Well casing corrosion constituents: chromium, iron, manganese, molybdenum, and nickel
- Field measurements to provide information on groundwater properties: dissolved oxygen, temperature, and turbidity

The analytical methods associated with the sampling constituents are provided in Table A-3 in Appendix A. Samples for metals that are analyzed by either analytical method 6010 or 6020 (as identified in Table A-3) will be collected as both filtered and unfiltered samples.

Consistent with the requirements of 40 CFR 265.92(e), water-level measurements at each monitoring well will be determined each time that a sample is obtained.

[2] Some supporting constituents (chloride, iron, manganese, sodium, and sulfate) that are needed to support interpretation of groundwater conditions are also required to be collected as groundwater quality parameters under 40 CFR 265.92(b)(2). The remaining supporting constituents are not required or subject to requirements under 40 CFR 265.

Table 3-1. Monitoring Well Network and Sample Schedule for LLBG WMA-2

Well Name	Purpose	WAC Compliant	RCRA-Required Parameters[a]												Supporting Constituents[b,c]			
				Contamination Indicator Parameters				Groundwater Quality Parameters[b]										
			Water-Level	pH	Specific Conductance	Total Organic Carbon	Total Organic Halogen	Chloride	Iron	Manganese	Phenols[d]	Sodium	Sulfate	Alkalinity	Anions[e]	Field Measurements[f]	Metals[g]
299-E34-2	Upgradient[h]	Y	E	S4	S4	S4	S4	A	A	A	A	A	A	S	S	S	S
299-E27-8	Downgradient	Y	E	S4	S4	S4	S4	A	A	A	A	A	A	S	S	S	S
299-E27-9	Downgradient	Y	E	S4	S4	S4	S4	A	A	A	A	A	A	S	S	S	S
299-E27-10	Downgradient	Y	E	S4	S4	S4	S4	A	A	A	A	A	A	S	S	S	S
299-E27-11	Downgradient	Y	E	S4	S4	S4	S4	A	A	A	A	A	A	S	S	S	S

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. Samples for metals that are analyzed by either analytical method 6010 or 6020 (as identified in Table A-3) will be collected as both filtered and unfiltered samples.

c. Supporting constituents specified in Table 2-4 are used to support interpretation of the required groundwater monitoring results and provide a better understanding of the potential condition of the network wells. Some constituents (i.e., chloride, iron, manganese, sodium, and sulfate) are also collected as groundwater quality parameters and are subject to collection requirements under 40 CFR 265.92. The remaining supporting constituents are not required, or subject to requirements, under 40 CFR 265. Supporting constituents will be sampled semiannually.

d. The specific phenols to be analyzed as groundwater quality parameters are identified in Table 3-2.

e. Anions include chloride, nitrate, and sulfate.

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

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

h. As presented in Section 3.2, there is no upgradient well available for the network due to the basalt outcrop that is above the water table in the area that is upgradient of the unit. Well 299-E34-2 is located crossgradient to groundwater flow from the location of regulated dangerous waste within LLBG WMA-2 (Trench 94) and will serve the function of the upgradient network well.

Table 3-1. Monitoring Well Network and Sample Schedule for LLBG WMA-2

Well Name	Purpose	WAC Compliant	RCRA-Required Parameters[a]												Supporting Constituents[b,c]			
				Contamination Indicator Parameters				Groundwater Quality Parameters[b]										
			Water-Level	pH	Specific Conductance	Total Organic Carbon	Total Organic Halogen	Chloride	Iron	Manganese	Phenols[d]	Sodium	Sulfate	Alkalinity	Anions[e]	Field Measurements[f]	Metals[g]

A = to be sampled annually
E = to be sampled at every event
LLBG = Low-Level Burial Grounds
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*
WMA = waste management area
Y = well is or will be constructed as a resource protection well (WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells")

Table 3-2. Phenols Analyzed as Groundwater Quality Constituents

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

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

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

CAS = Chemical Abstracts Service

3.1.1 Sample Schedule Impacts from Well Maintenance and Sampling Logistics

Well maintenance (e.g., pump repairs, periodic well cleaning, and redevelopment) and sampling logistics resulting from multiple factors including environmental (e.g., inclement weather) and access restrictions (e.g., heightened fire danger, area access restriction due to work by other Hanford Site 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 sampling schedule for a well within a given month. If a well cannot be sampled at the times determined by the FWS, then the FWS and Sample Management and Reporting group, along with the project scientist, consult to determine how best to recover or reschedule the sampling event as close to the original sampling date as possible. If it is observed during the presampling walkdown that one or more network wells cannot be sampled, then sampling of the well network does not begin and management is notified. Depending on the situation, the network sampling is rescheduled as soon as feasible to meet the schedule set forth in this plan. 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 scheduling sampling for the following month. In the event that a sampling delay has occurred and the representativeness of the samples is in question, DOE and Ecology may agree to resampling wells. DOE will provide informal notification to Ecology if sampling of the network is expected to be delayed past the end of the sampling period (e.g., quarterly, semiannual). Informal notification will be made within 4 weeks of the end of the sampling period. Ecology may provide input in a timely fashion to DOE on how to proceed. Missed or canceled sampling events are reported to DOE and are documented in the annual Hanford Site RCRA groundwater monitoring report (e.g., DOE/RL-2019-65).

3.1.2 Well Biofouling and Total Organic Carbon Results

Biofouling of wells can result in collection of nonrepresentative groundwater samples and produce nonrepresentative analytical results for TOC. In Hanford Site wells, biofouling is often associated with iron-oxidizing and manganese-oxidizing bacteria. The bacterial growths are physically manifested as slime or as filamentous or flocculent accumulations. The accumulations frequently occur in the screened interval and exhibit discrete coloration (e.g., rusty orange in the case of iron-oxidizing bacteria or black in the case of manganese-oxidizing bacteria).

TOC is a nonspecific analysis that is used as an indicator of the presence of organic compounds in groundwater. TOC represents organic compounds in the sample, including dissolved organic compounds as well as suspended organic particles that may be present in an unfiltered sample. Suspended organic materials in groundwater samples can include microbial biomass associated with well biofouling. TOC is used in detection monitoring as an indicator of the possible presence of regulated organic compounds, but the TOC measurement is nonspecific. Furthermore, the TOC measurement is subject to positive interference if suspended organic material (e.g., microbial biomass) or dissolved naturally occurring organic compounds (e.g., humic and fulvic acids) are present in the sample.

If elevated concentrations of TOC are measured within a well (particularly, if a TOC concentration above the critical mean is encountered), then well maintenance will be notified. Well maintenance activities are designed to reduce the impact of biomass transfer from the well and generation of a resultant high TOC value. Well maintenance may include cleaning/rehabilitation of the well to ensure that the groundwater samples collected are representative of ambient groundwater conditions and not the result of sampling of biomass material present within the well. A down-hole camera survey and well cleaning may be scheduled following receipt of an elevated TOC result where biofouling of the well is suspected. Subsequent to well maintenance activities, a well having an exceedance of the

critical mean for TOC will be sampled for confirmational laboratory split samples as required under 40 CFR 265.93(c)(2).

3.1.3 Well Casing Corrosion

Groundwater chemistry is routinely reviewed and evaluated. If the groundwater chemistry data for a well demonstrates a consistent upward trend over time for stainless steel corrosion constituents (chromium, iron, manganese, molybdenum, and nickel) in proportionate concentrations as found in stainless steel, it may be an indicator of corrosion. These data are used to provide a better understanding of the potential condition of the network wells and are used for information only.

3.2 Monitoring Well Network

The groundwater well network identified for interim status monitoring of LLBG WMA-2 comprises one crossgradient well that will be used for upgradient purposes (299-E34-2) and four downgradient wells (299-E27-8, 299-E27-9, 299-E27-10, and 299-E27-11) (Table 3-3).

The groundwater flow direction at LLBG WMA-2 is to the south (Table 1-2 in DOE/RL-2019-65 and Figure 7-36 in ECF-HANFORD-19-0091, *Hydraulic Gradient and Average Linear Velocity Calculations - Quarter 1 Calendar Year 2019*). Due to the basalt outcrop that is above the water-table upgradient of the unit, there is no upgradient well available for the network. Previous attempts to drill monitoring wells in the area upgradient of the unit were unsuccessful in providing groundwater from the unconfined aquifer (Section 2.5).

As discussed in Section 2.3, the portion of LLBG WMA-2 that contains regulated dangerous waste is within Trench 94, located in the northwest area of the WMA. Because there is no upgradient well available for the network, crossgradient well 299-E34-2, which is located west of the groundwater flow path from Trench 94, will serve the function of the upgradient network well. Sample results from well 299-E34-2 were previously used as the source for background comparison values (critical means) for the WMA (Section 2.9 in DOE/RL-2019-65). Figure 3-1 presents the groundwater monitoring network to be used in this plan. Information on the wells comprising the network is summarized in Table 3-3.

Wells 299-E27-17, 299-E34-9, 299-E34-10, and 299-E34-12 were included as downgradient wells in the previous monitoring plan; however, they are crossgradient and outside of the downgradient flow path from the location of the regulated waste in Trench 94. These four wells are not needed for monitoring the flow path from Trench 94 and are removed from the monitoring network.

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

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

Table 3-3. Attributes for Wells in the LLBG WMA-2 Groundwater Monitoring Network

Well Name	Completion Date	Easting* (m)	Northing* (m)	Top of Casing Elevation (m [ft]) (NAVD88)	Water Table Elevation (m [ft]) (NAVD88)	Depth of Water in Screen (m [ft])	Water-Level Date
299-E27-8	1987	574759.08	137044.18	195.50 (641.40)	121.60 (398.95)	1.9 (6.2)	12/19/2019
299-E27-9	1987	574917.65	137040.90	192.87 (632.78)	121.61 (398.97)	2.2 (7.2)	12/19/2019
299-E27-10	1987	575100.30	137052.48	191.43 (628.06)	121.60 (398.95)	1.6 (5.3)	11/7/2019
299-E27-11	1989	574652.93	137062.74	197.16 (646.86)	121.61 (398.98)	2.0 (6.5)	6/24/2019
299-E34-2	1987	574634.81	137220.69	193.36 (634.37)	121.59 (398.92)	1.9 (6.2)	11/6/2019

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

*Coordinates are in Washington State Plane (south zone), NAD83, *North American Datum of 1983*.

