RCRA-CN-01_DOE/RL-2010-92_R3

Interim Status Change Number 1: Interim Status Groundwater Monitoring Plan for the 216-A-37-1 PUREX Plant Crib

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

U.S. DEPARTMENT OF ENERGY | Richland Operations Office

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P.O. Box 550
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APPROVED
By Julia Raymer at 10:06 am, Jun 11, 2020

Release Approval Date

RCRA INTERIM STATUS GROUNDWATER MONITORING PLAN INTERIM CHANGE FORM

Change Number: *(Obtain Change Number From Interim Change Custodian)*		Date:
RCRA-CN-01_DOE/RL-2010-92_R3		4/30/2020
Document Number: DOE/RL-2010-92	**Title:** Interim Status Change Number 1: Interim Status Groundwater Monitoring Plan for the 216-A-37-1 PUREX Plant Crib	**Rev:** 3
Originator: Tessa Clark		**Phone:** 3605203189

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

-Change section reference from "A2.6" to "A2.5" in Table 2-3, page 2-33, in main file.
-Remove analysis of bicarbonate alkalinity, carbonate alkalinity, and hydroxide alkalinity from Table 2-4 and Table 3-1 (footnote c); specify "total alkalinity" in Table 2-4 and Table 3-1 (footnote c) of main file.
-Add "molybdenum" to Section 2.5 on pg. 2-19, Table 2-4 on pg. 2-34, Section 3.1 on pg. 3-1, and to Table 3-1, footnote "d."
-In Table 3-1, add "dissolved oxygen" to footnote "f," add superscript "k" to "Phenols," and add footnote "k. The specific phenols to be analyzed as groundwater quality parameters are identified in Table 3-1a."
-Add Table 3-1a, "Phenols Analyzed as Groundwater Quality Constituents" to pg. 3-3a and Table of Contents (Tables).
-Replace Appendix A in its entirety with an updated version of Quality Assurance Project Plan.
-Remove "The field sampling team will make a copy of the signed record before sample shipment and transmit the copy to the SMR group" from Section B5.3 in Appendix B.

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

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

-Alkalinity analyses that are not required to calculate charge balance equations are removed.
-Reference in Table 2-3 is changed to Section A2.5 to reference the applicable section in the updated Appendix A.
-Molybdenum is added as a corrosion constituent.
-Dissolved oxygen added to field parameters in Table 3-1.
-Table 3-1a added to clarify what phenols will be analyzed as groundwater quality constituents.
-Appendix A (Quality Assurance Project Plan) is replaced in its entirety due to multiple updates since issuance of the monitoring plan.
-Sentence removed from Section B5.3 is not applicable to the monitoring plan.

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

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

Role	Print First and Last Name	Signature	Date
Other:	K. M. Whitley	email approval attached	06/08/2020
S&GRP Environmental Compliance Officer:	S. M. Sexton	email approval attached	06/08/2020
CHPRC RCRA Groundwater Manager:	W. R. Faught	email approval attached	06/08/2020
DOE Subject Matter Expert:	R. D. Hildebrand	email approval attached	06/08/2020

Clark, Tessa J

From: PRC SharePoint <no-reply@sharepointonline.com>
Sent: Monday, June 8, 2020 3:39 PM
To: Clark, Tessa J
Cc: Clark, Tessa J
Subject: Electronic Approval has completed for document: RCRA-CN-01_DOE_RL-2010-92_R3.

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Electronic Approval started by Clark, Tessa J on 6/8/2020 2:24 PM
Comment: To comply with CHPRC's electronic signature directive, we are resending the RCRA groundwater monitoring plan redlines for secondary approval. This is required to process the plans in clearance.

Approved by Whitley, Kelly M on 6/8/2020 2:25 PM
Comment:

Approved by Faught, William R on 6/8/2020 2:38 PM
Comment:

Approved by Sexton, Sean M on 6/8/2020 3:04 PM
Comment:

Approved by Hildebrand, R D (Doug) on 6/8/2020 3:38 PM
Comment:

Change History of Interim Status Monitoring Plan DOE/RL-2010-92, Rev. 3, for the 216-A-37-1 PUREX Crib

Title	Document Number	Revision Number	Interim Change Number	Effective Date
Interim Status Groundwater Monitoring Plan for the 216-A-37-1 PUREX Crib	DOE/RL-2010-92	3	N/A	9/27/2017
Interim Status Groundwater Monitoring Plan for the 216-A-37-1 PUREX Crib	DOE/RL-2010-92	3	RCRA-CN-01_DOE/RL-2010-92_R3	4/30/2020

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Executive Summary

This document presents a revision to the 2017 groundwater monitoring plan[1] for the 216-A-37-1 Crib. This revised monitoring plan is based on the requirements for interim status facilities, as defined by the *Resource Conservation and Recovery Act of 1976*[2] (RCRA), and the implementing requirements in WAC 173-303-400,[3] which in turn specifies groundwater monitoring regulations under 40 CFR 265.[4]
The U.S. Department of Energy, Richland Operations Office is revising this groundwater monitoring plan to incorporate the addition of one new downgradient groundwater monitoring well (299-E25-95) proposed in Rev. 2 of the plan, and installed in 2017. This indicator evaluation program groundwater monitoring plan is the principal controlling document for conducting groundwater monitoring at the 216-A-37-1 Crib.

Currently, the 216-A-37-1 Crib is an inactive interim status treatment, storage, and disposal (TSD) unit in the 200-EA-1 Soil Operable Unit (OU), which is located above the underlying 200-PO-1 Groundwater OU. The 216-A-37-1 Crib is located southeast of the 200 East Area perimeter fence and was used for percolation to the soil column of evaporator process condensate from the 242-A Evaporator. The 216-A-37-1 Crib began operation in March 1977 and received spent halogenated and non-halogenated solvents and ammonia. Discharge of the evaporator process condensate to the 216-A-37-1 Crib continued through April 1989 when the crib was removed from service.

In 1994, the bottom of the diversion box was filled with grout to physically preclude inadvertent discharges to the crib. In July of 2000, vent risers from the crib were sealed to prevent potential passive radioactive emissions. In April 2007, the remaining space in the diversion box was filled with gravel to eliminate any hazard associated with a subsurface void. Subsequently, no additional interim stabilization measures were required.

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1 DOE/RL-2010-92, 2017, *Interim Status Groundwater Monitoring Plan for the 216-A-37-1 PUREX Plant Crib*, Rev. 2, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/pdf.cfm?accession=0071316H.

2 *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.

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

4 40 CFR 265, "Interim Status Standards for Owners and operators of hazardous Waste Treatment, Storage, and Disposal Facilities," *Code of Federal Regulations*. Available at: http://www.ecfr.gov/cgi-bin/text-idx?SID=24aad4966ac52acbeba416c2c1114889&mc=true&node=pt40.26.265&rgn=div5.

A groundwater quality assessment program in accordance with 40 CFR 265 was implemented in 1997. The groundwater quality assessment plan[5] combined the 216-A-10, 216-A-36B, and 216-A-37-1 Cribs based on their proximity, similarities in construction, waste history, and hydrogeologic regime. In 2010, a separate site-specific groundwater monitoring plan was developed for the 216-A-37-1 Crib[6] to monitor under the indicator evaluation program. Since monitoring for indicator parameters was initiated in 2010, statistical analyses of the parameters used as indicators of groundwater contamination have not shown an exceedance that resulted in the site entering into a groundwater quality assessment program. Thus, dangerous wastes from the 216-A-37-1 Crib subject to WAC 173-303-040[7] are not considered to have contaminated the groundwater beneath the 216-A-37-1 Crib. Therefore, the site remains under the indicator evaluation program described in 40 CFR 265.92.

This revised groundwater monitoring plan continues with the same detection monitoring requirements for indicator parameters and water quality constituents of the uppermost aquifer beneath the 216-A-37-1 Crib as the previous plan. This plan addresses the following:

- Number, locations, and depths of wells in the 216-A-37-1 Crib groundwater monitoring network
- Sampling and analytical methods of parameters required for groundwater contamination detection monitoring waste constituents
- Methods for evaluating groundwater quality information
- Schedule for groundwater monitoring at the 216-A-37-1 Crib

This revised plan uses the existing groundwater monitoring well network, as identified in the previous groundwater monitoring plan (DOE/RL-2010-92, Rev. 2), and incorporates the additional downgradient new well (299-E25-95) proposed in Rev. 2 and installed

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[5] PNNL-11523, 1997, *Combination RCRA Groundwater Monitoring Plan for the 216-A-10, 216-A-36B, and 216-A-37-1 PUREX Cribs*, Rev. 0, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D1662256.

[6] DOE/RL-2010-92, 2010, *Interim Status Groundwater Monitoring Plan for the 216-A-37-1 PUREX Plant Crib*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=1106170793.

[7] WAC 173-303-040, “Dangerous Waste Regulations,” “Definitions,” *Washington Administrative Code,* Olympia, Washington. Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-303-040.

in 2017. Groundwater flow direction determinations indicate that a southeast flow direction exists beneath the 216-A-37-1 Crib. Groundwater in the 216-A-37-1 Crib monitoring wells will be sampled and analyzed semiannually for the parameters used as indicators of groundwater contamination (pH, specific conductance, total organic carbon, and total organic halogen) and annually for parameters establishing groundwater quality (chloride, iron, manganese, phenols, sodium, and sulfate) in accordance with 40 CFR 265.92(b)(2)&(3) and (d). For the existing upgradient well (299-E25-35) added under Rev. 2 of this plan, and the new downgradient well (299-E25-95) proposed in Rev. 2 and installed in 2017, sampling for indicator parameters, groundwater quality parameters, and drinking water suitability parameters included in Appendix III to 40 CFR 265 will be performed quarterly at each well until 1 year of data is collected. Sampling for the new well 299-E25-95 is scheduled to begin October 2017.

Additional site-specific constituents will be sampled annually. These include nitrate, which is a degradation product of waste previously discharged to the crib, and supporting constituents (anions and metals) that will be used to support the evaluation of upgradient and downgradient water chemistry variations and identify any corrosion of well casings. Water-level measurements will be taken each time a sample is collected to satisfy 40 CFR 265.92(e).

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Contents

Appendices

Figures

Tables

Terms

Commented [CTJ1]: RCRA-CN-01_DOE/RL-2010-92_R3

AEA	*Atomic Energy Act of 1954*
bgs	below ground surface
CCU	Cold Creek Unit
CCUg	Cold Creek Unit gravel
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CSM	conceptual site model
DOE	U.S. Department of Energy
DOE-RL	DOE Richland Operations Office
DST	double-shell tank
DWS	drinking water standard
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
FWS	Field Work Supervisor
HSU	hydrostratigraphic unit
NAD83	*North American Datum of 1983*
NAVD88	*North American Vertical Datum of 1988*
OU	operable unit
PUREX	Plutonium Uranium Extraction
QAPjP	quality assurance project plan
RCRA	*Resource Conservation and Recovery Act of 1976*
TEDF	Treated Effluent Disposal Facility
TOC	total organic carbon
TOX	total organic halogen
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order* (Ecology et al., 1989a)
TSD	treatment, storage, and disposal
VOC	volatile organic compound

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1 Introduction

This document presents a revised (Rev. 3) groundwater monitoring plan for the 216-A-37-1 Crib and supersedes the previous plan (DOE/RL-2010-92, Rev. 2, *Interim Status Groundwater Monitoring Plan for the 216-A-37-1 PUREX Plant Crib*). The U.S. Department of Energy (DOE), Richland Operations Office (DOE-RL) is revising this groundwater monitoring plan to incorporate the addition of one new monitoring well (299-E25-95) proposed in Rev. 2 of the plan and installed in 2017. This groundwater monitoring plan is based on the requirements for interim status facilities, as defined by the *Resource Conservation and Recovery Act of 1976* (RCRA), with regulations promulgated by the Washington State Department of Ecology (Ecology) in the *Washington Administrative Code*, and the *Code of Federal Regulations* by reference (WAC 173-303-400, "Dangerous Waste Regulations," "Interim Status Facility Standards"; 40 CFR 265, "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," Subpart F, "Ground-Water Monitoring"). This plan is used to monitor the indicator parameters in groundwater samples that are used to determine whether dangerous waste or dangerous waste constituents have entered the groundwater. This plan is also used for monitoring the parameters used to establish groundwater quality.

The 216-A-37-1 Crib is an inactive interim status TSD unit designated as a landfill, as defined in WAC 173-303-040, "Definitions." In accordance with Section I.A of WA7890008967, *Hanford Facility Resource Conservation and Recovery Act (RCRA) Permit, Dangerous Waste Portion for the Treatment, Storage, and Disposal of Dangerous Waste* (hereafter referred to as the Hanford Facility RCRA Permit), the 216-A-37-1 Crib will continue to be considered an interim status unit until is it incorporated into Part III, V, or VI of the Hanford Facility RCRA Permit, or until interim status is terminated. Therefore, groundwater monitoring for 216-A-37-1 Crib continues under interim status requirements. This TSD unit received small quantities of spent halogenated and non-halogenated solvents as well as ammonia. For regulatory purposes, the TSD unit boundary of the 216-A-37-1 Crib is identified on the current Hanford Facility RCRA Permit Part A Form.

The 216-A-37-1 Crib is located in the 200-EA-1 Soil Operable Unit (OU), southeast of the 200 East Area perimeter fence (Figure 1-1). The crib is located above the underlying 200-PO-1 Groundwater OU. The crib was installed for percolation of 242-A Evaporator process condensate to the soil column. Operating records indicate that the 216-A-37-1 Crib began receiving process condensate from the 242-A Evaporator in March 1977. Discharge of the evaporator process condensate to the crib continued through April 1989, when the crib was removed from service.

The purpose of this groundwater monitoring plan is to present an updated groundwater monitoring program for the parameters used as indicators of groundwater contamination and groundwater quality from the 216-A-37-1 Crib, commonly referred to as an indicator evaluation program under interim status. 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 TSD units that are not impacting groundwater, as required by WAC 173-303-400(3) and 40 CFR 265, Subpart F. This monitoring plan is the principal controlling document for conducting groundwater monitoring at the 216-A-37-1 Crib.

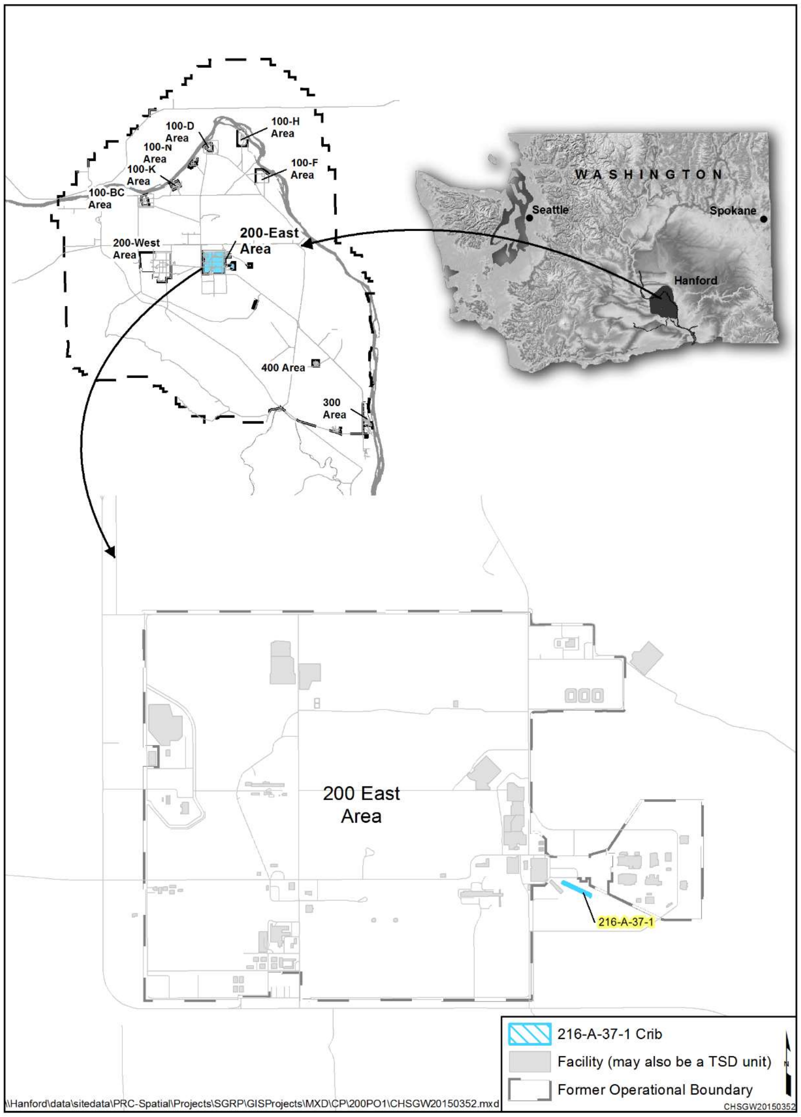

Figure 1-1. Location Map for the 216-A-37-1 Crib

The 216-A-37-1 monitoring network under Rev. 1 consisted of one upgradient and three downgradient wells. In the 2017 Rev. 2 plan, an additional upgradient monitoring well was added to the network. Two upgradient wells were needed to monitor the spatial variability in upgradient constituent concentrations impacting the TSD unit. A fourth downgradient well was proposed to provide better coverage downgradient of the TSD unit. The indicator evaluation program detailed in the Rev. 2 plan required semiannual sampling for parameters used as indicators of groundwater contamination, as well as annual sampling for parameters establishing groundwater quality for the two upgradient and four downgradient wells (inclusive of the proposed downgradient well). Additional site-specific constituents are collected annually, as well as supporting constituents including anions and metals that will be used to support the evaluation of upgradient and downgradient water chemistry variations. Water-level measurements are also required each time that a sample is collected to satisfy 40 CFR 265.92(e), "Sampling and Analysis." The downgradient well proposed in Rev. 2 of the plan (299-E25-95) was installed in 2017. This Rev. 3 plan incorporates the newly installed downgradient well into the network. Sampling for well 299-E25-95 is scheduled to begin October 2017.

This groundwater monitoring plan addresses the operational history, current hydrogeology, and conceptual site model (CSM) for the 216-A-37-1 Crib and incorporates knowledge about the potential for contamination originating from the crib and includes the following chapters and appendices;

- Chapter 2 summarizes background information and references other documents that contain more detailed information. It also describes the 216-A-37-1 Crib and the regulatory basis, types of waste present, the pertinent geology and hydrogeology beneath the 216-A-37-1 Crib, and it presents a brief history of groundwater monitoring. This information is summarized as a CSM to aid in development of the groundwater monitoring program.
- Chapter 3 describes the groundwater monitoring program, including the wells in the monitoring network, constituents analyzed, sampling frequency, and sampling protocols.
- Chapter 4 describes data evaluation and reporting.
- Chapter 5 provides an updated outline for a groundwater quality assessment plan.
- Chapter 6 contains the references cited in this plan.
- Appendix A provides the quality assurance project plan (QAPjP).
- Appendix B contains sampling protocols.
- Appendix C provides information for the wells within the groundwater monitoring network.

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2 Background

This chapter describes the 216-A-37-1 Crib and its operating history, regulatory basis, wastes and waste characteristics associated with the 216-A-37-1 Crib, local subsurface geology and hydrogeology, a summary of previous groundwater monitoring, and the CSM for the 216-A-37-1 Crib.

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

- DOE/RL-93-88, *Annual Report for RCRA Groundwater Monitoring Projects at Hanford Site Facilities for 1993*
- DOE/RL-96-61, *Hanford Site Background: Part 3, Groundwater Background*
- DOE/RL-2009-85, *Remedial Investigation Report for the 200-PO-1 Groundwater Operable Unit*
- DOE/RL-2010-92, Rev. 0, *Interim Status Groundwater Monitoring Plan for the 216-A-37-1 PUREX Plant Crib*
- DOE/RL-2010-92, Rev. 1, *Interim Status Groundwater Monitoring Plan for the 216-A-37-1 PUREX Plant Crib*
- DOE/RL-2015-07, *Hanford Site Groundwater Monitoring Report for 2014*
- PNNL-11523, Rev. 0, *Combination RCRA Groundwater Monitoring Plan for the 216-A-10, 216-A-36B, and 216-A-37-1 PUREX Cribs*
- PNNL-11523, Rev. 1, *Interim-Status RCRA Groundwater Monitoring Plan for the 216-A-10, 216-A-36B, and 216-A-37-1 PUREX Crib*s
- PNNL-12261, *Revised Hydrogeology for the Suprabasalt Aquifer System, 200-East Area and Vicinity, Hanford Site, Washington*
- WHC-EP-0342, Addendum 15, *242-A Evaporator Process Condensate Stream-Specific Report*
- WHC-MR-0517, *Listed Waste History at Hanford Facility TSD Units*

2.1 Facility Description and Operational History

Constructed in 1976, the 216-A-37-1 Crib is located southeast of the 200 East Area perimeter fence (Figure 2-1). When actively receiving effluent, the crib was about 2.4 to 4.3 m (8 to 14 ft) deep. A 25.4 cm (10 in.) diameter perforated, galvanized steel distribution pipe was placed 2 m (7 ft) below grade, near the top of the coarse gravel fill along the centerline of the crib. Waste was pumped to the crib through waste transfer piping to the diversion box located outside of the south end of the crib, and then to the crib for disposal. At the crib, the transfer piping connected to the perforated distributor pipe that evenly distributed effluent waste over the length of the crib within a 1.5 m (5 ft) thick bed of course gravel. The piping inlet to the crib was at its southeast end, which is at a lower elevation than the northwest end. This configuration favored infiltration at the southeastern end of the crib (Figure 2-2).

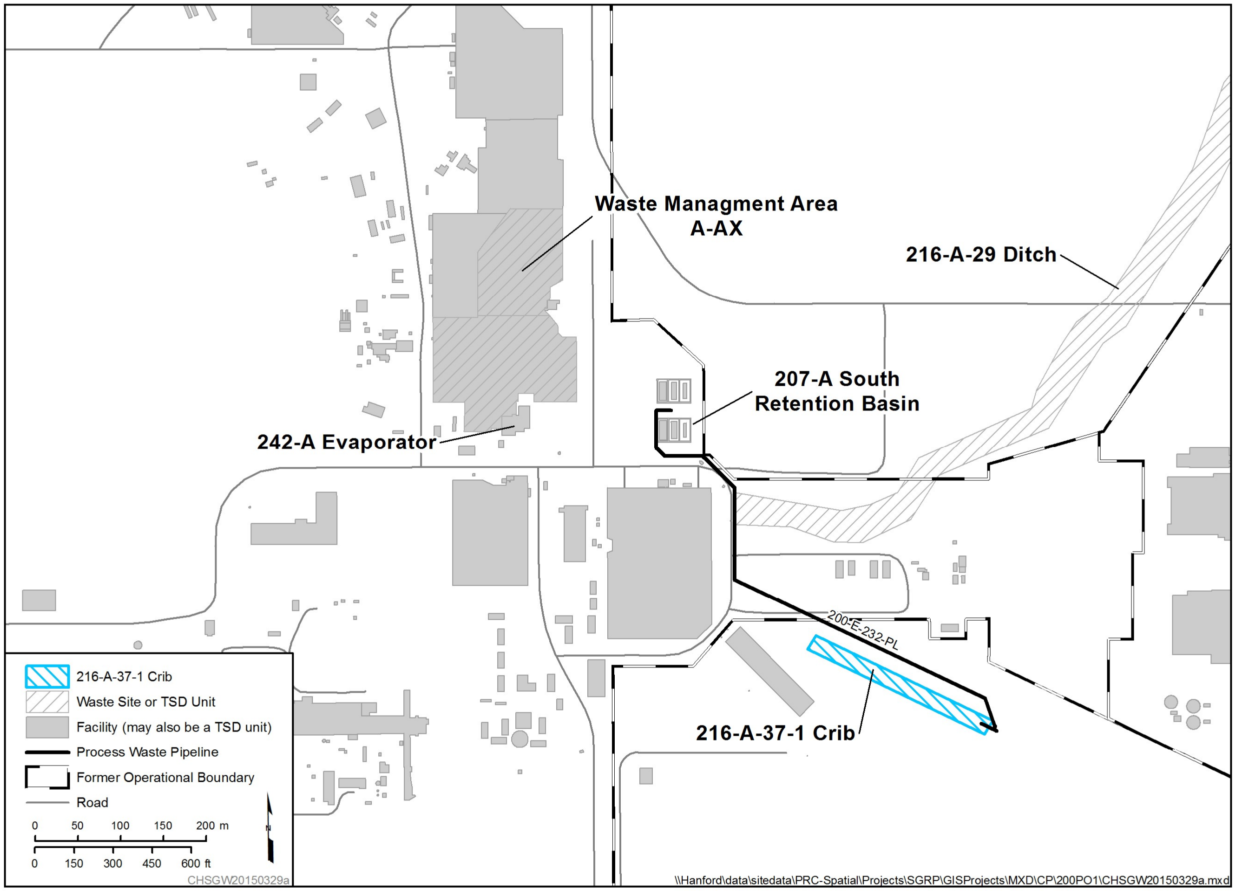

Figure 2-1. Site Map for the 216-A-37-1 Crib and Surrounding Facilities

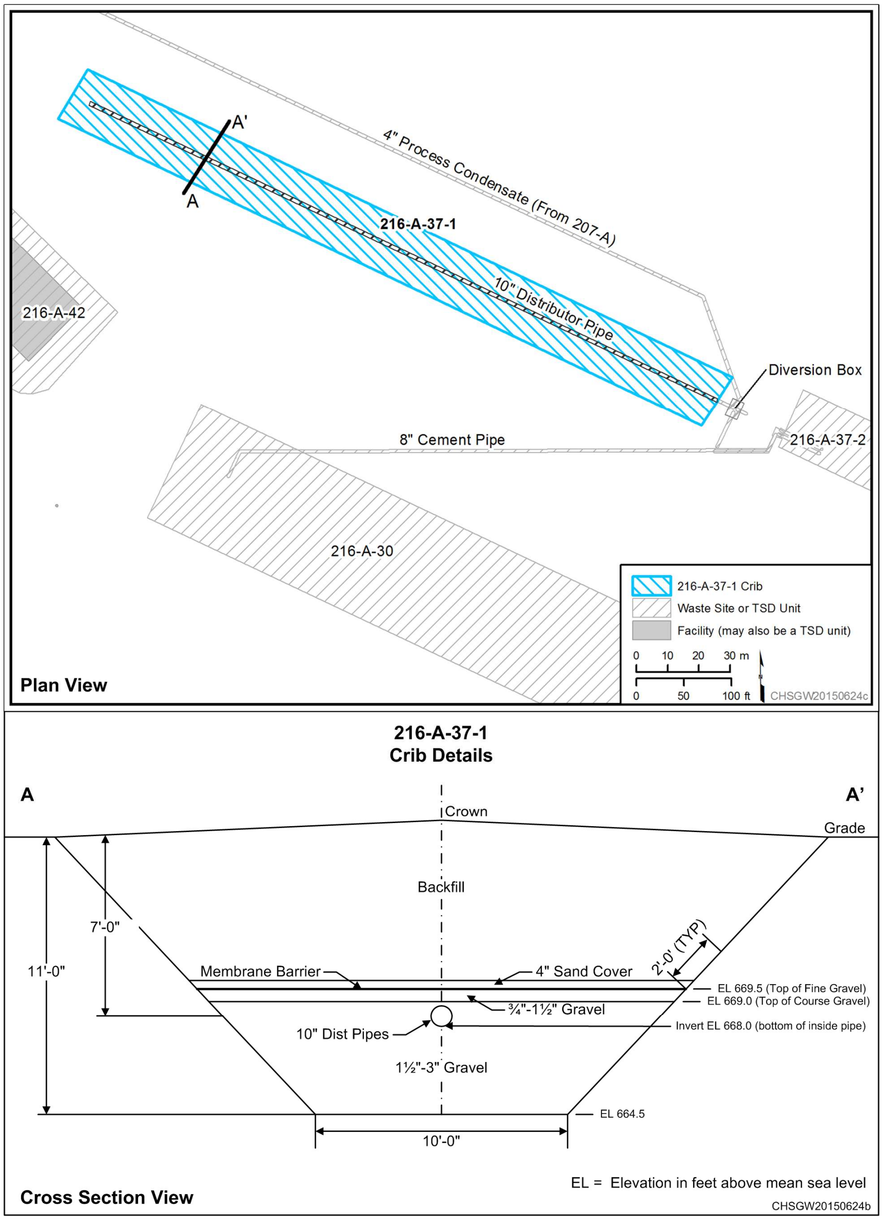

Figure 2-2. Construction Diagram for the 216-A-37-1 Crib

The 216-A-37-1 Crib began operation in March 1977 and was used for percolation of 242-A Evaporator process condensate to the soil column. All waste contributions to the 216-A-37-1 Crib originated from the 242-A Evaporator via the 207-A South Retention Basin. No waste treatment occurred at this TSD unit. The crib received waste water containing spent halogenated and non-halogenated solvents and ammonia.
The design capacity of the crib was estimated at 327,000 L/day (86,400 gal/day), based on the daily output of the evaporator. Discharge of the evaporator process condensate to the crib continued through April 1989, when the 216-A-37-1 Crib was removed from service. The diversion box was filled with grout to physically preclude inadvertent discharges to the 216-A-37-1 Crib. During its operational life, the 216-A-37-1 Crib received 380 million L (98 million gal) of process condensate from the 242-A Evaporator (DOE/RL-98-28, *200 Areas Remedial Investigation/Feasibility Study Implementation Plan – Environmental Restoration Program*).

