

Performance Monitoring Plan for the 200-ZP-1 Groundwater Operable Unit Remedial Action

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



P.O. Box 550
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Terms

amsl	above mean sea level
CCU	Cold Creek unit
CERCLA	<i>Comprehensive Environmental Response, Compensation, and Liability Act of 1980</i>
COC	contaminant of concern
CSM	conceptual site model
CY	calendar year
DOE	U.S. Department of Energy
DS	decision statement
EPA	U.S. Environmental Protection Agency
FY	fiscal year
gpm	gallons per minute
HEIS	Hanford Environmental Information System
MCL	maximum contaminant level
MNA	monitored natural attenuation
OU	operable unit
P&T	pump and treat
PMP	performance monitoring plan
RAO	remedial action objective
RD/RAWP	remedial design/remedial action work plan
ROD	Record of Decision
VOC	volatile organic compound

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1 Introduction

This revision of the performance monitoring plan (PMP) guides groundwater monitoring data collection activities and reflects necessary changes subsequent to implementing the 200-ZP-1 Groundwater Operable Unit (OU) remedial action. The selected remedy is described in EPA et al., 2008, *Record of Decision, Hanford 200 Area 200-ZP-1 Superfund Site, Benton County, Washington* (hereafter referred to as the 200-ZP-1 OU Record of Decision [ROD]). This PMP presents recommendations for the types of data that should be collected, the well networks that should be monitored, the frequency of data collection, and the analysis of the data to satisfy the requirements of the ROD. This PMP is not designed to monitor the treatment process of the treatment plant, does not serve as a compliance monitoring program for the treated effluent discharge from the treatment plant, and is not used to monitor the performance of any remedial activities for the 200-UP-1 OU. Monitoring of remedial activities for the 200-UP-1 OU is described in DOE/RL-2015-14, *Performance Monitoring Plan for the 200-UP-1 Groundwater Operable Unit Remedial Action*.

This PMP is a flexible, “living document” that may be modified based on changing hydraulic and contaminant distribution conditions at the 200-ZP-1 OU. Frequent modifications to the network are probable due to changing conditions (e.g., some wells in the PMP monitoring network will go dry due to pump and treat [P&T] operations). Also, improvements made to the conceptual site model (CSM), groundwater flow model, and three-dimensional contaminant distributions based on information from newly drilled extraction and injection wells could influence the PMP. Therefore, emphasis must be placed on the PMP being adaptable enough to specify performance monitoring regimes that make sense for the changing state of the site.

The 200-ZP-1 OU includes several groundwater plumes that span a 13 km² (5 mi²) area beneath the 200 West Area of the Hanford Site (Figure 1-1). The 200 Areas, which include the 200 East and 200 West Areas, contain permanent waste management facilities and former reprocessing facilities associated with plutonium concentration and recovery operations. The remedial investigation and feasibility studies (DOE/RL-2006-24, *Remedial Investigation Report for the 200-ZP-1 Groundwater Operable Unit*; and DOE/RL-2007-28, *Feasibility Study for the 200-ZP-1 Groundwater Operable Unit*) concluded that without remedial action, 200-ZP-1 groundwater contaminants would exceed risk threshold values for future industrial workers and residents who might use the groundwater as a drinking water supply. The contaminant concentrations also exceed federal and state maximum contaminant levels (MCLs) and state groundwater cleanup standards for use of the groundwater as a drinking water source. As stated in the 200-ZP-1 OU ROD (EPA et al., 2008), the major contaminant of concern (COC) for the OU is carbon tetrachloride. Other 200-ZP-1 COCs include total chromium, hexavalent chromium, nitrate, trichloroethene, iodine-129, technetium-99, and tritium.

The 200-ZP-1 OU ROD (EPA et al., 2008) presents the selected groundwater remedial action for restoring the aquifer, as well as the cleanup levels for the COCs. DOE/RL-2008-78, *200 West Area 200-ZP-1 Pump-and-Treat Remedial Design/Remedial Action Work Plan (RD/RAWP)*, describes the design and implementation of the remedial action process required by the ROD. This PMP describes the monitoring activities associated with the remedial action process, the remedial action objectives (RAOs), and the preferred remedial action alternative chosen to meet those RAOs.

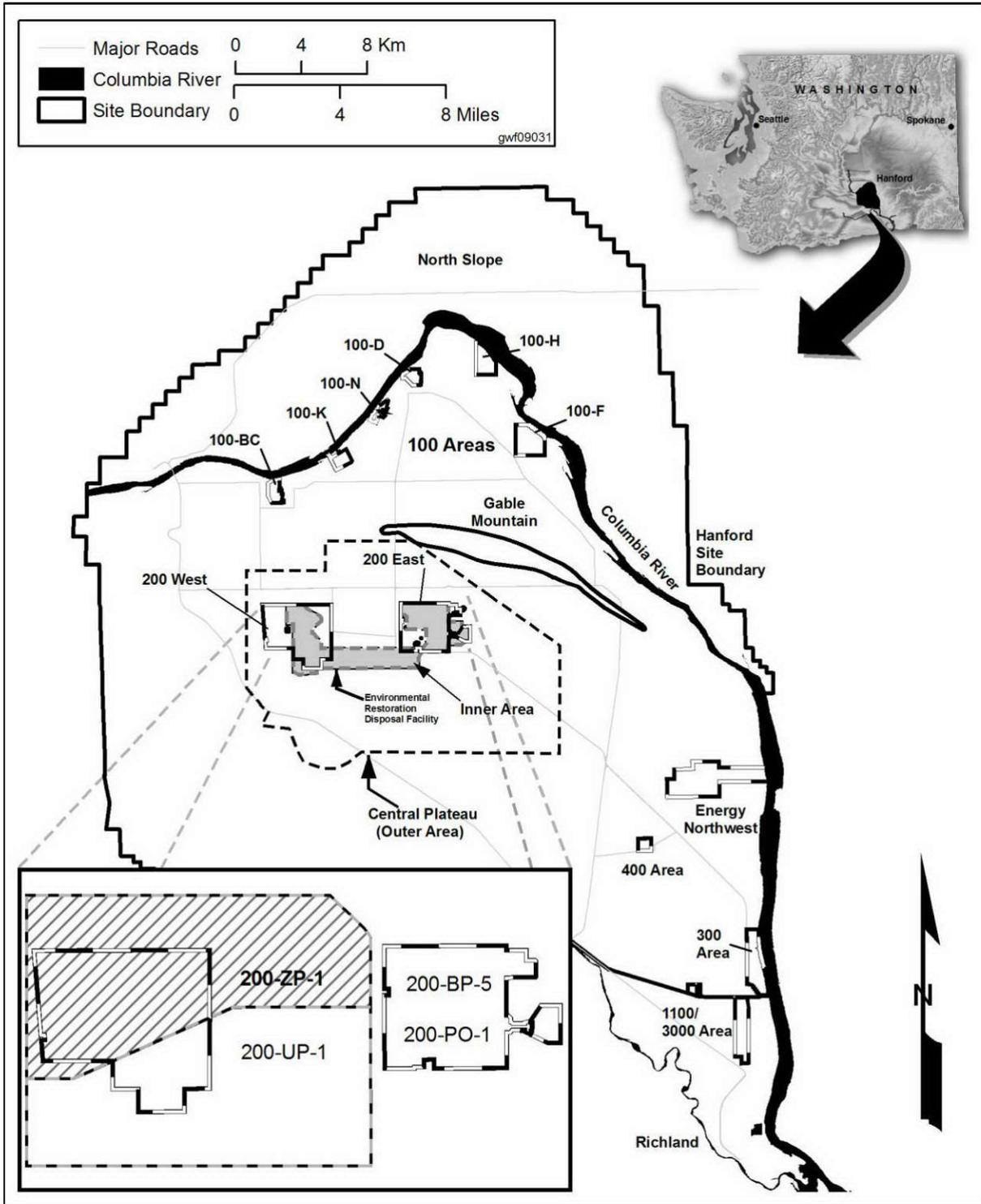


Figure 1-1. Site Location

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1 1.1 Remedial Action Objectives

2 Through its groundwater protection program, the state of Washington determined that the 200-ZP-1 OU
3 aquifer meets the *Washington Administrative Code* definition for potable groundwater and has
4 recognized it as a potential source of domestic drinking water. Consistent with the state's beneficial-use
5 determination, the contaminated groundwater will be restored to support future use as a potential
6 domestic drinking water supply. In accordance with this goal, the RAOs for remediating contaminated
7 200-ZP-1 OU groundwater are as follows:

- 8 • **RAO #1:** Return the 200-ZP-1 OU groundwater to beneficial use (restore groundwater to achieve
9 domestic drinking water levels) by achieving cleanup levels (Table 1-1). This objective is to be
10 achieved within the entire 200-ZP-1 OU groundwater plumes. The estimated time frame to achieve
11 cleanup levels is within 150 years.¹
- 12 • **RAO #2:** Apply institutional controls to prevent the use of groundwater until the cleanup levels
13 (Table 1-1) have been achieved. Within the entire OU groundwater plumes, institutional controls
14 must be maintained and enforced until the cleanup levels are achieved, which is estimated to be
15 within 150 years.¹
- 16 • **RAO #3:** Protect the Columbia River and its ecological resources from degradation and unacceptable
17 impact caused by contaminants originating from the 200-ZP-1 OU. This final objective is applicable
18 to the entire 200-ZP-1 OU groundwater plume. Protection of the Columbia River from impacts
19 caused by 200-ZP-1 OU contaminants must continue until the cleanup levels are achieved, which is
20 estimated to be within 150 years.¹

Table 1-1. Cleanup Levels for 200-ZP-1 OU Groundwater

COC	Cleanup Level	Units
Carbon tetrachloride	3.4*	µg/L
Chromium (total)	100	µg/L
Hexavalent chromium	48	µg/L
Nitrate	10,000	µg/L
Trichloroethene	1*	µg/L
Iodine-129	1	pCi/L
Technetium-99	900	pCi/L
Tritium	20,000	pCi/L

* The U.S. Department of Energy will clean up COCs for the 200-ZP-1 OU subject to WAC 173-340, "Model Toxics Control Act – Cleanup" (carbon tetrachloride and trichloroethene), so the excess lifetime cancer risk does not exceed 1×10^{-5} at the conclusion of the remedy. Groundwater standards are applicable or relevant and appropriate requirements which are used in the CERCLA cleanup process to select cleanup levels.

COC = contaminant of concern

OU = operable unit

¹ The RAOs identify the estimated time frame to achieve cleanup levels as 150 years. Further requirements in the ROD identify this time frame as 125 years, which is more conservative than the RAOs.

1.2 200-ZP-1 Operable Unit Selected Remedy

The selected remedy for the 200-ZP-1 OU consists of four components: (1) groundwater P&T, (2) monitored natural attenuation (MNA), (3) flow-path control, and (4) institutional controls. The first three components, which are the subject of this PMP, require periodic groundwater monitoring and data evaluation to assess remedy performance and determine when remedial action is complete. The fourth component does not require groundwater monitoring and is addressed separately in DOE/RL-2001-41, *Sitewide Institutional Controls Plan for Hanford CERCLA Response Actions and RCRA Corrective Actions*. Descriptions of the first three components of the selected remedy are presented in the following subsections.

1.2.1 Pump and Treat Component

The 200 West P&T design, well installations, and operations capture and treat contaminated groundwater to reduce the 200-ZP-1 COC mass by a minimum of 95 percent within 25 years. The P&T component is being implemented in combination with MNA to achieve the cleanup levels listed in Table 1-1 for all COCs within 125 years. Modeling performed for DOE/RL-2006-24, *Remedial Investigation Report for the 200-ZP-1 Groundwater Operable Unit*, indicates that groundwater carbon tetrachloride concentrations greater than 100 µg/L correspond to approximately 95 percent of the mass of carbon tetrachloride currently residing in the aquifer. The estimated pumping rate required to reduce this mass by 95 percent within 25 years is 7,570 L/min (2,000 gallons per minute [gpm]) using approximately 20 extraction wells and 16 injection wells.

Following extraction, the COCs in groundwater (except for tritium) will be treated to achieve the cleanup levels listed in Table 1-1. The treated groundwater will then be returned to the aquifer through injection wells. There is no cost-effective treatment technology to remove tritium from groundwater. However, the short half-life of tritium (12.3 years) will result in its decay below the cleanup standard before it leaves the 200 West Area industrial land-use zone.

The RD/RAWP (DOE/RL-2008-78) considers the need for treating other constituents (e.g., uranium) that may be captured by 200-ZP-1 OU extraction wells. While not 200-ZP-1 COCs, these constituents may be encountered during restoration from sources related to the other adjacent groundwater OUs.

1.2.2 Monitored Natural Attenuation Component

In addition to the 200 West P&T, natural attenuation processes will help reduce COC concentrations to their cleanup levels (Table 1-1). During the early stages of remedy implementation, the 200 West P&T accounts for a majority of the contaminant mass removal. In the outer regions of the plume, and during the latter stages of P&T operation, natural attenuation plays an increasing role in reducing COC concentrations. Natural attenuation processes expected to contribute to COC concentration reductions include abiotic degradation, volatilization (for trichloroethene and carbon tetrachloride), dispersion, sorption, and natural radioactive decay (for tritium). In accordance with the 200-ZP-1 OU ROD (EPA et al. 2008), natural attenuation will reduce COC concentrations to cleanup levels within 100 years of final 200 West P&T operations. The overarching requirement is to meet the groundwater cleanup levels listed in Table 1-1 within 125 years.

1.2.3 Flow-Path Control Component

Flow-path control will be achieved by injecting treated groundwater into the aquifer to the northeast and east (downgradient) of the groundwater contamination (Figure 1-2). Injecting treated water at these locations will slow the natural eastward flow of most of the groundwater and keep the 200-ZP-1 COCs within the hydraulic capture zone of the extraction wells. Injection wells installed to the west (upgradient)

1 will redirect groundwater flow to the east (toward the extraction wells), minimizing the potential for
2 groundwater in the northern portion of the aquifer to flow northward through Gable Gap toward the
3 Columbia River. Flow-path control also increases the time available for natural attenuation processes to
4 reduce COC concentrations in areas not captured by the extraction wells.

5 **1.3 Implementation of the Selected Remedy**

6 Since the 200-ZP-1 OU ROD (EPA et al., 2008) was signed in 2008, the 200 West P&T was constructed,
7 30 new extraction wells and 21 new injection wells were installed, and the interim system's 5 existing
8 injection wells were connected to the system. The 200 West P&T, with a hydraulic capacity of
9 9,464 L/min (2,500 gpm), began operations in 2012 after interim facility operations ended. The design of
10 the new 200 West extraction, injection, and monitoring well field continues to evolve due to data
11 collected and analyzed from drilling, sampling, and testing new wells. If sampling results indicate that
12 contamination below Ringold unit 8 (also known as the Ringold lower mud unit) is higher than the
13 contaminant levels above it, changes to the well design and locations will be made to appropriately
14 address this contamination and meet the cleanup levels specified in the ROD. These changes may include
15 constructing extraction wells below Ringold unit 8. Likewise, if high COC concentrations are found
16 below Ringold unit 8, then changes may include injecting treated water below it to provide a vertical
17 gradient to block eastern COC migration above the basalt and prevent contaminants from penetrating the
18 basalt. If contamination is above levels being addressed by MNA below Ringold unit 8, then extraction,
19 injection, and monitoring well construction may be required below Ringold unit 8 to monitor the
20 migration and containment of contaminants.

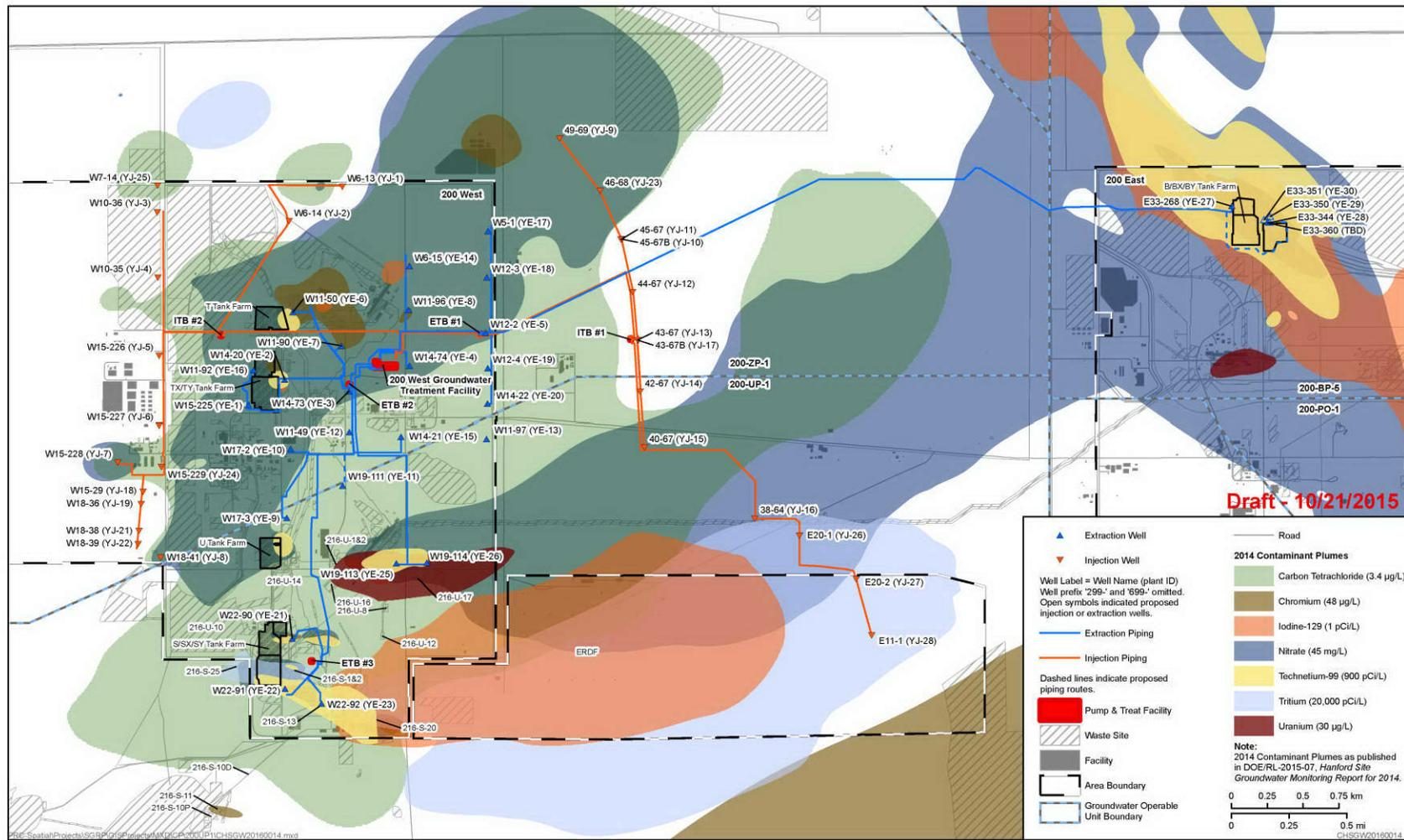
21 The new extraction wells are in areas with carbon tetrachloride concentrations greater than 100 µg/L
22 (Figure 1-2). This design concentrates active treatment on the most contaminated groundwater in
23 the relatively large plume. The eastern injection wells are in areas with carbon tetrachloride
24 concentrations less than 100 µg/L, but possibly greater than 5 µg/L (Figure 1-2). Groundwater
25 contaminated above cleanup levels downgradient of the eastern injection well fence will be addressed
26 by natural attenuation. The western injection wells are located where carbon tetrachloride concentrations
27 are around 5 µg/L.

28 The 200 West P&T extracts some groundwater and associated contaminants originating from the
29 200-UP-1 OU. However, since the 200-UP-1 contribution is minimal, three categories of monitoring
30 well networks have been defined for the 200-ZP-1 OU:

- 31 • A volatile organic compound (VOC) network for monitoring carbon tetrachloride and trichloroethene
32 throughout the entire 200 West Area.
- 33 • A 200-ZP-1 monitoring well network, which includes only monitoring wells within the
34 200-ZP-1 OU.
- 35 • Contaminant-specific networks for total and hexavalent chromium, iodine-129, nitrate,
36 technetium-99, tritium, and uranium (uranium is a 200-UP-1 OU COC monitored in the 200-ZP-1 OU
37 for tracking purposes only). The wells in each of the contaminant-specific networks are a subset of
38 the 200-ZP-1 network wells.

39 The carbon tetrachloride plume shown in Figure 1-2 represents the initial plume condition after P&T
40 started in 2012. The transport model carbon tetrachloride concentrations are documented in
41 ECF-200ZP1-13-0006, *Description of Groundwater Modeling Calculations for the Calendar Year 2012*
42 *(CY 2012) 200 Areas Pump-and-Treat Report*.

43



Source: DOE/RL-2013-14, Calendar Year 2012 Annual Summary Report for the 200-ZP-1 and 200-UP-1 Operable Unit Pump-and-Treat Operations.

Figure 1-2. 200 West P&T Well Field and Pipeline Routes Overlying the Carbon Tetrachloride Plume

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- 1 The appendices that accompany this PMP support the performance monitoring program:
- 2 • Appendix A presents the results from the data quality objective process used to develop the
3 sampling approaches.
 - 4 • Appendix B presents specific data collection details in the sampling and analysis plan for the
5 200-ZP-1 OU.
 - 6 • Appendix C presents the sampling schedule details for the performance monitoring network.
 - 7 • Appendix D presents maps of kriged carbon tetrachloride error variance supporting the data
8 gap analysis.
 - 9 • Appendix E presents the hydraulic monitoring well network and well construction details.
 - 10 • Appendix F presents the 200-ZP-1 OU performance monitoring well network construction details and
11 sample interval depth information.

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2 Conceptual Site Model

This chapter summarizes 200 West Area geology, hydrogeology, and groundwater information from the 200-ZP-1 OU ROD (EPA et al., 2008) and is included to provide an overview of the current understanding of the CSM.