NAVD88 = *North American Vertical Datum of 1988*

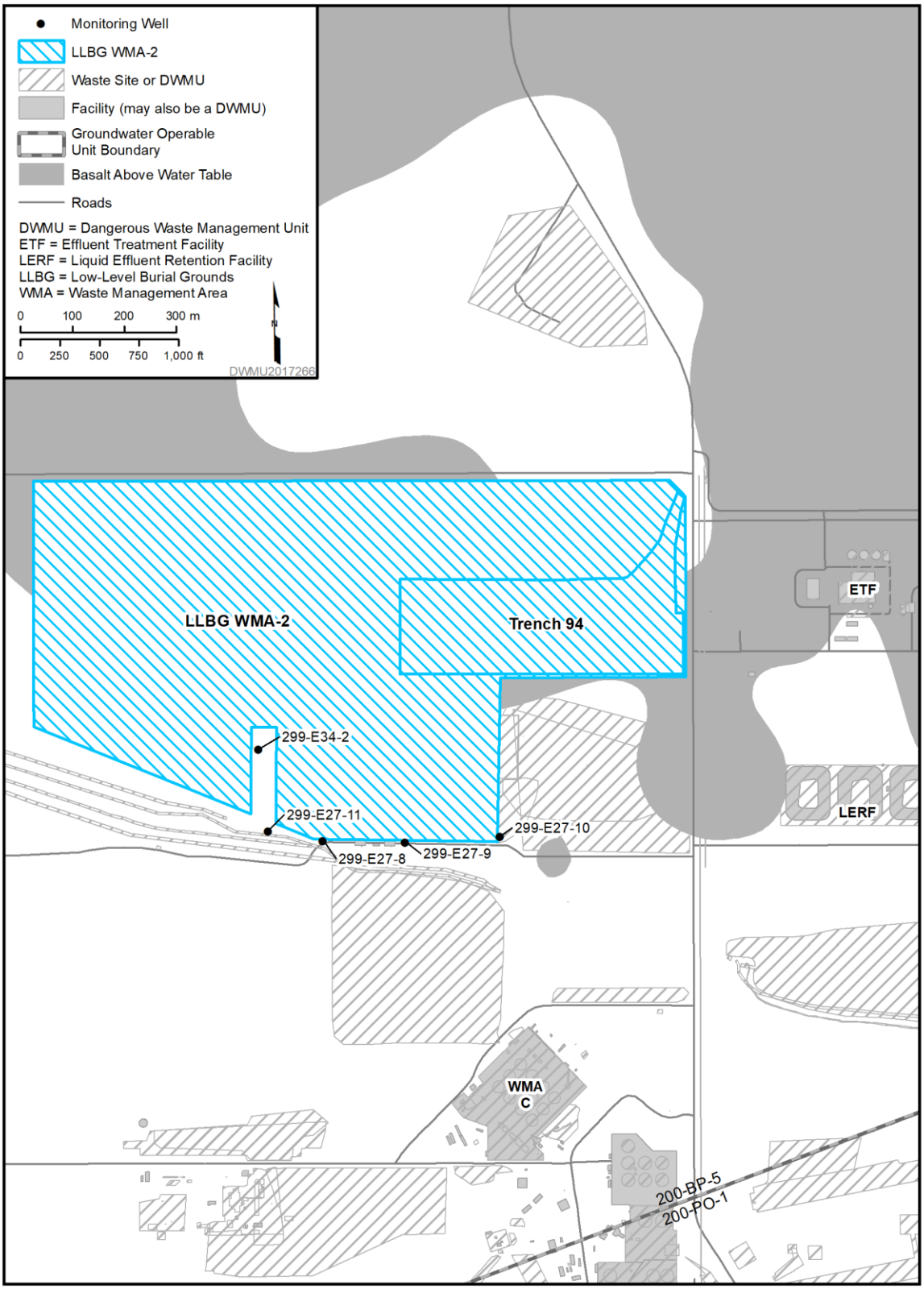

Figure 3-1. LLBG WMA-2 Monitoring Well Network

3.3 Differences Between this Plan and the Previous Plan

Table 3-4 identifies the main differences between this plan and the previous groundwater monitoring plan (DOE/RL-2009-76, as modified by RCRA-CN-01_DOE/RL-2009-76_R0).

Table 3-4. Main Differences Between this Monitoring Plan and the Previous Monitoring Plan

Type of Change	Previous Plan*	Current Plan	Justification Summary
Constituents	40 CFR 265 indicator parameters and groundwater quality parameters: included	Same	No change.
	Other analyses: Alkalinity, anions (chloride, fluoride, nitrate, nitrite, and sulfate), metals (calcium, chromium, iron, manganese, molybdenum, nickel, potassium, and sodium) dissolved oxygen, temperature, turbidity, and water level	Supporting constituents: alkalinity, anions (chloride, nitrate, and sulfate), and metals (calcium, chromium, iron, manganese, magnesium, molybdenum, nickel, potassium, and sodium) to provide additional groundwater information and detect well corrosion Field measurements: dissolved oxygen, temperature, turbidity, and water level	Fluoride and nitrite are not needed as supporting constituents. Other analytes retained and assigned to categories that are consistent with other RCRA sampling plans.
Sampling frequency	40 CFR 265 indicator parameters and groundwater quality parameters: semiannually	40 CFR 265 indicator parameters: semiannually 40 CFR 265 groundwater quality parameters: annually	Sampling frequency for groundwater quality parameters revised to align with requirements in 40 CFR 265.92(d)(1).
	Other analyses: Alkalinity, anions, metals, dissolved oxygen, temperature, turbidity, and water level: semiannually	Supporting constituents (alkalinity, anions, and metals): semiannually Field measurements: semiannually	No change.

Table 3-4. Main Differences Between this Monitoring Plan and the Previous Monitoring Plan

Type of Change	Previous Plan*	Current Plan	Justification Summary
Well network	Upgradient: 299-E34-15 299-E34-16	Crossgradient: 299-E34-2	Wells 299-E34-14, 299-E34-15, and 299-E34-16 were planned but were never drilled. Well 299-E34-13 was drilled in 2010 but did not produce water from the unconfined aquifer and was not used in the monitoring network. Due to basalt above the water table in the area upgradient of the LLBG WMA-2, no upgradient well is available for the network and previous efforts to drill upgradient monitoring wells were not successful. Wells 299-E27-17, 299-E34-2, 299-E34-9, 299-E34-10, and 299-E34-12 are crossgradient and outside of the downgradient flow path from the location of the regulated waste in Trench 94. Of these crossgradient wells, 299-E34-2 is located closest to Trench 94 and will serve the function of an upgradient well for this monitoring plan. Crossgradient wells 299-E27-17, 299-E34-9, 299-E34-10, and 299-E34-12 are not needed for monitoring the flow path from Trench 94 and are removed from the network.
	Downgradient: 299-E27-8 299-E27-9 299-E27-11 299-E27-17 299-E34-2 299-E34-9 299-E34-10 299-E34-12 299-E34-13 299-E34-14 Crossgradient: 299-E27-10	Downgradient: 299-E27-8 299-E27-9 299-E27-10 299-E27-11	
Groundwater flow direction	Southwest	South	Revised to reflect current flow direction at the unit.
Type of groundwater monitoring program	Indicator parameter monitoring	Same	No change.

Note: Complete reference citations are provided in Chapter 6.

*DOE/RL-2009-76, *Interim Status Groundwater Monitoring Plan for the LLBG WMA-2*, as modified by RCRA-CN-01_DOE/RL-2009-76_R0, *Interim Status Change Number 1: Interim Status Groundwater Monitoring Plan for the LLBG WMA-2*.

LLBG = Low-Level Burial Grounds

RCRA = *Resource Conservation and Recovery Act of 1976*

WMA = waste management area

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 DWMUs. 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).

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 LLBG WMA-2 operations have affected groundwater quality beneath the DWMU 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 (critical means) to test for potential impact to groundwater. Each time 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.

After the updated critical mean values are established, the basic procedure for statistical comparisons is as follows. Semiannually, the monitoring data from downgradient wells are compared to the upgradient[3] (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 (increases or decreases in the case of pH) over background (40 CFR 265.93(b) and Appendix IV, "Tests for Significance," to 40 CFR 265). Implementation of the statistical test method at the Hanford Site, including at LLBG WMA-2, 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 increase or decrease), then the well is resampled. 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, written notifications are made as detailed in Section 4.5 and in accordance with 40 CFR 265.93(d)(1).

[3] Due to basalt above the water table in the area upgradient of LLBG WMA-2, no upgradient well is available for the monitoring network and previous efforts to drill upgradient monitoring wells were not successful. Because there is no upgradient well available for the network, crossgradient well 299-E34-2, which is located west of the groundwater flow path from Trench 94 (where regulated waste within the WMA is located), will serve the function of the upgradient well for this monitoring plan. Sample results from well 299-E34-2 were used as the source for critical mean values calculated for use in 2019 (Section 2.9 in DOE/RL-2019-65).

4.3 Interpretation

Data are used to interpret groundwater conditions at LLBG WMA-2. Interpretive techniques may include the following:

- **Hydrographs:** Graph water levels versus time to determine decreases, increases, seasonal, or manmade fluctuations in groundwater levels.
- **Water table maps:** Use water table elevations from multiple wells to construct contour maps and to estimate flow directions. Groundwater flow is assumed to be perpendicular to the 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 groundwater monitoring network will continue to be reevaluated to ensure that it is adequate to monitor any changing hydrogeologic conditions beneath the unit. If flow changes are observed, the LLBG WMA-2 contaminant migration conceptual model and geochemical trends will be reevaluated to determine the adequacy of the network and any necessary modifications required for the network. If a change in the groundwater flow direction occurs and the monitoring network is no longer aligned to the flow direction, then the monitoring network will be modified and a revised monitoring plan will be prepared.

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; interpretation of these data are presented in the annual Hanford Site RCRA groundwater monitoring reports (e.g., DOE/RL-2019-65).

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 report (e.g., DOE/RL-2019-65) by March 1.

If an upgradient well comparison shows a significant increase (or pH decrease) relative to the statistical comparison value, that information is also reported (40 CFR 265.93(c)(1)) in the annual Hanford Site RCRA groundwater monitoring report (e.g., DOE/RL-2019-65) by March 1.

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)).

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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, the rate and extent of migration, and the 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 (e.g., 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
Contaminant Migration Conceptual Model
Monitoring Objectives
Groundwater Monitoring Program
Constituent List and Sampling Frequency
Monitoring Well Network
Sampling and Analysis Protocol
Data Evaluation and Reporting
Data Review
Data Evaluation
Interpretation
Annual Determination of Monitoring Network
Reporting, Recordkeeping, and Notification
Implementation Schedule
References
Appendix A – Quality Assurance Project Plan
Appendix B – Sampling Protocol
Appendix C – Well Construction

Note: Changes may be made to this outline, as applicable.

6 References

10 CFR 962, "Byproduct Material," *Code of Federal Regulations*. Available at: http://www.ecfr.gov/cgi-bin/text-idx?SID=24aad4966ac52acbeba416c2c1114889&mc=true&node=pt10.4.962&rgn=div5.