2.2 Regulatory Basis

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

In May 1989, DOE, the U.S. Environmental Protection Agency (EPA), and Ecology signed the Ecology et al., 1989a, *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 the 216-A-37-1 Crib. Groundwater monitoring is conducted at the 216-A-37-1 Crib in accordance with WAC 173-303-400(3) (and by reference, 40 CFR 265, Subpart F), which requires monitoring to determine whether the dangerous waste constituents from the TSD unit have entered the groundwater in the uppermost aquifer underlying the TSD unit.

Dangerous waste is regulated under RCW 70.105, "Hazardous Waste Management," and its 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). AEA states that these radionuclide materials are regulated at DOE facilities, exclusively by the DOE, acting pursuant to its AEA authority. Radionuclide materials are not hazardous/dangerous wastes and, therefore, are not subject to regulation by the state of Washington under RCRA or RCW 70.105.

The 216-A-37-1 Crib was monitored from July 1983 to June 1997 under the AEA (DOE/RL-2010-92, Rev. 1). The 216-A-37-1 Crib was one of several liquid effluent discharge sites that were initially excluded from the list of RCRA sites in the Tri-Party Agreement (Ecology et al., 1989). Under Tri-Party Agreement Milestones M-17-00A and M-17-00B, the excluded sites were the subject of a liquid effluent study to determine their environmental impact. As a result, the 216-A-37-1 Crib was monitored along with the non-RCRA active effluent discharge sites by the Operational Monitoring Program (DOE-RL-93-88). Some wells near the crib were also monitored as part of the 216-A-29 Ditch (Figure 2-1) RCRA groundwater assessment monitoring program. Listed wastes were identified in the effluent stream to the 216-A-37-1 Crib, as the result of effluent stream sampling performed between August 1985 and March 1989. The sampling results and waste designations were documented in 1990 in WHC-EP-0342, Addendum 15 (Appendix B and Chapter 5, respectively), thereby obligating the operator to monitor the site under RCRA regulations (Section 2.3 identifies wastes discharged to the 216-A-37-1 Crib).

Discharge to the crib was terminated in April 1989, and a RCRA Permit Application Part A Form was submitted for the site in February 1990. Subsequent investigations indicated the potential presence of chlorinated hydrocarbon solvents from facility operations, and a revised Part A Form was submitted in May 1993. The groundwater monitoring program for the 216-A-37-1 Crib, which included the 216-A-10 and 216-A-36B Cribs, was initiated in 1997 (PNNL-11523, Rev. 0), based on the interim status groundwater quality assessment monitoring requirements of 40 CFR 265(d)(3) and (d)(4) and WAC 173-303-400. The 1997 plan was designed as a groundwater quality assessment program due to elevated measurements of specific conductance in well 299-E17-9 at the 216-A-36B Crib. This combined monitoring approach was based on the proximity, similarities in construction, waste history, and hydrogeologic regime of the three cribs. The combined groundwater monitoring plan was revised in 2005 (PNNL-11523, Rev. 1). Radionuclides were removed from the plan because radionuclides are not monitored under RCRA (PNNL-11523, Rev. 1, Sections 1.1 and 1.2). Far-field wells were removed from the 216-A-37-1 monitoring network because they were primarily being used to monitor within and immediately outside of the tritium plume (PNNL-11523, Rev. 0, Table 5.1). These wells extended southeast from the 200 East Area to the Columbia River and were monitored under the 200-PO-1 OU *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) sampling and analysis plan DOE/RL-2003-04, *Sampling and Analysis Plan for the 200-PO-1 Groundwater Operable Unit*.

In 2010, the 216-A-37-1 Crib was separated from the Plutonium Uranium Extraction (PUREX) Cribs combined groundwater monitoring plan and entered into an indicator parameter evaluation program in accordance with WAC 173-303-400(3), “Interim Status Facility Standards” (and by reference, 40 CFR 265, Subpart F) which requires monitoring to determine whether the dangerous waste constituents from the TSD unit have entered the uppermost aquifer underlying the TSD unit. The 216-A-37-1 Crib returned to indicator parameter monitoring because specific conductance exceedances under the combined plan were attributed solely to the 216-A-36B Crib groundwater monitoring well (299-E17-9). In 2010, it was determined that 216-A-10 did not receive mixed waste after the effective date of the mixed waste rule in Washington State (August 19, 1987) and was no longer subject to regulation as a dangerous waste management unit. It was also determined that the distance between the 216-A-36B and 216-A-37-1 Cribs was great enough that different monitoring networks were appropriate for these two cribs. Therefore, a site-specific groundwater monitoring plan (DOE/RL-2010-92, Rev. 0) was developed for the 216-A-37-1 Crib. The site-specific groundwater monitoring plan was updated in 2011 (DOE/RL-2010-92, Rev. 1) to include a section outlining the constituent list and sampling frequency for the first year of monitoring for well 299-E25-47. First year monitoring was performed to meet upgradient monitoring requirements not previously established.

Due to the age of the Rev. 1 plan, a revised plan was issued in 2017 (DOE/RL-2010-92, Rev. 2) which added an additional existing upgradient and proposed an additional new downgradient well to the network. New downgradient well 299-E25-95 was installed in 2017 and is incorporated into the network under this revised plan (Rev. 3).

2.3 Waste Characteristics

Discharges received from the 242-A Evaporator process condensate (Figure 2-1) consisted of waste water potentially contaminated with spent halogenated and non-halogenated solvents (waste codes F001 through F005) and ammonia (state only toxicity waste code WT02), as described in the Hanford Facility RCRA Permit Application Part A Form (WA7890009867) for the 216-A-37-1 Crib. Listed waste constituents of concern related to waste codes F001, F002, F003, F004, and F005 are described in WHC-MR-0517 and listed in Table 2-1.

Table 2-1. Dangerous Waste Constituents Derived from the Hanford Facility RCRA Permit Application Part A Form Waste Codes for the 216-A-37-1 Crib

Listed Constituent	CAS No.	Listed Waste Code*
Acetone	67-64-1	F003 (State Only)
Cresol–m	108-39-4	F004
Cresol–o	95-48-7	F004
Cresol–p	106-44-5	F004
Methylene Chloride	75-09-2	F002
Methyl Ethyl Ketone	78-93-3	F005
Methyl Isobutyl Ketone	108-10-1	F003 (State Only)
1,1,1-Trichloroethane	71-55-6	F001

Source: WHC-MR-0517, *Listed Waste History at Hanford Facility TSD Units*.
Note: Does not include state only toxicity waste codes (WT02/ammonia).
* Dangerous waste source codes are from WAC 173-303-9904, “Dangerous Sources List.”
CAS = Chemical Abstracts Service

All waste contributions to the 216-A-37-1 Crib originated from the 242-A Evaporator. Prior to discharge to the crib, the waste passed through the 207-A South Retention Basin. Waste processed by the 242-A Evaporator is a mixed waste, as defined in WAC 173-303-040, that was received from the double-shell tank (DST) system. DST mixed waste is an aqueous solution containing dissolved cations and anions, sodium, potassium, aluminum, hydroxides, nitrates, nitrites, and a radioactive component. Slurry and process condensate are the two mixed waste streams generated at the 242-A Evaporator. The slurry is returned to the DST system. The process condensate is condensed vapor from the evaporation process. During crib operations, this condensate was transferred to the 207-A South Retention Basin for interim storage before it was disposed at the 216-A-37-1 Crib. The process design capacity of 327,000 L (86,400 gal) per day was based on the potential daily output of the 242-A Evaporator process condensate discharged to the crib via the 207-A South Retention Basin. Approximately 380 million L (98 million gal) of 242-A Evaporator process condensate containing trace quantities of chemicals and radionuclides are estimated to have been discharged to this crib (DOE/RL-98-28). The process condensate was mostly water containing small quantities of ammonia and inorganic constituents and trace quantities of volatile organics and radionuclides (WHC-EP-0342). Offgas from the process was routed through a de-entrainment unit, a pre-filter, and high-efficiency particulate air filters before being discharged to the environment. Constituents with vapor pressures substantially lower than water were likely not removed during the evaporation process and were returned as part of the concentrated slurry to the process system. Constituents with vapor pressures close to or higher than water were likely removed during the evaporation process and directed to the condensate filters and retention basin. The vapor pressure of water is 23.76 mm of mercury at 25°C (77°F) and the vapor pressures of cresol-m, -o, and -p are substantially lower than water. Therefore, these constituents were generally returned to the process system as part of the concentrated solution remaining after evaporation. The other constituents listed in Table 2-1 have vapor pressure near to or higher than water and were likely removed as an offgas during evaporation and treated by a de-entrainment unit and filters prior to being routed to the crib.

2.4 Geology and Hydrogeology

The geology and hydrogeology of the 200 East Area, including the region of the 216-A-37-1 Crib, are described in detail in the following documents:

- CP-57037, *Model Package Report Plateau to River Groundwater Transport Model Version 7.1*
- DOE/RL-2009-85, *Remedial Investigation Report for the 200-PO-1 Groundwater Operable Unit*
- DOE/RL-2011-01, *Hanford Site Groundwater Monitoring Report for 2010* (Chapter 2, "Overview of Hanford Hydrogeology and Geochemistry")
- DOE/RL-2015-07, *Hanford Site Groundwater Monitoring Report for 2014*
- ECF-Hanford-13-0029, *Development of the Hanford South Geologic Framework Model, Hanford Site, Washington*
- PNNL-12261, *Revised Hydrogeology for the Suprabasalt Aquifer System, 200-East Area and Vicinity, Hanford Site, Washington*
- SGW-54165, *Evaluation of the Unconfined Aquifer Hydraulic Gradient Beneath the 200 East Area, Hanford Site*

2.4.1 Stratigraphy

The general stratigraphy at the Hanford Site is presented in Figure 2-3. Stratigraphic units underlying the 200 East Area within the vicinity of the 216-A-37-1 Crib include the following (listed in order from youngest to oldest) (Section 3.4 in DOE/RL-2009-85):

- A discontinuous veneer of Holocene eolian silty sand or backfill mixtures of sand and gravel.
- Hanford formation – cataclysmic flood deposits equivalent to hydrostratigraphic unit (HSU) 1. The Hanford formation consists of three facies subunits (silt-dominated, sand-dominated, and gravel-dominated) that grade into one another both vertically and laterally (Figure 2-3). On the central plateau, the Hanford formation is sometimes further delineated into H1, H2, and H3 lithostratigraphic sequences. The H1 and H3 gravel sequences are not differentiated in those areas where the intervening sandy H2 sequence is absent. Units H1 and H3 consist of coarse-grained, basalt-rich, sandy gravels with varying amounts of silt/clay. These gravel units may also contain interbedded sand and or silt/clay lenses. The H2 sequence is dominated by sand to gravelly sand, with minor sandy gravel or silt/clay interbeds. Both the sand-dominated H2 and gravel-dominated H3 sequences are present near the 216-A-37-1 Crib.
- Cold Creek unit (CCU) – equivalent to HSUs 2 and 3. The CCU is often undifferentiated but has been subdivided regionally into three subunits which include the Cold Creek unit Z (Early Palouse Soil) and unit C (caliche), both of which are primarily located in 200 West Area, and unit G (pre-Missoula gravels), which is primarily located beneath 200 East Area and vicinity. In much of the 200 East Area, the CCU is characterized as a quartzo-feldspathic sandy gravel (unit G) above the Ringold Formation and below the more basaltic Hanford formation (PNNL-16407, *Geology of the Waste Treatment Plant Seismic Boreholes*; Sections 3.4 and 5.4 in RPP-23748, *Geology, Hydrogeology, and Mineralogy Data Package for the Single-Shell Tank Farm Waste Management Area at Hanford*; Section 3.4 in DOE/RL-2009-85; Section 2.2.6 in RPP-14430, *Subsurface Conditions Description of the C and A-AX Waste Management Area*; Section 2.4.1 in DOE/RL-2015-49, *Interim Status Groundwater Quality Assessment Plan for the Single Shell Waste Management Area A-AX*).

The Cold Creek unit Z is associated with fluvial overbank to eolian deposits, which can have variable thickness (PNNL-19277, *Conceptual Models for Migration of Key Groundwater Contaminants Through the Vadose Zone and Into the Unconfined Aquifer Below the B-Complex*; Section 3.1 in PNNL-16407).

- Ringold Formation unit E – equivalent to HSU 5. Fluvial deposits with thick layers of silty sandy gravel (conglomerate), intercalated with thinner beds of overbank silts and fine-grained paleosols. In the 200 East Area, HSU 5 is present only in the southern portion because, to the north, it has been removed by erosion or was not deposited.
- Ringold Formation, lower mud unit – equivalent to HSU 8. This unit is composed of a sequence of fluvial overbank, paleosol, and lacustrine silt and clay, with minor sand and gravel. This unit may locally create confining conditions, and isolate the Ringold Formation unit E from the underlying Ringold Formation unit A when all units are present and laterally continuous. Based on available geologic data (Figures 2-4, 2-5, and 2-6), the Ringold Formation lower mud does not create confining conditions directly underlying the 216-A-37-1 Crib.
- Ringold Formation unit A – equivalent to HSU 9. Unit 9 can be further subdivided into three hydrostratigraphic units based on markedly different lithologies and hydraulic properties. The primary subunit is characterized as a silt to clay-rich confining zone with lower permeability, classified as unit 9B. Subunits 9A and 9C have much higher permeabliities and lower clay content and consist of consolidated silty sandy gravel deposits.
- Bedrock consisting of Columbia River Basalt flows dip gently to the south toward the axis of the Cold Creek syncline. The two uppermost flows are within the Elephant Mountain Member of the Saddle Mountains Basalt.

Geologic cross-sections that include selected wells in the southern portion of the 200 East Area present the approximate stratigraphy underlying and adjacent to the 216-A-37-1 Crib (Figures 2-4, 2-5, and 2-6). Geologic contacts associated with the wells presented in the cross-sections are based on the contacts defined in Table A-2 of Attachment A within ECF-Hanford-13-0029. Definition of the stratigraphic units and contacts shown in each cross-section is consistent with the most current, integrated understanding of the subsurface geologic framework beneath the 200 East Area. In some cases, geologic contacts and stratigraphy from adjacent areas where data is available is projected to surrounding areas where data is less complete, utilizing the Leapfrog Hydro® geologic three-dimensional software (ECF-Hanford-13-0029). The resulting geologic representation of the subsurface can be examined using the cross-section generation tool provided in the web-based version of DOE/RL-2015-07. As indicated in each figure legend, geologic information associated with a well is projected to the cross-section within a buffer zone extending 75 m (246 ft) from either side of the cross-section line, resulting in approximate depths for stratigraphic contacts.

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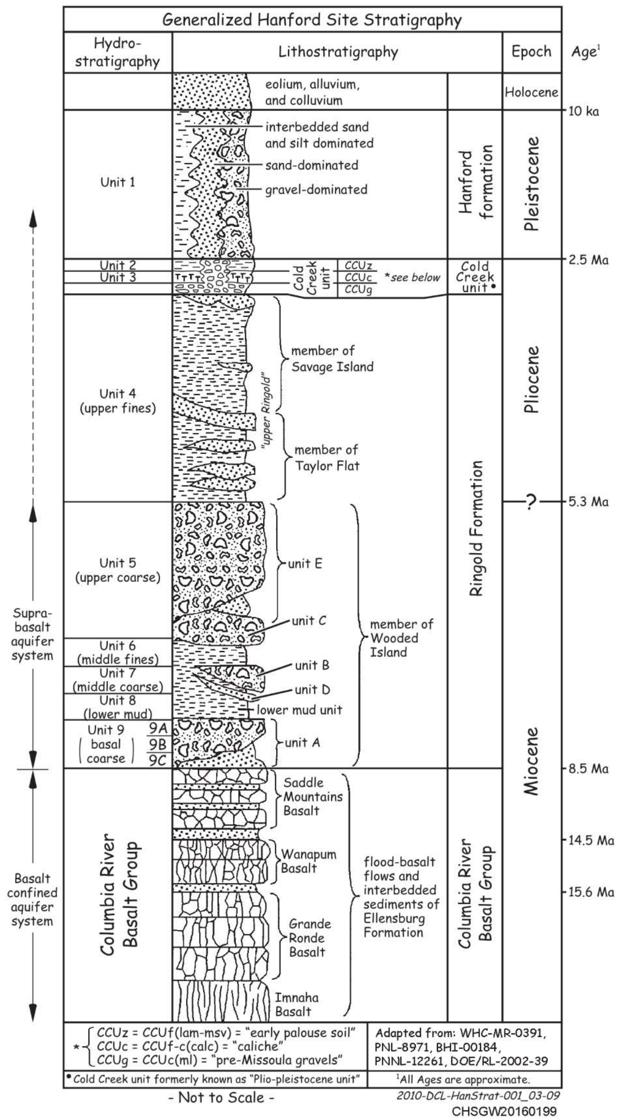


Note: Complete reference citations are provided in Chapter 6.

Figure 2-3. General Stratigraphy at the Hanford Site

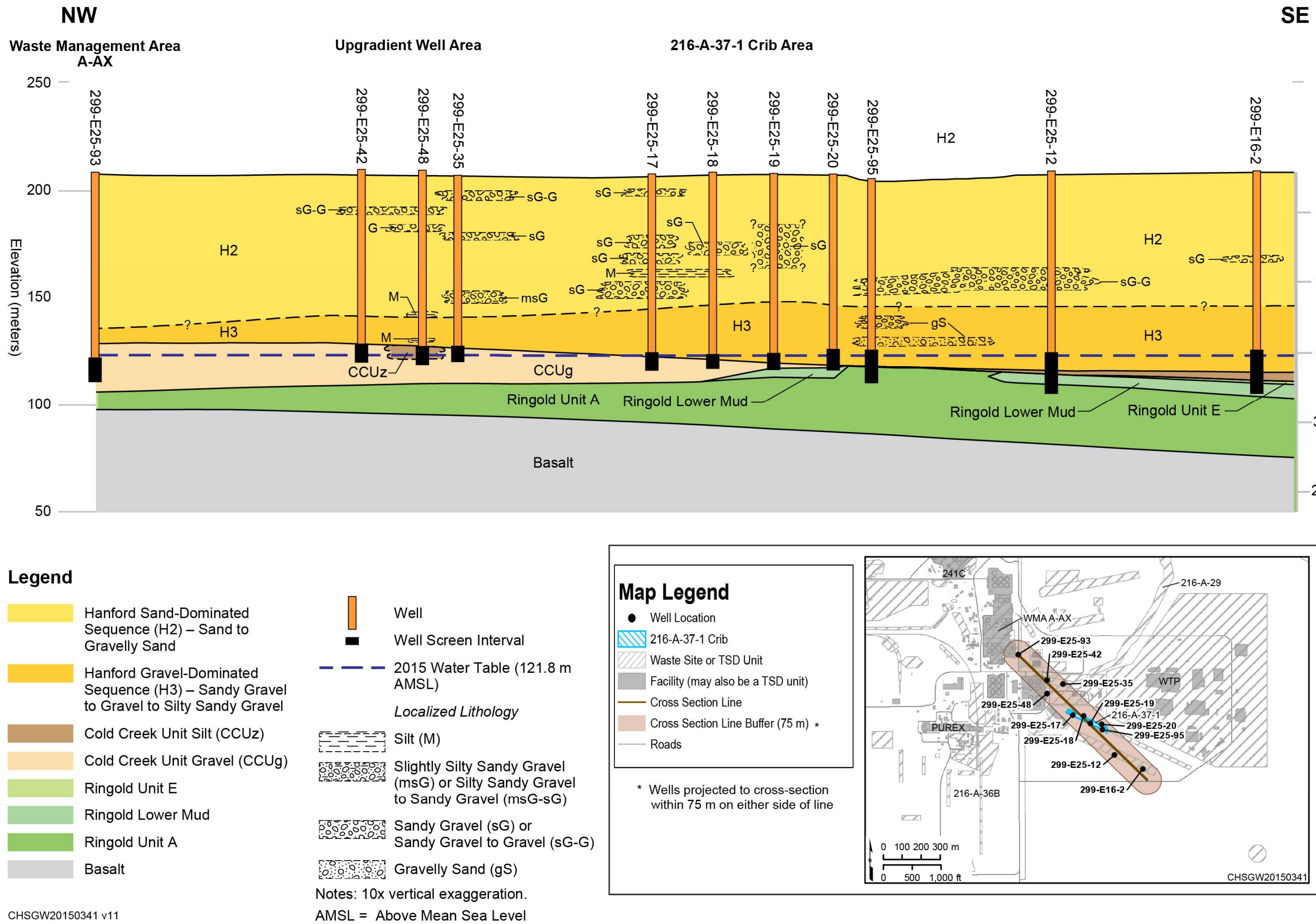


Figure 2-4. Northwest-Southeast Geologic Cross Section Showing the Stratigraphy Below the 216-A-37-1 Crib