2.1 Local Geology

The Hanford Site lies in a sediment-filled basin on the Columbia Plateau in southeastern Washington State. The 200-ZP-1 OU underlies the northern portion of the 200 West Area, which is on the western end of the Central Plateau, near the center of the Hanford Site (Figure 1-1). The Columbia River Basalt Group and a sequence of overlying sediments comprise the local geology. The overlying sediments are about 169 m (555 ft) thick and primarily consist of the Ringold Formation and Hanford formation, which consist of sand and gravel with some silt layers (Figures 2-1, 2-2, and 2-3). Surface elevations range from 200 to 217 m (660 to 712 ft) above mean sea level (amsl).

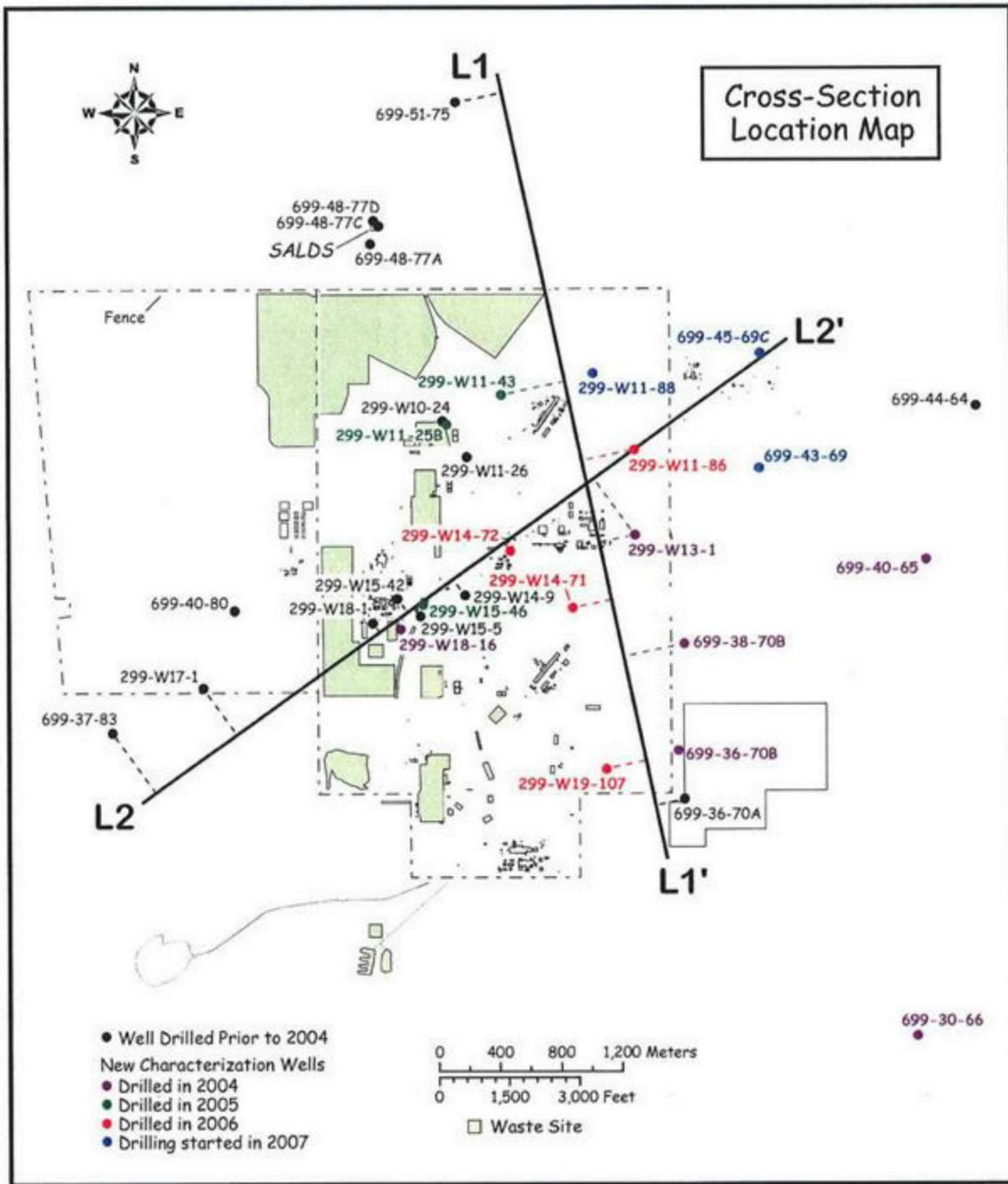
2.2 Local Hydrogeology

The sediment thickness above the water table (the vadose zone) ranges from 40 to 75 m (132 to 246 ft). Sediments in the vadose zone are the Ringold Formation (the uppermost Ringold unit E and the upper Ringold unit), the Cold Creek unit (CCU), and the Hanford formation. Erosion during cataclysmic flooding removed some of the Ringold Formation and CCU. Perched water (water above the water table) has historically been documented above the CCU at 200 Area locations. However, since most area liquid waste discharges were stopped in 1995, perched water is infrequently encountered.

Recharge to the 200 West Area unconfined aquifer is from artificial and natural sources. Natural recharge originates from precipitation, with recharge estimates ranging from 0 to 10 cm/yr (0 to 4 in./yr), largely dependent on soil texture and the type and density of vegetation. Artificial recharge historically occurred when effluents such as cooling water and process wastewater were disposed to the ground. The largest sources of artificial recharge ceased in 1995, with continuing Central Plateau artificial recharge largely due to onsite sanitary sewage treatment and disposal systems; leaks from potable and raw water lines; two state-approved land disposal structures; and small-volume, uncontaminated, miscellaneous waste streams. Small volumes of uncontaminated water may be used for dust suppression and contamination control during waste site excavation and facility construction activities.

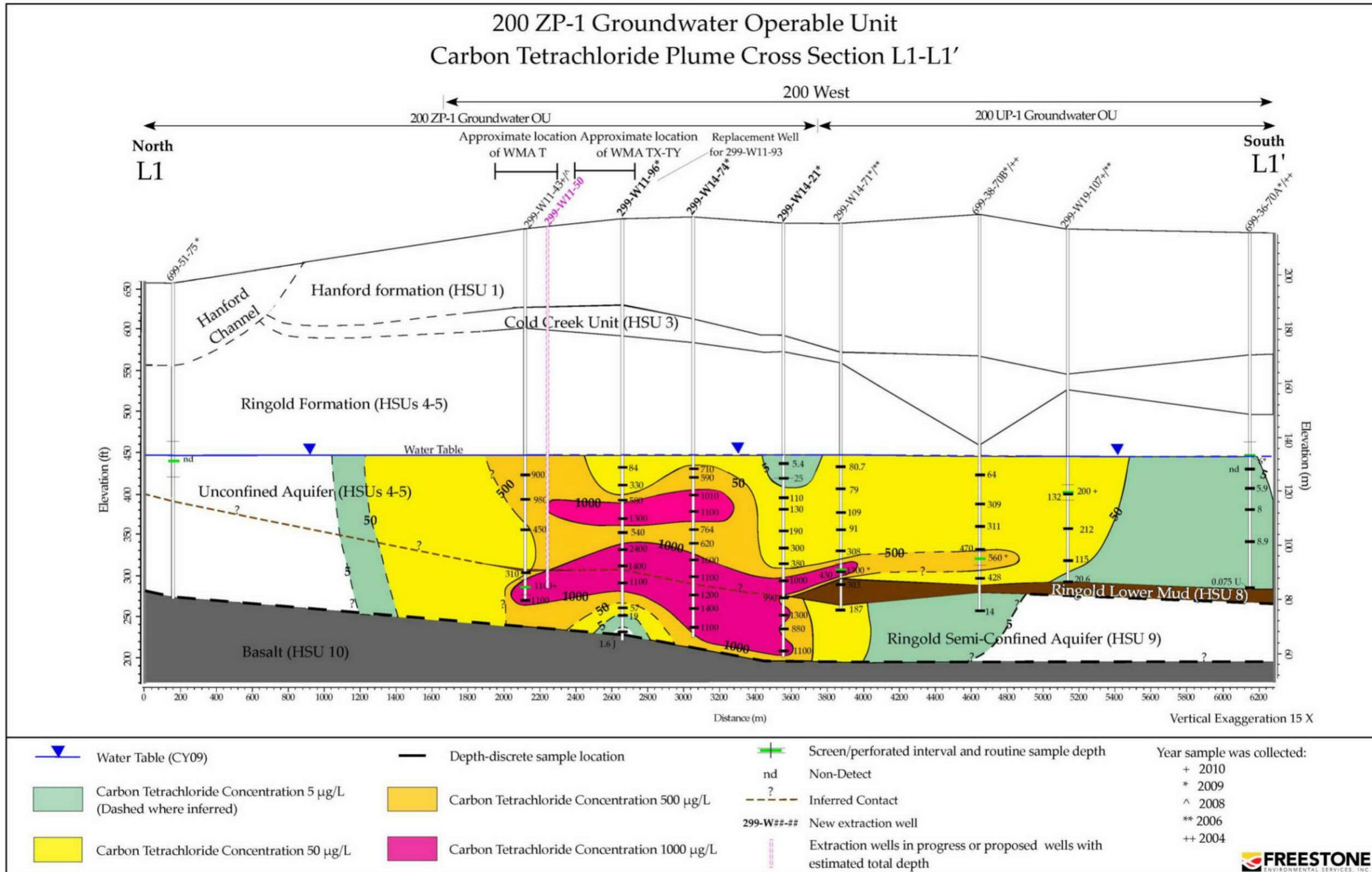
2.3 Groundwater

Groundwater is found in an upper, primarily unconfined aquifer system and in deeper, confined aquifers within the Ringold Formation and sedimentary interbeds in the basalt. The Columbia River is the primary discharge area for the unconfined and confined aquifers. The 200 West Area is located about 8 km (5 mi) south of the Columbia River. The 200-ZP-1 OU unconfined aquifer occurs in the Ringold Formation. Groundwater in the unconfined aquifer flows from areas where the water table is higher (west of the Hanford Site) to areas where it is lower (the Columbia River). In general, the direction of groundwater flow through the Central Plateau is predominantly easterly (from the 200 West Area to the 200 East Area).



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Figure 2-1. Location of Cross Sections, Including Wells Used for Interpretation

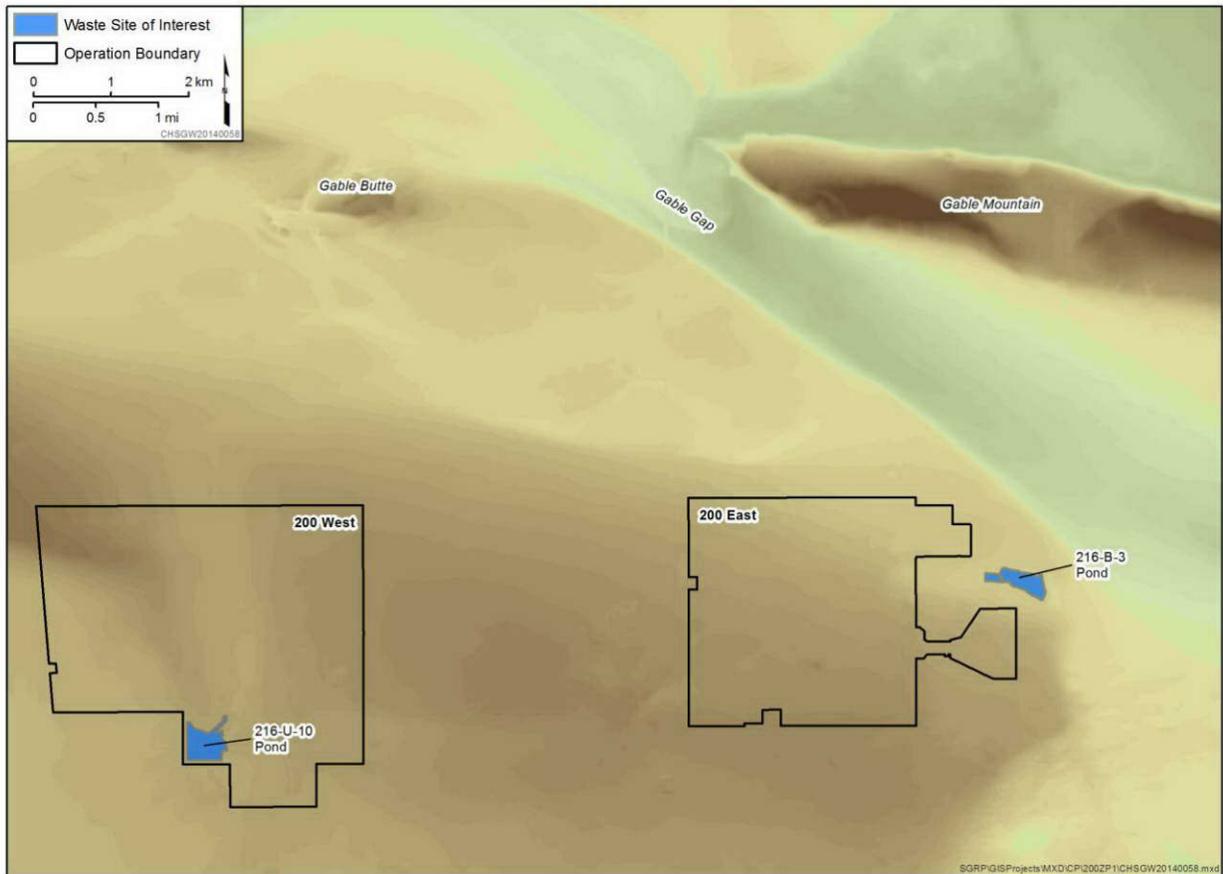


Note: This figure is modified from DOE/RL-2006-24, Remedial Investigation Report for the 200-ZP-1 Groundwater Operable Unit.

Figure 2-2. Hydrogeologic Cross Section for Wells with Depth-Discrete Carbon Tetrachloride Concentration Data, Northwest to Southeast (L1 to L1')

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1 Historical discharges to the ground greatly altered the groundwater flow regime, especially around the
 2 216-U-10 Pond in the 200 West Area and the 216-B-3 Pond in the 200 East Area. Discharges to the
 3 216-U-10 Pond resulted in a groundwater mound in excess of 26 m (85 ft) above the aquifer. Discharges
 4 to the 216-B-3 Pond created a hydraulic barrier to groundwater flow coming from the 200 West Area,
 5 deflecting it north through Gable Gap (between Gable Mountain and Gable Butte) or south of the
 6 216-B-3 Pond (Figure 2-4). As the hydraulic effects of these two discharge sites diminish, groundwater
 7 is expected to flow on an easterly course through the Central Plateau, with some flow continuing through
 8 Gable Gap.



9
 10 **Figure 2-4. Aerial View of Gable Butte, Gable Gap, Gable Mountain,**
 11 **and the 200 Areas, Including U Pond and B Pond**

12 The depth to the water table in the 200 West Area varies from about 50 m (164 ft) in the southwest
 13 corner near the former 216-U-10 Pond to greater than 100 m (328 ft) in the north. The groundwater flow
 14 is primarily to the east, except in the northern portion of the 200 West Area where the flow is to the
 15 east-northeast. Groundwater flow is locally influenced by the 200 West P&T and permitted effluent
 16 discharges at the State-Approved Land Disposal Site. The groundwater flow rates typically range from
 17 0.0001 to 0.5 m/d (0.00033 to 1.64 ft/d) across the 200-ZP-1 OU (EPA et al., 2008). The water table
 18 continues to decline at a rate of approximately 0.21 m/yr (0.69 ft/yr) because the large artificial recharge
 19 that created the elevated water table was eliminated when production ceased at the Hanford Site.

1 **2.4 Contaminant Distribution**

2 Figures 2-2 and 2-3 show cross sections of the carbon tetrachloride concentrations in the 200 West Area.
3 The figures depict a plume that is present at the water table in the source area and gradually dives into the
4 aquifer as it migrates downgradient. The downward migration of the plume is stopped by the relatively
5 fine-grained Ringold unit 8, which acts as a hydraulic barrier to vertical groundwater flow. Ringold
6 unit 8, also known as the Ringold lower mud unit, is discontinuous and relatively thin in places. This
7 allows the carbon tetrachloride plume to migrate downward to the basalt bedrock in those areas where the
8 Ringold unit 8 is missing. The carbon tetrachloride plume does not extend into the basalt bedrock that
9 defines the bottom of the alluvial aquifer system. Both the basalt bedrock and the Ringold unit 8 rise to
10 the northeast and force the carbon tetrachloride plume to gradually rise toward the surface as it migrates
11 eastward and as the saturated thickness of the aquifer decreases.

12 **2.5 Conceptual Site Model Uncertainties**

13 Several potential uncertainties associated with the current CSM could impact the success of 200-ZP-1 OU
14 remedial action. These uncertainties include (1) the effectiveness of the Ringold unit 8 as a barrier to
15 vertical contaminant migration, (2) the continuity of Ringold unit 8, and (3) the thickness of the
16 contaminant plume near the source areas. Near the contaminant source areas, Figures 2-2 and 2-3 depict
17 approximately 60 m (197 ft) of saturated aquifer above the confining unit, Ringold unit 8. Below the
18 confining unit, approximately 15 m (49 ft) of saturated aquifer is above the basalt bedrock. The continuity
19 of the confining unit and its effectiveness as a hydraulic barrier to the downward migration of
20 contaminants are important to the design of the new extraction well field. If the Ringold unit 8 confining
21 unit is a fairly effective hydraulic barrier and contaminants have not migrated below it, then the extraction
22 wells should only be completed above Ringold unit 8. If the Ringold unit 8 confining unit is not
23 an effective hydraulic barrier, is more discontinuous than previously believed, or contamination has
24 migrated below it, then the extraction wells may need to extract groundwater from both above and below
25 the Ringold unit 8. If contamination has migrated below the confining unit, the possibility of the carbon
26 tetrachloride plume extending into the basalt bedrock may need to be further evaluated.

27 In addition, few deep wells are located near the source areas that monitor carbon tetrachloride down to the
28 top of the Ringold unit 8 confining unit and below it to the top of the basalt bedrock. Therefore, the
29 thickness of the plume under the source area is relatively uncertain.

3 Design of the Performance Monitoring Program

This chapter presents the groundwater monitoring activities associated with implementing the 200-ZP-1 OU remedial action. The program for collecting the contaminant and hydraulic performance monitoring data is presented in this discussion, as well as guidance on how the monitoring data will be used to evaluate the success of the selected remedial action.

3.1 Contaminant Monitoring

Contaminant monitoring data will be collected over the projected 125-year lifetime of the remedial action to evaluate performance, optimize effectiveness, and determine when the remedial action is complete. The selection of the contaminant monitoring well network, sampling frequency, and analytical parameters are discussed in the following subsections.

3.1.1 Contaminant Monitoring Network

The 200-ZP-1 OU, VOC, and contaminant-specific well networks are presented in this PMP. The VOC and contaminant-specific well networks are scheduled to be sampled annually, while the 200-ZP-1 OU network wells are scheduled to be sampled for all of the COCs every 5 years to support the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA)* 5-year review. Sampling the VOC and 200-ZP-1 well networks for COCs included in the contaminant-specific network will generate sufficient data for quantitative analyses to address the nine decision statements (DSs) that are identified in the sampling and analysis plan (Appendix B, Section B1.3.2). These analyses include plume shell development (where data are used to prepare three-dimensional depictions of the extent of contamination) and contaminant transport modeling (to predict if the remedial system will remove 95 percent of the mass of COCs within 25 years and achieve cleanup levels within 125 years). Sampling the VOC and contaminant-specific well networks will also generate data for more qualitative analyses to address DSs #1, #2, and #5. These analyses include determining if new releases have occurred; evaluating trends in high-concentration areas of the plumes; and determining if contamination is expanding downgradient, laterally, or vertically.

The monitoring networks shown in Figures 3-1 through 3-7 will evolve over time as the 200 West P&T and natural attenuation remediation processes change contaminant concentrations and plume sizes. Some plume areas will be cleaned up more quickly than others, and extraction wells will likely be shut down in stages as they become increasingly inefficient to operate. Additionally, many of the shallow monitoring wells may go dry in areas that are the furthest away from the east and west injection wells. Therefore, while the 200 West P&T is operating, the monitoring well networks and constituent analyses will be evaluated on an annual basis. These evaluations will determine if monitoring wells will be dropped from the networks and if new wells should be added to the VOC or contaminant-specific well networks. Changes to the well network or constituent analyses that result from the annual reviews will be made with concurrence from the U.S. Department of Energy (DOE) and U.S. Environmental Protection Agency (EPA).

After the 200 West P&T is shut down, the monitoring well networks will be evaluated on a less frequent basis as the plumes change more slowly. At a minimum, the contaminant monitoring networks should be evaluated every 5 years in accordance with the CERCLA 5-year review process.

When developing the initial list of monitoring wells for the VOC network, a master list of available monitoring wells was queried from the well reports in the Environmental Dashboard Application database for the 200-ZP-1 and 200-UP-1 OUs. This query included well coordinates, well construction information, and historical purposes of the wells. Many of the well query results had missing information,

1 especially in regard to the older historic wells. This master list of monitoring wells was then reduced by
2 determining if wells were missing crucial information, were found to be dry, or were located outside the
3 area of interest for performance monitoring. Many wells on the master list were missing top and bottom
4 screen elevation data; however, this information was included in the 2008 carbon tetrachloride plume
5 shell data set. For these wells, the mid-screen elevation was supplied (Appendix C) from the plume shell
6 data set.

7 The remaining potential monitoring wells were then imported into the latest carbon tetrachloride plume
8 shell grid and were compared to the three-dimensional carbon tetrachloride distribution to qualitatively
9 evaluate their redundancy. At this stage of the evaluation, there was a relatively dense (i.e., well
10 separation ranging from 40 to 260 m [131 to 853 ft]) network of shallow monitoring wells in the tank
11 farm areas and a much more widely spaced (i.e., well separation ranges from 500 to 1,900 m [1,640 to
12 6,234 ft]) network of monitoring wells further to the east or deeper in the aquifer. Closely spaced
13 monitoring wells were thinned out by considering their three-dimensional spatial proximity to other
14 monitoring wells and their carbon tetrachloride concentrations. Monitoring wells that defined the high-
15 and low-concentration areas were maintained, while wells that provided little added definition of the
16 three-dimensional carbon tetrachloride distribution were excluded. The goal of this evaluation was to
17 improve future carbon tetrachloride plume shell development by providing a more spatially consistent and
18 complete network of wells that monitor elevations from the basalt bedrock to the water table and can
19 provide a more appropriate density of carbon tetrachloride data relative to the large scale of the plume.