13-AMRP-0192, 2013, "Notification of Resource Conservation and Recovery Act Indicator Parameter Exceedance at Low-Level Waste Management Area 2" (letter to J.A. Hedges, Washington State Department of Ecology, from J.A. Dowell), U.S. Department of Energy, Richland Operations Office, Richland, Washington, May 28. Available at: https://pdw.hanford.gov/document/0088664.

40 CFR 143.3, "National Secondary Drinking Water Regulations," "Secondary Maximum Contaminant Levels," *Code of Federal Regulations*. Available at: http://www.gpo.gov/fdsys/pkg/CFR-2010-title40-vol22/xml/CFR-2010-title40-vol22-sec143-3.xml.

40 CFR 264, "Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," Appendix IX, "Ground-Water Monitoring List," *Code of Federal Regulations*. Available at: https://www.govinfo.gov/content/pkg/CFR-2018-title40-vol28/pdf/CFR-2018-title40-vol28-part264.pdf.

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.

265.90, "Applicability."

265.91, "Ground-Water Monitoring System."

265.92, "Sampling and Analysis."

265.93, "Preparation, Evaluation, and Response."

265.94, "Recordkeeping and Reporting."

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

Appendix IV, "Tests for Significance."

Subpart F, "Ground-Water Monitoring."

Atomic Energy Act of 1954, as amended, 42 USC 2011, Pub. L. 83-703, 68 Stat. 919. Available at: https://www.govinfo.gov/content/pkg/USCODE-2010-title42/html/USCODE-2010-title42-chap23-divsnA.htm.

BHI-00179, 1995, *B Plant Aggregate Area Management Study Technical Baseline Report*, Rev. 00, Bechtel Hanford, Inc., Richland, Washington. Available at: https://pdw.hanford.gov/document/D198038144.

DOE/RL-91-03, 1991, *Annual Report for RCRA Groundwater Monitoring Projects at Hanford Site Facilities for 1990*, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: https://pdw.hanford.gov/document/D196047080.

DOE/RL-92-03, 1992, *Annual Report for RCRA Groundwater Monitoring Projects at Hanford Site Facilities for 1991*, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: https://pdw.hanford.gov/document/D196089863.

DOE/RL-93-09, 1993, *Annual Report for RCRA Groundwater Monitoring Projects at Hanford Site Facilities for 1992*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: https://pdw.hanford.gov/document/D196136826.

DOE/RL-93-88, 1994, *Annual Report for RCRA Groundwater Monitoring Projects at Hanford Site Facilities for 1993*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: https://pdw.hanford.gov/document/D196094135.

DOE/RL-2002-39, 2002, *Standardized Stratigraphic Nomenclature for Post-Ringold-Formation Sediments Within the Central Pasco Basin*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: https://pdw.hanford.gov/document/0081471H.

DOE/RL-2009-76, 2010, *Interim Status Groundwater Monitoring Plan for the LLBG WMA-2*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: https://pdw.hanford.gov/document/0084331.

DOE/RL-2011-01, 2011, *Hanford Site Groundwater Monitoring Report for 2010*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: https://pdw.hanford.gov/document/0093693.

DOE/RL-2011-118, 2012, *Hanford Site Groundwater Monitoring for 2011*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington, Available at: https://pdw.hanford.gov/document/0091795.

DOE/RL-2013-22, 2013, *Hanford Site Groundwater Monitoring for 2012*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington, Available at: https://pdw.hanford.gov/document/0087974.

DOE/RL-2014-32, 2014, *Hanford Site Groundwater Monitoring Report for 2013*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: https://pdw.hanford.gov/document/0084842.

DOE/RL-2015-07, 2015, *Hanford Site Groundwater Monitoring Report for 2014*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: https://pdw.hanford.gov/document/0080600H.

DOE/RL-2016-09, 2016, *Hanford Site Groundwater Monitoring Report for 2015*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: https://pdw.hanford.gov/document/0075314H.

DOE/RL-2016-66, 2017, *Hanford Site RCRA Groundwater Monitoring Report for 2016*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: https://pdw.hanford.gov/document/0072146H.

DOE/RL-2017-66, 2017, *Hanford Site Groundwater Monitoring Report for 2017*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: https://pdw.hanford.gov/document/0064709H.

DOE/RL-2018-65, 2019, *Hanford Site RCRA Groundwater Monitoring Report for 2018*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: https://pdw.hanford.gov/document/AR-01118.

DOE/RL-2019-65, 2020, *Hanford Site RCRA Groundwater Monitoring Report for 2019*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: https://pdw.hanford.gov/document/AR-03577.

ECF-HANFORD-13-0029, 2018, *Development of the Hanford South Geologic Framework Model, Hanford Site, Washington*, Rev. 5, CH2M HILL Plateau Remediation Company, Richland, Washington. Available at: https://pdw.hanford.gov/document/0064943H.

ECF-HANFORD-18-0035, 2020, *Central Plateau Vadose Zone Geoframework*, Rev. 0, CH2M HILL Plateau Remediation Company, Richland, Washington. Available at: https://www.osti.gov/servlets/purl/1603767.

ECF-HANFORD-19-0091, 2020, *Hydraulic Gradient and Average Linear Velocity Calculations - Quarter 1 Calendar Year 2019*, Rev. 0, CH2M HILL Plateau Remediation Company, Richland, Washington. Available at: https://pdw.hanford.gov/document/AR-03541.

ECN 113805, 1991, *Engineering Change Notice to WHC-SD-EN-AP-015, Rev. 0 Revised Groundwater Monitoring Plan For Low-Level Burial Grounds*, Westinghouse Hanford Company, Richland, Washington. Available at: https://pdw.hanford.gov/document/D196046436.

ECN 144234, 1991, *Engineering Change Notice to WHC-SD-EN-AP-015, Rev. 0 Revised Groundwater Monitoring Plan For Low-Level Burial Grounds*, Westinghouse Hanford Company, Richland, Washington. Available at: https://pdw.hanford.gov/document/D196066230.

ECN 618165, 1994, *Engineering Change Notice to WHC-SD-EN-AP-015, Rev. 0 Revised Groundwater Monitoring Plan For Low-Level Burial Grounds*, Westinghouse Hanford Company, Richland, Washington. Available at: https://pdw.hanford.gov/document/D196066230.

ECN 618180, 1995, *Engineering Change Notice to WHC-SD-EN-AP-015, Rev. 0 Revised Groundwater Monitoring Plan For Low-Level Burial Grounds*, Westinghouse Hanford Company, Richland, Washington. Available at: https://pdw.hanford.gov/document/D196007403.

EIS-0259, 1996, *Final Environmental Impact Statement on the Disposal of Decommissioned, Defueled Cruiser, Ohio Class, and Los Angeles Class Naval Reactor Plants*, U.S. Department of the Navy. Available at: https://energy.gov/sites/prod/files/EIS-0259-FEIS-01-1996_0.pdf.

Ecology, EPA, and DOE, 1989, *Hanford Federal Facility Agreement and Consent Order*, 2 vols., as amended, Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Olympia, Washington. Available at: http://www.hanford.gov/?page=81.

EPA 530/R-09-007, 2009, *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities Unified Guidance*, Office of Resource Conservation and Recovery, U.S. Environmental Protection Agency, Washington, D.C. Available at: https://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=P10055GQ.TXT.

Lindsey, K.A., 1996, *The Miocene to Pliocene Ringold Formation and Associated Deposits of the Ancestral Columbia River System, South-central Washington and North-central Oregon*, Open File Report 96-8, Washington Division of Geology and Earth Resources, Washington State Department of Natural Resources, Olympia, Washington. Available at: http://www.dnr.wa.gov/Publications/ger_ofr96-8_ringold_formation.pdf.

NAD83, 1991, *North American Datum of 1983*, as revised, National Geodetic Survey, Federal Geodetic Control Committee, Silver Spring, Maryland. Available at: http://www.ngs.noaa.gov/.

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

PNL-6772, 1987, *A Detection-Level Hazardous Waste Ground-Water Monitoring Compliance Plan for the 200 Areas Low-Level Burial Grounds and Retrievable Storage Units*, Pacific Northwest Laboratory, Richland, Washington. Available at: http://www.osti.gov/scitech/biblio/6201649.

PNL-6820, 1989, *Hydrogeology of the 200 Areas Low-Level Burial Grounds—An Interim Report: Volume 1: Text*, Vol. 1, Pacific Northwest Laboratory, Richland, Washington. Available at: https://pdw.hanford.gov/document/D195066506.

PNL-6820, 1989, *Hydrogeology of the 200 Areas Low Level Burial Grounds—An Interim Report: Volume 2: Appendixes*, Vol. 2, Pacific Northwest Laboratory, Richland, Washington. Available at: https://pdw.hanford.gov/document/D195066592. https://pdw.hanford.gov/document/D195066599.

PNNL-11793, 1998, *Hanford Site Groundwater Monitoring for Fiscal Year 1997*, Pacific Northwest National Laboratory, Richland, Washington. Available at: https://pdw.hanford.gov/document/D199132962.

PNNL-12261, 2000, *Revised Hydrogeology for the Suprabasalt Aquifer System, 200-East Area and Vicinity, Hanford Site, Washington*, Pacific Northwest National Laboratory, Richland, Washington. Available at: https://pdw.hanford.gov/document/0906180659.

PNNL-13116, 2000, *Hanford Site Groundwater Monitoring for Fiscal Year 1999*, Pacific Northwest National Laboratory, Richland, Washington. Available at: https://pdw.hanford.gov/document/D2736610. https://pdw.hanford.gov/document/D2736978.

PNNL-13404, 2001, *Hanford Site Groundwater Monitoring for Fiscal Year 2000*, Pacific Northwest National Laboratory, Richland, Washington. Available at: https://pdw.hanford.gov/document/D2743868. https://pdw.hanford.gov/document/D2786917.

PNNL-14187, 2003, *Hanford Site Groundwater Monitoring for Fiscal Year 2002*, Pacific Northwest National Laboratory, Richland, Washington. Available at: https://pdw.hanford.gov/document/D2752375. https://pdw.hanford.gov/document/D2755548.

PNNL-14548, 2004, *Hanford Site Groundwater Monitoring for Fiscal Year 2003*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-14548.pdf.

PNNL-14702, 2006, *Vadose Zone Hydrogeology Data Package for Hanford Assessments*, Rev. 1, Pacific Northwest National Laboratory, Richland, Washington. Available at: https://pdw.hanford.gov/document/0911300343.

PNNL-14753, 2006, *Groundwater Data Package for Hanford Assessments*, Rev. 1, Pacific Northwest National Laboratory, Richland, Washington. Available at: https://pdw.hanford.gov/document/0912020007. https://pdw.hanford.gov/document/0912020126.

PNNL-14859, 2004, *Interim Status Groundwater Monitoring Plan for Low-Level Waste Management Areas 1 to 4, RCRA Facilities, Hanford, Washington*, Rev. 0, Pacific Northwest National Laboratory, Richland, Washington. Available at: https://pdw.hanford.gov/document/D6541642.