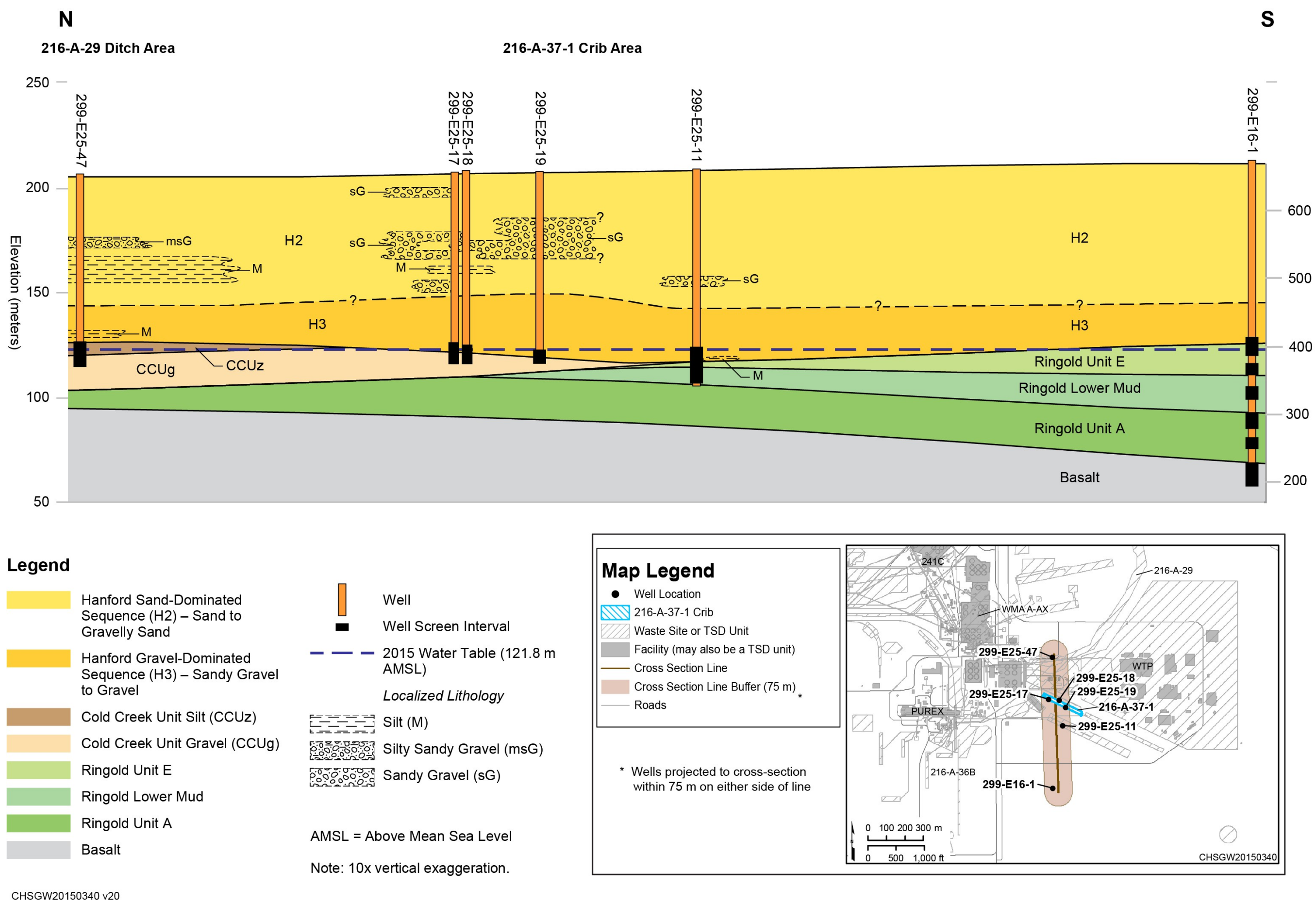


Figure 2-5. North-South Geologic Cross Section Showing the Stratigraphy Below the 216-A-37-1 Crib

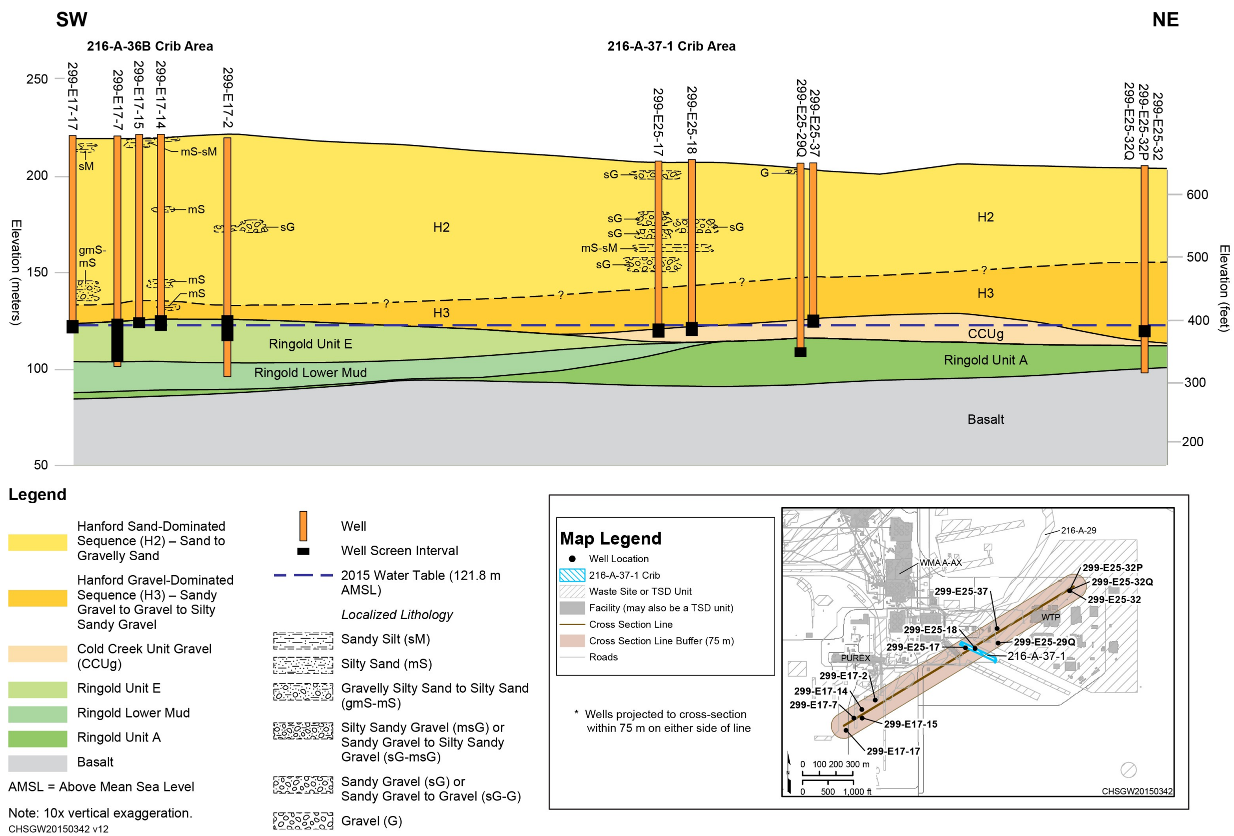


Figure 2-6. Southwest-Northeast Geologic Cross Section Showing the Stratigraphy Underlying the 216-A-37-1 Crib

2.4.2 Hydrogeology

The water table occurs within the lower Hanford formation gravel sequence (H3) or Cold Creek unit gravel (CCUg) underlying the crib. The uppermost aquifer underlying the 216-A-37-1 Crib extends from the water table surface within the Hanford formation H3 gravel sequence or Cold Creek Unit (depending on the specific location), through the Ringold Unit A (where no Ringold lower mud is present) to the top of the basalt surface (Figures 2-4, 2-5, and 2-6). The thickness of the unconfined aquifer below the 216-A-37-1 Crib ranges from 25 to 31 m (82 to 102 ft). The 216-A-37-1 Crib overlies a sequence of Hanford formation and CCU sediments that locally incised and removed the Ringold Formation unit E (HSU 5) and the Ringold Formation lower mud (HSU 8) (Figures 2-3 through 2-6). As a result, the overlying CCU lies unconformably on the Ringold Formation unit A (HSU 9) or the Ringold Formation lower mud (HSU 8) near the crib. Sediments comprising the Hanford formation and CCU have a relatively high hydraulic conductivity compared to the underlying Ringold Formation. Based on recent groundwater flow and transport modelling iterations for the 200-PO-1 OU, the calibrated average hydraulic conductivity for the Hanford formation gravel-dominated facies (H3) and CCU, where channelized flow occurs, is estimated to be approximately 17,000 m/day (55,777 ft/d) and 2.27 to 109 m/day (7.45 to 357.6 ft/d) in those areas without channelized flow where older sediment occurs (CP-57037). The calibrated average hydraulic conductivity for the Ringold Unit A is estimated to be approximately 5 m/d (16.4 ft/d) (DOE/RL-2009-85-ADD1, *Remedial Investigation Report for the 200-PO-1 Groundwater Operable Unit Addendum 1*, Table 3-3; CP-57037, Table 3-1). Additional information on hydraulic conductivities for geologic units in the 200 East Area is provided in Section 3.1 and Table 3.1 of PNNL-12261, Table 3-3 in DOE/RL-2009-85-ADD1, and Table 3-1 in CP-57037. Hydraulic conductivity of the sand and gravel-dominated sequence in Hanford formation and the pre-Missoula gravel deposits (i.e., CCU) generally ranges from 1 to 1,000,000 m/d and is much higher than any of the other units that compose the unconfined aquifer. Flow velocities in the uppermost aquifer below the 216-A-37-1 Crib have been estimated to range from 0.0036 to 0.6 m/d (0.012 to 1.97 ft/d) (DOE/RL-2015-07, Table B-1). Due to high hydraulic conductivity, the water table in the area where the crib is located is flat with an extremely low gradient (Figure 2-7) (SGW-54165, Section 2.2 and SGW-58828, *Water Table Maps for the Hanford Site 200 East Area, 2013 and 2014*, Section 2.2). The current water table elevation is 121.80 m (399.6 ft) above mean sea level (Figure 2-7) and occurs within the Hanford formation or CCU in the vicinity of the 216-A-37-1 Crib (Figures 2-4, 2-5, and 2-6).

2.4.3 Groundwater Flow Interpretation

Historically, water levels in the unconfined aquifer increased as much as 5.5 m (18 ft) above the pre-Hanford natural water table level near the PUREX Cribs (i.e., 216-A-10, 216-A-36B, and 216-A-37-1). This increase was the result of artificial recharge from liquid waste disposal operations (e.g., PUREX Cribs and B Pond) between the mid-1940s and 1997. The pre-Hanford groundwater flow was to the east and southeast in the southeastern portion of the 200 East Area. While the 216-B-3 Pond (B Pond consisting of 216-B-3-1, 216-B-3, 216-B-3A, 216-B-3B, and 216-B-3C) was in operation, artificial recharge created a significant groundwater mound, resulting in a radial flow pattern around B Pond that impeded flow towards the east and redirecting it to the southwest. As discharges to B Pond ceased, the mound at B Pond subsided, and groundwater flow directions in the southeastern portion of the 200 East Area and vicinity of the 216-A-37-1 Crib began to change. Currently, the unconfined aquifer in the 200 East Area has a very low hydraulic gradient, making it difficult to determine groundwater flow direction. The hydraulic gradient of the water table in the area around the 216-A-37-1 Crib is calculated to be 2.0×10^{-5} meters per meter (DOE/RL-2015-07) (Figure 2-7). Estimated flow directions in different portions of the 200 East Area have been determined through statistical analysis of water levels obtained from wells comprising the low gradient monitoring well network in conjunction with tracking contaminant plume movements (Figure 2-8).

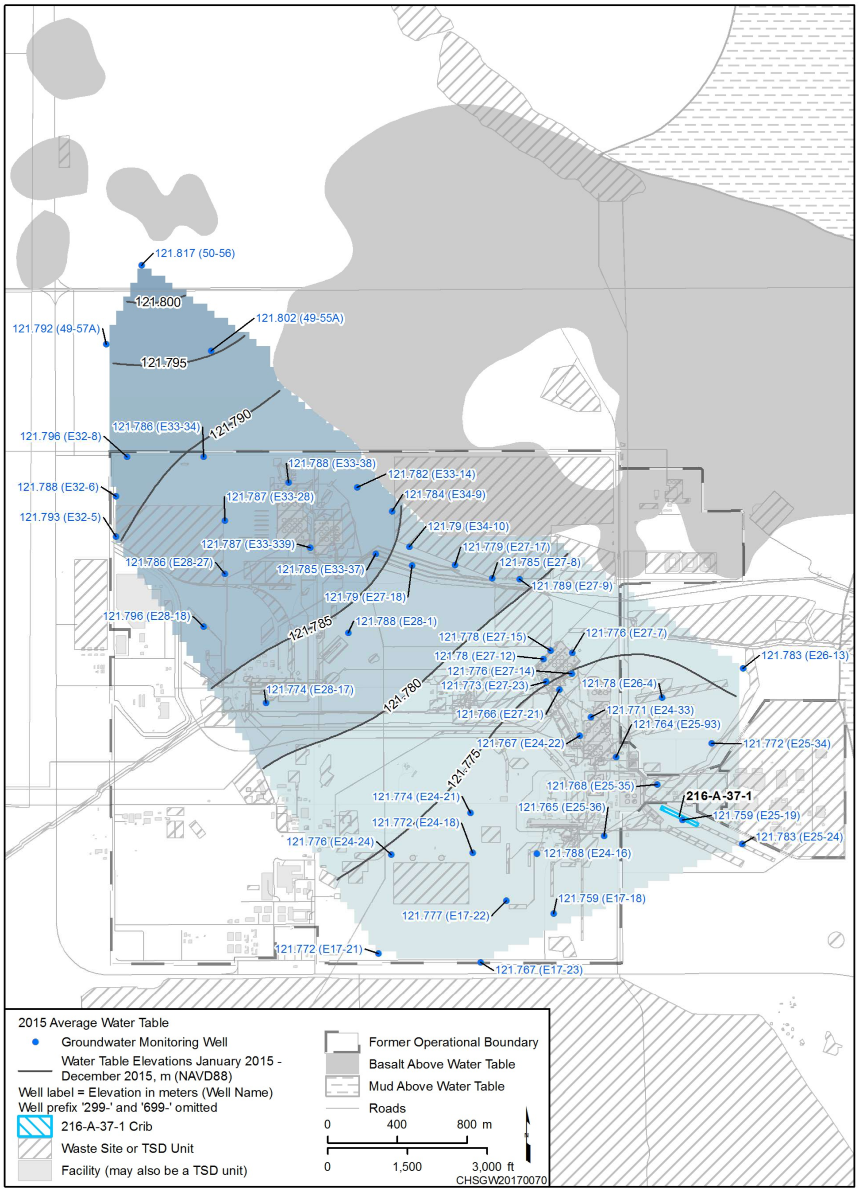
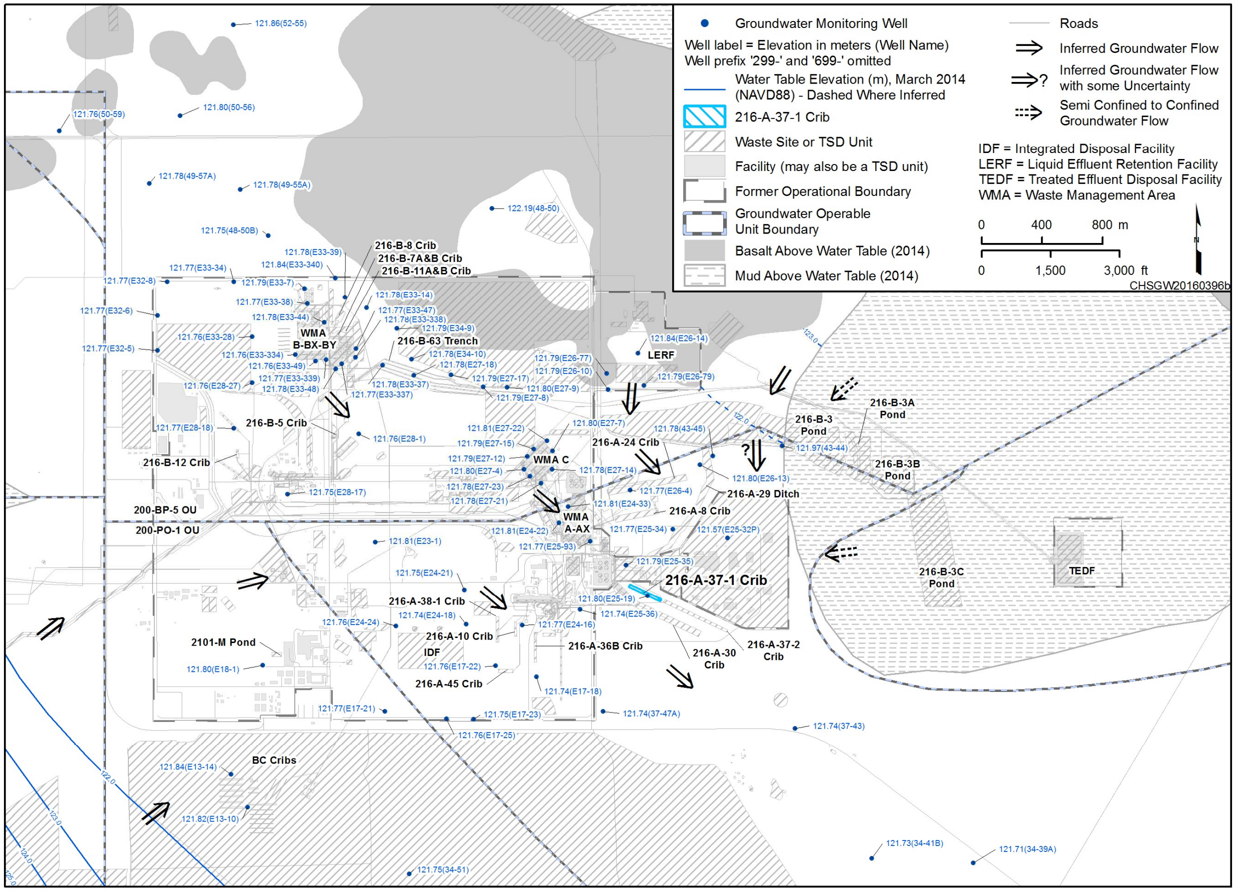


Figure 2-7. Average 2015 Water Table Surface, 200 East Area



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

Figure 2-8. 2014 Local Groundwater Flow Directions for the 200 East Area

In 2015, the local groundwater flow direction near the 216-A-37-1 Crib was interpreted to be southeast, based on measurements from the adjacent 216-A-29 low gradient monitoring network (Figure 2-9). Water table elevations and local flow directions occasionally show temporary changes due to discharges from the 200 East Area Treated Effluent Disposal Facility (TEDF) and possibly from elevated Columbia River water level (SGW-54165, Section 2.2 and SGW-58828, Section 2.2). The configuration of the 200 East Area water table at any given time results from the interaction of the river stage and stressors related to discharges to the TEDF, located east of 200 East Area. Discharges to TEDF are variable. The water table in 200 East Area responds to Columbia River stage changes via the high-transmissivity paleochannel that originates to the north, near 100-BC Area and extends through the eastern portion of the 200 East Area (Figure 2-10). Since 2011, discharges to the TEDF have not been substantial enough to cause a change in groundwater flow direction in 200 East, and flow has continued toward the southeast. The main effect of the TEDF discharges is to reduce the hydraulic gradient toward the southeast.

2.5 Summary of Previous Groundwater Monitoring

Groundwater monitoring was initiated at the 216-A-37-1 Crib in 1983 under AEA. The 216-A-37-1 Crib was monitored from July 1983 to June 1997 under the Hanford operational groundwater monitoring and the Hanford surveillance monitoring programs. Monitoring specification associated with the site have evolved since 1983 in response to implementation of RCRA monitoring requirements, recognition of changing groundwater flow directions, and evaluation of groundwater monitoring results.

Elevated concentrations of groundwater contaminants resulting in high specific conductance discovered during Hanford operational groundwater monitoring programs at the PUREX Cribs (well 299-E17-9 located at the 216-A-36B Crib) provided the basis for requiring groundwater quality assessment monitoring (WAC 173-303-400 and, by reference, 40 CFR 265.93(d)(3) and (d)(4), “Preparation, Evaluation, and Response”). In 1997, monitoring of the 216-A-37-1 Crib was initiated in conjunction with the 216-A-36B and 216-A-10 Cribs through an 11 well near-field monitoring network designated as part of groundwater quality assessment monitoring program (PNNL-11523, Rev. 0). The 216-A-37-1 Crib monitoring network included one upgradient (299-E25-31) and three downgradient wells (299-E25-17, 299-E25-19, and 699-37-47A) in the vicinity of the TSD unit (PNNL-11523, Rev. 0) (Figure 2-9). Wells designated as part of the 1997 monitoring network were retained in a revision to the PNNL-11523 (Rev. 0) monitoring plan published in 2005 (PNNL-11523, Rev. 1).

Based on sampling results collected under the 2005 groundwater monitoring plan, the 216-A-37-1 Crib was determined to be responsible for nitrate groundwater contamination and associated elevated specific conductance. Nitrate is not a dangerous waste constituent listed in Appendix 5 of WAC 173-303-080, “Dangerous Waste Lists,” and 173-303-100, “Dangerous Waste Criteria” (Ecology Publication No. 97-407, *Chemical Test Methods For Designating Dangerous Waste WAC 173-303-090 & -100*). Therefore, an indicator evaluation program (WAC 173-303-400(3), incorporating 40 CFR 265.92 through 265.93(b)(3)), was determined to be the appropriate program for the 216-A-37-1 Crib. In 2010, PNNL-11523 (Rev. 1) was replaced by DOE/RL-2010-92 (Rev. 0), which was a site-specific monitoring plan for the 216-A-37-1 Crib. At that time, two separate monitoring well networks were considered appropriate for the remaining cribs (216-A-36B and 216-A-37-1). In 2011, DOE/RL-2010-92 (Rev. 0) was revised to include the sampling frequency and constituent list for the first year of monitoring. The well network remained unchanged in DOE/RL-2010-92 (Rev. 1).

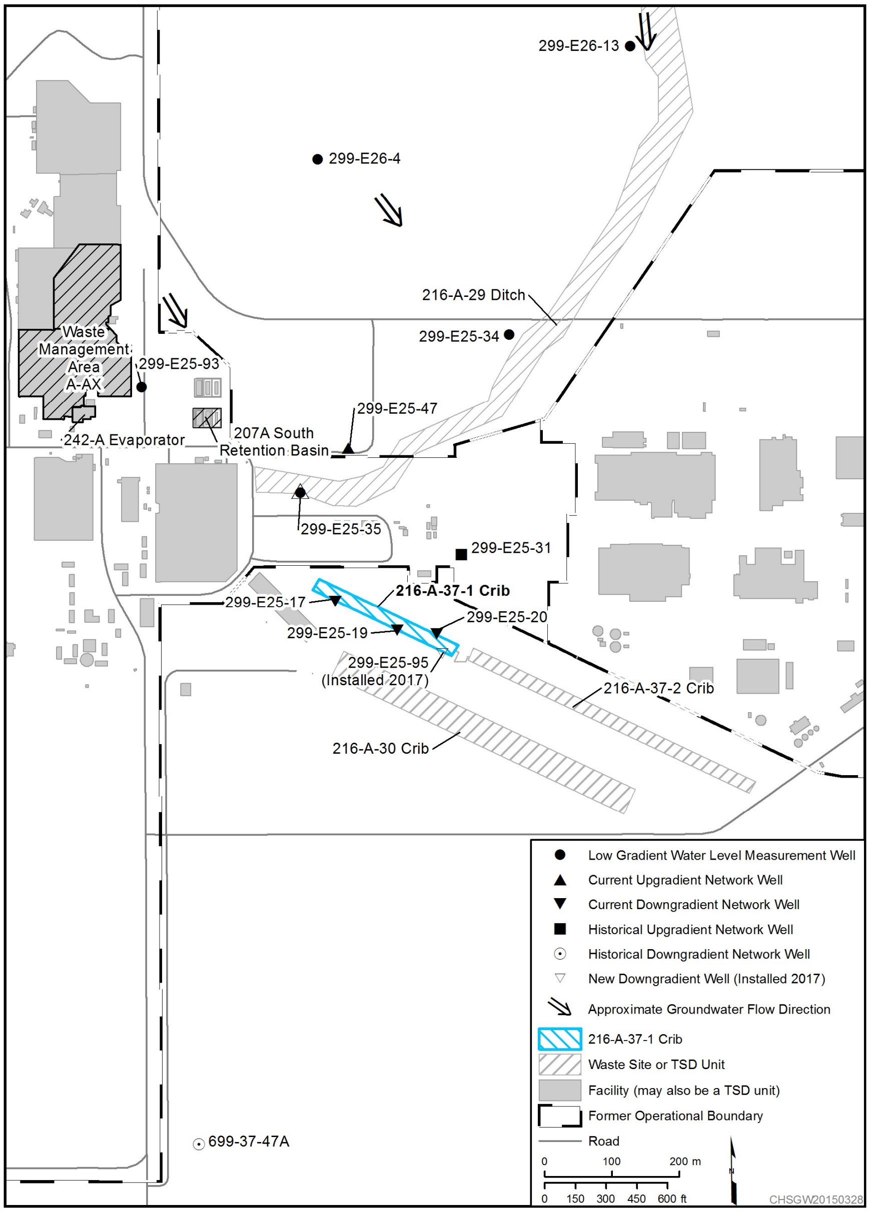


Figure 2-9. Estimated Local Flow Direction and Monitoring Networks near the 216-A-37-1 Crib

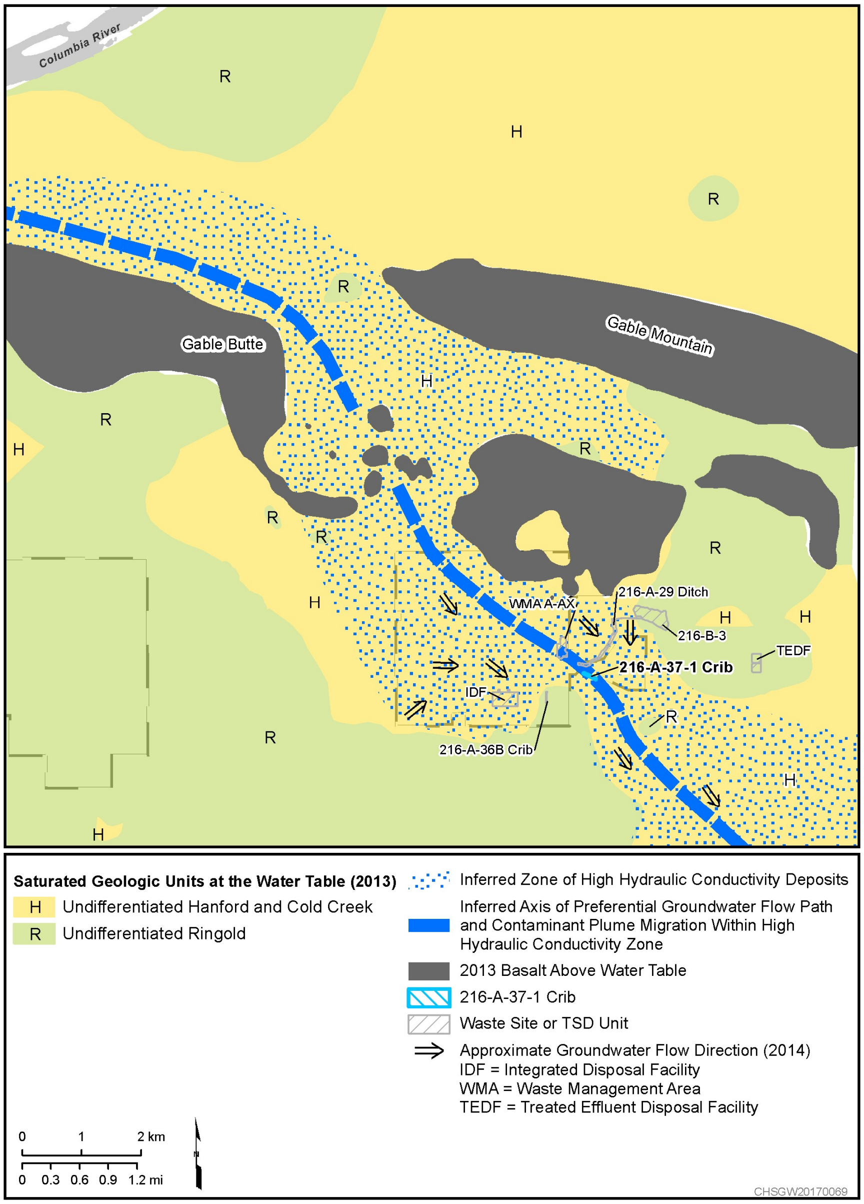


Figure 2-10. Generalized Representation of High Hydraulic Conductivity Zone Associated With Hanford and Cold Creek Paleochannel Deposits

In 2017, DOE/RL-2010-92 (Rev. 1) was revised due to the age of the plan and included the addition of one existing upgradient well and proposed one new downgradient well. In Rev. 2, the site-specific constituent list was revised to remove volatile organic compounds and to add nitrate, hexavalent chromium, and well corrosion products (iron, chromium, nickel, molybdenum, and manganese). The sampling frequency for network wells in Rev. 1 was unchanged in Rev. 2, with additional requirements for the first year of monitoring at wells that were added to the network. The downgradient well proposed in DOE/RL-2010-92, Rev. 2 was installed in 2017. Sampling frequency and constituents for new wells presented in Rev. 2 are utilized in this Rev. 3 plan. Table 2-2 provides a summary of groundwater monitoring plans of the 216-A-37-1 Crib.

