DOE/RL-2019-42
Revision 0

SAMPLING AND ANALYSIS PLAN FOR PERCHED WATER EXTRACTION AND MONITORING WELLS IN THE 200-DV-1 OPERABLE UNIT

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

U.S. DEPARTMENT OF ENERGY | Richland Operations Office

P.O. Box 550
Richland, Washington 99352

Approved for Public Release;
Further Dissemination Unlimited

DOE/RL-2019-42
Revision 0

SAMPLING AND ANALYSIS PLAN FOR PERCHED WATER EXTRACTION AND MONITORING WELLS IN THE 200-DV-1 OPERABLE UNIT

Date Published
September 2020

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

U.S. DEPARTMENT OF ENERGY | Richland Operations Office
P.O. Box 550
Richland, Washington 99352

APPROVED
By Janis D. Aardal at 2:51 pm, Sep 15, 2020

Release Approval | Date

Approved for Public Release;
Further Dissemination Unlimited

TRADEMARK DISCLAIMER

Reference herein to any specific commercial product, process, or service by tradename, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof or its contractors or subcontractors.

This report has been reproduced from the best available copy.

Printed in the United States of America

Signature Page

Title: *Sampling and Analysis Plan for Perched Water Extraction and Monitoring Wells in the 200-DV-1 Operable Unit*

Concurrence:

Print Name	Signature	Date
Michael W. Cline	Digitally signed by Michael W. Cline Date: 2020.09.16 08:46:41 -07'00'	
U.S. Department of Energy, Richland Operations Office		
	Digitally signed by Goswami, Dib (ECY) Date: 2020.09.16 09:14:59 -07'00'	
Washington State Department of Ecology		
CRAIG CAMERON	Digitally signed by CRAIG CAMERON Date: 2020.09.17 12:16:52 -07'00'	
U.S. Environmental Protection Agency		

This page intentionally left blank.

Contents

1 Introduction 1-1
1.1 Project Scope and Objective 1-7
1.1.1 Scope 1-7
1.1.2 Objectives 1-8
1.2 Background 1-8
1.2.1 Site Geology/Hydrology 1-9
1.2.2 Physical Setting 1-13
1.2.3 Sources of Contamination 1-13
1.2.4 Contaminant Plumes 1-16
1.3 Data Quality Objective Summary 1-16
1.3.1 Statement of the Problem 1-16
1.3.2 Decision Statements and Decision Rules 1-17
1.3.3 Data Inputs and Sampling Designs 1-18
1.4 Analytical Approach 1-19
1.5 Project Schedule 1-26
2 Quality Assurance Project Plan 2-1
2.1 Project Management 2-1
2.1.1 Project/Task Organization 2-1
2.1.2 Quality Objectives and Criteria 2-5
2.1.3 Methods-Based Analysis 2-5
2.1.4 Hydrogeologic and Physical Properties Analyses 2-9
2.1.5 Analytical Priority 2-11
2.1.6 Special Training/Certification 2-12
2.1.7 Documents and Records 2-12
2.2 Data Generation and Acquisition 2-14
2.2.1 Analytical Methods Requirements 2-15
2.2.2 Field Analytical Methods 2-18
2.2.3 Quality Control 2-18
2.2.4 Measurement Equipment 2-27
2.2.5 Instrument and Equipment Testing, Inspection, and Maintenance 2-27
2.2.6 Instrument/Equipment Calibration and Frequency 2-27
2.2.7 Inspection/Acceptance of Supplies and Consumables 2-27
2.2.8 Nondirect Measurements 2-27
2.2.9 Data Management 2-27
2.3 Assessment and Oversight 2-28
2.3.1 Assessments and Response Actions 2-28

2.3.2 Reports to Management 2-28
2.4 Data Review and Usability 2-28
2.4.1 Data Review and Verification 2-28
2.4.2 Data Validation 2-29
2.4.3 Reconciliation with User Requirements 2-29
3 Field Sampling Plan 3-1
3.1 Sampling Objectives/Design 3-1
3.2 Sample Locations and Frequency 3-2
3.2.1 Sampling Locations 3-2
3.3 Well Drilling and Completion 3-10
3.3.1 Borehole Drilling and Sampling 3-10
3.3.2 Well Completion 3-12
3.4 Well Development 3-15
3.4.1 Initial Well Development 3-15
3.4.2 Final Well Development 3-15
3.5 Sampling Methods 3-16
3.5.1 Sampling Procedure 3-16
3.5.2 Decontamination of Sampling Equipment 3-19
3.5.3 Radiological Field Data 3-20
3.6 Documentation of Field Activities 3-20
3.6.1 Corrective Actions and Deviations for Sampling Activities 3-21
3.7 Calibration of Field Equipment 3-21
3.8 Sample Handling 3-22
3.8.1 Containers 3-22
3.8.2 Container Labeling 3-22
3.8.3 Sample Custody 3-23
3.8.4 Sample Transportation 3-23
4 Reporting 4-1
5 Management of Waste 5-1
6 Health and Safety 6-1
7 References 7-1

Appendices

A 200-DV-1 Operable Unit Perched Water Proposed Extraction Well Profiles ..... A-i

B 200-DV-1 Operable Unit Perched Water Proposed Monitoring Well Profiles ..... B-i

Figures

Figure 1-1. Location of the 200-DV-1 OU Perched Water Zone in the B Complex Area 1-2
Figure 1-2. Summary of Phased Approach 1-3
Figure 1-3. Approximate Location of Proposed Phase 1 Perched Water Extraction and Monitoring Wells 1-6
Figure 1-4. Configuration of the CCU in the Perched Water Zone 1-10
Figure 1-5. Perched Water Zone Saturated Thickness 1-11
Figure 1-6. CCU Perching Silt Bottom Elevation in the Perched Water Zone 1-12
Figure 1-7. Topography of the B Complex Area 1-14
Figure 1-8. Location of the B-BX-BY Tank Farms in the B Complex Area 1-15
Figure 2-1. Project Organization 2-2
Figure 3-1. Conceptual Illustration of Telescoping During Drilling 3-11
Figure 3-2. Conceptual Illustration of Extraction Well Design 3-13
Figure 3-3. Conceptual Illustration of Monitoring Well Design 3-14

Tables

Table 1-1. Proposed Phase 1 Perched Water Extraction and Monitoring Wells with Estimated Geologic Contacts and Water Levels 1-5
Table 1-2. Decision Statements 1-17
Table 1-3. Decision Rules 1-17
Table 1-4. Summary of Data Inputs to Resolve DSs 1-18
Table 1-5. Constituents and Physical Properties for Soil/Sediment Samples During Drilling 1-19
Table 1-6. Constituents for Perched Water Post-Development Samples 1-22
Table 1-7. Hydrogeologic and Physical Characterization for the Perched Water Zone Analyses to Address DS #1 and DS #4 1-24
Table 1-8. Tiered Analyses for Contaminant Characterization of the Perched Water Zone to Address DS #2 and DS #4 1-24
Table 1-9. Tiered Analyses for Physical and Chemical Characterization of the Vadose Zone (Above and Below the Perched Water Zone) to Address DS #3 and DS #4 1-25
Table 2-1. Data Quality Indicators 2-6
Table 2-2. Change Control for Sampling Projects 2-12
Table 2-3. Performance Requirements for Sample Analysis 2-15
Table 2-4. QC Samples 2-19

Table 2-5. Field and Laboratory QC Elements and Acceptance Criteria 2-19
Table 2-6. Holding-Time Guidelines for Laboratory Analytes 2-25
Table 3-1. Summary of Perched Water Extraction and Monitoring Well Sampling 3-3

Terms

bgs	below ground surface
BTR	buyer's technical representative
CCU	Cold Creek unit
CCU-PZSd	Cold Creek unit – perched zone sand
CCU-PZSt	Cold Creek unit – perched zone silt
CCUg	Cold Creek unit gravel
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
COC	contaminant of concern
Cr(VI)	hexavalent chromium
CSM	conceptual site model
DOE	U.S. Department of Energy
DOE-RL	U.S. Department of Energy, Richland Operations Office
DOT	U.S. Department of Transportation
DQA	data quality assessment
DQI	data quality indicator
DQO	data quality objective
DR	decision rule
DS	decision statement
DUP	laboratory sample duplicate
EB	equipment blank
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
FSO	Field Sample Operations
FTB	full trip blank
FWS	field work supervisor
FY	fiscal year
HASQARD	*Hanford Analytical Services Quality Assurance Requirements Document*
HEIS	Hanford Environmental Information System

Hf1	Hanford formation unit 1
Hf2	Hanford formation unit 2
Hf3	Hanford formation unit 3
IATA	International Air Transportation Association
LCS	laboratory control sample
MB	method blank
MCL	maximum contaminant level
MS	matrix spike
MSD	matrix spike duplicate
NQAP	National Quality Assurance Program
NTCR	non-time-critical removal action
A OD	outer diameter
OU	operable unit
P&T	pump and treat
PNNL	Pacific Northwest National Laboratory
QA	quality assurance
QAPjP	quality assurance project plan
QC	quality control
QSM	Quality Systems Manual
RCRA	*Resource Conservation and Recovery Act of 1976*
RCT	radiological control technician
SAF	sample authorization form
SAP	sampling and analysis plan
SMR	Sample Management and Reporting
SPLIT	field split sample
SST	single-shell tank
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order*
WMA	waste management area
XMT	x-ray microtomography imaging

1 Introduction

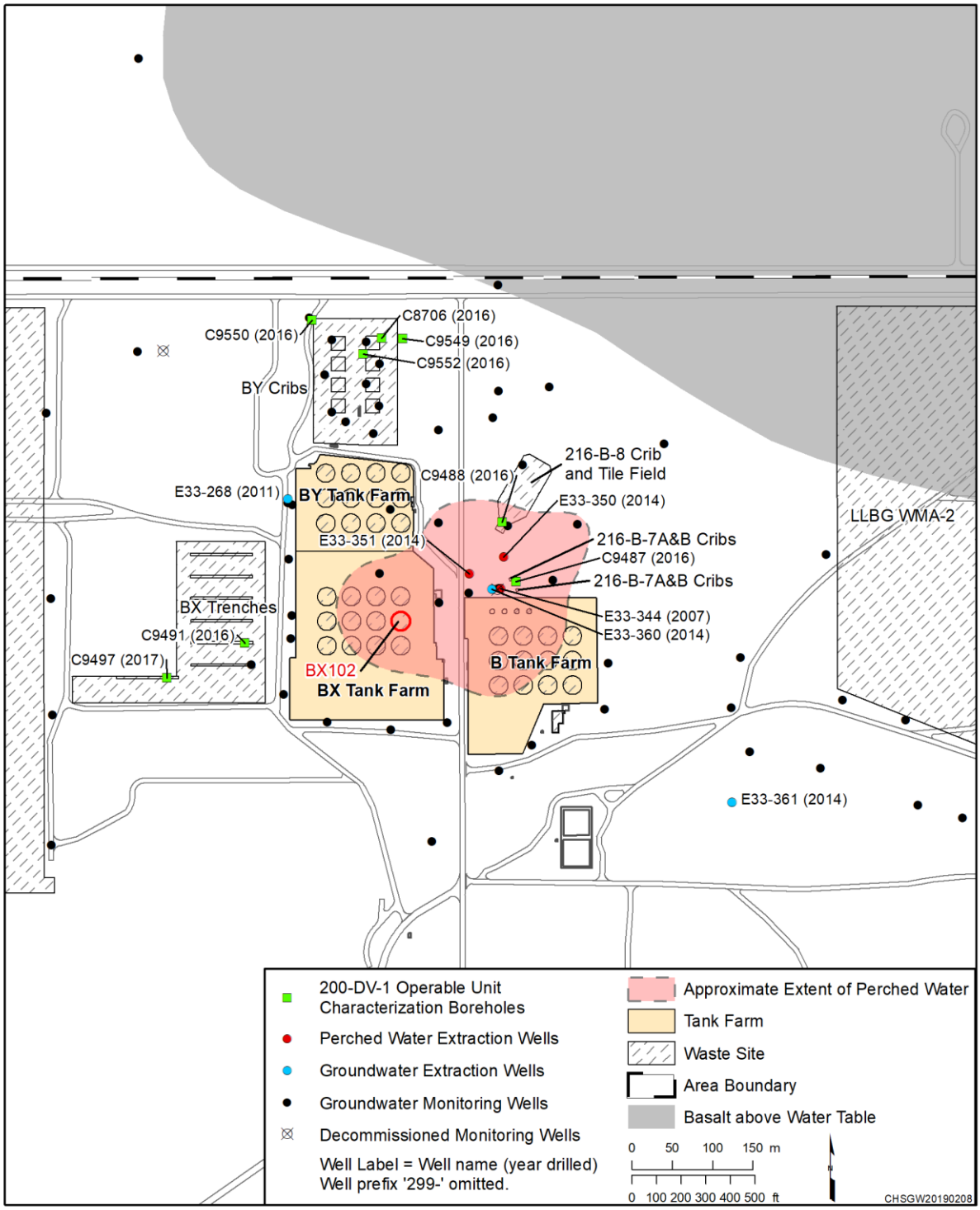
The 200-DV-1 Operable Unit (OU) perched water zone is located within the deep vadose zone in the B Complex in the 200 East Area of the U.S. Department of Energy (DOE) Hanford Site. The aggregate region referred to as the B Complex area includes Waste Management Area (WMA) B-BX-BY (B, BX, and BY Tank Farms) and the surrounding waste disposal sites (e.g., cribs and trenches). Figure 1-1 shows the location of the 200-DV-1 OU perched water zone and the waste sites. The perched water zone contains elevated levels of uranium, technetium-99, nitrate, and other contaminants of concern (COCs) and is located in the vadose zone above a fine-grained unit (perching silt layer) that overlies the unconfined aquifer in the 200-BP-5 OU.

DOE/RL-2014-34, *Action Memorandum for 200-DV-1 Operable Unit Perched Water Pumping/Pore Water Extraction*, was issued in 2014 for extracting contaminated water from the perched water zone and transferring it to the 200 West pump and treat (P&T). The extracted water is then treated and injected into the aquifer below the 200 West Area. The goal of this non-time-critical removal action (NTCRA) is to remove uranium, technetium-99, nitrate, total chromium, hexavalent chromium ((Cr(VI)), and tritium from the perched water zone.

The removal action is designed to recover as much perched water as practical in accordance with DOE/RL-2014-37, *Removal Action Work Plan for 200-DV-1 Operable Unit Perched Water Pumping/ Pore Water Extraction*, while awaiting issuance of the 200-DV-1 OU Record of Decision. Due to the hydraulic properties and relatively thin saturated thickness of the perched water zone, flow to the three existing extraction wells has been limited. SGW-63236, *200-DV-1 Future Perched Water Well Evaluation*, documents the hydraulic analysis of the perched water zone, and the different options evaluated to increase the perched water extraction rate.

A phased approach will be implemented to enable the collection of the best available information to support activities related to increasing the perched water extraction rate and removal of contaminant mass. Activities are currently divided into three phases. Phase 1 consists of the installation of 12 wells (8 extraction and 4 monitoring) that are vertically screened in the perched water zone and located outside of the tank farm fence line. The Phase 1 activities are anticipated to span from fiscal year (FY) 2020 through FY 2022; however, the actual schedule will be based on the priority of Hanford Site work and available funding each FY. Phase 2 involves evaluating the installation of a single horizontal extraction well extending beneath the B and BX Tank Farms versus installation of multiple vertical extraction and monitoring wells within the B and BX Tank Farm boundaries. Phase 2 activities are expected to be initiated in FY 2020. Phase 3 activities will be determined based on the information obtained from Phase 1 and 2 activities. The characterization results and extraction well performance information obtained under this sampling and analysis plan (SAP), combined with the Phase 2 horizontal and vertical well installation comparative evaluation, will be used to inform activities necessary during Phase 3 to further increase the perched water extraction rate. Figure 1-2 summarizes the activities within each phase and depicts the relationship among the three phases.

This SAP describes the field sampling activities associated with installing the Phase 1 monitoring and extraction wells in the 200-DV-1 OU perched water zone to support the NTCRA (DOE/RL-2014-34) to increase the perched water extraction rate and also collect information to enable evaluation of remediation alternatives within and surrounding the perched water zone for the protection of groundwater.
The information gathered will be used to refine the conceptual site model (CSM) for the perched water zone and the vadose zone above and below the perched water zone with respect to its size, contaminant distribution, and properties related to the effectiveness of water extraction and other potential remedies.



Note: Modified from Figure 1-1 in SGW-63236, *200-DV-1 Future Perched Water Well Evaluation*.

Figure 1-1. Location of the 200-DV-1 OU Perched Water Zone in the B Complex Area

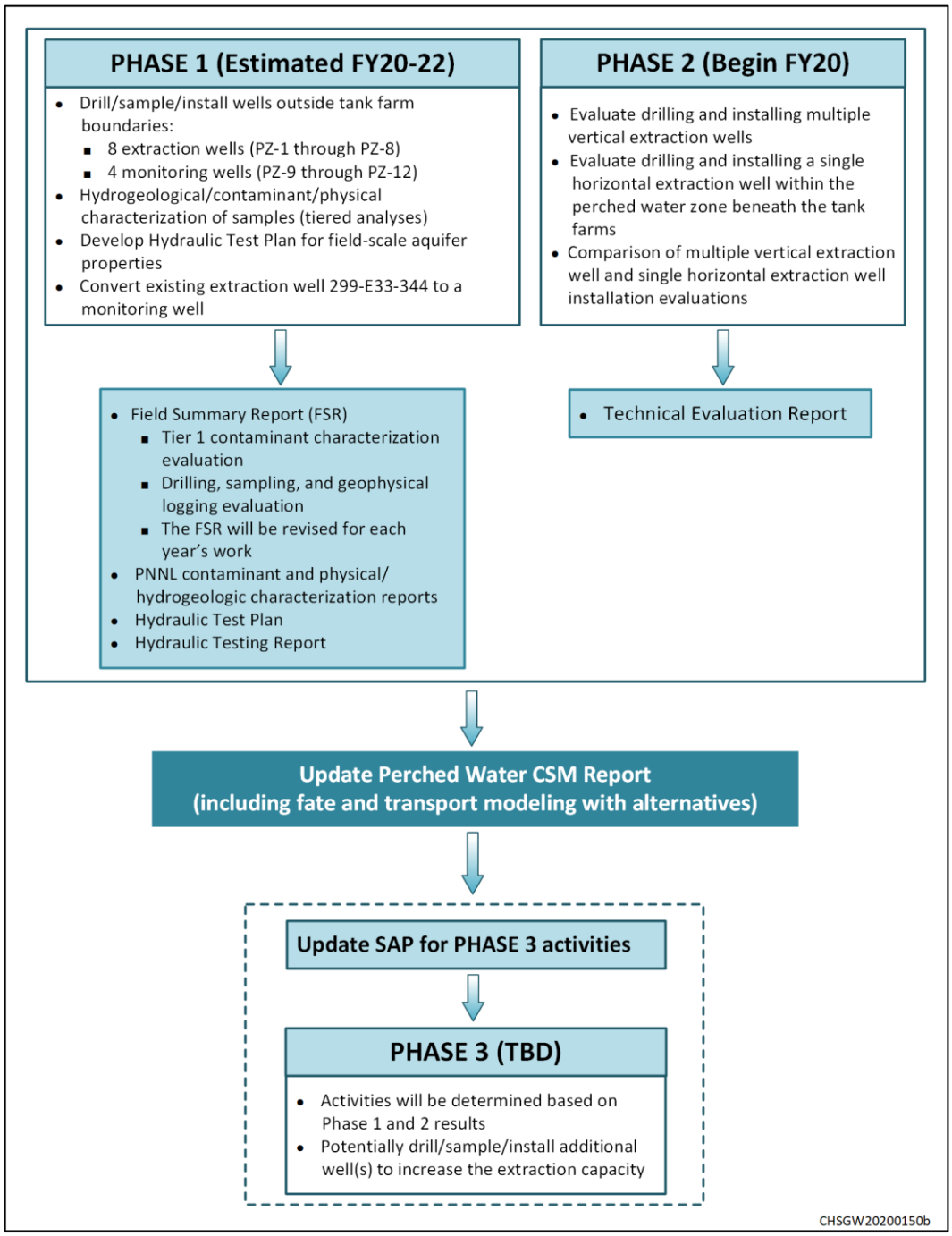


Figure 1-2. Summary of Phased Approach

Phase 1 is planned to include installing eight new extraction wells (PZ-1 through PZ-8) and four new monitoring wells (PZ-9 though PZ-12). The locations of these wells and associated characterization activities are detailed in this SAP. The tentative plan for FY 2020 is to install two of the eight extraction wells (299-E33-269 [D0112] and 299-E33-270 [D0113]). Installation of the remaining Phase 1 extraction and monitoring wells is anticipated for FY 2021 and FY 2022. These 12 initial wells (299-E33-269 [D0112], 299-E33-270 [D0113], 299-E33-371 [D0120], 299-E33-362 [D0121], 299-E33-363 [D0122], and 299-E33-364 [D0123]), 299-E33-365 [D0124], 299-E33-366 [D0125], 299-E33-367 [D0126], 299-E33-368 [D0127], 299-E33-369 [D0128], and 299-E33-370 [D0129]) will be vertically screened and installed at locations that can be readily accessed outside of the tank farms. Table 1-1 lists the extraction and monitoring wells proposed for installation during Phase 1, as well as the known key hydrogeologic units and anticipated depths for each well. Figure 1-3 shows the approximate locations of the proposed wells. It is planned that the extraction wells installed during each FY will be hooked up to the network for operation not less than annually. For example, wells installed in FY 2020 are intended to become operational in late FY 2020 or early FY 2021. The actual schedule for installation, construction, and operation of the extraction and monitoring wells will be determined based on priority of Hanford Site work activities and available funding each FY.

During Phase 1, field-scale aquifer properties will be evaluated through a series of hydraulic testing activities outlined in a hydraulic test plan that will be developed subsequent to and outside of the direct scope of this SAP. The plan will identify appropriate testing methods for the selected portions of the perched water zone based on the location of the newly constructed wells and existing well network.

Four options to remove perched water contaminants were evaluated in SGW-63236. These options were (1) installing multiple vertical perched water extraction wells, (2) installing dual-screened extraction wells, (3) installing vertical perched water drainage boreholes, and (4) installing a single horizontal perched water extraction well. Two of the four options evaluated in SGW-63236 (i.e., installing dual-screened extraction wells screened in both the perched water and underlying unconfined aquifer, and installing vertical drainage boreholes to drain perched water into the underlying unconfined aquifer) are not being evaluated further because these options conflict with WAC 173-160-181, “Minimum Standards for Construction and Maintenance of Wells,” “What Are the Requirements for Preserving the Natural Barrier to Ground Water Movement Between Aquifers?” which prohibits the interconnection of aquifers.

The analyses summarized in SGW-63236 suggest installing multiple vertical extraction wells or a single horizontal extraction well could significantly increase the perched water extraction rate. SGW-63236 cautions that the successful installation of a horizontal extraction well is dependent on the accuracy of existing borehole and geophysical logs and may present health/safety and waste management issues when dealing with drilling fluids and development water. Some challenges for installing vertically screened wells within the tank farm fence include waste management and the amount of infrastructure that affects well locations and limits maneuvering a large drill rig. SGW-63236 recommends that site-specific conditions be considered in future cost estimates for each of the four scenarios evaluated before a decision is made regarding the most effective option to increase perched water removal.

Table 1-1. Proposed Phase 1 Perched Water Extraction and Monitoring Wells with Estimated Geologic Contacts and Water Levels

Well Location	Well Name	Extraction Well (EW) Monitoring Well (MW)	Well ID	Easting[b] (m)	Northing[b] (m)	Elevation (m)	Elevation (ft)	Estimated Total Depth (ft bgs)	Estimated Depth to Perched Water (ft bgs)	Estimated Depth to Groundwater (ft bgs)	Estimated Depth to Geologic Contacts[a] (ft bgs)							
											Hf1	Hf2	Hf3	Upper Silt-Dominated CCU	CCU-PZSd	CCU-PZSt	CCUg	Basalt
PZ1	299-E33-371	EW	D0120	573701	137361	199.7	655.2	280	226	255	1	36	183	217	224	235	239	266
PZ2[c]	299-E33-269	EW	D0112	573776	137386	198.8	652.2	284	226	253	9	37	210	215	222	238	244	264
PZ3[c]	299-E33-270	EW	D0113	573839	137429	197.9	649.3	282	226	250	14	43	210	218	222	233	238	260
PZ4	299-E33-365	EW	D0124	573833	137389	198.0	649.6	280	225	250	7	39	214	216	221	231	239	261
PZ5	299-E33-366	EW	D0125	573704	137311	198.9	652.4	274	223	253	0	34	187	213	221	229	233	265
PZ6	299-E33-367	EW	D0126	573809	137457	194.0	636.5	280	212	237	5	40	173	202	207	218	226	247
PZ7	299-E33-370	EW	D0129	573743	137448	199.4	654.2	278	227	255	15	44	189	218	222	233	241	264
PZ8	299-E33-368	EW	D0127	573739	137383	198.6	651.6	280	224	252	1	37	204	214	221	234	238	263
PZ9	299-E33-369	MW	D0128	573725	137439	196.9	646.0	245	218	N/A	2	30	182	209	213	224	232	N/A
PZ10	299-E33-362	MW	D0121	573757	137425	199.4	654.2	246	228	N/A	13	39	200	214	220	232	241	N/A
PZ11	299-E33-363	MW	D0122	573706	137342	199.4	654.2	242	225	N/A	0	36	185	216	224	233	237	N/A
PZ12	299-E33-364	MW	D0123	573823	137444	199.0	653.0	248	213	N/A	4	34	186	204	209	220	227	N/A

a. The estimated depths to geologic contacts are based on the Hanford South Geologic Framework Model, as documented in ECF-HANFORD-13-0029, *Development of the Hanford South Geologic Framework Model, Hanford Site, Washington*; CP-60925, *Model Package Report: The Central Plateau Vadose Zone Geoframework Version 1.0*; and ECF-200DV1-18-0036, *B-Complex Perched Zone Geoframework, 200 East, Hanford Site*.

b. Locations may need to be adjusted based on overhead power or underground interferences.

c. Well is scheduled to be installed in fiscal year 2020. The actual schedule for well installation, construction, and operation will be determined based on priority of Hanford Site work activities and available funding each fiscal year.

bgs = below ground surface
CCU = Cold Creek unit
CCU-PZSd = Cold Creek unit – perched zone sand
CCU-PZSt = Cold Creek unit – perched zone silt
CCUg = Cold Creek unit gravel
EW = extraction well
Hf1 = Hanford formation unit 1
Hf2 = Hanford formation unit 2
Hf3 = Hanford formation unit 3
ID = identification
MW = monitoring well
N/A = not applicable

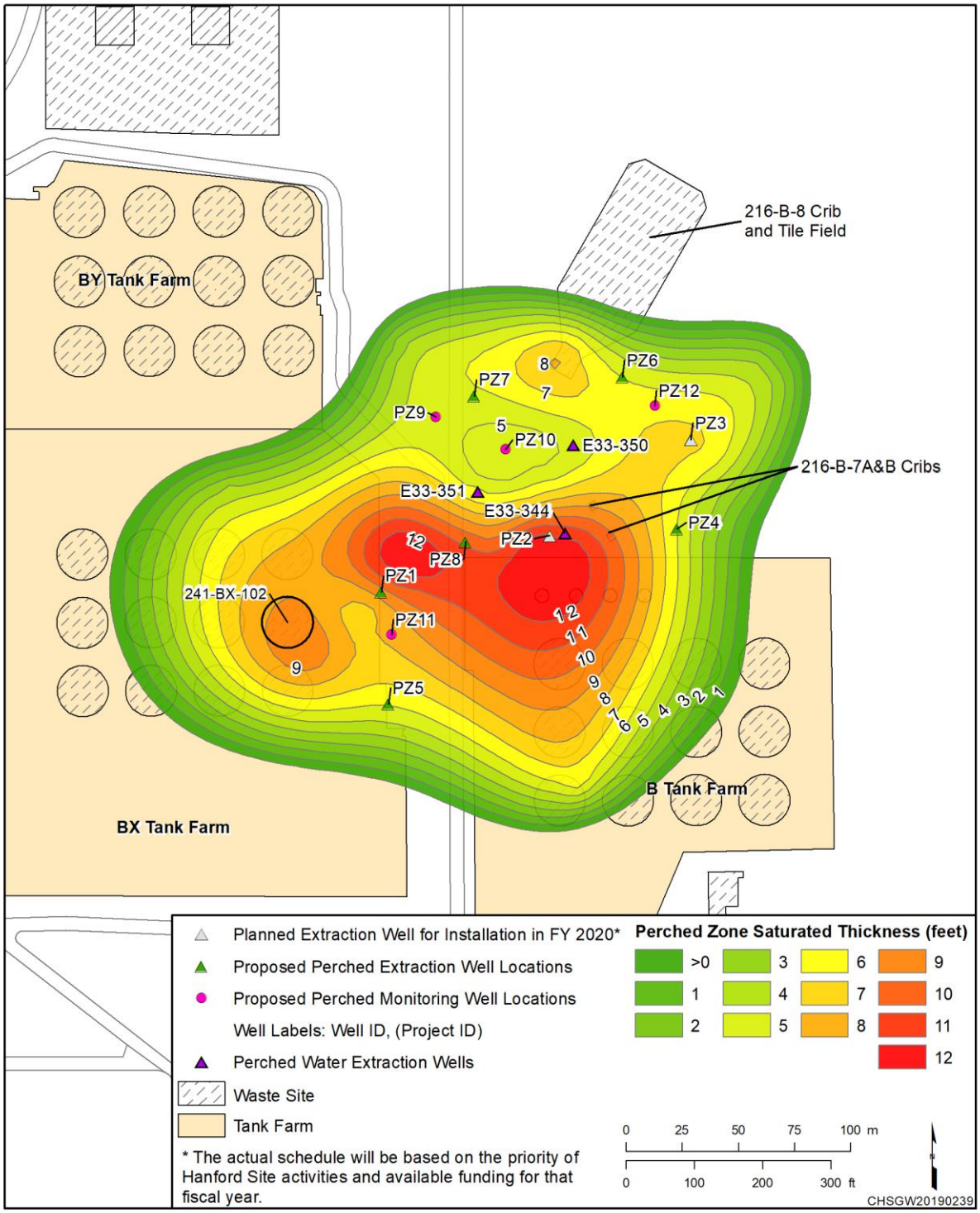


Figure 1-3. Approximate Location of Proposed Phase 1 Perched Water Extraction and Monitoring Wells

Phase 2, which is anticipated to occur concurrently with Phase 1, will further evaluate installing vertically screened extraction and monitoring wells within the tank farm boundaries compared to installing a single horizontal extraction well extending beneath the B and BX Tank Farms under Hanford Site-specific conditions. Both of these approaches to drilling bring a set of unique challenges, which will be evaluated as part of Phase 2 activities. Installation of additional vertically screened extraction wells within the B and BX Tank Farm boundaries or a single horizontal extraction well extending beneath the tank farms would likely both increase extraction rates and place extraction capabilities closer to the areas of largest contaminant concentration in the perched water zone, thereby increasing the contaminant mass removal rate. Evaluation of these two alternative drilling scenarios will be documented in a technical evaluation report, which is anticipated to serve as a blueprint for pursuing drilling in Phase 3.

It is intended that the geologic information and the sampling and testing results from the Phase 1 well drilling and installation will be used in combination with the Phase 2 alternative drilling scenario evaluation to select the appropriate approach (e.g., additional vertical or a single horizontal extraction wells) for Phase 3. Phase 3 activities will be documented in a future update to this SAP.

The collection of measurements and observations provides an opportunity for integration with other projects and activities. This information and knowledge will be shared with other projects through integration activities. Measurements and observations collected under this SAP consider the vadose zone data needs identified for the B Complex.

1.1 Project Scope and Objective

The scope and objective for this SAP are provided in the following sections.

1.1.1 Scope

Efforts to address contamination present in the 200-DV-1 OU perched water zone in the B Complex have progressed from initial discovery of the perched water zone to a treatability test (DOE/RL-2011-40, *Field Test Plan for the Perched Water Pumping/Pore Water Extraction Treatability Test*), characterization efforts (DOE/RL-2014-51, *Sampling and Analysis Plan for 200-DV-1 Operable Unit Perched Water Pumping/Pore Water Extraction*; PNNL-19277, *Conceptual Models for Migration of Key Groundwater Contaminants Through the Vadose Zone and Into the Unconfined Aquifer Below the B-Complex*; PNNL-27846, *Physical and Hydraulic Properties of Sediments from the 200-DV-1 Operable Unit*), and the current NTCRA (DOE/RL-2014-34). Information gathered through these efforts identified the characteristics of the contaminated hydrogeological system that interacts with the perched water zone, including the physical and hydrogeological limitations to the extraction rate of contaminated perched water. The current rate of contaminated perched water removal using the three existing vertical extraction wells is very low (<3.8 L/min [<1 gal/min]) and is not effective for dewatering the perched water zone. Based on this information, it is necessary to increase the extraction rate of contaminated perched water and provide additional information to guide future remediation decisions for the perched water zone and the associated contaminated hydrogeological system.

A recent hydraulic analysis examined extraction well configuration options for increasing the rate of contaminated perched water removal (SGW-63236). This assessment, as well as other existing information for the perched water zone and the overall hydrogeological system, was used to guide planning to install additional extraction and monitoring wells within the perched water zone to increase the extraction rate. During installation, data will be collected to characterize the subsurface and contamination, and the data will be used to support phased implementation of the additional extraction capacity (Phase 3 activities), as well as to provide input to future remedy decisions that may include other remediation approaches such as in situ remediation and/or control of the hydrogeological system.

To enable the collection of the best and most appropriate information available, data collection for Phase 1 will use a tiered analysis approach for subsurface physical, hydraulic, geochemical, and contaminant conditions within and surrounding the perched water zone. Tier 1 analyses include physical properties testing and total aqueous and sediment contaminant concentration analyses. Depending on the Tier 1 test/analytical results, a sample may undergo more in-depth testing. Section 1.4 provides details regarding the tiered analytical approach and how it will be implemented. Data collection under this SAP will be focused to fill data gaps in the existing characterization information for the perched zone using the tiered approach to guide the type and location of the analyses to be conducted.

1.1.2 Objectives

The primary objectives of this SAP include the following:

- Collect information on properties of the Cold Creek unit – perched zone sand (CCU-PZSd) to optimize installing wells in the perched water zone to increase the rate of contaminated perched water extraction and to monitor associated changes in perched water contaminant concentrations.
- Collect information to enable evaluation of remediation alternatives within and surrounding the perched water zone for protection of groundwater.
- Refine the CSM of the perched water zone with respect to its size, contaminant distribution, and properties related to the effectiveness of water extraction and other potential remedies.