PNNL-14859-ICN-1, 2006, *Interim Status Groundwater Monitoring Plan for Low-Level Waste Management Areas 1 to 4, RCRA Facilities, Hanford, Washington*, Interim Change Notice 1, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-14859icn1.pdf.

PNNL-19277, 2010, *Conceptual Models for Migration of Key Groundwater Contaminants Through the Vadose Zone and Into the Unconfined Aquifer Below the B-Complex*, Pacific Northwest National Laboratory, Richland, Washington. Available at: https://pdw.hanford.gov/document/0084238.

RCRA-CN-01_DOE/RL-2009-76_R0, 2020, *Interim Status Change Number 1: Interim Status Groundwater Monitoring Plan for the LLBG WMA-2*, dated June 11, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: https://pdw.hanford.gov/document/AR-03866.

RCW 70.105, "Hazardous Waste Management," *Revised Code of Washington*, Olympia, Washington. Available at: http://apps.leg.wa.gov/RCW/default.aspx?cite=70.105.

RHO-RE-ST-12P, 1984, *An Assessment of Aquifer Intercommunication in the B Pond-Gable Mountain Pond Area of the Hanford Site*, Rockwell Hanford Operations, Richland, Washington. Available at: https://pdw.hanford.gov/document/D196002251.

Resource Conservation and Recovery Act of 1976, 42 USC 6901, et seq. Available at: https://elr.info/sites/default/files/docs/statutes/full/rcra.pdf.

SGW-41072, 2009, *Liquid Effluent Retention Facility Characterization Report*, Rev. 0, CH2M HILL Plateau Remediation Company, Richland, Washington. Available at: https://pdw.hanford.gov/document/0906160165.

SGW-52162, 2012, *Seismic Reflection Investigation at the Liquid Effluent Retention Facility, 200 East Area, Hanford Site Richland, Washington*, Rev. 0, CH2M HILL Plateau Remediation Company, Richland, Washington. Available at: https://pdw.hanford.gov/document/0071843H.

SGW-52467, 2012, *Integrated Surface Geophysical Investigation Results at Liquid Effluent Retention Facility, 200 East Area, Hanford, Washington*, Rev. 0, CH2M HILL Plateau Remediation Company, Richland, Washington. Available at: https://pdw.hanford.gov/document/0073389H.

SGW-54165, 2014, *Evaluation of the Unconfined Aquifer Hydraulic Gradient Beneath the 200 East Area, Hanford Site*, Rev. 0, CH2M HILL Plateau Remediation Company, Richland, Washington. Available at: https://pdw.hanford.gov/document/0085682.

SGW-60338, 2017, *Historical Changes in Water Table Elevation and Groundwater Flow Direction at Hanford: 1944 to 2014*, Rev. 0, CH2M HILL Plateau Remediation Company, Richland, Washington. Available at: https://pdw.hanford.gov/document/0072270H.

Toxic Substances Control Act of 1976, Pub. L. 94-469, as amended, 15 USC 2601, et seq. Available at: https://www.govinfo.gov/content/pkg/STATUTE-90/pdf/STATUTE-90-Pg2003.pdf.

WA7890008967, *Hanford Facility Resource Conservation and Recovery Act (RCRA) Permit, Dangerous Waste Portion for the Treatment, Storage, and Disposal of Dangerous Waste*, Revision 8c, as amended, Washington State Department of Ecology. Available at: https://fortress.wa.gov/ecy/nwp/permitting/hdwp/rev/8c/index.html.

WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells," *Washington Administrative Code*, Olympia, Washington. Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-160.

WAC 173-303, "Dangerous Waste Regulations," *Washington Administrative Code*, Olympia, Washington. Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-303.

303-400, "Interim Status Facility Standards."

303-071, "Excluded Categories of Waste."

WAC 173-340-705, "Model Toxics Control Act—Cleanup," "Use of Method B," *Washington Administrative Code*, Olympia, Washington. Available at: https://apps.leg.wa.gov/wac/default.aspx?cite=173-340.

WHC-EP-0912, 1996, *The History of the 200 Area Burial Ground Facilities*, 2 vols., Westinghouse Hanford Company, Richland, Washington. Available at: https://www.osti.gov/scitech/servlets/purl/827767. https://www.osti.gov/scitech/servlets/purl/16778.

WHC-MR-0204, 1990, *200-East and 200-West Areas Low-Level Burial Grounds Borehole Summary Report*, Westinghouse Hanford Company, Richland, Washington. Available at: https://pdw.hanford.gov/document/D196038070.

WHC-MR-0391, 1992, *Field Trip Guide to the Hanford Site*, Westinghouse Hanford Company, Richland, Washington. Available at: https://pdw.hanford.gov/document/D196136627.

WHC-SD-EN-AP-015, 1989, *Revised Ground-Water Monitoring Plan for the 200 Areas Low-Level Burial Grounds*, Rev. 0, prepared by Pacific Northwest Laboratory for Westinghouse Hanford Company, Richland, Washington. Available at: https://pdw.hanford.gov/document/D195063349.

WHC-SD-EN-TI-012, 1992, *Geologic Setting of the 200 East Area; An Update*, Rev. 0, Westinghouse Hanford Company, Richland, Washington. Available at: https://pdw.hanford.gov/document/E0019549.

WHC-SD-EN-TI-019, 1992, *Hydrogeologic Model for the 200 East Groundwater Aggregate Area*, Rev. 0, Westinghouse Hanford Company, Richland, Washington. Available at: https://pdw.hanford.gov/document/D196113608.

WHC-SD-EN-TI-290, 1994, *Geologic Setting of the Low-Level Burial Grounds*, Rev. 0, Westinghouse Hanford Company, Richland, Washington. Available at: http://www.osti.gov/scitech/servlets/purl/10192359.

WHC-SD-WM-TI-260, 1986, *Water Inflow Investigation at the 218-E-12A and 218-E-12B Burial Grounds*, Rev. 0, Rockwell Hanford Operations, Richland, Washington. Available at: https://pdw.hanford.gov/document/0082369H.

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

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Appendix A

Quality Assurance Project Plan

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Terms

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

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A1 Introduction

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

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

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

A2 Project Management

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

A2.1 Project/Task Organization

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

A2.1.1 U.S. Department of Energy Manager

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

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

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

A2.1.3 U.S. Department of Energy Prime Contractor Management

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

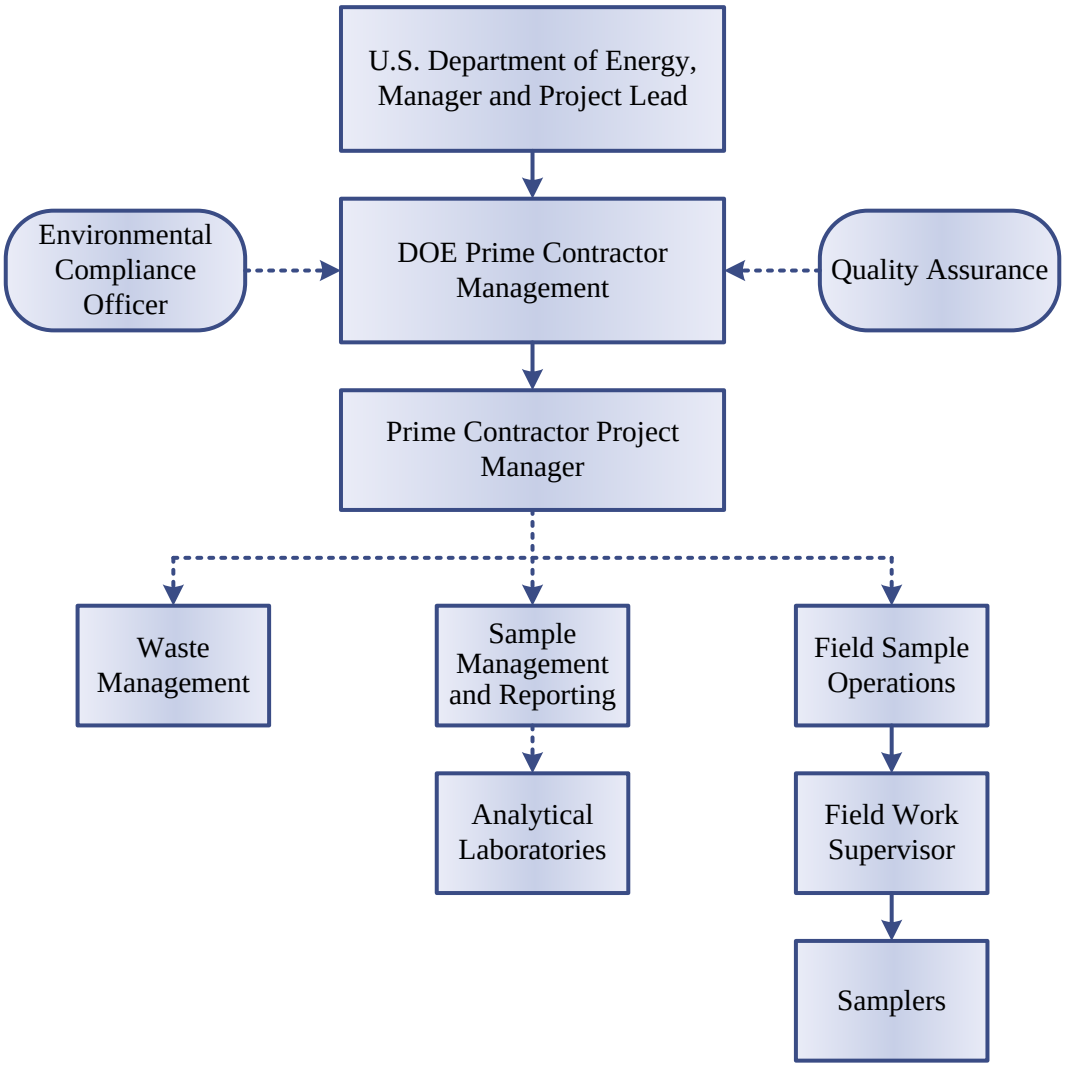

Figure A-1. Project Organization

A2.1.4 Prime Contractor Project Manager

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

A2.1.5 Sample Management and Reporting Group

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

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

A2.1.6 Field Sample Operations

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

A2.1.7 Quality Assurance

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

A2.1.8 Environmental Compliance Officer

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

A2.1.9 Waste Management

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

A2.1.10 Analytical Laboratories

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

A2.2 Problem Definition/Background

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

A2.3 Project/Task Description

The focus of this plan is to monitor the parameters used as indicators of groundwater contamination and for parameters establishing groundwater quality in accordance with 40 CFR 265.92, “Sampling and Analysis,” evaluate the well network, and interpret analytical results. The indicator parameters to be monitored, along with the monitoring wells and frequency of sampling, are provided in the main

text (Chapter 3). Information about the collection and analyses of groundwater from the monitoring network is provided in this appendix and in Appendix B.