20 After the potential monitoring well network was reduced by considering the usefulness of each well for
21 defining the carbon tetrachloride plume, the other COCs were considered. Monitoring wells that defined
22 the high concentrations of other COCs, or that were otherwise important to the definition of the other
23 COC plumes, were added back into the network. This step added some wells in the tank farm areas and
24 also wells that are potentially downgradient of the leading edge of the carbon tetrachloride plume
25 (because other COCs, such as nitrate, have plume leading edges that extend further to the east).

26 The contaminant monitoring well network was established during the fiscal year (FY)/calendar year
27 (CY) 2012 baseline sampling (the year before 200 West P&T operation startup). Some wells initially
28 proposed for the VOC well network were rejected due to inaccessibility or lack of water. The VOC
29 network includes 95 wells (Figure 3-1), and associated construction details are presented in Appendix F.
30 The contaminant-specific well networks include variable numbers of wells (Figures 3-2 through 3-7).
31 The VOC monitoring network covers the entire 200 West Area, and 47 of the wells in the
32 contaminant-specific network are in the 200-UP-1 OU. The 47 wells in the 200-UP-1 OU were not
33 considered for monitoring the other 200-ZP-1 COCs. The remaining 48 wells comprise the 200-ZP-1 OU
34 network. Sampling efforts are coordinated between the 200-UP-1 and 200-ZP-1 OU projects to reduce
35 redundancy and costs.

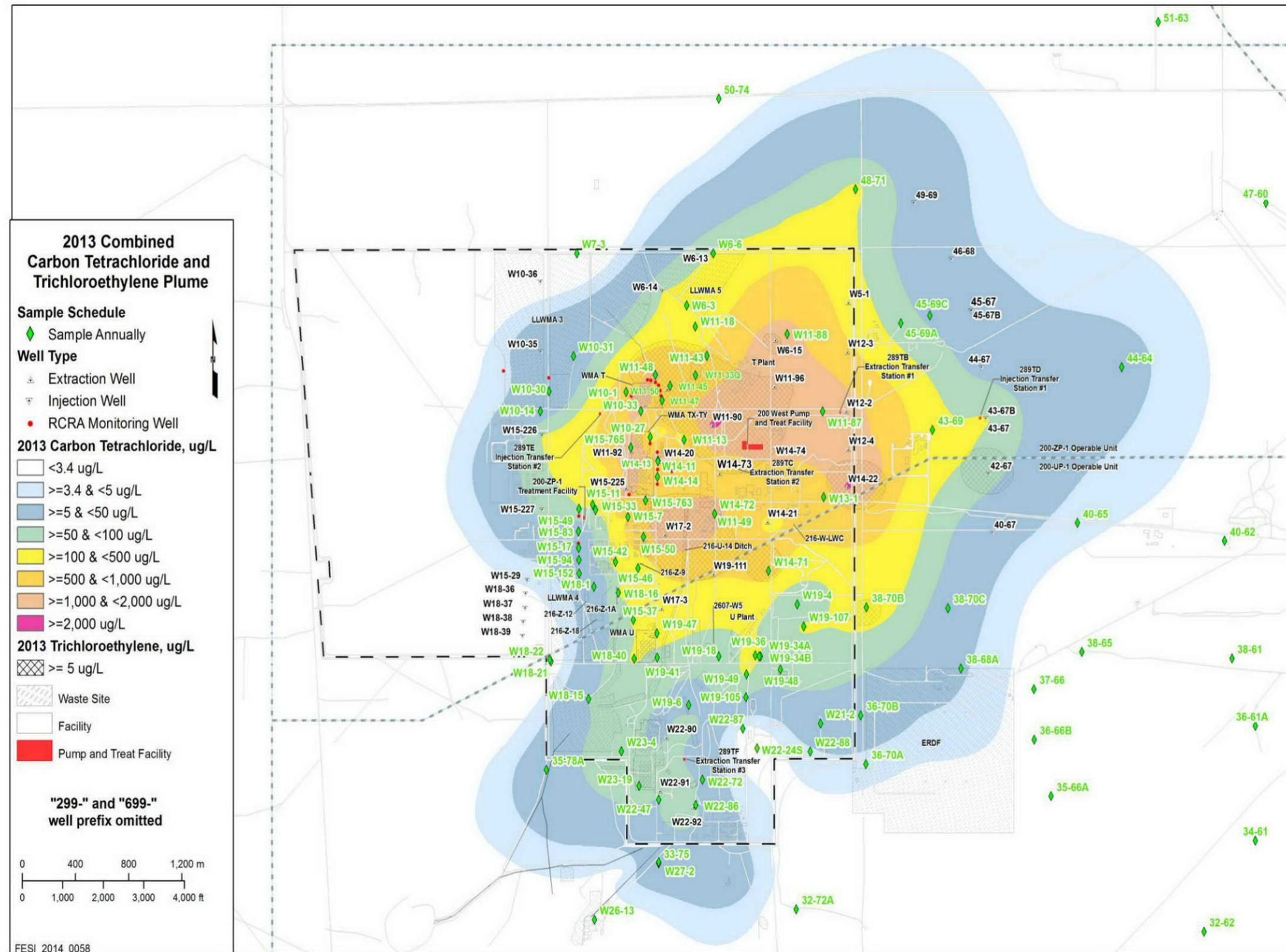


Figure 3-1. Contaminant Monitoring Well Network (VOC)

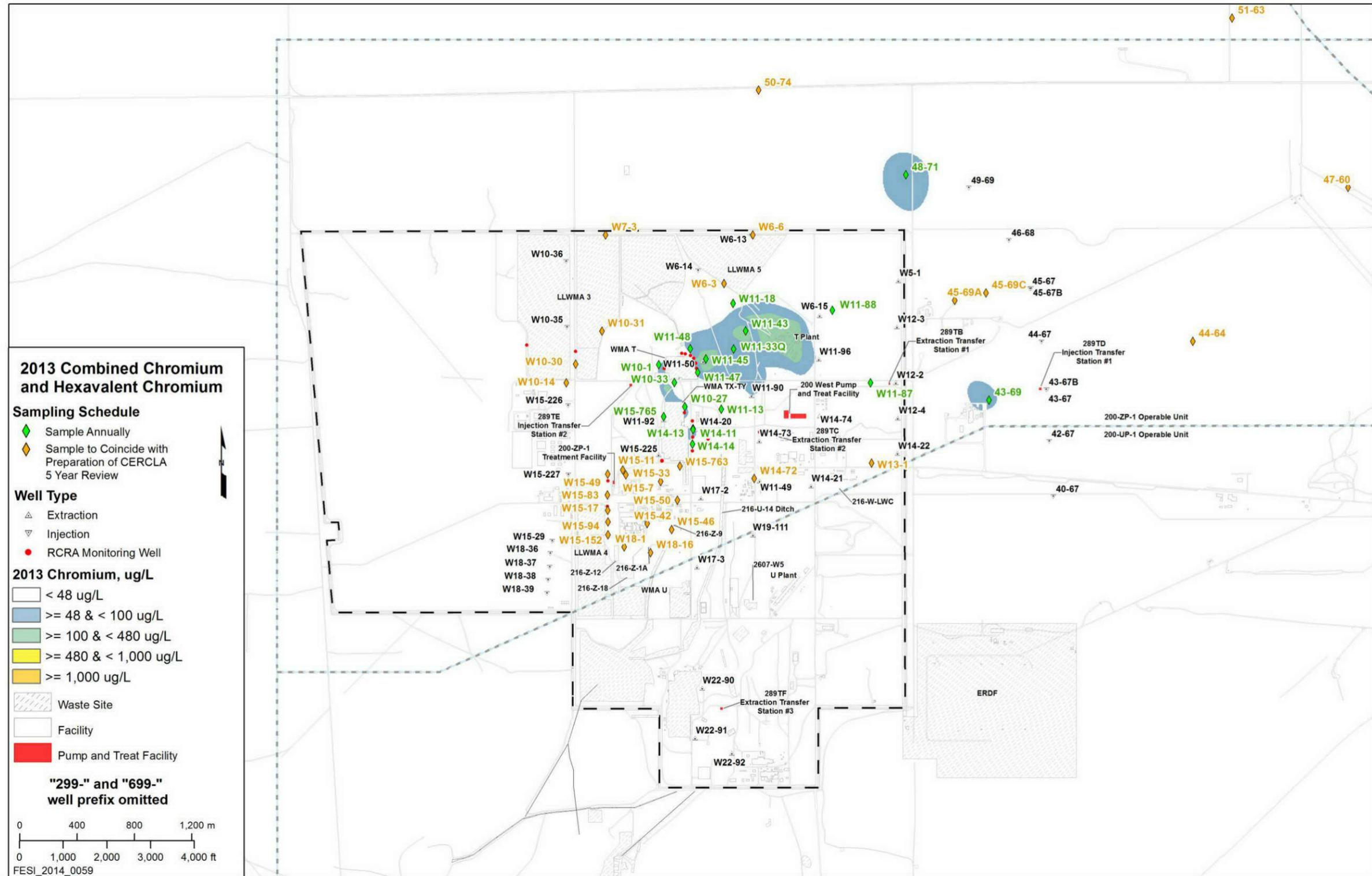


Figure 3-2. Contaminant-Specific Monitoring Well Network (Chromium)

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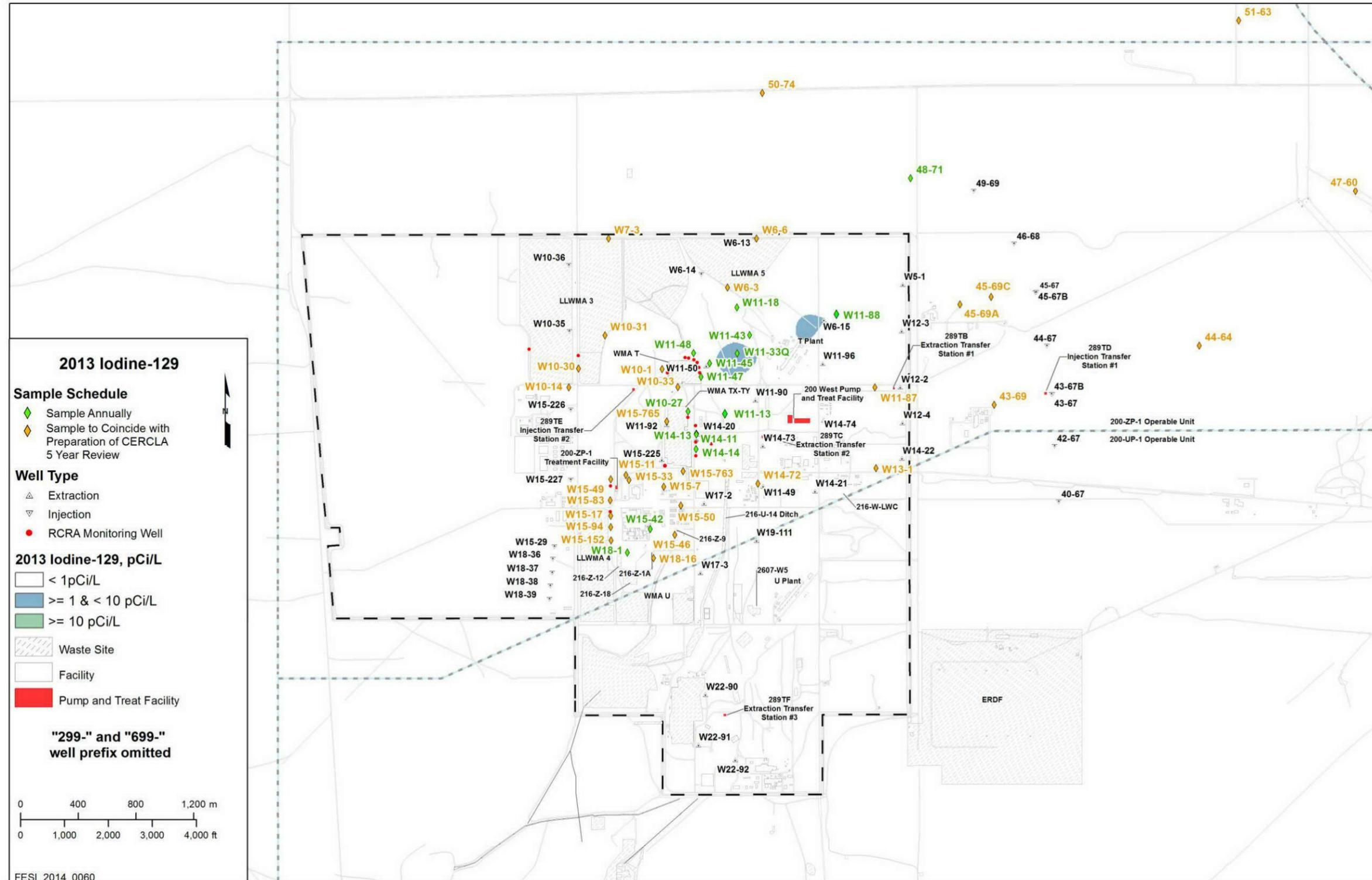


Figure 3-3. Contaminant-Specific Monitoring Well Network (Iodine-129)

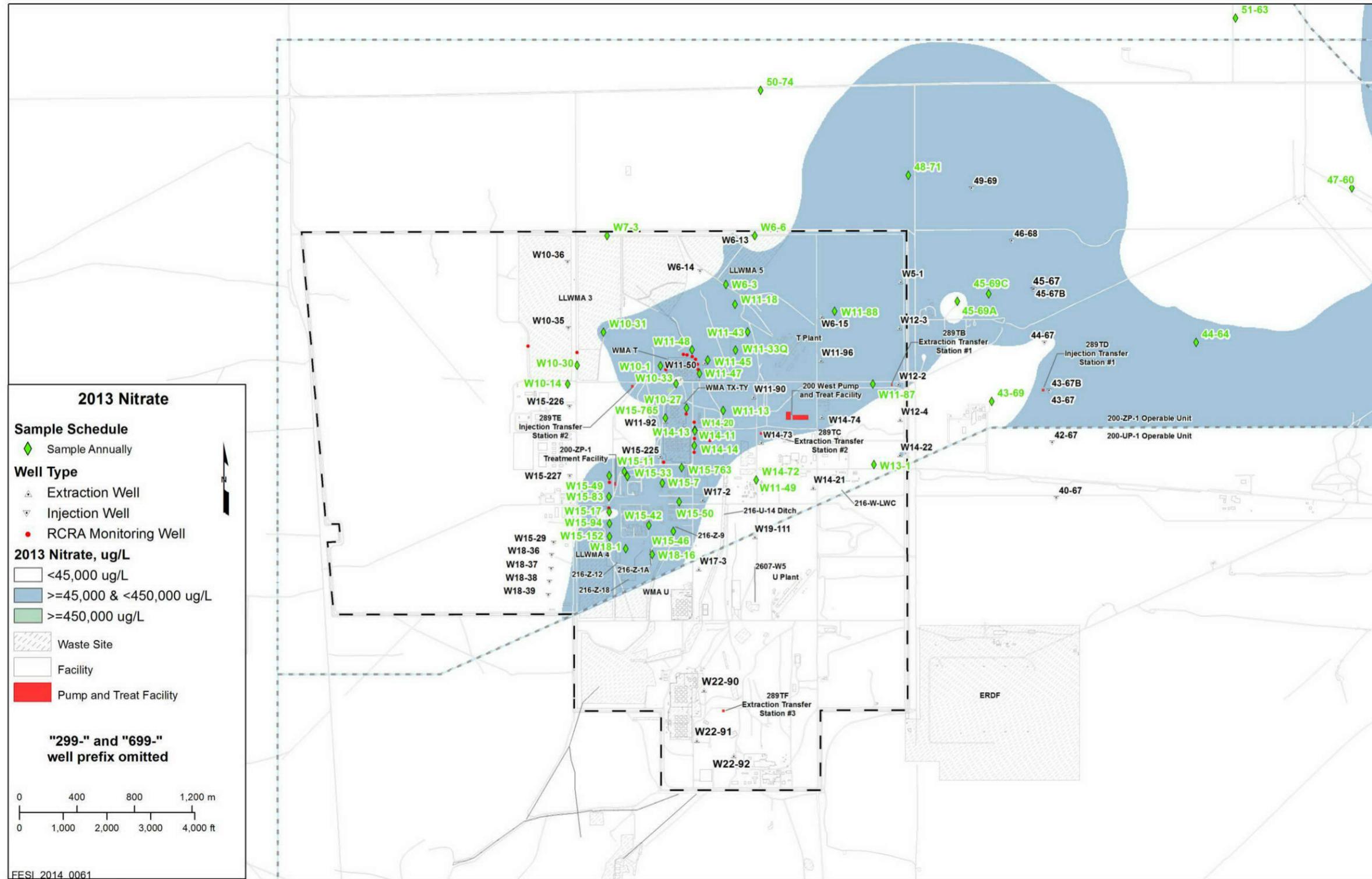


Figure 3-4. Contaminant-Specific Well Monitoring Network (Nitrate)

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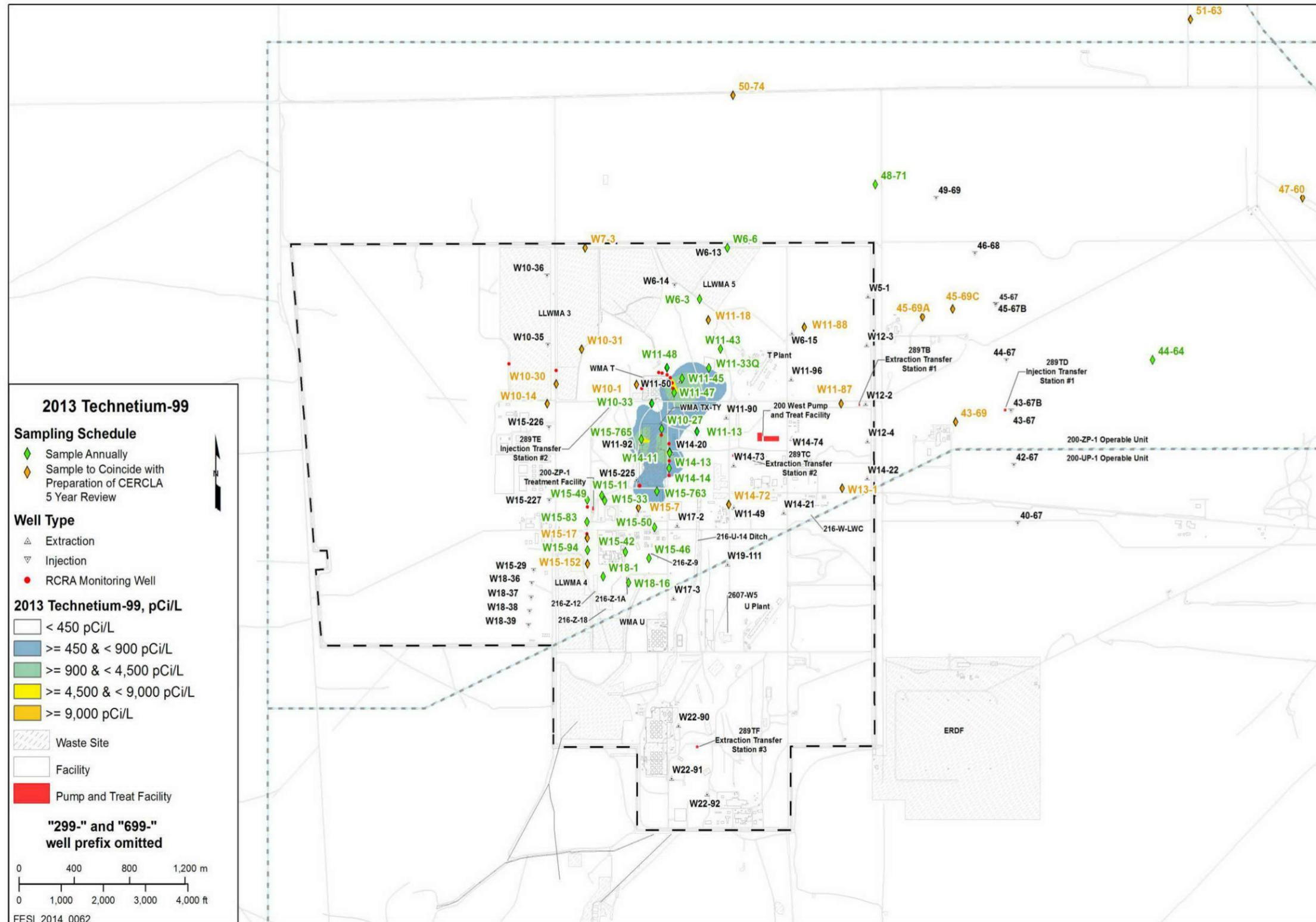


Figure 3-5. Contaminant-Specific Monitoring Well Network (Technetium-99)

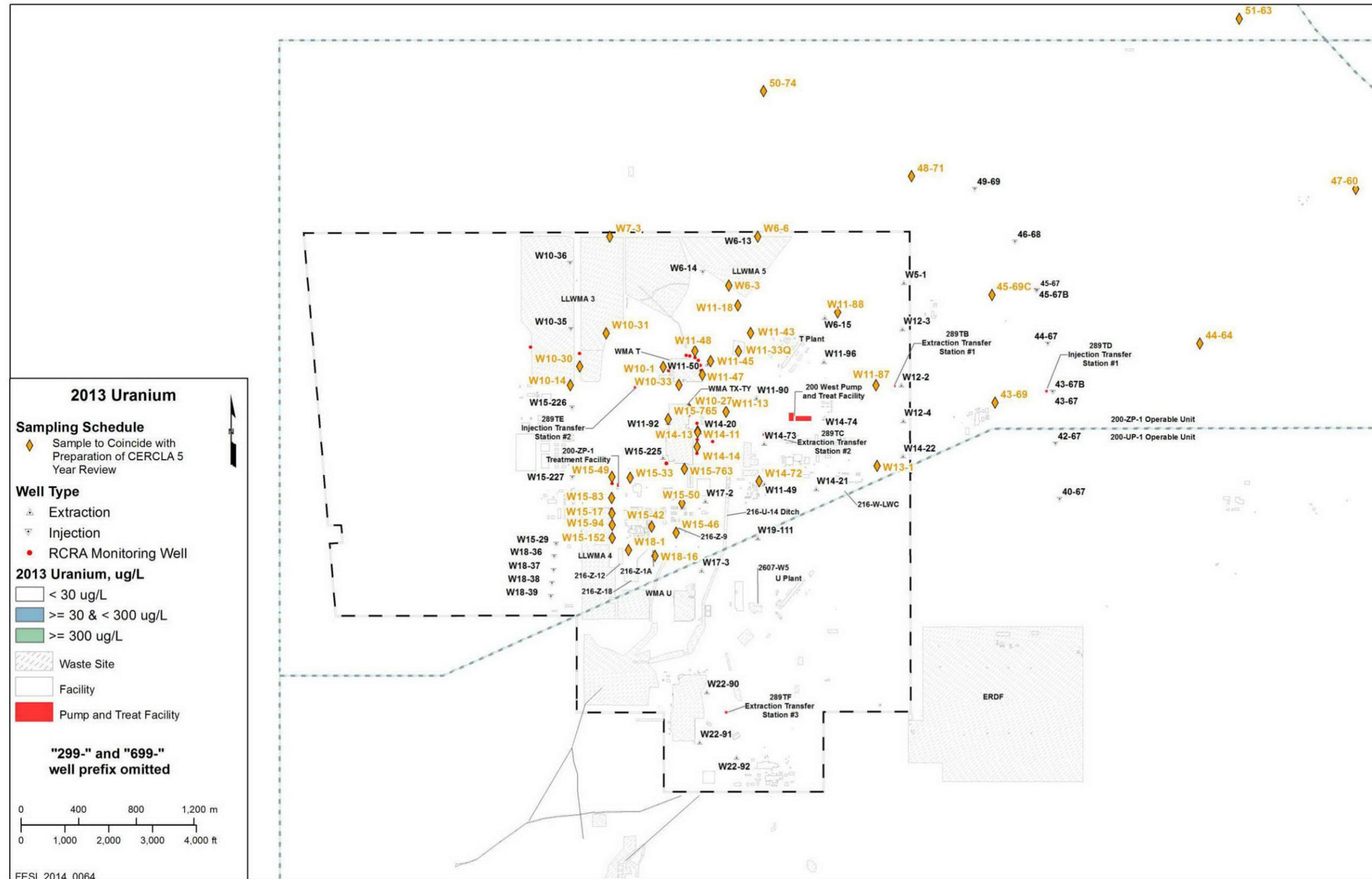


Figure 3-7. Contaminant-Specific Well Monitoring Network (Uranium)

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3.1.2 Data Gaps in Monitoring Well Coverage

A comparison of the available monitoring well coverage to the latest three-dimensional carbon tetrachloride plume shell revealed several areas that lack coverage. These data gaps resulted in areas of relatively large uncertainty in the carbon tetrachloride plume shell. In support of this data gap analysis, maps of kriged carbon tetrachloride error variance were produced for several elevation intervals in the aquifer. These maps reveal the areas in the kriged three-dimensional carbon tetrachloride plume shell with the greatest error variance or relative uncertainty (Appendix D). While these maps provide information about data distribution uncertainty, the maps depend on the kriging parameters used to generate them.