Section 1.3 summarizes the data quality objectives (DQOs) that guide this SAP.

1.2 Background

Contaminated perched water is present within the deep vadose zone in the B Complex. Liquid waste containing uranium and other contaminants was discharged to the subsurface in the B Complex area through engineered waste disposal sites from 1946 through 1974 (Section 2.1.1 in DOE/RL-2011-102, *Remedial Investigation/Feasibility Study and RCRA Facility Investigation/ Corrective Measures Study Work Plan*). The most significant unplanned release of waste occurred when tank 241-BX-102 was overfilled in 1951. Perched water conditions are present in the vadose zone above a fine-grained unit (perching silt layer) that is located a few feet above the unconfined aquifer within the B Complex area (200-BP-5 OU). Figure 1-1 shows the approximate location of the perched water zone in relation to the B-BX-BY Tank Farms and nearby liquid disposal sites.

The contaminated perched water is slowly migrating downward through the vadose zone, entering the underlying unconfined aquifer and contributing to groundwater contamination. The ongoing contaminant leaching from the perched water zone to the underlying aquifer has also contaminated the vadose zone beneath the perched water.

As described in SGW-58147, *Annual Performance Report for the 200-DV-1 Operable Unit Perched Water Extraction, Fiscal Year 2014*, geophysical logging results for well 299-E33-18 showed increasing uranium concentrations over time along the outside of the casing and downward toward the water table. Data indicate that well 299-E33-18 (an older, unsealed well) may have provided a more direct travel pathway for the perched water vadose zone contamination to migrate to the unconfined aquifer. Well 299-E33-18 was plugged with cement grout and decommissioned on June 26, 2013, to eliminate the potential for contaminant migration along the unsealed well.

The action memorandum (DOE/RL-2014-34) authorized a NTCRA to extract water from the perched water zone and transfer it to the 200 West P&T, where the water is treated then injected into the aquifer in the 200 West Area. Three wells (299-E33-344, 299-E33-350, and 299-E33-351) are currently used to

extract contaminated perched water to mitigate its future migration to groundwater (Figure 1-1). However, the combined pumping rate from these three wells is low (<3.8 L/min [<1 gal/min]), and additional extraction wells are needed to increase extraction in the perched water zone to remove contaminant mass.

1.2.1 Site Geology/Hydrology

The subsurface geologic interpretation in the B Complex area is based primarily on borehole and geophysical logs. ECF-200DV1-18-0036, *B-Complex Perched Zone Geoframework, 200 East, Hanford Site*, discusses the three-dimensional geoframework modeling that has been performed for the B Complex area. In this area, the Hanford formation consists of the thinner Hanford formation upper gravel-dominated sequence near the ground surface (Hanford formation unit 1 [Hf1] composed of interstratified gravel, sand, and minor silt); followed by the thicker Hanford formation sand-dominated sequence (Hanford formation unit 2 [Hf2] composed of interstratified sand and silt with local gravel horizons); followed by the Hanford formation lower gravel-dominated sequence (Hanford formation unit 3 [Hf3] composed of interstratified gravel and sand with local silt and/or clay horizons).

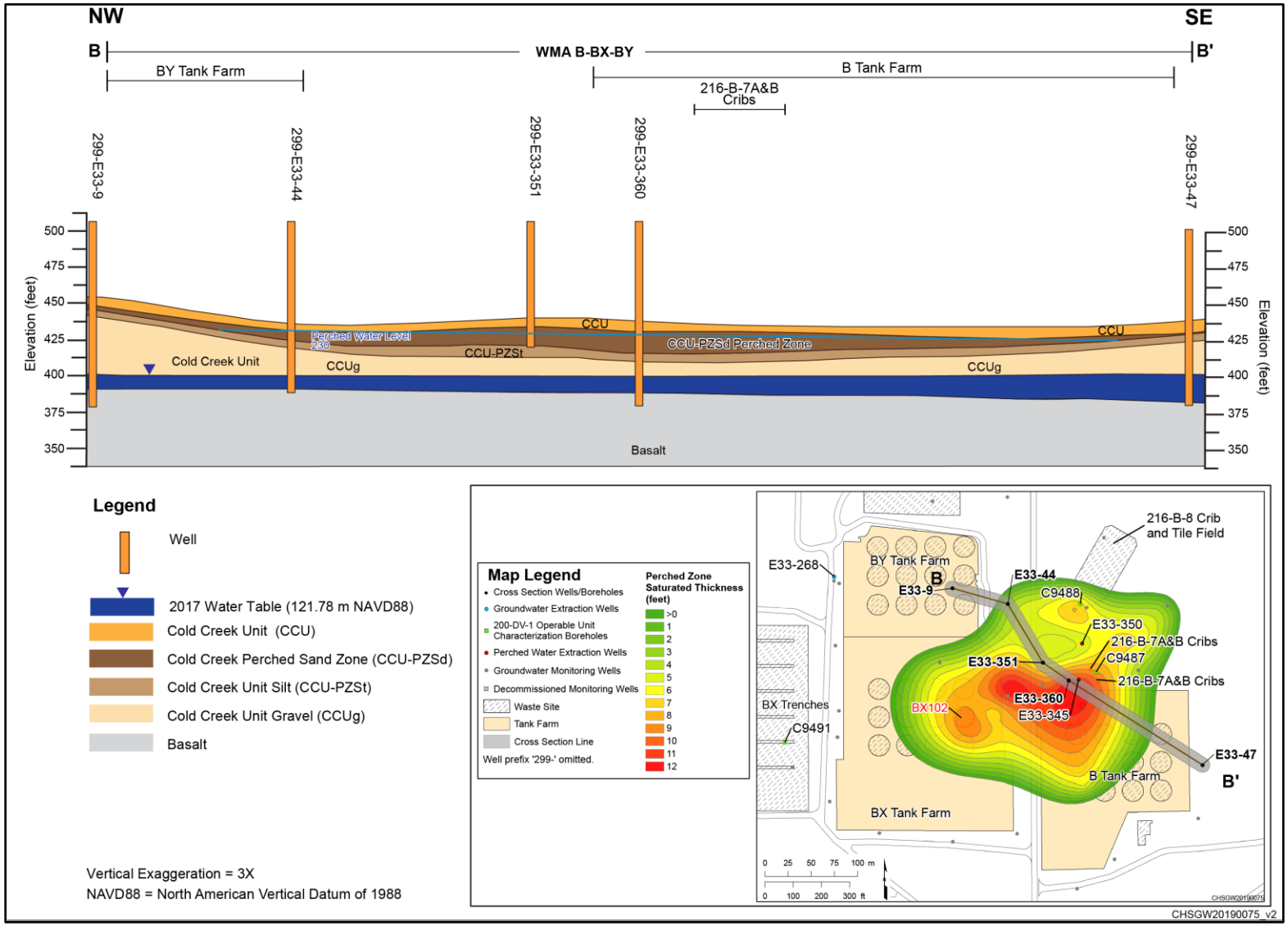
The Cold Creek unit (CCU) lies below the Hanford formation. The structure of the CCU low-permeability layer has resulted in the formation of a perched water zone, which intercepts contaminated water migrating through the vadose zone. Transition from the high-permeability Hanford formation to the CCU occurs deep in the vadose zone at elevations of 136 to 130 m (446.2 to 426.5 ft) above mean sea level. The CCU is bounded by the underlying basalt formation.

The CCU is subdivided into four zones, which are shown in Figure 1-4. The upper silt-dominated CCU is the top of the perched zone sequence and is mostly sandy silt to silt. The CCU-PZSd is located below the upper silt-dominated CCU. The CCU-PZSd contains perched water and is composed of a very fine sand and silt. The CCU perched zone silt (CCU-PZSt) is low-permeability perching silt and is located below the CCU-PZSd zone. The CCU-PZSt is on top of a higher permeability sand and gravel zone, designated as the CCU gravel (CCUg). The CCUg contains the unconfined aquifer.

The CCU-PZSd ranges in thickness from 0 to approximately 4.9 m (16 ft) at depths of approximately 67 to 72 m (220 to 236 ft) below ground surface (bgs) (Figure 1-4). The CCU-PZSd saturated thickness ranges from 0 to approximately 3.7 m (12 ft) (Figure 1-5). The hydraulic properties of the CCU-PZSd are summarized in Section 1.4.2 of SGW-63236.

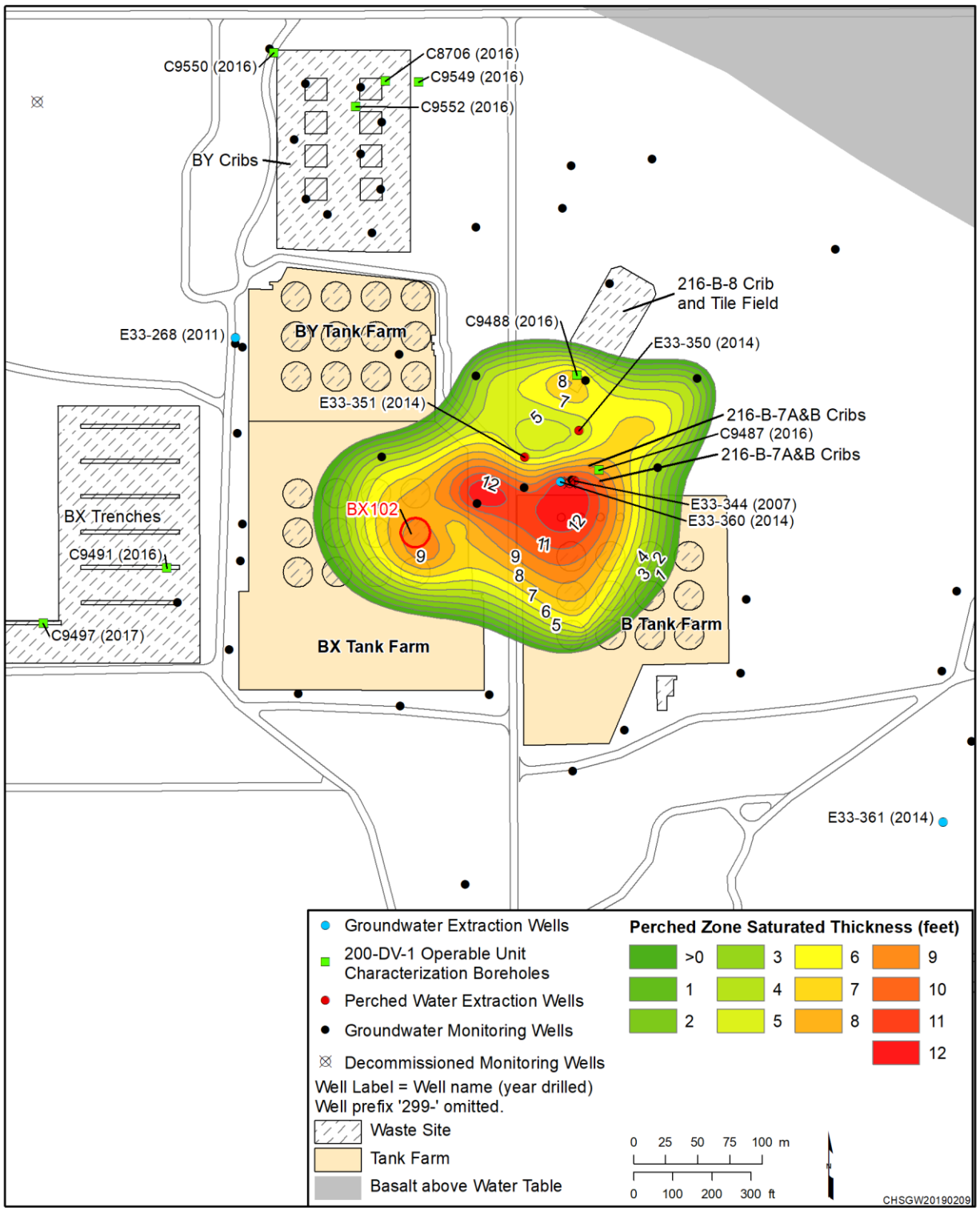
Figure 1-6 presents the CCU-PZSt bottom elevation and a southwest- to northeast-trending cross section. The perched water zone occupies a roughly southwest- to northeast-trending oval that is somewhat bowl-shaped in cross section. The depth to the perched water is roughly 69 to 70 m (227 to 230 ft) bgs. The CCU-PZSt thickness ranges from 0 to approximately 2.7 m (9 ft).

Perched water extraction was conducted from 2011 through 2015 using well 299-E33-344. Wells 299-E33-350 and 299-E33-351 were drilled and sampled in 2014 and were used for extraction beginning in 2016 when the NTCRA action was implemented (DOE/RL-2014-34). Boreholes C9487 and C9488 were drilled and sampled in 2016 to characterize two 200-DV-1 OU waste sites (216-B-8 Crib and 216-B-7A&B Cribs). The hydraulic properties of the perched water zone were derived from field hydraulic tests (i.e., single-well slug tests and single/multi-well pumping tests) using the three extraction wells and grain-size analyses from the two characterization boreholes. These hydraulic tests are described in Appendix B of PNNL-27846; and the grain-size analyses are presented in PNNL-26266, *Geochemical, Microbial, and Physical Characterization of 200-DV-1 Operable Unit B-Complex Cores from Boreholes C9552, C9487, and C9488 on the Hanford Site Central Plateau.*



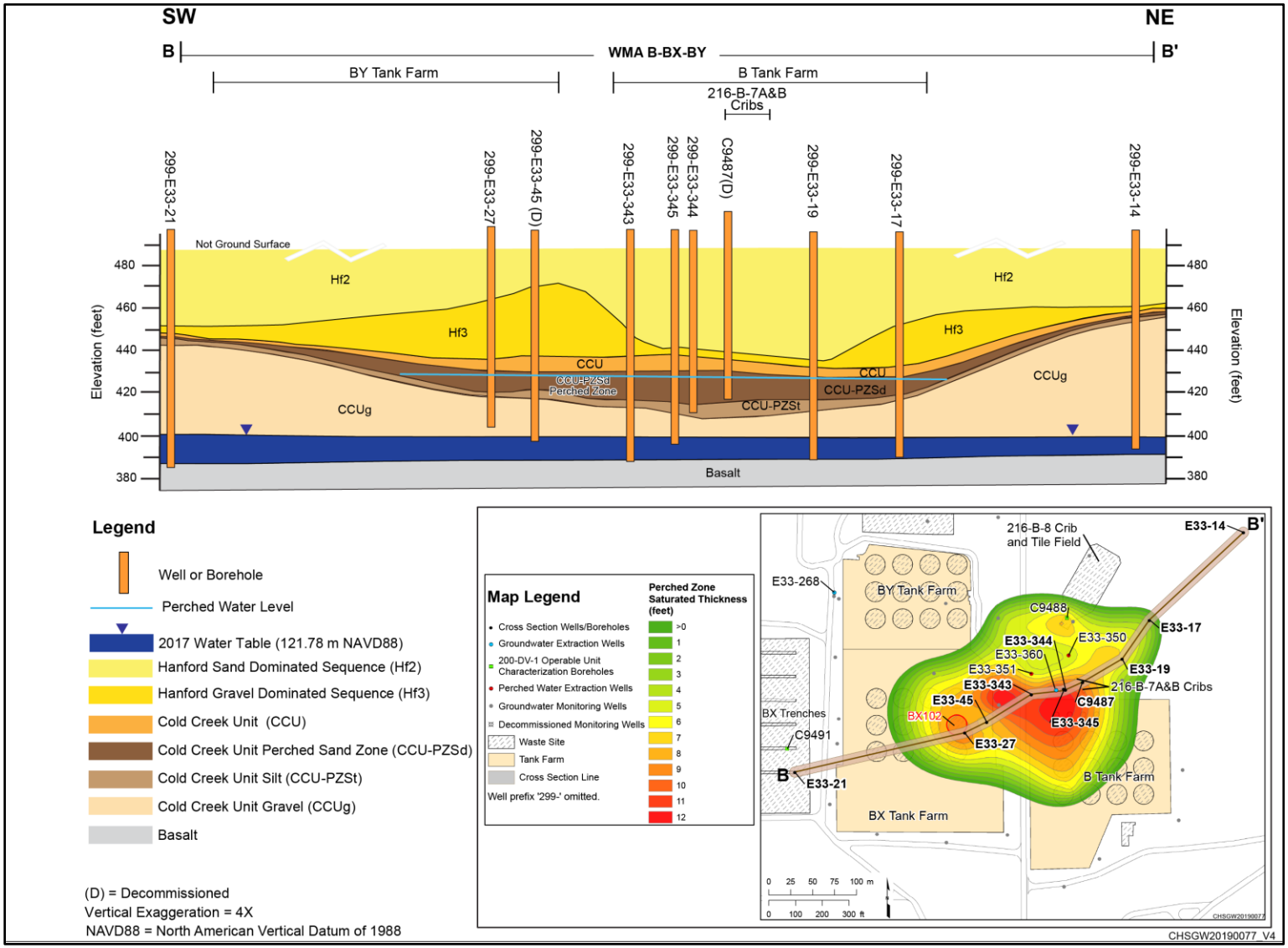
Note: Modified from Figure 1-5 in SGW-63236, *200-DV-1 Future Perched Water Well Evaluation*.

Figure 1-4. Configuration of the CCU in the Perched Water Zone



Note: Modified from Figure 1-6 in SGW-63236, *200-DV-1 Future Perched Water Well Evaluation*.

Figure 1-5. Perched Water Zone Saturated Thickness



Note: Modified from Figure 1-7 in SGW-63236, *200-DV-1 Future Perched Water Well Evaluation*.

Figure 1-6. CCU Perching Silt Bottom Elevation in the Perched Water Zone

The results from perched water samples collected from each of the three extraction wells in March, April, and May 2016 show strong evidence that the perched water zone is recharged by local precipitation (Section 5.0 in PNNL-26341, *Letter Report: Stable Hydrogen and Oxygen Isotope Analysis of B-Complex Perched Water Samples*).

1.2.2 Physical Setting

Figure 1-7 shows the topography of the B Complex area. The three perched water extraction wells are located on a local, flat area on the north side of the B Tank Farm. The flat area was created in 1992 by consolidating an area of contaminated soil into a spoil pile. The northern and eastern sides of the spoil pile slope relatively steeply downward from the local flat area.

Access challenges for the placement of new wells include the sloping topography, areas of potential subsidence, drilling within the tank farms, and underground and overhead utilities and infrastructure. Drilling new wells may be precluded in areas of sloping topography shown in Figure 1-7.

Three 200-DV-1 OU waste sites overlie the perched water zone: 216-B-7A&B Cribs, 216-B-8 Crib, and 216-B-11A&B Cribs. Figure 1-8 shows the locations of these waste sites relative to the approximate extent of the perched water zone. A description of the waste sites is provided in Appendix C of DOE/RL-2011-102.

Due to the close proximity to waste cribs, areas of potential subsidence will need to be considered when locating wells near the 200-DV-1 OU waste sites.

WMA B-BX-BY contains three single-shell tank (SST) *Resource Conservation and Recovery Act of 1976* (RCRA) treatment, storage, and disposal units that include tanks with domed tops, waste transfer lines, leak detection systems, and tank ancillary equipment (Figure 1-7). A general description of the B-BX-BY Tank Farms, which comprise the WMA, is provided in Section 2.1.2 of DOE/RL-2011-102.

Underground and overhead utilities and infrastructure will need to be considered when drilling new wells within the perched water zone area. Proposed well locations in this SAP may need to be adjusted to avoid potential subsidence and underground/overhead power or other interferences.

1.2.3 Sources of Contamination

The perched water contains uranium, technetium-99, nitrate, total chromium, Cr(VI), and tritium at concentrations above maximum contaminant levels (MCLs), as identified in the action memorandum (DOE/RL-2014-34). Cleanup levels were not established in the action memorandum for perched water because the objective is to remove the contaminated water rather than clean up the water and leave it in place.

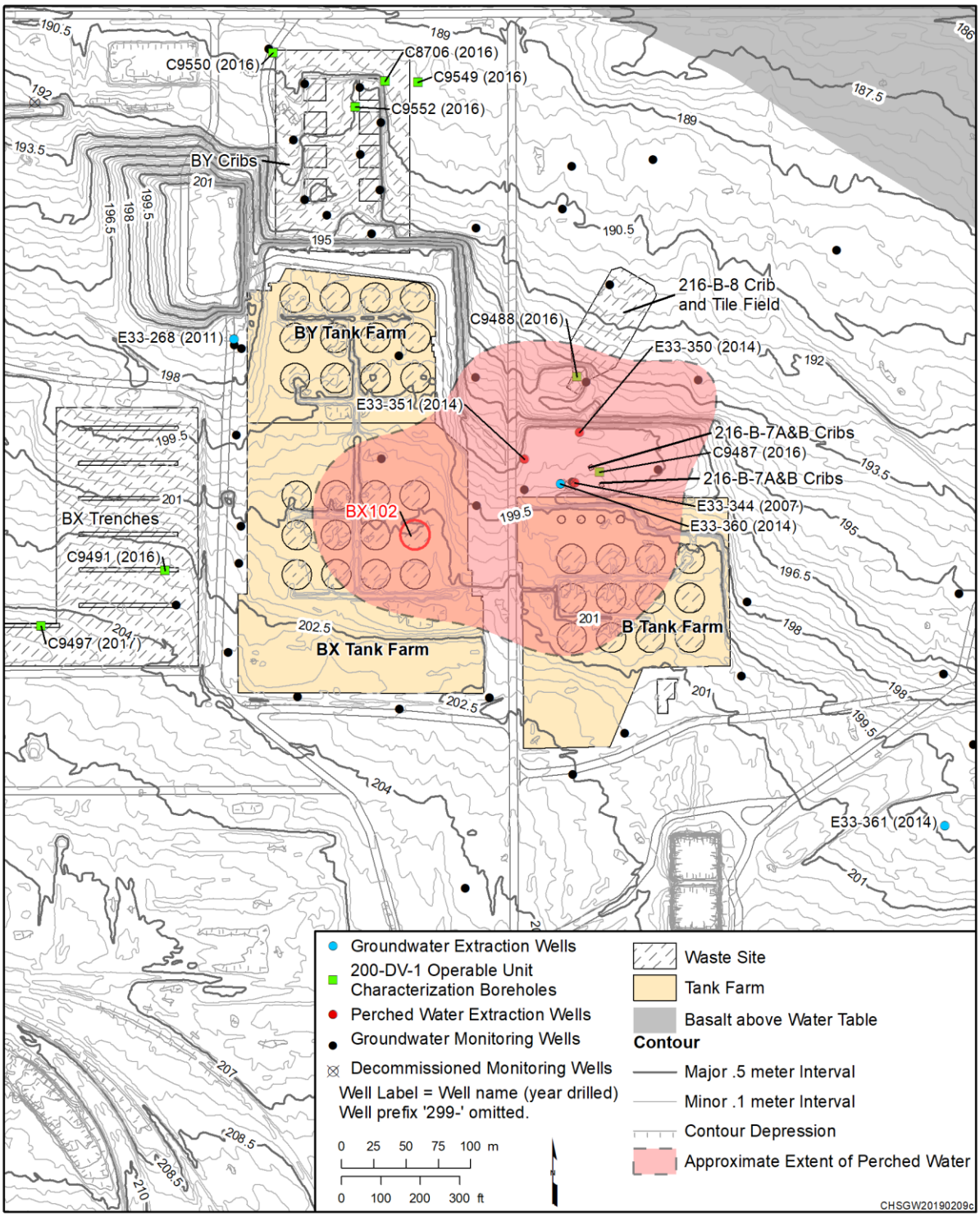


Figure 1-7. Topography of the B Complex Area

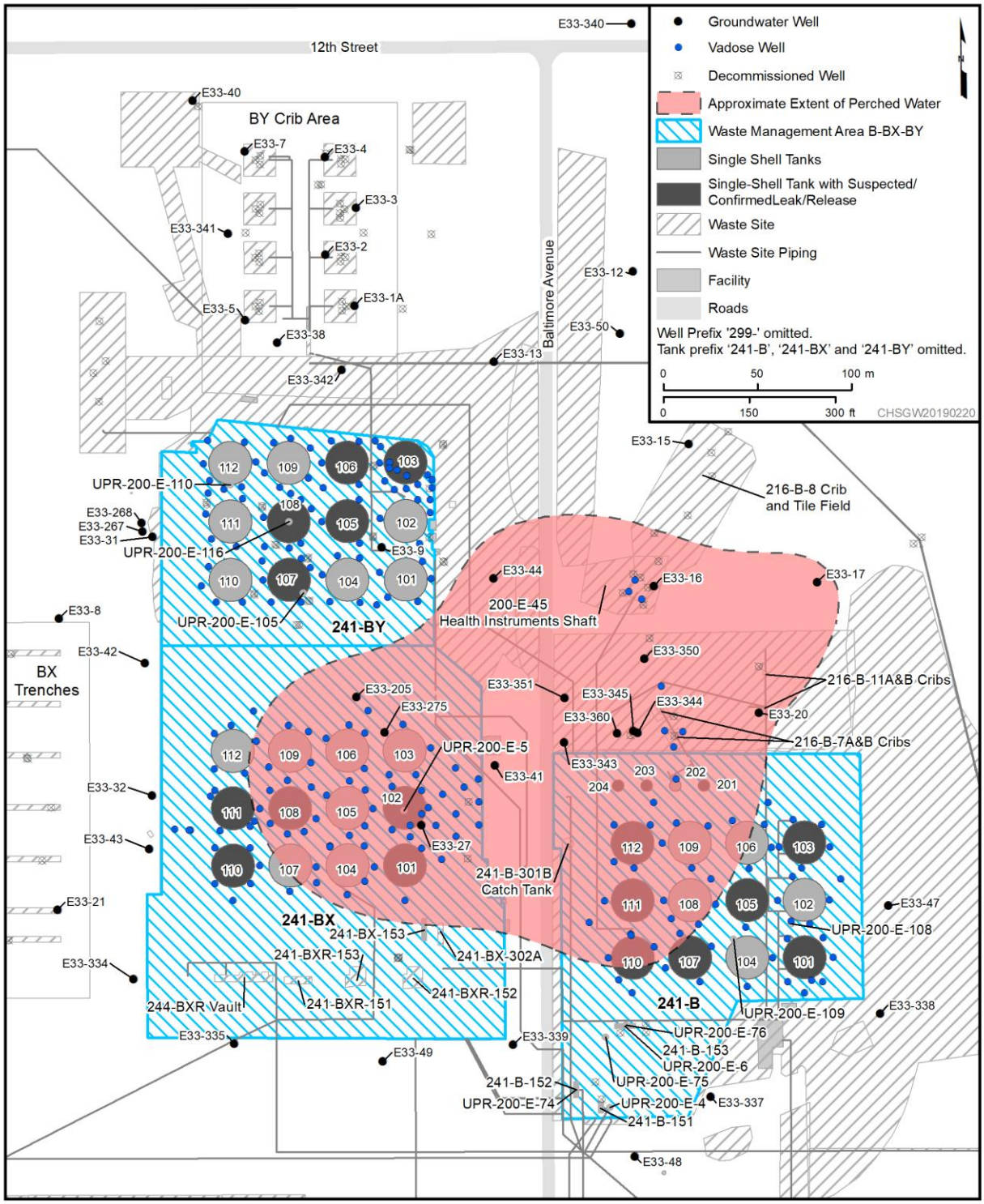


Figure 1-8. Location of the B-BX-BY Tank Farms in the B Complex Area

The major sources of the contaminated perched water are thought to be 200-DV-1 OU waste sites 216-B-7A&B and 216-B-8 Cribs (which were used for subsurface infiltration of liquid wastes) and SST 241-BX-102 (which released liquid waste to the subsurface when it was inadvertently overfilled). Table 4-4 in DOE/RL-2009-127, *Remedial Investigation Report for the 200-BP-5 Groundwater Operable Unit*, provides the following summary information regarding the sources:

- **216-B-7A&B Cribs:** Moderately contaminated waste stream with technetium-99, chromium, and nitrate
- **216-B-8 Crib:** Moderately contaminated waste stream with technetium-99, iodine-129, chromium, and nitrate
- **Unplanned release UPR-200-E-131 (near tank 241-BX-102):** Highly contaminated waste stream that included uranium, technetium-99, tritium, iodine-129, and nitrate

Table 3-1 in DOE/RL-2009-127 lists the waste streams discharged to the 216-B-7A&B and 216-B-6 Cribs. The volume and inventory estimates discharged to these cribs are listed in Table 3-2. Sampling results and uranium isotopic signatures from the 2008 drilling and sampling of wells 299-E33-343, 299-E33-344, and 299-E33-345 indicate that uranium from UPR-200-E-131 (near tank 241-B-102) migrated northeast from the tank (Sections 3.4.2, 3.4.3, 9.3, and 9.8 in PNNL-19277).

The BY Cribs and 216-B-50 Crib are located north of the BY Tank Farm, and the 216-B-57 Crib is located northwest of the BY Tank Farm. These 200-DV-1 OU waste sites are unlikely to have contributed contamination to the perched water zone.

1.2.4 Contaminant Plumes

The perched water is a persistent source of contamination to the underlying unconfined aquifer in the 200-BP-5 OU (DOE/RL-2013-52, *Sampling and Analysis Plan for Perched Water Wells C8914 and C8915 in the 200-DV-1 Operable Unit*). A NTCRA authorized via DOE/RL-2016-41, *Action Memorandum for 200-BP-5 Operable Unit Groundwater Extraction*, is being performed in the 200-BP-5 OU to remove uranium and technetium-99 from groundwater.

1.3 Data Quality Objective Summary

The DQO process is a strategic planning approach to define the criteria that a data collection design should satisfy. This process is used to ensure that the type, quantity, and quality of environmental data used in decision making will be appropriate for the intended application. The DQOs for this SAP were developed in accordance with EPA/240/B-06/001, *Guidance on Systematic Planning Using the Data Quality Objectives Process* (EPA QA/G-4). The DQO process involves a series of logical steps used to plan for the resource-effective acquisition of environmental data. The performance and acceptance criteria are determined through the DQO process, which serves as the basis for designing the plan to collect data (including the well design process) of appropriate quality and sufficient quantity to support project goals. This section summarizes the key outputs from the DQO process.

1.3.1 Statement of the Problem

Perched water containing contaminants from historical releases and discharges from several nearby facilities used to dispose liquid process waste is a significant, persistent contaminant source to the underlying unconfined aquifer in the 200-BP-5 OU. Additional extraction wells are needed to increase the removal rate of contaminated perched water. Additional soil/sediment and perched water contaminant concentration data, along with updated perched water extraction data, are needed to enable evaluation of

remediation alternatives within and surrounding the perched water zone for protection of groundwater and to refine the CSM of the perched water zone.

1.3.2 Decision Statements and Decision Rules

The DQO process identifies the key decisions and goals that must be addressed to achieve the final solution to the problem statement. This SAP addresses extraction and monitoring well installations and associated data collection at selected depths and locations to solve the problem statement. The key questions that the data collection must address are presented in decision statements (DSs).

The DSs consolidate potential questions and alternative actions. Decision rules (DRs) are generated from the DSs. A DR is an "IF…THEN…ELSE" statement incorporating the parameter of interest, unit decision making, action level, and actions resulting from resolution of the decision. Tables 1-2 and 1-3 present the DSs and DRs, respectively, as identified during the DQO process.

Table 1-2. Decision Statements

DS #	Decision Statement
1	Determine whether the hydrogeologic characteristics and physical parameters of the perched water zone (i.e., upper silt-dominated CCU, CCU-PZSd, and CCU-PZSt) are adequately understood to support design, construction, and operation of extraction and monitoring wells.
2	Determine whether the contamination in the perched water zone is adequately understood to support planning and implementation of treatment of contamination in the perched water zone.
3	Determine whether the physical and chemical parameters in the vadose zone (i.e., including the zone above the upper-silt dominated CCU and CCUg immediately below the CCU-PZSt) are adequately understood to support design, construction, and operation of extraction wells as well as implementation of treatment of the perched water zone.
4	Determine whether the extraction rate potential for each well and collectively for an enhanced extraction well network can be estimated in relation to predicting perched water dewatering performance.

CCU = Cold Creek unit
CCUg = Cold Creek unit gravel
CCU-PZSd = Cold Creek unit – perched zone sand
CCU-PZSt = Cold Creek unit – perched zone silt
DS = decision statement

Table 1-3. Decision Rules

DS #	DR #	Decision Rule
1	1	If the hydrogeologic characteristics and physical parameters of the perched water zone are adequately understood to support design, construction, and operation of extraction and monitoring wells, then no further data collection is required. Otherwise, collect additional data to define these properties for the perched water zone.
2	2	If the contamination in the perched water zone is adequately understood to support planning and implementation of treatment of the contamination, then no further data collection is required. Otherwise, collect additional contamination data.
3	3	If the physical and chemical parameters in the vadose zone (above and below the perched water zone) are adequately determined to support design, construction, and operation of extraction and monitoring wells and to support planning and implementation of treatment, then no further data collection is required. Otherwise, collect additional data to define these properties.
4	4	If the extraction rate potential for each well and collectively for an enhanced extraction well network can be estimated in relation to predicting perched water dewatering performance, then no further data collection is required. Otherwise, conduct additional analyses to provide these estimates.

DR = decision rule
DS = decision statement

1.3.3 Data Inputs and Sampling Designs

The supplemental data gathered from installing eight extraction and four monitoring wells in the 200-DV-1 OU perched water zone will address the DSs identified in Table 1-2. Table 1-4 summarizes the primary data inputs needed to resolve the DSs.