A2.4 Quality Assurance Objectives and Criteria

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

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

A2.5 Documents and Records

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

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

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

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

By March 1, groundwater monitoring results are reported in the Hanford Site RCRA groundwater monitoring report (e.g., DOE/RL-2019-65, *Hanford Site RCRA Groundwater Monitoring Report for 2019*).

Table A-1. Data Quality Indicators

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

Table A-1. Data Quality Indicators

Data Quality Indicator (QC Element)[a]	Definition	Determination Methodologies	Possible Corrective Actions
Comparability (field duplicate, field splits, laboratory control samples, matrix spikes, and matrix spike duplicates)	Comparability expresses the degree of confidence with which one dataset can be compared to another. It is dependent upon the proper design of the sampling program and will be satisfied by ensuring that the approved plans are followed and that proper sampling and analysis techniques are applied.	Use identical or similar sample collection and handling methods, sample preparation and analytical methods, holding times, and quality assurance protocols.	If data are not comparable to other datasets: • Identify appropriate changes to data collection and/or analysis methods. • Identify quantifiable bias, if applicable. • Qualify the data as appropriate. • Resample and/or reanalyze if needed. • Revise sampling/analysis protocols to ensure future comparability.
Completeness (no QC element; addressed in data usability assessment)	Completeness is a measure of the amount of valid data collected compared to the amount of data planned. Measurements are considered valid if they are unqualified or qualified as estimated data during validation. Field completeness is a measure of the number of samples collected versus the number of samples planned. Laboratory completeness is a measure of the number of valid measurements compared to the total number of measurements planned.	Compare the number of valid measurements completed (samples collected or samples analyzed) with those established by the project's quality criteria (data quality objectives or performance/acceptance criteria).	If dataset does not meet the completeness objective: • Identify appropriate changes to data collection and/or analysis methods. • Identify quantifiable bias, if applicable. • Resample and/or reanalyze if needed. • Revise sampling/analysis protocols to ensure future completeness.

Table A-1. Data Quality Indicators

Data Quality Indicator (QC Element)[a]	Definition	Determination Methodologies	Possible 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 processes to limit preferential selection or loss of sample media. • Use sample handling processes, including proper sample preservation, that limit the loss or gain of constituents to the sample media. • Analytical data that are known to be affected by either sampling or analytical bias are flagged to indicate possible bias. • Laboratories that are known to generate biased data for a specific analyte are asked to correct their methods to remove the bias as practicable. Otherwise, samples are sent to other laboratories for analysis.
Sensitivity (method detection limit, practical quantitation limit, and relative percent difference)	Sensitivity is an instrument's or method's minimum concentration that can be reliably measured (i.e., instrument detection limit or limit of quantitation).	Determine the minimum concentration or attribute to be measured by an instrument (instrument detection limit) or by a laboratory (limit of quantitation). The lower limit of quantitation[b] is the lowest level that can be routinely quantified and reported by a laboratory.	If detection limits do not meet objective: • Request reanalysis or remeasurement using methods or analytical conditions that will meet required detection or limit of quantitation. • Qualify/reject the data before use.

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

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

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

QC = quality control

Table A-2. Change Control for Monitoring Plans

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

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

DOE = U.S. Department of Energy
Ecology = Washington State Department of Ecology
RCRA = *Resource Conservation and Recovery Act of 1976*

A3 Data Generation and Acquisition

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

A3.1 Analytical Method Requirements

Sample analytical methods are presented in Table A-3. Equivalent or updated Washington State Department of Ecology-accredited methods may be substituted for the methods identified in Table A-3.

Table A-3. Analytical Methods for the Low-Level Burial Grounds Waste Management Area-2

CAS Number[a]	Waste Constituent (Alternate Name)	Analytical Method[b]	PQL (µg/L)
General Chemistry			
ALKALINITY	Alkalinity, total as CaCO3	310.1, Standard Method 2320, Standard Method 4500	5250
TOC	Total organic carbon	9060	1050
59473-04-0	Total organic halogen	9020	31.5
Anions[c]			
16887-00-6	Chloride	300, 9056	400
14797-55-8	Nitrate, as NO3	300, 9056	525

Table A-3. Analytical Methods for the Low-Level Burial Grounds Waste Management Area-2

CAS Number[a]	Waste Constituent (Alternate Name)	Analytical Method[b]	PQL (µg/L)
Field Measurements			
--	pH	150.1, 9040, Standard Method 4500 H+	N/A
--	Dissolved oxygen	360.1, Standard Method 4500 O	N/A
--	Specific conductance	120.1, 9050, Standard Method 2520 B-97	N/A
--	Temperature	170.1	N/A
--	Turbidity	180.1, Standard Method 2130 B	N/A
Metals			
7440-70-2	Calcium	6010	1050
7440-47-3	Chromium	6020	10.5
7439-89-6	Iron	6010	105
7439-92-1	Lead	6020	3.15
7439-96-5	Manganese	6020	10.5
7439-98-7	Molybdenum	6020	5.25
7440-02-0	Nickel	6020	21
7440-09-7	Potassium	6010	5250
7440-23-5	Sodium	6010	1050
Semivolatile Organic Compounds			
95-57-8	2-Chlorophenol	8270	10.5
95-48-7	2-Methylphenol (o-Cresol)	8270	10.5
88-75-5	2-Nitrophenol (o-Nitrophenol)	8270	10.5
58-90-2	2,3,4,6-Tetrachlorophenol	8270	52.5
120-83-2	2,4-Dichlorophenol	8270	10.5
105-67-9	2,4-Dimethylphenol (2,4-Xylenol)	8270	10.5
51-28-5	2,4-Dinitrophenol	8270	52.5
95-95-4	2,4,5-Trichlorophenol	8270	10.5
88-06-2	2,4,6-Trichlorophenol	8270	10.5
87-65-0	2,6-Dichlorophenol	8270	10.5

Table A-3. Analytical Methods for the Low-Level Burial Grounds Waste Management Area-2

CAS Number[a]	Waste Constituent (Alternate Name)	Analytical Method[b]	PQL (µg/L)
108-39-4[d]	3-Methylphenol (m-Cresol)	8270	--
59-50-7	4-Chloro-3-methylphenol (p-Chloro-m-cresol)	8270	10.5
106-44-5[d]	4-Methylphenol (p-Cresol)	8270	--
534-52-1	4,6-Dinitro-o-cresol (4,6-Dinitro-2-methyl phenol)	8270	52.5
88-85-7	Dinoseb (2-sec-Butyl-4,6-dinitrophenol)	8270	21
100-02-7	p-Nitrophenol (4-Nitrophenol)	8270	21
87-86-5	Pentachlorophenol	8270	52.5
108-95-2	Phenol	8270	10.5

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

a. Value in this column is either the CAS number or the constituent identifier if no CAS number exists.

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

c. Dilutions for certain ion chromatography constituents may be necessary, potentially raising the PQL above the limits provided.

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

CAS = Chemical Abstracts Service
EPA = U.S. Environmental Protection Agency
N/A = not applicable
PQL = practical quantitation limit

A3.2 Field Analytical Methods

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

A3.3 Quality Control

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

Table A-4. QC Samples

Sample Type	Frequency	Characteristics Evaluated
Field QC		
Equipment blanks	1 in 20 samples when nondedicated equipment is used[a]	Contamination from nondedicated sampling equipment
Field duplicates	1 in 20 well trips[b]	Reproducibility/sampling precision
Field splits	As needed	Interlaboratory comparability
Full trip blanks	1 in 20 well trips[b]	Contamination from containers preservative reagents, storage, or transportation
Analytical QC[c]		
Laboratory control samples	One per analytical batch[d]	Method accuracy
Laboratory sample duplicates	One per analytical batch[d]	Laboratory reproducibility and precision
Matrix spikes	One per analytical batch[d]	Matrix effect/laboratory accuracy
Matrix spike duplicates	One per analytical batch[d]	Laboratory reproducibility, and method accuracy and precision
Method blanks	One per analytical batch[d]	Laboratory contamination
Surrogates	Added to each sample and QC sample	Recovery/yield for organic compounds

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

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

b. A "well trip" is defined as any time a well is accessed for sampling. Field duplicates and full trip blanks are run at a frequency of 1 in 20 well trips (i.e., 5% of the well trips) for all groundwater monitoring wells sampled within any given month (for all groundwater monitoring programs).

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

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

QC = quality control

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

Analyte[a]	QC Element	Acceptance Criteria	Corrective Action
General Chemistry			
Alkalinity	MB	<MDL or <5% sample concentration	Flag with "C"
	LCS	80% to 120% recovery	Flag with "o"[b]

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

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

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

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

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

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

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

b. The reporting laboratory will apply the "o" flag with SMR group concurrence.

c. Applies when at least one result is greater than the laboratory PQL.

d. Either a DUP or an MS/MSD is to be analyzed to determine measurement precision. If there is insufficient sample volume, an LCS duplicate is analyzed with the acceptance criteria defaulting to the ≤20% RPD criteria.

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

Analyte[a]	QC Element	Acceptance Criteria	Corrective Action

e. After review, corrective actions are determined on a case-by-case basis. Corrective actions may include a laboratory recheck or flagging the data.

f. For common laboratory contaminants such as acetone, methylene chloride, 2-butanone, toluene, and phthalate esters, the acceptance criteria is <5 times the MDL.

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

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

Data flags:

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

A3.3.1 Field Quality Control Samples

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

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

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

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

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

- **Full trip blanks:** FTBs are used to monitor for potential sample contamination from the sampling container, preservation reagents, or storage conditions. FTBs are prepared with high-purity water and sealed prior to traveling to the sampling site, transported to the sampling site (not opened in the field), and then shipped as part of the sample set to the laboratory. The bottle set is either for volatile organic analysis only or identical to the set that will be collected in the field. Collected FTBs are typically analyzed for the same constituents as the samples from the associated sampling event.

A3.3.2 Laboratory Quality Control Samples

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

- **Laboratory control sample:** A control matrix (e.g., reagent water) spiked with analytes representative of the target analytes or a certified reference material that is used to evaluate laboratory accuracy.

- **Laboratory sample duplicate:** A second aliquot of a sample that is taken through the entire sample preparation and analytical process. DUPs are used to evaluate the precision of a method in a given sample matrix.

- **Matrix spike:** An aliquot of a sample spiked with a known concentration of target analyte(s) that is then taken through the entire sample preparation and analytical process. An MS is used to assess the bias of a method in a given sample matrix. Thus, MS results are an indicator of the effect the sample matrix has on the accuracy of measurement of the target analytes.