Commented [TC2]: RCRA-CN-01_DOE/RL-2010-92_R3

Table 2-2. Summary of Groundwater Monitoring Plans for the 216-A-37-1 Crib

Document	Date Issued	Monitoring Program*	Summary
PNNL-11523, Rev. 0	June 1997	Groundwater Quality Assessment	Groundwater quality assessment program was developed due to elevated specific conductance in a well monitoring the 216-A-36B Crib. Monitoring for the 216-A-10, 216-A-36B, and 216-A-37-1 Cribs was combined into one groundwater assessment plan.
PNNL-11523, Rev. 1	July 2005	Groundwater Quality Assessment	Updated the monitoring well network and site-specific constituents.
DOE/RL-2010-92, Rev. 0	October 2010	Indicator Evaluation Program	Site-specific indicator evaluation program was initiated for the 216-A-37-1 Crib.
DOE/RL-2010-92, Rev. 1	June 2011	Indicator Evaluation Program	Updated the constituent list and sampling frequency for monitoring during the first year.
DOE/RL-2010-92, Rev. 2	May 2017	Indicator Evaluation Program	Updated the monitoring well network and site-specific constituents.

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

While the 216-B-3 Pond (B Pond) was in operation, the groundwater flow direction was in a radial pattern from the pond. Cessation of wastewater discharge to B Pond led to changes to the local groundwater flow direction in the vicinity of the 216-A-37-1 Crib, from west to south. From 1997 until 2005, well 299-E25-31, located northeast of the crib, monitored upgradient conditions when flow was toward the west (Figure 2-9). The location of well 299-E25-31 was appropriate as an upgradient well for the 216-A-37-1 Crib at that time because it was located between the pond and the crib.

Prior to 1997, AEA monitoring conducted for the PUREX Cribs detected ammonia (ammonium ion). Ammonium ion (more recently ammonia) was analyzed in groundwater samples through 2006, but analyses for this constituent were discontinued due to infrequent detections. Detected results ranged from the method detection limit (approximately 7 µg/L) to 850 µg/L. Similarly, volatile organic compounds (VOCs) were analyzed in groundwater samples collected from 1987 to 1994 for the PUREX Cribs (216-A-10, 216-A-37-1, and 216-A-36B) but were discontinued because VOCs were not detected. Throughout much of that time period, however, the method detection limit was 5 µg/L. Since that period, lower detection limits (e.g., 1 µg/L) were utilized for analysis of VOCs.

Since 1996, other constituents have been detected (e.g., zinc, chromium, arsenic, and vanadium). Detections for zinc and chromium occur intermittently; zinc has shown low concentration level trending, and chromium levels have been below the drinking water standard (DWS). Arsenic concentrations have been at background levels (the 95 percent confidence level is 11.8 µg/L [DOE/RL-96-61]).

In 2005, in response to changing flow directions, well 299-E25-31 was no longer considered suitable as an upgradient well for the monitoring network and was replaced by well 299-E25-47 (which is compliant with WAC 173-160, "Minimum Standard for Construction and Maintenance of Wells"). Well 299-E25-47 is north of the 216-A-37-1 Crib and provided better representation of upgradient groundwater (Figure 2-9). This well is located near the 216-A-29 Ditch and has been sampled since 1992 in conjunction with the CERCLA monitoring program. Another well change occurred in 2010 as part of the monitoring network revisions presented in DOE/RL-2010-92 (Rev. 0); well 699-37-47A was removed as a downgradient well, and existing well 299-E25-20, which had been sampled since 1980, was added to provide coverage for the southeastern end of the crib (Figure 2-9). In 1987, sampling for metals, anions, VOCs, semivolatile organic compounds, total organic carbon (TOC), and total organic halogen (TOX) began at well 299-E25-20.

Monitoring conducted between 1995 and 2014 identified a continued presence of nitrate below the 216-A-37-1 Crib at concentrations exceeding the 10 mg/L DWS for nitrogen in nitrate (equivalent to 45 mg/L nitrate). Currently, a nitrate plume occurs beneath the southeastern portion of the crib (Figure 2-11). Plume delineation underlying the waste site is based on a nitrate concentration above the DWS. Nitrate concentrations have gradually been increasing, with the highest levels generally being associated with well 299-E25-20, located at the southeastern end of the crib (Figures 2-9 and 2-12). Concentrations above the DWS have not historically been observed in upgradient wells. The ongoing presence of a nitrate at the 216-A-37-1 Crib indicates that the crib is a probable source of nitrate contamination. West of the 216-A-37-1 Crib, a more extensive nitrate plume across the western portion of the 200 East Area in the vicinity of the 216-A-10 and 216-A-36B Cribs (Figure 2-11), extends into the 200-BP-5 Groundwater OU, located north of the 200-PO-1 Groundwater OU. Nitrate plumes in the 200 East area are monitored under CERCLA by the well networks associated with the 200-PO-1 and 200-BP-5 Groundwater OUs (Figure 2-11).

Increasing sulfate concentrations have been noted in the downgradient network wells since 1996. Downgradient well 299-E25-17 has shown the greatest rate of increase and the highest sulfate concentrations (Figures 2-9 and 2-13). The increasing sulfate values observed in the network wells are consistent with recent mapping of sulfate levels in the 200 East Area (Figure 2-14). Encroachment of the sulfate plume is also shown by rising specific conductance values observed in upgradient well 299-E25-35 (Figure 2-15). This well will be utilized in the revised monitoring network presented in this plan (see Chapter 3) to reflect upgradient conditions impacting the 216-A-37-1 Crib. Some of the higher concentration regions of the sulfate plume are migrating toward the 216-A-37-1 Crib, as seen in the rising specific conductance values measured in well 299-E25-17 (Figure 2-15). Specific conductance has also been increasing in upgradient wells 299-E25-47 and 299-E25-35, as it has for other wells along the 216-A-29 Ditch and 216-A-37-1 Crib. Increasing concentration trending of nitrate and sulfate correlates with the increasing specific conductance values measured in network wells.

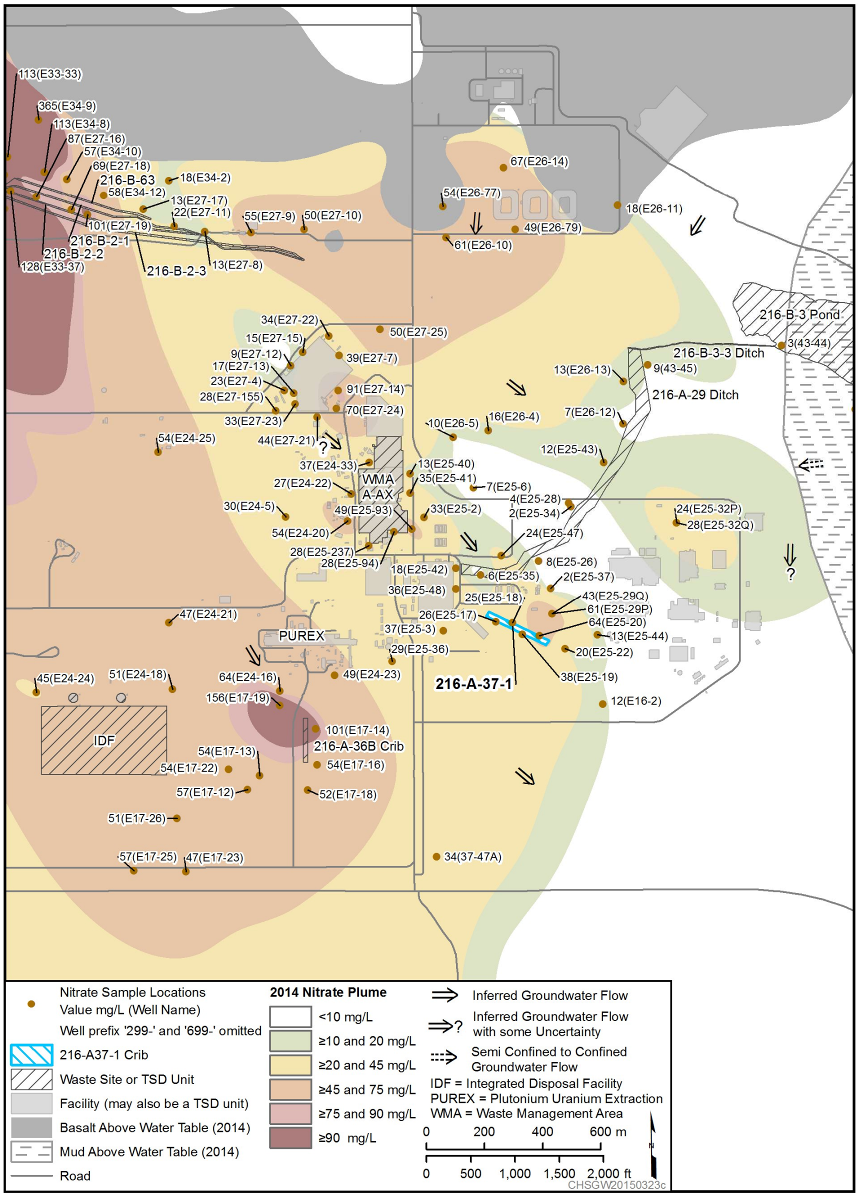


Figure 2-11. Distribution of Nitrate for 2014 in the Vicinity of the 216-A-37-1 Crib

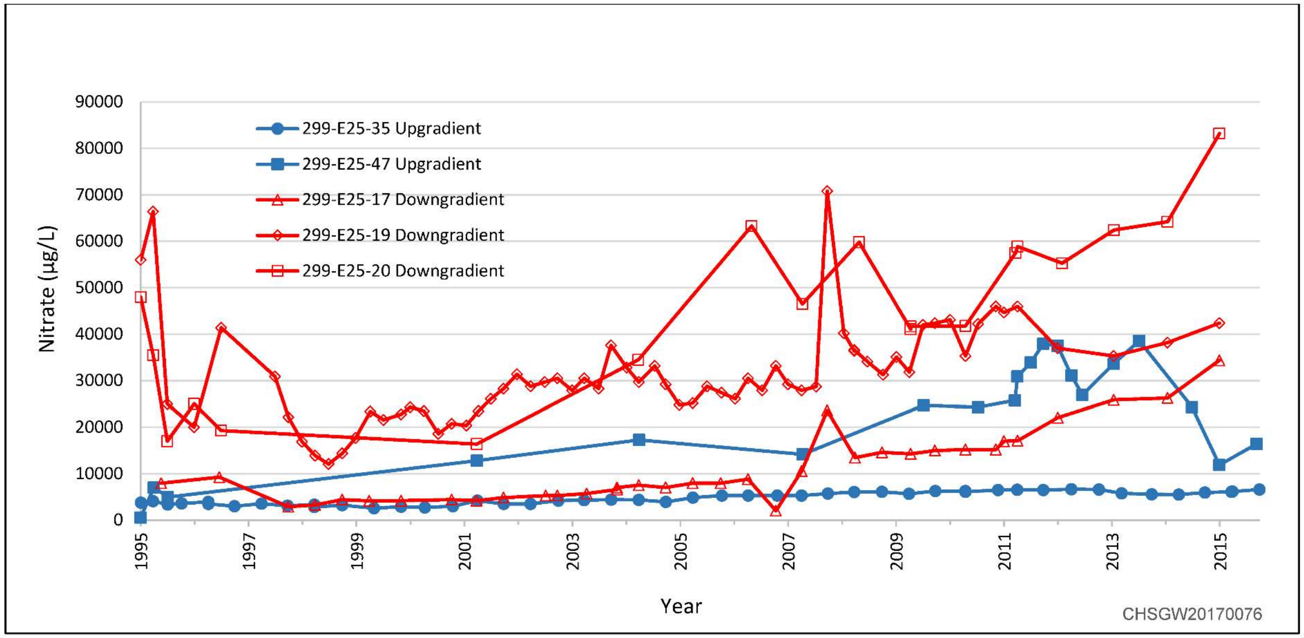


Figure 2-12. Time Series Plot Showing Changes in Nitrate Concentrations in Upgradient and Downgradient Monitoring Wells

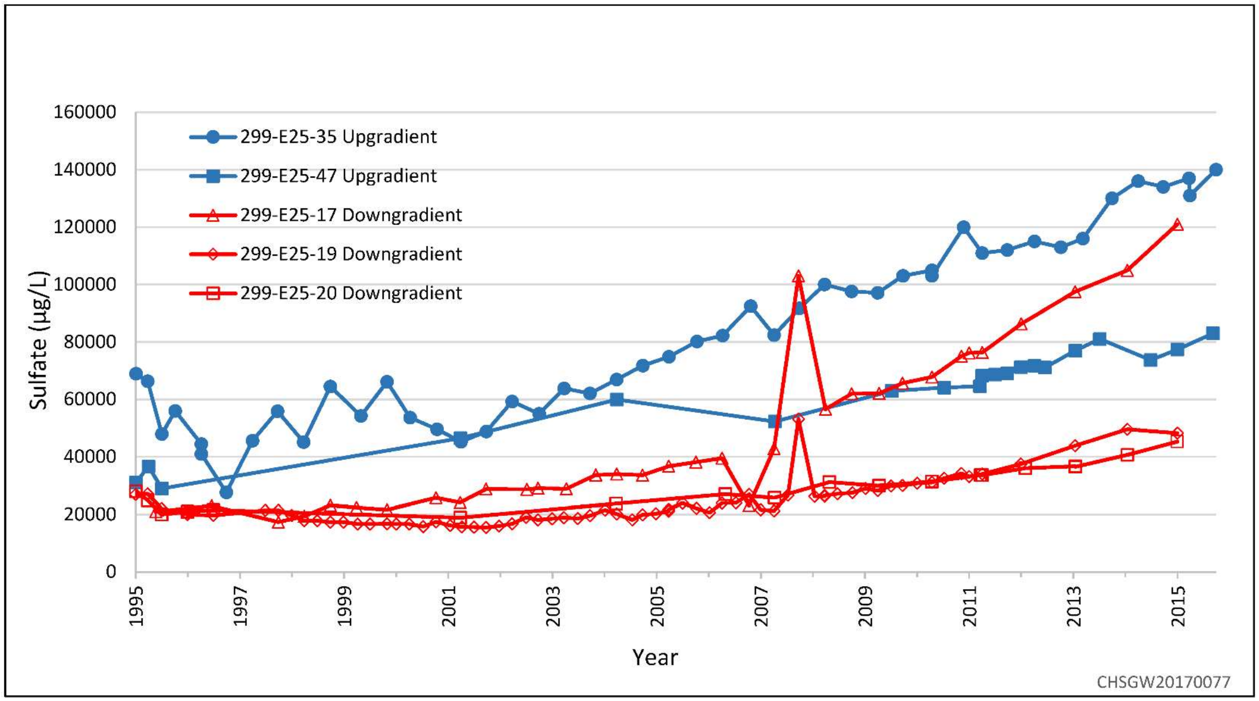


Figure 2-13. Time Series Plot Showing Changes in Sulfate Concentrations in Upgradient and Downgradient Monitoring Wells

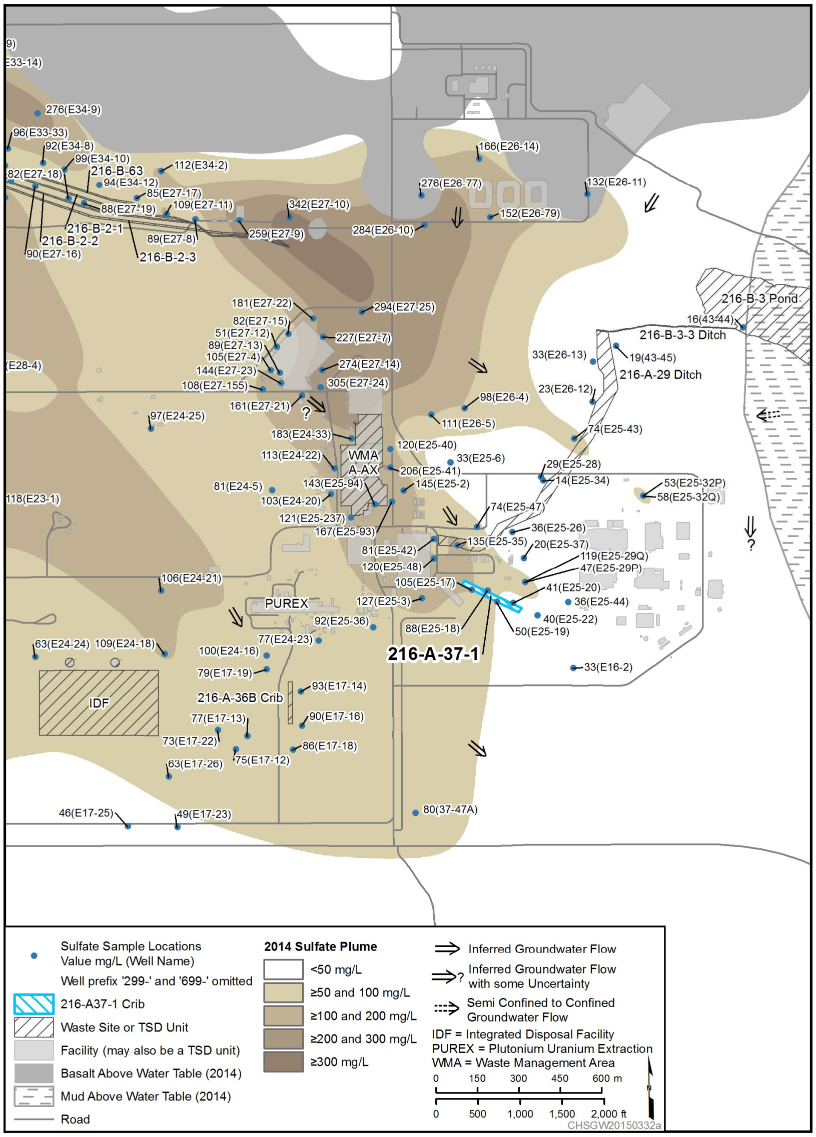


Figure 2-14. Distribution of Sulfate for 2014 in the Vicinity of 216-A-37-1 Crib

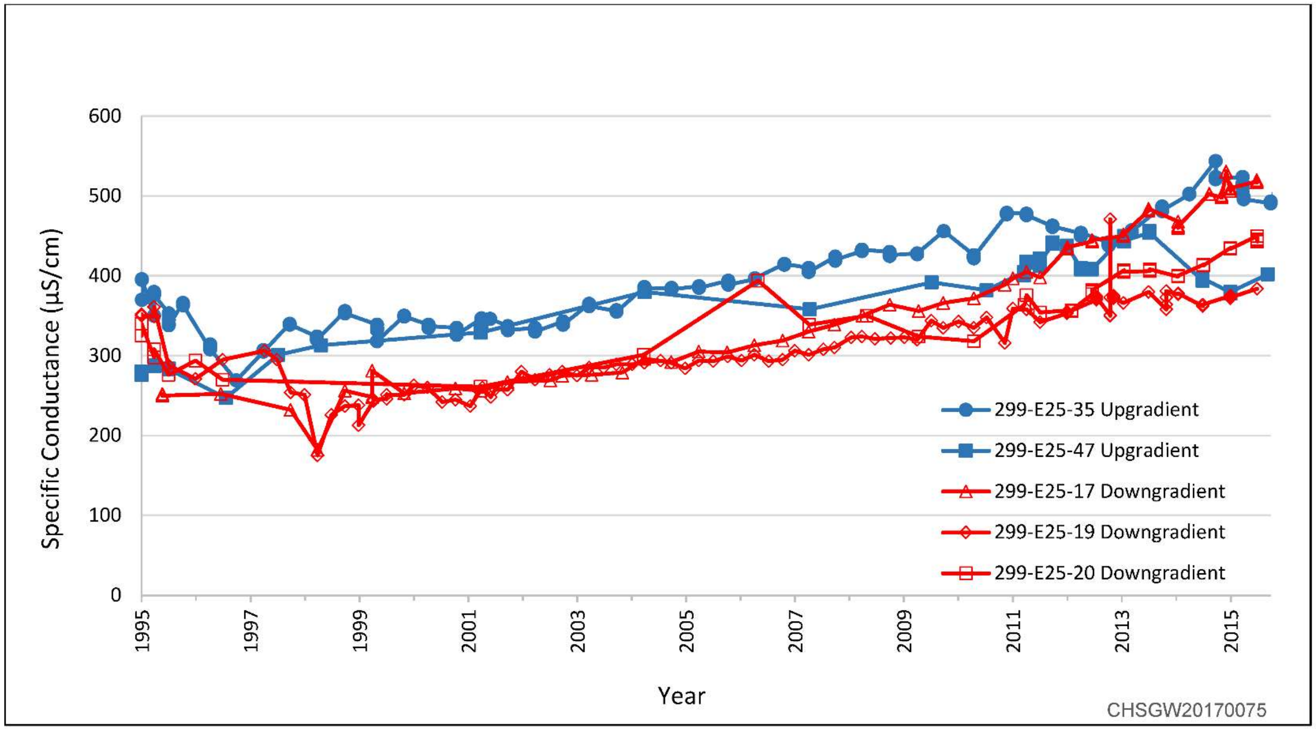


Figure 2-15. Time Series Plot Showing Increasing Specific Conductance Values in Upgradient and Downgradient Monitoring Wells

Based on results from the groundwater quality assessment, an indicator evaluation monitoring program (as described in 40 CFR 265.92) was reinstated at the 216-A-37-1 Crib per 40 CFR 264.93(d)(6) in 2010. During the first year of the indicator parameter monitoring program, the primary objective of monitoring was to establish initial background concentrations in accordance with 40 CFR 265.92(c)(1) and (2) for well 299-E25-47. Well 299-E25-47 (upgradient) was sampled quarterly for the indicator parameters (pH, specific conductance, total organic carbon, and total organic halogen) and groundwater quality parameters (chloride, iron, manganese, phenols, sodium, and sulfate), and semiannually for VOCs, because it did not have sufficient data for indicator parameter monitoring and had little background data. In the established downgradient wells, indicator parameters and VOCs were analyzed semiannually, and groundwater quality parameters and alkalinity were analyzed annually. The field parameters (temperature, turbidity, and water level) were collected every time the wells were sampled.

Per DOE/RL-2010-92 (Rev. 0), if VOCs were detected in downgradient wells (and not upgradient wells), analysis for the detected constituents would continue. Following completion of the first year monitoring requirements outlined in DOE/RL-2010-92 (Rev. 1), sampling frequency for all wells was established as semiannual for indicator parameters and field parameters, and annual for groundwater quality parameters.

The 216-A-37-1 Crib has remained under an interim status indicator evaluation monitoring program (as described in 40 CFR 265.92) since 2010. Statistical analyses of the parameters used as indicators of groundwater contamination have not shown an exceedance since implementation of DOE/RL-2010-92 (Rev. 0). Thus, dangerous wastes subject to WAC 173-303 are not considered to have contaminated the groundwater beneath the 216-A-37-1 Crib.