Table 1-4. Summary of Data Inputs to Resolve DSs

Data Inputs	DS #
Data Collection Specified in this SAP	
Sediment physical properties (bulk density, particle density, total porosity, particle size distribution, and saturated hydraulic conductivity) sample results from new extraction and monitoring wells to provide a better understanding of the hydrogeology to support design, construction, and operation of extraction and monitoring wells.	1, 3, and 4
Visual observations of cementation in samples from new extraction and monitoring wells to provide a better understanding of perching conditions to support design, construction, and operation of extraction wells.	1
X-ray microtomography images of the samples from new extraction and monitoring wells to provide visual characterization for sample selection for hydraulic conductivity measurements to support design, construction, and operation of extraction wells.	1 and 3
Hydraulic head distribution observations during drilling to better define hydraulic conditions to support design, construction, and operation of extraction wells.	1 and 4
Slug testing results to better define the vertical profile of hydraulic conductivity for the perched water zone to support design, construction, and operation of extraction and monitoring wells.	1 and 4
Geologic observations (during drilling, using visual observation and/or geophysical logging) of the contacts and transitions between the upper silt-dominated CCU, CCU-PZSd, and CCU-PZSt to better define the geologic framework to support design, construction, and operation of extraction and monitoring wells.	1 and 4
Geophysical logging (spectral gamma ray and neutron moisture) of each casing string of extraction and monitoring wells to better define the geologic framework to support design, construction, and operation of extraction and monitoring wells. Geophysical logs can also be used to characterize gamma-emitting contamination in the subsurface.	1, 2, and 3
Perched water (aqueous contaminants) sample results from new extraction and monitoring wells to better define the lateral and vertical extent and distribution of contaminant plumes to support planning and implementation of treatment of contamination in the perched water zone.	2, 3, and 4
Sediment (sorbed contaminants) sample results from new extraction and monitoring wells to better define the sorbed versus aqueous contaminant concentrations to support planning and implementation of treatment of contamination in the perched water zone.	2, 3, and 4
Contaminant transport-related (distribution coefficients, mineral phases, cementation, sediment geochemical parameters and organic content, and uranium isotopic ratios) sample results from extraction and monitoring wells to better define the transport parameters and potential sources to support planning and implementation of treatment of contamination in the perched water zone.	2, 3, and 4
Data Collection to be Specified in a Subsequent Hydraulic Test Plan*	
Hydraulic testing (TBD*) to better define large-scale transmissivity and storage properties to support design, construction, and operation of extraction and monitoring wells.	1 and 4
Hydraulic testing (TBD*) to better define the hydraulic conductivity for the CCU-PZSd to support design, construction, and operation of extraction and monitoring wells.	1 and 4

Table 1-4. Summary of Data Inputs to Resolve DSs

Data Inputs	DS #
Hydraulic testing (TBD*) to better define the vertical hydraulic conductivity (leakage factor) to support design, construction, and operation of extraction and monitoring wells, and planning and implementation of treatment of contamination in the perched water zone.	1, 2, and 3

*Data collection efforts for field hydraulic properties will mostly be specified and conducted under a separate hydraulic testing test plan that will be developed following the issuance of this SAP. Although not detailed in this SAP, development of the hydraulic testing test plan and completion of the associated aquifer hydraulic testing work are required tasks under this SAP.

CCU = Cold Creek unit
CCU-PZSd = Cold Creek unit – perched zone sand
CCU-PZSt = Cold Creek unit – perched zone silt
DS = decision statement
SAP = sampling and analysis plan
TBD = to be determined

Chapter 3 discusses the data collection efforts required to resolve each DS, the estimated number of depth-discrete samples to be collected from each well, the analyses to be performed on individual samples, and additional testing to be performed and measurements to be collected (e.g., slug testing and geophysical logging).

1.4 Analytical Approach

Table 1-5 lists the total sediment contaminant concentration constituents and physical properties for analysis of soil/sediment samples collected during drilling. Table 1-6 lists the chemical and radiochemical constituents for which perched water samples (collected post-development) will be analyzed.

Table 1-5. Constituents and Physical Properties for Soil/Sediment Samples During Drilling

COC	CAS Number*	Purpose
Sediment Constituents		
Americium-241	14596-10-2	200-DV-1 OU waste site COPC
Carbon-14	14762-75-5	Used for comparison to perched water concentrations; 200-DV-1 OU waste site COPC
Cesium-137	10045-97-3	200-DV-1 OU waste site COPC
Cobalt-60	10198-40-0	200-DV-1 OU waste site COPC
Europium-152	14683-23-9	200-DV-1 OU waste site COPC
Europium-154	15585-10-1	200-DV-1 OU waste site COPC
Europium-155	14391-16-3	200-DV-1 OU waste site COPC
Iodine-129	15046-84-1	Used for comparison to perched water concentrations; 200-DV-1 OU waste site COPC
Neptunium-237	13994-20-2	200-DV-1 OU waste site COPC
Nickel-63	13981-37-8	200-DV-1 OU waste site COPC
Plutonium-238	13981-16-3	200-DV-1 OU waste site COPC
Plutonium-239/240	PU-239/240	200-DV-1 OU waste site COPC
Strontium-90	10098-97-2	200-DV-1 OU waste site COPC
Technetium-99	14133-76-7	Used for comparison to perched water concentrations; 200-DV-1 OU waste site COPC

Table 1-5. Constituents and Physical Properties for Soil/Sediment Samples During Drilling

COC	CAS Number*	Purpose
Tritium	10028-17-8	Used for comparison to perched water concentrations; 200-DV-1 OU waste site COPC
Uranium-233	13968-55-3	Used for comparison to perched water concentrations; 200-DV-1 OU waste site COPC
Uranium-234	13966-29-5	Used for comparison to perched water concentrations; 200-DV-1 OU waste site COPC
Uranium-235	15117-96-1	Used for comparison to perched water concentrations; 200-DV-1 OU waste site COPC
Uranium-238	U-238	Used for comparison to perched water concentrations; 200-DV-1 OU waste site COPC
Aluminum	7429-90-5	200-DV-1 OU waste site COPC
Antimony	7440-36-0	200-DV-1 OU waste site COPC
Arsenic	7440-38-2	Used for comparison to perched water concentrations
Barium	7440-39-3	Constituent for other 200-DV-1 OU borings in area
Cadmium	7440-43-9	Used for comparison to perched water concentrations; 200-DV-1 OU waste site COPC
Calcium	7440-70-2	Used for comparison to perched water concentrations
Chromium, total	7440-47-3	Used for comparison to perched water concentrations; 200-DV-1 OU waste site COPC
Chromium, hexavalent	18540-29-9	Used for comparison to perched water concentrations; 200-DV-1 OU waste site COPC
Copper	7440-50-8	200-DV-1 OU waste site COPC
Iron	7439-89-6	Used for comparison to perched water concentrations, to establish baseline geochemistry, and to evaluate reduction-oxidation minerals
Lead	7439-92-1	200-DV-1 OU waste site COPC
Magnesium	7439-95-4	Used for comparison to perched water concentrations
Manganese	7439-96-5	Used for comparison to perched water concentrations, to establish baseline geochemistry, and to evaluate reduction-oxidation minerals; 200-DV-1 OU waste site COPC
Mercury	7439-97-6	200-DV-1 OU waste site COPC
Molybdenum	7439-98-7	Used for comparison to perched water concentrations
Nickel	7440-02-0	Used for comparison to perched water concentrations; 200-DV-1 OU waste site COPC
Potassium	7440-09-7	Used for comparison to perched water concentrations
Selenium	7782-49-2	200-DV-1 OU waste site COPC
Silver	7440-22-4	200-DV-1 OU waste site COPC
Sodium	7440-23-5	Used for comparison to perched water concentrations
Uranium	7440-61-1	Used for comparison to perched water concentrations; 200-DV-1 OU waste site COPC
Ammonia	7664-41-7	200-DV-1 OU waste site COPC

Table 1-5. Constituents and Physical Properties for Soil/Sediment Samples During Drilling

COC	CAS Number*	Purpose
Cyanide	57-12-5	Used for comparison to perched water concentrations; 200-DV-1 OU waste site COPC
Alkalinity	ALKALINITY	Used for comparison to perched water concentrations
Bicarbonate alkalinity	HCO3ALKALINITY	Used for comparison to perched water concentrations
Carbonate alkalinity	CO3ALKALINITY	Used for comparison to perched water concentrations
Chloride	16887-00-6	Used for comparison to perched water concentrations; 200-DV-1 OU waste site COPC
Fluoride	16984-48-8	Used for comparison to perched water concentrations; 200-DV-1 OU waste site COPC
Nitrate	14797-55-8	Used for comparison to perched water concentrations, 200-DV-1 OU waste site COPC
Nitrite	14797-65-0	Used for comparison to perched water concentrations; 200-DV-1 OU waste site COPC
Phosphate	14265-44-2	200-DV-1 OU waste site COPC
Sulfate	14808-79-8	Used for comparison to perched water concentrations; 200-DV-1 OU waste site COPC
Sulfide	18496-25-8	Used for comparison to perched water concentrations
pH	N/A	Used for comparison to perched water concentrations and to establish baseline geochemistry
Total organic carbon	TOC	Used for comparison to perched water concentrations and to establish baseline geochemistry
Total inorganic carbon	TINC	Used for comparison to perched water concentrations and to establish baseline geochemistry
Sediment Physical Properties		
Bulk density, particle density, and porosity	N/A	Used in evaluating soil texture needed to support geologic interpretation and interpretation of physical and chemical testing data, and for providing parameter inputs to fate and transport modeling
Particle size distribution	N/A	Used in evaluating soil texture needed to support geologic interpretation and interpretation of physical and chemical testing data, as well as the design, construction, and operation of extraction and monitoring wells
Saturated hydraulic conductivity	N/A	Used in geologic interpretation and provides parameter inputs to fate and transport modeling

Note: Modified from Table 1-2 in DOE/RL-2011-104, *Characterization Sampling and Analysis Plan for the 200-DV-1 Operable Unit*; as amended by TPA-CN-668, *Tri-Party Agreement Change Notice Form: TPA-CN-668: DOE/RL-2011-104, REV. 0, Characterization Sampling and Analysis Plan for the 200-DV-1 Operable Unit*, which removed radium-226, radium-228, and thorium-232 from the list of COPCs for the 200-DV-1 OU.

*The Hanford Environmental Information System database constituent identification number is used.

CAS = Chemical Abstracts Service
COC = contaminant of concern
COPC = contaminant of potential concern
N/A = not applicable
OU = operable unit

Table 1-6. Constituents for Perched Water Post-Development Samples

COC	CAS Number[a]
Technetium-99	14133-76-7
Tritium	10028-17-8
Nitrate	14797-55-8
Chromium, total [b]	7440-47-3
Chromium, hexavalent	18540-29-9
Uranium [b]	7440-61-1[b]
Non-COC	**CAS Number[a]**
Carbon-14	14762-75-5
Iodine-129	15046-84-1
Uranium-233	13968-55-3
Uranium-234	13966-29-5
Uranium-235	15117-96-1
Uranium-238	U-238
Arsenic[b]	7440-38-2
Cadmium[b]	7440-43-9
Calcium[b]	7440-70-2
Iron[b]	7439-89-6
Magnesium[b]	7439-95-4
Manganese[b]	7439-96-5
Molybdenum[b]	7439-98-7
Nickel[b]	7440-02-0
Potassium[b]	7440-09-7
Sodium[b]	7440-23-5
Alkalinity	ALKALINITY
Bicarbonate alkalinity	HCO3ALKALINITY
Carbonate alkalinity	CO3ALKALINITY
Cyanide[c]	57-12-5 and FREE-CN
Chloride	16887-00-6
Fluoride	16984-48-8
Nitrite	14797-65-0
Sulfate	14808-79-8
Sulfide	18496-25-8
Total inorganic carbon	TINC
Total organic carbon	TOC
Total dissolved solids	TDS

Table 1-6. Constituents for Perched Water Post-Development Samples

COC	CAS Number[a]
Field Parameters[d]	
Dissolved oxygen	N/A
Oxidation-reduction potential	N/A
pH	N/A
Specific conductance	N/A
Temperature	N/A
Turbidity	N/A
Barometric pressure[e]	N/A

Note: Perched water COCs are identified in DOE/RL-2014-34, *Action Memorandum for 200-DV-1 Operable Unit Perched Water Pumping/Pore Water Extraction*.

a. The Hanford Environmental Information System database constituent identification number is used.

b. Both filtered and unfiltered samples will be collected for all metal constituents except hexavalent chromium (filtered only).

c. The post-development perched water sample will be analyzed for both free and total cyanide.

d. Field screening parameters will be collected in accordance with DOE/RL-96-68, *Hanford Analytical Services Quality Assurance Requirements Document, Vol. 3, Field Analytical Technical Requirements*.

e. Barometric pressure readings will be taken from the nearest in-service Hanford Site barometric station to a well at the approximate time of sampling.

CAS = Chemical Abstracts Service
COC = contaminant of concern
N/A = not applicable

A tiered approach for analyses will be used on individual samples for the data collection necessary to resolve the DSs previously described. The following discussion and tables describe the tiered approach and how it will be implemented to address specific DSs.

Hydrogeologic characterization of the perched water zone supporting DS #1 and DS #4 will be performed at all well locations for the proposed samples and analyses described in Table 1-7. Particle size distribution for well construction will be determined by a light scattering method using sample material provided to Pacific Northwest National Laboratory (PNNL). In addition, a slug test will be performed at each well after final development. Information regarding slug testing is provided in Section 3.5.1.4. During a slug test, the water level in a well is quickly changed by inserting, removing, or otherwise displacing a known volume of water inside the well. The subsequent water-level response is then monitored until the imposed displacement has recovered to the static or pre-test water level. These data are used to estimate hydraulic properties representing aquifer conditions in proximity to the well. The information gathered will support development of the technical basis for increasing perched water extraction.

Characterization of contaminants in the perched water zone (supporting DS #2 and DS #4) will be accomplished using a tiered approach. Table 1-8 lays out this tiered approach. Tier 1 includes characterizing contaminant distribution based on the analyses of aqueous and sediment samples from all well locations. Samples will be selected for specific Tier 2 analyses based on the Tier 1 analysis results and/or physical properties characteristics. For example, if total uranium is detected in a sample (Tier 1

analysis), then the sample will be analyzed for isotopic uranium (Tier 2 analysis). Tier 2 analyses and testing include more advanced analytical techniques designed to investigate contaminant geochemistry and mobility. The information obtained through these tiered analyses is intended to create the technical basis for increasing contaminant recovery via extraction and to support future evaluation of remediation alternatives within the perched water zone for protection of groundwater.

Table 1-7. Hydrogeologic and Physical Characterization for the Perched Water Zone Analyses to Address DS #1 and DS #4

Analysis	Targeted Units	Proposed Locations for Analyses
Sediment physical characteristics[a]	Upper silt-dominated CCU, CCU-PZSd, and CCU-PZSt	Sample(s) from each hydrogeologic unit at all well locations
Visual examination of cementation[a]	CCU-PZSt	At all well locations
X-ray microtomography imaging[a]	CCU-PZSd and CCU-PZSt	Selected core(s) from each hydrogeologic unit at all well locations
Field-derived hydraulic aquifer properties[b]	CCU-PZSd	Hydraulic test plan
Hydraulic conductivity[a]	CCU-PZSd and CCU-PZSt	Selected core(s) from each hydrogeologic unit at all well locations
Hydraulic head distribution	CCU-PZSd	At all well locations
Geophysical and geologic logging	Upper silt-dominated CCU, CCU-PZSd, and CCU-PZSt	At all well locations

a. Testing/analysis performed by Pacific Northwest National Laboratory per Section 2.1.4.

b. Data collection efforts for field hydraulic properties will be specified and conducted under a separate hydraulic testing test plan that will be developed following the issuance of this SAP. Although not detailed in this SAP, development of the hydraulic testing test plan and completion of the associated aquifer hydraulic testing work are required tasks under this SAP.

CCU = Cold Creek unit
CCU-PZSd = Cold Creek unit – perched zone sand
CCU-PZSt = Cold Creek unit – perched zone silt
SAP = sampling and analysis plan

Table 1-8. Tiered Analyses for Contaminant Characterization of the Perched Water Zone to Address DS #2 and DS #4

Analysis	Targeted Units	Proposed Locations for Analyses
Tier 1		
Total aqueous and sediment contaminant concentrations (e.g., water/acid extractions)	Upper silt-dominated CCU, CCU-PZSd, and CCU-PZSt	Sample(s) from each hydrogeologic unit at all well locations
Tier 2		
Contaminant mobility and mineral phase analyses (e.g., column leaching, solid phase, and cementation analyses)[a]	Select samples based on Tier 1 analysis results	
Sediment sorptive/reactive capacity (e.g., Fe/Mn extractions)[a]		
Aqueous/sediment geochemistry[a]		
Uranium isotope analysis[b]		

Table 1-8. Tiered Analyses for Contaminant Characterization of the Perched Water Zone to Address DS #2 and DS #4

Analysis	Targeted Units	Proposed Locations for Analyses

a. Testing/analysis performed by Pacific Northwest National Laboratory per Section 2.1.4.

b. Results for total uranium and technetium-99 from Tier 1 analyses will be used to facilitate the selection of samples for Tier 2 analyses. Isotopic uranium analysis will be performed for a sample if total uranium is detected at a concentration greater than the PQL. For samples where total uranium or technetium-99 are detected (greater than the PQL), Tier 2 analyses will be performed.

CCU = Cold Creek unit
CCU-PZSd = Cold Creek unit – perched zone sand
CCU-PZSt = Cold Creek unit – perched zone silt
PQL = practical quantitation limit

Table 1-9 presents the tiered approach and the analyses to address DS #3 and DS #4. The physical and chemical characterization of the vadose zone (i.e., zones above the upper silt-dominated CCU and immediately below the CCU-PZSt and above the water table, and the CCUg) will begin with determining contaminant concentrations (aqueous and sediment) and physical properties testing (Table 1-5) at all locations for the CCUg (Tier 1 analyses). Tier 2 analyses are proposed based on the Tier 1 results. This information is needed to determine the extent of contamination and the potential for contaminant migration into and outside of the perched water zone.

Table 1-9. Tiered Analyses for Physical and Chemical Characterization of the Vadose Zone (Above and Below the Perched Water Zone) to Address DS #3 and DS #4

Analysis	Targeted Units	Proposed Locations for Analyses
Tier 1		
Total aqueous and sediment contaminant concentrations (e.g., water/acid extractions)	CCUg, above the upper silt-dominated CCU	Sample at all well locations
X-ray microtomography imaging[a]	CCUg	Selected core(s) at all well locations
Sediment physical characterization[a]	CCUg, above the upper silt-dominated CCU	Samples at all wells
Visual examination of cementation[a]	CCUg	Sample(s) at all well locations
Tier 2		
Aqueous/sediment geochemistry[a]	CCUg	Select samples based on the results of contaminant concentrations in the CCUg (Tier 1)
Contaminant mobility and mineral phase analyses (e.g., column leaching, solid-phase, and cementation analyses)[a]	CCUg	
Hydraulic conductivity[a]	CCUg	
Aqueous/sediment geochemistry[a]	Above the upper silt-dominated CCU	Select samples based on the results of contaminant concentrations in these units as determined during Tier 2 analyses
Contaminant mobility and mineral phase analyses (e.g., column leaching and solid-phase analyses)[a]	Above the upper silt-dominated CCU	
Uranium isotope analysis[b]	Above the upper silt-dominated CCU	

Table 1-9. Tiered Analyses for Physical and Chemical Characterization of the Vadose Zone (Above and Below the Perched Water Zone) to Address DS #3 and DS #4

Analysis	Targeted Units	Proposed Locations for Analyses

a. These tests/analyses will be performed by Pacific Northwest National Laboratory per Section 2.1.4.

b. Isotopic uranium analysis will be triggered based on the total uranium analysis results for each sample. Isotopic uranium analysis will be performed for a sample if total uranium is detected at a concentration greater than the practical quantitation limit.

CCU = Cold Creek unit

CCUg = Cold Creek unit gravel

1.5 Project Schedule

A phased approach will be followed for installing and sampling the new perched water extraction and monitoring wells. Phase 1 (from FY 2020 through FY 2022) will include installing eight new extraction wells (PZ-1 through PZ-8) and four new monitoring wells (PZ-9 though PZ-12). The tentative plan for FY 2020 is to install two of the eight extraction wells, with installation of the remaining Phase 1 extraction and monitoring wells anticipated to occur in FY 2021 and FY 2022. The actual schedule for installation, construction, and operation of the extraction and monitoring wells will be determined based on priority of Hanford Site work activities and available funding each FY.

The Phase 2 comparative evaluation of vertical drilling within the B-BX-BY Tank Farm boundaries and horizontal drilling of a single extraction well will be initiated in FY 2020. The geologic information and the sampling and testing results from the Phase 1 well drilling and installation, along with the alternative drilling scenario evaluations, are intended to provide the information necessary to plan Phase 3. The actual schedule for work to be performed will be determined based on priority of Hanford Site work activities and available funding each FY.

2 Quality Assurance Project Plan

A quality assurance project plan (QAPjP) establishes the quality requirements for environmental data collection. It includes planning, implementation, and assessment of sampling tasks, field measurements, laboratory analysis, and data review. This chapter describes the applicable environmental data collection requirements and controls based on the quality assurance (QA) elements found in EPA/240/B-01/003, *EPA Requirements for Quality Assurance Project Plans* (EPA QA/R-5); and DOE/RL-96-68, *Hanford Analytical Services Quality Assurance Requirements Document* (HASQARD). DoD/DOE, 2019, *Department of Defense (DoD) Department of Energy (DOE) Consolidated Quality Systems Manual (QSM) for Environmental Laboratories* (hereinafter referred to as the DoD/DOE Quality Systems Manual [QSM]), is also discussed. Section 7.8 of Ecology et al., 1989b, *Hanford Federal Facility Agreement and Consent Order Action Plan* (Tri-Party Agreement Action Plan), requires QA/quality control (QC) and sampling and analysis activities to specify the QA requirements for past-practice processes. This QAPjP also describes applicable requirements and controls based on guidance in Washington State Department of Ecology (Ecology) Publication No. 04-03-030, *Guidelines for Preparing Quality Assurance Project Plans for Environmental Studies*; and EPA/240/R-02/009, *Guidance for Quality Assurance Project Plans* (EPA QA/G-5). This QAPjP supplements the contractor's environmental QA program plan.

This QAPjP includes the following sections that describe the quality requirements and controls applicable to Hanford Site OU sampling activities:

- Section 2.1, "Project Management"
- Section 2.2, "Data Generation and Acquisition"
- Section 2.3, "Assessment and Oversight"
- Section 2.4, "Data Review and Usability"

2.1 Project Management

The following sections discuss the project goals, planned management approaches, and planned output documentation.

2.1.1 Project/Task Organization

The contractor, or its approved subcontractor, is responsible for planning, coordinating, sampling, and shipping samples to the laboratory. The contractor is also responsible for preparing and maintaining configuration control of the SAP and assisting the DOE Richland Operations Office (DOE-RL) project manager in obtaining approval of the SAP and future proposed revisions to the SAP. The project organization is described in the following sections and is shown in Figure 2-1.

2.1.1.1 Regulatory Lead

Ecology is the lead regulatory agency for the 200-DV-1 OU and is responsible for regulatory oversight of cleanup projects and activities. The U.S. Environmental Protection Agency (EPA) retains approval authority for all SAPs. Ecology works with EPA and DOE-RL to resolve concerns regarding the work described in this SAP in accordance with Ecology et al., 1989a, *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement).

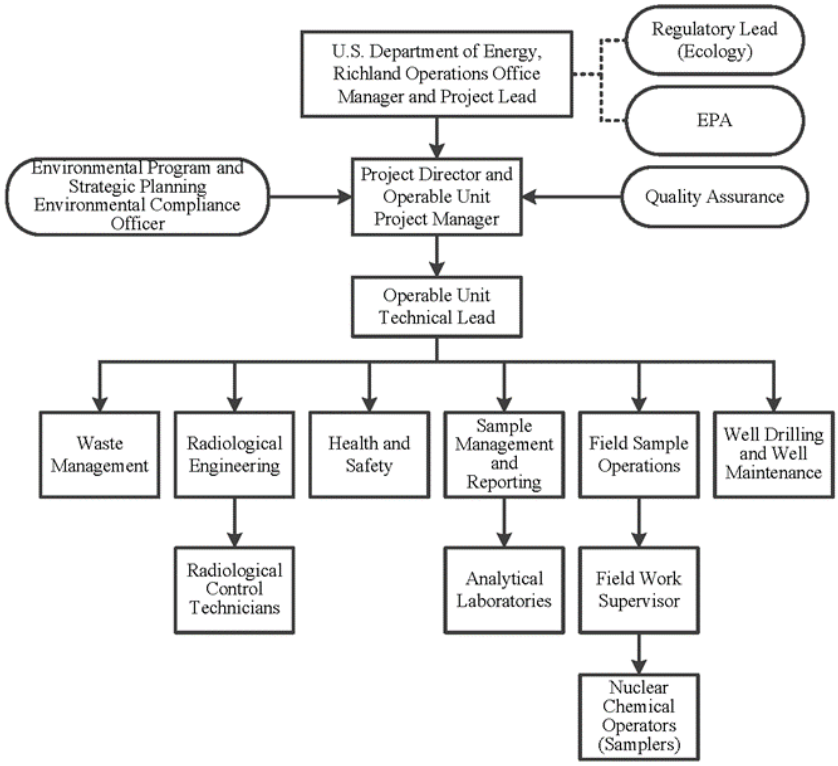


Figure 2-1. Project Organization

2.1.1.2 DOE-RL Manager

Hanford Site cleanup in the 200-DV-1 OU is the responsibility of DOE-RL. The DOE-RL 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* (CERCLA); RCRA; the *Atomic Energy Act of 1954* (AEA); and the Tri-Party Agreement (Ecology et al., 1989a).

2.1.1.3 DOE-RL Project Lead

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

2.1.1.4 Remedy Selection and Implementation Project Director

The Remedy Selection and Implementation project director provides oversight and coordinates with DOE-RL and primary contractor management in support of sampling and reporting activities. The Remedy Selection and Implementation project director also provides support to the OU project manager to ensure that work is performed safely and cost effectively.

2.1.1.5 Operable Unit Project Manager

The OU project manager (or designee) is responsible and accountable for project-related activities including coordinating with DOE-RL, the regulatory agencies, and contractor management in support of sampling activities to ensure that work is performed safely, compliantly, and cost effectively. In addition, the OU project manager (or designee) is also responsible for managing sampling documents

and requirements, field activities, subcontracted tasks, and for ensuring that the project file is properly maintained.

2.1.1.6 Operable Unit Technical Lead

The OU technical lead is responsible for developing specific sampling design, analytical requirements, and QC requirements, either independently or as defined through a systematic planning process. The OU technical lead ensures that sampling and analysis activities (as delegated by the OU project manager) are carried out in accordance with the SAP and works closely with the environmental compliance officer, QA, Health and Safety, the well drilling and well maintenance group, the field work supervisor (FWS), and the Sample Management and Reporting (SMR) organization to integrate these and other technical disciplines in planning and implementing the work scope.

2.1.1.7 Sample Management and Reporting

The SMR organization oversees offsite analytical laboratories, coordinates laboratory analytical work to ensure that laboratories conform to the requirements of this plan, and verifies that laboratories are qualified to perform Hanford Site analytical work. SMR generates field sampling documents, labels, and instructions for field sampling personnel and develops the sample authorization form (SAF), which provides information and instructions to the analytical laboratories. SMR ensures that field sampling documents are revised to reflect approved changes. SMR receives analytical data from the laboratories, ensures that the data are appropriately reviewed, performs data entry into the Hanford Environmental Information System (HEIS) database, and arranges for data validation and recordkeeping. SMR is responsible for resolving sample documentation deficiencies or issues associated with Field Sample Operations (FSO), laboratories, or other entities. SMR is also responsible for informing the OU project manager of any issues reported by the analytical laboratories.

2.1.1.8 Field Sampling Operations

FSO is responsible for planning and coordinating field sampling resources. The FWS directs the nuclear chemical operators (samplers) who collect samples in accordance with this SAP and corresponding standard methods and work packages. The FWS ensures that deviations from field sampling documents or issues encountered in the field are documented appropriately (e.g., in the field logbook). This includes documenting additional sampling requirements as determined by the OU technical lead and OU project manager based on field conditions. The FWS ensures that samplers are appropriately trained and available. Samplers collect samples in accordance with sampling requirements. Samplers also complete field logbooks, data forms, and chain-of-custody forms (including any shipping paperwork), and enable delivery of the samples to the analytical laboratory.

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

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

2.1.1.9 Quality Assurance

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

2.1.1.10 Environmental Compliance Officer

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

2.1.1.11 Health and Safety

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

2.1.1.12 Radiological Engineering

Radiological Engineering is responsible for the following:

- Providing radiological engineering and project health physics support
- Conducting as low as reasonably achievable reviews, exposure and release modeling, and radiological controls optimization
- Identifying radiological hazards and ensuring appropriate controls are implemented to maintain worker exposures to hazards at as low as reasonably achievable levels
- Interfacing with the project Health and Safety representative and other appropriate personnel as needed to plan and direct project radiological control technician (RCT) support

2.1.1.13 Waste Management

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

2.1.1.14 Analytical Laboratories

The analytical laboratories accept, manage, prepare, and analyze samples in accordance with established methods and the requirements of their subcontract, and provide necessary data packages containing analytical and QC results. Laboratories provide explanations of results to support data review and in response to resolution of analytical issues. Laboratory quality requirements are consistent with HASQARD requirements (DOE/RL-96-68). The laboratories are evaluated under the DOE Consolidated Audit–Accreditation Program or its successor programs to DoD/DOE (2019) QSM requirements. The HASQARD requirements (beyond those within the DoD/DOE QSM) are also evaluated under the DOE Consolidated Audit–Accreditation Program. Laboratories are accredited by Ecology for the Tier 1 chemical and radiochemical analyses performed under this SAP.

The hydrogeological and physical properties analyses performed by PNNL will be done in accordance with the methods and requirements listed in Table 2-3 (or equivalent), with any modifications necessary based on the specialized testing. The methodologies and laboratory analytical approach for the specialized testing are described in the PNNL laboratory plans and procedures using a quality approach in accordance with ASME NQA-1-2012, *Quality Assurance Requirements for Nuclear Facility Applications*.

2.1.1.15 Well Drilling and Well Maintenance

The well drilling and maintenance and the well coordination and planning managers are responsible for the following:

- Planning, coordinating, and executing drilling construction
- Performing well maintenance activities
- Coordinating with the OU technical lead regarding field constraints that could affect sampling design
- Coordinating well decommissioning with DOE-RL in accordance with the substantive standards of WAC 173-160

2.1.2 Quality Objectives and Criteria

The QA objective of this plan is to ensure that the generation of analytical data of known and appropriate quality is acceptable and useful in order to meet the evaluation requirements identified in this SAP. Data descriptors known as data quality indicators (DQIs) help determine the acceptability and usefulness of data to the user. The principal DQIs (precision, accuracy, representativeness, comparability, completeness, bias, and sensitivity) are defined for the purposes of this SAP in Table 2-1.

Data quality is defined by the degree of rigor in the acceptance criteria assigned to the DQIs. The acceptance criteria are typically set by the analytical method itself; however, project-specific requirements require more stringent acceptance criteria. Section 2.2.1 lists the project-specific acceptance criteria. 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 DQIs are evaluated during a process to assess data usability (Section 2.4.3).

2.1.3 Methods-Based Analysis

Laboratory testing for the analytes discussed in Section 2.2.1 may include nontarget analytes that are part of the analytical method (i.e., methods-based reporting). The additional constituents that are part of the method and reported by the laboratory are for informational purposes. Analytical performance requirements will be applicable only to the analytes specific to this SAP. Poor QC related to nontarget analyte results would not result in any required corrective action by the laboratory, except for the application of proper result qualification flags.

Table 2-1. Data Quality Indicators

Data Quality Indicator (QC Element)[a]	Definition	Determination Methodologies	Corrective Actions
Precision (field duplicates, laboratory sample duplicates, and matrix spike duplicates)	Precision measures the agreement among a set of replicate measurements. Field precision is assessed through the collection and analysis of field duplicates. Analytical precision is estimated by duplicate/ replicate analyses, usually on laboratory control samples, spiked samples, and/or field samples. The most commonly used estimates of precision are the relative standard deviation and, when only two samples are available, the relative percent difference.	Use the same analytical instrument to make repeated analyses on the same sample. Use the same method to make repeated measurements of the same sample within a single laboratory. Acquire replicate field samples for information on sample acquisition, handling, shipping, storage, preparation, and analytical processes and measurements.	If duplicate data do not meet objective: • Evaluate apparent cause (e.g., sample heterogeneity). • Request reanalysis or remeasurement. • Qualify the data before use.
Accuracy (laboratory control samples, matrix spikes, tracers, and carriers	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.
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 2-1. Data Quality Indicators

Data Quality Indicator (QC Element)[a]	Definition	Determination Methodologies	Corrective Actions
Comparability (field duplicate, field splits, laboratory control samples, matrix spikes, and matrix spike duplicates)	Comparability expresses the degree of confidence with which one data set can be compared to another. It is dependent upon the proper design of the sampling program and will be satisfied by ensuring that the approved plans are followed and that proper sampling and analysis techniques are applied.	Use identical or similar sample collection and handling methods, sample preparation and analytical methods, holding times, and QA protocols.	If data are not comparable to other data sets: • Identify appropriate changes to data collection and/or analysis methods. • Identify quantifiable bias, if applicable. • Qualify the data as appropriate. • Resample and/or reanalyze if needed. • Revise sampling/analysis protocols to ensure future comparability.
Completeness (no QC element; addressed in data usability assessment)	Completeness is a measure of the amount of valid data collected compared to the amount 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 data sets do 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 practices to limit preferential selection or loss of sample media. • Use sample handling practices, including proper sample preservation, that limit the loss or gain of constituents to the sample media. • Analytical data that are known to be affected by either sampling or analytical bias are flagged to indicate possible bias. • Laboratories that are known to generate biased data for a specific analyte are asked to correct their methods to remove the bias as best as practicable. Otherwise, samples are sent to other laboratories for analysis.

Table 2-1. Data Quality Indicators

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

Note: Based on SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods* (current update).

a. Acceptance criteria for QC elements are provided in Table 2-5.

b. For purposes of this sampling and analysis plan, the lower limit of quantitation is interchangeable with the practical quantitation limit.

QA = quality assurance

QC = quality control

2.1.4 Hydrogeologic and Physical Properties Analyses

Samples for physical property determinations will be collected to provide site-specific values to support screen design and modeling efforts. General soil properties of interest include pH, moisture content, saturated hydraulic conductivity, grain-size distribution, porosity, and soil bulk density. Hydrogeologic and physical property samples will be analyzed in accordance with the methods specified in Table 2-3. These samples will generally be collected from lithologies that represent the major facies in the vadose zone. The samples will be collected concurrently with geochemical split-spoon sample intervals (where possible), which ensures that the physical properties can be related back to the depth of the geochemical sample results. Physical properties analyses will be conducted as described in Tables 1-5, 1-7, 1-9, and 2-3 with specific split-spoon liners for the analyses selected by the OU technical lead in coordination with the project team and PNNL.

A subset of intact cores from particular hydrostratigraphic units of interest will be selected by the project team for x-ray microtomography imaging (XMT). The XMT results can be used to help guide selection of specific core samples for physical and hydraulic property characterization. The XMT system is located in the Environmental Molecular Science Laboratory at PNNL. The nominal resolution of the XMT system is approximately 1/1,000th of the largest sample dimension, which is sufficient for nondestructive imaging of individual gravel and larger size particles (as well as defects and voids) within the intact core samples. For the purposes of this work, the XMT images generated are qualitative and for information purposes only.