To reduce some of the more significant uncertainty in the carbon tetrachloride plume delineation, several new monitoring wells are proposed. Table 3-1 lists the locations and estimated mid-screen elevations of the proposed new monitoring wells. If installed and routinely sampled, these wells could significantly reduce this uncertainty. Priority rankings (highest priority is ranked as 1, lowest priority is ranked as 8) were assigned to each well based on the well's potential to reduce carbon tetrachloride distribution uncertainty. While some of these data gaps may be temporarily filled by one-time sampling when the proposed new extraction wells are drilled, the data gaps will remain and add uncertainty to future plume shells and transport simulations. If the new monitoring wells are not installed, these data gaps may ultimately hinder optimization of the 200 West P&T system.

Proposed new monitoring wells MW1A, MW1B, and MW2 would help delineate the northern and northeastern boundaries of the carbon tetrachloride plume. Well 299-W11-87 has carbon tetrachloride concentrations of 1,980 µg/L at 103 m (338 ft) amsl, and well 299-W11-88 has carbon tetrachloride concentrations of 850 µg/L at 94 m (308 ft) amsl; however, there are no monitoring wells screened at appropriate elevations to delineate the northern and northeastern extent of these high concentrations. These new monitoring wells, which were installed in 2016, are also positioned between the western and eastern injection well fences, within the area of groundwater extraction.

Proposed new monitoring wells MW3A, MW3B, and MW3C would fill gaps in the monitoring network between upgradient wells (e.g., 299-W10-33 and 299-W14-11) and downgradient wells (e.g., 299-W11-86 and 299-W11-87). This data gap is about 1,325 m (4,347 ft) in the middle of the 200 West P&T extraction well field, with upgradient and downgradient carbon tetrachloride concentrations greater than 1,000 µg/L. Well screen A should be completed below Ringold unit 8 to help delineate the northern extent of the deep carbon tetrachloride found at well 299-W13-1. Well screens B and C would be completed above Ringold unit 8.

Proposed new monitoring wells MW4A and MW4B would improve deep monitoring coverage near the source areas west of the TX/TY Tank Farms. The proposed new monitoring wells are also intended to provide deep monitoring coverage near the first 200 West P&T extraction well (299-W15-225) that was installed in 2009. Well screens A and B would be completed above Ringold unit 8.

Proposed new monitoring wells MW5A and MW5B would provide monitoring coverage above and below the existing monitoring well screen at well 299-W14-72 (mid-screen elevation of 88 m [289 ft] amsl). As with proposed new monitoring wells MW3A, B, and C, these proposed new wells are located in the middle of the new 200 West P&T extraction well field, upgradient of well 299-W13-1 that monitors deep aquifer carbon tetrachloride concentrations greater than 500 µg/L. Well screen A is intended to be completed below Ringold unit 8, and screen B would be completed above Ringold unit 8.

Table 3-1. Proposed New Monitoring Wells

Well Priority	Well Name	Easting (m)	Northing (m)	Estimated Mid-Screen Elevation (m amsl)
1	MW7B	568900	135945	120
	MW7A	568900	135945	100
2	MW1A	568369	137743	90
	MW1B	568369	137743	110
3	MW3A	567578	136476	73
	MW3B	567578	136476	92
	MW3C	567578	136476	112
4	MW5A	567374	135941	70
	MW5B	567374	135941	110
5	MW2	567591	137577	111
6	MW4A	566638	136251	80
	MW4B	566638	136251	100
7	MW6A	566941	135175	80
	MW6B	566941	135175	106
8	MW8A	568670	136810	98
	MW8B	568670	136810	120

amsl = above mean sea level

- 1 Proposed new monitoring wells MW6A and MW6B would provide deep (mid-screen elevations of 80 and
2 106 m [263 and 348 ft] amsl) monitoring coverage northeast of the U Tank Farm near the carbon
3 tetrachloride source areas. These wells would help delineate the southern boundary of the
4 high-concentration area of the carbon tetrachloride plume under the source areas. Well screen A would be
5 completed below Ringold unit 8, and well screen B would be completed above Ringold unit 8.
- 6 Proposed new monitoring wells MW7A and MW7B would help delineate the downgradient extent of
7 the contamination found at sampling location 299-W13-1 and would help fill in the gap in monitoring
8 coverage between monitoring wells 299-W13-1 and 699-40-65. Proposed new monitoring wells MW8A
9 and MW8B would help delineate the downgradient extent of the contamination found at 299-W11-87 and
10 help fill in the 1,888 m (6,168 ft) gap in monitoring coverage between wells 299-W11-87 and 699-44-64.
11 Well screen B would be completed above Ringold unit 8 (if there is sufficient saturated thickness), and
12 well screen A would be completed below Ringold unit 8. The proposed new monitoring wells are located
13 upgradient of the 200 West P&T system's eastern injection well fence and downgradient of the
14 extraction wells.

3.1.3 Contaminant Monitoring Frequency

An initial baseline sampling round was conducted using the VOC well network for all COCs and uranium during FY/CY 2012. This was followed by another sampling round of the VOC well network for all COCs and uranium in FY/CY 2013 to generate data after the first year of remedial system operation. The data collected from this sampling event, in addition to the data collected from drilling and sampling the new extraction and injection wells, were used to construct baseline three-dimensional contaminant plume shells for each COC. This data set is the most comprehensive sampling data available and represents the most accurate initial masses and plume volumes for each COC (DOE/RL-2013-14, *Calendar Year 2012 Annual Summary Report for the 200-ZP-1 and 200-UP-1 Operable Unit Pump-and-Treat Operations*). These initial masses will be used to calculate the mass removal statistics for each COC over the life of the remedial system operation to support DS #4.

During early operation of the 200 West P&T, groundwater samples will be collected from the VOC and contaminant-specific monitoring well networks on an annual basis. The groundwater flow velocities typically range from 0.0001 to 0.5 m/d (0.00033 to 1.64 ft/d) across the 200-ZP-1 OU, with an upperbound value of 0.5 m/d (1.64 ft/d) that corresponds to a maximum groundwater flow rate of about 180 m/yr (591 ft/yr). For the closely spaced, shallow monitoring wells in the tank farm areas (well separation ranging from 40 to 260 m [131 to 853 ft]), the minimum time for groundwater at one well to reach the next downgradient well could range from 0.2 to 1.4 years. For the more widely spaced monitoring locations (well separation ranging from 500 to 1,900 m [1,640 to 6,234 ft]), the minimum time for groundwater at one well to reach the next downgradient well could range from 2.7 to 10.5 years. There is little to no recharge of the aquifer from precipitation, and there are no signs of seasonal fluctuations in groundwater flow. Thus, contaminant sampling and subsequent delineation of contaminant distributions on an annual basis is appropriate given the size of the plumes, the groundwater flow velocities, and well spacing within the available monitoring well network.

Contaminant monitoring network sampling will coincide with CERCLA 5-year review preparations to provide a comprehensive data set to assess the progress of the remedial action against the RAOs and the DSs. This sampling may also include vertical profile sampling in existing monitoring wells to delineate each contaminant plume in three-dimensional space. In later 200 West P&T operations, when contaminant concentrations change less rapidly, the annual sampling frequency of the monitoring well networks will be re-evaluated.

After the P&T system is shut down, the frequency of contaminant monitoring will be evaluated based on the observed rate of change of the contaminant plumes. The contaminant monitoring frequency for monitoring wells near the last extraction wells shut down should be adequate to monitor for possible contaminant rebound in the years following well shutdown. Contaminant monitoring samples will be collected at least every 5 years to support the CERCLA 5-year review.

Each extraction well is currently sampled quarterly. The data are needed to track contaminant mass removal, calibrate the COC plume shells, and optimize the mass removal performance for each extraction well. While extraction well contaminant concentrations are only needed every other year for plume shell calibration purposes, it is prudent to monitor extraction well concentrations more frequently. The pumping rates and effective screen intervals of each extraction well may need to be optimized (especially during the first few years of operation) to maximize the mass removed per volume of groundwater extracted. The data are also needed to track contaminant mass removal during the remedial action. Some COCs may be detectable above cleanup levels in samples from individual extraction wells but may not be detectable in the combined treatment plant influent samples. Therefore, without individual

1 extraction well sampling results, the mass removal for COCs could not be tracked using only the
2 combined treatment plant influent samples.

3 Once contaminant distributions and system operation have stabilized, the extraction well sampling
4 frequency and the list of analytical constituents will be evaluated and possibly changed with DOE and
5 EPA concurrence.

6 Treatment plant influent and effluent sampling is currently performed monthly. Reductions in sampling
7 frequency or the constituents analyzed will be made with DOE and EPA concurrence.

8 **3.1.4 Contaminant Monitoring Analytical Parameters**

9 During the initial baseline sampling, contaminant samples collected from the monitoring wells
10 were analyzed for the COCs and other potential contaminants listed in Appendix A, Table A-1, as well as
11 the biogeochemical and field screening parameters listed in Appendix A, Table A-2. Subsequently, the
12 constituents monitored were reviewed, and a reduced list of constituents was developed for each
13 monitoring well with the intention of analyzing for the entire suite of contaminants and parameters listed
14 in Tables A-1 and A-2 every 5 years to coincide with preparation of the CERCLA 5-year review.
15 The review of constituents assessed the data trends in the Hanford Environmental Information System
16 (HEIS) database from 1990 through 2013 for each well and considered constituents for reduction with
17 respect to the baseline plumes prepared for DOE/RL-2013-14. The review determined that the analytical
18 parameters analyzed for each monitoring well will be sufficient to delineate each contaminant plume in
19 three-dimensional space, with sub-cleanup level concentrations surrounding each contaminant plume to
20 define their boundaries.

21 The initial HEIS database query was limited to tritium, total and hexavalent chromium, iodine-129,
22 technetium-99, and uranium² in 200-ZP-1 OU monitoring wells only. Carbon tetrachloride,
23 trichloroethene, and nitrate were not considered for any reduction in analyses because they are ubiquitous
24 throughout the 200-ZP-1 OU. Data with specific laboratory and review qualifiers were omitted from the
25 data set, along with in-process and vertical profile data. Data were also omitted if they were considered
26 inconclusive, such as data points with minimum detection levels or minimum detectable activities greater
27 than the 200-ZP-1 OU ROD (EPA et al., 2008) cleanup levels. Also, undetected qualified data for
28 radiological constituents were replaced with one-half of the minimum detectable activity.

29 The data for each constituent were assembled to show the number of samples collected from 1990
30 through 2013, with sub-data categories for the number of nondetects, the number of nondetects greater
31 than the cleanup level, the number of detections, the number of detections greater than the cleanup level
32 with the associated year(s), the first year sampled, the latest year sampled, and data trends in the context
33 of the cleanup level. Each constituent and well was then evaluated against appropriate plume maps to
34 determine if reduced frequencies of analysis were appropriate for each constituent. This evaluation
35 considered the geographic location of the well with respect to the plume and data trends. Wells that were
36 within the plume, were above the cleanup level, had increasing trends, were recently above the cleanup
37 level (warranting continued monitoring), or were the first well downgradient were not considered for
38 reduction. In some cases, the first well downgradient, or the sentinel well, was an extraction well
39 currently on a quarterly monitoring schedule. The wells considered for reduced monitoring frequency
40 did not have detections above the cleanup level and were stable or downward-trending below the
41 cleanup level.

² Uranium is included for tracking purposes only and is not a COC in the 200-ZP-1 OU.

1 Contaminant monitoring samples collected from the extraction wells and the combined treatment plant
2 influent and effluent will be analyzed for the contaminants listed in Appendix A, Table A-1.

3 Beginning in FY 2014, the frequency of sampling for biogeochemical parameters analyzed to track
4 natural attenuation processes was reduced to once every 5 years in conjunction with the CERCLA 5-year
5 review. Also, annual sampling for the full suite of parameters listed in Appendix A, Table A-2 was part of
6 the remedial system baseline sampling, and this annual sampling frequency was reduced to once every
7 5 years due to active P&T operations. When the 200 West P&T operations cease, the frequency of
8 sampling for these parameters will be re-evaluated.

9 **3.2 Hydraulic Monitoring**

10 Hydraulic monitoring data will be collected over the lifetime of the remedial action to evaluate
11 performance and optimize effectiveness. The selection of the hydraulic monitoring well network and
12 measurement frequency are described in the following subsections.

13 **3.2.1 Hydraulic Monitoring Network**

14 The hydraulic monitoring well network is shown in Figure 3-8, and the available well construction details
15 are listed in Appendix E. Hydraulic monitoring will be conducted for the duration of the 200 West P&T
16 operation. The hydraulic monitoring well network was derived using the same master list of available
17 monitoring wells previously described for developing the contaminant monitoring network. This list was
18 reduced to provide a more consistently spaced network of well screens, covering elevations ranging from
19 the basalt bedrock to the water table interface. Since hydraulic stresses are more homogeneous than
20 contaminant concentrations, this network is less dense and more regularly spaced than the contaminant
21 monitoring network. A few monitoring wells near the new 200 West P&T extraction wells were added
22 to the network to provide data regarding extraction well influence on local hydraulic conditions in the
23 aquifer. The monitoring wells cover a spatial area that exceeds the boundaries of the plumes and the
24 200 West P&T, so the hydraulic monitoring data can provide useful model calibration data.

25 Many of the hydraulic monitoring wells have transducers and data loggers to semicontinuously measure
26 groundwater elevations. These wells are shown in Figure 3-8 and are listed in Appendix E. The hydraulic
27 monitoring well locations were chosen for the following reasons:

- 28 • Around the margins of the plumes, the wells help confirm inward or very much reduced gradients.
- 29 • In the core of the plumes, near the extraction wells, the wells collectively identify the magnitude and
30 shape of the depression caused by pumping.
- 31 • Between the 200-ZP-1 and 200-UP-1 OUs, the wells help identify flow directions, which will become
32 more important over time.

33 After shutting down the 200 West P&T operation, the hydraulic monitoring network will be re-evaluated.
34 The density of the monitoring well network will likely be reduced to reflect the return of hydraulic
35 gradients to a more regional groundwater flow pattern.

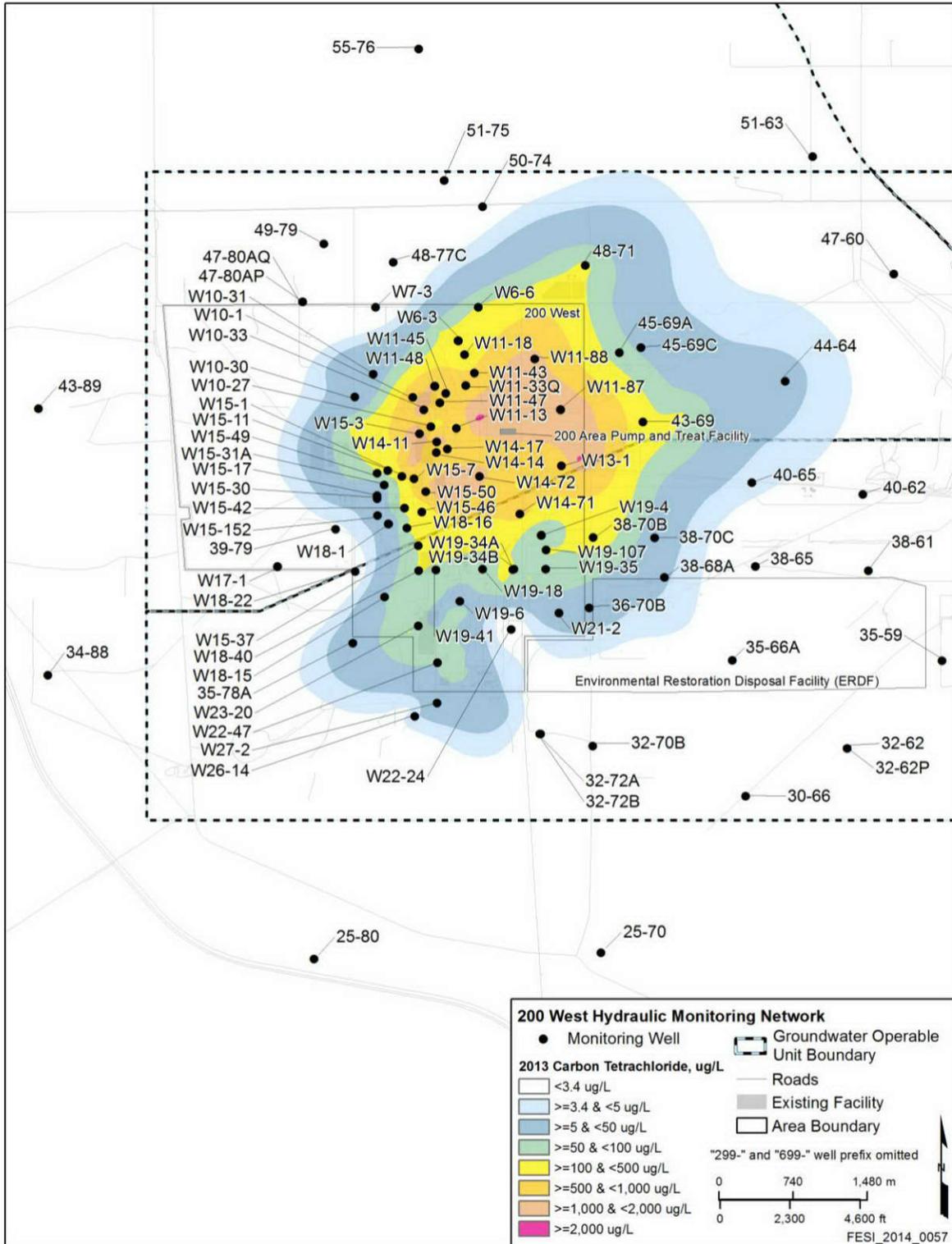


Figure 3-8. Hydraulic Monitoring Well Network

1
 2
 3

1 **3.2.2 Hydraulic Monitoring Frequency**

2 While the 200 West P&T is operational, a synoptic (concurrent) set of hydraulic monitoring data will
3 be collected from the hydraulic monitoring well network on an annual basis to be coordinated with
4 the annual sitewide water table mapping task (generally in March) to avoid duplication of effort.
5 Also, pre-remedial system startup data was collected from the network to provide baseline 200-ZP-1 OU
6 hydraulic data. Changing remedial system groundwater extraction and injection rates result in changes to
7 the three-dimensional groundwater head field, which can affect extraction well performance and plume
8 capture success. Currently, the 200-ZP-1 OU water table continues to decline at a rate of approximately
9 0.21 m/yr (0.69 ft/yr) due to eliminating the historical large influx of artificial recharge that created the
10 elevated water table. Therefore, annual hydraulic monitoring is prudent to ensure that the remedial system
11 is operating optimally.

12 While the 200 West P&T is operating, the need for semicontinuously measured groundwater elevations
13 from transducer-equipped hydraulic monitoring wells will be evaluated and the wells equipped with
14 transducers as needed. The aggressive pumping rates, low aerial recharge, and limited lateral inflow
15 could cause some extraction well pumping rates to become unsustainable. Thus, the transient data logger
16 groundwater elevation data will be evaluated to monitor the sustainability of the extraction well field and
17 to optimize pumping possibly by rebalancing upgradient and downgradient injection to ensure
18 implementation of a sustainable remedy.