- **Matrix spike duplicate:** A replicate spiked aliquot of a sample that is subjected to the entire sample preparation and analytical process. MSD results are used to determine the bias and precision of a method in a given sample matrix.

- **Method blank:** An analyte-free matrix to which the same reagents are added in the same volumes or proportions as used in the sample processing. The MB is carried through the complete sample preparation and analytical process. The MB is used to quantify contamination resulting from the sample preparation and analysis.

- **Surrogate:** Used only in organic analyses, a compound added to every sample in the analysis batch (field samples and QC samples) prior to preparation. SURs are typically similar in chemical composition to the analyte being determined, but they are not normally encountered. SURs are expected to respond to the preparation and analytical process in a manner similar to the analytes of interest. Because SURs are added to every sample and QC sample, they are used to evaluate overall method performance in a given matrix.

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

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

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

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

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

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

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

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

EPA = U.S. Environmental Protection Agency

A3.4 Measurement Equipment

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

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

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

A3.6 Instrument/Equipment Calibration and Frequency

Field equipment calibration is discussed in Appendix B.

A3.7 Inspection/Acceptance of Supplies and Consumables

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

A3.8 Nondirect Measurements

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

A3.9 Data Management

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

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

A4 Data Review and Usability

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

A4.1 Data Review and Verification

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

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

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

A4.2 Data Validation

Data validation is performed at the discretion of the Prime Contractor Project Manager, under the direction of the SMR group. The decision to perform validation is based on the results of QC samples for individual well networks and discussions with the staff member assigned by the Prime Contractor Project Manager. If conducted, data validation (third-party) will be performed at a minimum frequency of 5% per method. Data validation evaluates the analytical quality of data from samples specifically collected for this plan.

A4.3 Reconciliation with User Requirements

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

A5 References

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."

265.94, "Recordkeeping and Reporting."

Subpart F, "Ground-Water Monitoring."

APHA/AWWA/WEF, 2017, *Standard Methods for the Examination of Water and Wastewater*, 23rd Edition, American Public Health Association, American Water Works Association, and Water Environment Federation, Washington, D.C.

Atomic Energy Act of 1954, as amended, 42 USC 2011, Pub. L. 83-703, 68 Stat. 919. Available at: https://www.energy.gov/sites/prod/files/2017/10/f38/Atomic%20Energy%20Act%20of%201954%20%28AEA%29%20in%20U.S.C..pdf.

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

DOE/RL-2019-65, 2020, *Hanford Site RCRA Groundwater Monitoring Report for 2019*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: https://pdw.hanford.gov/document/AR-03577.

Ecology, EPA, and DOE, 1989, *Hanford Federal Facility Agreement and Consent Order*, 2 vols., as amended, Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Olympia, Washington. Available at: http://www.hanford.gov/?page=81.

EPA-600/4-79/020, 1983, *Methods for Chemical Analysis of Water and Wastes*, Office of Research and Development, U.S. Environmental Protection Agency, Washington, D.C. Available at: https://pdw.hanford.gov/document/D196019611.

EPA/600/R-93/100, 1993, *Methods for the Determination of Inorganic Substances in Environmental Samples*, Office of Research and Development, U.S. Environmental Protection Agency, Washington, D.C. Available at: https://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=30002U3P.txt.

Resource Conservation and Recovery Act of 1976, 42 USC 6901, et seq. Available at: https://elr.info/sites/default/files/docs/statutes/full/rcra.pdf.

SW-846, 2019, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods*, as amended, Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington, D.C. Available at: https://www.epa.gov/hw-sw846.

SW-846 Compendium, as amended, Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington, D.C. Available at: https://www.epa.gov/hw-sw846/sw-846-compendium.

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.

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Appendix B

Sampling Protocol

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Terms

DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
IATA	International Air Transport Association
QA	quality assurance
QC	quality control

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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, "Dangerous Waste Regulations," has been conducted since the mid-1980s. Hanford Site groundwater sampling methods contain sampling precautions to be taken; identify equipment and its use; cleaning and decontamination practices; records and documentation; and sample collection, management, and control activities. Together, Appendices A and B discuss the sampling and analysis elements for the groundwater monitoring plan: sample collection, sample preservation and holding times, chain-of-custody control, analytical methods, and field and laboratory quality assurance (QA)/quality control (QC).

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

B2 Sampling Methods

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

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

Groundwater samples will be collected according to the current and applicable field practices. Groundwater samples are collected after field measurements of purged groundwater have stabilized as follows:

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

Dissolved oxygen will also be measured in the field. Dissolved oxygen is not required to be stable prior to sample collection.

Environmental-grade electric submersible pumps will typically be used for well purging and sample collection in existing wells with a flow rate not exceeding 7.6 L/min (2 gal/min). In the event a well exhibits insufficient productivity to support purging and sampling using the environmental-grade electric submersible pumps, adjustable-rate bladder pumps with typical flow rates of 0.1 to 0.5 L/min (0.026 to 0.13 gal/min) may be employed. As environmental-grade electric submersible pumps are replaced when they reach the end of their service lives due to age, normal wear, or failure, they will be replaced with adjustable-rate bladder pumps. The same purge protocol described for environmental-grade electric submersible pumps will be used for the adjustable-rate bladder pumps.

Unless special directions are provided by the staff assigned by the Prime Contractor Project Manager at the time of the sample collection, wells are typically purged at a flow rate not to exceed

7.6 L/min (2 gal/min). Purging will continue until stable readings of selected field water quality parameters are achieved (as described above).

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

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

Samples may be filtered in the field using a 0.45 µm filter as noted on the chain-of-custody form. Unfiltered samples are collected in conjunction with filtered samples to determine if metal constituents being monitored (excluding hexavalent chromium, if one of the monitored constituents) occur as both suspended and dissolved phases, or in only one state. The evaluation of suspended and dissolved metals provides supporting information for groundwater geochemical characteristics, as well as indication of well integrity such as the presence of dislodged well encrustation, well corrosion products, or failure of the well screen filter pack. For certain types of samples, preservatives are required. Based on the analytical methods used, preservatives are generally added to the collection bottles before their use in the field. Sample preservation and holding times for groundwater samples are provided in Appendix A (Table A-6) and are based on the analytical method identified in Appendix A (Table A-3). Container types, preservatives, and volumes will be identified on the chain-of-custody form. This groundwater monitoring plan defines a sample as a filled sample bottle for purposes of starting the clock for holding time restrictions.

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

B2.1 Decontamination of Drilling and Sampling Equipment

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

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

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

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

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

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

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

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

B2.2 Water Levels

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

B3 Documentation of Field Activities

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

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

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

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

B4 Calibration of Field Equipment

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

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

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

B5 Sample Handling

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

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

B5.1 Containers

Samples will be collected, where and when appropriate, in break-resistant containers. The field sample collection record will indicate the lot number of the bottles used in sample collection. When commercially precleaned

containers are used in the field, the name of the manufacturer, lot identification, and certification will be retained for documentation.

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

B5.2 Container Labeling

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

B5.3 Sample Custody

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

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

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

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

Sample custody will be maintained within subcontract laboratories in accordance with documented protocols.

B5.4 Sample Transportation

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

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

B6 Management of Waste

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

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

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

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

B7 References

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

APHA/AWWA/WEF, 2017, *Standard Methods for the Examination of Water and Wastewater*, 23rd Edition, American Public Health Association, American Water Works Association, and Water Environment Federation, Washington, D.C.

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

Ecology, EPA, and DOE, 1989, *Hanford Federal Facility Agreement and Consent Order Action Plan*, as amended, Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Olympia, Washington. Available at: http://www.hanford.gov/?page=82.

EPA-600/4-79/020, 1983, *Methods for Chemical Analysis of Water and Wastes*, Office of Research and Development, U.S. Environmental Protection Agency, Washington, D.C. Available at: https://pdw.hanford.gov/document/D196019611.

IATA, *Dangerous Goods Regulations*, current edition, International Air Transport Association, Montreal, Quebec, Canada.

Resource Conservation and Recovery Act of 1976, 42 USC 6901, et seq. Available at: https://elr.info/sites/default/files/docs/statutes/full/rcra.pdf.

SW-846, 2019, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods*, as amended, Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington D.C. Available at: https://www.epa.gov/hw-sw846.

WAC 173-303, "Dangerous Waste Regulations," *Washington Administrative Code*, Olympia, Washington. Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-303.

Appendix C

Well Construction

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C1 Introduction

This appendix provides the following information for the Low-Level Burial Ground (LLBG) Waste Management Area (WMA)-2 groundwater monitoring wells:

- Well name
- Hydrogeologic unit to be monitored (i.e., 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-5 provide the well construction and completion summary for both upgradient and downgradient wells selected for the LLBG WMA-2 well 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 LLBG WMA-2 Network

Well 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])	Drilling Method
299-E27-8	TU	125.8 (412.7)	119.7 (392.7)	6.1 (20.0)	Cable tool
299-E27-9	TU	125.3 (411.1)	119.4 (391.8)	5.9 (19.3)	Cable tool
299-E27-10	TU	126.2 (413.9)	120.0 (393.6)	6.2 (20.3)	Cable tool
299-E27-11	TU	126.0 (413.5)	119.6 (392.5)	6.4 (21.0)	Cable tool
299-E34-2	TU	125.8 (412.7)	119.7 (392.7)	6.1 (20.0)	Cable tool

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

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

Battelle Pacific Northwest Laboratories

AS-BUILT DIAGRAM

Well Number 299-E27-8 Geologist S. M. Goodwin/P. White, K.R. Oster, M.A. Chamness Page 1 of 2

Reviewed by [illegible] Date 12-18-87

Construction Data: Description	Construction Data: Diagram	Depth in Feet	Geologic/Hydrologic Data: Diagram Litho.	Geologic/Hydrologic Data: Lithologic Description	Drill rate ft/hr
cement 0-4.5'		5'		silty sandy gravel	1.7'
16" carbon steel casing		10'		" " "	2.5'
		15'		" " "	3.3'
		20'		" " "	5.0'
		25'		SL. SILTY GRAVELLY SAND	3.8'
bentonite crumbles 4.5'-216'		30'		SILTY SANDY GRAVEL	5.5'
		35'		" "	2.0'
		40'		" "	10.0'
		45'		" "	7.5'
		50'		SLIGHTLY SILTY GRAVELLY SAND	4.3
12" carbon steel casing		55'		SILTY SANDY GRAVEL	12.0'
		60'		" "	2.9'
		65'		" "	3.0
		70'		SL. SILTY GRAVELLY SAND	6.0
		75'		" "	8.6'
		80'		SILTY SANDY GRAVEL	10.0
		85'		" " "	7.5'
		90'		" " "	2.2
		95'		GRAVELLY SILTY SAND	6.0
		100'		SILTY SANDY GRAVEL	4.6'
		105'		" " "	3.8
10" carbon steel casing		110'		SL. SILTY GRAVELLY SAND	2.5
		115'		GRAVELLY SAND	2.5
		120'		SL. SILTY GRAVELLY SAND	2.5
		125'		" " "	4.0
8" carbon steel casing		130'		" " "	6.7