2.1.4.1 Geochemical Analyses

All geochemical study and analytical testing will be performed using a graded National Quality Assurance Program (NQAP) approach detailed in PNNL plans and procedures. The NQAP complies with DOE O 414.1D, *Quality Assurance*; and 10 CFR 830, Subpart A, “Nuclear Safety Management,” “Quality Assurance Requirements.” The NQAP uses ASME NQA-1-2012, Subpart 4.2.1, “Guidance on Graded Application of Nuclear Quality Assurance Standard for Research and Development,” as the basis for its graded approach to quality. Specific split-spoon liners and the specific set of analyses that will be applied will be selected by the OU technical lead in coordination with the project team and PNNL.

Samples will be analyzed for aqueous and sediment contaminant concentrations (following water and acid extractions) in accordance with Tables 1-8 and 1-9 using testing methods listed in Table 2-3 for the contaminants listed in Table 1-5. Based on these results, specialized testing will be conducted to determine contaminant geochemistry and sediment conditions for a selected set of samples (defined as Tier 2 analyses in Table 1-8 and as Tier 2 and Tier 3 analyses in Table 1-9). All geochemical analyses and testing (for the listed constituents in Table 1-5) conducted at PNNL will use the Table 2-3 methods and requirements (or equivalent), with any modifications necessary based on the specialized testing. Methodologies and laboratory analytical approaches for specialized testing are described in PNNL laboratory plans and procedures using the NQAP quality approach.

2.1.4.1.1 Sequential Extraction

Sequential extraction will be used to evaluate contamination mobility by determining the percentage of contaminants and key associated compounds present in the extractable phases of sediment samples and associated pore water. This test will involve a series of six sequential liquid extractions 91:3 sediment solution (Gleyzes et al., 2002, “Fractionation studies of trace elements in contaminated soils and sediments: a review of sequential extraction procedures”; Beckett, 1989, “The Use of Extractants in Studies on Trace Metals in Soils, Sewage Sludges, and Sludge-Treated Soils”; Larner et al., 2006, “Comparative study of optimized BCR sequential extraction scheme and acid leaching of elements in

certified reference material NIST 2711"; Sutherland and Tack, 2002, "Determination of Al, Cu, Fe, Mn, Pb, and Zn in certified reference materials using the optimized BCR sequential extraction procedure"; Massop and Davison, 2003, "Comparison of original and modified BCR sequential extraction procedures for the fractionation of copper, iron, lead, manganese, and zinc in soils and sediments") on the <2 mm grain-size fraction with measurement of targeted contaminants and constituents in the extracted solution. The sequential extractions will use the following reagents:

- **Extraction 1:** Artificial porewater (50 minutes) (PNNL-24297, *Extended Leach Testing of Simulated LAW Cast Stone Monoliths*)
- **Extraction 2:** 0.5M magnesium-nitrate (50 minutes)
- **Extraction 3:** pH 5 sodium-acetate (50 minutes)
- **Extraction 4:** pH 2.3 acetic acid/calcium-nitrate (5 days)
- **Extraction 5:** oxalate solution (50 minutes)
- **Extraction 6:** 8M nitric acid (2 hr at 95°C)

Extractions 1 through 5 will be conducted at room temperature (20°C to 25°C [68°F to 77°F]). An additional parallel extraction is also conducted using a 0.0144M $NaHCO_3$ + 0.0028M Na_2CO_3 solution (pH of 9.3) for 1,000 hours (Kohler et al., 2004, "Methods for Estimating Adsorbed Uranium (VI) and Distribution Coefficients of Contaminated Sediments").

2.1.4.1.2 Batch Leach Testing

Batch leach testing will be used to characterize the desorption or dissolution kinetics of contaminants. These batch experiments will use approximately 50 g of sediment and 200 mL of air-saturated artificial pore water (PNNL-24297). The low sediment-to-water ratio (compared to field at approximately 5 to 10 g/mL) should result in contaminant desorption to pore water and dissolution of some surface phases. Samples will be taken at specific times (e.g., 1, 10, 30, 100, 300, and 1,000 hours) to evaluate a wide range of time scales that are relevant to field-scale contaminant transport. The samples will be 0.45 µm filtered and analyzed for the targeted contaminants and constituents. Pre- and post-test sediments will be analyzed by acid extraction for the targeted contaminant and constituents.

2.1.4.1.3 Flow-Through Soil Column Leach Testing

Flow-through soil column leach tests are conducted to qualify the rate at which contaminants can be mobilized from the sediment. Tests will be performed using repacked sediment (<2 mm). The column (approximately 2.4 cm in diameter by 30 cm in length) will be filled in increments and tamped while being filled to minimize void space and channelized flow within the columns. The columns will be packed to a bulk density of approximately 1.65 g/cm^3 (or similar to that calculated from adjacent intact core liners, recognizing the difference in gran-size distribution).

Column leach tests are performed by slowly injecting air-saturated artificial pore water (PNNL-24297) into an upflow direction to remove as much trapped air as possible, thus creating near-water-saturation conditions. Experiments will be run for at least 50 to 100 pore volumes and will include stop-flow events. An example of a typical column experiment effluent sample collection is as follows:

- 0 to 2 pore volumes, 10 effluent samples
- 2 to 10 pore volumes, 10 effluent samples
- 10 to 60 pore volumes, 10 effluent samples
- 60 to 100 pore volumes, 4 effluent samples

Stop-flow events range from 10 to 1,000 hours with no flow to provide time for contaminants present in one or more surface phases on the sediment surface to partition into pore water (i.e., from diffusion from intraparticle pore space or time-dependent dissolution of precipitate phases or slow desorption). Stop flow will be conducted at approximately 2, 10, and 50 pore volumes. Samples will be analyzed for the targeted contaminants and constituents.

2.1.4.1.4 Ferrous/Ferric Extractions

Contaminant transport may be moderated by valence states of iron; therefore, iron extractions are used to quantify changes in the available iron(II) (ferrous) and iron(III) (ferric) in borehole sediment.

The iron extractions are conducted in an anaerobic chamber and consist of the following:

- 1M $CaCl_2$
- 0.5M HCl
- 5 M HCl
- 0.25M NH_2OH
- Dithionite-citrate-bicarbonate solution

The quantity of aqueous iron(II) from each extraction will be measured using the FerroZine method (Gibbs, 1976, "Characterization and application of FerroZine iron reagent as a ferrous iron indicator") and iron(II) plus iron(III) after reduction. Ferrous iron is divided into four subfractions and determined from the extraction results in the following manner: ion-exchangeable iron(II) (a), $FeCO_3$ and FeS (b – a), residual iron(II) (e – b), and total Fe(II) (e) (Heron et al., 1994, "Speciation of Fe(II) and Fe(III) in Contaminated Aquifer Sediments Using Chemical Extraction Techniques"). Similarly, the ferric iron was divided into three subfractions defined by poorly crystalline and amorphous iron(III) oxides (c) (Chao and Zhou, 1983, "Extraction Techniques for Selective Dissolution of Amorphous Iron Oxides from Soils and Sediments"), crystalline iron(III) oxides (d – c), and total iron(III) (e). Extraction solutions will also be analyzed for manganese.

2.1.4.2 Mineral-Phase Analyses

The mineralogy of the selected sediment samples will be characterized by x-ray diffraction of the <2 mm size, and the clay mineralogy will be characterized on the <2 µm size fraction. In addition, a scanning electron microscope with energy dispersive detector will be used to identify contaminant surface phases, if within detection limits of the instrument. For example, the energy dispersive detector detection limit is 500 µg/g for uranium. In some cases, contaminants precipitate with specific surface phases, so at a micron scale, contaminants are at a higher concentration than the bulk extracted concentration (i.e., enabling detection at a lower bulk concentration). Results from the scanning electron microscope with energy dispersive detector analysis are for informational purposes.

2.1.4.2.1 Cementation Analysis

Visual examination of cementation will be conducted for all CCU-PZSt samples selected for physical characterization. The information gathered from visual examination will be qualitative in nature; however, geochemical data collected per Table 1-5 will be used to support this analysis.

2.1.5 Analytical Priority

If insufficient sample material is generated from the first attempt at collecting a sediment sample in a noncontinuous sample interval (due to incomplete recovery), another sample will be collected immediately below the initially sampled interval. If not enough sample material is collected for total sediment contaminant concentration analyses at a depth interval specified within a continuous sample

interval, the OU technical lead will be consulted to adjust/determine which liner(s) will be designated for these analyses (Table 3-1 and Section 3.5.1). Insufficient perched water sample volume is not considered to be a concern. It is intended that all required analyses will be performed.

2.1.6 Special Training/Certification

Workers receive a level of training that is commensurate with their responsibility for collecting and transporting samples and is compliant with applicable DOE orders and government regulations. The FWS, in coordination with line management, will ensure that special training requirements for field personnel are met.

Training has been instituted by the contractor management team to meet training and qualification programs that satisfy multiple training drivers imposed by applicable DOE, *Code of Federal Regulations*, and *Washington Administrative Code* requirements.

Training records are maintained for each employee in an electronic training record database. The contractor's training organization maintains the training records system. Line management confirms that an employee's training is appropriate and up to date prior to performing work under this SAP.

2.1.7 Documents and Records

The OU project manager (or designee) is responsible for ensuring that the current version of the SAP is being used and for providing any updates to field personnel. Version control is maintained by the administrative document control process. Table 2-2 defines the types of changes that may impact sampling and the associated approvals, notifications, and documentation requirements.

Table 2-2. Change Control for Sampling Projects

Type of Change[a]	Action	Documentation
Minor field change: Changes that have no adverse effect on the technical adequacy of the sampling activity or the work schedule.	The field personnel recognizing the need for a field change will consult with the OU project manager (or designee) prior to implementing the field change.	Minor field changes will be documented in the field logbook. The logbook entry will include the field change, the reason for the field change, and the names and titles of those approving the field change.
Minor change. Changes to approved plans that do not affect the overall intent of the plan or schedule.	The OU project manager will inform DOE-RL and the regulatory lead of the change. The lead regulatory agency and EPA determines there is no need to revise the document.	Documentation of this change approval would be via project managers' meeting minutes or comparable Tri-Party Agreement change notice.[b]
Revision necessary: The lead regulatory agency determines that changes to approved plans require revision to document.	If it is anticipated that a revision is necessary, the OU project manager will inform DOE-RL and the lead regulatory agency. The lead regulatory agency and EPA determine that the change requires revision to the document.	Formal revision of the sampling document.

References: DOE/RL-96-68, *Hanford Analytical Services Quality Assurance Requirements Document*.
Ecology et al., 1989a, *Hanford Federal Facility Agreement and Consent Order*.
Ecology et al, 1989b, *Hanford Federal Facility Agreement and Consent Order Action Plan*.
a. Consistent with DOE/RL-96-68 and with Sections 9.3 and 12.4 of Tri-Party Agreement Action Plan (Ecology et al., 1989b).
b. Section 9.3 of the Tri-Party Agreement Action Plan (EPA et al., 1989b) defines the minimum elements of a change notice.

DOE-RL = U.S. Department of Energy, Richland Operations Office
EPA = U.S. Environmental Protection Agency
OU = operable unit
Tri-Party Agreement = *Hanford Federal Facility Agreement and Consent Order*

Regarding minor field changes, the project scientist (in coordination with the soil and groundwater subject matter expert) will approve deviations from the SAP that do not have an adverse effect on the technical integrity or adequacy of the sampling activity. Examples of minor field changes include the following:

- During perched water sampling, most perched water samples will be pumped, although use of another method may by authorized by the OU technical lead.
- The sample depths provided in this SAP are estimated based on known characterization data and geology collected from nearby wells. For this reason, adjustments to the sample depths are anticipated. The sample depths may be altered during drilling in consultation with the OU technical lead.
- During split-spoon sampling, if insufficient material is recovered or the split spoon is overdriven, then (when feasible) a second split-spoon sample will be collected prior to advancing the borehole. If there is not sufficient sample volume recovered during split-spoon sampling (after collection of a second sample immediately below the initial interval), laboratory-approved minimum sample volumes will be used to run all required sample analyses.
- Perched water samples may not be collected before a minimum of three well casing volumes have been purged and the water chemistry (e.g., temperature, pH, and conductivity) has stabilized within 10% variance over three consecutive measurements, unless approved by the OU technical lead. Note that one borehole volume is acceptable if water chemistry (e.g., temperature, pH, and conductivity) has stabilized within 10% variance over three consecutive measurements for depth-discrete perched water samples collected during drilling.

Regarding minor changes, the project scientist (in coordination with the soil and groundwater subject matter expert) will consult with DOE-RL about deviations from the SAP that do not affect the overall intent of the plan. Examples of minor changes include the following:

- Changing the type of sample being collected (e.g., collecting continuous grab samples instead of continuous cores)
- Selecting a different well construction material and/or well design
- Changing to a different drilling method

The OU technical lead, in coordination with the soil and groundwater subject matter expert, will inform DOE-RL and Ecology of deviations from the SAP that affect the overall intent and schedule and may require revision to the approved plan.

Logbooks are required to document field sampling activities. The logbook must be identified with a unique project name and number. Only authorized individuals may make entries into the logbooks. Logbooks will be controlled in accordance with internal work requirements and processes. Data forms are also required for field activities and will be controlled in accordance with internal work requirements and processes.

The FWS and SMR are responsible for ensuring that the field instructions are maintained and aligned with revisions or approved changes to the SAP. SMR will ensure that deviations from the SAP (i.e., minor field changes, as documented in Table 2-2) are reflected in revised field sampling documents for the samplers and the analytical laboratory. All other changes need to be documented by the OU technical lead through Tri-Party Agreement change notice or an update to the SAP. The FWS or

appropriate field crew supervisor will ensure that deviations from the SAP or problems encountered in the field are documented appropriately (e.g., in the field logbook).

The OU project manager, FWS, or designee is responsible for communicating field corrective action requirements and ensuring that immediate corrective actions are applied to field activities. The OU project manager is also responsible for ensuring that project files are appropriately set up and maintained. The project files will contain project records or references to their storage locations. Project files may include the following information:

- Operational records and logbooks
- Data forms
- Global positioning system data (a copy will be provided to SMR)
- Inspection or assessment reports and corrective action reports
- Field summary reports
- Interim progress reports
- Final reports
- Photographs

The following records are managed and maintained by SMR personnel:

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

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). Documentation and records, regardless of medium or format, are controlled in accordance with internal work requirements and processes that ensure accuracy and retrievability of stored records. Records required by the Tri-Party Agreement (Ecology et al., 1989a) will be managed in accordance with Tri-Party Agreement requirements.

2.2 Data Generation and Acquisition

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

2.2.1 Analytical Methods Requirements

The analytical method requirements are discussed in this section. Table 2-3 lists the performance requirements for soil/sediment and water sample analyses (not including those performed by PNNL). The specialized geochemical analyses (Tier 2 and 3 analyses) conducted at PNNL (Section 2.1.4) will use the Table 2-3 methods requirements (or equivalent), with any modifications necessary based on the specialized test methodology and/or analytical approach described in PNNL's NQAP quality approach.

Table 2-3. Performance Requirements for Sample Analysis

Constituent	CAS Number[a]	MCL or WAC (µg/L)[b]	Analytical Method[c]	PQL for Water (µg/L)[d]	PQL for Soil/ Sediment (µg/kg)[d]
General Chemical Parameters					
pH	—	—	9040 (water), 9045 (soil)	N/A	N/A
Chromium (VI)[e]	18540-29-9	48	7196	10.5	500
Alkalinity[e]	ALKALINITY	—	310.1, Standard Method 2320, Standard Method 4500	5,250	N/A
Bicarbonate alkalinity[e]	HCO3ALKALINITY	—	310.1, Standard Method 2320, Standard Method 4500	5,250	N/A
Carbonate alkalinity[e]	CO3ALKALINITY	—	310.1, Standard Method 2320, Standard Method 4500	5,250	N/A
Total dissolved solids	TDS	—	160.1, Standard Method 2540	21,000	—[f]
Total organic carbon[e]	TOC	—	9060, 415.1	1,050	100,000
Total inorganic carbon[e]	TINC	—	9060, 415.1	1,050	100,000
Inorganics – Ammonia, Anions, and Cyanide					
Ammonia	7664-41-7	—	350.1	—[f]	500
Cyanide[e, g]	57-12-5 and FREE-CN	10	9014, 9012	15.75 (total) 2.0(free)	1,000 (total)
Chloride[e]	16887-00-6	250,000	9056, 300.0	400	55,000
Fluoride[e]	16984-48-8	4,000	9056, 300.0	525	25,000
Nitrate[e]	14797-55-8	10,000	9056, 300.0	525	12,500
Nitrite[e]	14797-65-0	1,000	9056, 300.0	525	12,500
Phosphate	14265-44-2	—	9056, 300.0	—[f]	5,000
Sulfate[e]	14808-79-8	250,000	9056, 300.0	1,050	27,500
Sulfide[e]	18496-25-8	—	Standard Methods 4500-S, 376.1, 9034	2,100	25,000
Inorganics – Metals					
Aluminum	7429-90-5	16,000	6020	—[f]	5,000
Antimony	7440-36-0	6	6010	—[f]	1,200
Arsenic	7440-38-2	10	6020	10.5	1,000
Barium	7440-39-3	—	6020	—[f]	2,000
Cadmium	7440-43-9	5	6020	2.1	200
Calcium	7440-70-2	—	6010	1,050	100,000

Table 2-3. Performance Requirements for Sample Analysis

Constituent	CAS Number[a]	MCL or WAC (µg/L)[b]	Analytical Method[c]	PQL for Water (µg/L)[d]	PQL for Soil/ Sediment (µg/kg)[d]
Chromium (total)	7440-47-3	100	6020	10.5	1,000
Copper	7440-50-8	640	6020	—[f]	1,000
Iron	7439-89-6	11,000	6010	105	25,000
Lead	7439-92-1	15	6020	—[f]	300
Magnesium	7439-95-4	—	6010	1,050	100,000
Manganese	7439-96-5	750	6020	5.25	1,000
Mercury	7439-97-6	2	7471	—[f]	200
Molybdenum	7439-98-7	80	6020	5.25	500
Nickel	7440-02-0	100	6020	21	500
Potassium	7440-09-7	—	6010	5,250	500,000
Selenium	7782-49-2	50	6020	—[f]	500
Silver	7440-22-4	80	6010 (soil), 6020 (water)	—[f]	1,000
Sodium	7440-23-5	—	6010	1,050	100,000
Uranium (total)[h]	7440-61-1	30	6020	1.05	150
Radionuclides					
Americium-241	14596-10-2	—	AEA	—[f]	1
Carbon-14[e]	14762-75-5	2,000	LSC	50	5
Cesium-137	10045-97-3	—	GEA	—[f]	0.1
Cobalt-60	10198-40-0	—	GEA	—[f]	0.1
Europium-152	14683-23-9	—	GEA	—[f]	0.1
Europium-154	15585-10-1	—	GEA	—[f]	0.1
Europium-155	14391-16-3	—	GEA	—[f]	0.1
Iodine-129[e]	15046-84-1	1	LEPS-GEA, LSC, GPC	1	2
Neptunium-237	13994-20-2	—	AEA	—[f]	1
Nickel-63	13981-37-8	—	LSC	—[f]	10
Plutonium-238	13981-16-3	—	AEA	—[f]	1
Plutonium-239/240	PU-239/240	—	AEA	—[f]	1
Strontium-90	10098-97-2	—	GPC	—[f]	2
Technetium-99[e]	14133-76-7	900	LSC	50	5
Hydrogen-3 (tritium)[e]	10028-17-8	20,000	LSC	700	N/A
Uranium-233/234[i, j]	U-233/234	4,830	AEA	1	1
Uranium-235/236[i, j]	U-235/236	2,770	AEA	1	1
Uranium-238[h]	U-238	1,580	AEA	1	1
Soil/Physical Properties[k]					
Moisture content	N/A	N/A	ASTM D2216-19	N/A	N/A
Bulk density	N/A	N/A	ASTM D7263-09	N/A	N/A
Particle density	N/A	N/A	ASTM D854-14 or ASTM D5550-14	N/A	N/A

Table 2-3. Performance Requirements for Sample Analysis

Constituent	CAS Number[a]	MCL or WAC (µg/L)[b]	Analytical Method[c]	PQL for Water (µg/L)[d]	PQL for Soil/ Sediment (µg/kg)[d]
Porosity (apparent)	N/A	N/A	Calculated from bulk density and particle density (ASTM D7263-09)	N/A	N/A
Particle size distribution	N/A	N/A	ASTM D422 or ASTM D6913-17 or ASTM B822-17	N/A	N/A
Saturated hydraulic conductivity	N/A	N/A	PNNL operating procedure DVZ-OP-1 (consistent with ASTM D5084-16 and ASTM D5856-15 but is performed using an enhanced experimental apparatus setup)	N/A	N/A
X-ray microtomography imaging	N/A	N/A	—	N/A	N/A
Field Measurements					
Dissolved oxygen	N/A	N/A	—	N/A	N/A
Oxidation-reduction potential	N/A	N/A	–	N/A	N/A
pH	N/A	N/A	—	N/A	N/A
Specific conductance	N/A	N/A	—	N/A	N/A
Temperature	N/A	N/A	—	N/A	N/A
Turbidity	N/A	N/A	—	N/A	N/A
Barometric pressure[l]	N/A	N/A	—	N/A	N/A

Note: The ASTM methods included in this table are as follows:

ASTM B822-17, *Standard Test Method for Particle Size Distribution of Metals Powders and Related Compounds by Light Scattering.*

ASTM D422, *Sieve Analysis.*

ASTM D854-14, *Standard Test Method for Specific Gravity of Soil Solids by Water Pycnometer.*

ASTM D2216-19, *Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass.*

ASTM D5084-16a, *Standard Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter.*

ASTM D5550-14, *Standard Test Method for Specific Gravity of Soil Solids by Gas Pycnometer.*

ASTM D5856-15, *Standard Test Methods for Measurement of Hydraulic Conductivity of Porous Materials Using a Rigid-Wall Compaction-Mold Permeameter.*

ASTM D6913/D6913M-17, *Standard Test Methods for Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis.*

ASTM D7263-09(2018)e2, *Standard Test Methods for Laboratory Determination of Density (Unit Weight) of Soil Specimens.*

Table 2-3. Performance Requirements for Sample Analysis

Constituent	CAS Number[a]	MCL or WAC (µg/L)[b]	Analytical Method[c]	PQL for Water (µg/L)[d]	PQL for Soil/ Sediment (µg/kg)[d]

a. The Hanford Environmental Information System database constituent identification number is used.

b. WAC 173-340-720, Method B, "Model Toxics Control Act—Cleanup," "Groundwater Cleanup Standards."

c. For EPA Methods 160.1, 310.1, 350.1, 376.1, and 415.1, see EPA/600/4-79/020, *Methods for Chemical Analysis of Water and Wastes.* For EPA Method 300.0, see EPA/600/R-93/100, *Methods for the Determination of Inorganic Substances in Environmental Samples.* For four-digit EPA methods, see SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods* (current update). For standard methods, see APHA/AWWA/WEF, 2017, *Standard Methods For the Examination of Water and Wastewater*. Equivalent methods may be substituted.

d. For radionuclides, values in this column are the minimum detectable concentrations in "pCi/L" for water and "pCi/g" for soil/other media. PQLs are listed in laboratory contracts, and those listed in the current contract for the laboratory will be used. The actual PQLs achieved may vary from those listed in this table.

e. Analyte is considered high analytical priority for soil/sediment samples for comparison to aqueous sample concentrations.

f. Analysis for the constituent in this matrix is not required; therefore, the PQL is not listed.

g. Soil/sediment samples will be analyzed for total cyanide. The post-development perched water sample will be analyzed for both free and total cyanide.

h. Perched water samples are anticipated to have uranium concentrations approaching the saturation point.

i. Isotopic uranium analysis is a Tier 2 analysis and will be performed on samples for which total uranium was detected.

j. Uranium-233, uranium-234, and uranium-235 are listed as contaminants of potential concern in DOE/RL-2011-104, *Characterization Sampling and Analysis Plan for the 200-DV-1 Operable Unit*; as amended by TPA-CN-668, *Tri-Party Agreement Change Notice Form: TPA-CN-668: DOE/RL-2011-104, REV. 0, Characterization Sampling and Analysis Plan for the 200-DV-1 Operable Unit*. However, these isotopes are indistinguishable individually by the laboratory analytical methods used for environmental samples and will be analyzed and reported as uranium-233/uranium-234 and uranium-235/uranium-236.

k. Testing/analysis is performed by PNNL.

l. Barometric pressure readings will be taken from the nearest in-service Hanford Site barometric station to a well at the approximate time of sampling.

AEA = alpha energy analysis
ASTM = ASTM International (formerly the American Society for Testing and Materials)
CAS = Chemical Abstracts Service
EPA = U.S. Environmental Protection Agency
GEA = gamma energy analysis
GPC = gas proportional counting
LEPS = low-energy photon spectroscopy
LSC = liquid scintillation counting
MCL = maximum contaminant level
N/A = not applicable
PNNL = Pacific Northwest National Laboratory
PQL = practical quantitation limit
WAC = *Washington Administrative Code*

Updated EPA methods and nationally recognized standard methods may be substituted for the analytical methods identified in Table 2-3 in order to follow any changed requirements in method updates. The new method must achieve project DQOs as well as, or better than, the replaced method. The analyses and testing performed by PNNL will be conducted using PNNL-developed procedures.

2.2.2 Field Analytical Methods

Field screening and survey data will be measured in accordance with HASQARD requirements (DOE/RL-96-68). Field analytical methods are performed in accordance with the manufacturers' manuals. Table 2-3 provides the parameters for field measurements.

2.2.3 Quality Control

The QC requirements specified in the SAP must be followed in the field and by the analytical laboratory to ensure that reliable data are obtained. Field QC samples will be collected to evaluate the potential for cross-contamination and to provide information pertinent to sampling variability. Laboratory QC samples estimate the precision, bias, and matrix effects of the analytical data. Table 2-4 summarizes the field and laboratory QC samples, and Table 2-5 lists the acceptance criteria for field and laboratory QC. Data will be qualified and flagged in the HEIS database, as appropriate.

Additional QC measures include laboratory audits and participation in nationally based performance evaluation studies. The contract laboratories participate in national studies such as the EPA-sanctioned Water Pollution and Water Supply Performance Evaluation studies. Audit results are used to improve performance.

Table 2-4. QC Samples

Sample Type	Primary Characteristics Evaluated	Frequency
Field QC		
Equipment blank	Contamination from nondedicated sampling equipment	As needed[a]
Full trip blank	Contamination from containers, preservative reagents, storage, or transportation	One per 20 samples collected per matrix
Field duplicate samples	Reproducibility/sampling precision	One per 20 samples collected per matrix[b]
Field split samples	Interlaboratory comparability	As needed
Laboratory Batch QC[c]		
Carrier	Recovery/yield	Added to each sample and QC sample[d]
Method blanks	Laboratory contamination	One per analytical batch[d]
Laboratory sample duplicate	Laboratory reproducibility and precision	One per analytical batch[d]
Matrix spikes	Matrix effect/laboratory accuracy	One per analytical batch[d]
Matrix spike duplicate	Laboratory reproducibility, and method accuracy and precision	One per analytical batch[d]
Tracers	Recovery/yield	Added to each sample and QC
Laboratory control	Method accuracy	One per analytical batch[d]

a. Vendor-provided borehole equipment and pumps are considered dedicated equipment, and equipment blanks are not required.

b. Field duplicate samples will only be collected if sufficient volume of sample material is collected.

c. Batching across projects is allowed for similar matrices (e.g., Hanford Site groundwater).

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

QC = quality control

Table 2-5. Field and Laboratory QC Elements and Acceptance Criteria

Analyte	QC Element	Acceptance Criteria	Corrective Action
General Chemical Parameters			
Alkalinity, bicarbonate alkalinity, carbonate alkalinity	MB	< MDL <5% sample concentration	Flag with “C”
	LCS	80% – 120% recovery	Flag with “o”[a]
	DUP[b] or MS/MSD[c]	≤20% RPD (water) ≤35% RPD (soil)	Review data[d]
	MS/MSD[c]	75% – 125% recovery	Flag with “N”
	EB, FTB	< MDL <5% sample concentration	Flag with “Q”
	Field duplicate[b]	≤20% RPD (water) See footnote e (soil)	Review data[d]

Table 2-5. Field and Laboratory QC Elements and Acceptance Criteria

Analyte	QC Element	Acceptance Criteria	Corrective Action
Hexavalent chromium	MB	< MDL <5% sample concentration	Flag with "C"
	LCS	80% – 120% recovery	Flag with "o"[a]
	DUP[b] or MS/MSD[c]	≤20% RPD (water) ≤35% RPD (soil)	Review data[d]
	MS/MSD[c]	75% – 125% recovery	Flag with "N"
	EB, FTB	< MDL <5% sample concentration	Flag with "Q"
	Field duplicate	≤20% RPD (water) See footnote e (soil)	Review data[d]
Total dissolved solids	MB	< MDL <5% sample concentration	Flag with "C"
	LCS	80% – 120% recovery	Flag with "o"[a]
	DUP[b]	≤20% RPD	Review data[d]
	EB, FTB	< MDL <5% sample concentration	Flag with "Q"
	Field duplicate[b]	≤20% RPD	Review data[d]
Total organic carbon/ total inorganic carbon	MB	< MDL <5% sample concentration	Flag with "C"
	LCS	80% – 120% recovery	Flag with "o"[a]
	DUP[b] or MS/MSD[c]	≤20% RPD (water) ≤35% RPD (soil)	Review data[d]
	MS/MSD[c]	75% – 125% recovery	Flag with "N"
	EB, FTB	< MDL <5% sample concentration	Flag with "Q"
	Field duplicate[b]	≤20% RPD See footnote e (soil)	Review data[d]
Inorganics – Ammonia, Anions, and Cyanide			
Anions by IC	MB	< MDL <5% sample concentration	Flag with "C"
	LCS	80 – 120% recovery	Review data[d]
	DUP[b] or MS/MSD[c]	≤20% RPD (water) ≤35% RPD (soil)	Review data[d]
	MS/MSD[c]	75% – 125% recovery	Flag with "N"
	EB, FTB	< MDL <5% sample concentration	Flag with "Q"
	Field duplicate[b]	≤20% RPD (water) See footnote e (soil)	Review data[d]

Table 2-5. Field and Laboratory QC Elements and Acceptance Criteria

Analyte	QC Element	Acceptance Criteria	Corrective Action
Ammonia	MB	< MDL <5% sample concentration	Flag with "C"
	LCS	80% – 120% recovery	Flag with "o"[a]
	DUP[b] or MS/MSD[c]	≤20% RPD (water) ≤35% RPD (soil)	Review data[d]
	MS/MSD[d]	75% – 125% recovery	Flag with "N"
	EB, FTB	< MDL <5% sample concentration	Flag with "Q"
	Field duplicate[b]	≤20% RPD (water) See footnote e (soil)	Review data[d]
Cyanide	MB	< MDL <5% sample concentration	Flag with "C"
	LCS	80% – 120% recovery	Flag with "o"[a]
	DUP[b] or MS/MSD[c]	≤20% RPD (water) ≤35% RPD (soil)	Review data[d]
	MS/MSD[c]	75% – 125% recovery	Flag with "N"
	EB, FTB	< MDL <5% sample concentration	Flag with "Q"
	Field duplicate[b]	≤20% RPD (water) See footnote e (soil)	Review data[d]
Sulfide	MB	< MDL <5% sample concentration	Flag with "C"
	LCS	80% – 120% recovery	Flag with "o"[a]
	DUP[b] or MS/MSD[c]	≤20% RPD ≤35% RPD (soil)	Review data[d]
	MS/MSD[c]	75% – 125% recovery	Flag with "N"
	EB, FTB	< MDL <5% sample concentration	Flag with "Q"
	Field duplicate[b]	≤20% RPD See footnote e (soil)	Review data[d]
Inorganics – Metals			
ICP/AES metals, ICP/MS metals, and mercury by CVAA	MB	< MDL <5% sample concentration	Flag with "C"
	LCS	80% – 120% recovery	Flag with "o"[a]
	DUP[b] or MS/MSD[c]	≤20% RPD (water) ≤35% RPD (soil)	Review data[d]
	MS/MSD[c]	75% – 125% recovery	Flag with "N"
	EB, FTB	< MDL <5% sample concentration	Flag with "Q"
	Field duplicate[b]	≤20% RPD (water) See footnote e (soil)	Review data[d]

Table 2-5. Field and Laboratory QC Elements and Acceptance Criteria

Analyte	QC Element	Acceptance Criteria	Corrective Action
Radionuclides			
AEA (americium-241, neptunium-237, plutonium-238, plutonium-239/240; uranium [isotopic])	MB	< MDC <5% sample activity concentration	Flag with "B"
	LCS	80% – 120% recovery or statistically derived limits[f]	Flag with "o"[a]
	DUP	≤20% RPD (water) ≤30% RPD (soil)	Review data[d]
	Tracer	30% – 105% recovery	Review data[d]
	EB, FTB	< MDC <5% sample activity concentration	Flag with "Q"
	Field duplicate[b]	≤20% RPD (water) See footnote e (soil)	Review data[d]
GEA (cesium-137, cobalt-60, europium-152, europium-154, europium-155)	MB	< MDC <5% sample activity concentration	Flag with "B"
	LCS	80% – 120% recovery or statistically derived limits[f]	Flag with "o"[a]
	DUP[b]	≤20% RPD (water) ≤30% RPD (soil)	Review data[d]
	EB, FTB	< MDC <5% sample activity concentration	Flag with "Q"
	Field duplicate[b]	≤20% RPD (water) See footnote e (soil)	Review data[d]
Iodine-129	MB	< MDC <5% sample activity concentration	Flag with "B"
	LCS	80% – 120% recovery or statistically derived limits[f]	Flag with "o"[a]
	DUP[b]	≤20% RPD (water) ≤30% RPD (soil)	Review data[d]
	Carrier	40% – 110% recovery	Review data[d]
	EB, FTB	< MDC <5% sample activity concentration	Flag with "Q"
	Field duplicate[b]	≤20% RPD (water) See footnote e (soil)	Review data[d]
Nickel-63	MB	< MDC <5% sample activity concentration	Flag with "B"
	LCS	80% – 120% recovery or statistically derived limits[f]	Flag with "o"[a]
	DUP[b]	≤20% RPD (water) ≤30% RPD (soil)	Review data[d]
	MS	75% – 125% recovery	Review data[d]
	Carrier	40% – 110% recovery	Review data[d]
	EB, FTB	< MDC <5% sample activity concentration	Flag with "Q"
	Field duplicate[b]	≤20% RPD (water) See footnote e (soil)	Review data[d]

Table 2-5. Field and Laboratory QC Elements and Acceptance Criteria

Analyte	QC Element	Acceptance Criteria	Corrective Action
Strontium-90	MB	< MDC <5% sample activity concentration	Flag with "B"
	LCS	80% – 120% recovery or statistically derived limits[f]	Flag with "o"[a]
	DUP[b]	≤20% RPD (water) ≤30% RPD (soil)	Review data[d]
	Tracer	30% – 105% recovery	Review data[d]
	Carrier	40% – 110% recovery	Review data[d]
	EB, FTB	< MDC <5% sample activity concentration	Flag with "Q"
	Field duplicate[b]	≤20% RPD (water) Footnote e (soil)	Review data[d]
Carbon-14, technetium-99, tritium	MB	< MDC <5% sample activity concentration	Flag with "B"
	LCS	80% – 120% recovery or statistically derived limits[f]	Flag with "o"[a]
	DUP [b]	≤20% RPD (water) ≤30% RPD (soil)	Review data[d]
	MS	75 – 125% recovery	Flag with "N"
	EB, FTB	< MDC <5% sample activity concentration	Flag with "Q"
	Field duplicate[b]	≤20% RPD (water) See footnote e (soil)	Review data[d]

Note: This table applies only to laboratory analyses. Depth to water, dissolved oxygen, oxidation-reduction potential, pH, specific conductance, temperature, and turbidity are not listed because they are measured in the field.

a. The reporting laboratory will apply the "o" flag with Sample Management and Reporting concurrence.

b. Applies when at least one result is greater than the laboratory practical quantitation limit (chemical analyses) or greater than five times the minimum detectable activity (radiochemical analyses).

c. Either a DUP or MS/MSD is to be analyzed to determine measurement precision. If there is insufficient sample volume, an LCS duplicate is analyzed with the acceptance criteria defaulting to the ≤20% RPD criteria (water) or ≤30% RPD criteria (soil).