Groundwater monitoring activities at the 216-A-37-1 Crib under this groundwater monitoring plan (DOE/RL-2010-92, Rev. 3) sample from a network of 6 wells. Samples are analyzed semiannually for parameters used as indicators of groundwater contamination and annually for parameters establishing groundwater quality. Site-specific constituents will be monitored annually, except for field parameters to be monitored during each sampling event. Water-level measurements are collected each time that a sample is obtained from a network well. Site-specific constituents are also sampled annually. The network wells are included in the annual comprehensive March water-level measurement campaign (SGW-38815, *Water-Level Monitoring Plan for the Hanford Site Soil and Groundwater Remediation Project*). Groundwater monitoring results are summarized for the 216-A-37-1 Crib in the annual Hanford Site RCRA groundwater monitoring report (e.g., DOE/RL-2016-12, *Hanford Site Groundwater Monitoring Report for 2015*).

2.6 Conceptual Site Model

Groundwater flow and potential contaminant transport strongly influence the groundwater monitoring strategy. Therefore, having a CSM of hydrogeologic and potential contaminant conditions is necessary for development a practical groundwater monitoring plan. A groundwater CSM is an evolving hypothesis that identifies important features, actual and possible events, and processes that control groundwater and contaminant movement. This CSM is based on the results of previous geological and hydrogeological studies, and groundwater monitoring results (Section 4 in PNNL-11523 [Rev. 1], Section 4 in PNNL-12261, Sections 3.4 and 3.6 in DOE/RL-2009-85, and annual groundwater monitoring reports).

The generalized hydrogeologic characteristics below the 216-A-37-1 Crib are shown in Figure 2-16. The CSM includes the following site characteristics and assumptions:

- Liquid wastes are released in the crib and migrate through the vadose zone and into the groundwater.
- As the mobile constituents in the vadose zone intercept and mix with groundwater in the unconfined aquifer, the constituents move laterally with groundwater flow.
- The persistence of an isolated nitrate plume below the 216-A-37-1 Crib suggests a continuing source of nitrate contamination in the vadose zone (Figure 2-11). Increasing nitrate levels in surrounding wells upgradient of the crib indicates there is additional nitrate contribution from a diffuse nitrate mass migrating through the area.
- Groundwater contamination, if any, tends to be higher in concentration near the water table; thus, wells are most often screened (or casings perforated) near the water table (PNL-2724, *Vertical Contamination in the Unconfined Groundwater at the Hanford Site, Washington*).
- Groundwater flow in more recent years has reverted toward the flow pattern that existed before large discharges to B Pond. A southeast flow direction near the 216-A-37-1 Crib is indicated based on contaminant plume migration in the area and measurements obtained from adjacent wells comprising low gradient water table measurement network (Figures 2-8 and 2-9). The water table elevation in the 200 East Area has declined significantly since discharges to B Pond completely ceased in 1997. The rate of decline has decreased during the last 5 years. Wells in the area have shown a decrease in the water table elevation of only 0.07 to 0.15 m (0.2 to 0.5 ft) between 2010 and 2015.
- Near the 216-A-37-1 Crib, a large region of channel deposits comprised of Hanford formation and older CCU sediments extends across the southeastern portion of 200 East Area (Figure 2-10). Channel sediments fill an erosional scour that has removed a portion of the older Ringold Formation sediment (i.e., unit E and the Ringold lower mud unit north and northeast of the site (Figures 2-4, 2-5, and 2-6). Where the Ringold lower mud is present, it acts as a confining or semiconfining layer above the Ringold Formation unit A. North and northeast of the crib, the Cold Creek directly overlays sand and gravel of the Ringold Formation unit A. The uppermost lithologic sequence underlying the crib consists of both the sand and gravel sequences within the Hanford formation (H2 and H3), underlain by gravels comprising the Cold Creek Unit (CCUg) (Figures 2-4, 2-5, and 2-6).
- Geologic contacts shown below wells presented in the cross-sections are based on interpolated geologic contacts using the Leapfrog geologic three-dimensional software (ECF-Hanford-13-0029) and the cross-section generation tool provided in the web-based version of DOE/RL-2015-07. As indicated in each cross-section figure legend, geologic information associated with a well is projected to the cross-section within a buffer zone extending 75 m (246 ft) from either side of the cross-section line, resulting in approximate depths for stratigraphic contacts. Definition of the stratigraphic units present is based on the most current, integrated understanding of the subsurface geologic framework beneath an area and in some cases utilizes projected geologic contacts and stratigraphy from adjacent areas where data is available, utilizing the Leapfrog geologic three-dimensional software. Projected lithologic contacts suggest that the Ringold lower mud may partially confine the Ringold Formation unit A south of the 216-A-37-1 Crib (Figure 2-5).
- As shown in Figures 2-4, 2-5, and 2-6, hydraulic communication can occur between the Hanford, CCU, and the unconfined or partially confined sediments comprising the Ringold Unit A. Directly west of the 216-A-37-1 Crib, where ancestral channel scour was not as pronounced, Ringold Unit E is present underlying the Hanford formation (Figure 2-6).

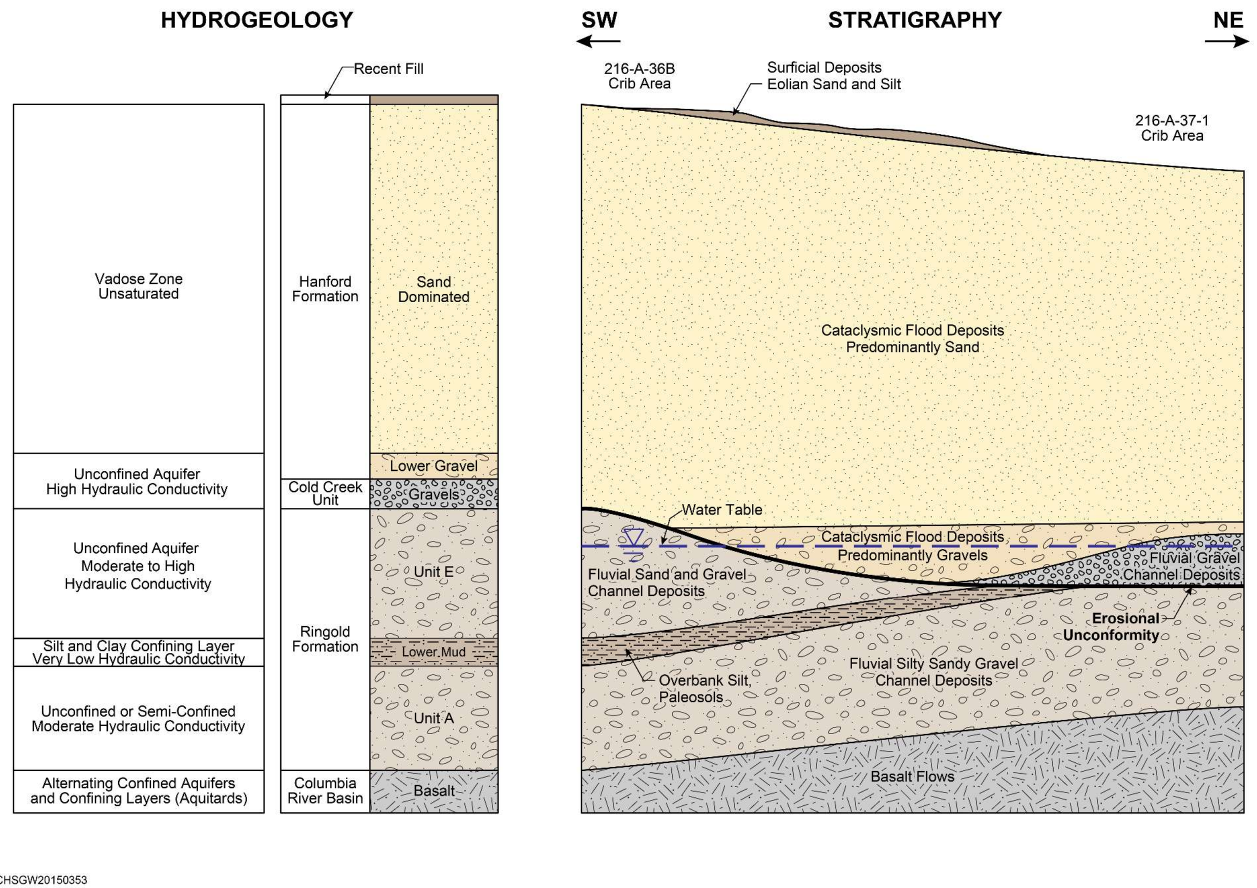


Figure 2-16. General Representation of Hydrogeologic Characteristics Underlying the 216-A-37-1 Crib and Southeastern Portion of the 200 East Area

- Hydraulic conductivity of Hanford and Cold Creek sediments are generally higher than that of Ringold units A or E, although in some areas within 200 East, the hydraulic conductivity of the upper portion of the Ringold unit E appears similar to that of the Hanford and Cold Creek. Where these stratigraphic units are found laterally or vertically juxtaposed as the result of the depositional environment, contaminants may preferentially flow in the Hanford or Cold Creek versus Ringold units.
- Regionally, there is an upward hydraulic gradient within the confined Ringold aquifer. Groundwater flow may occur from the confined Ringold Formation unit A into the highly transmissive Hanford and Cold Creek channel-fill sediments in areas along the channel margins where these stratigraphic units are in contact (Figures 2-8 and 2-10).

2.7 Monitoring Objectives

The groundwater monitoring program at the 216-A-37-1 Crib is conducted with the objective of determining the facility's impact, if any, on the quality of the underlying groundwater. This groundwater monitoring plan addresses specifically those applicable dangerous waste requirements for interim status TSD units where no impact to groundwater has been identified. The regulatory requirements applicable to this groundwater monitoring plan are found in WAC 173-303-400(3) and 40 CFR 265.90 through 265.94, "Recordkeeping and Reporting." Table 2-3 identifies where each groundwater monitoring element of the pertinent regulations is addressed within this plan. Additional anions and cations (Table 2-4) will also be collected for general groundwater chemistry, which will support the evaluation of upgradient and downgradient water chemistry variations (e.g., data used for Stiff diagrams and charge balance determinations).

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

Groundwater Monitoring Element	Pertinent Requirement*	Section Where Requirement Is Addressed in Monitoring Plan
Applicability	40 CFR 265.90, "Applicability" (a) Within one year after the effective date of these regulations, the owner or operator of a surface impoundment, landfill, or land treatment facility which is used to manage hazardous waste must implement a ground-water monitoring program capable of determining the facility's impact on the quality of ground water in the uppermost aquifer underlying the facility, except as §265.1 and paragraph (c) of this section provide otherwise. (b) Except as paragraphs (c) and (d) of this section provide otherwise, the owner or operator must install, operate, and maintain a ground-water monitoring system which meets the requirements of §265.91, and must comply with §§265.92 through 265.94. This ground-water monitoring program must be carried out during the active life of the facility, and for disposal facilities, during the post-closure care period as well.	Chapter 1

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

Groundwater Monitoring Element	Pertinent Requirement*	Section Where Requirement Is Addressed in Monitoring Plan
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 number, locations, and depths must ensure that they immediately detect any statistically significant amounts of dangerous waste or dangerous waste constituents that migrate from the waste management area to the uppermost aquifer.	Section 3.2
Well configuration	40 CFR 265.91: (c) All monitoring wells must be cased in a manner that maintains the integrity of the monitoring well 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
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

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

Groundwater Monitoring Element	Pertinent Requirement*	Section Where Requirement Is Addressed in Monitoring Plan
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. (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. (d) After the first year, all monitoring wells must be sampled and the samples analyzed with the following frequencies: (1) Samples collected to establish ground-water quality must be obtained and analyzed for the parameters specified in paragraph (b)(2) of this section at least annually. (2) Samples collected to indicate ground-water contamination must be obtained and analyzed for the parameters specified in paragraph (b)(3) of this section at least semi-annually. (e) Elevation of the ground-water surface at each monitoring well must be determined each time a sample is obtained.	Section 3.1 and Appendix B, Section B2.2

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

Groundwater Monitoring Element	Pertinent Requirement*	Section Where Requirement Is Addressed in Monitoring Plan
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. (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.	Sections 4.1, 4.2, 4.3 and Appendix A

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

Groundwater Monitoring Element	Pertinent Requirement*	Section Where Requirement Is Addressed in Monitoring Plan
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 ~~A2.6~~ A2.5 and A3.9

Commented [CTJ3]: RCRA-CN-01_DOE/RL-2010-92_R3

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

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

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

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

RCRA = *Resource Conservation and Recovery Act of 1976*

TSD = treatment, storage, and disposal

Table 2-4. Additional Monitoring Objectives

Monitoring Objective	TSD Unit-Specific Constituents/ Field Measurements*
Site-specific - nitrate is a degradation product of waste previously discharged to the 216-A-37-1 Crib.	Nitrate
Alkalinity constituents – used in ion balance and to support water chemistry analysis.	Total alkalinity ~~Alkalinity, bicarbonate (from alkalinity), carbonate (from alkalinity), hydroxyl ion~~
Metals – additional metals used in ion balance and to support water chemistry analysis.	Calcium, magnesium, potassium
Metals – additional metals used to identify corrosion of well casing.	Chromium, hexavalent chromium, iron, manganese, molybdenum, and nickel
Anions – additional anions used in ion balance and to support water chemistry analysis.	Fluoride, nitrate, nitrite
Field parameters provide information on water properties at the time of sampling.	Temperature and turbidity

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

TSD = treatment, storage, and disposal

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Commented [TC5]: RCRA-CN-01_DOE/RL-2010-92_R3

3 Groundwater Monitoring Program

This chapter describes the groundwater monitoring indicator evaluation program for the 216-A-37-1 Crib consisting of parameters used as indicators of groundwater contamination, parameters establishing groundwater quality, a monitoring well network, and sampling and analysis protocols. The monitoring program presented herein has not been revised from that presented in the previous plan (DOE/RL-2010-92, Rev. 2), which proposed the new well incorporated in this revision. This revision incorporates the new downgradient well (299-E25-95) installed in 2017 into the monitoring network. This revision supersedes the monitoring program of the previous plan.

3.1 Constituents List and Sampling Frequency

Table 3-1 presents the wells in the groundwater monitoring network, the parameters analyzed, and the sampling frequency for monitoring of the 216-A-37-1 Crib. 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, sulfate) will be sampled and analyzed annually (40 CFR 265.92(b)(2) and (d)(1)). Water-level measurements at each monitoring well will be determined each time that a sample is obtained (40 CFR 265.92(e)). Though not required by regulation, site-specific constituents will be sampled annually and are identified in Table 2-4. These include nitrate, which is a degradation product of waste previously discharged to the crib and supporting constituents (anions and metals) to support analysis of general water chemistry in the upgradient and downgradient monitoring areas and comparative analysis of general groundwater characteristics in the monitoring area. Supporting constituents also include chromium, hexavalent chromium, iron, manganese, molybdenum, and nickel which are monitored to detect corrosion of well casings.

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In the previous plan, existing upgradient well 299-E25-35 and proposed downgradient well (299-E25-95) were added to the 216-A-37-1 Crib monitoring network. Well 299-E25-95 was installed in 2017 and is scheduled to begin sampling in October 2017. Each of these wells will be sampled quarterly for 1 year for contamination indicator parameters and groundwater quality parameters in Table 3-1. In addition to the monitoring in Table 3-1, these wells will be sampled quarterly for 1 year for the drinking water suitability parameters included in Appendix III to 40 CFR 265 (Table 3-2). Monitoring for the Appendix III parameters in Table 3-2 will be performed concurrently with the monitoring required in Table 3-1. Quarterly sampling for 299-E25-35 was initiated under the previous plan and will be continued as applicable under this plan until the monitoring criteria is completed.

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

RCRA-CN-01_DOE/RL-2010-92_R3

Table 3-1. Monitoring Well Network for the 216-A-37-1 Crib

Well Name	Purpose	WAC Compliant	RCRA Required Parameters[a]													Site-Specific Constituents				
			Water Level	Contamination Indicator Parameters				Groundwater Quality Parameters						Supporting Constituents				Site-Specific[g]
				pH	Specific Conductance	Total Organic Carbon	Total Organic Halogen	Chloride	Iron (Filtered and Unfiltered)[b]	Manganese (Filtered and Unfiltered)[b]	Phenols[k]	Sodium (Filtered and Unfiltered)[b]	Sulfate	Alkalinity[c]	Metals (Filtered and Unfiltered)[b,d]	Anions[e]	Field Parameters[f]	
299-E25-35[h]	Upgradient	Y	Q	Q4	Q4	Q4	Q4	Q	Q	Q	Q	Q	Q	A	A	A	Q	A
299-E25-35[i]	Upgradient	Y	S	S4	S4	S4	S4	A	A	A	A	A	A	A	A	A	S	A
299-E25-47	Upgradient	Y	S	S4	S4	S4	S4	A	A	A	A	A	A	A	A	A	S	A
299-E25-17	Downgradient	N[j]	S	S4	S4	S4	S4	A	A	A	A	A	A	A	A	A	S	A
299-E25-19	Downgradient	N[j]	S	S4	S4	S4	S4	A	A	A	A	A	A	A	A	A	S	A
299-E25-20	Downgradient	N[j]	S	S4	S4	S4	S4	A	A	A	A	A	A	A	A	A	S	A
299-E25-95[h]	Downgradient	Y	Q	Q4	Q4	Q4	Q4	Q	Q	Q	Q	Q	Q	A	A	A	Q	A
299-E25-95[i]	Downgradient	Y	S	S4	S4	S4	S4	A	A	A	A	A	A	A	A	A	S	A

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

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

c. Alkalinity includes total alkalinity ~~analysis of bicarbonate alkalinity, carbonate alkalinity, and hydroxide alkalinity.~~

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Commented [CTJ8]: RCRA-CN-01_DOE/RL-2010-92_R3

Table 3-1. Monitoring Well Network for the 216-A-37-1 Crib

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

d. Includes analysis of calcium, magnesium, and potassium to support water chemistry analysis and chromium, hexavalent chromium, iron, manganese, molybdenum, and nickel to identify well casing corrosion.

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

f. Includes dissolved oxygen, temperature, and turbidity.

g. Nitrate will be monitored as a site-specific constituent because it is a degradation product of waste previously discharged to the 216-A-37-1 Crib.

h. Constituents and sampling frequency for 1 year of monitoring. During the 1 year monitoring period, additional analyses will be performed at this well as described in Table 3-2.

i. Constituents and sampling frequency after the 1 year of monitoring described in footnote.

j. Well identified for replacement consistent with sitewide cleanup priorities described in Milestone M-024-58 of Ecology et al., 1989b, *Hanford Federal Facility Agreement and Consent Order Action Plan*.

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

A	=	to be sampled annually
N	=	well is not constructed as a resource protection well (WAC 173-160, "Minimum Standard for Construction and Maintenance of Wells")
Q	=	to be sampled quarterly
Q4	=	to be sampled quarterly, with quadruplicate samples collected during each event
S	=	to be sampled semiannually
S4	=	to be sampled semiannually, with quadruplicate samples collected during each event
RCRA	=	*Resource Conservation and Recovery Act of 1976*
WAC	=	*Washington Administrative Code*
Y	=	well is constructed as a resource protection well (WAC 173-160)

RCRA-CN-01_DOE/RL-2010-92_R3

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Commented [CTJ10]: RCRA-CN-01_DOE/RL-2010-92_R3

Commented [CTJ11]: RCRA-CN-01_DOE/RL-2010-92_R3

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

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

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

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

CAS = Chemical Abstracts Service

Commented [CTJ1]: RCRA-CN-01_DOE/RL-2010-92_R3

Table 3-2. Constituents and Sampling Frequency for 1 Year of Monitoring at Wells Added to the 216-A-37-1 Crib Network

Well Name	Water Level	40 CFR 265 Appendix III Parameters[a]																				
		Arsenic (Filtered and Unfiltered)[b]	Barium (Filtered and Unfiltered)[b]	Cadmium (Filtered and Unfiltered)[b]	Chromium (Filtered and Unfiltered)[b]	Fluoride	Lead (Filtered and Unfiltered)[b]	Mercury	Nitrate (as N)	Selenium (Filtered and Unfiltered)[b]	Silver (Filtered and Unfiltered)[b]	Endrin	Lindane	Methoxychlor	Toxaphene	2,4,-D	2,4,5-TP Silvex	Radium	Gross Alpha	Gross Beta	Coliform Bacteria	Turbidity
299-E25-35	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q
299-E25-95	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q

References:

40 CFR 265, "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," Appendix III, "EPA Interim Primary Drinking Water Standards."

DOE/RL-2010-92, 2017, *Interim Status Groundwater Monitoring Plan for the 216-A-37-1 PUREX Plant Crib*, Rev. 2, U.S. Department of Energy, Richland Operations Office, Richland Washington.

a. Monitoring for the Appendix III parameters will be performed for 1 year and will be performed concurrently with monitoring required in Table 3-1. Quarterly sampling of well 299-E25-35 was initiated under DOE/RL-2010-92, Rev. 2 and will continue as applicable until 1 year of data is collected. Well 299-E25-95 is scheduled to begin sampling in October 2017.

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

Q = to be sampled quarterly

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

3.1.2 Well Biofouling and TOC Results

Biofouling of wells can result in collection of non-representative groundwater samples and produce non-representative analytical results for TOC. In Hanford Site wells, biofouling is often associated with iron 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 non-specific analysis that is used as an indicator of the presence of organic compounds in groundwater. TOC represents organic compounds in the sample; this includes 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 non-specific. 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 activities to address accumulated microbiological growth in the well will be performed. 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 will 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. Well cleaning will be completed per the contractor’s standard operating procedures. A down-hole camera survey and well cleaning will be scheduled immediately following receipt of elevated TOC result where biofouling of the well is suspected. Subsequent to completing the cleaning 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).

3.2 Monitoring Well Network

Numerous groundwater wells exist in the vicinity of the 216-A-37-1 Crib. Not all wells meet WAC 173-160 construction standards. The following criteria were used to select wells for RCRA monitoring of the 216-A-37-1 Crib:

- Location of the downgradient wells with respect to the waste site boundary and groundwater flow path (wells closest to the waste site boundary were prioritized for use because they would provide the most immediate indication of a release)
- Well screen position with respect to the water table (wells constructed with screens positioned closest to the vadose zone/water table interface were preferred for indicating contaminant presence in groundwater resulting from a nearby waste site release)

- Suitable well construction such that the sampling data provided will be comparable with other network wells
- Compliance with WAC 173-160

The three existing downgradient wells (299-E25-17, 299-E25-19, and 299-E25-20) used for monitoring the 216-A-37-1 Crib are considered appropriate for the monitoring objectives, but are not compliant with WAC 173-160. Per agreement between DOE and Ecology, noncompliant wells are identified and placed on the prioritized drilling schedule for replacement consistent with site-wide cleanup priorities as described in Milestone M-024-58, which is contained in the Tri-Party Agreement Action Plan (Ecology et al., 1989b, *Hanford Federal Facility Agreement and Consent Order Action Plan*), as revised. The three downgradient wells have been included in this milestone for future replacement.

In the previous plan, well 299-E25-95 (New Well 1) was proposed immediately south, near the eastern end of the 216-A-37-1 Crib to provide additional downgradient coverage. This well was installed in 2017 and is incorporated into the network. Well 299-E25-95 is scheduled to begin sampling in October 2017.

The 216-A-37-1 monitoring network under Rev. 1 consisted of one upgradient and three downgradient wells (Figure 2-9). One upgradient well located north of the crib (299-E25-47) was no longer considered suitable by itself for monitoring the southeast groundwater flow and upgradient constituent concentrations. Two upgradient wells were needed to monitor spatial variability in upgradient constituent concentrations impacting the site. This upgradient well was augmented with the addition of well 299-E25-35 (which is compliant with WAC 173-160) under Rev. 2. Well 299-E25-35 is an existing downgradient well within the monitoring network of the nearby 216-A-29 Ditch; however, it was added to the 216-A-37-1 monitoring well network as an upgradient well. Wells 299-E25-47 and 299-E25-35 are located north and north-northwest, respectively, of the 216-A-37-1 Crib and provide better coverage and representation of the upgradient groundwater constituents migrating to the southeast that impact the site. The upgradient wells 299-E25-35 and 299-E25-47 are retained under this revised plan. Figure 3-1 presents the groundwater monitoring network to be utilized in this plan. Information on the wells comprising the updated network is summarized in Table 3-3.

Well 299-E25-35 is located south of the 216-A-29 Ditch and has been sampled since 1988. Specific conductance, nitrate, and sulfate levels have been consistently increasing in this well, as it has for other wells upgradient of the 216-A-37-1 Crib and the 216-A-29 Ditch since 1998 (Figure 2-15). Specific conductance levels in downgradient wells comprising the 216-A-37-1 well network (Figure 2-15) are related to the southeast migration of sulfate (Figures 2-13 and 2-14) and nitrate (Figures 2-11 and 2-12) plumes through the monitoring area and to nitrate levels associated with the crib (Figures 2-11 and 2-12).