A-1800-186 (3/87)

Figure C-1. Well 299-E27-8 Construction and Completion Summary (1 of 2)

Battelle Pacific Northwest Laboratories

AS-BUILT DIAGRAM

Well Number 299-E27-8 Geologist Goodwin / White, K.R. Oster, M.A. Chamness Page 2 of 2

Reviewed by J.L. McShane Date

Construction Data: Description	Construction Data: Diagram	Depth in Feet	Geologic/Hydrologic Data: Diagram Litho.	Geologic/Hydrologic Data: Lithologic Description	Drilling rate (ft/hr)
		137		GRAVELLY SAND	2.5
10" carbon steel casing		140		SL. SILTY GRAVELLY SAND	6.
		145		GRAVELLY SAND	10
		150		SL. SILTY GRAVELLY SAND	10
		155		GRAVELLY SAND	10
		160		" "	2.9
		165		" "	3.3
8" carbon steel casing		170		SILTY SANDY GRAVEL	6.3
		175		SANDY GRAVEL	2.0
4" stainless steel casing		180		" "	6.0
centralizers		185		" "	4.3
bentonite crumbles 4.5'-216'		190		GRAVELLY SAND	2.4
		195		SL. SILTY SL. GRAVELLY SAND	2.7
		200		SILTY SANDY GRAVEL	1.1
		205		" " "	2.5
		210		" " "	.8
		215		" " "	1.7
volclay pellets 216'-221'		220		" " "	4.5
Depth to water 229.4' 8/4/87		225		" " "	1.8
		230		" " "	2.5
4" 20 slot st. steel screen		236		" " "	3.3
		240		GRAVELLY SAND	1.5
silica sand 221'-257'		245		" "	2
8" .30 slot st. steel telescoping screen		250		SANDY GRAVEL	3
		255		" "	1.8
				Basalt - 256.5'	

TD = 257'

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Figure C-1. Well 299-E27-8 Construction and Completion Summary (2 of 2)

Battelle Pacific Northwest Laboratories

AS-BUILT DIAGRAM

Well Number 299-E27-9 Geologist S.M. Goodwin, P. White, K.R. Oster, R. Hagen, M.A. Chamness Page 1 of 2

Reviewed by D.L. McDaniel Date 12-21-87

Construction Data: Description	Construction Data: Diagram	Depth in Feet	Geologic/Hydrologic Data: Diagram Litho.	Geologic/Hydrologic Data: Lithologic Description	Drill Rate (ft/hr)
cement 0'-2.3'		5		SILTY SANDY GRAVEL	1.7
		10		" " "	5
		15		" " "	3.3
16" carbon steel casing		20		" " "	0.9
		25		" " "	2
		30		" " "	5
12" carbon steel casing		35		" " "	2.7
		40		" " "	3.8
		45		" " "	2.9
10" carbon steel casing		50		" " "	8.6
		55		" " "	~10
		60		" " "	~5
8" carbon steel casing		65		" " "	2.6
		70		" " "	2.5
		75		" " "	2.8
4" stainless steel casing		80		SILTY GRAVELLY SAND	6
		85		SANDY GRAVEL	5.4
		90		SILTY SANDY GRAVEL	6
		95		" " "	5.4
		100		SL. SILTY GRAVELLY SAND	≥ 3.3
		105		" " " "	4.5
bentonite crumbles 2033'-2.3'		110		SL. SILTY, SL. GRAVELLY SAND	4
		115		" " " " "	15.2
		120		SL. SILTY GRAVELLY SAND	2.4
		125		GRAVELLY SAND	29.4
		130		SANDY GRAVEL	~29

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Figure C-2. Well 299-E27-9 Construction and Completion Summary (1 of 2)

Battelle Pacific Northwest Laboratories

AS-BUILT DIAGRAM

Well Number 299-E27-9 Geologist S.M. Goodwin, P. White, R. Hagen, K.R. Oster, M.A. Chamness Page 2 of 2

Reviewed by D.L. McGhan Date 12-21-87

Construction Data		Depth in Feet	Geologic/Hydrologic Data		
Description	Diagram		Diagram Litho.	Lithologic Description	Drill Rate (ft/hr)
		135		SL. SILTY GRAVELLY SAND	4
		140		SL. SILTY, SL. GRAVELLY SAND	8.6
		145		SL. SILTY GRAVELLY SAND	7.5
bentonite crumbles 203.3'-23'		150		" " " "	6
		155		SL. SILTY, SL. GRAVELLY SAND	5
		160		SL. SILTY GRAVELLY SAND	6
		165		SILTY SANDY GRAVEL	5
		170		" " "	2.9
10" carbon steel casing		175		SL. SILTY GRAVELLY SAND	5.4
		180		" " " "	20
		185		SILTY SANDY GRAVEL	2.9
8" carbon steel casing		190		" " "	10
4" stainless steel casing		195		" " "	7.5
		200		" " "	3.8
volclay pellets 203.3'-210.5'		205		SL. SILTY GRAVELLY SAND	3.3
		210		" " " "	17.9
4" stainless steel screen		216		" " " "	4
219.85'-240.1'		221		" " " "	10
water table 221.1' 8/13/87		226		SILTY SANDY GRAVEL	8.6
20/30 silica sand 210.5'-245'		231		" " "	2.2
		236		" " "	6.7
		241		" " "	10
8" stainless steel telescoping screen	TD = 245.23'	245		" " "	1.4
				basalt at 245'	

A-1800-186 (3/87)

Figure C-2. Well 299-E27-9 Construction and Completion Summary (2 of 2)

Battelle Pacific Northwest Laboratories

AS-BUILT DIAGRAM

Well Number 299-E27-10 Geologist K.R. Oster / P. White Page 1 of 2

R. Hagen, M.A. Chauness, S. Dudziak, R. Premzic, S. Airhart, S. Goodwin

Reviewed by D.L. McKhann Date 12-21-87

Construction Data		Depth in Feet	Geologic/Hydrologic Data	
Description	Diagram		Diagram Litho.	Lithologic Description
cement 0'-2'		5'		SILTY SANDY GRAVEL
		10		" " "
		15		SANDY GRAVEL
		20		" "
16" carbon steel casing		25		" "
		30		SILTY SANDY GRAVE
		35		" " "
		40		" " "
12" carbon steel casing		45		" " "
		50		" " "
		55		" " "
		60		" " "
10" carbon steel casing		65		" " "
		70		" " "
		75		" " "
		80		" " "
8" carbon steel casing		85		" " "
		90		" " "
		95		" " "
		100		" " "
		105		" " "
4" stainless steel casing		110		" " "
		115		" " "
		120		" " "
		125		" " "
		126		SLIGHTLY SILTY GR. SAND

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Figure C-3. Well 299-E27-10 Construction and Completion Summary (1 of 2)

Battelle Pacific Northwest Laboratories

AS-BUILT DIAGRAM

Well Number 299-E27-10 Geologist K.R. Oster / P. White Page 2 of 2

R. Hagen, S. Dudziak, H.A. Chauness, R. Premzie, S. Aikhart, S. Goodwin

Reviewed by D.L. Mahan Date 12-21-87

Construction Data: Description	Construction Data: Diagram	Depth in Feet	Geologic/Hydrologic Data: Diagram Litho.	Geologic/Hydrologic Data: Lithologic Description	Drill rate (ft/hr)
10" Carbon Steel Casing		130		SLIGHTLY SILTY GRAVELLY SAND	2.6
		135		" " " "	10
		140		" " " "	8.6
		145		SILTY SANDY GRAVEL (Δ at 142')	2.7
8" Carbon Steel Casing		150		" " "	2
		155		" " "	2.2
		160		SILTY GRAVELLY SAND	2.3
bentonite crumbles 200'-2'		165		" " "	5.4
		170		SLIGHTLY GRAVELLY SAND	<1.7
4" stainless steel casing		175		SILTY SANDY GRAVEL	≥2.3
		180		" " "	1.8
		185		SILTY GRAVELLY SAND	2.2
centralizers		190		SILTY SANDY GRAVEL	1.6
		195		SLIGHTLY SILTY GRAVELLY SAND	1.4
volclay pellets 206'-200'		200		" " "	8.6
4" stainless steel screen		205		SL. SILTY, SL. GRAVELLY SAND	4
		210		SLIGHTLY SILTY SAND	8.6
DIW 215.8, 8/5/87		215		GRAVELLY SILTY SAND	3.8
20/30 silica sand 240'-206'		220		SILTY SANDY GRAVEL	5
		225		" " "	2.9
10'11" of 8" stainless		230		SAND	2.1
steel telescoping screen		235		SANDY GRAVEL (Δ at 233')	1.3
		240		" "	2.7
	TD = 240'			Basalt at ~240'	

A-1800-186 (3/87)

Figure C-3. Well 299-E27-10 Construction and Completion Summary (2 of 2)

WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method: Cable tool
Drilling Fluid Used: 200 E Water Supply
Driller's Name: Garcia
Drilling Company: Kaiser Engineers
Date Started: 27Jun89

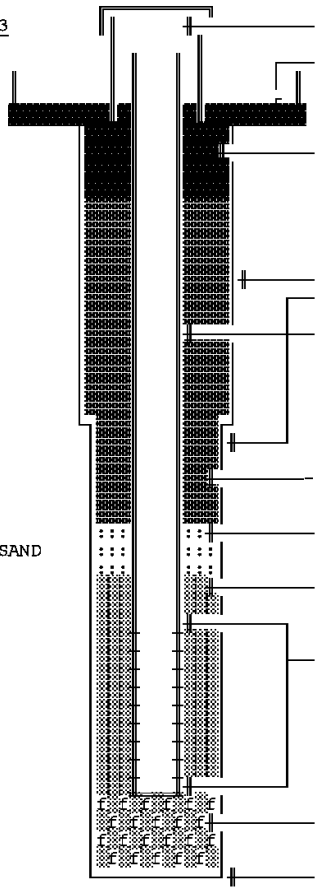
Sample Drive barrel Method: Hard tool
Additives Used: Not documented
WA State Lic Nr: Not documented
Company Location: Hanford
Date Complete: 18Oct89

WELL NUMBER: 299-E27-11
TEMPORARY WELL NO:
Hanford Coordinates: N/S N 44,557.6 E/W W 49,990.3
State NAD83 N 137,063.0m E 574,653.2m
Coordinates: N 449,731 E 2,245,221
Start Card #: Not documented T____ R____ S_____
Elevation Ground surface: 640.34-ft (Brass cap)