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

e. A field duplicate RPD for soil is not recommended because of possible soil matrix heterogeneity effects.

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

AEA = alpha energy analysis
CVAA = cold-vapor atomic absorption
DUP = laboratory sample duplicate
EB = equipment blank
FTB = full trip blank
GEA = gamma energy analysis
IC = ion chromatography
ICP/AES = inductively coupled plasma/atomic emission spectroscopy
ICP/MS = inductively coupled plasma/mass spectrometry
LCS = laboratory control sample
MB = method blank
MDC = minimum detectable concentration
MDL = method detection limit
MS = matrix spike
MSD = matrix spike duplicate
QC = quality control
RPD = relative percent difference

Table 2-5. Field and Laboratory QC Elements and Acceptance Criteria

Analyte	QC Element	Acceptance Criteria	Corrective Action

Data flags:

B, C = possible laboratory contamination; analyte was detected in the associated MB
N = result may be biased; associated MS result was outside the acceptance limits
o = result may be biased; associated LCS result was outside the acceptance limits
Q = problem with associated field QC blank; results were out of limits

2.2.3.1 Field Quality Control Samples

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

- **Field duplicates:** Independent samples collected as close as possible to the same time and same location as the schedule sample and intended to be identical. Field duplicates are placed in separate sample containers and analyzed independently. Field duplicates are used to determine precision for both sampling and laboratory measurements.
- **Field splits (SPLITs):** Two samples collected as close as possible to the same time and same location and intended to be identical. SPLITs will be stored in separate containers and analyzed by different laboratories for the same analytes. SPLITs are interlaboratory comparison samples used to evaluate comparability between laboratories.
- **Equipment blanks (EBs):** High-purity water passed through or poured over, or silica sand poured over, decontaminated sampling equipment identical to the sample set collected and placed in sample containers, as identified on the SAF. The EB sample bottles are placed into storage containers with samples from the associated sampling event and are analyzed for the same constituents as samples from the sampling event. EBs are used to evaluate decontamination process effectiveness; these samples are not required for disposable sampling equipment.
- **Full trip blanks (FTBs):** Bottles prepared by the sampling team before traveling to the sampling site. The preserved bottle set is either for volatile organic analysis only or is identical to the set that will be collected in the field. The bottles are filled with high-purity water and then sealed and transported (unopened) to the field in the same storage containers used for samples collected that day. Collected FTBs are typically analyzed for the same constituents as the samples from the associated sampling event. FTBs are used to evaluate potential sample contamination from the sample bottles, preservative, handling, storage, and transportation.

2.2.3.2 Laboratory Quality Control Samples

Internal QA/QC programs are maintained by laboratories used by the project. Laboratory QA includes a comprehensive QC program that includes the use of laboratory control samples (LCSs), laboratory sample duplicates (DUPs), matrix spikes (MSs), matrix spike duplicates (MSDs), and method blanks (MBs). These QC analyses are required by EPA methods (e.g., those in SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods* [current update]) and will be run at the frequency specified in the respective references unless superseded by agreement. The QC checks outside of control

limits are documented in analytical laboratory reports during data usability assessments (if performed). Table 2-4 lists the laboratory QC checks and their typical frequencies, and Table 2-5 lists the acceptance criteria. Descriptions of the various types of laboratory QC samples are as follows:

- **Laboratory control sample (LCS):** A control matrix (e.g., reagent water) spiked with analytes representing the target analytes or certified reference material used to evaluate laboratory accuracy.
- **Laboratory sample duplicate (DUP):** An intralaboratory replicate sample that is used to evaluate the precision of a method in a given sample matrix.
- **Matrix spike (MS):** An aliquot of a sample spiked with a known concentration of target analyte(s). The MS is used to assess the bias of a method in a given sample matrix. Spiking occurs prior to sample preparation and analysis.
- **Matrix spike duplicate (MSD):** A replicate spiked aliquot of a sample that is subjected to the entire sample preparation and analytical process. MSD results are used to determine the bias and precision of a method in a given sample matrix.
- **Method blank (MB):** An analyte-free matrix to which the same reagents are added in the same volumes or proportions as used in the sample processing. The MB is carried through the sample preparation and analytical procedure and is used to quantify contamination resulting from the analytical process.
- **Tracer:** A known quantity of radioactive isotope that is different from that of the isotope of interest but is expected to behave similarly and is generally added to a sample aliquot prior to the sample preparation step. A tracer does not chemically interfere with the target radioisotope during radiochemical preparation, separation, and counting. Sample results are generally corrected based on tracer recovery.
- **Carrier:** A known quantity of radioactive isotope that is different from that of the isotope of interest but is expected to behave similarly and is added to an aliquot of prepared sample (e.g., extracted/leached) prior to specific radiochemical manipulations (e.g., separations). The carrier can indicate matrix-related effect remaining after preparation but gives no measure of the efficiency of the original preparation step. Carrier recovery is used to correct the radiochemical yield in a specific sample.

Laboratories are required to analyze samples within the holding times specified in Table 2-6. In some instances, constituents in the samples not analyzed within holding times may be compromised by volatilization, decomposition, or by other chemical changes. Data from samples analyzed outside of holding times are flagged in the HEIS database with an “H.”

Table 2-6. Holding-Time Guidelines for Laboratory Analytes

Constituent/ Parameter	Preservation[a]	Holding Time
General Chemistry Parameters		
pH	None	Analyze immediately
Alkalinity	Store ≤6°C	14 days
Ammonia	Store ≤6°C adjust pH to <2 with H_2SO_4 (water) Store ≤6°C (soil)	28 days

Table 2-6. Holding-Time Guidelines for Laboratory Analytes

Constituent/ Parameter	Preservation[a]	Holding Time
Cyanide	Store ≤6°C adjust pH NaOH > 12 (water) Store ≤6°C (soil)	14 days/14 days[b]
Hexavalent chromium	Store ≤6°C	24 hours (water) 30 days/24 hours (soil)[c]
Total dissolved solids	Store ≤6°C	7 days
Total inorganic carbon/ total organic carbon	Store ≤6°C, adjust pH to <2 with H_2SO_4 or HCl (water) Store ≤6°C (soil)	28 days
Inorganics – Anions		
Nitrate, nitrite, phosphate	Store ≤6°C	48 hours (water) 28 days/48 hours (soil)[d]
Chloride, fluoride, sulfate	Store ≤6°C	28 days (water) 28 days/28 days (soil)[e]
Sulfide	Store ≤6°C, ZnAc + NaOH to pH >9 (water) Store ≤6°C (soil)	7 days
Inorganics – Metals		
ICP/AES and ICP/MS	Adjust pH to <2 with HNO_3 (water) None (soil)	6 months
Mercury[f]	None (soil)	28 days
Radionuclides		
Tritium, carbon-14, iodine-129	None	6 months
All other radionuclides (technetium-99, isotopic uranium, americium-241, cesium-137, cobalt-60, isotopic europium, nickel-63, neptunium-237, isotopic plutonium, strontium-90)	Adjust pH to <2 with HNO_3 (water) None (soil)	6 months

Notes:

For the specialized geochemical studies conducted at Pacific Northwest National Laboratory, the holding time clock will begin when the laboratory opens a liner and removes sediment for analysis.

Container types and volumes will be identified on the chain-of-custody form.

This table only applies to laboratory analyses. Depth to water, dissolved oxygen, reduction-oxidation potential, pH, specific conductance, temperature, and turbidity are not listed because they are measured in the field.

a. 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.

b. Holding time for cyanide analysis of soil samples is 14 days from collection to extraction and 14 days from extraction to analysis.

c. The holding time for hexavalent chromium analysis of soil samples is 30 days from collection to extraction and 24 hours from extraction to analysis.

d. The holding time for nitrate, nitrite, and phosphate analysis of soil samples is 28 days from collection to extraction and 48 hours from extraction to analysis.

e. The holding time for chloride, fluoride, and sulfate analysis of soil samples is 28 days from collection to extraction and 28 days from extraction to analysis.

f. Analysis for mercury is only required for soil/sediment samples in this sampling and analysis plan. The listed preservation and holding-time information is for soil/sediment/solid samples.

ICP/AES = inductively coupled plasma/atomic emission spectroscopy

ICP/MS = inductively coupled plasma/mass spectrometry

2.2.4 Measurement Equipment

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

2.2.5 Instrument and Equipment Testing, Inspection, and Maintenance

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

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

2.2.6 Instrument/Equipment Calibration and Frequency

Section 3.7 discusses field equipment calibration. Analytical laboratory instruments are calibrated in accordance with the laboratory's QA plan and applicable Hanford Site requirements.

2.2.7 Inspection/Acceptance of Supplies and Consumables

Consumables, supplies, and reagents will be reviewed in accordance with SW-846 (current update) requirements and will be appropriate for their use. Supplies and consumables used in support of sampling and analysis activities are procured in accordance with internal work requirements and processes. Responsibilities and interfaces necessary to ensure that items procured/acquired for the contractor meet the specific technical and quality requirements must be in place. The procurement system ensures that purchased items comply with applicable procurement specifications. Supplies and consumables are checked and accepted by users prior to use.

2.2.8 Nondirect Measurements

Data obtained from sources such as computer databases, programs, literature files, and historical databases will be technically reviewed to the same extent as data generated as part of any sampling and analysis QA/QC effort. Data used in evaluations will be identified by source.

2.2.9 Data Management

The SMR organization, in coordination with the OU project manager, is responsible for ensuring that analytical data are appropriately reviewed, managed, and stored in accordance with applicable programmatic requirements governing data management methods.

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

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

2.3 Assessment and Oversight

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

2.3.1 Assessments and Response Actions

Assessments may be performed to verify compliance with the requirements outlined in this SAP, project field instructions, the QAPjP, methods, and regulatory requirements. Deficiencies identified by these assessments will be reported in accordance with existing programmatic requirements. The project line management chain coordinates the corrective actions/deficiency resolutions in accordance with the QA program, the corrective action management program, and associated methods implementing these programs. When appropriate, corrective actions will be taken by the OU project manager (or designee). A data usability assessment will be performed for the identified SAP activities. The data usability assessment results will be provided to the OU project manager. No other planned assessments have been identified. If circumstances arise in the field dictating the need for additional assessments, then additional assessments will be performed.

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

2.3.2 Reports to Management

Program and project management (as appropriate) will be made aware of deficiencies identified by assessments. Issues reported by the laboratories are communicated to SMR, which then initiates a sample issue resolution form. The process is used to document analytical or sample issues and to establish resolution with the OU project manager. If an assessment finding results in sampling issues that affect a regulatory requirement, DOE will be informed and the matter will be discussed with the regulatory agencies.

2.4 Data Review and Usability

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

2.4.1 Data Review and Verification

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

The criteria for verification include, but are not limited to, review for contractual compliance (samples were analyzed as requested), use of the correct analytical method, transcription errors, correct application of dilution factors, appropriate reporting of dry weight versus wet weight, and correct

application of conversion factors. Field QA/QC results will be reviewed to ensure that the results are usable.

The OU technical lead performs data reviews to help determine if observed changes reflect potential data errors, which may result in submitting a request for data review on questionable data. The laboratory may be asked to check calculations or reanalyze the sample. In extreme cases, another sample may be collected. Results of the request for the data review process are used to flag the data appropriately in the HEIS database and/or to add comments.

2.4.2 Data Validation

Data validation is an independent assessment to ensure data reliability. Analytical data validation provides a level of assurance that an analyte is present or absent. Validation may also include the following:

- Verification of instrument calibrations
- Evaluation of analytical results based on method blanks
- Recovery of various internal standards
- Correctness of uncertainty calculations
- Correctness of identification and quantification of analytes
- Effect of quality deficiencies on data reliability

The contractor follows the data validation process described in EPA-540-R-2017-001, *National Functional Guidelines for Inorganic Superfund Methods Data Review*; and EPA-540-R-2017-002, *National Functional Guidelines for Organic Superfund Methods Data Review*, adjusted for use with SW-846 (current update), HASQARD (DOE/RL-96-68), and radiochemistry methods. The criteria for data validation are based on a graded approach, using five levels of validation (Levels A through E). Level A is the lowest level and is the same as verification. Level E is a 100% review of all data (e.g., calibration data and calculations of representative samples from the data set). Data validation will be performed to Level C, which is a review of the QC data. Level C validation consists of a review of the QC data and specifically requires verification of deliverables; requested versus reported analytes; and qualification of the results based on evaluation of analytical holding times, method blank results, MS/MSD results, and duplicate sample results. Level C data validation is generally equivalent to Level 2A (EPA 540-R-08-005, *Guidance for Labeling Externally Validated Laboratory Analytical Data for Superfund Use*). Level C data validation, if requested (or required) will be performed on at least 5% of the data by matrix and analyte group under the direction of SMR. Analyte group refers to categories such as radionuclides, volatile chemicals, semivolatiles, metals, and anions. The goal is to include each of the various analyte groups and matrices during the data validation process. The DOE-RL project lead or OU project manager may specify a higher percentage of data to be validated or that data validation be performed at higher levels.

2.4.3 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. The data quality assessment (DQA) process is the scientific and statistical evaluation of previously verified and validated data to determine if information obtained from environmental data operations are of the right type, quality, and quantity to support their intended use (usability). The DQA process uses the entirety of the collected data to determine usability for decision making. If a statistical sampling design was used during field sampling activities, then the DQA will be performed following guidance in EPA/240/B-06/003, *Data Quality Assessment: Statistical Methods for Practitioners* (EPA QA/G-9S). When judgmental (focused) sampling designs are implemented in the field, DQIs such as precision, accuracy/bias, representativeness,

comparability, completeness, and sensitivity for the specific data sets (individual data packages) will be evaluated in accordance with EPA/240/R-02/004, *Guidance on Environmental Data Verification and Data Validation* (EPA QA/G8). Data verification and data validation are integral to the statistical DQA data evaluation process and the DQI evaluation process. Results of the DQA or DQI processes will be used by the OU project manager to interpret the data and determine if the DQOs for this activity have been met.

3 Field Sampling Plan

The objective of the field sampling plan is to clearly identify project sampling and analysis activities. The field sampling plan uses the sampling design identified during the DQO process and identifies sampling locations, the total number of samples to be collected, the sampling procedures to be implemented and analyses to be performed.

As described in Chapter 1, activities intended to increase the perched water extraction and contaminant mass removal rates are currently planned in three Phases. Phase 1 involves installing vertically screened perched water extraction wells and monitoring wells outside the B, BX, and BY Tank Farm fence lines. Phase 2 consists of the comparative evaluation of installing vertically screened perched water extraction and monitoring wells inside the B and BY Tank Farms versus a single horizontal perched water extraction well extending beneath the tank farms. Phase 3 activities, which are intended to further increase perched water extraction rates, will be planned based on information obtained from Phase 1 and Phase 2 activities.

This SAP describes the field sampling activities for Phase 1 monitoring and extraction wells being installed in the 200-DV-1 OU perched water zone to increase the rate of perched water extraction. Results from the field activities will enable evaluation of remediation alternatives within and surrounding the perched water zone for protection of groundwater. The activities in Phase 1 include installing eight extraction wells and four monitoring wells in the 200-DV-1 OU perched water zone. Field activities for additional phases will be captured in updates to this SAP.

Field sampling for Phase 1 activities includes collecting sediment samples to be analyzed for the constituents and physical properties identified through the DQO process (Table 1-5). Additionally, a tiered analysis approach will be used to select sediment samples from within the perched water zone and in the vadose zone (above and below the perched water zone) to undergo laboratory contaminant mobility and geochemical studies at PNNL (Section 1.4). Post-development perched water samples will be analyzed for the constituents identified through the DQO process (Table 1-6).

The supplemental data gathered from the installation of wells will address the DSs identified in Table 1-2. Table 1-4 summarizes the primary data inputs needed to resolve the DSs. The data will be used to support performance evaluation of the selected remedy by improving the understanding of the perched zone. The data will also support P&T optimization efforts focused on the perched water extraction. The sampling design will be updated if needed for implementation of work beyond Phase 1.

Additional details regarding field-specific sample collection requirements are provided in the following sections.

3.1 Sampling Objectives/Design

The sampling design is judgmental. In judgmental sampling, the selection of sampling units (i.e., the number and location and/or timing of collecting samples) is based on knowledge of the feature or condition under investigation and on professional judgment. Judgmental sampling is distinguished from probability-based sampling in that inferences are based on professional judgment, not statistical scientific theory. Therefore, conclusions about the target population are limited and depend entirely on the validity and accuracy of professional judgment.

3.2 Sample Locations and Frequency

Figure 1-3 shows the locations of the proposed locations for the eight extraction wells and four monitoring wells. Table 3-1 provides a summary of sampling locations for the extraction and monitoring wells, as well as method and frequency of sampling and targeted geologic formations. Figures A-1 through A-8 in Appendix A depict the depth intervals to be sampled for the extraction wells, and Figures B-1 through B-4 in Appendix B depict the depth intervals to be sampled for the monitoring wells.

3.2.1 Sampling Locations

This section identifies the locations of the Phase 1 proposed extraction and monitoring wells and defines the sampling and analysis requirements for the samples and measurements to be collected from these wells. Figure 1-3 presents the approximate locations for the wells proposed in this SAP (listed in Table 1-1). The actual locations will be determined based on field reconnaissance of current site conditions to comply with the *National Historic Preservation Act of 1966* and avoid restrictions, roads, waste sites, and other obstructions. Additional samples may be collected at the discretion of the project manager if unexpected conditions are encountered that indicate the need for additional data (e.g., discolored soil/sediment suggesting presence of a contaminant). Geophysical logging of the cased portion of each well is planned (Table 1-4) and will be conducted based on direction from the drilling manager and Section 3.5.1.5 of this SAP. Table 3-1 lists the locations and depths to be sampled at each well. One slug test will be performed in each well after well acceptance. Slug tests will be conducted in accordance with DOE prime contractor (or its approved subcontractor) procedures (Section 3.5.1.4). After well acceptance, the wells may be hydraulically tested as part of the hydraulic test plan for evaluating field-scale aquifer properties. During Phase 1, field-scale aquifer properties will be evaluated through a series of hydraulic testing activities to be outlined in a hydraulic test plan that will be developed subsequent to and outside of the direct scope of this SAP. The plan will identify appropriate testing methods for the selected portions of the perched water zone based on the location of the newly constructed wells and existing well network.

The well locations identified in this SAP were selected based on information regarding contaminant distribution and migration, as well as the currently modeled saturated thickness of the perched water zone and current extraction rates observed in the field. Extraction wells are sited in locations that are (1) projected to have at least 1.5 m (5 ft) of saturated thickness (ECF-200DV1-18-0036), (2) to approximate the ideal well spacing of 50 m (165 ft) (determined in SGW-63236), and (3) to avoid any known drilling or operational obstacles. Monitoring wells are positioned between extraction wells and are distributed throughout the perched zone to monitor as efficiently as possible. Details for the location selections are as follows:

- D0112 (PZ2, 299-E33-269) is an extraction well located near existing extraction well 299-E33-344, which will be converted to a monitoring well after D0012 is completed. The configuration of this well pair is ideal for pump tests in the center of the perched zone. D0112 is scheduled to be installed in FY 2020 (funding-dependent).
- D0113 (PZ3, 299-E33-270) is an extraction well located on the eastern edge of the perched zone where the saturated thickness is modeled to be 2.2 m (7.3 ft). D0113 is scheduled to be installed in FY 2020 (funding-dependent).

Table 3-1. Summary of Perched Water Extraction and Monitoring Well Sampling

Sampling Location	Well Name	Well ID	Saturated Zone Sampling During Drilling					Geologic Archive Grab Sampling[a, c, f]
			Split-Spoon Soil Samples[a, b]		Post-Development Perched Water Samples[a, d] (ft bgs)	Slug Tests[e] (ft bgs)	Targeted Geologic Formation	
			Estimated Depth (ft bgs)	Designated for Analytical Laboratory[c]				
PZ1	299-E33-371	D0120	35, 88, 110, 120, 130, 140, 150, 160	"C" liner for each interval	—	—	Hf2	Every 1.5 m (5 ft), or where lithologic changes occur, from ground surface to total depth. Collect geologic archive grab samples in pint-size jar and a chip tray from drill cuttings.
			170 – 217 (continuous)	"C" liner at 170, 180, 190, 200	—	—	Hf3	
			217 – 245 (continuous)	"C" liner at 220, 230, 237, 242	226 – 235	226 – 235	Upper silt-dominated CCU, CCU-PZSd, CCU-PZSt, CCUg	
			251 – 256 (continuous)	"C" liner at 255	—	—	CCUg	
PZ2[g]	299-E33-269	D0112	38, 88, 163	"C" liner for each interval	—	—	Hf2	Every 1.5 m (5 ft), or where lithologic changes occur, from ground surface to total depth. Collect geologic archive grab samples in pint-size jar and a chip tray from drill cuttings.
			200	"C" liner for each interval	—	—	Hf3	
			214 – 249 (continuous)	"C" liner at 217, 225, 239, 245	226 – 238	226 – 238	Upper silt-dominated CCU, CCU-PZSd, CCU-PZSt, CCUg	
			249 – 253 (continuous)	"C" liner at 251	—	—	CCUg	

Table 3-1. Summary of Perched Water Extraction and Monitoring Well Sampling

Sampling Location	Well Name	Well ID	Saturated Zone Sampling During Drilling					Geologic Archive Grab Sampling[a, c, f]
			Split-Spoon Soil Samples[a, b]		Post-Development Perched Water Samples[a, d] (ft bgs)	Slug Tests[e] (ft bgs)	Targeted Geologic Formation	
			Estimated Depth (ft bgs)	Designated for Analytical Laboratory[c]				
PZ3[g]	299-E33-270	D0113	42, 92, 167	"C" liner for each interval	—	—	Hf2	Every 1.5 m (5 ft), or where lithologic changes occur, from ground surface to total depth. Collect geologic archive grab samples in pint-size jar and a chip tray from drill cuttings.
			215	"C" liner for each interval	—	—	Hf3	
			217 – 243 (continuous)	"C" liner at 219, 224, 234, 245	226 – 233	226 – 233	Upper silt-dominated CCU, CCU-PZSd, CCU-PZSt, CCUg	
			245 – 250 (continuous)	"C" liner at 247	—	—	CCUg	
PZ4	299-E33-365	D0124	38, 90, 163	"C" liner for each interval	—	—	Hf2	Every 1.5 m (5 ft), or where lithologic changes occur, from ground surface to total depth. Collect geologic archive grab samples in pint-size jar and a chip tray from drill cuttings.
			213	"C" liner for each interval	—	—	Hf3	
			215 – 243 (continuous)	"C" liner at 218, 225, 235, 240	225 – 231	225 – 231	Upper silt-dominated CCU, CCU-PZSd, CCU-PZSt, CCUg	
			245 – 250 (continuous)	"C" liner at 247	—	—	CCUg	
PZ5	299-E33-366	D0125	34, 88, 187	"C" liner for each interval	—	—	Hf2	Every 1.5 m (5 ft), or where lithologic changes occur, from ground surface to total depth. Collect geologic archive grab samples in pint-size
			198	"C" liner for each interval	—	—	Hf3	
			213 – 237 (continuous)	"C" liner at 215, 225, 231, 234	223 – 229	223 – 229	Upper silt-dominated CCU, CCU-PZSd, CCU-PZSt, CCUg	

Table 3-1. Summary of Perched Water Extraction and Monitoring Well Sampling

Sampling Location	Well Name	Well ID	Saturated Zone Sampling During Drilling					Geologic Archive Grab Sampling[a, c, f]
			Split-Spoon Soil Samples[a, b]		Post-Development Perched Water Samples[a, d] (ft bgs)	Slug Tests[e] (ft bgs)	Targeted Geologic Formation	
			Estimated Depth (ft bgs)	Designated for Analytical Laboratory[c]				
			248 – 253 (continuous)	"C" liner at 261	—	—	CCUg	jar and a chip tray from drill cuttings.
PZ6	299-E33-367	D0126	40, 88, 172	"C" liner for each interval	—	—	Hf2	Every 1.5 m (5 ft), or where lithologic changes occur, from ground surface to total depth. Collect geologic archive grab samples in pint-size jar and a chip tray from drill cuttings.
			198	"C" liner for each interval	—	—	Hf3	
			202 – 230 (continuous)	"C" liner at 205, 210, 220, 227	212 – 218	212 – 218	Upper silt-dominated CCU, CCU-PZSd, CCU-PZSt, CCUg	
			232 – 237 (continuous)	"C" liner at 234	—	—	CCUg	
PZ7	299-E33-370	D0129	44, 88, 188	"C" liner for each interval	—	—	Hf2	Every 1.5 m (5 ft), or where lithologic changes occur, from ground surface to total depth. Collect geologic archive grab samples in pint-size jar and a chip tray from drill cuttings.
			198	"C" liner for each interval	—	—	Hf3	
			217 – 246 (continuous)	"C" liner at 219, 225, 235, 243	227 – 233	227 – 233	Upper silt-dominated CCU, CCU-PZSd, CCU-PZSt, CCUg	
			250 – 255 (continuous)	"C" liner at 252	—	—	CCUg	
PZ8	299-E33-368	D0127	36, 88, 163	"C" liner for each interval	—	—	Hf2	Every 1.5 m (5 ft), or where lithologic changes occur, from
			200	"C" liner for each interval	—	—	Hf3	

Table 3-1. Summary of Perched Water Extraction and Monitoring Well Sampling

Sampling Location	Well Name	Well ID	Saturated Zone Sampling During Drilling					Geologic Archive Grab Sampling[a, c, f]
			Split-Spoon Soil Samples[a, b]		Post-Development Perched Water Samples[a, d] (ft bgs)	Slug Tests[e] (ft bgs)	Targeted Geologic Formation	
			Estimated Depth (ft bgs)	Designated for Analytical Laboratory[c]				
			214 – 243 (continuous)	"C" liner at 216, 224, 236, 240	224 – 234	224 – 234	Upper silt-dominated CCU, CCU-PZSd, CCU-PZSt, CCUg	ground surface to total depth. Collect geologic archive grab samples in pint-size jar and a chip tray from drill cuttings.
			247 – 252 (continuous)	"C" liner at 249	—	—	CCUg	
PZ9	299-E33-369	D0128	30, 88, 182	"C" liner for each interval	—	—	Hf2	Every 1.5 m (5 ft), or where lithologic changes occur, from ground surface to total depth. Collect geologic archive grab samples in pint-size jar and a chip tray from drill cuttings.
			200	"C" liner for each interval	—	—	Hf3	
			209 – 232 (continuous)	"C" liner at 210, 216, 226	218 – 224	218 – 224	Upper silt-dominated CCU, CCU-PZSd, CCU-PZSt, CCUg	
PZ10	299-E33-362	D0121	38, 88, 163	"C" liner for each interval	—	—	Hf2	Every 1.5 m (5 ft), or where lithologic changes occur, from ground surface to total depth. Collect geologic archive grab samples in pint-size jar and a chip tray from drill cuttings.
			200	"C" liner for each interval	—	—	Hf3	
			213 – 241 (continuous)	"C" liner at 215, 225, 235	228 – 232	228 – 232	Upper silt-dominated CCU, CCU-PZSd, CCU-PZSt, CCUg	
PZ11	299-E33-363	D0122	35, 88, 185	"C" liner for each interval	—	—	Hf2	Every 1.5 m (5 ft), or where lithologic changes occur, from ground surface to total depth. Collect geologic archive grab
			200	"C" liner for each interval	—	—	Hf3	
			216 – 237 (continuous)	"C" liner at 218, 227, 235	225 – 233	225 – 233	Upper silt-dominated CCU,	

Table 3-1. Summary of Perched Water Extraction and Monitoring Well Sampling

Sampling Location	Well Name	Well ID	Saturated Zone Sampling During Drilling					Geologic Archive Grab Sampling[a, c, f]
			Split-Spoon Soil Samples[a, b]		Post-Development Perched Water Samples[a, d] (ft bgs)	Slug Tests[e] (ft bgs)	Targeted Geologic Formation	
			Estimated Depth (ft bgs)	Designated for Analytical Laboratory[c]				
							CCU-PZSd, CCU-PZSt, CCUg	samples in pint-size jar and a chip tray from drill cuttings.
PZ12	299-E33-364	D0123	38, 88, 186	"C" liner for each interval	—	—	Hf2	Every 1.5 m (5 ft), or where lithologic changes occur, from ground surface to total depth. Collect geologic archive grab samples in pint-size jar and a chip tray from drill cuttings.
			200	"C" liner for each interval	—	—	Hf3	
			204 – 227 (continuous)	"C" liner at 206, 213, 224	213 – 220	213 - 220	Upper silt-dominated CCU, CCU-PZSd, CCU-PZSt, CCUg	

a. Samples will be collected in accordance with Section 3.5. Sample collection is planned to satisfy the data needs for each geologic formation as detailed in Tables 1-7, 1-8, and 1-9. The sample intervals listed are anticipated depths based on the estimated depths to perched water and geologic contacts listed in Table 1-1 for each well. The actual depths to perched water and to geologic contacts may be found to be different during drilling. During drilling, the field geologist (in consultation with the geology subject matter expert) will identify the depth at which the transition between target geologic formations and perched water occur, and may adjust sample depth(s) in response to these conditions, in consultation with the OU technical lead, provided that the target formation is sampled and the intent of the sample interval is achieved. The following must be considered when adjusting sample intervals:

- The samples within the Hf2 are intended to be collected either at depths corresponding to information gathered from nearby boreholes (e.g., zones of moisture, manmade radionuclides, or silt zones) or approximately evenly space throughout the formation.
- With the exception of PZ1 (D0120, 299-E33-371), one sample is planned within the Hf3 and is intended to be collected either at depths corresponding to information gathered from nearby boreholes (e.g., zones of moisture, manmade radionuclides, or silt zones) or at a depth to represent the formation. At PZ1, continuous samples are planned, starting within the Hf2 and go through to the top of the CCUg above the unconfined aquifer.
- Continuous sampling is planned to start at the approximate transition from Hf3 to the upper silt-dominated CCU and go through to the top of the CCUg above the unconfined aquifer.