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

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

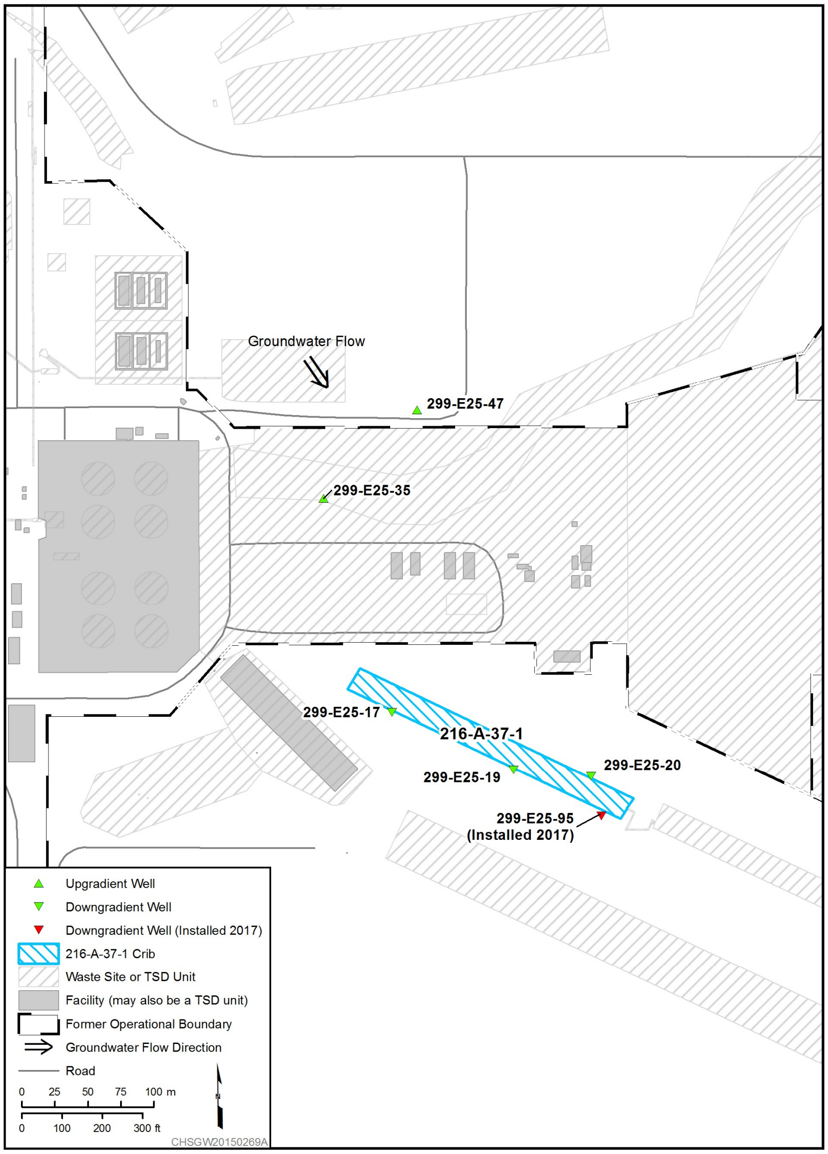

Figure 3-1. 216-A-37-1 Crib Monitoring Well Network

Table 3-3. Attributes for Wells in the 216-A-37-1 Crib Groundwater Monitoring Network

Well Name	Completion Date	Easting[a] (m)	Northing[a] (m)	Screen Top (m [ft] bgs) and Elevation (m [ft]) [b]	Screen bottom (m [ft] bgs) and Elevation (m [ft]) [b]	Water Depth (m [ft] bgs) and Elevation (m [ft])[b]	Remaining Water Column (m [ft])	Water Table Measurement Date
299-E25-35[c]	1988	575708.3	135864.7	94.2 (309.0) 111.4 (365.5)	100.6 (330.0) 105.0 (344.5)	83.6 (274.3) 122.04 (400.49)	17.0 (55.8)	7/24/2016
299-E25-47[c]	1992	575779.0	135931.5	80.2 (263.1) 125.2 (410.8)	86.3 (283.2) 119.1 (390.7)	83.7 (274.6) 121.71 (399.31)	2.7 (8.9)	7/10/2016
299-E25-17	1976	575760.2	135702.5	83.2 (273.0) 123.4 (404.9)	89.9 (295.0) 116.7 (382.9)	84.9 (278.5) 121.7 (399.28)	5.0 (16.4)	7/10/2016
299-E25-19	1976	575852.3	135659.0	82.3 (270.0) 124.6 (408.8)	89.9 (295.0) 117.0 (383.9)	85.3 (279.9) 121.65 (399.11)	4.7 (15.4)	7/10/2016
299-E25-20	1976	575910.9	135654.0	82.0 (269.0) 124.5 (408.5)	89.6 (294.0) 116.9 (383.5)	85.0 84.9(278.5) 121.61 (398.98)	4.7 (15.4)	7/10/2016
299-E25-95	2017	575916.0[d]	135628.0[d]	84.5 (277.4) 122.0 (400.4)	93.7 (307.4) 112.9 (370.4)	85.0 (278.9) 121.6 (398.9)	8.7 (28.5)	6/5/2017

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

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

c. Upgradient well.

d. Coordinates and well screen elevation data derived from pre-drilling land survey information. No post-drilling survey information available at the time of groundwater monitoring plan revision.

bgs = below ground surface

3.3 Differences between This Plan and Previous Plan

Table 3-4 identifies the main differences between this plan and the previous groundwater monitoring plan.

The previous plan used two existing wells (299-E25-35 and 299-E25-47) for upgradient monitoring, which are retained under the current monitoring well network. The downgradient well network is consistent with the previous plan and is being updated to incorporate the additional downgradient well (299-E25-95) that was proposed in Rev. 2 and installed in 2017. The additional downgradient well will provide better coverage of downgradient groundwater conditions associated with the crib. Wells 299-E25-35 and 299-E25-95 will each be sampled quarterly for indicator parameters, groundwater quality parameters, and drinking water suitability parameters included in Appendix III to 40 CFR 265 until 1 year of quarterly data are collected. Quarterly sampling of well 299-E25-35 was initiated under Rev. 2 and will continue as applicable until the sampling criteria are complete. Quarterly sampling for well 299-E25-95 is scheduled to begin in October 2017.

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

Type of Change	Previous Plan*	Current Plan	Justification Summary
Constituents	Indicator parameters, groundwater quality parameters, water chemistry constituents, site-specific constituents	Same	No change
Sampling Frequency	Indicator parameters (semiannual), Groundwater quality parameters (annual), Water level measurements (every sampling event), Additional constituents (annual), field parameters (semiannual) Wells 299-E25-35 and New Well 1 will be sampled quarterly for indicator parameters, groundwater quality parameters, and drinking water suitability parameters included in Appendix III to 40 CFR 265 for 1 year.	Same	No change

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

Type of Change	Previous Plan*	Current Plan	Justification Summary
Well Network	Two upgradient wells, four downgradient wells Upgradient: 299-E25-35 299-E25-47 Downgradient: 299-E25-17 299-E25-19 299-E25-20 New Well 1	Two upgradient wells, four downgradient wells Upgradient: 299-E25-35 299-E25-47 Downgradient: 299-E25-17 299-E25-19 299-E25-20 299-E25-95 (New Well 1)	New Well 1 (299-E25-95) proposed in previous plan was installed in 2017 and was added to provide better coverage of downgradient groundwater conditions associated with the crib.
Groundwater Flow Direction	South to southeast	Same	No change
Type of Groundwater Monitoring Program	Indicator evaluation program	Same	No change
Background Arithmetic Mean Recalculated	Calculated annually using two upgradient wells	Same	No change
Groundwater Quality Assessment Plan Outline	Outline provided in Chapter 5	Same	No change

* DOE/RL-2010-92, Rev. 2, Interim Status Groundwater Monitoring Plan for the 216-A-37-1 PUREX Plant Crib.

3.4 Sampling and Analysis Protocol

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

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 the 216-A-37-1 Crib operations have affected groundwater quality beneath the TSD unit, which is determined based on the results of specified statistical tests. Under this plan, sampling activities and statistical evaluation methods are based on 40 CFR 265, Subpart F (incorporated by reference into WAC 173-303-400). These interim status regulations require the use of a statistical method that compares mean concentrations of the four general groundwater contamination indicator parameters (pH, specific conductance, TOC, and TOX) to background levels to test for potential impact to groundwater. Each time that a monitoring well is sampled, four replicate samples for TOC and TOX are collected, and four replicate field measurements are made for pH and specific conductance.

The basic procedure for statistical comparisons is as follows. Twice each year, monitoring data from downgradient wells are compared to the upgradient (background) results for each of the four indicator parameters. The arithmetic mean and variance must be calculated based on at least four replicate measurements on each sample, for each well monitored, and then compared with the background arithmetic mean obtained (40 CFR 265.92(c)(2)) and updated as discussed in Chapter 5 of EPA 530/R-09-007, *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities Unified Guidance*. The comparison must consider each of the individual wells in the monitoring system and must use the Student's t-test at the 0.01 level of significance to determine statistically significant increases (and decreases, in the case of pH) over background (40 CFR 265.93(b) and Appendix IV to 40 CFR 265). Implementation of the statistical test method at the Hanford Site, including at the 216-A-37-1 Crib, 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. The practice of annually updating the background values is consistent with statistical evaluation methods for TSD units in final status under WAC 173-303-645(8)(h), "Releases from Regulated Units," "General Groundwater Monitoring Requirements."

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

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

4.3 Interpretation

Data are used to interpret groundwater conditions at the 216-A-37-1 Crib. Interpretive techniques include the following:

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

- **Water table maps:** Use water table elevations from multiple wells to construct contour maps and to estimate flow directions. Groundwater flow is assumed to be perpendicular to 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 current groundwater monitoring network will continue to be re-evaluated to ensure that it is adequate to monitor the any changing hydrogeologic conditions beneath the unit. If flow changes are observed, the 216-A-37-1 Crib CSM and geochemical trends will be re-evaluated to determine network efficiency and any necessary modifications required for the network.

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

4.5 Reporting and Notification

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

If 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-2016-12).

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

5 Outline for Groundwater Quality Assessment Plan

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

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

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

Table 5-1. Suggested Groundwater Quality Assessment Plan Outline

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

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

6 References

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265.91, "Ground-Water Monitoring System."

265.92, "Sampling and Analysis."

265.93, "Preparation, Evaluation, and Response."

265.94, "Recordkeeping and Reporting."

Subpart F, "Ground-Water Monitoring."

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Appendix A

Quality Assurance Project Plan

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Contents

Tables

Figure

Terms

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

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A1 Introduction

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

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

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

A2 Project Management

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

A2.1 Project/Task Organization

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

A2.1.1 U.S. Department of Energy Manager

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

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

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

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

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

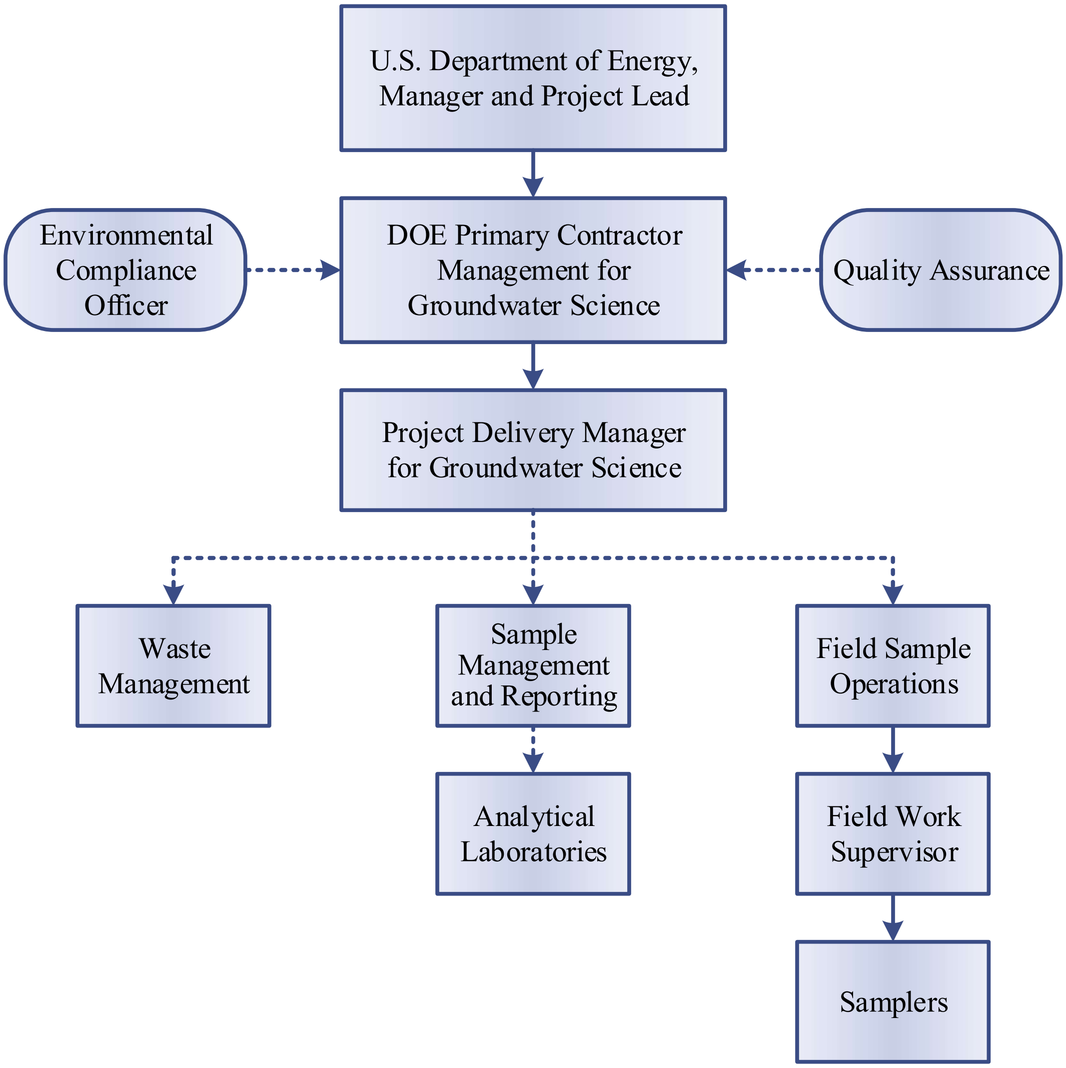

Figure A-1. Project Organization

A2.1.4 Project Delivery Manager for Groundwater Science

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

A2.1.5 Sample Management and Reporting Group

The SMR group oversees offsite analytical laboratories, coordinates laboratory analytical work with this plan, and verifies that laboratories are qualified for performing Hanford Site analytical work. They generate field sampling documents, labels, and instructions for field sampling personnel and develop sample authorization forms, which provide information and instruction to the analytical laboratories. The SMR group revises field sampling documents to reflect approved changes. This group's responsibilities include receiving analytical data from the laboratories, performing data entry into the Hanford Environmental Information System (HEIS) database, arranging for data validation and recordkeeping. The SMR group is responsible for resolving sample documentation deficiencies or issues associated with Field Sample Operations (FSO), laboratories, or other entities. They are responsible for informing the Project Delivery Manager for Groundwater Science (or designee) of any issues reported by the analytical laboratories.

A2.1.6 Field Sample Operations

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

A2.1.7 Quality Assurance

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

A2.1.8 Environmental Compliance Officer

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

A2.1.9 Waste Management

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

A2.1.10 Analytical Laboratories

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

A2.2 Problem Definition/Background

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

A2.3 Project/Task Description

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

A2.4 Quality Assurance Objectives and Criteria

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

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

Table A-1. Data Quality Indicators

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

Table A-1. Data Quality Indicators

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

Table A-1. Data Quality Indicators

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

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

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

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

QC = quality control

A2.5 Documents and Records

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

Table A-2. Change Control for Monitoring Plans

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

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

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

Ecology = Washington State Department of Ecology

RCRA = *Resource Conservation and Recovery Act of 1976*

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

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

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

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

A3 Data Generation and Acquisition

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

A3.1 Analytical Method Requirements

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

Table A-3. Analytical Methods for the DWMU

CAS Number	Waste Constituent (Alternate Name)	Analytical Method[a]	Practical Quantitation Limit (µg/L)
General Chemistry			
ALKALINITY	Alkalinity, total as CaCO3	310.1, Standard Method 2320, Standard Method 4500	5250
18540-29-9	Hexavalent chromium	7196	10.5
18496-25-8	Sulfide (total)	376.1, Standard Method 4500S	2100
TOC	Total organic carbon	415.1, 9060	1050
59473-04-0	Total organic halogen	9020	31.5
Anions[b]			
16887-00-6	Chloride	300, 9056	400
16984-48-8	Fluoride	300, 9056	525
14797-55-8	Nitrate, as NO3	300, 9056	250
14797-65-0	Nitrite, as NO2	300, 9056	250
14808-79-8	Sulfate	300, 9056	1050
Field Measurements			
--	Dissolved oxygen	360.1, Standard Method 4500 O	N/A
--	pH	150.1, 9040, Standard Method 4500 H+	N/A
--	Specific conductance	120.1, 9050, Standard Method 2520 B-97	N/A
--	Temperature	170.1	N/A

Table A-3. Analytical Methods for the DWMU

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

Table A-3. Analytical Methods for the DWMU

CAS Number	Waste Constituent (Alternate Name)	Analytical Method[a]	Practical Quantitation Limit (µg/L)
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
Drinking Water Suitability Parameters[d]			
7440-38-2	Arsenic	6020	10.5
7440-39-3	Barium	6020	5.25
7440-43-9	Cadmium	6020	2.1
7440-47-3	Chromium	6020	10.5
16984-48-8[b]	Fluoride	300, 9056	525
7439-92-1	Lead	6020	3.15
7439-97-6	Mercury	7470	0.5
14797-55-8[b]	Nitrate, as NO3	300, 9056	250
7782-49-2	Selenium	6020	10.5
7440-22-4	Silver	6020	5.25
72-20-8	Endrin	8081	0.1
58-89-9	gamma-BHC (Lindane; hexachlorocyclohexane)	8081	0.0525
72-43-5	Methoxychlor	8081	0.5
8001-35-2	Toxaphene	8081	2.625
94-75-7	2,4-D (2,4-Dichlorophenoxy acetic acid)	8151	20
93-72-1	Silvex (2,4,5-TP)	8151	1.05
ALPHA-RA	Radium (total alpha)	Gas Flow Proportional Counting	1 pCi/L
12587-46-1	Gross Alpha	Gas Proportional Counting	3 pCi/L
12587-47-2	Gross Beta	Gas Proportional Counting	4 pCi/L
--	Coliform Bacteria	Standard Method 9223	N/A
--	Turbidity	180.1, Standard Method 2130 B	N/A

Table A-3. Analytical Methods for the DWMU

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

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

a. For EPA Methods 180.1 and 300, see EPA/600/R-93/100, *Methods for the Determination of Inorganic Substances in Environmental Samples.* For EPA Methods 120.1, 150.1, 170.1, 310.1, 360.1 376.1 and 415.1, see EPA/600/4-79/020, *Methods for Chemical Analysis of Water and Wastes*. For four-digit EPA methods, see the SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Compendium*. For Standard Methods, see APHA/AWWA/WEF, 2017, *Standard Methods for the Examination of Water and Wastewater*.
b. Dilutions for certain ion chromatography constituents may be necessary, potentially raising the practical quantitation limit above the limits provided.
c. Analyzed and reported as 3 & 4 Methylphenol (CAS number 65794-96-9). The PQL for 3 & 4 Methylphenol is 20 µg/L
d. Parameters characterizing the suitability of groundwater as a drinking water supply as presented in 40 CFR 265, "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," Appendix III, "EPA Interim Primary Drinking Water Standards," were monitored for 1 year at the wells identified in Table 3-2 of the main text.

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

A3.2 Field Analytical Methods

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

A3.3 Quality Control

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

Table A-4. QC Samples

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

Table A-4. QC Samples

Sample Type	Frequency	Characteristics Evaluated
Full trip blanks	1 in 20 well trips[b]	Contamination from containers preservative reagents, storage, or transportation
Analytical QC[c]		
Carrier	Added to each sample and quality control	Recovery/yield
Laboratory control samples	One per analytical batch[d]	Method accuracy
Laboratory sample duplicates	One per analytical batch[d]	Laboratory reproducibility and precision
Matrix spikes	One per analytical batch[d]	Matrix effect/laboratory accuracy
Matrix spike duplicates	One per analytical batch[d]	Laboratory reproducibility, and method accuracy and precision
Method blanks	One per analytical batch[d]	Laboratory contamination
Surrogates	Added to each sample and QC sample	Recovery/yield for organic compounds

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

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

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

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

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

QC = quality control

VOC = volatile organic compound

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

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

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

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

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

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

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

Analyte[a]	QC Element	Acceptance Criteria	Corrective Action
Phenols gas chromatography/mass spectrometry	MB	<MDL <5% sample concentration	Flag with "B"
	LCS	70% to 130% recovery or % recovery statistically derived[f]	Flag with "o"[b]
	DUP[c] or MS/MSD[d]	≤20% RPD	Review data[e]
	MS/MSD[d]	% recovery statistically derived[f]	Flag with "T"
	SUR	% recovery statistically derived[f]	Review data[e]
	EB, FTB	<MDL <5% sample concentration	Flag with "Q"
	Field duplicate[c]	≤20% RPD	Review data[e]
Herbicides			
Herbicides by gas chromatography	MB	<MDL <5% sample concentration	Flag with "B"
	LCS	70% to 130% recovery or % recovery statistically derived[f]	Flag with "o"[b]
	DUP[c] or MS/MSD[d]	≤20% RPD	Review data[e]
	MS/MSD[d]	% recovery statistically derived[f]	Flag with "N"
	SUR	% recovery statistically derived[f]	Review data[e]
	EB, FTB	<MDL <5% sample concentration	Flag with "Q"
	Field duplicate[c]	≤20% RPD	Review data[e]
Pesticides			
Pesticides by gas chromatography	MB	<MDL <5% sample concentration	Flag with "B"
	LCS	70% to 130% recovery or % recovery statistically derived[f]	Flag with "o"[b]
	DUP[c] or MS/MSD[d]	≤20% RPD	Review data[e]
	MS/MSD[d]	% recovery statistically derived[f]	Flag with "N"
	SUR	% recovery statistically derived[f]	Review data[e]
	EB, FTB	<MDL <5% sample concentration	Flag with "Q"
	Field duplicate[c]	≤20% RPD	Review data[e]
Other Drinking Water Suitability Parameters			
Coliform	MB	Pass/Fail[g]	Review Data[e]
	LCS	Pass/Fail[g]	Review Data[e]
	DUP	Pass/Fail[g]	Review Data[e]

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

Analyte[a]	QC Element	Acceptance Criteria	Corrective Action
	EB, FTB	Pass/Fail[g]	Flage with “Q”
	Field Duplicate[c]	Pass/Fail[g]	Review Data[e]
Gross alpha	MB	<MDA <5% sample activity concentration	Flag with “B”
	LCS	80 to 120% recovery or statistically derived limits[f]	Flag with “o”[b]
	DUP[c]	≤20% RPD	Review data[e]
	EB, FTB	< MDA < 5% sample activity concentration	Flag with “Q”
	Field Duplicate[c]	≤20% RPD	Review data[e]
Gross beta	MB	<MDA <5% sample activity concentration	Flag with “B”
	LCS	80 to 120% recovery or statistically derived limits[f]	Flag with “o”[b]
	DUP[c]	≤20% RPD	Review data[e]
	EB, FTB	< MDA < 5% sample activity concentration	Flag with “Q”
	Field Duplicate[c]	≤20% RPD	Review data[e]
Total Alpha Radium by Gas Flow Proportional Counting Coliform	MB	<MDA <5% sample activity concentration	Flag with “B”
	LCS	80 to 120% recovery or statistically derived limits[f]	Flag with “o”[b]
	DUP[c]	≤20% RPD	Review data[e]
	Carrier	40%-110% recovery	Review data[e]
	EB, FTB	< MDA < 5% sample activity concentration	Flag with “Q”
	Field Duplicate[c]	≤20% RPD	Review data[e]

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

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

a. See Table A-3 for constituent list and analytical methods.
b. The reporting laboratory will apply the “o” flag with SMR group concurrence.
c. Applies when at least one result is greater than the laboratory PQL.
d. Either a DUP or an MS/MSD is to be analyzed to determine measurement precision (if there is insufficient sample volume, a laboratory control sample duplicate is analyzed with the acceptance criteria defaulting to the ≤20% RPD criteria).

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. Laboratory-determined, statistically derived control limits based on historical data are used here. Control limits are reported with the data.
g. Passing QC; MB = no colonies detected, LCS = appropriate colonies detected, DUP = colonies detected/undetected are consistent with sample.

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

Data Flags

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

A3.3.1 Field Quality Control Samples

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

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

[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.

are intended to be identical and are collected as close as possible in time and location. Each sample in the sample-duplicate pair receives its own unique sample number.

- **Field splits:** SPLITs are two samples that are intended to be identical and are collected as close as possible in time and location. SPLITs will be stored in separate containers and analyzed by different laboratories for the same analytes. SPLITs are interlaboratory comparison samples used to evaluate comparability between laboratories.
- **Full trip blanks:** FTBs are used to monitor for potential sample contamination from the sampling container, preservation reagents, or storage conditions. FTBs are prepared high-purity water and sealed prior to traveling to the sampling site, transported to the sampling site (not opened in the field), and then shipped as part of the sample set to the laboratory. The bottle set is either for volatile organic analysis only or identical to the set that will be collected in the field. Collected FTBs are typically analyzed for the same constituents as the samples from the associated sampling event.

A3.3.2 Laboratory Quality Control Samples

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

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

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

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
Hexavalent chromium	Store ≤6°C	24 hours
Sulfide	Store ≤6°C, adjust pH to > 9 with zinc acetate and sodium hydroxide	7 days
Total organic carbon	Store <6°C, adjust pH to <2 with sulfuric acid or hydrochloric acid	28 days
Total organic halogen	Store <6°C, adjust pH to <2 with sulfuric acid	28 days
Anions		
Chloride, Fluoride, Sulfate	Store ≤6°C	28 days
Nitrate, Nitrite	Store ≤6°C	48 hours
Metals		
Metals by inductively coupled plasma-atomic emission spectrometry	Adjust pH to <2 with nitric acid	6 months
Metals by inductively coupled plasma/mass spectrometry	Adjust pH to <2 with nitric acid	6 months
Mercury by cold-vapor atomic absorption	Adjust pH to <2 with nitric acid	28 days
Semivolatile Organic Compounds		
Phenols by gas chromatography/mass spectrometry	Store ≤6°C	7 days before extraction 40 days after extraction
Herbicides		
Herbicides	Store <6°C	7 days before extraction 40 days after extraction
Pesticides		
Pesticides	Store <6°C	7 days before extraction 40 days after extraction
Other Drinking Water Suitability Parameters		
Coliform	Store ≤6°C	6 hours
Gross alpha/Gross beta	Adjust pH to <2 with nitric acid	6 months

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

Constituent[a]	Preservation[b]	Holding Time
Total alpha radium by gas flow proportional counting	Adjust pH to <2 with nitric acid	6 months

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 [if applicable], temperature, and turbidity) are not listed because they are measured in the field.