19 While the 200 West P&T is operational, flow rates will be measured in each extraction and injection well,
20 and for the combined treatment plant influent, on a semicontinuous basis.

21 After the 200 West P&T has been shut down, the frequency of hydraulic monitoring in monitoring wells
22 will be evaluated based on how rapidly the water table stabilizes. At a minimum, a synoptic set of
23 hydraulic monitoring data will be collected from the hydraulic monitoring well network every 5 years
24 in accordance with the CERCLA 5-year review.

25 **3.3 Performance Monitoring Analysis and Reporting**

26 Results of performance monitoring will be analyzed and reported annually during the early years of the
27 remedy. The first monitoring event was documented in the DOE/RL-2013-14. A suggested performance
28 monitoring report outline, which is applicable during the early years of the remedy, is shown below.
29 It should be noted, however, that not all of the report elements included in the suggested outline may be
30 applicable to each performance period.

31

Suggested Performance Monitoring Report Outline

1 Introduction

- 1.1 Purpose
- 1.2 Period of Performance
- 1.3 Report Organization

2 Remedial System Operation

- 2.1 Overview of Remedial System
- 2.2 Remedial System Monitoring Data
 - 2.2.1 Extraction and Injection Well Flow Rates
 - 2.2.2 Extraction Well Sampling Data
 - 2.2.3 Treatment Plant Influent and Effluent Flow Rates
 - 2.2.4 Treatment Plant Influent and Effluent Sampling Data
- 2.3 Analysis of Remedial System Monitoring Data
 - 2.3.1 Extraction Well Mass Removal
 - 2.3.2 Treatment Plant Mass Removal

3 Hydraulic Monitoring

- 3.1 Hydraulic Monitoring Network
- 3.2 Hydraulic Monitoring Data
 - 3.2.1 Synoptic Survey Data
 - 3.2.2 Transducer Data
- 3.3 Analysis of Hydraulic Monitoring Data
 - 3.3.1 Evaluation of Two-Dimensional Water Table
 - 3.3.2 Impacts to Remedy from Changing Groundwater Elevations

4 Contaminant Monitoring

- 4.1 Contaminant Monitoring Network and Parameters
- 4.2 Contaminant Monitoring Data
 - 4.2.1 Contaminants of Concern
 - 4.2.2 Natural Attenuation Daughter Products and Field Parameters
- 4.3 Analysis of Contaminant Monitoring Data
 - 4.3.1 Evaluation of Two-Dimensional Contaminant of Concern Plume Boundaries
 - 4.3.2 Contaminant Plume Cross Sections
 - 4.3.3 New Releases of Contaminants of Concern
 - 4.3.4 Downgradient Plume Expansion
 - 4.3.5 Natural Attenuation Rates and Transformation Products
- 4.4 Plume Shell Development
 - 4.4.1 Contaminant Data Sets
 - 4.4.2 Interpolation of Contaminant Concentrations
 - 4.4.3 Plume Shell Masking
 - 4.4.4 Contaminant Mass and Volume
 - 4.4.5 Plume Shell Uncertainty

Suggested Performance Monitoring Report Outline (cont'd.)

5 Groundwater Flow Model Development

- 5.1 Model Calibration
 - 5.1.1 Model Calibration Data Set
 - 5.1.2 Analysis of Calibration Residuals
- 5.2 Simulated Three-Dimensional Hydraulic Capture
- 5.3 Impact of Calibration Residuals on Simulated Hydraulic Capture

6 Contaminant Transport Modeling

- 6.1 Contaminant Transport Parameters
- 6.2 Contaminant Transport Model Calibration
 - 6.2.1 Comparison of Observed and Simulated Extraction Well Concentrations
 - 6.2.2 Comparison of Observed and Simulated Remedial System Mass Removal
- 6.3 Predictive Contaminant Transport Simulations
 - 6.3.1 Evaluation of 25-Year 95 Percent Contaminant of Concern Mass Removal Milestone
 - 6.3.2 Evaluation of 125-Year Contaminant of Concern Cleanup Milestone

7 Progress Toward Meeting Remedial Action Objectives

8 Conclusions

- 8.1 Changes to the Conceptual Site Model
- 8.2 Key Decisions Addressed by Performance Monitoring Data Collection
 - 8.2.1 Decision Statement #1
 - 8.2.2 Decision Statement #2
 - 8.2.3 Decision Statement #3
 - 8.2.4 Decision Statement #4
 - 8.2.5 Decision Statement #5
 - 8.2.6 Decision Statement #6
 - 8.2.7 Decision Statement #7
 - 8.2.8 Decision Statement #8
 - 8.2.9 Decision Statement #9

9 Recommendations

10 References

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4 References

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Appendix A

Data Quality Objectives

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Terms

COC	contaminant of concern
DQO	data quality objective
DS	decision statement
EPA	U.S. Environmental Protection Agency
gpm	gallons per minute
NTU	nephelometric turbidity unit
OU	operable unit
PMP	performance monitoring plan
RAM	residual analysis method
ROD	Record of Decision
USGS	U.S. Geological Survey
WAC	<i>Washington Administrative Code</i>

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A1 Data Quality Objectives

The data quality objectives (DQOs) for the 200-ZP-1 Operable Unit (OU) performance monitoring plan (PMP) were developed in accordance with the *Guidance on Systematic Planning Using the Data Quality Objectives Process* (EPA/240/B-06/001). The DQO process involves a series of logical steps that guide managers or staff to a plan for the resource-effective acquisition of environmental data. The DQO process is used to establish performance and acceptance criteria, which serve as the basis for designing the plan for collecting data of sufficient quality and quantity to support the goals of the study. The DQO process consists of the following seven iterative steps.

1. State the problem.
2. Identify the goal(s) of the study.
3. Identify the information inputs.
4. Define the boundaries of the study.
5. Develop the analytic approach.
6. Specify performance or acceptance criteria.
7. Develop the plan for obtaining data.

Each of the steps is further discussed in the following sections.

A2 State the Problem

The first step in the DQO process is to define the problem. In the case of the 200-ZP-1 OU, sufficient monitoring data must be collected to optimally operate the groundwater pump-and-treat system and to verify that the contaminated groundwater is being remediated to the level specified in the *Record of Decision, Hanford 200 Area, 200-ZP-1 Superfund Site, Benton County, Washington* (Ecology et al., 2008).

A3 Identify the Goal(s) of the Study

The second step of the DQO process identifies the key decisions and/or goals that must be addressed to achieve the final solution to the problem. As stated in the Record of Decision (ROD) (Ecology et al., 2008), the selected remedy combines pump-and-treat, monitored natural attenuation, flow-path control, and institutional controls to solve the problem. The performance monitoring goals for the first three of these components are addressed by this PMP. Monitoring data shall be collected over the life of the remedial action to evaluate its performance and optimize its effectiveness. The key questions that the data collection must address, along with alternative actions that may result based on the analysis of the collected data, are presented below as a series of decision statements (DSs).

- **DS #1:** Determine if there are any new releases of contaminants of concern (COCs) that could impact the effectiveness of the remedy and necessitate changes to the remedial action and/or PMP; otherwise, continue with the current remedial action and PMP.
- **DS #2:** Determine if potentially toxic and/or mobile transformation products are being generated at concentrations large enough to justify their inclusion in the list of COCs with associated cleanup levels; otherwise, continue with the current list of COCs and associated cleanup levels.

- **DS #3:** Determine if changes are occurring in environmental conditions that may reduce the efficacy of the pump-and-treat system, natural attenuation processes, and the flow-path control actions, thereby necessitating changes to the remedial action and/or PMP; otherwise, continue with the current remedial action and PMP.
- **DS #4:** Determine if the pump-and-treat system will remove at least 95 percent of the mass of COCs in 25 years or less, and thereby achieve remedy goals for the pump-and-treat phase of the remedy; otherwise, evaluate modifications to the pump-and-treat system that could achieve the stated goal for the pump-and-treat phase of the remedy.
- **DS #5:** Determine if contamination is expanding downgradient, laterally or vertically after the pump-and-treat component has been turned off, thereby necessitating an evaluation of the predicted success of the remedial action; otherwise, continue with the current remedial action and PMP.
- **DS #6:** Determine if the current remedy design is predicted to achieve cleanup levels for all COCs within 125 years, and thereby achieve the overall remedial goal; otherwise, evaluate modifications to the remedial action that could achieve the stated goal for the overall remedy.
- **DS #7:** Determine if remediation has been successfully completed and a recommendation can be made for no further action; otherwise, continue with the current remedial action and PMP or determine if a technical impracticability waiver should be invoked.
- **DS #8:** Determine if certain areas of the contaminant plumes are not responding to pump-and-treat remediation as expected, and therefore require the evaluation of other technologies for a more focused or “hot spot” remedy; otherwise, no new action is required.
- **DS #9:** Once 95 percent of the mass of COCs have been removed, determine if there is rebound in COC concentrations, which would require the pump-and-treat system to be turned back on; otherwise, leave the pump-and-treat system off and continue with monitor natural attenuation.

A4 Identify the Information Inputs

The third step of the DQO process identifies the data and information that may be needed to resolve the DSs listed in Section A3. The types and specifications of data that are collected are summarized as follows.

- **Contaminant sampling data for the groundwater monitoring network:** Contaminant sampling for the monitoring well network is spatially sufficient to include possible 200 West Area contaminant sources in its coverage, as well as to delineate the horizontal and vertical extent of COC contamination above the cleanup levels. The groundwater samples are analyzed for the COCs listed in Table A-1. Analytical method detection limits are equal to or less than the cleanup levels listed in Table 1-1 in the main text. Groundwater samples are also analyzed for COC degradation products (Table A-1), as well as key biogeochemical and field parameters (Table A-2). The maximum acceptable detection limits for the COC degradation products are listed in Table A-1.

Table A-1. Contaminant Monitoring Constituents

Constituent	Maximum Acceptable Detection Limit	Units	Data Use
Contaminants of Concern			
Carbon tetrachloride	3.4 ^a	µg/L	Delineate carbon tetrachloride plume
Chromium (total)	100	µg/L	Delineate chromium plume
Hexavalent chromium	48	µg/L	Delineate chromium plume
Nitrate	10,000 ^b	µg/L (as N)	Delineate nitrate plume
Trichloroethylene	1 ^a	µg/L	Delineate trichloroethylene plume
Iodine-129	1	pCi/L	Delineate iodine-129 plume
Technetium-99	900	pCi/L	Delineate technetium-99 plume
Tritium	20,000	pCi/L	Delineate tritium plume
Other Potential Contaminants			
Uranium (from 200-UP-1 Operable Unit)	30 ^b	µg/L	Delineate uranium plume
Chloroform	70 ^b	µg/L	Evaluate carbon tetrachloride natural attenuation
Dichloromethane	5 ^b	µg/L	Evaluate carbon tetrachloride natural attenuation
Chloromethane	NA ^c	NA	Evaluate carbon tetrachloride natural attenuation
cis-1,2-Dichloroethene	70 ^b	µg/L	Evaluate TCE natural attenuation
Vinyl chloride	2 ^b	µg/L	Evaluate TCE natural attenuation
Chloride	1,000	µg/L	Evaluate chlorinated solvent natural attenuation
Nitrite	1,000 ^b	µg/L (as N)	Evaluate nitrate natural attenuation

a. The U.S. Department of Energy will clean up contaminants of concern for the 200-ZP-1 Operable Unit subject to WAC 173-340, "Model Toxics Control Act – Cleanup" (carbon tetrachloride and trichloroethylene) so the excess lifetime cancer risk does not exceed 1×10^{-5} at the conclusion of the remedy.

b. Federal drinking water standard.

c. No federal drinking water standard.

NA = not available

TCE = trichloroethylene

WAC = *Washington Administrative Code*

Table A-2. Biogeochemical and Field Screening Monitoring Parameters

Constituent	Typical Method	Units	Data Use
Biogeochemical Parameters			
Total organic carbon	EPA 415.1	mg/L	Evaluate natural attenuation
Total dissolved solids	EPA 160.1	mg/L	Evaluate natural attenuation, identify new releases
Sulfate	EPA 300.0A	mg/L	Evaluate natural attenuation
Sulfide	EPA 9215	mg/L	Evaluate natural attenuation
Iron	EPA 6010B	µg/L	Evaluate natural attenuation
Manganese	EPA 6010B	µg/L	Evaluate natural attenuation
Alkalinity	EPA 310.1	mg/L (as carbonate)	Evaluate natural attenuation
Carbonate content (bicarbonate and carbonate)	EPA 310.1	mg/L (as carbonate and bicarbonate)	Evaluate natural attenuation
Field Screening Parameters			
Temperature	Hach® HQ40d (or equivalent)	°C	Evaluate well purge for sampling
pH	Hach HQ40d (or equivalent)	pH unit	Evaluate well purge for sampling
Specific conductance	EPA 1201.1	mS/cm	Evaluate well purge for sampling
Turbidity	Hach 2100P Turbidimeter HQ40d (or equivalent)	NTU	Evaluate well purge for sampling
Dissolved oxygen	Hach HQ40d (or equivalent)	mg/L	Evaluate natural attenuation
Reduction-oxidation potential	USGS "National Field Manual for the Collection of Water-Quality Data"	mV	Evaluate natural attenuation

Notes: Hach® is registered trademark of the Hach Company, Loveland, Colorado.

"National Field Manual for the Collection of Water-Quality Data," U.S. Geological Survey Techniques of Water-Resources Investigations, Book 9, Chapters A1 through A9.

EPA = U.S. Environmental Protection Agency

NTU = nephelometric turbidity unit

USGS = U.S. Geological Survey

- **Hydraulic monitoring network data:** The hydraulic monitoring well network spatially covers an area larger than the area covered by the pump-and-treat extraction and injection wells. The spatial density of monitoring wells is the greatest in the area bounded by the east and west injection well fences (shown in Figure 1-2 [see main text]). The monitoring wells have sufficient vertical coverage to monitor elevations ranging from the basalt bedrock up to the water table interface. Operating extraction wells are not included in the groundwater elevation monitoring well network. The hydraulic monitoring data includes manually measured groundwater elevations collected as a synoptic data set (i.e., data that are all collected on the same day or at least under the same pumping and recharge conditions) and/or transducer-measured groundwater elevations collected semi-continuously. Measured groundwater elevations are accurate to the nearest 0.61 cm (0.02 ft).
- **Remedial system monitoring data:** Extraction and injection well flow rates are measured at each well on a semi-continuous basis using in-line flow meters accurate to 5 percent of the pumping rate. Combined influent and effluent contaminant monitoring samples are collected from the treatment plant influent and effluent sampling ports while the extraction wells are pumping, preferably at design rates. The samples are analyzed for the COCs listed in Table 1-1 (see main text), and the analytical method detection limits are equal to or less than the cleanup levels listed in Table 1-1 (main text). Extraction well contaminant monitoring samples are collected from the sampling port at each individual extraction well while the well is pumping, preferably at the design rate. The samples are analyzed for the COCs listed in Table 1-1, and the analytical method detection limits are equal to or less than the cleanup levels listed in Table 1-1.

A4.1 Data Inputs to Resolve Decision Statement #1

Groundwater sampling data collected from the contaminant monitoring well network are necessary to determine if new releases of COCs occur. The sampling data are used to establish concentration trends in monitor wells and to delineate the three-dimensional boundary of each contaminant plume at the cleanup-level concentration.

Hydraulic monitoring data, extraction and injection well flow rate data, and extraction well contaminant sampling data are needed to determine if any new releases of COCs could impact the effectiveness of the remedy. Hydraulic monitoring data and the 200 West Area calibrated groundwater flow model are used to evaluate if any new releases are outside of the hydraulic capture zone of the pump-and-treat system. Extraction and injection well flow rates are needed for model input. The contaminant transport model is used to predict if any new releases of COCs will impact either the goal of 95 percent mass removal within 25 years and/or the goal of aquifer cleanup within 125 years. The most current three-dimensional plume shell, constructed from the groundwater contaminant sampling data for each COC, is needed to initialize the contaminant concentrations in the model. Extraction well contaminant sampling data are used to determine if any new releases of COCs could impact the treatment process.

A4.2 Data Inputs to Resolve Decision Statement #2

Groundwater sampling data collected from the contaminant monitoring well network are used to determine if potentially toxic and/or mobile transformation products are generated within the OU. Monitoring for potential COC degradation products is critical for evaluating natural attenuation processes and may indicate that COC degradation products are present at concentrations that could impact the success of the remedial action. The analytical method detection limits listed in Table A-1, which are the federal drinking water maximum contaminant levels, are the comparison levels needed to evaluate the concentrations of any potentially toxic and/or mobile transformation products.

A4.3 Data Inputs to Resolve Decision Statement #3

Hydraulic monitoring data and groundwater contaminant sampling data are used to determine if changes occur in environmental conditions that may reduce the efficacy of the pump-and treat system, natural attenuation processes, and flow-path control actions. Groundwater elevations have been decreasing in the 200 West Area for several years and are expected to decrease further in the pump-and-treat system extraction well field. These decreases in groundwater elevation may cause monitoring wells to go dry and may require removing the wells from the monitoring well network. The aggressive pumping rates, low aerial recharge, and limited lateral inflow could also cause some extraction well pumping rates to be unsustainable. Thus, groundwater elevation data are needed to monitor the hydraulic response of the aquifer to the operation of the pump-and-treat system. Monitoring of the COC degradation products, as well as the biogeochemical and field measurement parameters is critical for evaluation of the natural attenuation processes. Thus, groundwater sampling data collected from the contaminant monitoring well network are used to monitor changes that may be occurring in environmental conditions that could reduce the efficacy of the natural attenuation processes.

A4.4 Data Inputs to Resolve Decision Statement #4

Groundwater contaminant sampling data, extraction, and injection well flow rate data, and extraction well and combined treatment plant influent and effluent contaminant sampling data are used to verify and/or predict if the pump-and-treat system will remove at least 95 percent of the mass of COCs in 25 years or less. The 200 West Area calibrated groundwater flow and contaminant transport model is used to predict if the pump-and-treat system will remove at least 95 percent of the mass of COCs in 25 years or less. A contaminant transport run spanning at least 25 years will be needed for each COC. The most current three-dimensional plume shell, constructed from the groundwater contaminant sampling data for each COC, is needed to initialize the contaminant concentrations in the model. Extraction well contaminant sampling data may be used to calibrate each COC plume shell. Current and anticipated extraction and injection well flow rates will also be needed as input to the model. A starting mass for each COC was needed to calculate percentage contaminant mass reduction for each COC. The starting masses for each COC are provided in *Description of Modeling Analyses in Support of the 200-ZP-1 Remedial Design/Remedial Action Work Plan* (DOE/RL-2009-38), although the current plume shells and starting masses are re-evaluated after completing drilling and sampling at each new extraction and injection well location. The combined treatment plant influent and effluent contaminant sampling data, extraction well contaminant sampling data, and extraction well and treatment plant influent flow rate data are used to calculate the actual contaminant mass removed by the pump-and-treat system.

A4.5 Data Inputs to Resolve Decision Statement #5

Groundwater contaminant sampling data collected from the monitoring well network will be used to determine if contamination is expanding downgradient, laterally, or vertically after the pump-and-treat system has been shut down. Plots of measured contaminant concentration trends in downgradient monitoring wells may be needed to evaluate the expansion and/or migration of the contaminant plumes. Additionally, three-dimensional contaminant plume shells (constructed from the groundwater contaminant sampling data for each COC) may be needed to evaluate contaminant distributions and calculate plume volumes and contaminant masses.

A4.6 Data Inputs to Resolve Decision Statement #6

Groundwater contaminant sampling data, extraction and injection well flow rate data, and extraction well contaminant sampling data are used to determine if the current remedy design is predicted to achieve cleanup levels for all COCs within 125 years. The existing 200 West Area calibrated groundwater flow and contaminant transport model is used to predict if the pump-and-treat system will achieve cleanup levels for all COCs within 125 years. A contaminant transport run spanning at least 125 years is needed for each COC. The most current three-dimensional plume shell, constructed from the groundwater contaminant sampling data for each COC, will be needed to initialize the contaminant concentrations in the model. Extraction well contaminant sampling data may be used to calibrate each COC plume shell. Current and anticipated extraction and injection well flow rates will also be needed as input to the model if the simulation starts while the pump-and-treat system is still operating.

A4.7 Data Inputs to Resolve Decision Statement #7

Groundwater contaminant sampling data will be used to determine if remediation has been successfully completed.

A4.8 Data Inputs to Resolve Decision Statement #8

Groundwater contaminant sampling data are used to determine if certain areas of the contaminant plumes are not responding to pump-and-treat remediation.

A4.9 Data Inputs to Resolve Decision Statement #9

Groundwater contaminant sampling data will be used to determine if there is a rebound in contaminant plumes after 95 percent of the mass of COCs have been removed and the pump-and-treat system has been turned off.

A5 Define the Boundaries of the Study

In the fourth step of the DQO process, the spatial and temporal features pertinent to the decision-making process are identified. The 200-ZP-1 performance monitoring network must verify that cleanup levels have been achieved in all areas of the groundwater plumes. Spatially, this covers an area from the western injection well fence to the eastern leading edges of the plumes. Elevations range from the top of the basalt bedrock to the water table interface. The current 200-ZP-1 site conceptual model does not include any COC concentrations greater than cleanup levels in the basalt bedrock. Performance monitoring is expected to continue temporally until cleanup levels have been achieved, which is estimated to be 125 years.

A6 Develop the Analytic Approach

The fifth step of the DQO process involves developing an analytic approach that outlines how the performance monitoring data will be used to make decisions regarding the progress of the selected remedy. The analytical approach for using the data inputs to resolve each of the DSs is presented in the following subsections.