Table 3-1. Summary of Perched Water Extraction and Monitoring Well Sampling

Sampling Location	Well Name	Well ID	Saturated Zone Sampling During Drilling					Geologic Archive Grab Sampling[a, c, f]
			Split-Spoon Soil Samples[a, b]		Post-Development Perched Water Samples[a, d] (ft bgs)	Slug Tests[e] (ft bgs)	Targeted Geologic Formation	
			Estimated Depth (ft bgs)	Designated for Analytical Laboratory[c]				

The field geologist will notify the drilling buyer's technical representative and contact the OU technical lead (or designee) if unexpected conditions are encountered in the field that may warrant collection of additional samples. Additional samples may be collected at the discretion of the project manager if unexpected conditions are encountered that indicate the need for additional data.

b. As information is collected from each installed well, sampling intervals and the number of samples collected may be adjusted for the remaining wells. Split-spoon soil samples will be collected and analyzed for sediment constituents and physical properties listed in Table 2-3. If field screening instruments indicate radiological contamination above background at a given interval, two additional samples will be obtained. One sample will be sent for 24-hour turnaround gamma energy analysis and one additional sample for testing based on the gamma energy analysis results (as determined by the project manager).

c. The soil/sediment sample liner C from each depth interval listed will be transported to an offsite laboratory for contaminant concentration analyses (Tier 1) listed in Table 2-3. The remainder of the split-spoon liners (liners A, B, and D, and liner C from those intervals not listed) will be transported to Pacific Northwest National Laboratory for special testing and analysis (Tables 1-7, 1-8, and 1-9) based on Tier 1 results and sample characteristics. The special testing and analysis methods are described in Section 2.1.4. Particle size distribution throughout the continuous sample intervals will be determined by PNNL using ASTM B822-17, *Standard Test Method for Particle Size Distribution of Metals Powders and Related Compounds by Light Scattering*.

d. Baseline perched water samples will be collected and analyzed after final well development and analyzed for the constituents listed in Table 2-3 (at standard turnaround times) and field screening parameters. Filtered and unfiltered samples will be collected for all metals (except hexavalent chromium). A filtered sample will be collected for hexavalent chromium analysis.

e. One slug test will be performed at each well following well acceptance. Slug tests will be conducted in accordance with U.S. Department of Energy prime contractor (or its approved subcontractor) procedures.

f. Collection of archive samples or grab samples for sieve analysis may not be possible at some depths given the continuous split-spoon samples collected through the perched water zone and anticipated high radiological readings. If elevated radiological readings are encountered, sieve and archive grab samples will not be collected; however, sample cores from these intervals will be available for additional analysis and testing, if needed. Filter pack mesh and well screen slot sizes will be selected based, in part, on particle size distribution for sediments in the perched water zone, which will be determined by light scattering (ASTM B822-17). These analyses will be performed at a quick turnaround (4 to 5 working days) from the split-spoon sample material provided to PNNL.

g. Well is scheduled to be installed during fiscal year 2020. The actual schedule for installation, construction, and operation of the extraction and monitoring wells will be determined based on priority of Hanford Site work activities and available funding each fiscal year.

bgs	=	below ground surface	ID	=	identification
CCU	=	Cold Creek unit	Hf2	=	Hanford formation unit 2
CCU-PZSd	=	Cold Creek unit – perched zone sand	Hf3	=	Hanford formation unit 3
CCU-PZSt	=	Cold Creek unit – perched zone silt	OU	=	operable unit
CCUg	=	Cold Creek unit gravel	PNNL	=	Pacific Northwest National Laboratory

- D0120 (PZ1, 299-E33-371) is an extraction well located near aquifer monitoring well 299-E33-41 and is directly outside of the BX Tank Farm eastern fence. This location was selected to be as near as possible to the observed uranium vadose plume derived from the 241-BX-102 tank overfill event. Additionally, the saturated thickness is expected to be nearly 3 m (10 ft) at this location. Access for drilling and installing the well is complicated by nearby power lines and tank farm operations. Planning for drilling D0120 will require additional time compared to the wells planned for the northeast side of the perched zone.
- D0125 (PZ5, 299-E33-366) is an extraction well located south of D0120 (PZ1) and directly outside of the BX Tank Farm eastern fence. Information derived from this location will be helpful for characterizing the BX-102 uranium plume. The saturated thickness is modeled to be 1.8 m (6 ft) at this location. The same logistical complications that apply to D0120 also apply to the D0125 location and a similar amount of time and resources will be required to plan for drilling this well.
- D0124 (PZ4, 299-E33-365) is an extraction well located south of D0113 (PZ3) and is on the eastern edge of the perched water zone. The saturated thickness is modeled to be 1.6 m (5.3 ft) at this location.
- D0126 (PZ6, 299-E33-367) is an extraction well located in the northeastern portion of the perched zone where the saturated thickness is modeled to be 1.8 m (6 ft).
- D0129 (PZ7, 299-E33-370) is an extraction well located in the northern portion of the perched water zone. This location is likely to change as new information is obtained from the drilling and operation of extraction well D0126 (PZ6). The current proposed location of D0129 is directly beneath active power lines, which is not allowable per drilling procedures. However, moving the well in any direction moves the location too close to other extraction wells (given the current understanding of the radius of influence for extraction wells in the perched zone) or into areas where there is not sufficient saturated thickness to extract. These conditions may change over the lifecycle of this SAP, so D0129 may be executable in the future.
- D0127 (PZ8, 299-E33-368) is an extraction well located west of D0112 (PZ2) and on the east side of the main road. It is in the thickest portion of the perched zone, but it is only 37 m (121.4 ft) from D0112 and 24 m (78.7 ft) from well 299-E33-350. This well will only be drilled in this location if it is determined that extraction wells have a smaller radius of influence than is currently being calculated.
- D0121 (PZ10, 299-E33-362) is a monitoring well located between existing extraction wells 299-E33-350 and 299-E33-351.
- D0123 (PZ12, 299-E33-364) is a monitoring well located between D0113 (PZ3) and D0126 (PZ6).
- D0122 (PZ11, 299-E33-363) is a monitoring well located between D0120 (PZ1) and D0125 (PZ5). The same logistical complications that apply to D0120 and D0125 also apply to D0122, and a similar amount of time and resources will be required to plan for drilling this well.
- D0128 (PZ9) is a monitoring well located west of D0129 (PZ7) and will only be drilled if D0129 is drilled.

Vadose zone soil sample depths listed in Table 3-1 were selected based on surrounding analytical and/or geophysical log data (where present), with the goal of having several samples per hydrostratigraphic unit. If historical geophysical logs from boreholes near a planned well indicated elevated moisture, manmade radionuclides, or silt zones, then a soil sample was scheduled at the corresponding depth in the planned well. The same criteria were applied to the review of analytical sample results from nearby boreholes.

Where there were no geophysical logs or analytical sample results within 10 m (33 ft) of a planned well, the soil sample depths were selected to approximate even distribution throughout the vadose zone hydrostratigraphic units. Continuous sampling intervals are scheduled throughout the CCU layers associated with the perched water zone, starting at a few feet above the perched water zone and continuing through to a few feet below the perched water zone (but above the unconfined aquifer) in all wells.

3.3 Well Drilling and Completion

Well drilling and completion will be performed in accordance with the substantive standards of WAC 173-160 for resource protection wells specifically, and any additional applicable subpart found therein. The drilling method will likely use a cable tool (with drive barrel method) or a sonic technique; however, the final drilling method will be determined during negotiation of the drilling contract.

3.3.1 Borehole Drilling and Sampling

Borehole drilling can be conducted using a variety of different environmental drilling rigs, depending on data needs and safety considerations. For application to the perched water interval characterization, borehole drilling commonly uses a type of rig with the following capabilities:

- Enable control of contaminated cuttings
- Permit spectral gamma, neutron moisture, and other types of downhole geophysical logging
- Provide adequate soil return to support soil sampling, either through a split-spoon sampler or through a grab sample.

All drilling will use a method approved by the project and will conform to site-specific technical specifications for environmental drilling services, as well as be able to accommodate the use of a split-spoon sampler (or similarly sized sampling configuration) for the collection of sediment samples at depths ranging from ground surface to the top of basalt. Drill rigs will generally require a gravel pad and, in some cases, a gravel access road. Cleaning and decontamination of the rig, the casing, and all equipment (including sampling equipment) that contacts the soil below the surface and/or the perched water and the groundwater zones will also be performed in accordance with this SAP.

Multiple casing strings (commonly referred to as telescoping) will be required to reach the proposed total depth for the boreholes needed for the extraction wells to minimize transport of contaminants through the vadose zone, the perched water zone, and the aquifer during drilling operations. Figure 3-1 illustrates the step-wise telescoping process for drilling. The temporary casing will be downsized in the CCU-PZSt prior to reaching the CCUg for extraction wells. The nominal temporary casing (or hole, in the case of basalt) diameter for the borehole at total depth shall be no less than 12 in. outer diameter (OD) for extraction wells and 8 in. OD for monitoring wells to retain the minimum 2 in. annulus called for in the substantive standards of WAC 173-160. A bentonite pellet seal or a natural granular bentonite seal will be placed and hydrated prior to any and all downsizing to eliminate contaminant drag-down via the casing strings and/or the creation of a preferential pathway for contaminants or water. The borehole must be sealed in the CCU-PZSt prior to downsizing and continuing with drilling through the remainder of the CCU-PZSt and into the underlying CCUg in accordance with WAC 173-160 requirements. Installation of this seal must be confirmed by evacuating water from the borehole and monitoring for recharge prior to resuming drilling. If measurable recharge is not observed, drilling can continue through the CCU-PZSt.

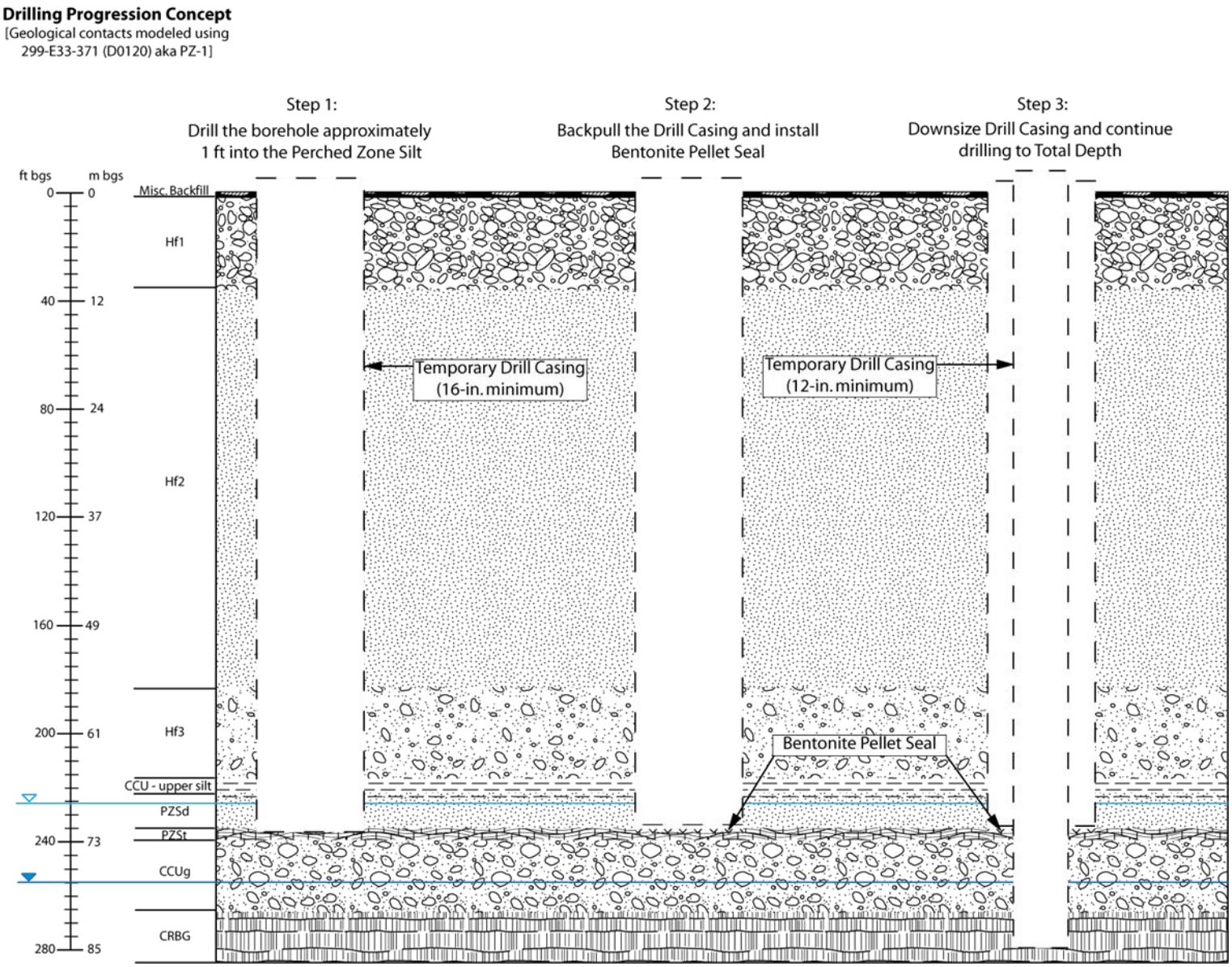


Figure 3-1. Conceptual Illustration of Telescoping During Drilling

Samples will be collected at each well as described in Table 3-1. Section 3.2.1 presents the methodology and requirements for sediment and perched water sampling, slug testing, and borehole geophysical logging.

3.3.2 Well Completion

Figures 3-2 and 3-3 provide conceptual illustrations of the well designs for the eight extraction wells and the four monitoring wells, respectively, to be installed in the 200-DV-1 OU perched water zone as part of Phase 1 activities. Extraction wells will be constructed with 8 in. diameter casing, and monitoring wells will be constructed with 4 in. diameter casing. The extraction wells are designed with deep sumps to increase the storage volume within the well with the intent to decrease cycling of the pumps, extend the life of the pump, and increase the total volume extracted over time. Actual well designs (including screen lengths and locations) will be determined by observations made, geophysical logging, and characterization data collected during drilling. Particle size distribution analysis will be used to size the filter pack mesh and select well screen slot size. Field conditions (elevated radiological readings and continuous sampling) are expected to preclude the collection of grab samples for sieve analysis in the perched water zone. Therefore, the filter pack mesh and well screen slot sizes will be based, in part, on particle size distribution determined by laser light scattering (ASTM B822-17, *Standard Test Method for Particle Size Distribution of Metals Powders and Related Compounds by Light Scattering*) performed on a quick turnaround (4 to 5 working days) from the split-spoon sample material provided to PNNL.

The wells will be constructed with a Type 304 or 316 stainless-steel, continuous wire-wrap screen (vee-wire or similar, depending on application and particle size distribution analysis results), on top of a Schedule 10 Type 304/304L or 316/316L stainless-steel sump with end cap that is approximately 12.2 m (40 ft) long for extraction wells. Monitoring wells will be constructed with no sump. A Schedule 10 Type 304/304L or 316/316L stainless-steel riser will be used to extend the permanent well through the vadose zone to approximately 0.6 m (2 ft) above ground surface. Stainless-steel centralizers will be located at the bottom and top of each screen (for both the extraction and monitoring wells) and every 12.2 m (40 ft) thereafter to ensure that the permanent well is centered within the borehole. Screen slot size and filter pack mesh will be determined after evaluating the quick-turnaround particle size distribution results from the sediment sample material provided to PNNL. Colorado silica sand (or equivalent quality material) will be used for the filter pack.

Portland cement grout will be used for sealing the well from ground surface to 3 m (10 ft). Type I/II Portland cement with 5% natural sodium bentonite powder will be used for the cement grout. Coated or noncoated sodium bentonite pellets and/or natural granular sodium bentonite (chunks, chips, or crumbles) will be used for sealing the well above the filter pack (from 3 m [10 ft] bgs) and immediately below the filter pack, through the CCU-PZSt. The well below the CCU-PZSt will be sealed with bentonite slurry (consisting of at least 20% solids) to the top of basalt to further prevent cross-communication between the perched zone and the aquifer. Portland cement grout will be used to seal the well within the basalt. If a bentonite slurry or cement grout is used, it will be placed down the annulus by tremie pipe in accordance with WAC 173-160 requirements.

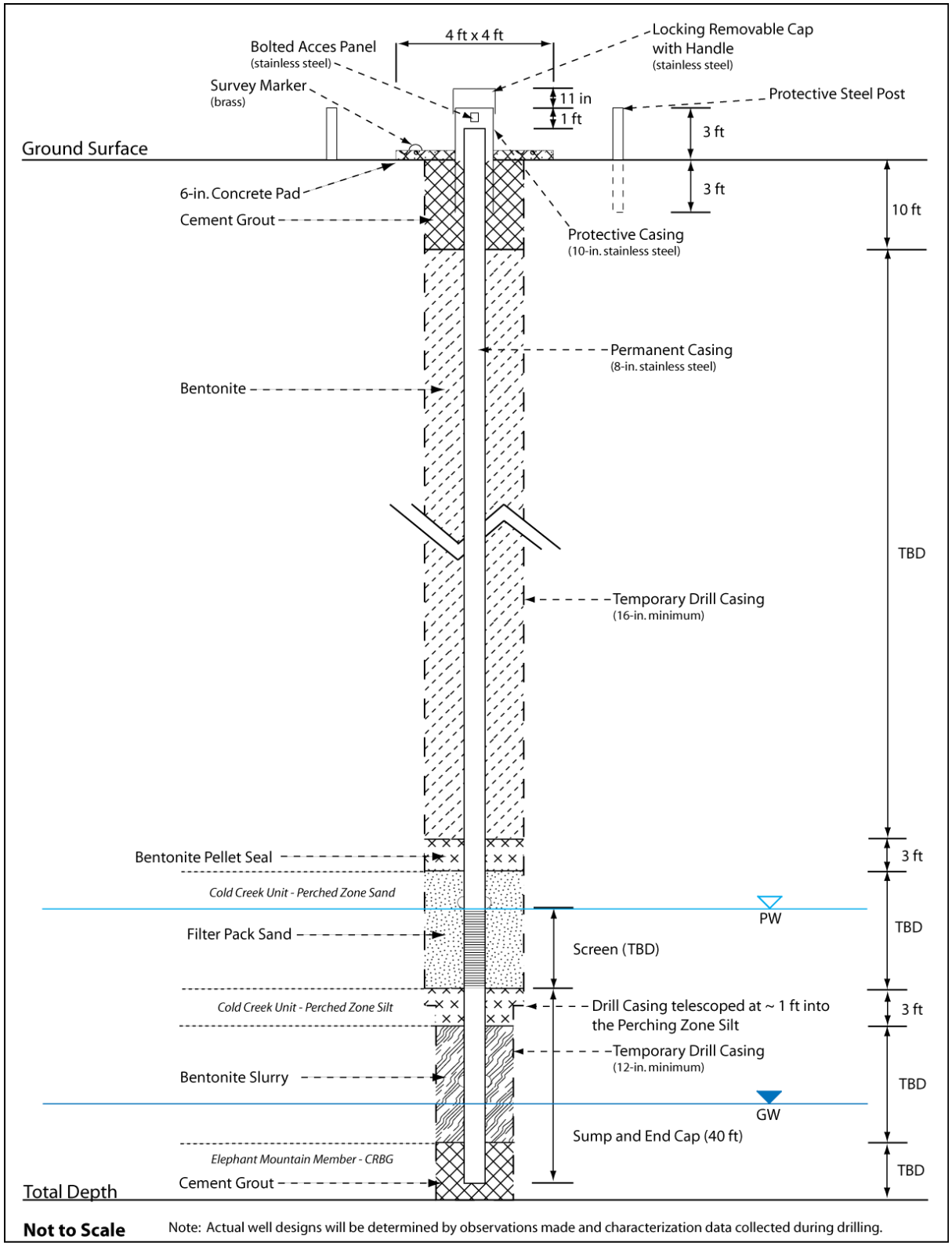


Figure 3-2. Conceptual Illustration of Extraction Well Design

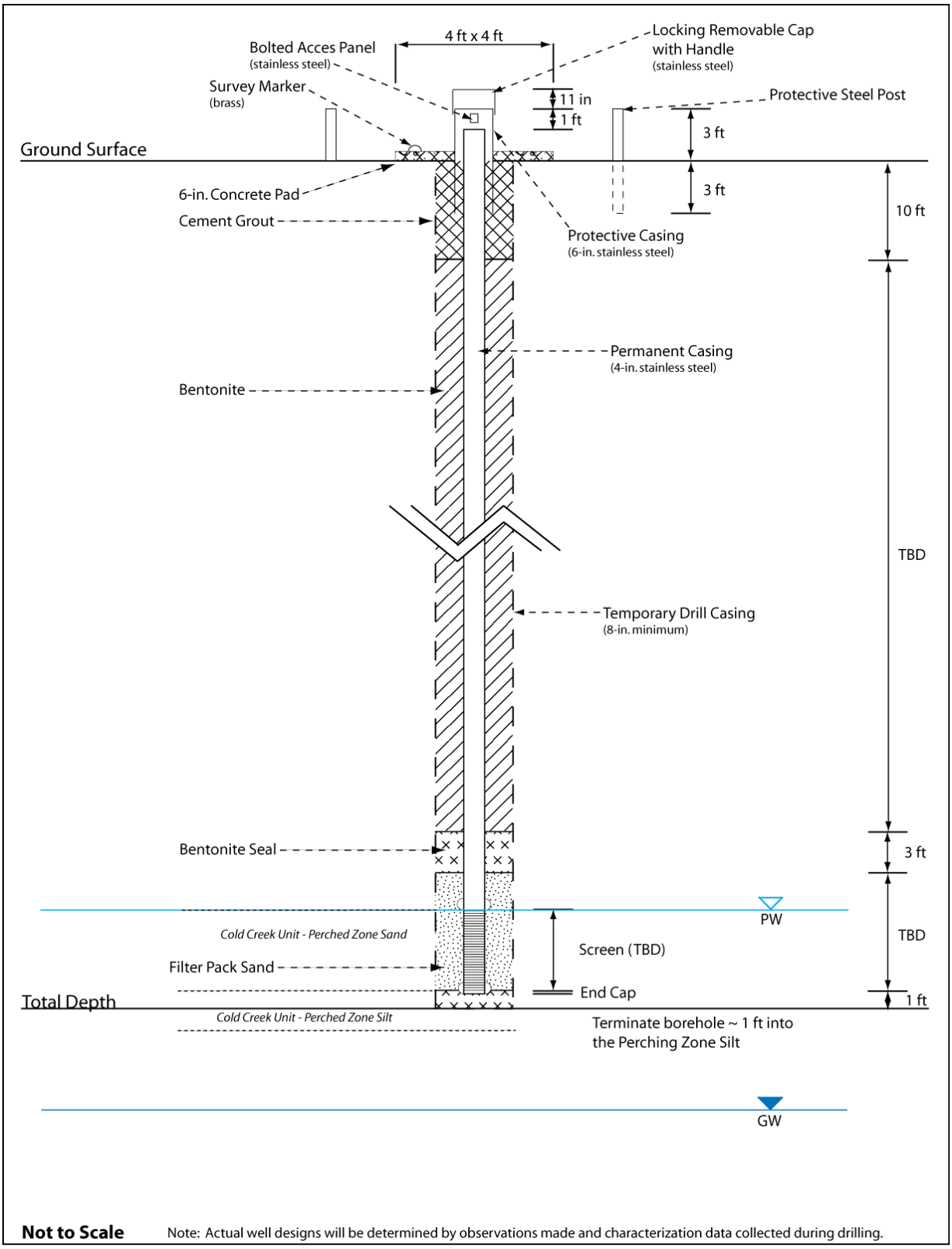


Figure 3-3. Conceptual Illustration of Monitoring Well Design

Surface construction consisting of a protective casing monument; protective bollards; and a steel-reinforced, high-strength concrete pad must be in place prior to job completion. The protective casing will be a minimum 2 in. larger in diameter than the permanent casing and made from stainless-steel (Type 304/304L/304E or 316) or Schedule 40 carbon steel. The protective casing will rise approximately 0.9 m (3 ft) above ground surface and be cemented at least 0.6 m (2 ft) into the ground. The permanent well casing will extend to approximately 0.6 m (2 ft) above ground surface, which should put the top of the permanent casing approximately 0.3 m (1 ft) below the top of the protective casing. The protective casing will have a lockable well cap that extends approximately 27.9 cm (11 in.) above the top of the protective casing. An access panel will be provided on the protective casing (as shown in Figures 3-1 and 3-2). A brass survey marker with the well identification, well name, and date of completion inscribed will be installed on the north side of the concrete pad. Four protective bollards (each at least 3 in. in diameter) will be set in concrete around the concrete pad. Three bollards will extend at least 0.9 m (3 ft) above the ground and will be cemented at least 0.6 m (2 ft) into the ground; the fourth bollard will be removable for well access. Bollards will be located no more than 0.3 m (1 ft) from the corner of the concrete pad and will be painted yellow. If the completion differs from the WAC 173-160 minimum standards, a comparable alternative specification will be used that will provide equal or greater human health and resource protection than the minimum standards.

3.4 Well Development

The objectives of well development are to settle the filter pack, remove formation fines, prevent uncontrolled infiltration of fines, and ensure efficient hydraulic communication of the well with the surrounding aquifer. Well development will be conducted in two stages, with initial development and final development.

3.4.1 Initial Well Development

Initial development will be performed during well completion in conjunction with placement of the filter pack. Surging using a dual-flange surge block settles the filter pack and begins to pull drilling-generated fines and aquifer sediment fines from the borehole wall to improve hydraulic communication with the aquifer. Surging during the filter pack placement generates turbulence along the annulus and borehole wall that will enhance borehole efficiency by removing fines and setting the filter pack grains firmly in place throughout the annulus.

Surging should be carried out evenly in 0.9 m (3 ft) intervals. Fines will be removed from the well, as necessary, using a sand pump or other apparatus. A dart bailer is not recommended for this process because the use of this tool runs an increased risk of puncturing the bottom of the well. Well surging will continue until there is <3 cm (0.1 ft) of filter pack drop in the well annulus per 15 minutes of surge time. Each interval shall be surged until the field geologist (in consultation with the OU technical lead) deems the development satisfactory.

3.4.2 Final Well Development

Final well development shall be performed as follows:

- Bail fines from the well to within 0.15 m (0.5 ft) of the bottom of the sump in preparation for final development.
- Due to low water flow, the development pump (using a pump sleeve or shroud) shall be placed at the bottom of the constructed well, and the well will be pumped dry three times at a minimum to effect low-stress hydraulic communication between the formation and the screen.

- Physical parameters (e.g., turbidity, temperature, pH, and conductivity) will be measured periodically to monitor well development.
- Development will continue until the well water has been determined stabilized by the field geologist, in consultation with the OU technical lead (or designee) and drilling buyer's technical representative (BTR). A turbidity measurement of <5 nephelometric turbidity units is the target and will be attempted to be met. However, due to the expected low flow rates, well development will be considered complete once water has been determined stabilized (temperature, pH, and conductivity have stabilized [at least three consecutive measurements with <10% mean variance]) regardless of turbidity measurement.
- The post-development perched water sample will be collected upon completion of final well development.

3.5 Sampling Methods

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

- Field screening measurements
- Radiological screening
- Borehole sampling
- Perched water sampling
- Water-level measurements

3.5.1 Sampling Procedure

Procedures from the DOE prime contractor (or its approved subcontractor) will be used for sampling. Depth-discrete soil and sediment samples will be collected using split-spoon sampling equipment and methods at the locations and intervals identified in Table 3-1. The split-spoon samples will be used for the analyses listed in Table 2-3. Additional depth-discrete grab soil or sediment samples will be collected from drill cuttings, as listed in Table 3-1.

3.5.1.1 Split-Spoon Sampling and Analysis

Split-spoon sampling and analysis will be used to evaluate the identified analytes listed in Table 1-5. Table 3-1 identifies the split-spoon samples (depth and liner) designated for chemical and radiochemical analyses at an offsite laboratory. For intervals requiring chemical and radiochemical analysis, liner C will not be sent intact to an offsite laboratory for analysis. The material will need to be placed in bottles and then sent to the laboratory. The remainder of the split-spoon liners will be transported to PNNL for designated physical and geochemical testing and analysis (Sections 1.4 and 2.1.4). These studies require intact split-spoon samples. Split-spoon liners will be sealed in the field, labeled as described below, and delivered with chain-of-custody forms to the laboratories.

Each split-spoon sampler will be equipped with four separate, 6 in. long liners. The percent recovery for each split spoon will be recorded. If insufficient material at a noncontinuous sample interval is recovered to perform all analyses, a second split-spoon sample will be collected prior to advancing the borehole. If there is not sufficient sample volume recovered from these back-to-back samples to perform all of the planned analyses for that interval, the OU technical lead (or designee) will be consulted to determine the analytical and testing priority. If insufficient sample volume is collected to perform total sediment contaminant concentration analyses at a depth interval specified within a continuous sample interval, the OU technical lead will be consulted to adjust/determine which liner(s) will be designated for these analyses.

The sample intervals listed in Table 3-1 are anticipated and based on the estimated depths to perched water and geologic contacts listed in Table 1-1 for each well. The actual depths to perched water and to the geologic contacts may be different during drilling. During drilling, the field geologist (in consultation with the geology subject matter expert) will identify the depth at which the transition between target formations and perched water occur and, in consultation with the OU technical lead, may adjust the sample depth in response to these conditions, provided the target formation is sampled and the intent of the sample interval is achieved. The following must be considered when adjusting sample intervals:

- The samples within the Hf2 are intended to be collected either at depths corresponding to information gathered from nearby boreholes (e.g., zones of moisture, manmade radionuclides, or silt zones) or approximately evenly space throughout the formation.
- With the exception of PZ1 (D0120, 299-E33-371), one sample is planned within the Hf3 and is intended to be collected either at depths corresponding to information gathered from nearby boreholes (e.g., zones of moisture, manmade radionuclides, silt zones) or at a depth to represent the formation. At PZ1, continuous samples are planned, starting within the Hf2 and through to the top of the CCUg above the unconfined aquifer.
- Continuous sampling is planned to start at the approximate transition from Hf3 to the upper silt-dominated CCU and continue on through top of the CCUg above the unconfined aquifer.

The field geologist will notify the drilling BTR and the BTR will contact the OU technical lead (or designee) if unexpected conditions are encountered in the field that may warrant collection of additional samples. Additional samples may be collected at the discretion of the project manager if unexpected conditions are encountered that indicate the need for additional data.

Immediately following retrieval of the split-spoon sample from the borehole, the liners will be examined from the ends and their condition inspected. Void space will be carefully filled in the end of the liners with crumpled aluminum foil to minimize separation of the sediment in the liner, and end caps and sealing tape will be added to hold the end caps in place. Each liner will be sequentially labeled “A,” “B,” “C,” and “D” from the bottom (deepest) liner (A) to the uppermost liner (D). Each 6 in. long liner will also be labeled at the top and bottom with the appropriate depths (e.g., 12.2 m and 12.3 m [40.0 ft and 40.5 ft]). A continuous line will be drawn the length of the liner with an arrow pointing to the shallowest end of the liner. Each liner will be labeled with the well identification number (e.g., D0106). The sealed and labeled liners will be placed in plastic bags and sealed, placed in a cooler with freezer packs or ice, and maintained upright (on end) during storage and transport.

A geologic description and photographs of the intact sediment from the split-spoon sample liners will be obtained prior to subsampling for analyses at PNNL. The geology subject matter expert will be consulted to select the appropriate liners for the study because the target sample intervals (specifically within the CCU) are expected to be thin and may require expert identification (e.g., the target sample intervals may not be present in some of the liners).

3.5.1.2 Grab Sampling and Analysis

To gain a better understanding of the vadose zone geology, grab samples will be collected from the drill cuttings. Grab samples will be collected at uniform sampling intervals (typically 1.5 m [5 ft]) and placed into glass mason jars (Table 3-1).

3.5.1.3 Hydrogeologic and Physical Properties Analysis

Samples for physical property analyses will be collected to provide site-specific values to support well design and modeling efforts. General soil properties of interest include pH, moisture content, saturated hydraulic conductivity, grain-size distribution, porosity, and soil bulk density. Hydrogeologic and physical property samples will be analyzed in accordance with the methods specified in Table 2-3. These samples will generally be collected from lithologies that represent the major facies in the vadose zone. The samples will be collected concurrently with geochemical split-spoon sample intervals (where possible), which ensures that the physical properties can be correlated to the depth of the geochemical sample results. Physical properties analyses will be conducted as described in Tables 1-5, 1-7, 1-8, and 2-3 with specific split-spoon liners for analysis selected by the OU technical lead in coordination with the project team and PNNL.

A subset of intact cores from particular hydrostratigraphic units of interest will be selected by the project team for XMT. The imaging results can be used to help guide selection of specific core samples for physical and hydraulic property characterization.

3.5.1.4 Slug Testing

A slug test will be conducted at each well after well completion and final development. During a slug test, the water level in a well is quickly changed by inserting, removing, or otherwise displacing a known volume of water inside the well. The subsequent water-level response is then monitored until the imposed displacement has recovered to the static or pre-test water level. These data are used to estimate hydraulic properties representing aquifer conditions in proximity to the well. Slug tests will be conducted according to the site procedure.

Supplemental post-development hydraulic testing will be specified and conducted under a separate hydraulic testing test plan that will be developed separately following issuance of this SAP. Although not detailed in this SAP, development of the hydraulic testing test plan and completion of the associated hydraulic testing work are required tasks under this SAP. Additional guidance for performing slug tests will be specified in this hydraulic test plan.

3.5.1.5 Borehole Geophysical Logging

Borehole geophysical logging of each well will include spectral gamma ray and neutron moisture logging methods after the well has reached total depth. Geophysical logging of the cased portion of each well is planned and will be conducted based on direction from the drilling manager. Geophysical logging of each casing string of extraction and monitoring wells will be performed to better define the geologic framework in order to support design, construction, and operation of the extraction and monitoring wells. The basalt will not be geophysically logged.

3.5.1.6 Perched Water Sampling

Perched water samples will be collected from the extraction and monitoring wells at the intervals specified in Table 3-1 after well construction, during development, and acceptance and in accordance with the current revision of applicable operating procedures. Sample collection for routine monitoring will be performed under the established SAP (DOE/RL-2014-51) via Tri-Party Agreement change notice.

Most water samples will be collected using a submersible pump. A bailer will be used to collect samples only if the sample cannot be collected using a pump. Prior to sample capture, the pump will be operated for a sufficient period of time to provide stabilized field readings. The perched water samples will be submitted for the analyses listed in Table 2-3.

3.5.1.7 Sample Preservation and Holding Time

Preservatives are required for certain types of samples. Preservatives (based on the media type and analytical methods) are added to the collection bottles before their use in the field. Perched water samples may require filtering in the field, as noted on the chain-of-custody form. Both filtered and nonfiltered samples will be submitted for metals analysis, with the exception of Cr(VI). Only filtered perched water samples will be submitted for Cr(VI) analysis.

To ensure sample and data usability, the sampling associated with this SAP will be performed in accordance with HASQARD requirements (DOE/RL-96-68) for sample collection, collection equipment, sample handling, and sample shipment to the laboratory.

Table 2-6 specifies the sample preservation and holding-time requirements for perched water samples. These requirements are in accordance with the analytical methods specified in Table 2-3. The container types, preservatives, and volumes will be identified on the SAF and chain-of-custody form. This SAP defines a "sample" as a set of filled sample bottles for the purpose of beginning holding-time restrictions.

Holding times are the maximum periods allowed between sample collection and laboratory analysis, as summarized in Table 2-6. 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, 2017, *Standard Methods For the Examination of Water and Wastewater*; and SW-846 (current update). Recommended holding times are also provided in HASQARD (DOE/RL-96-68).

For the specialized geochemical studies conducted at PNNL, the holding-time clock will begin when the laboratory opens a liner and removes sediment for analysis.

3.5.2 Decontamination of Sampling Equipment

Sampling equipment will be decontaminated in accordance with sampling equipment decontamination methods. To prevent potential sample contamination, 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 is performed using high-purity water 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 high-purity water in three sequential containers. After the third high-purity water rinse, equipment that is stainless steel or glass is rinsed in a 1M nitric acid solution (pH <2). Equipment is then rinsed with high-purity water in three sequential containers (the high-purity water rinses following the acid rinse are conducted in separate water containers that are not used for detergent rinse). Following the final high-purity water rinse, equipment is rinsed in hexane and then placed on a rack to dry. Dry equipment is loaded into a drying oven, and 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, the equipment is baked for 20 minutes and then cooled. The equipment is then removed from the oven, and the equipment is wrapped in clean, unused aluminum foil using surgeon's gloves. The wrapped equipment is stored in a custody-locked, controlled access area.

The drill rig derrick, all downhole equipment, and temporary casing will be decontaminated in the field (e.g., high pressure and temperature wash, at a minimum) before mobilization and demobilization at each drilling location. If core barrel equipment is used to collect samples, the drive head will be wiped down between sampling events.

3.5.3 Radiological Field Data

Alpha and beta/gamma data collection in the field will be used as needed to support sampling and analysis efforts. Cuttings from drilled boreholes (excluding slough) will generally be field screened for evidence of radiological contamination. Screening will be conducted visually and with field instruments in accordance with 10 CFR 835, "Occupational Radiation Protection." Radiological screening will be performed by the RCT or other qualified personnel in accordance with Hanford Site procedures. The RCT will record field measurements, noting the depth of the sample and the instrument reading. Measurements will be relayed to the field geologist (for aquifer tubes and wells) for daily inclusion in the field logbook or operational records, as applicable.