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

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

EPA = U.S. Environmental Protection Agency

A3.4 Measurement Equipment

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

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

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

A3.6 Instrument/Equipment Calibration and Frequency

Field equipment calibration is discussed in Appendix B.

A3.7 Inspection/Acceptance of Supplies and Consumables

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

A3.8 Nondirect Measurements

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

A3.9 Data Management

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

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

A4 Data Review and Usability

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

A4.1 Data Review and Verification

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

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

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

A4.2 Data Validation

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

A4.3 Reconciliation with User Requirements

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

A5 References

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Appendix B

Sampling Protocol

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Contents

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Terms

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

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B1 Introduction

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

This appendix provides more specific elements of the sampling protocols and techniques used for the groundwater monitoring plan. Chapter 3 of the groundwater monitoring plan identifies the monitoring wells that will be sampled, constituents to be analyzed, and sampling frequency for the groundwater monitoring at the 216-A-37-1 Crib.

B2 Sampling Methods

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

- Field screening measurements
- Groundwater sampling
- Water level measurements

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

- **pH** – two consecutive measurements agree within 0.2 pH units
- **Temperature** – two consecutive measurements agree within 0.2°C (32.3°F)
- **Conductivity** – two consecutive measurements agree within 10 percent of each other
- **Turbidity** – less than 5 nephelometric turbidity units (NTUs) prior to sampling (or project scientist's recommendation)

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

Field measurements (except for turbidity) are obtained using a flow-through cell. Groundwater is pumped directly from the well to the flow-through cell. At the beginning of the sample event, field crews attach a clean, stainless-steel sampling manifold to the riser discharge. The manifold has two valves and two ports: one port is used only for purgewater, and the other port is used to supply water to the flow-through cell. Probes are inserted into the flow-through cell to measure pH, temperature, and conductivity. Turbidity is measured by inserting a sample vial into a turbidimeter. The purgewater is then discharged to the purgewater truck.

Once field measurements have stabilized, the hose supplying water to the flow-through cell is disconnected and a clean, stainless-steel drop leg is attached for sampling. The flow rate is reduced during sampling to minimize loss of volatiles (if any) and prevent over filling the bottles. Sample bottles are filled in a sequence designed to minimize loss of volatiles (if any). Filtered samples are collected after collection of the unfiltered samples. For some constituents (e.g., metals), both filtered and unfiltered samples are collected. If additional samples require filtration (e.g., at turbidity greater than 5 NTUs), an inline, disposable 0.45 µm filter is used.

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

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

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

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

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

Sample preservation and holding-time requirements are specified for groundwater samples in Appendix A, Table A-6. These requirements are in accordance with the analytical method specified in Appendix A, Table A-3. The container types, preservatives, and volumes will be identified on the chain-of-custody form. This groundwater monitoring plan defines a sample as a filled sample bottle for purposes of starting the clock for holding-time restrictions.

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

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

B2.1 Decontamination of Sampling Equipment

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

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

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

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

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

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

[1] High-purity water that is generally defined as water that has been distilled, deionized, or any combination of distillation, deionization, reverse osmosis, activated carbon filtration, ion exchange, particulate filtration, or other polishing techniques (DOE/RL-96-68).

B2.2 Water Levels

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

B3 Documentation of Field Activities

Logbooks or data forms are required for field activities and will be used in accordance with HASQARD (DOE/RL-96-68) requirements. A logbook must be identified with a unique project name and number. The individual(s) responsible for logbooks will be identified in the front of the logbook, and only authorized persons may make entries in logbooks. Logbook entries will be reviewed by the sampling Field Work Supervisor (FWS), cognizant scientist/engineer, or other responsible manager; the review will be documented with a signature and date. Logbooks will be permanently bound, waterproof, and ruled with sequentially numbered pages. Pages will not be removed from logbooks for any reason. Entries will be made in indelible ink. Corrections will be made by marking through the erroneous data with a single line, entering the correct data, and initialing and dating the changes.

Data forms may be used to collect field information; however, information recorded on data forms must follow the same requirements as those for logbooks. The data forms must be referenced in the logbooks.

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

- Day and date; time task started; weather conditions; and names, titles, and organizations of personnel performing the task.
- Purpose of visit to the task area.
- Site activities in specific detail (e.g., maps and drawings) or the forms used to record such information (e.g., soil boring log or well completion log). Also, details of any field tests that were conducted; reference to any forms that were used, other data records, and methods followed in conducting the activity.
- Details of any field calibrations and surveys that were conducted. Reference any forms that were used, other data records, and the methods followed in conducting the calibrations and surveys.
- Details of any samples collected and the preparation (if any) of splits, duplicates, matrix spikes, or blanks. Reference the methods followed in sample collection or preparation; list location of sample collected, sample type, each label or tag numbers, sample identification, sample containers and volume, preservation method, packaging, chain-of-custody form number, and analytical request form number pertinent to each sample or sample set; and note the time and the name of the individual to whom custody of samples was transferred.
- Time, equipment type, serial or identification number, and methods followed for decontaminations and equipment maintenance performed. Reference the page number(s) of any logbook where detailed information is recorded.

- Any equipment failures or breakdowns that occurred, with a brief description of repairs or replacements.

B3.1 Corrective Actions and Deviations for Sampling Activities

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

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

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

B4 Calibration of Field Equipment

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

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

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

B5 Sample Handling

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

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

B5.1 Containers

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

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

B5.2 Container Labeling

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

B5.3 Sample Custody

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

Shipping requirements will determine how sample shipping containers are prepared for shipment. The analyses requested for each sample will be indicated on the accompanying chain-of-custody form. Each time the responsibility for custody of the sample changes, new and previous custodians will sign the record and note the date and time. ~~The field sampling team will make a copy of the signed record before sample shipment and transmit the copy to the SMR group.~~

Commented [CTJ1]: RCRA-CN-01_DOE/RL-2010-92_R3

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

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

- Shipped-to information (i.e., analytical laboratory performing the analysis)

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

B5.4 Sample Transportation

Packaging and transportation instructions shall comply with applicable transportation regulations and U.S. Department of Energy (DOE) requirements. Regulations for classifying, describing, packaging, marking, labeling, and transporting hazardous materials, hazardous substances, and hazardous wastes are enforced by the U.S. Department of Transportation (DOT) as described in 49 CFR 171, "Transportation," "General Information, Regulations, and Definitions," through 49 CFR 177, "Carriage by Public Highway."[2] Carrier specific requirements, defined in the current edition of International Air Transport Association (IATA) *Dangerous Goods Regulations*, shall also be used when preparing sample shipments conveyed by air freight providers.

Samples containing hazardous constituents shall be considered hazardous material in transportation and transported according to DOT/IATA requirements. If the sample material is known or can be identified, then it will be classified, described, packaged, marked, labeled, and shipped according to the specific instructions for that material. Appropriate laboratory notifications will be made, if necessary, through the SMR project coordinator.

B6 Management of Waste

Waste materials are generated during sample collection, processing, and subsampling activities. Waste will be managed in accordance with DOE/RL-2004-18, *Waste Control Plan for the 200-PO-1 Groundwater Operable Unit*. For waste designation purposes, wells listed in Table 3-1 in the main text of the monitoring plan may be surveyed in the Hanford Environmental Information System and the maximum concentration for each analyte within the most recent 5 years will be evaluated for use in creating a waste profile, if required.

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

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

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

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

B7 Health and Safety

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

B8 References

10 CFR 830, "Nuclear Safety Management," *Code of Federal Regulations*. Available at: http://www.ecfr.gov/cgi-bin/text-idx?SID=47e3de0454360a17406cb89ade0c966d&mc=true&node=pt10.4.830&rgn=div5.

10 CFR 835, "Occupational Radiation Protection," *Code of Federal Regulations.* Available at: http://www.ecfr.gov/cgi-bin/text-idx?SID=57ef404ac6f4734a67fd97302b2d7f7f&node=pt10.4.835&rgn=div5.

10 CFR 851, "Worker Safety and Health Program," *Code of Federal Regulations*. Available at: http://www.ecfr.gov/cgi-bin/text-idx?SID=47e3de0454360a17406cb89ade0c966d&mc=true&node=pt10.4.851&rgn=div5.

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49 CFR 171, "General Information, Regulations, and Definitions."

49 CFR 172, "Hazardous Materials Table, Special Provisions, Hazardous Materials Communications, Emergency Response Information, Training Requirements, and Security Plans."

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49 CFR 175, "Carriage by Aircraft."

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Appendix C

Well Construction

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Contents

Figures

Tables

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C1 Introduction

This appendix provides the following information for the 216-A-37-1 Crib groundwater monitoring wells:

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

Figures C-1 through C-6 provide well construction and completion summaries for the 216-A-37-1 Crib monitoring wells.

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 216-A-37-1 Crib Network

Well or Aquifer Tube Name	Hydrogeologic Unit Monitored	Elevation Top of Open Interval (m [ft] NAVD88)	Elevation Bottom of Open Interval (m [ft] NAVD88)	Open Interval Length (m [ft])
299-E25-17	TU	123.4 (404.9)	116.7 (382.9)	6.7 (22.0)
299-E25-19	TU	124.6 (408.8)	117.0 (383.9)	7.6 (24.9)
299-E25-20	TU	124.5 (408.5)	116.9 (383.5)	7.6 (24.9)
299-E25-35	TU	111.4 (365.5)	105.0 (344.5)	6.4 (21.0)
299-E25-47	TU	125.2 (410.8)	119.1 (390.7)	6.1 (20.0)
299-E25-95*	TU	122.0 (400.4)	112.9 (370.4)	9.1 (30)

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

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

* Screen elevation data derived from pre-drilling land survery information. No post-drilling survey information available at the time of this groundwater monitoring plan revision.

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

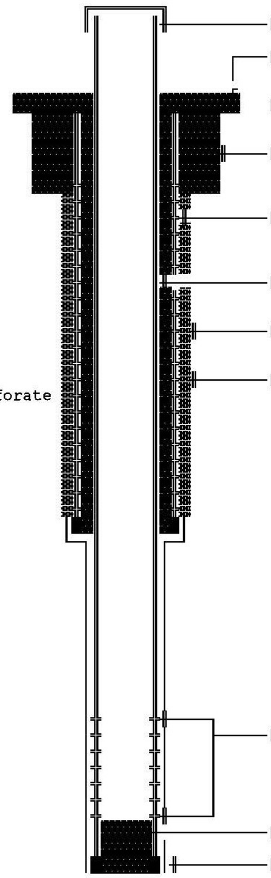
WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method: Cable tool	Sample Method: Drive barrel	WELL NUMBER: 299-E25-17 TEMPORARY WELL NO:
Drilling Fluid Used: Not documented	Additives Used: Bentonite	Hanford Coordinates: N/S N 40,086 E/W W 46,570
Driller's Name: H. Baker	WA State Lic Nr: Not documented	State Coordinates: N 445,268 E 2,248,652
Drilling Company: Not documented	Company Location: Pasco, WA	Start Card #: Not documented T___ R___ S___
Date Started: 24May76	Date Complete: 21Jul76	Elevation Ground surface: 688.1-ft Estimated

Depth to water: ~275 ft Jul76
(Ground surface) 271.4-ft Mar92

GENERALIZED STRATIGRAPHY — Driller's Log

0-5: 90%f-cSAND, 10%fGRAVEL
5-20: 80%f-cSAND, 20%fGRAVEL
20-25: 70%f-cSAND, 30%fGRAVEL
25-30: vf-cSAND
30-50: 90%f-cSAND, 10%fGRAVEL
50-55: f-cSAND
55-65: 90%f-cSAND, 10%fGRAVEL
65-75: f-cSAND
75-85: 90%f-cSAND, 10%fGRAVEL
85-90: 80%f-cSAND, 20%fGRAVEL
90-95: 60%f-cSAND, 40%fGRAVEL
95-100: 80%f-cSAND, 20%fGRAVEL
100-120: 80%f-cSAND, 20%mGRAVEL
120-132: 70%m-cSAND, 30%fGRAVEL (2-in SILT @ 125-ft)
132-133: SILT & vfSAND
133-150: 80%f-cSAND, 20%fGRAVEL (Stopped drilling to perforate and grout)
150-160: 60%f-cSAND, 40%fGRAVEL
160-175: 60%m-cSAND, 40%f-mGRAVEL
175-180: 80%f-cSAND, 20%fGRAVEL
180-185: f-cSAND
185-190: 80%f-cSAND, 20%fGRAVEL
190-210: 70%m-cSAND, 30%fGRAVEL
210-220: 80%f-cSAND, 20%fGRAVEL
220-225: 60%f-cSAND, 20%GRAVEL, 20%COBBLES
225-245: Not documented
245-300: 60%m-cSAND, 40%fGRAVEL



Elevation of reference point: [690.00-ft] (top of casing)
Height of reference point above ground surface [1.9-ft]
Depth of surface seal [20.0-ft]
Type of surface seal: Cement grout between 8 and 16-in casings 0-20-ft, as 16-in assumed pulled back. 2-ft pad, depth indeterminate
8-in ID carbon steel casing, 0-150-ft
6-in ID carbon steel casing, +1.9-300-ft
Hole diameter, 9-in nominal 20-150-ft
Annular seal, Bentonite mud/cement Perforated 20-127 ft, 4 cuts/rd/ft Grouted w/bentonite drilling mud, Filled casing with cement and drilled out. Cement grouted between 6 & 8-in casing.
6-in casing perforations, 273-295-ft, 4 cuts/rd/ft
Cement plug 295-300-ft
Borehole drilled depth: [300-ft]

Drawing By: RKL/2E25-17.ASB
Date : 07Sep93
Reference : HANFORD WELLS

Figure C-1. Well 299-E25-17 Construction and Completion Summary (page 1 of 2)

SUMMARY OF CONSTRUCTION DATA AND FIELD OBSERVATIONS
RESOURCE PROTECTION WELL - 299-E25-17

WELL DESIGNATION	:	299-E25-17
RCRA FACILITY	:	Not applicable
CERCLA UNIT	:	200 Aggregate Area Management Study
HANFORD COORDINATES	:	N 40,086 W 46,570
LAMBERT COORDINATES	:	N 445,268 E 2,248,652
DATE DRILLED	:	Jul76
DEPTH DRILLED (GS)	:	300-ft
MEASURED DEPTH (GS)	:	Not documented
DEPTH TO WATER (GS)	:	~275-ft, Jul76; 271.4-ft, 26Mar92
CASING DIAMETER	:	8-in, carbon steel, 0-150-ft; 6-in, carbon steel, +1.9-300-ft
ELEV TOP CASING	:	690.00-ft
ELEV GROUND SURFACE	:	688.1-ft, Estimated
PERFORATED INTERVAL	:	8-in casing, 20-127-ft; 6-in casing, 273-295-ft
SCREENED INTERVAL	:	Not applicable
COMMENTS	:	FIELD INSPECTION, 03Mar92, 6-in carbon steel casing. Capped and locked ~2-ft pad, no posts, no permanent identification. Not in radiation zone.
AVAILABLE LOGS	:	Driller
TV SCAN COMMENTS	:	Not applicable
DATE EVALUATED	:	Not applicable
EVAL RECOMMENDATION	:	Not applicable
LISTED USE	:	Water levels measured 07Jan86-26Mar92,
CURRENT USER	:	PNL sitewide sampling 93
PUMP TYPE	:	None documented
MAINTENANCE	:	

Figure C-1. Well 299-E25-17 Construction and Completion Summary (page 2 of 2)

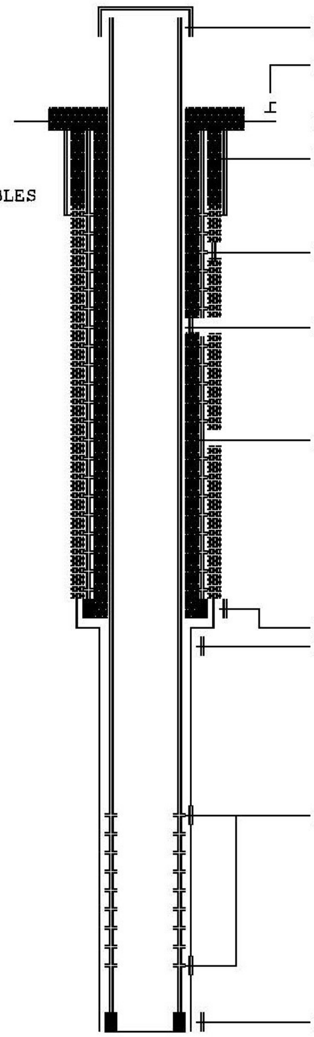
WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method: Cable tool	Sample Method: Hard tool (nom)	WELL NUMBER: 299-E25-19 TEMPORARY WELL NO:
Drilling Fluid Used: Water	Additives Used: Bentonite	Hanford Coordinates: N/S N 39,935 E/W W 46,060
Driller's Name: Baker	WA State Lic Nr: Not documented	State Coordinates: N 445,119 E 2,249,163
Drilling Company: Not documented	Company Location: Pasco, WA	Start Card #: Not documented T ___ R ___ S ___
Date Started: 22Jul76	Date Complete: 03Sep76	Elevation Ground surface: Not documented

Depth to water: 272 ft Sep76
(Ground surface) ~274-ft 17Jun93

GENERALIZED STRATIGRAPHY   Driller's Log

0-40: GRAVEL and SAND
40-65: SAND with GRAVEL
65-95: GRAVEL and SAND
95-125: SAND and GRAVEL, some COBBLES
125-130: SAND
130-145: SAND with GRAVEL
145-215: SAND and GRAVEL
215-220: SAND
220-255: SAND, GRAVEL and COBBLES
255-260: SAND
260-300: GRAVEL and SAND



Elevation of reference point: [677.20-ft]
(top of casing)

Height of reference point above ground surface [ND]

Depth of surface seal [20.0-ft]

Type of surface seal:
Cement grout between 8 and 10-in casing 0-20 ft, 10-in casing left in hole
2-ft pad, depth indeterminate

8-in ID carbon steel casing, 0-150-ft

6-in ID carbon steel casing, +ND-300-ft

Annular seal,
Bentonite grout between 6 & 8-in casing
Perforated 20-150-ft, 4 cuts/rd/ft
Grouted with bentonite. Bentonite bailed and grouted w/cement. Bailed cement and set 6-in casing. Grouted between 6 & 8-in; 8 & 10-in casings. Used 300-gals.

Hole diameter,
20-150-ft, 9-in nominal
150-300-ft, 7-in nominal

6-in casing perforations, 270-295-ft, 4 holes/ft

Borehole drilled depth: [300-ft]

Drawing By: RKL/2E25-19.ASB
Date : 07Sep93
Reference : HANFORD WELLS

Figure C-2. Well 299-E25-19 Construction and Completion Summary (page 1 of 2)

SUMMARY OF CONSTRUCTION DATA AND FIELD OBSERVATIONS
RESOURCE PROTECTION WELL - 299-E25-19

WELL DESIGNATION :	299-E25-19
RCRA FACILITY :	A-29 Ditch
CERCLA UNIT :	200 Aggregate Area Management Study
HANFORD COORDINATES :	N 39,935 W 46,060
LAMBERT COORDINATES :	N 445,119 E 2,249,4163
DATE DRILLED :	Sep76
DEPTH DRILLED (GS) :	300-ft
MEASURED DEPTH (GS) :	Not documented
DEPTH TO WATER (GS) :	272-ft, Sep76; ~274-ft 17Jun93
CASING DIAMETER :	10-in carbon steel, 0-10-ft; 8-in, carbon steel, 0-150-ft; 6-in, carbon steel, +ND-300-ft
ELEV TOP CASING :	677.20-ft, [15May86]
ELEV GROUND SURFACE :	Not documented
PERFORATED INTERVAL :	8-in casing, 20-150; 6-in casing, 270-295-ft
SCREENED INTERVAL :	Not applicable
COMMENTS :	FIELD INSPECTION, 22Aug89, 6-in carbon steel casing. Capped and locked 2-ft pad, no posts, no permanent identification.
AVAILABLE LOGS :	Driller
TV SCAN COMMENTS :	Not applicable
DATE EVALUATED :	Not applicable
EVAL RECOMMENDATION :	Not applicable
LISTED USE :	A29 Ditch Quarterly water level measurement, 09Dec86-17Jun93;
CURRENT USER :	WHC ES&M w/l monitoring and RCRA sampling, PNL sitewide sampling 93
PUMP TYPE :	Electric submersible
MAINTENANCE :	

Figure C-2. Well 299-E25-19 Construction and Completion Summary (page 2 of 2)

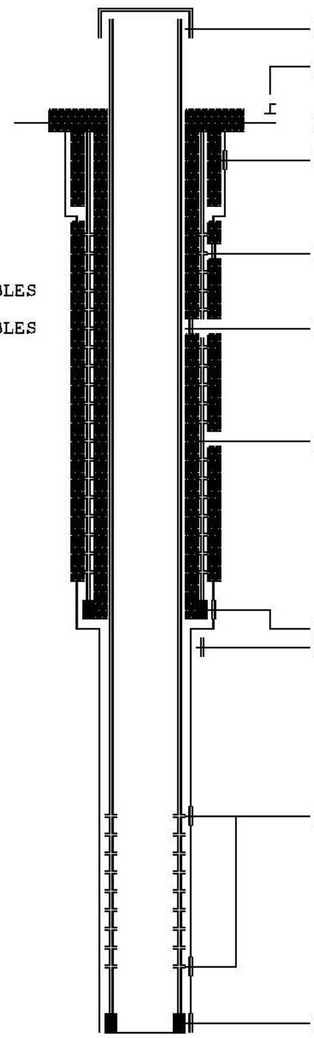
WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method: Cable tool	Sample Method: Hard tool (nom)	WELL NUMBER: 299-E25-20 TEMPORARY WELL NO: 4
Drilling Fluid Used: Water	Additives Used: Bentonite	Hanford Coordinates: N/S N 39,925 E/W W 45,875
Driller's Name: Egan	WA State Lic Nr: Not documented	State Coordinates: N 445,109 E 2,249,348
Drilling Company: Not documented	Company Location: Not documented	Start Card #: Not documented T___ R___ S___
Date Started: 20May76	Date Complete: 06Aug76	Elevation Ground surface: Not documented

Depth to water: 271-ft Aug76
(Ground surface) ~273-ft 17Jun93

GENERALIZED STRATIGRAPHY   Driller's Log

0-160: SAND
160-175: Pebbly SAND
175-190: SAND
190-200: Pebbly SAND
200-210: SAND and PEBBLES
210-215: SAND
215-220: Pebbly SAND
220-225: SAND
225-245: SAND & PEBBLES, some COBBLES
245-260: SAND and COBBLES
260-270: SAND & PEBBLES, some COBBLES
270-280: SAND & PEBBLES
280-300: SAND, PEBBLES & COBBLES



Elevation of reference point: [676.30-ft]
(top of casing)
Height of reference point above ground surface [ND]

Depth of surface seal [20.0-ft]
Type of surface seal:
Cement grout between 8 and 10-in casing 0-20-ft as 10-in pulled back.
2-ft pad, depth indeterminate

8-in ID carbon steel casing, 0-150-ft

6-in ID carbon steel casing, +ND-300-ft

Annular seal,
Cement grout between 6 and 8-in casing.
Perforated 21-149-ft, 4 cuts/rd/ft.
Used 270-gals cement
at 5.5-gals water/bag cement.