A6.1 Approach to Resolve Decision Statement #1

Groundwater contaminant sampling data are and will be evaluated to determine if any new releases of COCs have occurred. Monitoring well concentration trends are and will be evaluated, and the sampling data are and will be used to update the three-dimensional plume shell for each contaminant. If contaminant concentrations in a monitoring well are stable and/or increasing, and there is no known upgradient dissolved-phase contaminant mass to support these stable and/or increasing concentrations, then there may be a new release. Dissolved-phase contaminant mass may also be present in a low-conductivity zone and/or contaminant mass adsorbed onto fine-grained, low-conductivity materials that is slowly solubilizing and acting as a continuing source. Whatever the mechanism, it should be evident from evaluation of concentration trends in monitoring data and comparison of current to previous contaminant plume shells, that if an area of a COC plume is not responding to the pump-and-treat system, then that area should be evaluated as a possible new release of COCs. Understanding the three-dimensional distribution of the contaminant concentrations as the contaminant plumes evolve is essential to success of the selected remedy. Contaminant plume shells will be used for the following:

- Visualizing the distribution of dissolved-phase groundwater contamination in three dimensions
- Estimating the dissolved-phase contaminant mass and volume of the plumes
- Initializing contaminant concentrations in the groundwater model for running contaminant transport simulations

Plume shells are constructed by interpolating the scattered concentration data points to a grid using ordinary kriging. Kriging is a linear, unbiased, least-squares spatial interpolation method that uses a weighted-average estimator to approximate the value of a regionalized variable at a spatial location (*An Introduction to Applied Geostatistics* [Isaaks and Srivastava, 1989]). The kriging process is used to generate a single best estimate of each contaminant distribution. Each plume shell should be masked to mitigate artifacts of the kriging process that would otherwise produce hydraulically unreasonable extrapolation of contaminant concentrations into areas with no data coverage. The mask is applied in plan view and is used to define the maximum lateral extent of contamination present at concentrations above the cleanup level. Outside the plan view mask boundary, interpolated contaminant concentrations are set to 0 µg/L. The use of kriging to generate plume shells in this manner should mitigate some of the subjectivity that can accompany manual contouring of contaminant concentration data.

Observed extraction well effluent concentrations can be used along with the contaminant transport model to calibrate the COC plume shells and the model. The COC plume shells can be imported into the contaminant transport model, which can then be run to obtain simulated extraction well contaminant concentrations. These simulated concentrations can then be compared to the observed extraction well concentrations to calibrate the plume shells and model in an iterative process. This calibration process may result in changes to the plume shells and/or model and is another way to use all available lines of evidence to monitor the remedy performance.

A new release can impact the effectiveness of the remedy in several ways. The contaminant concentration can be large enough to exceed the maximum design concentration for the contaminant in the combined treatment plant influent. The 200 West Area calibrated groundwater flow and contaminant transport model is used to predict the influent contaminant concentrations in individual extraction wells. The individual extraction well influent concentrations can be summed to predict the combined treatment plant contaminant influent concentrations. These simulated treatment plant influent concentrations can then be compared to the maximum design concentrations to determine if a new release has added sufficient contaminant mass to a contaminant plume to impact the treatment process.

A new release can also impact the effectiveness of the remedy if the spatial position of the new release is outside the hydraulic capture zone of the pump-and-treat system extraction wells. The three-dimensional hydraulic capture zones of the remedial system extraction wells are delineated using particle-tracking simulations and a groundwater flow model solution. In these simulations, one particle is started in each model cell in the area of the hydraulic monitoring network. Particles that are started in the model cells located within the capture zones migrate to an extraction well and are captured. Particles starting in model cells outside the capture zones discharge to exit points in the model other than the extraction wells. The capture zones are then illustrated by three-dimensional visualization software, which creates bounding surfaces between the captured and uncaptured portions of the aquifer. Superpositioning the three-dimensional capture zones over the three-dimensional plume shells reveals whether each COC is being captured by the pump-and-treat system. These three-dimensional capture zones can be presented in plan view as a set of two-dimensional slices through the aquifer, superimposed over the applicable two-dimensional slices through the three-dimensional contaminant plume shells. Comparison of the capture zones to the COC distributions is used to evaluate contaminant capture.

Early in the life of the remedy, the majority of extracted water will likely come from storage depletion in the aquifer, which will diminish over time as the extracted water increasingly originates from horizontal flow toward the wells. However, the ultimate steady-state extent of capture may take considerable time to develop and may never be achieved in the center of the extraction well field. Since some of the treated groundwater directed to the eastern injection well field will be lost to the regional eastward groundwater flow regime, aggressive pumping rates, low aerial recharge, and limited lateral inflow could cause groundwater elevations in some extraction wells to continue decreasing over the life of the remedial action. This situation could result in a valid capture zone that can only be simulated using a transient model solution with particle migration over the time period of the transient model run. In the early life of the remedy, such capture zones would be very limited in aerial extent and of limited usefulness for evaluating plume capture and optimizing pumping rates. If the end of the transient model run is considered to be a snapshot in time and is treated as a quasi-steady-state, and if the particles are allowed to migrate to their final destinations as in a steady-state run, then a more extensive and useful capture zone can be generated. It should be noted that the simulated quasi-steady-state capture zone will be less extensive laterally than the true steady-state capture zone, and this difference should be taken into account when evaluating plume capture.

If plume capture is being evaluated shortly after system startup, other methods of capture analysis can be used that focus on measured groundwater elevations and gradient analysis. These methods also evaluate capture at one point in time and do not generate the steady-state capture zone. While two-dimensional kriging of water-level data with hydrologic drift terms can be used to present the extraction well hydraulic capture zones using two-dimensional particle tracking, the capture zones are of limited usefulness for evaluating the capture of complex three-dimensional contaminant plumes. Because 70 to 80 m (229.7 to 262.5 ft) of saturated aquifer in the OU and potential low-conductivity zones (Ringold Unit 8) may bifurcate the contaminant plumes into upper and lower lobes, the extraction well hydraulic capture zones are best generated and visualized in three-dimensions using the groundwater flow model with three-dimensional particle tracking.

Finally, the new release could add enough contaminant mass to the plume to adversely impact either the goal of 95 percent mass removal within 25 years or the goal of aquifer cleanup within 125 years. These potential impacts to the effectiveness of the remedy could necessitate changes to the remedial action and/or the PMP.

Several potential changes can be made to the remedial action to accommodate any new releases. Individual extraction well pumping rates and/or production intervals can be adjusted so the combined treatment plant influent concentrations remain within design limits. Individual extraction well pumping rates and/or production intervals can also be adjusted to extend hydraulic capture into the area of the new release. Additional extraction wells can be added to the system to capture the new release, and these may be newly constructed extraction wells and/or conversion of existing monitoring wells to extraction wells. Additional treatment capacity can be added to the treatment plant to handle the higher contaminant concentrations caused by the new release.

Changes can be made to the PMP to accommodate any new releases. New monitoring wells can be added to the monitoring well network to help delineate the three-dimensional extent of the new contaminant release, and these may be newly constructed monitoring wells or existing monitoring wells not previously included in the monitoring well network.

A6.2 Approach to Resolve Decision Statement #2

Groundwater sampling data are evaluated to determine if potentially toxic and/or mobile transformation products are generated within the OU. This evaluation is typically performed by analyzing concentration changes in the parent COC and the COC degradation products. This analysis applies to COCs that are commonly degraded in the environment and, in the case of the 200-ZP-1 OU, includes carbon tetrachloride, trichloroethylene, and nitrate. The rates of decline in the parent compound and the formation of the degradation product will be used to derive degradation rates. The degradation rates will be included in the 200 West Area contaminant transport model and will be used to evaluate whether natural attenuation will achieve cleanup levels within the time period specified in the ROD.

If potentially toxic and/or mobile transformation products are generated at large enough concentrations, it is possible that these products may pose a risk to the success of the selected remedy and should be included in the list of COCs with associated cleanup levels. Concentrations of any toxic and/or mobile transformation products will be compared to the federal drinking water maximum contaminant levels (Table A-1) to evaluate their inclusion in the list of COCs. The *Remedial Investigation Report for the 200-ZP-1 Groundwater Operable Unit* (DOE/RL-2006-24) and the *Feasibility Study for the 200-ZP-1 Groundwater Operable Unit* (DOE/RL-2007-28) can be reviewed to determine if the potential risks posed by the transformation products were analyzed and what concentrations were considered when the current list of COCs was developed.

If it is determined that one or more potentially toxic and/or mobile transformation products should be included in the list of COCs, then the PMP should be modified to include the applicable transformation products as COCs.

A6.3 Approach to Resolve Decision Statement #3

Groundwater elevation data is necessary to determine if changes are occurring in environmental conditions that may reduce the efficacy of the pump-and-treat system and the flow-path control actions. The data includes transient groundwater elevations measured using transducers with data loggers and more long-term, quasi-steady-state data measured during synoptic groundwater elevation surveys.

Groundwater elevations have been decreasing in the 200 West Area for several years and are expected to continue decreasing in the pump-and-treat system extraction well field. The decreases in groundwater elevation may cause monitoring wells to go dry, resulting in removal of the wells from the monitoring well network. In the short term, the aggressive pumping rates, low aerial recharge, and limited lateral inflow could cause some extraction well pumping rates to become unsustainable. Thus, the transient data

logger groundwater elevation data may be evaluated to monitor the sustainability of the extraction well field and to optimize pumping possibly by re-balancing upgradient and downgradient injection to ensure that a sustainable remedy is implemented. The more long-term, quasi-steady-state data measured during synoptic groundwater elevation surveys should be used to generate water table maps to evaluate groundwater elevations and their impacts on the monitoring well networks and flow-path control actions.

The potentiometric surface of water table elevations is generated from the hydraulic monitoring data to help understand groundwater flow directions in the 200-ZP-1 OU. Water table elevations are best reported as a two-dimensional plan view map. The two-dimensional water table elevation map is best generated by kriging the data with an expression (drift term) that describes the response of groundwater levels to pumping at the extraction wells (“Kriging Water Levels with a Regional-Linear and Point-Logarithmic Drift” [Tonkin and Larson, 2002]). This kriging method eliminates the need to include water levels measured in the extraction wells, which can introduce significant errors to the water table map. If groundwater flow directions vary with depth, several two-dimensional plan view maps may be needed for different elevation intervals in the aquifer.

Groundwater monitoring for key biogeochemical and field parameters will be used to determine if changes occur in environmental conditions that may reduce the efficacy of natural attenuation processes.

In order to evaluate remediation by natural attenuation, it needs to be determined if contaminant mass is being destroyed. The biogeochemical parameters (Table A-2) help identify if the appropriate conditions exist in the aquifer to support COC destruction. The monitoring constituents (Tables A-1 and A-2) can be used in mass balance calculations to determine if decreases in contaminant and electron acceptor/donor concentrations can be directly correlated to increases in daughter compounds. The simplest way to accomplish this is by mapping of concentration changes in reactants (contaminants, electron acceptors and donors) or products of the biogeochemical process (e.g., dissolved iron and chloride) that degrade or immobilize the contaminants. These maps can be measured to determine if these transformation processes are active at the site. Biodegradation rate constants can be calculated from time-series data of the measured COC concentrations in conjunction with aquifer hydrogeologic parameters such as seepage velocity and dilution.

A6.4 Approach to Resolve Decision Statement #4

The groundwater contaminant transport model is used to predict if the pump-and-treat system will remove at least 95 percent of the mass of COCs in 25 years or less. This analysis uses the three-dimensional contaminant plume shell for each COC as the starting concentration in the model and transporting the contaminant plume forward in time for at least 25 years. Current and future anticipated extraction and injection well flow rates are needed as input to the model. Using the simulated extraction well contaminant concentrations and flow rates, the contaminant mass removed by each extraction well can be calculated. The percentage mass removed for each COC can be calculated by summing the simulated mass removed by each extraction well and dividing that by the starting mass for each COC.

If the model simulation predicts that 95 percent of the contaminant mass will not be removed in 25 years, then modifications to the pump-and-treat system should be evaluated. Improvements in mass removal may be achieved through pump-and-treat system optimization. This usually involves using the model to evaluate changes to extraction and injection well flow rates and production intervals (by packering off the upper or lower screen interval) to maximize contaminant mass removal. If the 95 percent mass removal goal cannot be met through system optimization, then other options might include operating more extraction wells, increasing the capacity of the treatment plant and pumping the existing extraction well harder, and/or evaluating other technologies for a more focused or “hot spot” remedy.

The combined treatment plant influent and effluent contaminant sampling data, extraction well contaminant sampling data, and extraction well and treatment plant influent flow rate data are used to calculate the actual contaminant mass removed by the pump-and-treat system. Contaminant mass removal can be calculated by multiplying the difference in the treatment plant influent and effluent contaminant concentrations by the influent flow rate and the elapsed time at that concentration and flow rate. However, some COCs may not be detectable in the combined treatment plant influent samples but are detectable in samples collected from one or more of the extraction wells. In this case, a more accurate mass removal can be calculated using the individual extraction well contaminant sampling and flow rate data and summing the mass removed from the individual extraction wells to obtain the total mass removal for the COC.

While the ROD states that the system will be designed to capture and treat contaminated groundwater to reduce the mass of the COCs by a minimum of 95 percent within 25 years, using mass removal as the only remediation metric to shut down the system could be problematic. The most likely scenario is that some extraction wells will cleanup faster than others and before the 95 percent mass removal milestone for each COC has been reached. These wells will be shut down based on their influent contaminant concentrations and the monitoring well sample concentrations within their hydraulic capture zones. The ROD states that carbon tetrachloride concentrations in groundwater above 100 µg/L correspond to approximately 95 percent of the mass of carbon tetrachloride residing in the aquifer. Therefore, it may be appropriate to shut down individual extraction wells when their carbon tetrachloride concentrations, as measured in the extraction wells and monitoring wells within the hydraulic capture zones of the extraction wells, fall below 100 µg/L. However, this assumes that the other COCs have been remediated to acceptable levels, and the ROD only includes the final cleanup levels for the other COCs. Most likely, the pump-and-treat system shutdown will consist of a series of judgment-based decisions regarding both concentration and mass removal remediation metrics. Potential rebound of contaminant concentrations will be monitored by the long-term natural attenuation monitoring program, and extraction wells will be reactivated if necessary.

A6.5 Approach to Resolve Decision Statement #5

Groundwater sampling data will be evaluated to determine if contamination is expanding downgradient, laterally, or vertically after the pump-and-treat system has been shut down. The pump-and-treat system is designed to capture carbon tetrachloride concentrations above 100 µg/L, and some carbon tetrachloride contamination may likely be present downgradient of the pump-and-treat system that is beyond the remedial system capture zone. The downgradient migration of this lower concentration contamination should not be supported by any upgradient higher concentration contamination that has escaped capture by the remedial system.

The trends in measured concentrations for downgradient monitoring wells will be analyzed to draw conclusions about the expansion and/or migration of the contaminant plumes. Three-dimensional contaminant plume shells will be updated for each COC using the most current sampling data. Plume volume and contaminant mass statistics can be generated from the plume shells. The contaminant distributions and statistics can be compared to those from the previous plume shell versions to evaluate expansion or contraction of each COC plume.

If evaluation of groundwater sampling data indicates that a COC plume may be expanding downgradient and the remedial system is still operating, several courses of action may be taken. Extraction and injection well flow rates and/or production intervals may be adjusted to improve the hydraulic capture of escaping contaminant mass. New extraction wells may be installed to capture the escaped contaminant mass that is supporting the downgradient plume expansion.

A6.6 Approach to Resolve Decision Statement #6

The groundwater contaminant transport model is used to predict if the current remedy design will achieve cleanup levels for all COCs within 125 years. This analysis can be accomplished by using the three-dimensional contaminant plume shell for each COC as the starting concentration in the model and transporting the contaminant plume forward in time for at least 125 years. Current and future anticipated extraction and injection well flow rates can be supplied to the model as input. An animation can be made for each COC, displaying the contaminant concentrations greater than or equal to the cleanup level as the plume migrates over time. If the simulated contaminant concentrations remain significantly above the cleanup level during the 125-year period, the remedy goal may not be achieved within the desired remedial timeframe.

If the model simulation predicts that the 125-year aquifer cleanup goal may not be achieved, modifications to the remedial action should be evaluated. The pump-and-treat system may require longer operation to remove additional contaminant mass to meet the aquifer cleanup goal. While the system is operating, improvements in mass removal may be achieved through pump-and-treat system optimization, as previously described.

A6.7 Approach to Resolve Decision Statement #7

The groundwater sampling data will be evaluated to determine if the remediation has been successfully completed. If contaminant concentrations in all monitoring wells, for all COCs, have decreased to below the cleanup levels for at least 5 years, then a recommendation should be made for no further action.

A6.8 Approach to Resolve Decision Statement #8

The groundwater sampling data will be evaluated on an annual basis to determine if any areas of the contaminant plumes are not responding to pump-and-treat remediation. If one or more areas are identified, options will be evaluated.

A6.9 Approach to Resolve Decision Statement #9

Annual (or less frequent) groundwater sampling data will be collected and analyzed for each of the COCs to determine if there is rebound in COC concentrations.

A7 Specify Performance or Acceptance Criteria

The sixth step of the DQO process involves deriving the performance or acceptance criteria that the collected data need to achieve in order to minimize the possibility of either making erroneous conclusions or failing to keep uncertainty in estimates to within acceptable levels. Typically, the decision rule as a statistical hypothesis test is specified in this section, and the consequences of making incorrect decisions from the test are examined. However, statistical tests of the monitoring data to support the end of this remedial action have not been developed as part of this PMP and may not be applicable. More quantitative specifications of data quality should be defined and presented as part of the quality assurance project plan when the performance monitoring criteria have been agreed upon by the stakeholders. This section presents the potential uncertainties associated with the performance monitoring data to be collected and the potential impacts of those uncertainties.

A7.1 Groundwater Levels

Groundwater-level data consist of several components:

- Depth-to-water measurement
- Surveyed elevation of the top of casing
- Surveyed northing and easting coordinates of the well
- Elevation interval in the aquifer of which the depth to water is representative (well screen top and bottom elevations)

The most critical components of groundwater-level data are the depth-to-water measurement and the top-of-casing elevation. Elevations for the top of casing are typically specified to the nearest 0.3 cm (0.01 ft), and depth-to-water measurements are typically specified to the nearest 0.61 cm (0.02 ft). Errors on the order of a couple of hundredths of a foot can be significant in situations where small horizontal hydraulic gradients are expected (e.g., in hydraulic stagnation zones between competing extraction wells) or when calculating vertical hydraulic gradients. In such sensitive areas, capture zone analyses can result in significant errors, leading to loss of plume capture or wasted over-pumping.

Groundwater elevation errors can be detected by preparing a two-dimensional water table map and looking for irregularities in the elevation contours. Also, a groundwater elevation data set can be compared to the previously collected data set to look for irregularities. While difficult to detect, these errors can be managed by designing hydraulic capture zones conservatively with a margin of safety so small errors in measured groundwater elevations do not lead to loss of plume capture.

Ground surface elevations are typically provided to the nearest 0.03 m (0.10 ft), which is used along with the top and bottom screen depths to calculate the top and bottom screen elevations. Errors up to 1.5 m (5 ft) in top and bottom screen elevations would likely have little impact on the use of groundwater elevation data because hydraulic stresses are transmitted fairly easily through the aquifer. Since much of the well construction data for the 200-ZP-1 OU monitoring wells is historical, screened interval data from monitoring wells may have the potential for significant uncertainty. However, well screen elevation errors are likely not a significant concern for groundwater elevation data since the vertical spatial position of groundwater elevation measurement is typically taken as the mid-screen elevation in the well. These mid-screen elevation data points can be used in the groundwater flow model by comparing them to simulated heads taken from model grid cell center elevations.

Typically, surveyed northing and easting coordinates are provided to the nearest 0.03 m (0.10 ft). However, errors of up to 1.5 m (5 ft) in well coordinates should have little impact on any processes or significant decisions. In addition, well coordinates are relatively easy to verify in the field. Thus, well coordinate errors are likely not a concern.

A7.2 Pumping Rates

Measured pumping rates are used to monitor system performance and ensure that the system is operating within design specifications. Pumping rates are also used in model calibration, plume shell calibration, model simulations, and extraction well contaminant mass removal calculations. Pumping rates should be measured on a semi-continuous basis using in-line flow meters accurate to 5 percent of the flow rate.

Extraction well flow rate errors can be detected by comparing the sum of the extraction well pumping rates to the combined influent flow rate at the treatment plant. Pumping rate errors of a couple of

gallons per minute would have little impact on the simulated capture zone for an extraction well pumping at 379 L/min (100 gallons per minute [gpm]). For mass removal calculations for an extraction well with an influent carbon tetrachloride concentration of 1,000 $\mu\text{g/L}$, for every 3.8 L/min (1 gpm) error in flow rate, there would be an approximately 2 kg/year error in calculated contaminant mass extracted. If the carbon tetrachloride plume is assumed to have a dissolved-phase mass above the cleanup level of approximately 1,221 kg, then this error is approximately 0.2 percent of the plume mass. To put this in perspective, under current Hanford Site laboratory contracts using *Test Methods for Evaluation of Solid Waste, Physical/Chemical Methods* (SW-846) Method 8260, the reported carbon tetrachloride concentrations are to be accurate to within ± 20 percent. For an extraction well pumping at 379 L/min (100 gpm) with an influent carbon tetrachloride concentration of 1,000 $\mu\text{g/L}$, this percentage of error could result in the calculated mass extracted being under or over reported by approximately 40 kg/year. This is equivalent to a 76 L/min (20 gpm) flow rate error for a 379 L/min (100 gpm) flow rate. Therefore, pumping rate errors of a couple of gallons per minute should have little impact on any significant decisions.

A7.3 Contaminant Concentrations

Contaminant concentration data consist of several components, including the actual groundwater sample, subsequent laboratory analysis, and the three-dimensional spatial position from which the sample originated in the aquifer. Contaminant concentrations from analytical laboratory analyses are needed to construct three-dimensional contaminant plume shells, to calculate the contaminant mass extracted from the extraction wells, and to ultimately verify the achievement of cleanup levels. To meet this goal, the analytical method detection limits should be equal to or less than the cleanup levels.

Failure to set analytical laboratory detection limits equal to or less than the cleanup levels could result in groundwater contaminant monitoring data of insufficient quality to determine a successful cleanup. Since three-dimensional contaminant plume shells are usually constructed with the lowest concentration isosurface set at the cleanup level, use of analytical laboratory detection limits above the cleanup levels will result in a lack of data to establish the plume shell outer boundaries. This will result in errors in the reported mass and volume statistics, errors in extraction well capture analyses, and errors in simulated contaminant transport.