3.6 Documentation of Field Activities

Logbooks and data forms are required for sampling field activities and will be used in accordance with HASQARD requirements (DOE/RL-96-68). A logbook must be identified with a unique project name and number. Only authorized persons may make entries in logbooks. Logbook entries will be reviewed by the 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 the data forms is as follows:
- Day and date; time task started; weather conditions; and names, titles, and organizations of personnel performing the task, as well as the following:
  - 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, DUPs, MSs, or blanks. Reference the methods followed for sample collection or preparation; list the location of the 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 sample custody was transferred.
- Time, equipment type, serial or identification number, and methods followed for decontaminations and equipment maintenance performed. Reference the page numbers of any logbook where detailed information is recorded.
- Any equipment failures or breakdowns that occurred, with a brief description of repairs or replacements.

3.6.1 Corrective Actions and Deviations for Sampling Activities

The OU project manager, FWS, appropriate field crew supervisors, and SMR personnel must document deviations from protocols and issues pertaining to sample collection, chain-of-custody forms, target analytes, contaminants, sample transport, or noncompliant monitoring. An example of a deviation would be 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 OU project manager, FWS, field crew supervisors, or SMR personnel will be responsible for communicating field corrective action requirements and for ensuring that corrective actions are applied to field activities as soon as practical.

Changes in sample activities that require notification, approval, and documentation will be performed as specified in Table 2-2 and Section 2.1.7.

3.7 Calibration of Field Equipment

Onsite environmental instruments are calibrated in accordance with the manufacturers' 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 will 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 HASQARD requirements (DOE/RL-96-68). Calibration of radiological field instruments at the Hanford Site is performed by the Mission Support Alliance prime contractor, as specified by their calibration program.

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.
- Calibration of radiological field instruments on the Hanford Site is performed by the MSA prime contractor, as specified by their calibration program.

- Daily calibration checks, as required, 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. Manufacturers' recommendations for storage and handling of standards (if any) will be followed. Expired standards will not be used for calibration.

3.8 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. If during the chain-of-custody process it is discovered that the custody tape has been tampered with or broken on the sample bottle, the sample will be analyzed but the results will include a flag to indicate that custody was broken. If the custody tape has been tampered with or broken on the cooler, the sample custodian shall note this on the sample receiving documentation.

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

3.8.1 Containers

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

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

If required, the Radiological Control organization will measure the contamination levels and the dose rates associated with the filled sample containers. This information and other data will be used to select proper packaging, marking, labeling, and shipping paperwork and to verify that the sample can be received by the analytical laboratory in accordance with the laboratory's radioactivity acceptance criteria. If the dose rate on the outside of a sample container or the curie content exceeds levels acceptable by an offsite laboratory, the FWS (in consultation with SMR) can send smaller sample volumes to the laboratory.

3.8.2 Container Labeling

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

3.8.3 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 sample or 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 sample custody changes, the 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 SMR.

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

- Project name
- Collectors' names
- Unique sample number
- Date, time, and location (or traceable reference thereto) of sample collection
- Matrix
- Preservatives
- Chain-of-possession information (i.e., signatures and printed names of each individual involved in the transfer of sample custody and storage locations, and dates/times of receipt and relinquishment)
- Requested analyses (or reference thereto)
- Number of sample containers per unique sample identification number
- 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 SMR so special direction for analysis can be provided to the laboratory if deemed necessary.

3.8.4 Sample Transportation

Packaging and transportation instructions will comply with applicable transportation regulations and 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 177, "Carriage by Public Highway."[1] Carrier-specific requirements defined in the current edition of International Air Transportation Association (IATA) *Dangerous Goods Regulations* will also be used when preparing sample shipments conveyed by air freight providers.

[1] 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.

Samples containing hazardous constituents above regulated amounts will be considered hazardous material in transportation and will be transported in accordance with DOT/IATA requirements. If the sample material is known or can be identified, then it will be 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.

Materials are classified by DOT/IATA as radioactive when the isotope specific activity concentration and the exempt consignment limits described in 49 CFR 173, “Shippers—General Requirements for Shipments and Packagings,” are exceeded. Samples will be screened (or relevant historical data will be used) to determine if these values are exceeded. When screening or historical data indicate that samples are radioactive, the radioactive samples will be properly classified, described, packaged, marked, labeled, and transported in accordance with DOT/IATA requirements.

Prior to shipping radioactive samples to the laboratory, the organization responsible for shipping will notify the laboratory of the approximate number of and the radiological levels of the samples. This notification is conducted through the SMR project coordinator. The laboratory is responsible for ensuring that the applicable license limits are not exceeded. Prior to sample receipt, the laboratory will provide SMR with written acceptance for the samples with elevated radioactive contamination or dose.

4 Reporting

The work performed under this SAP and the results and information acquired will be presented in multiple reports. The laboratories will report sample results in analytical data packages. A data usability assessment will be performed on the analytical results obtained. The sampling activities performed and results obtained under this SAP will be documented in a field summary report. The field summary report will summarize the activities performed (e.g., drilling, sampling, and logging), present a synopsis of the data usability assessment findings, and further evaluate the results obtained. The field summary report and data usability assessment will address issues encountered and the potential impacts to the information obtained. It is intended that one field summary report will be produced and updated annually with information obtained from additional well installations. The special studies/testing performed by PNNL will be presented in summary reports.

This page intentionally left blank.

5 Management of Waste

Waste materials are generated during sample collection, processing, and subsampling activities. Waste will be managed in accordance with the DOE/RL-2016-22, *Waste Management Plan for Perched Water Pumping/Pore Water Extraction, 200-DV-1 Operable Unit*. For waste designation purposes, analytical data for wells 299-E33-350 and 299-E33-351 may be queried in the HEIS database, 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-2009-80, *Investigation Derived Waste Purgewater Management Work Plan*. Packaging and labeling during waste storage and transportation will meet the applicable substantive federal and/or state requirements. 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.

Pursuant to 40 CFR 300.440, “National Oil and Hazardous Substances Pollution Contingency Plan,” “Procedures for Planning and Implementing Off-Site Response Actions,” approval from the CERCLA DOE-RL remedial project manager is required before returning unused samples or waste from offsite laboratories.

This page intentionally left blank.

6 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; and 10 CFR 835. 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. Site-specific health and safety plans will be used to supplement the general health and safety program.

This page intentionally left blank.

7 References

10 CFR 830, "Nuclear Safety Management," Subpart A, "Quality Assurance Requirements," *Code of Federal Regulations*. Available at: http://www.ecfr.gov/cgi-bin/text-idx?c=ecfr&rgn=div5&view=text&node=10:4.0.2.5.27&idno=10.

10 CFR 835, "Occupational Radiation Protection," *Code of Federal Regulations*. Available at: http://www.ecfr.gov/cgi-bin/text-idx?SID=15c56aeaa1e8ea2a2fb3914f862177e0&mc=true&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.

29 CFR 1910.120, "Occupational Safety and Health Standards," "Hazardous Waste Operations and Emergency Response," *Code of Federal Regulations*. Available at: http://www.ecfr.gov/cgi-bin/text-idx?c=ecfr&rgn=div8&view=text&node=29:5.1.1.1.8.8.33.14&idno=29.

40 CFR 300.440, "National Oil and Hazardous Substances Pollution Contingency Plan," "Procedures for Planning and Implementing Off-Site Response Actions," *Code of Federal Regulations*. Available at: https://www.ecfr.gov/cgi-bin/text-idx?SID=9d017d3e61ae765ef63782a344541f8c&mc=true&node=se40.30.300_1440&rgn=div8.

49 CFR, "Transportation," *Code of Federal Regulations*. Available at: http://www.ecfr.gov/cgi-bin/text-idx?SID=670b98fcf27b2244917cfdf3293b16e4&tpl=/ecfrbrowse/Title49/49cfrv2_02.tpl#0.

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

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

173, "Shippers—General Requirements for Shipments and Packagings."

175, "Carriage by Aircraft."

177, "Carriage by Public Highway."

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

ASME NQA-1-2012, 2013, *Quality Assurance Requirements for Nuclear Facility Applications*, American National Standards Institute/American Society of Mechanical Engineers, New York, New York.

ASTM B822-17, *Standard Test Method for Particle Size Distribution of Metals Powders and Related Compounds by Light Scattering*, ASTM International, West Conshohocken, Pennsylvania.

ASTM D422, *Sieve Analysis*, ASTM International, West Conshohocken, Pennsylvania.

ASTM D854-14, *Standard Test Method for Specific Gravity of Soil Solids by Water Pycnometer*, ASTM International, West Conshohocken, Pennsylvania.

ASTM D2216-19, *Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass*, ASTM International, West Conshohocken, Pennsylvania.

ASTM D5084-16a, *Standard Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter*, ASTM International, West Conshohocken, Pennsylvania.

ASTM D5550-14, *Standard Test Method for Specific Gravity of Soil Solids by Gas Pycnometer*, ASTM International, West Conshohocken, Pennsylvania.

ASTM D5856-15, *Standard Test Methods for Measurement of Hydraulic Conductivity of Porous Materials Using a Rigid-Wall Compaction-Mold Permeameter*, ASTM International, West Conshohocken, Pennsylvania.

ASTM D6913/D6913M-17, *Standard Test Methods for Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis*, ASTM International, West Conshohocken, Pennsylvania.

ASTM D7263-09(2018)e2, *Standard Test Methods for Laboratory Determination of Density (Unit Weight) of Soil Specimens*, ASTM International, West Conshohocken, Pennsylvania.

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

Beckett, P.H.T., 1989, "The Use of Extractants in Studies on Trace Metals in Soils, Sewage Sludges, and Sludge-Treated Soils," B.A. Stewart (ed.), *Advances in Soil Science*, Vol. 9, Springer-Verlag New York, New York, New York.

Chao, T.T., and Liyi Zhou, 1983, "Extraction Techniques for Selective Dissolution of Amorphous Iron Oxides from Soils and Sediments," *Soil Science Society of America Journal* 47:225-232.

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

CP-60925, 2018, *Model Package Report: The Central Plateau Vadose Zone Geoframework Version 1.0*, Rev. 0, CH2M HILL Plateau Remediation Company, Richland, Washington. Available at: https://pdw.hanford.gov/document/0065500H.

DoD/DOE, 2019, *Department of Defense (DoD) Department of Energy (DOE) Consolidated Quality Systems Manual (QSM) for Environmental Laboratories*, Version 5.3, U.S. Department of Defense Environmental Data Quality Workgroup and U.S. Department of Energy Consolidated Audit Program, Washington, D.C. Available at: https://denix.osd.mil/edqw/documents/manuals/qsm-version-5-3-final/.

DOE O 414.1D, Chg 1 (Admin Chg), 2013, *Quality Assurance*, U.S. Department of Energy, Washington, D.C. Available at: https://www.directives.doe.gov/directives-documents/400-series/0414.1-BOrder-d-admchg1.

DOE/RL-96-68, 2014, *Hanford Analytical Services Quality Assurance Requirements Document, Volume 1, Administrative Requirements; Volume 2, Sampling Technical Requirements; Volume 3, Field Analytical Technical Requirements; and Volume 4, Laboratory Technical Requirements*, Rev. 4, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at:
http://www.hanford.gov/files.cfm/DOE-RL-96-68-VOL1-04.pdf.
http://www.hanford.gov/files.cfm/DOE-RL-96-68-VOL2-04.pdf.
http://www.hanford.gov/files.cfm/DOE-RL-96-68-VOL3-04.pdf.
http://www.hanford.gov/files.cfm/DOE-RL-96-68-VOL4-04.pdf.

DOE/RL-2009-80, 2009, *Investigation Derived Waste Purgewater Management Work Plan*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: https://pdw.hanford.gov/document/0094946.

DOE/RL-2009-127, 2009, *Remedial Investigation Report for the 200-BP-5 Groundwater Operable Unit*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: https://pdw.hanford.gov/document/0064655H.

DOE/RL-2011-40, 2011, *Field Test Plan for the Perched Water Pumping/Pore Water Extraction Treatability Test*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: https://pdw.hanford.gov/document/0093355.

DOE/RL-2011-102, 2016, *Remedial Investigation/Feasibility Study and RCRA Facility Investigation/Corrective Measures Study Work Plan*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: https://pdw.hanford.gov/document/0075538H.

DOE/RL-2011-104, 2012, *Characterization Sampling and Analysis Plan for the 200-DV-1 Operable Unit*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: https://pdw.hanford.gov/document/1202020261.

Modified by:

TPA-CN-668, 2015, *Tri-Party Agreement Change Notice Form: TPA-CN-668: DOE/RL-2011-104, REV. 0, Characterization Sampling and Analysis Plan for the 200-DV-1 Operable Unit*, dated June 17, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: https://pdw.hanford.gov/document/0081112H.

DOE/RL-2013-52, 2013, *Sampling and Analysis Plan for Perched Water Wells C8914 and C8915 in the 200-DV-1 Operable Unit*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: https://pdw.hanford.gov/document/0081987H.

DOE/RL-2014-34, 2014, *Action Memorandum for 200-DV-1 Operable Unit Perched Water Pumping/Pore Water Extraction*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: https://pdw.hanford.gov/document/0082284H.

DOE/RL-2014-37, 2015, *Removal Action Work Plan for 200-DV-1 Operable Unit Perched Water Pumping / Pore Water Extraction*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: Available at:
https://pdw.hanford.gov/document/0079128H.

DOE/RL-2014-51, 2014, *Sampling and Analysis Plan for 200-DV-1 Operable Unit Perched Water Pumping/Pore Water Extraction*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: https://pdw.hanford.gov/document/0079127H.

DOE/RL-2016-22, 2016, *Waste Management Plan for Perched Water Pumping/Pore Water Extraction, 200-DV-1 Operable Unit*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: https://pdw.hanford.gov/document/0076174H.

DOE/RL-2016-41, 2016, *Action Memorandum for 200-BP-5 Operable Unit Groundwater Extraction*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: https://pdw.hanford.gov/document/0073242H.

ECF-200DV1-18-0036, 2019, *B-Complex Perched Zone Geoframework, 200 East, Hanford Site*, Rev. 0, CH2M HILL Plateau Remediation Company, Richland, Washington. Available at: https://pdw.hanford.gov/document/AR-03735.

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

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

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

Ecology Publication No. 04-03-030, 2004, *Guidelines for Preparing Quality Assurance Project Plans for Environmental Studies*, revised December 2016, Washington State Department of Ecology, Olympia, Washington. Available at: https://fortress.wa.gov/ecy/publications/documents/0403030.pdf.

EPA/240/B-01/003, 2001, *EPA Requirements for Quality Assurance Project Plans*, EPA QA/R-5, Office of Environmental Information, U.S. Environmental Protection Agency, Washington, D.C. Available at: https://www.epa.gov/sites/production/files/2016-06/documents/r5-final_0.pdf.

EPA/240/B-06/001, 2006, *Guidance on Systematic Planning Using the Data Quality Objectives Process* (EPA QA/G-4), Office of Environmental Information, U.S. Environmental Protection Agency, Washington, D.C. Available at: https://www.epa.gov/sites/production/files/documents/guidance_systematic_planning_dqo_process.pdf.

EPA/240/B-06/003, 2006, *Data Quality Assessment: Statistical Methods for Practitioners*, EPA QA/G-9S, Office of Environmental Information, U.S. Environmental Protection Agency, Washington, D.C. Available at: https://www.epa.gov/sites/production/files/2015-08/documents/g9s-final.pdf.

EPA/240/R-02/004, 2002, *Guidance on Environmental Data Verification and Data Validation*, EPA QA/G-8, Office of Environmental Information, U.S. Environmental Protection Agency, Washington, D.C. Available at: https://www.epa.gov/sites/production/files/2015-06/documents/g8-final.pdf.

EPA/240/R-02/009, 2002, *Guidance for Quality Assurance Project Plans*, EPA QA/G-5, Office of Environmental Information, U.S. Environmental Protection Agency, Washington, D.C. Available at: https://www.epa.gov/sites/production/files/2015-06/documents/g5-final.pdf.

EPA 540-R-08-005, 2009, *Guidance for Labeling Externally Validated Laboratory Analytical Data for Superfund Use*, OSWER No. 9200.1-85, Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington, D.C. Available at: https://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=P1002WWF.TXT.

EPA-540-R-2017-001, 2017, *National Functional Guidelines for Inorganic Superfund Methods Data Review*, Office of Superfund Remediation and Technology Innovation, U.S. Environmental Protection Agency, Washington, D.C. Available at: https://www.epa.gov/sites/production/files/2017-01/documents/national_functional_guidelines_for_inorganic_superfund_methods_data_review_01302017.pdf.

EPA-540-R-2017-002, 2017, *National Functional Guidelines for Organic Superfund Methods Data Review*, Office of Superfund Remediation and Technology Innovation, U.S. Environmental Protection Agency, Washington, D.C. Available at: https://www.epa.gov/sites/production/files/2017-01/documents/national_functional_guidelines_for_organic_superfund_methods_data_review_013072017.pdf.

EPA/600/4-79/020, 1983, *Methods for Chemical Analysis of Water and Wastes*, Office of Research and Development, U.S. Environmental Protection Agency, Washington, D.C. Available at: http://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=30000Q10.TXT.

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

Gibbs, Charles R., 1976, "Characterization and application of FerroZine iron reagent as a ferrous iron indicator," *Analytical Chemistry* 48(8):1197-1201.

Gleyzes, Christine, Sylvaine Tellier, and Michel Astruc, 2002, "Fractionation studies of trace elements in contaminated soils and sediments: a review of sequential extraction procedures," *Trends in Analytical Chemistry* 21(6 & 7):451-467.

Heron, Gorm, Catherine Crouzet, Alain C. M. Bourg, and Thomas H. Christensen, 1994, "Speciation of Fe(II) and Fe(III) in Contaminated Aquifer Sediments Using Chemical Extraction Techniques," *Environmental Science and Technology* 28(9):1698-1705.

IATA, 2019, *Dangerous Goods Regulations*, 60th Edition, International Air Transport Association, Montreal, Quebec, Canada.

Kohler, Matthias, Gary P. Curtis, David E. Meece, and James A. Davis, 2004, "Methods for Estimating Adsorbed Uranium (VI) and Distribution Coefficients of Contaminated Sediments," *Environmental Science and Technology* 38(1):240-247.

Larner, Bronwyn, Andrew J. Seen, and Ashley T. Townsend, 2006, "Comparative study of optimized BCR sequential extraction scheme and acid leaching of elements in certified reference material NIST 2711," *Analytica Chimica Acta* 556(2):444-449.

Massop, Katherine F. and Christine M. Davison, 2003, "Comparison of original and modified BCR sequential extraction procedures for the fractionation of copper, iron, lead, manganese, and zinc in soils and sediments," *Analytica Chimica Acta* 478(1):111-118.

National Historic Preservation Act of 1966, Pub. L. 89-665, as amended, 16 USC 470, et seq. Available at: https://www.nps.gov/history/local-law/nhpa1966.htm.

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

PNNL-24297, 2016, *Extended Leach Testing of Simulated LAW Cast Stone Monoliths*, Rev. 1, Pacific Northwest National Laboratory, Richland, Washington. Available at: https://www.pnnl.gov/main/publications/external/technical_reports/PNNL-24297Rev1.0.pdf.

PNNL-26266, 2017, *Geochemical, Microbial, and Physical Characterization of 200-DV-1 Operable Unit B-Complex Cores from Boreholes C9552, C9487, and C9488 on the Hanford Site Central Plateau*, Pacific Northwest National Laboratory, Richland, Washington. Available at: https://pdw.hanford.gov/document/0084238.

PNNL-26341, 2017, *Letter Report: Stable Hydrogen and Oxygen Isotope Analysis of B-Complex Perched Water Samples*, Pacific Northwest National Laboratory, Richland Washington. Available at: https://www.pnnl.gov/main/publications/external/technical_reports/PNNL-26341.pdf.

PNNL-27846, 2018, *Physical and Hydraulic Properties of Sediments from the 200-DV-1 Operable Unit*, Pacific Northwest National Laboratory, Richland Washington. Available at: https://www.pnnl.gov/main/publications/external/technical_reports/PNNL-27846.pdf.

Price-Anderson Amendments Act of 1988, Pub. L. 100-408, Aug. 20, 1988, 102 Stat. 1066, 42 USC 2010, et seq. Available at: https://www.govinfo.gov/content/pkg/STATUTE-102/pdf/STATUTE-102-Pg1066.pdf.

Resource Conservation and Recovery Act of 1976, Pub. L. 94-580, 42 USC 6901 et seq. Available at: https://www.gpo.gov/fdsys/pkg/STATUTE-90/pdf/STATUTE-90-Pg2795.pdf.

SGW-58147, 2015, *Annual Performance Report for the 200-DV-1 Operable Unit Perched Water Extraction, Fiscal Year 2014*, Rev. 0, CH2M HILL Plateau Remediation Company, Richland, Washington. Available at: https://pdw.hanford.gov/document/0081530h.

SGW-63236, 2019, *200-DV-1 Future Perched Water Well Evaluation*, Rev. 0, CH2M HILL Plateau Remediation Company, Richland, Washington. Available at: https://pdw.hanford.gov/document/AR-03701.

Sutherland, Ross A. and Filip M.G. Tack, 2002, "Determination of Al, Cu, Fe, Mn, Pb, and Zn in certified reference materials using the optimized BCR sequential extraction procedure," *Analytica Chimica Acta* 454(2):249-257.

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

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

173-160-181, "Minimum Standards for Construction and Maintenance of Wells," "What Are the Requirements for Preserving the Natural Barrier to Ground Water Movement Between Aquifers?"

WAC 173-340-720, "Model Toxics Control Act—Cleanup," "Groundwater Cleanup Standards," Washington Administrative Code, Olympia, Washington. Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-340-720.

This page intentionally left blank.

Appendix A

200-DV-1 Operable Unit Perched Water Proposed Extraction Well Profiles

This page intentionally left blank.

Figures

Figure A-1. Proposed Extraction Well PZ-1 Profile A-2
Figure A-2. Proposed Extraction Well PZ-2 Profile A-3
Figure A-3. Proposed Extraction Well PZ-3 Profile A-4
Figure A-4. Proposed Extraction Well PZ-4 Profile A-5
Figure A-5. Proposed Extraction Well PZ-5 Profile A-6
Figure A-6. Proposed Extraction Well PZ-6 Profile A-7
Figure A-7. Proposed Extraction Well PZ-7 Profile A-8
Figure A-8. Proposed Extraction Well PZ-8 Profile A-9

This page intentionally left blank.

A 200-DV-1 Operable Unit Perched Water Proposed Extraction Well Profiles

Figures A-1 through A-8 present well profiles for proposed extraction wells to be installed in the 200-DV-1 Operable Unit perched water zone to support characterization of the perched water zone and to increase extraction of the perched water by expanding the extraction well network. The well profiles summarize the estimated depths to geologic contacts, anticipated sampling intervals, and potential well construction for each proposed extraction well.