Hole diameter,
20-150-ft, 9-in nominal
150-300-ft, 7-in nominal

6-in casing perforations,
269-294-ft, 4 cuts/rd

Borehole drilled depth: [300-ft]

Drawing By: RKL/2E25-20.ASB
Date : 07Sep93
Reference : HANFORD WELLS

Figure C-3. Well 299-E25-20 Construction and Completion Summary (page 1 of 2)

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                    SUMMARY OF CONSTRUCTION DATA AND FIELD OBSERVATIONS
                           RESOURCE PROTECTION WELL - 299-E25-20

WELL DESIGNATION     :    299-E25-20
RCRA FACILITY        :    A-29 Ditch
CERCLA UNIT          :    200 Aggregate Area Management Study
HANFORD COORDINATES  :    N   39,925  W   45,875
LAMBERT COORDINATES  :    N  445,109  E 2,249,348
DATE DRILLED         :    Aug76
DEPTH DRILLED  (GS)  :    300-ft
MEASURED DEPTH (GS)  :    Not documented
DEPTH TO WATER (GS)  :    271-ft, Aug76;
                          ~273-ft, 17Jun93
CASING DIAMETER      :    8-in, carbon steel, 0-150-ft;
                          6-in, carbon steel, +ND-300-ft
ELEV TOP CASING      :    676.47-ft, [27Mar92-NGVD'29]
ELEV GROUND SURFACE  :    Not documented
PERFORATED INTERVAL  :    21-149 and 269-294-ft
SCREENED INTERVAL    :    Not applicable
COMMENTS             :    FIELD INSPECTION, 22Aug89,
                          6-in carbon steel casing. Capped and locked
                          2-ft pad, no posts, no permanent identification.
AVAILABLE LOGS       :    Driller
TV SCAN COMMENTS     :    Not applicable
DATE EVALUATED       :    Not applicable
EVAL RECOMMENDATION  :    Not applicable
LISTED USE           :    A29 Ditch Quarterly water level measurement, 01Jan87-17Jun93;
CURRENT USER         :    WHC ES&M w/l monitoring, sampling and RCRA sampling;
                          PNL sitewide sampling 93
PUMP TYPE            :    Electric submersible
MAINTENANCE          :
```

Figure C-3. Well 299-E25-20 Construction and Completion Summary (page 2 of 2)

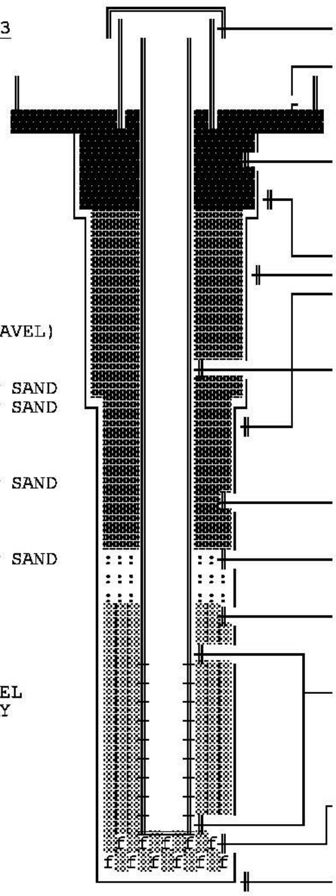
WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method: Cable tool	Sample Method: Not documented	WELL NUMBER: 299-E25-35
Drilling Fluid Used: 200E Area Water	Additives Used: Not documented	TEMPORARY WELL NO:
Driller's Name: Amos/Wamsley	WA State Lic Nr: 1224 (Amos)	Hanford Coordinates: N/S N 40,616.7 E/W W 46,538.5
Drilling Company: Kaiser Engineers	Company Location: Hanford	State Coordinates: N 445,799 E 2,248,682
Date Started: 03May88	Date Complete: 27Aug88	Start Card #: Not documented T___ R___ S___
		Elevation Ground surface: 670.98-ft (Brass cap)

Depth to water: 264.3-ft Aug88
(Ground surface) 268.9-ft 22Jun93

GENERALIZED Geologist's
STRATIGRAPHY Log

0-10: Slightly silty SAND
10-15 Silty SAND
15-20: Sandy GRAVEL
20-30: Silty sandy GRAVEL
30-55: SAND
55-60: Silty gravelly SAND
60-75: Gravelly SAND
75-85: Sandy GRAVEL
85-100: Slightly gravelly SAND
100-115: Gravelly SAND
115-120: SAND (Note: 116-119: GRAVEL)
120-125: Silty SAND
125-130: Gravelly SAND
130-135: Slightly gravelly silty SAND
135-160: Slightly silty gravelly SAND
160-165: Slightly silty SAND
165-170: Slightly silty slightly gravelly SAND
170-175: Slightly silty gravelly SAND
175-185: Silty sandy GRAVEL
185-190: Slightly silty slightly gravelly SAND
190-210: Slightly silty gravelly SAND
210-220: Silty sandy GRAVEL
220-235: Sandy GRAVEL
235-240: Slightly silty SAND
240-245: Silty sandy GRAVEL
245-250: Gravelly SAND
250-255: Silty sandy GRAVEL
255-260: Silty/clayey sandy GRAVEL
260-265: Gravelly sandy SILT/CLAY
265-270: CLAY/SILT
270-275: Slighlty gravelly slightly silty SAND
275-280: Slightly gravelly SAND
280-285: SAND



Elevation of reference point: [674.39-ft]
(top of casing)
Height of reference point above ground surface [3.4-ft]
Depth of surface seal [3-19.5-ft]
Type of surface seal:
Cement grout 3-19.5-ft
4x4-ft x 4-in concrete pad extends 3.0-ft into annulus
Hole diameter,
3.0-20.2-ft, 13-in nominal
20.2-145.3-ft, 11-in nominal
145.3-285-ft, 9-in nominal
4-in ID T304 stainless steel casing, +ND-260.5-ft
Bentonite crumbles, 19.5-250.9-ft
Bentonite pellets, 250.9-256.2-ft
Silica sand pack, 256.2-~281.0-ft, 10-20-mesh
4-in stainless steel screen, 260.5-281.0-ft, #20-slot
Fill, ~281-285.0-ft
Borehole drilled depth: [285.0-ft]

Drawing By: RKL/2E25-35.ASB
Date : 08Sep93
Reference : HANFORD WELLS

Figure C-4. Well 299-E25-35 Construction and Completion Summary (page 1 of 2)

SUMMARY OF CONSTRUCTION DATA AND FIELD OBSERVATIONS
RESOURCE PROTECTION WELL - 299-E25-35

WELL DESIGNATION	:	299-E25-35
RCRA FACILITY	:	A-29 Ditch
CERCLA UNIT	:	200 Aggregate Area Management Study
HANFORD COORDINATES	:	N 40,616.7 W 46,538.5 [28Oct88-200E]
LAMBERT COORDINATES	:	N 445,799 E 2,248,682 [HANCONV]
DATE DRILLED	:	Aug88
DEPTH DRILLED (GS)	:	285-ft
MEASURED DEPTH (GS)	:	284.3-ft, 09Apr93
DEPTH TO WATER (GS)	:	264-ft, Aug88; 268.9-ft, 22Jun93
CASING DIAMETER	:	6-in, stainless steel, +3.4--0.5-ft; 4-in, stainless steel, +ND-260.5-ft
ELEV TOP CASING	:	674.39-ft, [28Oct88-200E]
ELEV GROUND SURFACE	:	670.98-ft, Brass cap [28Oct88-200E]
PERFORATED INTERVAL	:	Not applicable
SCREENED INTERVAL	:	260.5-281.0-ft, 4-in stainless steel, #20-slot
COMMENTS	:	FIELD INSPECTION, 09Apr93; 4 and 6-in stainless steel casing. 4-ft by 4-ft concrete pad, 4 posts, 1 removable. Capped and locked, brass cap in pad with well ID. Not in radiation zone.
AVAILABLE LOGS	:	Geologist
TV SCAN COMMENTS	:	Not applicable
DATE EVALUATED	:	Not applicable
EVAL RECOMMENDATION	:	Not applicable
LISTED USE	:	A29 Ditch monthly water level measurement, 18Oct88-22Jun93;
CURRENT USER	:	WHC ES&M w/l monitoring and RCRA sampling, PNL sitewide w/l monitoring 93
PUMP TYPE	:	Hydrostar
MAINTENANCE	:	

Figure C-4. Well 299-E25-35 Construction and Completion Summary (page 2 of 2)

A4794 / 299-E25-47

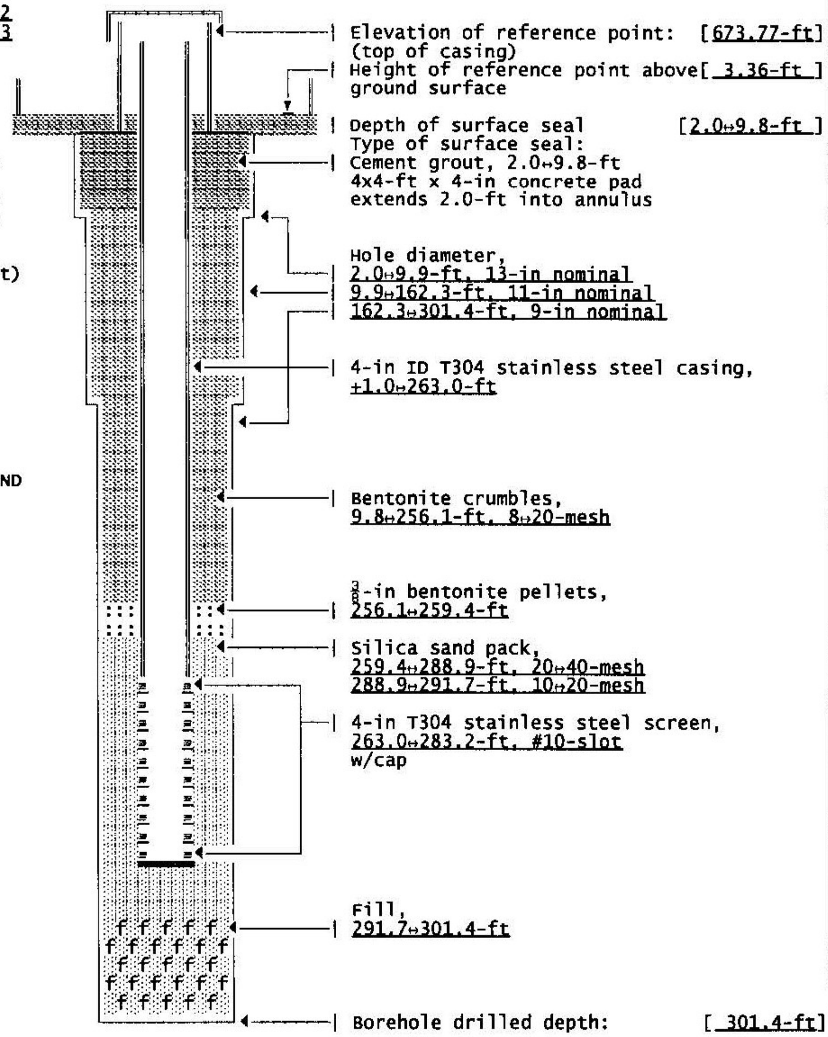
WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method: Downhole hammer Backhoe/Air rotary	Sample Method: Air returns Continous	WELL NUMBER: 299-E25-47 TEMPORARY WELL NO:
Drilling Fluid Used: None	Additives Used: None documented	Hanford Coordinates: N/S N 40,835.3 E/W W 46,306.1
Driller's Name: D. Mingo	WA State Lic Nr: Not documented	State NAD83 Coordinates: N 135,931.0m 446,018 E 575,778.6m 2,248,914
Drilling Company: Jensen Drilling Co	Company Location: Not documented	Start Card #: Not documented T___ R___ S___
Date Started: 14Jul92	Date Complete: 06Aug92	Elevation Ground surface: 670.41-ft (Brass cap)

Depth to water: 266.7-ft 06Aug92
(Ground surface) 268.0-ft 22Jun93

GENERALIZED STRATIGRAPHY | Geologist's Log

0↔24: SAND
24↔30: Sl gravelly (pebbly) SAND
30↔100: SAND
(1-in SILT lens @ 90-ft)
100↔115: Sl silty sandy (pebble) GRAVEL
115↔130: SAND
130↔162: SILT (SAND lens @ 144-ft)
162↔175: SAND
175↔180: Gravelly SAND
180↔195: SAND
195↔225: Gravelly (pebble) SAND
225↔228: SILT
228↔262: SAND
(HANFORD Fine/RINGOLD contact @ 262-ft)
262↔266: SILT
266↔280: SAND
280↔295: Sl gravelly (pebbly) SAND
295↔300: Gravelly (pebbly) SAND
300↔301.4: SAND



Drawing By: RKL/2E25-47.ASB
Date : 08Sep93
Reference : WHC-SD-EN-DP-054

Figure C-5. Well 299-E25-47 Construction and Completion Summary (page 1 of 2)

SUMMARY OF CONSTRUCTION DATA AND FIELD OBSERVATIONS
RESOURCE PROTECTION WELL - 299-E25-47

WELL DESIGNATION	:	299-E25-47
RCRA FACILITY	:	Grout
CERCLA UNIT	:	Not applicable
HANFORD COORDINATES	:	N 40,835.4 W 46,306.1 [30Dec92-200E]
LAMBERT COORDINATES	:	N 446,018 E 2,248,914 [HANCONV]; N 135,931.0m E 575,778.6m [NAD83-30Dec92]
DATE DRILLED	:	Aug92
DEPTH DRILLED (GS)	:	301.4-ft
MEASURED DEPTH (GS)	:	283.6-ft, 03Nov92
DEPTH TO WATER (GS)	:	266.7-ft, 06Aug92 268.0-ft, 22Jun93
CASING DIAMETER	:	6-in, stainless steel, +3.4↔~0.5-ft; 4-in, stainless steel, +1.0↔263.0-ft
ELEV TOP CASING	:	673.77-ft, [30Dec92-NGVD'29]
ELEV GROUND SURFACE	:	670.41-ft, Brass cap [30Dec92-NGVD'29]
PERFORATED INTERVAL	:	Not applicable
SCREENED INTERVAL	:	263.0↔283.2-ft, 4-in stainless steel, #10-slot
COMMENTS	:	FIELD INSPECTION, 03Nov92; 4 and 6-in stainless steel casing. 4-ft by 4-ft concrete pad, 4 posts, 1 removable. Capped and locked, brass cap in pad with well ID. Not in radiation zone.
AVAILABLE LOGS	:	Geologist
TV SCAN COMMENTS	:	Not applicable
DATE EVALUATED	:	Not applicable
EVAL RECOMMENDATION	:	Not applicable
LISTED USE	:	A-29 Ditch monthly water level measurement, 14Dec92↔22Jun93;
CURRENT USER	:	WHC ES&M w/l monitoring and RCRA sampling, PNL sitewide sampling 93
PUMP TYPE	:	Hydrostar, @ 281.0-ft (GS)
MAINTENANCE	:	

Figure C-5. Well 299-E25-47 Construction and Completion Summary (page 2 of 2)

WELL SUMMARY SHEET — Page 1 of 4

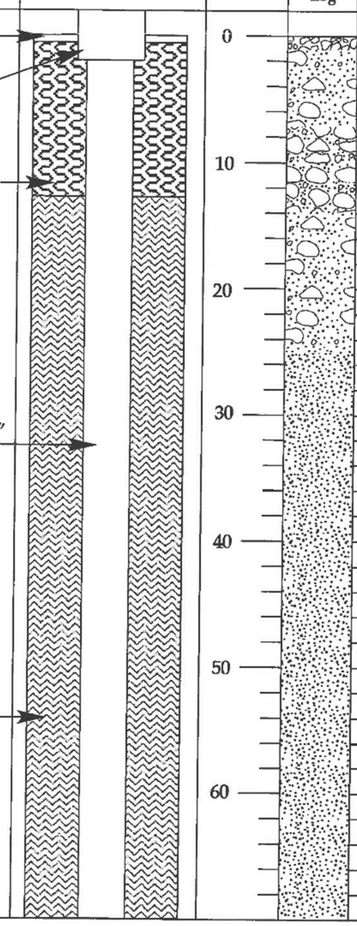
Well ID : C9630	Well Name: 299-E25-95
Start Date: 05/22/2017	Finish Date: 06/08/2017
Project: 5 M-24 Monitoring Wells in 200E OU	Location: SW corner of 216-A-37-1 Crib

CONSTRUCTION DATA / **GEOLOGIC/HYDROLOGIC DATA**

Description | Diagram | Depth in Feet | Graphic Log | Lithologic Description (ft bgs)

Construction Description:

- Concrete Pad: 0.50 ft above ground surface (ags)
- 6-in Protective Casing: 3.00 ft ags - 2.00 ft below ground surface (bgs)
- Type I/II Portland Cement Grout: 0.0 - 12.6 ft bgs
- 4-in I.D. Schedule 10, Type 304/304L, Stainless Steel Blank Casing: 2.12 ft ags - 277.38 ft bgs
- Medium Bentonite Chips: 12.6 - 268.4 ft bgs



Lithologic Description (ft bgs):

- 0.0 - 1.0 Crushed Gravel Drill Pad
- 1.0 - 7.0 Gravelly Sand (gS)
- 7.0 - 14.0 Sandy Gravel (sG)
- 14.0 - 25.0 Gravelly Sand (gS)
- 25.0 - 145.0 Sand (S)

Reported By:	Print Name	Title	Signature	Date
	Kat Robertson	Geologist	[signature]	08/09/17

Reviewed By:	Print Name	Title	Signature	Date
	Kelly Whitley	Well Coordinator	[signature]	8/21/17

For Office Use Only

OR Doc Type:	WMU Code(s):

A-6003-643 (REV 2)

Figure C-6. Well 299-E25-95 Construction and Completion Summary (page 1 of 4)

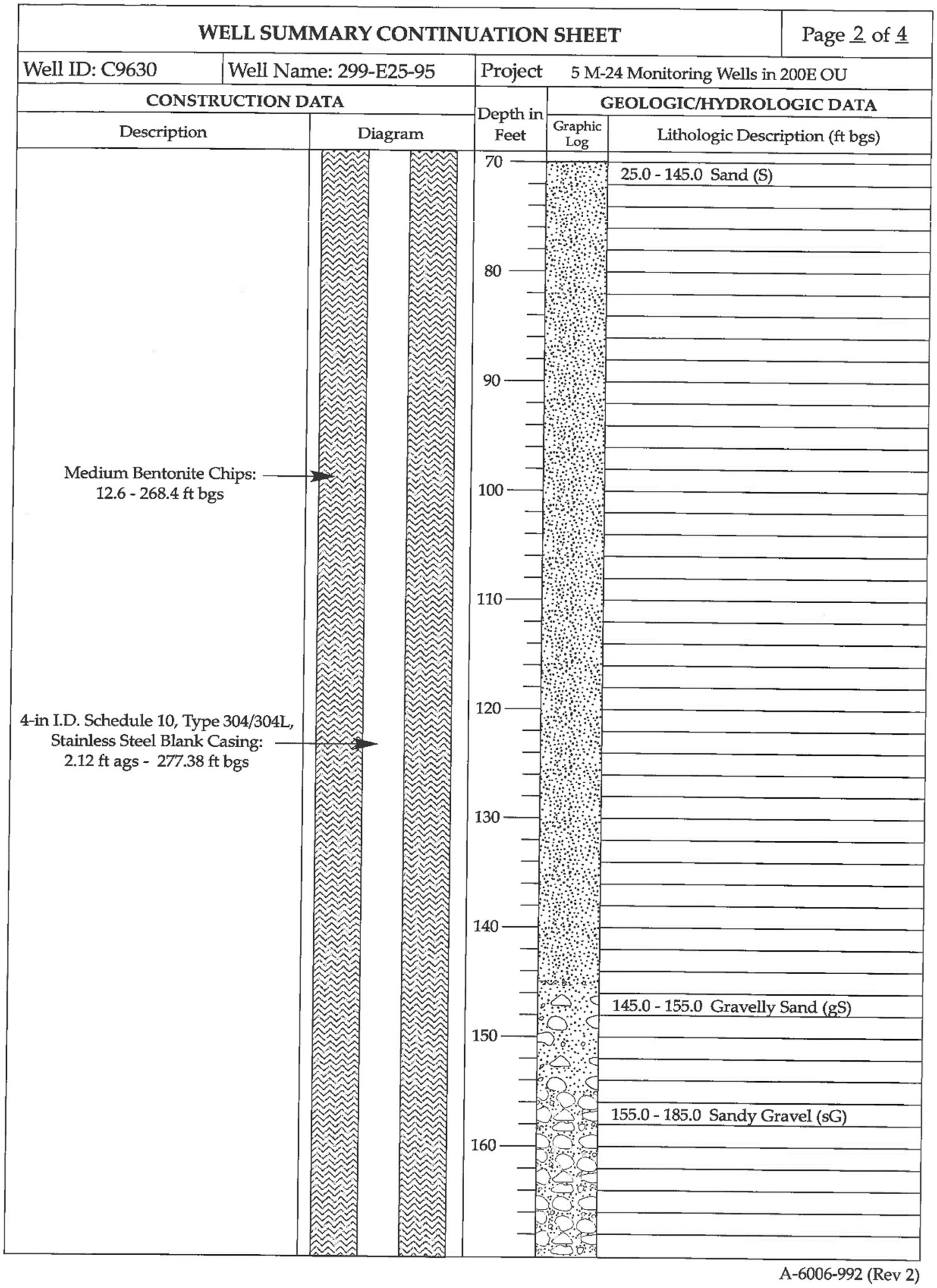


Figure C-6. Well 299-E25-95 Construction and Completion Summary (page 2 of 4)

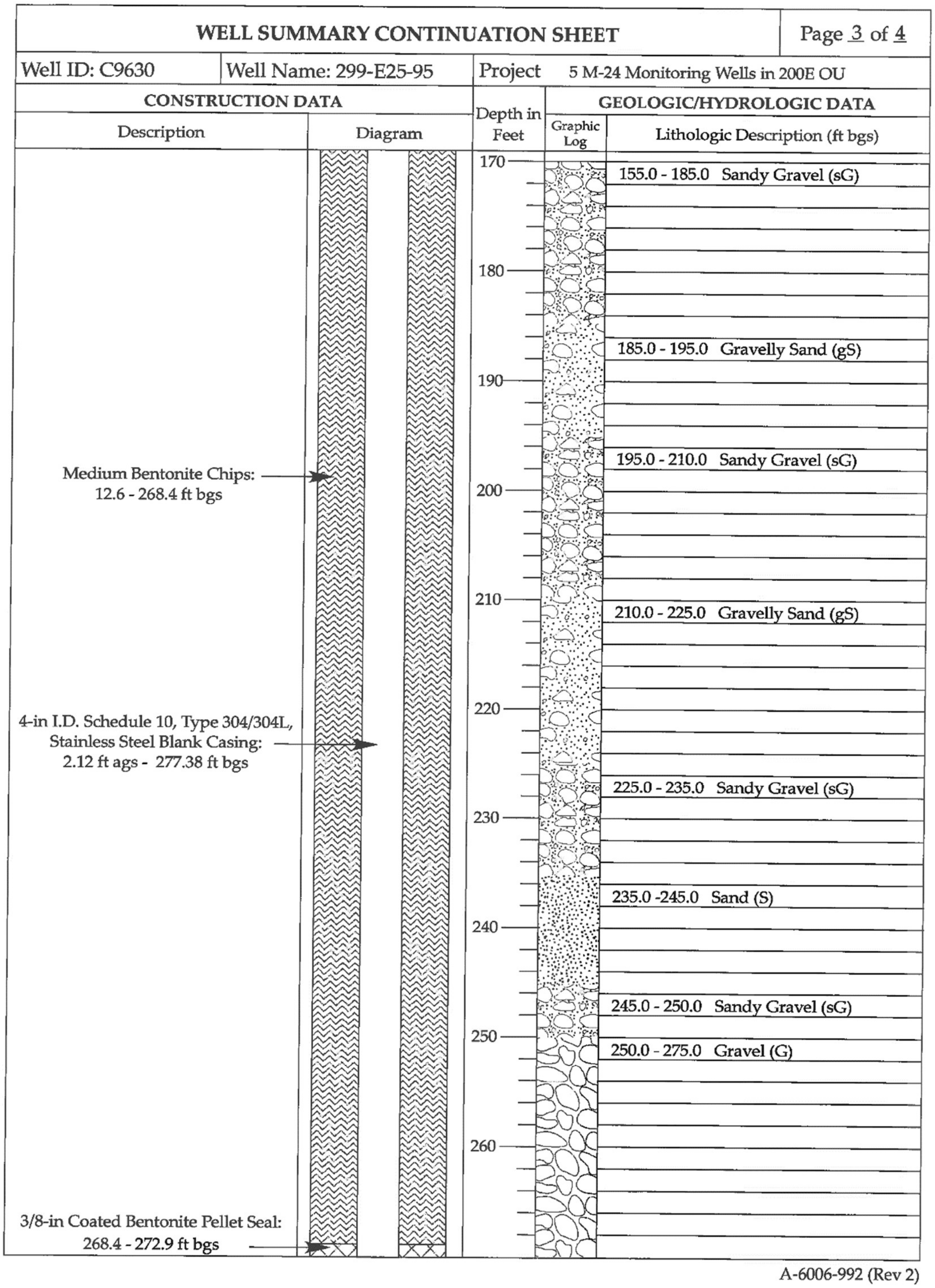
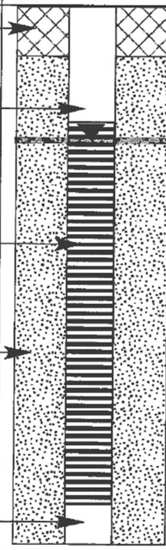


Figure C-6. Well 299-E25-95 Construction and Completion Summary (page 3 of 4)

WELL SUMMARY CONTINUATION SHEET — Page 4 of 4

Well ID: C9630	Well Name: 299-E25-95	Project 5 M-24 Monitoring Wells in 200E OU

CONSTRUCTION DATA

Description	Diagram
3/8-in Coated Bentonite Pellet Seal: 268.4 - 272.9 ft bgs	
4-in I.D. Schedule 10, Type 304/304L, Stainless Steel Blank Casing: 2.12 ft ags - 277.38 ft bgs	
4-in I.D. Schedule 10, Type 304/304L, 20-slot (0.020 in.) Stainless Steel Screen: 277.38 - 307.38 ft bgs	
10-20 mesh Premier Colorado Silica Filter Pack Sand: 272.9 - 311.3 ft bgs	
4-in I.D. Schedule 10, Type 304/304L, Stainless Steel Sump: 307.38 - 310.38 ft bgs	

GEOLOGIC/HYDROLOGIC DATA

Depth in Feet	Graphic Log	Lithologic Description (ft bgs)
270		250.0 - 275.0 Gravel (G)
		275.0 - 280.0 Sandy Gravel (sG)
		Static Water Level: 278.9 ft bgs (06/05/17)
280		280.0 - 285.0 Gravelly Sand (gS)
		285.0 - 311.3 Sandy Gravel (sG)
290		
300		
310		Total Depth: 311.3 ft bgs (05/25/17)
320		

Straightness Test: Pass, 06/05/17
Total Depth: 311.3 ft bgs

Depths are in ft below ground surface.

Borehole drilled with 9-in O.D. casing from 0.0 - 311.3 ft bgs

All temporary drill casing was removed from the ground.

A-6006-992 (Rev 2)

Figure C-6. Well 299-E25-95 Construction and Completion Summary (page 4 of 4)

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/.