Other types of errors, such as random nonrepresentative samples and/or laboratory analyses, should have limited impact on any significant decisions regarding remedy performance. Typically, if a sample result seems erroneous and the result is critical (i.e., the result significantly changes the site conceptual model, indicates loss of capture, or falsely indicates plume cleanup), the sampling is repeated at that location to verify the result. Significant decisions are not generally based on one sample result. An erroneous sample result could impact the kriged concentrations in a limited area of a contaminant plume shell. However, the plume shells are usually regenerated on an annual basis, so the error would be relatively short lived.

Horizontal spatial position errors are usually of such a small magnitude that they would have little impact on any processes or significant decisions. Surveyed northing and easting coordinates typically are provided to the nearest 0.03 m (0.10 ft). Errors of up to 1.5 m (5 ft) in well coordinates would usually have little impact. In addition, well coordinates are relatively easy to verify in the field. Thus, well coordinate errors are likely not a concern.

Ground surface elevations typically are provided to the nearest 0.03 m (0.10 ft), which is usually used along with the top and bottom screen depths to calculate the top and bottom screen elevations. Errors in top and bottom screen elevations of a couple of feet would likely have little impact on the use of concentration data. However, contaminant concentrations tend to be highly vertically heterogeneous and

an error of 3.0 m (10 ft) or more in a screened interval could introduce significant errors in the three-dimensional contaminant plume shells. Since much of the well construction data is historical for the older 200-ZP-1 OU monitoring wells, the potential exists for significant errors in the reported well screened intervals. Such errors could potentially lead to errors in the three-dimensional contaminant plume shells and potential loss of plume capture.

Another vertical spatial position problem with the 200-ZP-1 OU monitoring wells is that many of the wells have relatively long screened intervals. The screen length for groundwater monitoring wells typically ranges from 1.5 m (5 ft) to 4.6 m (20 ft); however, many 200-ZP-1 OU monitoring wells have screen lengths in excess of 9.1 m (30 ft). The variations in screen length can lead to uncertainties in the vertical position from which groundwater samples were extracted and can cause high contaminant-concentration intervals to be diluted by less contaminated groundwater from other aquifer intervals. Again, such errors could potentially lead to errors in the three-dimensional contaminant plume shells and loss of plume capture.

Vertical spatial position errors in contaminant concentration sampling data are relatively difficult to detect and manage. Well construction information for a particular monitoring well should be reviewed if samples collected from the well do not make sense in relation to other upgradient and downgradient samples. However, the relatively low density of samples usually makes it difficult to detect these types of errors. In general, the uncertainty in three-dimensional contaminant plume delineation caused by the sparse sampling network is much greater than all of the other sources of contaminant concentration uncertainty. This uncertainty is then added to by the relative coarseness of the contaminant transport model grid and the uncertainty in the model transport parameters. These errors are mostly managed by using professional judgment when evaluating the three-dimensional plume shells and resulting model simulations for consistency with the site conceptual model and hydrologic principles, as well as by questioning any discrepancies.

A7.4 Other Measured Parameters

Key biogeochemical parameters included with laboratory analyses are listed in Table A-2. Evaluation of these parameters may provide a better understanding of natural attenuation conditions and/or reaction pathways within the reactive zones of the plumes. Errors in the measurement of these parameters would usually have little impact on any significant decisions regarding natural attenuation processes.

Key groundwater parameters typically measured in the field at each sampled monitoring well during each monitoring round are listed in Table A-2. These parameters may be monitored continuously in a flow-through cell apparatus during monitoring well sampling. Stable readings are an indication that sufficient purgewater has been withdrawn from a well and that a representative sample of the groundwater can be collected. These parameters are also important for monitoring natural attenuation processes. Errors in the field measurement of these parameters would usually have little impact on any significant decisions regarding natural attenuation processes.

A7.5 Model Predictions

The groundwater flow and transport model is an important tool for simulating hydraulic capture and predicting whether the remedial goals of 95 percent mass reduction within 25 years and aquifer cleanup within 125 years will be achieved. However, uncertainties are associated with the use of the model that can lead to a sense of false confidence in the accuracy of the model predictions. These uncertainties can be minimized by using multiple lines of evidence to increase the confidence in model predictions by ensuring that all available data are used. Some of the available methods are described below.

The ability of the groundwater flow model to accurately simulate hydraulic capture should be evaluated by using a residual analysis method (RAM) technique. The RAM technique compares the simulated head distribution from the model to the measured groundwater elevations and displays the difference in terms of hydraulic capture. This is a useful technique for determining if the model calibration is adequate and ensures that the available data are used to make important decisions regarding plume capture and remedial system optimization. The RAM technique for analyzing hydraulic data includes the following steps.

1. Calculate the head residuals between the groundwater elevations measured at the synoptic monitoring wells and the simulated heads from the groundwater flow model using the remedial system extraction and injection rates recorded during the synoptic monitoring event.
2. Analyze the spatial distribution of model results and the application of head residuals to amend the model results and produce an estimated potentiometric head distribution that closely approximates the measured data while retaining the hydraulic insight of the model.
3. Apply the amended flow field to generate estimated remedial system hydraulic capture zones.

Particle tracking should be used to generate the capture zones using both the unadjusted simulated head field and the RAM-amended head field that more closely matches the actual hydraulic conditions based on the measured groundwater elevations. Application of the RAM technique may indicate that the current 200 West Area groundwater flow model is not adequate to accurately predict plume capture and migration, in which case the model should be recalibrated. The groundwater elevation data collected during the most recent water-level monitoring event would provide the calibration targets for the model recalibration.

The ability of the groundwater transport model to accurately simulate plume migration depends, in part, on the accuracy of the starting concentration distribution (three-dimensional plume shell) and the contaminant transport parameters used in the model. The three-dimensional plume shell for each contaminant will adequately represent the available sampling data at the sampling locations based on the method of construction (kriging). The uncertainty involves the areas in between the sampling locations and the outer boundaries of the plume shells. Thus, the accuracy of each three-dimensional plume shell can be increased by providing additional sampling locations; however, increasing the number of monitoring wells is expensive. Another method that can be used to reduce this uncertainty involves using measured extraction well contaminant concentrations as calibration targets for the contaminant transport model and adjusting each plume shell contaminant distribution until the simulated extraction well concentrations agree with the measured extraction well concentrations. Also, the outer plume boundaries (both horizontal and vertical) can be controlled during kriging by using control points and masking to ensure that the plume boundaries do not extend above the water table (into bedrock) and, in general, agree with the site conceptual model and professional judgment. Use of these methods ensures that all available lines of evidence are being used to construct the three-dimensional contaminant distributions.

The contaminant transport parameters used in the model can be evaluated by migrating older plume shell versions forward in time and comparing the simulated contaminant concentrations to the most recent measured contaminant concentrations at selected monitoring well locations. This evaluation can reduce the uncertainty in the transport parameters that control the physical, chemical, and biological processes that influence contaminant fate and transport, and may result in changes to the model parameters that control dispersion, retardation, and biodegradation. These methods ensure that all available lines of evidence are used to reduce the uncertainty associated with model predictions.

A8 Develop the Plan for Obtaining Data

The seventh step of the DQO process is to develop the sampling and analysis design to generate data needed to address the goals of the selected 200-ZP-1 OU remedy. The design for collecting contaminant concentration, hydraulic, and flow rate monitoring data is presented in Chapter 3 in the main text and Appendix B of this PMP.

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Appendix B

200-ZP-1 Groundwater Operable Unit Sampling and Analysis Plan

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Terms

AEA	alpha energy analysis
ALARA	as low as reasonably achievable
amsl	above mean sea level
BTR	buyer's technical representative
CAS	Chemical Abstracts Service
CERCLA	<i>Comprehensive Environmental Response, Compensation, and Liability Act of 1980</i>
COC	contaminant of concern
DOE	U.S. Department of Energy
DOE-RL	DOE, Richland Operations Office
DOH	Department of Health
DOT	U.S. Department of Transportation
DQA	data quality assessment
DQI	data quality indicator
DQO	data quality objective
DS	decision statement
DUP	duplicate
EB	equipment blank
ECO	environmental compliance officer
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
FEAD	format for electronic analytical data
FSO	Field Sampling Operations
FTB	full trip blank
FWS	field work supervisor
FXR	field transfer blank
GC	gas chromatography
GC/MS	gas chromatography/mass spectrometry

HASQARD	<i>Hanford Analytical Services Quality Assurance Requirements Document</i> (DOE-RL-96-68)
HEIS	Hanford Environmental Information System
IC	ion chromatography
ICP	inductive coupled plasma
ICP/AES	inductively coupled plasma/atomic emission spectroscopy
ICP/MS	inductive coupled plasma/mass spectrometry
ID	identification
LCS	laboratory control sample
LLWMA	low-level waste management area
MB	method blank
MDA	minimum detectable activity
MDL	method detection limit
MNA	monitored natural attenuation
MS	matrix spike
MSD	matrix spike duplicate
MTCA	Model Toxics Control Act (WAC 173-340)
N/A	not applicable
NAP	natural attenuation evaluation parameter
NCO	nuclear chemical operator (sampler)
OU	operable unit
P&T	pump and treat
PMP	performance monitoring plan
QA	quality assurance
QAPjP	quality assurance project plan
QC	quality control
RCRA	<i>Resource Conservation and Recovery Act of 1976</i>
RCT	radiological control technician
ROD	Record of Decision
RPD	relative percent difference

SAF	sample authorization form
SALDS	State-Approved Land Disposal Site
SAP	sampling and analysis plan
SMILE	Sample Management Integrated Lifecycle Environment
SMR	Sample Management and Reporting
SPLIT	field split
SUR	surrogate
Tri-Party Agreement	<i>Hanford Federal Facility Agreement and Consent Order</i> (Ecology et al., 1989)
VOA	volatile organic analysis or volatile organic analyte
VOC	volatile organic compound
WMA	waste management area
WTPH-D	Washington State Department of Ecology total petroleum hydrocarbons as diesel
WTPH-G	Washington State Department of Ecology total petroleum hydrocarbons as gasoline

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B1 Introduction

This document presents the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) groundwater monitoring program for the 200-ZP-1 Groundwater Operable Unit (OU) (Figure B-1). This sampling and analysis plan (SAP) describes monitoring activities associated with implementation of the selected remedy for the 200-ZP-1 OU, as presented in EPA et al., 2008, *Record of Decision, Hanford 200 Area, 200-ZP-1 Superfund Site, Benton County, Washington* (hereafter referred to as the 200-ZP-1 OU Record of Decision [ROD]). This SAP supersedes previous CERCLA groundwater sampling and analysis documents for the OU, including DOE/RL-2003-55, *Remedial Investigation/Feasibility Study Work Plan for the 200-ZP-1 Groundwater Operable Unit*.

The CERCLA groundwater monitoring requirements in the 200-ZP-1 OU are addressed by this SAP. Programmatic requirements for other sampling within the 200-ZP-1 area (e.g., *Resource Conservation and Recovery Act of 1976* [RCRA]) will continue to be performed pursuant to other sampling plans, and those requirements are not included in this SAP. RCRA groundwater monitoring is conducted for Waste Management Areas (WMAs) T and TX-TY and Low-Level Waste Management Areas (LLWMAs) 3 and 4 under separate plans. The data collected under the separate plans are considered to be supplementary groundwater quality information to the CERCLA OU process.

DOE/RL-2015-56, *Hanford Atomic Energy Act Surveillance Groundwater Monitoring Plan*, was issued in December 2015 and includes monitoring specifications of the upper basalt-confined aquifer and the Ringold confined aquifer. Groundwater within the upper basalt-confined aquifer is monitored because it is a potential pathway for contaminants to move offsite. The confined to semiconfined aquifer within the Ringold unit A is present beneath most of the Hanford Site. The confined aquifer sampling will be continued under DOE/RL-2015-56 and not included under this SAP.

The 200-ZP-1 OU comprises groundwater contaminated by releases from facilities and waste sites associated with former plutonium concentration and recovery operations at Z Plant and plutonium separation operations at T Plant. The 200-ZP-1 OU underlies the northern portion of the 200 West Area, located at the western end of the Central Plateau. The 200 West Area lies about 8 km (5 mi) south of the Columbia River and 11 km (7 mi) from the nearest Hanford Site boundary. The 200-ZP-1 OU includes several groundwater contaminant plumes that span an area approximately 13 km² (5 mi²) beneath the Hanford Site 200 West Area.

Contaminants of concern (COCs) identified in the 200-ZP-1 OU ROD (EPA et al., 2008) include carbon tetrachloride, trichloroethene, total chromium (trivalent and hexavalent), nitrate, iodine-129, technetium-99, and tritium. Carbon tetrachloride is the primary COC, with the other COCs (except nitrate) occurring in smaller commingled plumes that lie within the carbon tetrachloride plume boundary.

This plan consists of six chapters with the remainder of this section addressing the project scope and objectives, background, summary of data quality objectives (DQOs), COCs, and project schedule. Section B2 discusses the quality assurance (QA) requirements, Section B3 provides the field sampling plan. Sections B4 and B5 address waste management and health and safety requirements. Section B6 provides the sampling interval information for wells within the 200-ZP-1 OU groundwater monitoring network.

1 **B1.1 Project Scope and Objective**

2 The objectives of this sampling and analysis plan are as follows:

- 3 • Describe the methods used to collect the data necessary to assess performance of the 200 West pump
4 and treat (P&T)
- 5 • Assess monitored natural attenuation (MNA) in the 200-ZP-1 OU
- 6 • Assess flow-path control elements of the selected remedy in the 200-ZP-1 OU

7 This SAP includes the following COCs, which are identified in the 200-ZP-1 OU ROD
8 (EPA et al., 2008): carbon tetrachloride, trichloroethene, total chromium (trivalent and hexavalent),
9 nitrate, iodine-129, technetium-99, and tritium.

10 As part of the DQO process described in Appendix A, historical sampling locations and the analytical
11 results generated from the 200-ZP-1 OU monitoring network from January 1990 through December 2012
12 were reviewed in conjunction with this SAP. The locations of monitoring wells with respect to the 2012
13 plume configurations were analyzed, with the objective of optimizing the current well network and
14 sampling requirements. The analysis was directed at defining those wells needed for contaminant
15 monitoring and determining an appropriate sampling frequency.

16 The monitoring well network identified in this SAP is designed to collect groundwater data sufficient to
17 assess the performance of the remedy. This SAP data will be reported in the Hanford Site groundwater
18 annual report. Performance monitoring under this SAP will continue until 2137.

19 Table B-1 identifies the existing documents that have current sampling requirements associated with
20 the 200-ZP-1 OU and identifies which of the existing documents are completely superseded by this SAP.

21 **B1.2 200-ZP-1 Operable Unit Background**

22 The 200 Areas are located on a broad, relatively flat plain that constitutes a local topographic high,
23 commonly referred to as the Central Plateau. The 200-ZP-1 OU underlies the northern portion of the
24 200 West Area, located at the western end of the Central Plateau.

25 Hydrogeology, groundwater flow, contaminant plumes, and source of contamination are summarized in
26 the following subsections. An overview of the DQO process directing the sampling objectives is
27 provided, and the the contaminants are also identified.

28 **B1.2.1 Site Geology/Hydrology**

29 The Hanford Site lies in a sediment-filled basin on the Columbia Plateau in southeastern Washington
30 State (Figure B-1). The Central Plateau is a relatively flat, prominent terrace near the center of the
31 Hanford Site. The 200-ZP-1 OU underlies the northern portion of the 200 West Area, which is on the
32 western end of the Central Plateau. The geology underlying the 200 West Area comprises, in descending
33 order, the Hanford formation, the Cold Creek unit, the Ringold Formation, and the Columbia River Basalt
34 Group. The suprabasalt sediments are approximately 169 m (555 ft) thick and primarily consist of the
35 Ringold Formation and Hanford formation, which are composed of sand and gravel, with some silt layers
36 (Figures B-2, B-3, and B-4).

Table B-1. Summary of Sampling Plans with Overlapping Requirements

Document Number/Rev.	Document Title	Scope	Data Use	New 200-ZP-1 OU SAP
DOE/RL-2009-115, Rev. 1 (published January 2014)	<i>Performance Monitoring Plan for the 200-ZP-1 Groundwater Operable Unit Remedial Action</i>	Provides groundwater data necessary to track the extent and concentration of groundwater contaminant plumes.	Results address the full extent of the remedy performance evaluations and are reported in the annual Hanford Site groundwater monitoring report.	Monitoring requirements identified in this updated SAP will supersede the requirements identified in the previous 200-ZP-1 OU groundwater monitoring plan.
DOE/RL-2012-59, Rev. 0 (published October 2013)	<i>Sampling and Analysis Plan for Groundwater Surveillance Monitoring on the Hanford Site</i>	Part of the document identifies the locations, sampling frequency, and analytical requirements for confined aquifer wells located across multiple groundwater OUs. Provides monitoring requirements for the upper basalt-confined aquifer and the Ringold confined aquifer. Includes monitoring wells that are also identified in DOE/RL-2003-04 and DOE/RL-2007-31, Appendix A.	Monitoring results support Hanford Site environmental surveillance. The plan also supports DOE/RL-91-50, <i>Hanford Site Environmental Monitoring Plan</i> (which is required by DOE orders), and DOE/RL-89-12, <i>Hanford Site Ground Water Protection Management Plan</i> .	Sampling and analysis of wells monitoring the upper basalt-confined aquifer within the 200-ZP-1 OU interest area are addressed in DOE/RL-2012-59. To eliminate duplication, monitoring of the basalt-confined aquifer wells are not included in the new SAP.

Notes:

DOE/RL-89-12, *Hanford Site Ground Water Protection Management Plan*.DOE/RL-91-50, *Hanford Site Environmental Monitoring Plan*.DOE/RL-2003-04, *Sampling and Analysis Plan for the 200-PO-1 Groundwater Operable Unit*.DOE/RL-2007-31, *Remedial Investigation/Feasibility Study Work Plan for the 200-PO-1 Groundwater Operable Unit*.

OU = operable unit

SAP = sampling and analysis plan

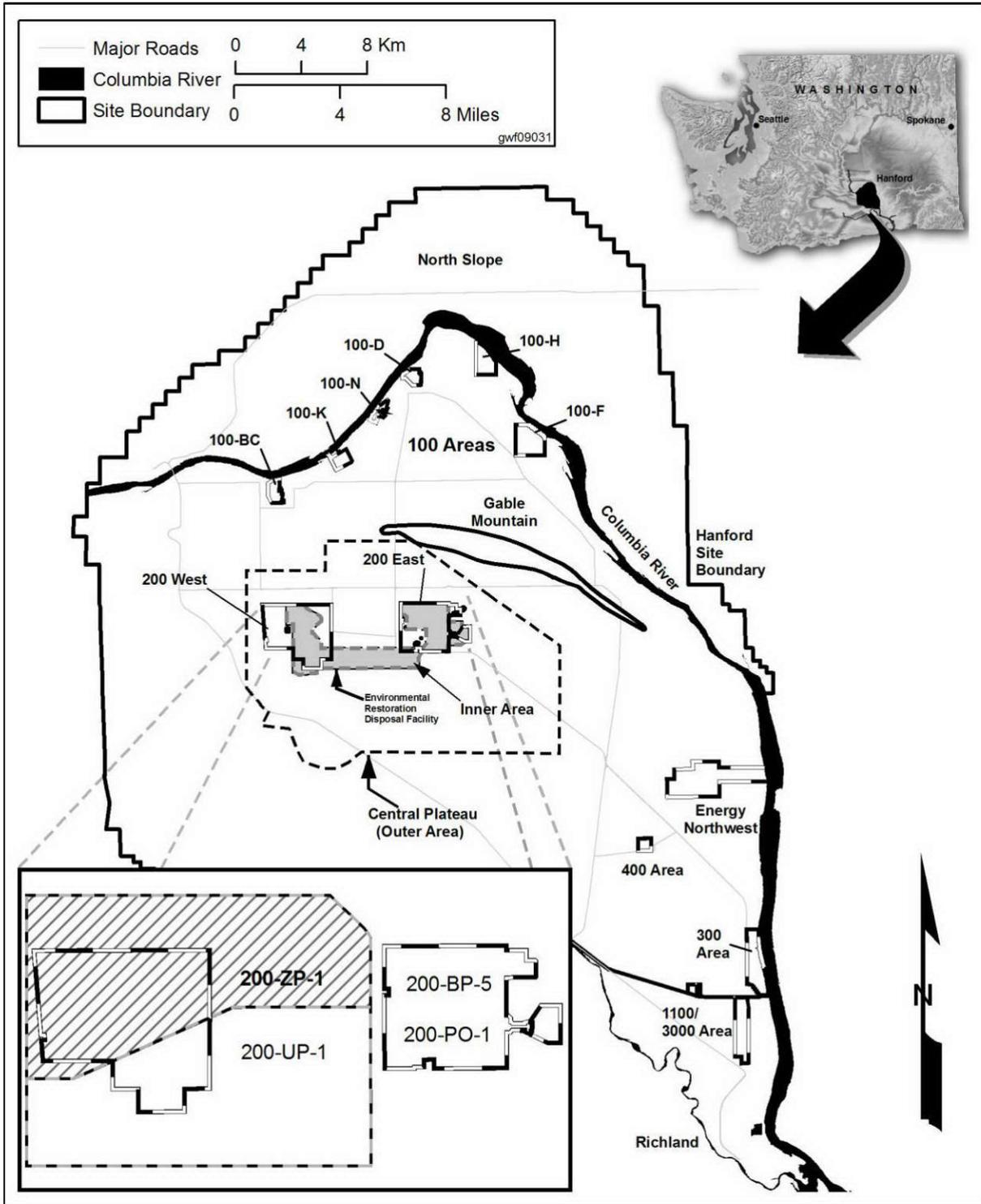
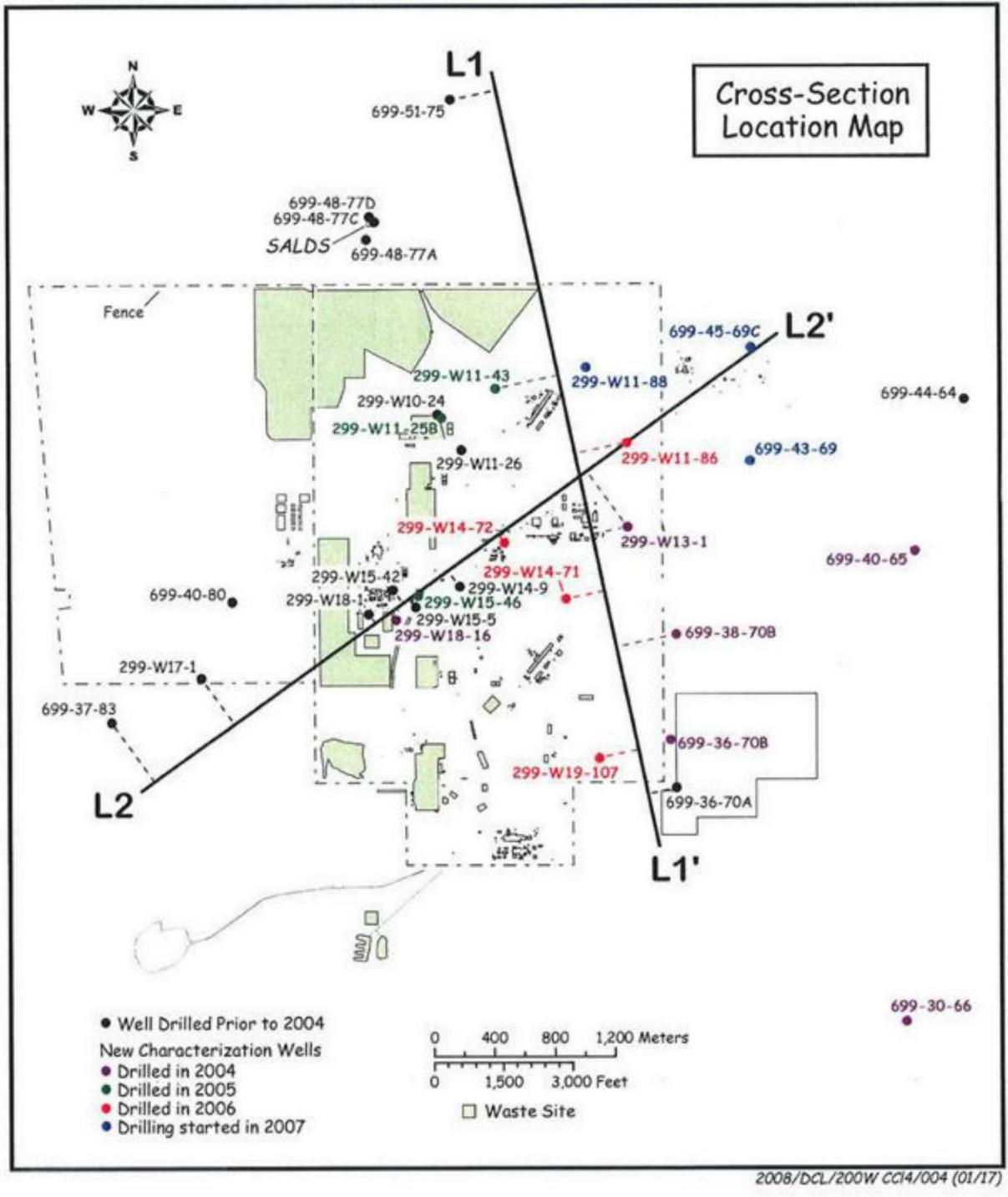