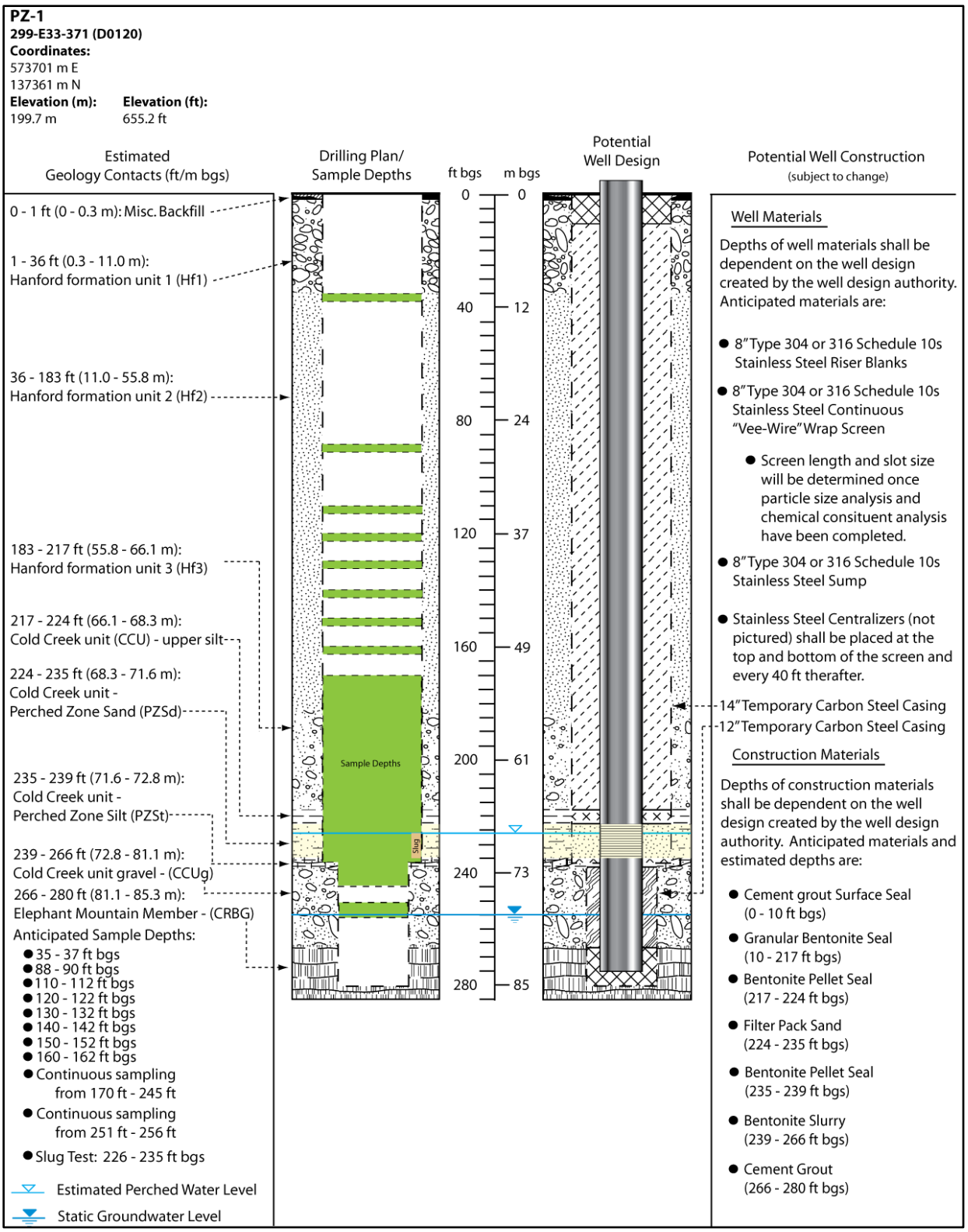


Figure A-1. Proposed Extraction Well PZ-1 Profile

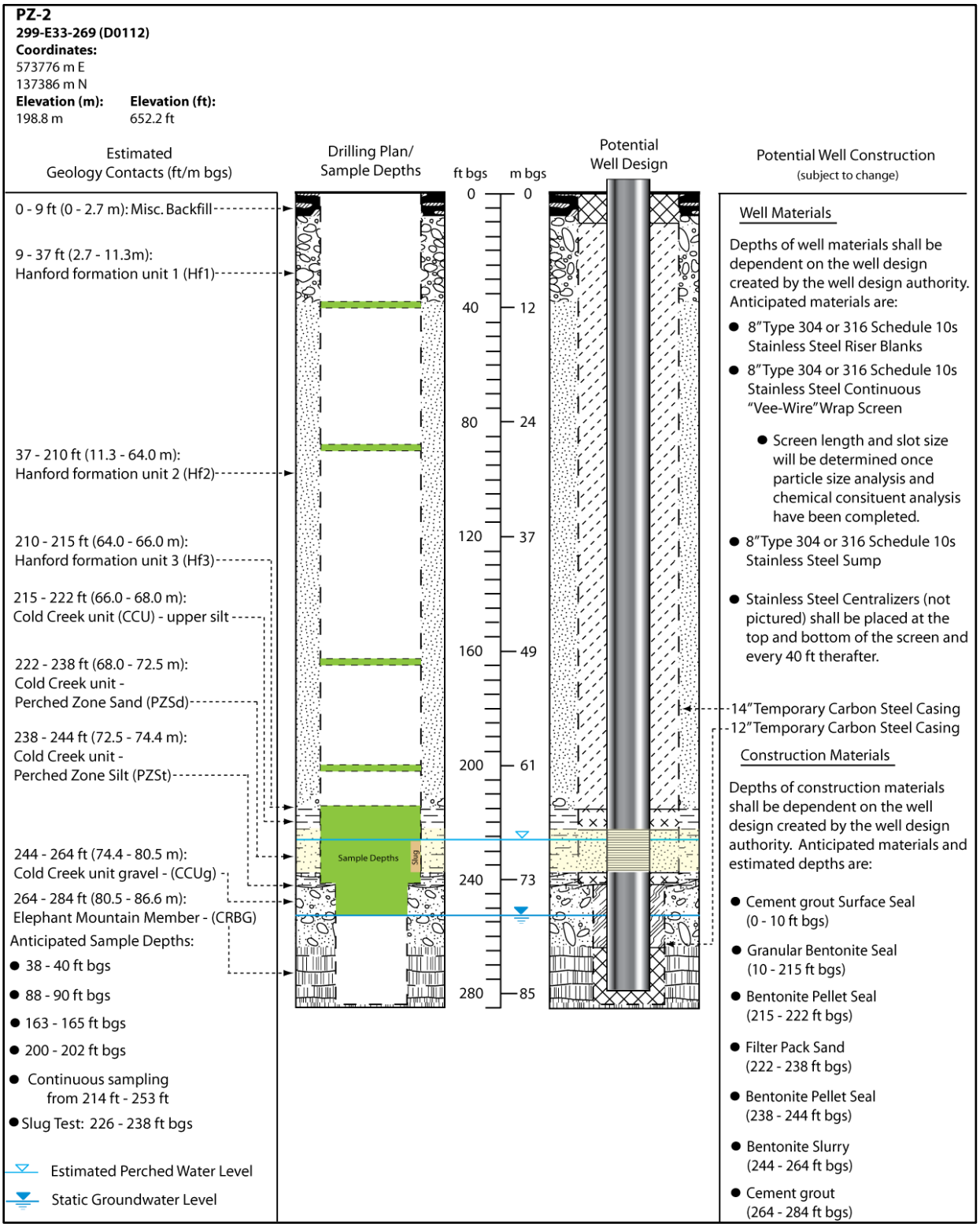


Figure A-2. Proposed Extraction Well PZ-2 Profile

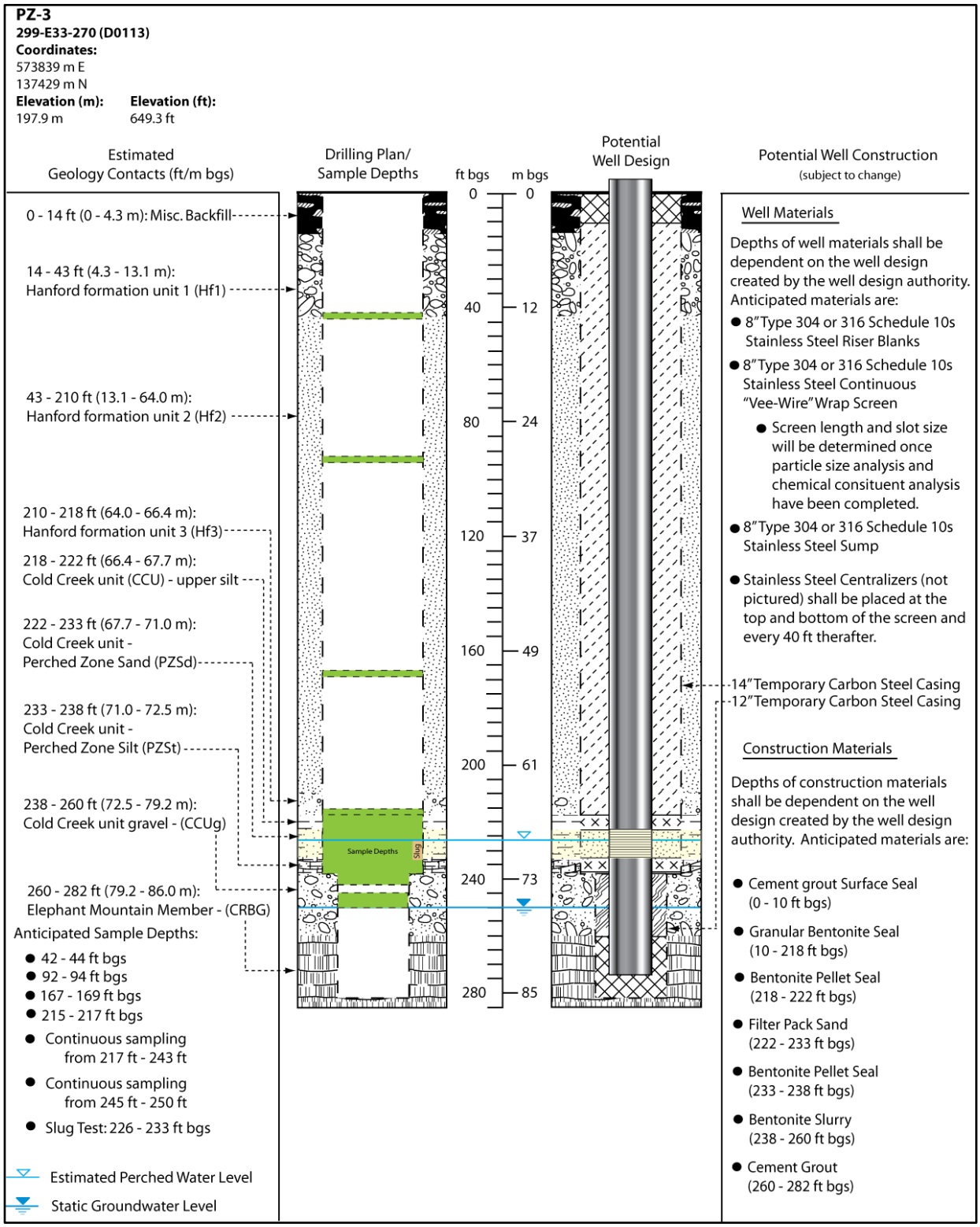


Figure A-3. Proposed Extraction Well PZ-3 Profile

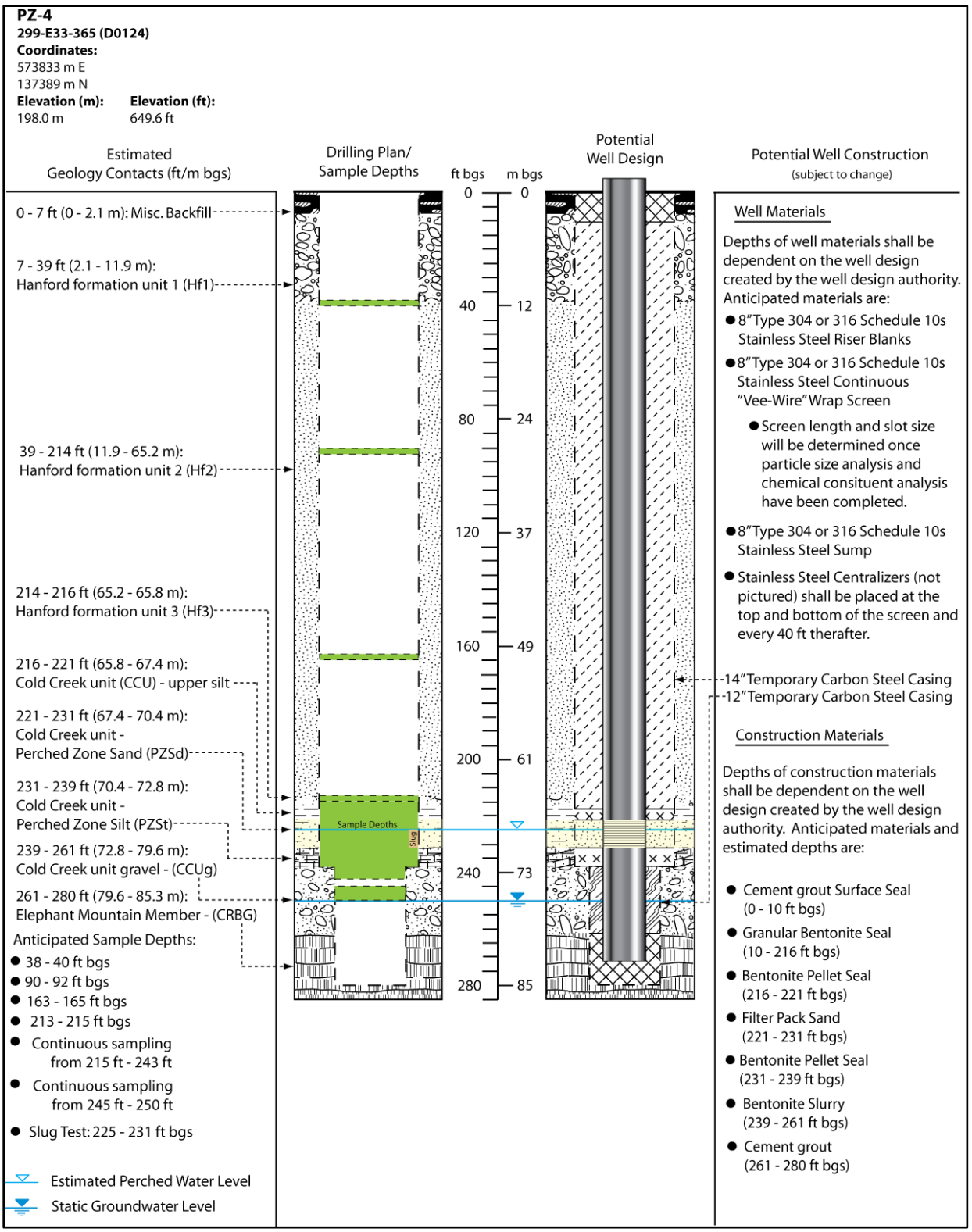


Figure A-4. Proposed Extraction Well PZ-4 Profile

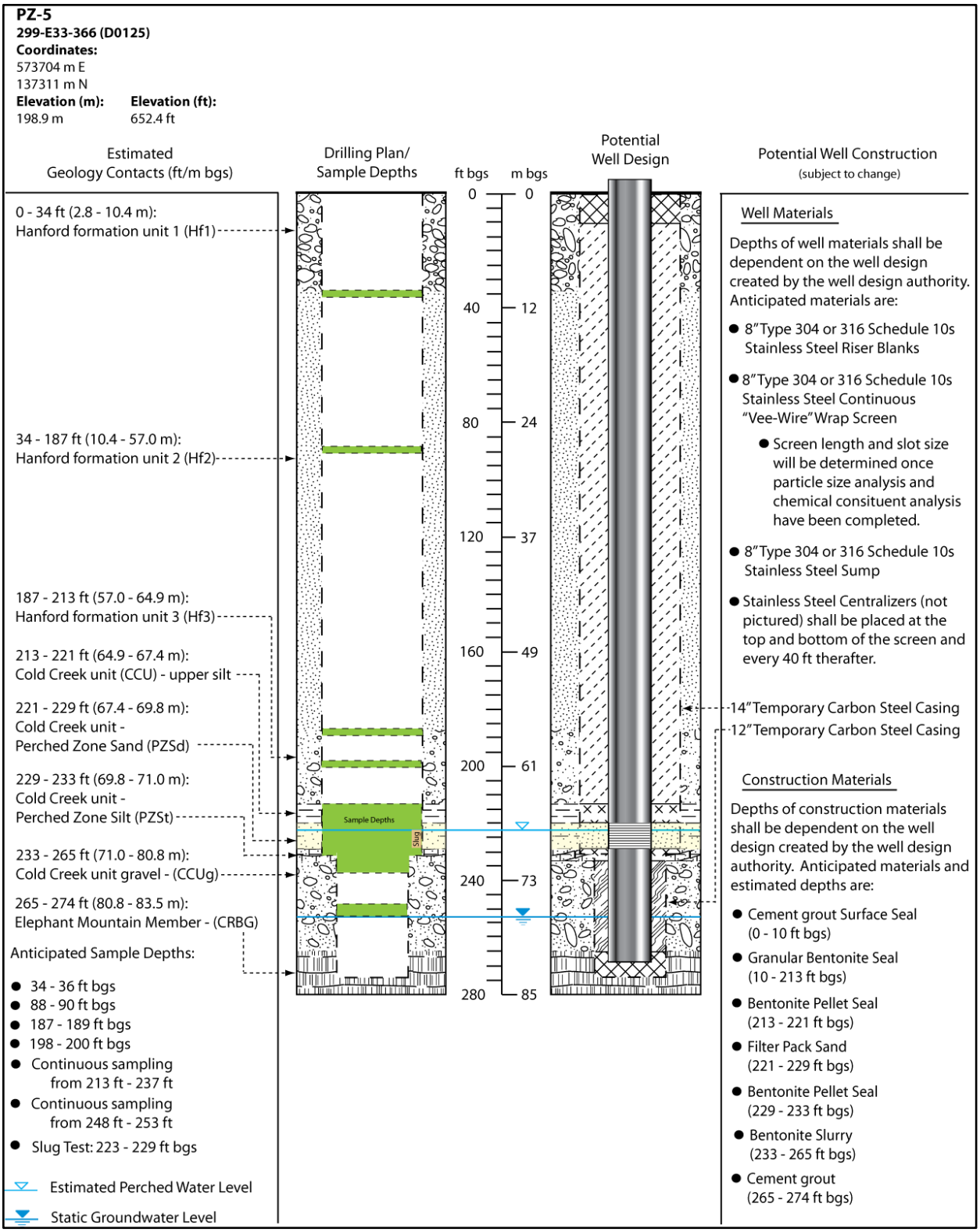


Figure A-5. Proposed Extraction Well PZ-5 Profile

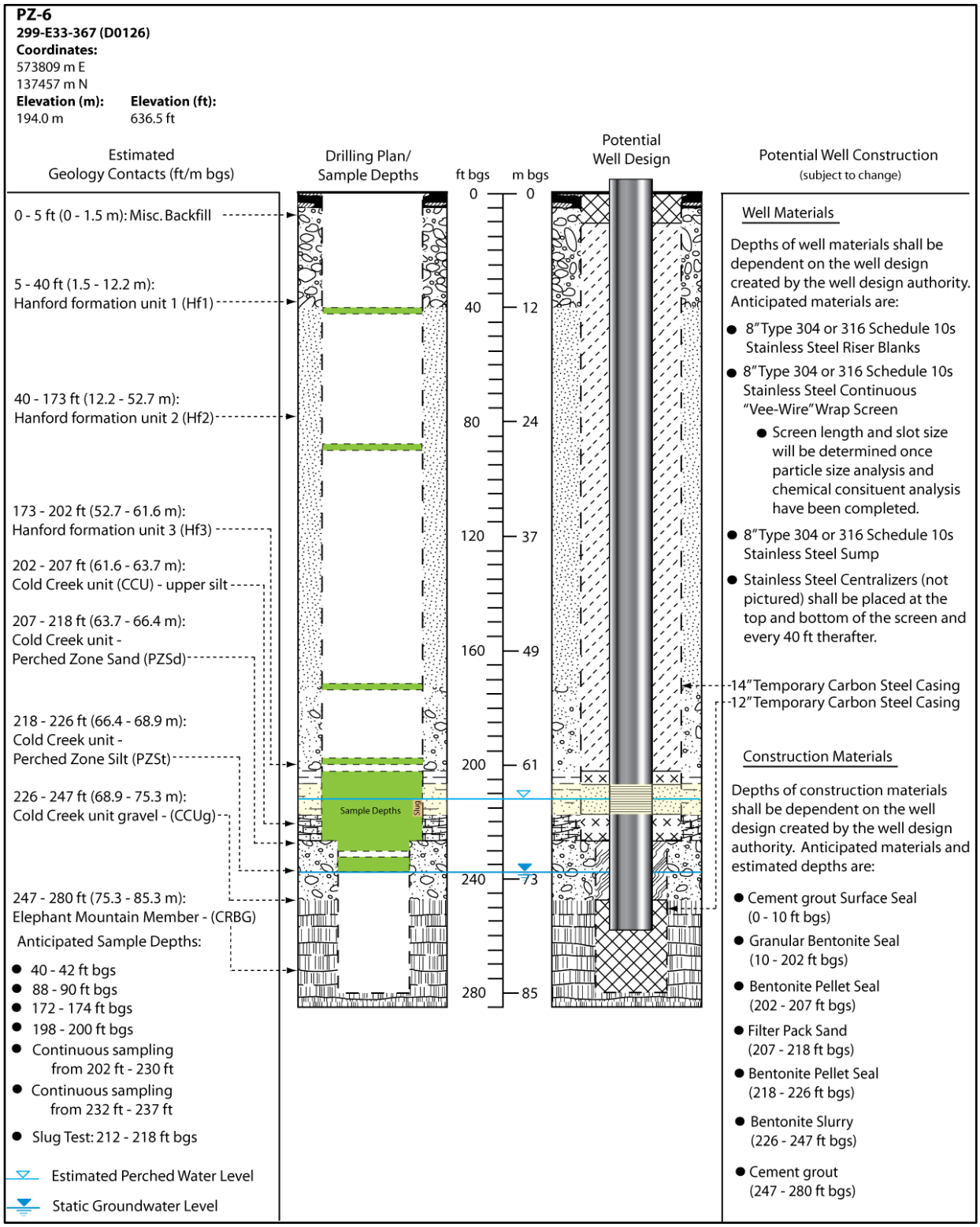


Figure A-6. Proposed Extraction Well PZ-6 Profile

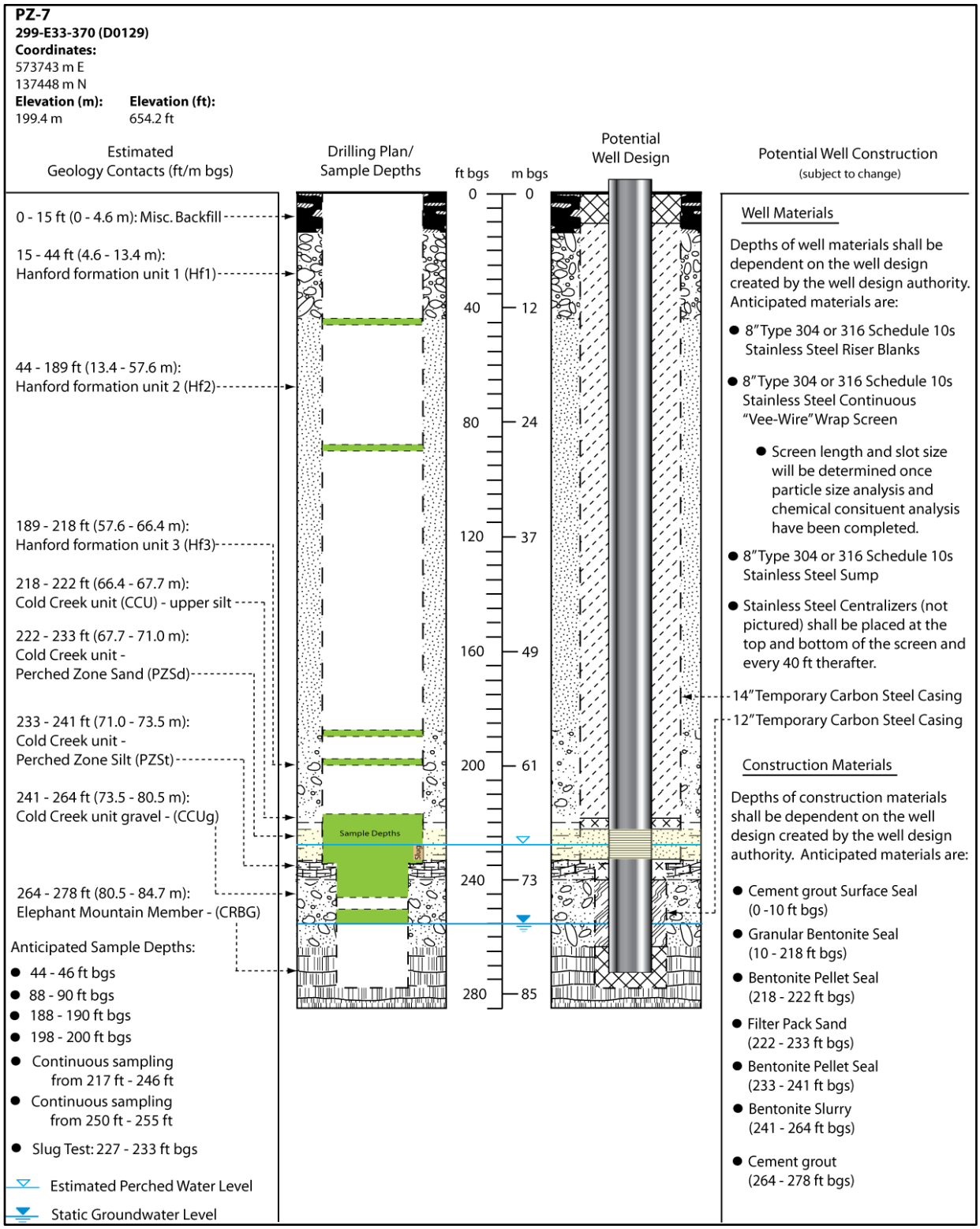


Figure A-7. Proposed Extraction Well PZ-7 Profile

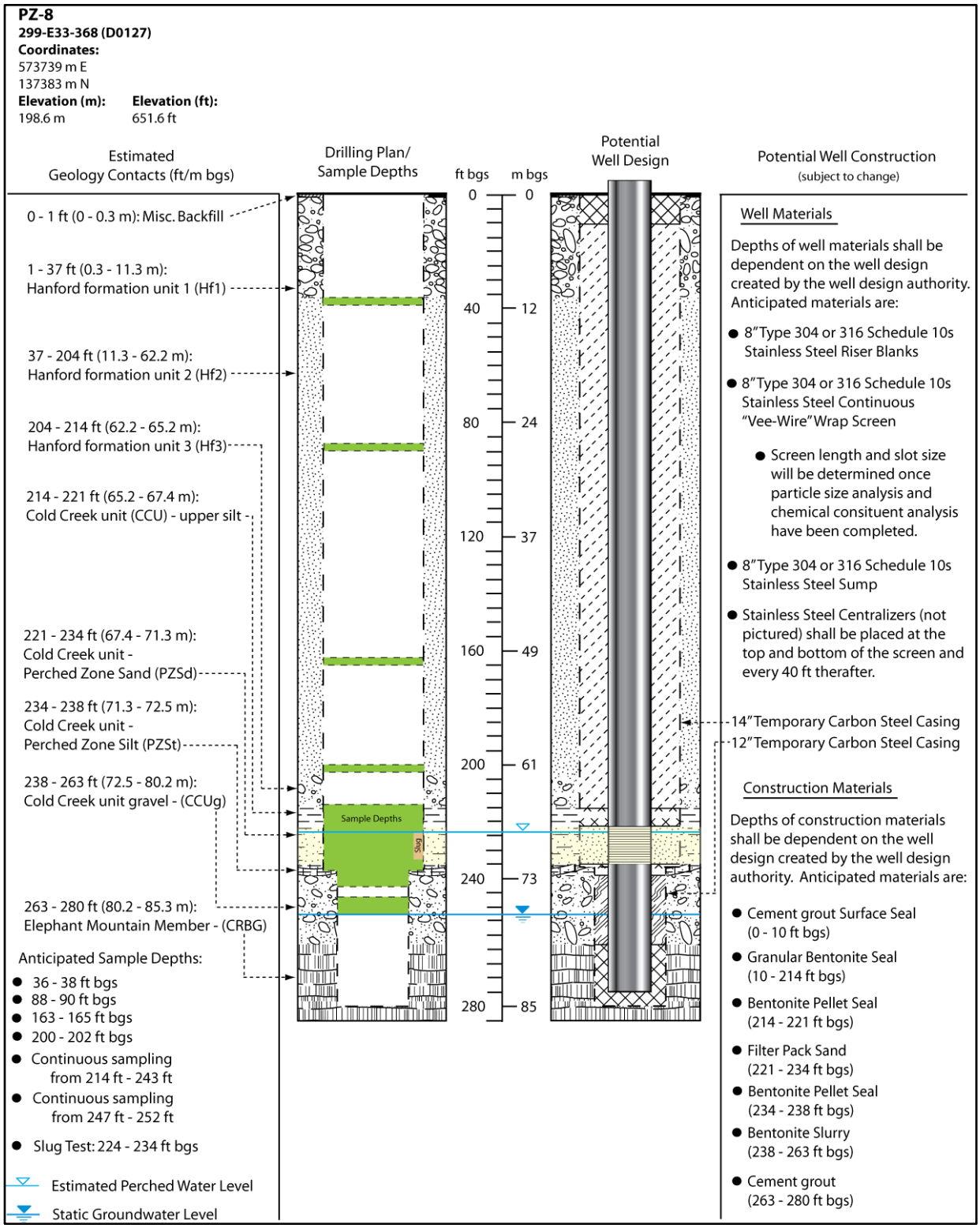


Figure A-8. Proposed Extraction Well PZ-8 Profile

This page intentionally left blank.

Appendix B

200-DV-1 Operable Unit Perched Water Proposed Monitoring Well Profiles

This page intentionally left blank.

Figures

Figure B-1. Proposed Monitoring Well PZ-9 Profile B-2
Figure B-2. Proposed Monitoring Well PZ-10 Profile B-3
Figure B-3. Proposed Monitoring Well PZ-11 Profile B-4
Figure B-4. Proposed Monitoring Well PZ-12 Profile B-5

This page intentionally left blank.

B 200-DV-1 Operable Unit Perched Water Proposed Monitoring Well Profiles

Figures B-1 through B-4 present well profiles for proposed monitoring wells to be installed in the 200-DV-1 Operable Unit perched water zone to support characterization of the perched water zone and monitor performance of the perched water extraction well network. The well profiles summarize the estimated depths to geologic contacts, anticipated sampling intervals, and potential well construction for each proposed monitoring well.

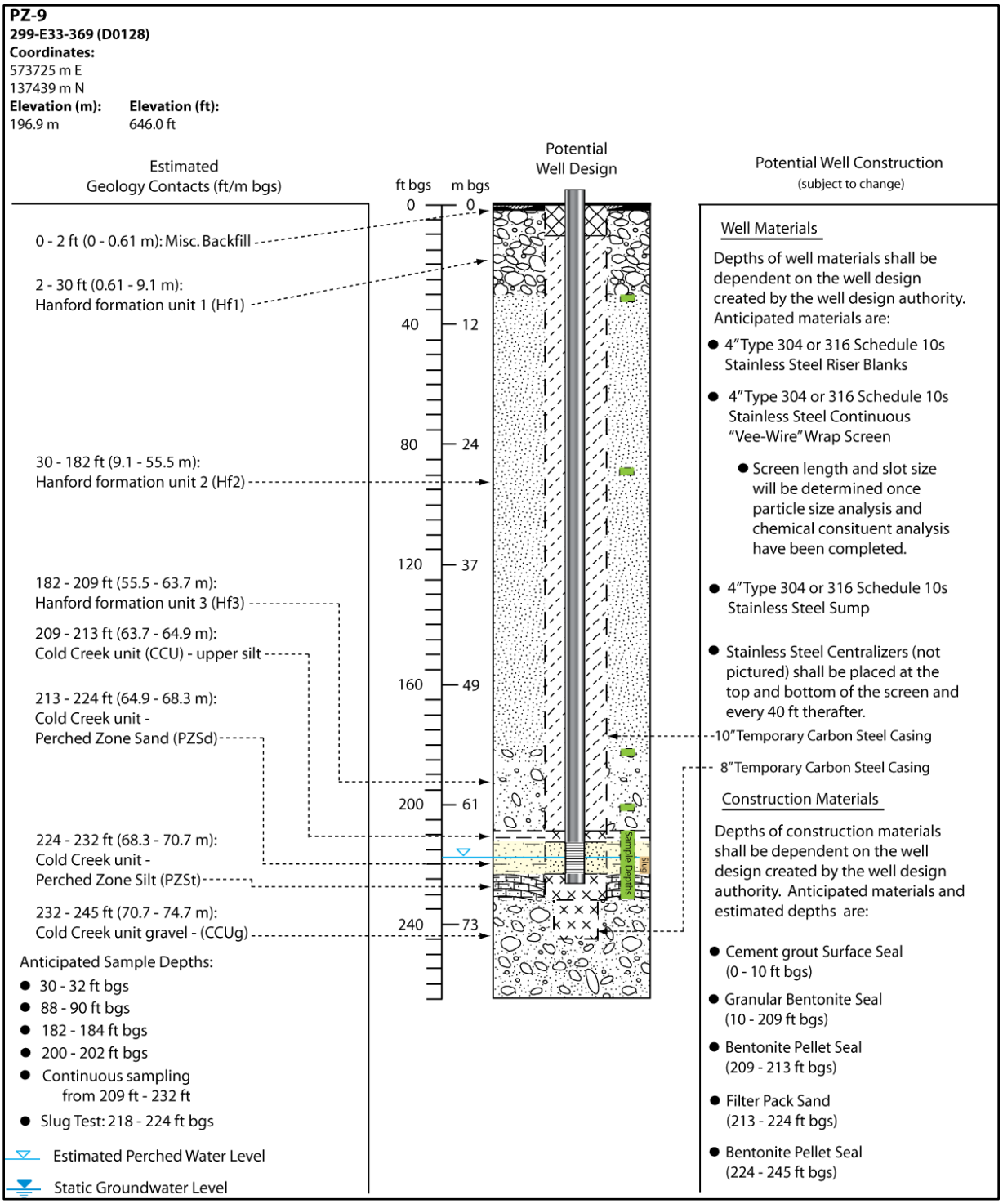


Figure B-1. Proposed Monitoring Well PZ-9 Profile

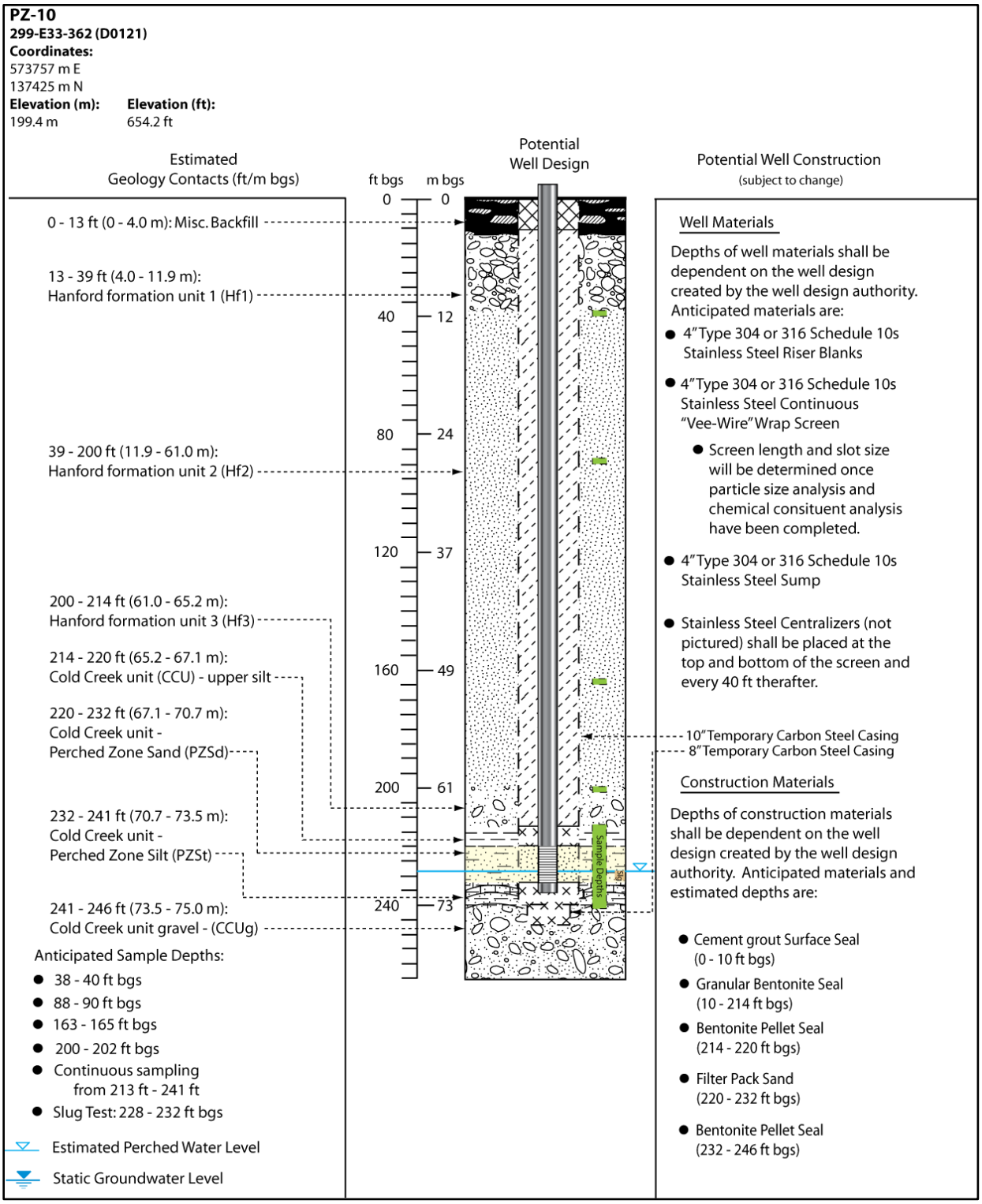


Figure B-2. Proposed Monitoring Well PZ-10 Profile

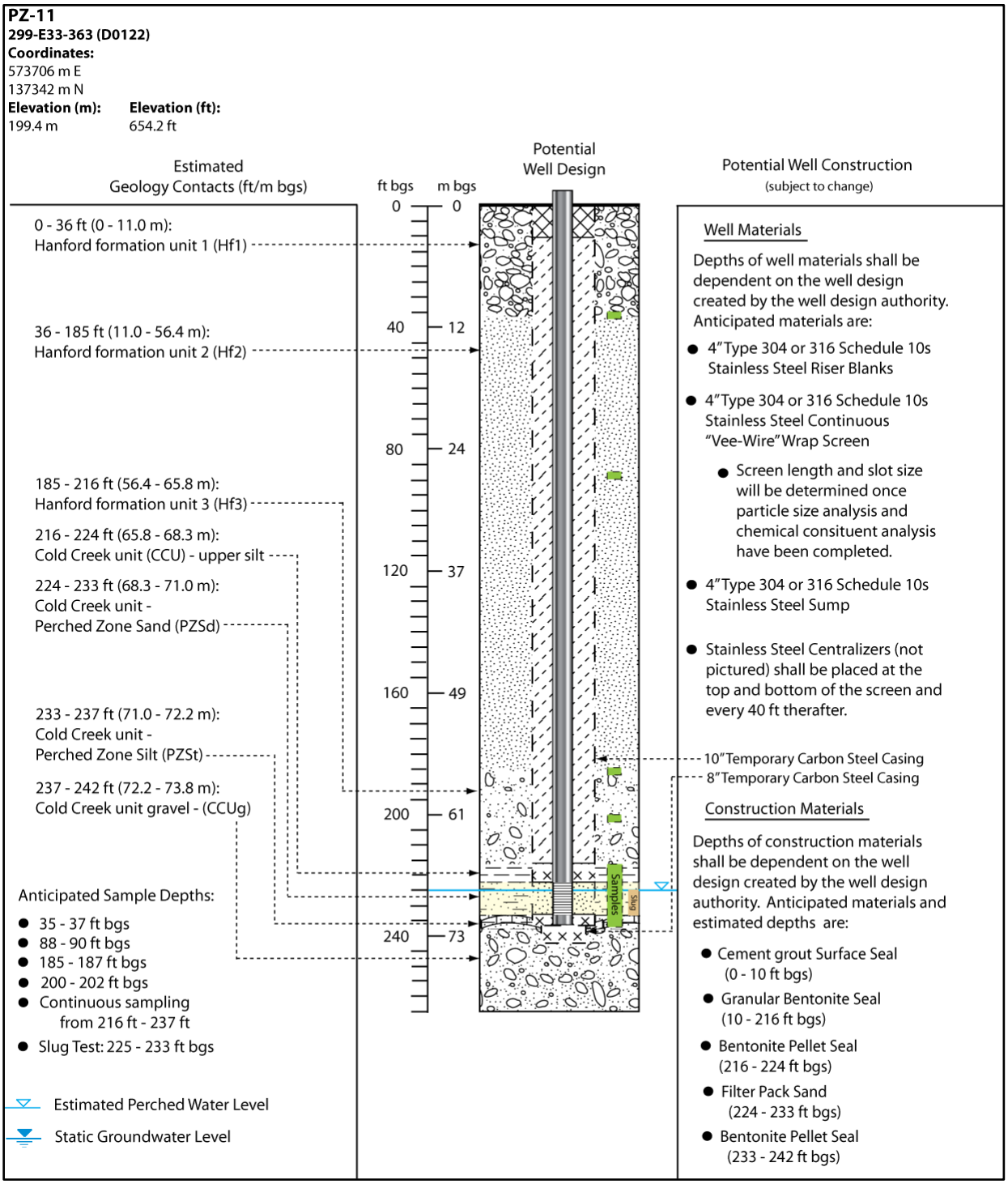


Figure B-3. Proposed Monitoring Well PZ-11 Profile

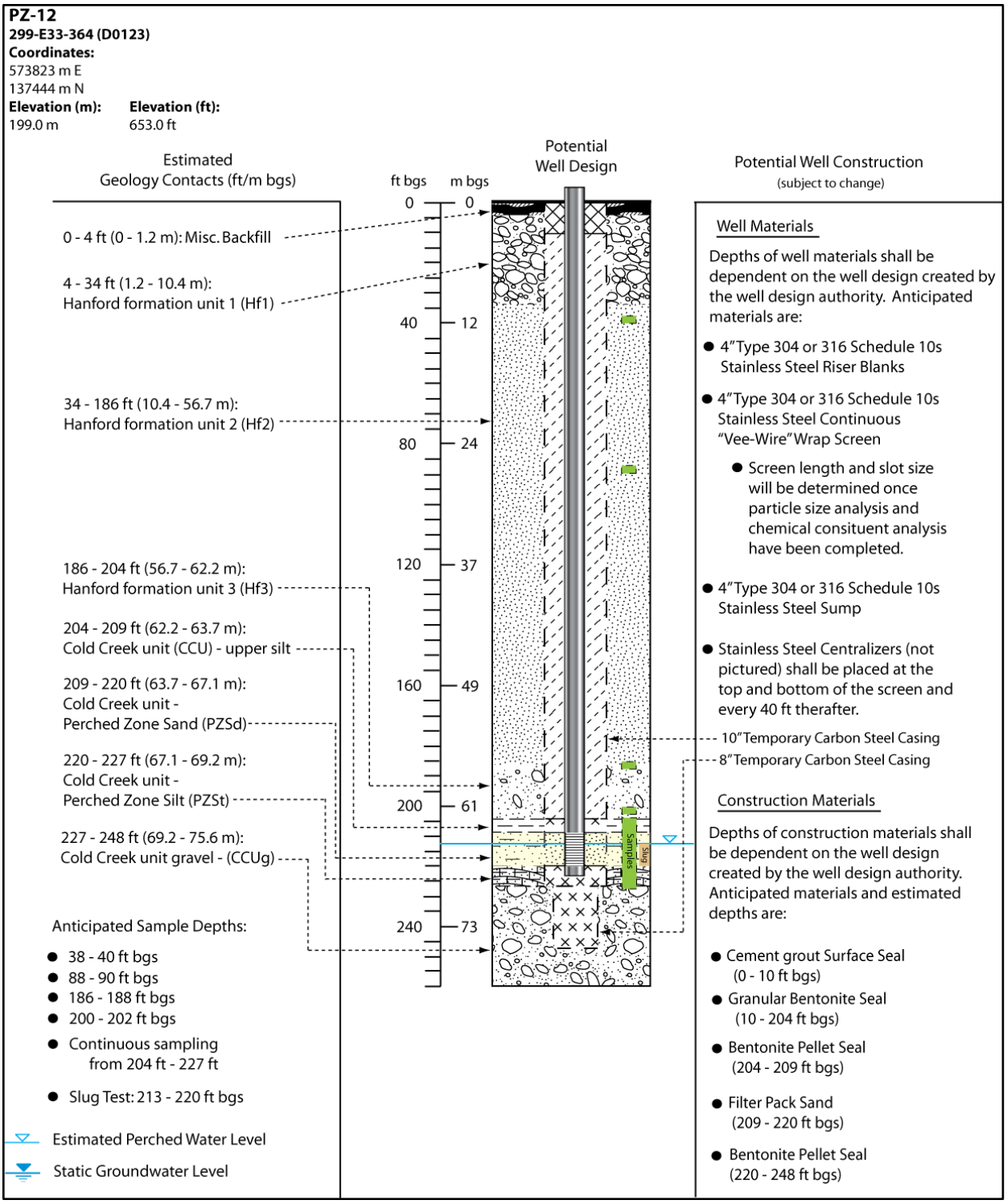


Figure B-4. Proposed Monitoring Well PZ-12 Profile

This page intentionally left blank.