Depth to water: 234.4-ft Jul89
(Ground surface) 238.6-ft 23Jun93

GENERALIZED Geologist's STRATIGRAPHY Log

0-15: Sl. muddy gravelly SAND
15-20: Muddy sandy GRAVEL
20-25: Sandy GRAVEL
25-30: Sl. muddy gravelly SAND
30-35: Muddy sandy GRAVEL
35-40: Sandy GRAVEL
40-50: Muddy sandy GRAVEL
50-55: Sl. gravelly SAND
55-60: Gravelly SAND
60-65: SAND
65-85: Gravelly SAND
85-90: Sl. gravelly SAND
95-100: Sl. gravelly SAND
100-105: SAND
105-120: Sandy GRAVEL
120-125: Gravelly SAND
125-135: Sandy GRAVEL
135-155: Gravelly SAND
155-160: Sl. gravelly SAND
160-165: Gravelly SAND
165-175: Sandy GRAVEL
175-185: Sl. muddy gravelly SAND
185-195: Gravelly SAND
195-200: Sl. gravelly sl. muddy SAND
205-210: Muddy sandy GRAVEL
210-215: Sandy GRAVEL
215-220: Muddy sandy GRAVEL
220-245: Sandy GRAVEL
245-250: Sl. gravelly SAND
250-255: Muddy SAND
255-260: SAND
260-262: GRAVEL
262-264.7: BASALT



Elevation of reference point: [643.29-ft]
(top of 6-in casing)
Height of reference point above ground surface [2.95-ft]
Depth of surface seal [2-19.5-ft]
Type of surface seal:
Cement grout to 19.5-ft w/Portland cement 4-ft x 4-ft x 6-in surface pad extending 2.0-ft into annulus
Hole diameter,
2-143.9-ft, 11-in nominal
143.9-264.7-ft, 9-in nominal
4-in ID stainless steel casing, +1.9-230.4-ft
Bentonite crumbles, 19.5-223.5-ft
¼-in Volclay pellets, 223.5-227.4-ft
Silica sand pack, 227.4-251.4-ft, 20-40 mesh
4-in stainless steel screen, 230.4-251.4-ft, #10-slot w/channel pack
Backfill, 251.4-264.7-ft
Borehole drilled depth: [264.7-ft]

Drawing By: RKL/2E27-11.ASB
Date : 09Sep93
Reference : WHC-MR-0204

Figure C-4. Well 299-E27-11 Construction and Completion Summary (1 of 2)

SUMMARY OF CONSTRUCTION DATA AND FIELD OBSERVATIONS
RESOURCE PROTECTION WELL - 299-E27-11

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WELL DESIGNATION     :   299-E27-11
RCRA FACILITY        :   Low Level Burial Grounds, 218-E-12B
CERCLA UNIT          :   200 Aggregate Area Management Study
HANFORD COORDINATES  :   N  44,557.6   W    49,990.3  [12Jun90-200E]
LAMBERT COORDINATES  :   N 449,731     E 2,245,221    [HANCONV]
                         N 137,063.0m  E   574,653.2m [12Jun90-NAD83]
DATE DRILLED         :   Oct89
DEPTH DRILLED  (GS)  :   264.7-ft
MEASURED DEPTH (GS)  :   Not documented
DEPTH TO WATER (GS)  :   234.4-ft, Jul89,
                         238.6-ft, 23Jun93
CASING DIAMETER      :   4-in, stainless steel, +1.9-230.4-ft.
                         6-in, stainless steel, +2.95--0.5-ft
ELEV TOP CASING      :   643.29-ft,           [12Jun90-200E]
ELEV GROUND SURFACE  :   640.34-ft, Brass cap [12Jun90-200E]
PERFORATED INTERVAL  :   Not applicable
SCREENED INTERVAL    :   4-in stainless steel with channel pack, 230.4-251.4-ft
COMMENTS             :   FIELD INSPECTION, 07Feb90,
                         4-in stainless steel casing, 6-in protective casing.  Capped and locked.
                         4-ft by 4-ft concrete pad, 4 posts, brass marker with stamped ID.
                         Not in radiation zone.
                         OTHER;
AVAILABLE LOGS       :   Geologist, Driller
TV SCAN COMMENTS     :   Not applicable
DATE EVALUATED       :   Not applicable
EVAL RECOMMENDATION  :   Not applicable
LISTED USE           :   LLBG quarterly water level measurement, 01Dec89-23Jun93;
CURRENT USER         :   WHC ES&M w/l monitoring and RCRA sampling,
                         PNL sitewide sampling 93
PUMP TYPE            :   Hydrostar
MAINTENANCE          :
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Figure C-4. Well 299-E27-11 Construction and Completion Summary (2 of 2)

WELL CONSTRUCTION AND COMPLETION SUMMARY A4877

Drilling Method: Cable tool
Drilling Fluid Used: 200 E Water Supply
Driller's Name: Amos/St. George
Drilling Company: Kaiser Engineers
Date Started: 18Jul87

Sample Method: Drive barrel Hard tool
Additives Used: Not documented
WA State Lic Nr: ND/1224
Company Location: Hanford
Date Complete: 30Sep87

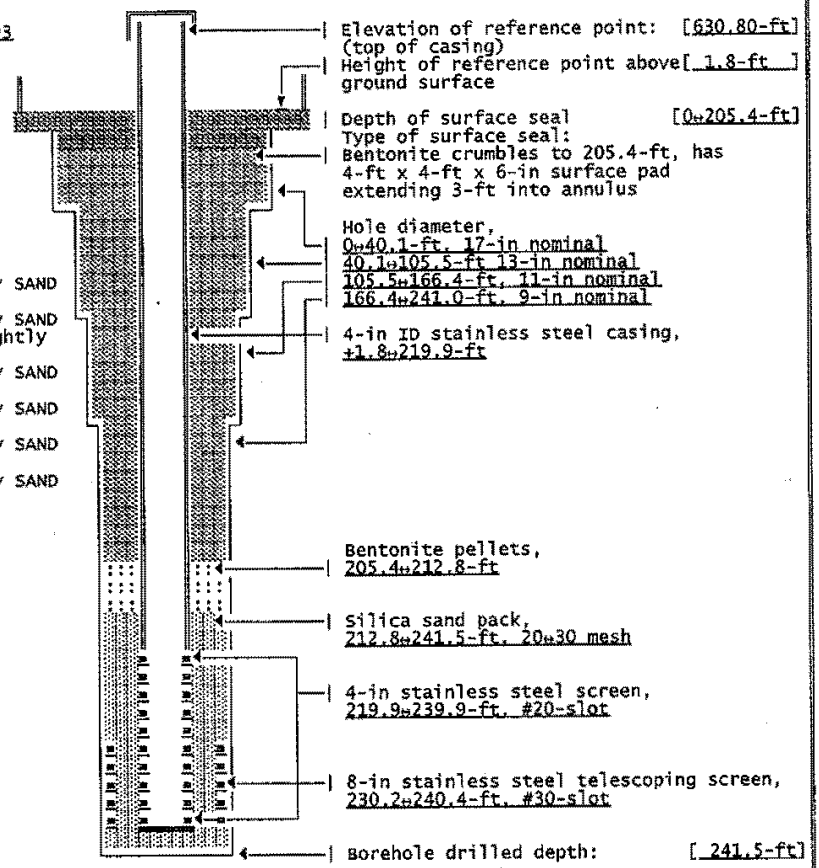
WELL NUMBER: 299-E34-2
TEMPORARY WELL NO:
Hanford Coordinates: N/S N 45,076 E/W W 50,048
State Coordinates: N 450,249 E 2,245,161
Start Card #: Not documented T R S
Elevation Ground surface: 629.03-ft (Brass cap)

Depth to water: 223.5-ft Jul87
(Ground surface)227.0-ft 28Jun93

GENERALIZED STRATIGRAPHY Log

Geologist's

0-12: Silty sandy GRAVEL
12-50: Sandy GRAVEL
50-60: Silty sandy GRAVEL
60-70: Sandy GRAVEL
70-75: Silty sandy GRAVEL
75-95: Sandy GRAVEL
95-120: Gravelly SAND
120-125: Sandy GRAVEL
125-130: Slightly silty gravelly SAND
130-135: Gravelly SAND
135-140: Slightly silty gravelly SAND
140-145: Slightly gravelly, slightly silty SAND
145-155: Slightly silty gravelly SAND
155-170: Gravelly SAND
170-180: Slightly silty gravelly SAND
180-185: Gravelly SAND
185-190: Slightly silty gravelly SAND
190-195: Silty sandy GRAVEL
195-210: Slightly silty gravelly SAND
210-240: Silty sandy GRAVEL
240-241: Slightly silty SAND
241 : BASALT



Drawing By: RKL/2E34-02.ASB
Date : 13Sep93
Reference : HANFORD WELLS

Figure C-5. Well 299-E34-2 Construction and Completion Summary (1 of 2)

SUMMARY OF CONSTRUCTION DATA AND FIELD OBSERVATIONS
RESOURCE PROTECTION WELL - 299-E34-2

WELL DESIGNATION	:	299-E34-2
RCRA FACILITY	:	Low Level Burial Grounds, 218-E-10
CERCLA UNIT	:	200 Aggregate Area Management Study (200-BP-5)
HANFORD COORDINATES	:	N 45,076 W 50,048 [07Dec87]
LAMBERT COORDINATES	:	N 450,249 E 2,245,161 [HANCONV]
DATE DRILLED	:	Sep87
DEPTH DRILLED (GS)	:	241.5-ft
MEASURED DEPTH (GS)	:	Not documented
DEPTH TO WATER (GS)	:	223.5-ft, Jul87 227.0-ft, 28Jun93
CASING DIAMETER	:	4-in, stainless steel, +1.8↔219.9-ft.
ELEV TOP CASING	:	630.80-ft, [07Dec87]
ELEV GROUND SURFACE	:	629.03-ft, Brass cap [07Dec87]
PERFORATED INTERVAL	:	Not applicable
SCREENED INTERVAL	:	219.9↔239.9-ft, 4-in stainless steel, #20-slot; 230.2↔240.4-ft, 8-in stainless steel, #30-slot
COMMENTS	:	FIELD INSPECTION, 07Feb90, 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. Not in radiation zone. OTHER;
AVAILABLE LOGS	:	Geologist, Driller
TV SCAN COMMENTS	:	Not applicable
DATE EVALUATED	:	Not applicable
EVAL RECOMMENDATION	:	Not applicable
LISTED USE	:	200 BP-1 quarterly water level measurement, 01Dec87↔28Jun93;
CURRENT USER	:	WHC ES&M w/l monitoring and RCRA sampling, WHC ER characterization, PNL sitewide sampling and w/l monitoring 93
PUMP TYPE	:	Hydrostar
MAINTENANCE	:	

Figure C-5. Well 299-E34-2 Construction and Completion Summary (2 of 2)

C2 Reference

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