Figure B-1. Site Location

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Figure B-2. Location of Geologic Cross Sections

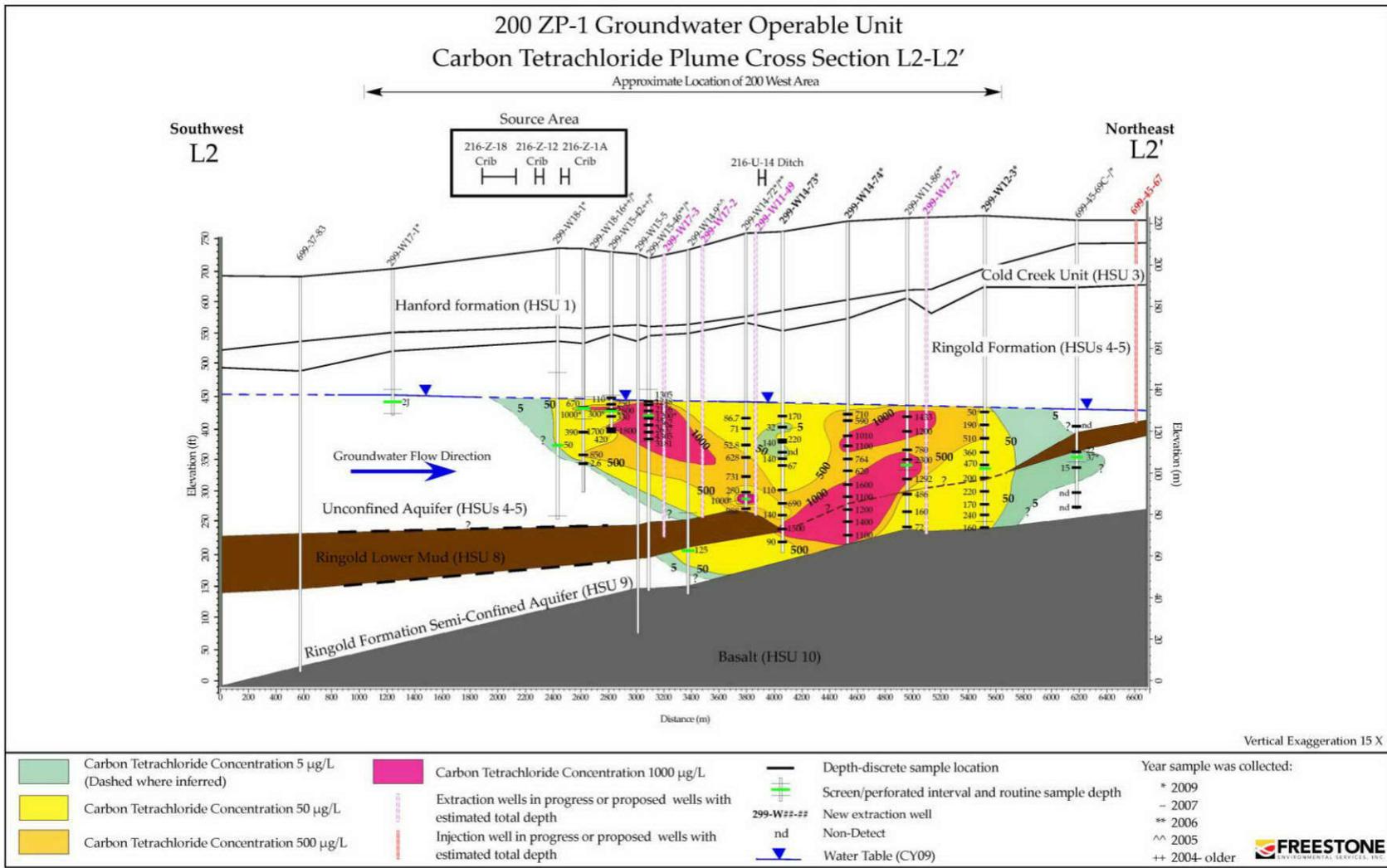


Figure B-4. Hydrogeologic Cross Section L2 to L2' (Southwest to Northeast)

1 The uppermost aquifer in the 200-ZP-1 OU is an unconfined aquifer that occurs in the Ringold
2 Formation. Groundwater in the unconfined aquifer flows from areas where the water table is higher
3 (west of the Hanford Site) to areas where the water table is lower (the Columbia River). The water table
4 depth in the 200 West Area varies from about 50 m (164 ft) in the southwest corner near the former
5 216-U-1 Pond to greater than 100 m (328 ft) to the north.

6 **B1.2.2 Groundwater Flow**

7 Groundwater flows predominantly east beneath the Central Plateau, from the 200 West Area to the
8 200 East Area, at velocities typically ranging from 0.0001 to 0.5 m/d (0.00033 to 1.64 ft/d). Historical
9 effluent discharges in the 200 West Area altered the groundwater flow regime, especially around the
10 216-U-10 Pond. Seepage from this pond raised the water table elevation, which in turn temporarily
11 deflected groundwater flow to the north. As the discharges ceased, the water table declined and the
12 eastwardly groundwater flow pattern was restored.

13 **B1.2.3 Sources of Groundwater Contamination**

14 Groundwater COCs include carbon tetrachloride, chromium (total and hexavalent), iodine-129, nitrate,
15 technetium-99, trichloroethene, and tritium (EPA et al., 2008). Carbon tetrachloride is the main COC in
16 groundwater, forming a plume greater than 13 km² (5 mi²) in area extending north, south, and east from
17 the source areas. The primary carbon tetrachloride and trichloroethene sources were associated with
18 discharges of liquid waste from plutonium separation processes at the Plutonium Finishing Plant to the
19 216-Z-1A, 216-Z-9, and 216-Z-18 Cribs and Trenches. Figures B-3 and B-4 show the vertical distribution
20 of carbon tetrachloride in the 200-ZP-1 OU. The lateral distribution of carbon tetrachloride (and
21 trichloroethene which is co-located with carbon tetrachloride) and six additional COCs, as well as
22 extraction and injection well locations, are shown on Figure B-5.

23 Sources of chromium, hexavalent chromium, iodine-129, nitrate, trichloroethene, technetium-99, and
24 tritium contamination in 200-ZP-1 OU were releases from past leaks in single-shell tanks and pipelines in
25 WMA T and WMA TX-TY, and liquid waste disposal from plutonium-processing operations to cribs
26 and trenches adjacent to the WMAs. Except for nitrate, the remaining contaminant plumes within the
27 200-ZP-1 OU are located within the boundaries of the carbon tetrachloride plume (Figure B-5).

28 **B1.2.4 Contaminant Plumes**

29 In accordance with the 200-ZP-1 OU ROD (EPA et al., 2008), contaminant distributions within the
30 200-ZP-1 OU are represented by three categories:

- 31 • A high-concentration zone of carbon tetrachloride contamination close to ponds, cribs, and trenches
32 that were used to dispose liquid wastes. Data do not indicate a continuing source.
- 33 • A larger, dispersed or low-concentration zone of carbon tetrachloride contamination that has migrated
34 from the discharge locations or that overlies the high-concentration zone. This less contaminated
35 groundwater can occur above the high-concentration zone where large quantities of lower
36 concentration effluent were discharged during or after the high-concentration waste discharges.
- 37 • An area of technetium-99 contamination near WMA T and WMA TX-TY.

1 The monitoring program obtains data from a network of monitoring wells that have been evaluated to
 2 develop a constituent-specific set of analyses for each well. For each contaminant (excluding carbon
 3 tetrachloride and trichloroethene), each well identified for monitoring was evaluated in the context of
 4 geographic location relative to the plume in the 200-ZP-1 OU and the data trends relative to the cleanup
 5 level (this evaluation included data collected as part of the performance monitoring plan (PMP) efforts,
 6 including data that date back to 1990). For volatile organic compounds (VOCs) such as carbon
 7 tetrachloride and trichloroethene, the monitoring well network extends into the 200-UP-1 OU in order to
 8 track the plume and mass removal to meet the performance metrics provided in the 200-ZP-1 OU ROD
 9 (EPA et al., 2008). The contaminant-specific sampling will be augmented by sampling each well for all
 10 COCs to support the preparation of the CERCLA 5-year review.

11 Table B-2 presents the final cleanup levels for 200-ZP-1 OU groundwater. These cleanup levels
 12 were developed using federal drinking water maximum contaminant levels; the criteria and equations in
 13 the Model Toxics Control Act (MTCA) (WAC 173-340, “Model Toxics Control Act—Cleanup”)
 14 Method B cleanup levels for potable groundwater (WAC 173-340-720(4)(b)(iii)(A),
 15 WAC 173-340-720(4)(b)(iii)(B), and WAC 173-340-720(7)(b), “Groundwater Cleanup Standards”),
 16 and the federal standards for radionuclides.

Table B-2. Final Cleanup Levels for 200-ZP-1 OU Groundwater

COC	Units	Final Cleanup Level
Carbon tetrachloride	µg/L	3.4*
Trichloroethene	µg/L	1*
Chromium (total)	µg/L	100
Hexavalent chromium	µg/L	48
Nitrate-nitrogen	mg/L	10
Iodine-129	pCi/L	1
Technetium-99	pCi/L	900
Tritium	pCi/L	20,000

* The U.S. Department of Energy will clean up COCs for the 200-ZP-1 Operable Unit subject to the requirements of WAC 173-340, “Model Toxics Control Act—Cleanup” (carbon tetrachloride and trichloroethene), so the excess lifetime cancer risk does not exceed 1×10^{-5} at the conclusion of the remedy.

COC = contaminant of concern

17 **B1.3 Data Quality Objectives Summary**

18 In association with development of this SAP, the DQO process was undertaken to support the
 19 identification of sampling requirements appropriate for the current SAP objectives. The DQO process
 20 followed for this SAP and its resulting application to refine the well network and focus the sampling
 21 requirements is provided in Appendix A. The purpose of the DQO process was to support the
 22 optimization of the routine monitoring network for the 200-ZP-1 OU for 125 years. Each of the DQO
 23 steps is summarized in the following subsections.

1 **B1.3.1 Statement of the Problem**

2 The first step in the DQO process is to define the problem. In the case of the 200-ZP-1 OU, sufficient
3 monitoring data must be collected and evaluated to optimally operate the groundwater P&T system and
4 to verify that the contaminated groundwater is being remediated to the levels identified in the
5 200-ZP-1 OU ROD (EPA et al., 2008).

6 **B1.3.2 Identify the Goals of the Study**

7 The second step of the DQO process identifies the key decisions and goals that must be addressed to
8 achieve the final solution to the problem. As stated in the 200-ZP-1 OU ROD (EPA et al., 2008), the
9 selected remedy combines P&T, MNA, flow-path control, and institutional controls to solve the problem.
10 The performance monitoring goals for the first three of these components are addressed by this SAP.
11 Monitoring data shall be collected over the lifecycle of the remedial action to evaluate its performance
12 and optimize its effectiveness. The key questions that the data collection must address, as well as the
13 alternative actions that may result based on the analysis of the collected data, are presented as a series of
14 decision statements (DSs).

- 15 • **DS #1:** Determine if there are any new releases of COCs that could impact the effectiveness of the
16 remedy and necessitate changes to the remedial action or the PMP; otherwise, continue with the
17 current remedial action and the PMP.
- 18 • **DS #2:** Determine if potentially toxic or mobile transformation products are being generated at
19 concentrations large enough to justify their inclusion in the list of COCs with associated cleanup
20 levels; otherwise, continue with the current list of COCs and associated cleanup levels.
- 21 • **DS #3:** Determine if changes are occurring in environmental conditions that may reduce the efficacy
22 of the P&T system, natural attenuation processes, and the flow-path control actions, thereby
23 necessitating changes to the remedial action or the PMP; otherwise, continue with the current
24 remedial action and the PMP.
- 25 • **DS #4:** Determine if the P&T system will remove at least 95 percent of the mass of COCs in 25 years
26 or less, and thereby achieve remedy goals for the P&T phase of the remedy; otherwise, evaluate
27 modifications to the P&T system that could achieve the stated goal for the P&T phase of the remedy.
- 28 • **DS #5:** Determine if contamination is expanding downgradient, laterally, or vertically after the P&T
29 component has been turned off, thereby necessitating an evaluation of the predicted success of the
30 remedial action; otherwise, continue with the current remedial action and the PMP.
- 31 • **DS #6:** Determine if the current remedy design is predicted to achieve cleanup levels for all COCs
32 within 125 years, and thereby achieve the overall remedial goal; otherwise, evaluate modifications to
33 the remedial action that could achieve the stated goal for the overall remedy.
- 34 • **DS #7:** Determine if remediation has been successfully completed and a recommendation can be
35 made for no further action; otherwise, continue with the current remedial action and the PMP or
36 determine if a technical impracticability waiver should be invoked.
- 37 • **DS #8:** Determine if certain areas of the contaminant plumes are not responding to P&T remediation
38 as expected and, therefore, require the evaluation of other technologies for a more focused or “hot
39 spot” remedy; otherwise, no new action is required.

- 1 • **DS #9:** Once 95 percent of the mass of COCs had been removed, determine if there is rebound
2 in COC concentrations, which would require the P&T system to be turned back on; otherwise, leave
3 the P&T system off and continue with MNA.

4 **B1.3.3 Identify the Information Inputs and Analytical Approach**

5 Steps 3 and 5 of the DQO process identify the data and analytical approach necessary to resolve the DSs
6 listed in Section B1.3.2. This information is summarized in Table B-3.

7 **B1.3.4 Define the Boundaries of the Study**

8 In the fourth step of the DQO process, the spatial and temporal features pertinent to the decision-making
9 process are identified. The 200-ZP-1 OU performance monitoring network must verify that cleanup levels
10 have been achieved in all areas of the the OU's groundwater plumes. Spatially, this covers an area from
11 the western injection well fence to the eastern leading edges of the plumes. Elevations range from the top
12 of the basalt bedrock to the water table interface. The current 200-ZP-1 OU CSM does not include any
13 COC concentrations greater than cleanup levels in the basalt bedrock. Performance monitoring is
14 expected to continue until cleanup levels have been achieved, which is estimated to be 125 years, 25 years
15 for active P&T, and 100 years for MNA.

16 **B1.3.5 Specify Performance or Acceptance Criteria**

17 The sixth step of the DQO process involves deriving the performance or acceptance criteria that the
18 collected data must achieve in order to minimize the possibility of either making erroneous conclusions
19 or failing to keep uncertainty in estimates within acceptable levels. Typically, the decision rule as
20 a statistical hypothesis test is specified in this step, and the consequences of making incorrect decisions
21 from the test are examined. However, statistical tests of the monitoring data to support the end of this
22 remedial action were not developed as part of this DQO process and may not be applicable. Therefore,
23 typically accepted performance criteria for the data to be gathered under this SAP are presented in
24 Table B-4.

25 **B1.3.6 Develop the Plan for Obtaining Data**

26 The seventh step of the DQO process is to develop the sampling and analysis design to generate the data
27 needed to address the nine DSs. The design for collecting contaminant concentration, hydraulic, and flow
28 rate monitoring data is presented in the Chapter 3 in the main text. The monitoring well network is
29 described in Section B1.4; and the designs for the water level, flow rate, COC, and MNA programs are
30 presented in Section B3.

31 **B1.4 Groundwater Monitoring Well Network**

32 The data necessary to address the DSs described in Section B1.3.2 will be collected over the projected
33 125-year lifetime of the remedial action to evaluate performance, optimize effectiveness, and determine
34 when the remedial action is complete. The selection of the contaminant monitoring well network,
35 sampling frequency, and analytical parameters are discussed in Section 3.1 in the main text.

Table B-3. DQO Step 3 and Step 5 – Information Inputs and Analytical Approach

DS #	Data Inputs*	Analytical Approach*
DS #1: Determine if there are any new releases of COCs that could impact the effectiveness of the remedy and necessitate changes to the remedial action or the PMP, or both.	Groundwater sampling data collected from the contaminant monitoring well network. Hydraulic monitoring data, extraction and injection well flow rate data, and extraction well contaminant sampling data.	Groundwater contaminant sampling data will be evaluated to determine if any new releases of COCs have occurred. Concentration trends for contaminant monitoring and well sampling will be evaluated, and the sampling data will be used to update the three-dimensional plume shell for each contaminant. If contaminant concentrations in a monitoring well are stable or increasing and there is no known upgradient dissolved-phase contaminant mass to support these stable or increasing concentrations, then there may be a new release.
DS #2: Determine if potentially toxic or mobile transformation products are being generated at concentrations large enough to justify their inclusion in the list of COCs with associated cleanup levels.	Groundwater sampling data collected from the contaminant monitoring well network.	Groundwater sampling data will be evaluated to determine if potentially toxic or mobile transformation products are generated within the OU. This evaluation is typically performed by analyzing concentration changes in the parent COC and the COC degradation products. This analysis applies to COCs that are commonly degraded in the environment, and in the case of the 200-ZP-1 OU, includes carbon tetrachloride, trichloroethene, and nitrate. The rates of decline in the parent compound and the formation of the degradation products will be used to derive degradation rates. The degradation rates will be included in the 200 West Area contaminant transport model and will be used to evaluate whether natural attenuation will achieve cleanup levels within the time period specified in EPA et al., 2008, <i>Record of Decision, Hanford 200 Area, 200-ZP-1 Superfund Site, Benton County, Washington</i> .
DS #3: Determine if changes are occurring in environmental conditions that may reduce the efficacy of the P&T system, natural attenuation processes, and flow-path control actions, thereby necessitating changes to the remedial action or PMP.	Hydraulic monitoring data and groundwater contaminant sampling data.	Groundwater elevation data will be necessary to determine if changes are occurring in environmental conditions that may reduce the efficacy of the P&T system and the flow-path control action. The data should include transient groundwater elevations measured using transducers with data loggers and more long-term, quasi-steady-state data measured during synoptic groundwater elevation surveys. The transient data logger groundwater elevation data may be evaluated to monitor the sustainability of the extraction well field and to optimize pumping, possibly by rebalancing upgradient and downgradient injection to ensure that a sustainable remedy is implemented. The more long-term, quasi-steady-state data measured during synoptic groundwater elevation surveys should be used to generate water table maps to evaluate groundwater elevations and their impacts on the monitoring well networks and flow-path control actions. The potentiometric surface of water table elevations will be defined using hydraulic monitoring data to help understand groundwater flow directions in the 200-ZP-1 OU. Groundwater monitoring for key biogeochemical and field parameters will be used to determine if changes occur in environmental conditions that may reduce the efficacy of natural attenuation processes. In order to evaluate remediation by natural attenuation, a determination must be made whether the contaminant mass is being degraded. The biogeochemical parameters help to identify if the appropriate conditions exist in the aquifer to support COC degradation. The monitoring constituents can be used in mass balance calculations to determine if decreases in contaminant and electron acceptor and donor concentrations can be directly correlated to increases in daughter compounds. The simplest way to accomplish this is by mapping of concentration changes in reactants (contaminants, electron acceptors, and donors) or products of the biogeochemical process (e.g., dissolved iron and chloride) that degrade or immobilize the contaminants. These maps can be measured to determine if transformation processes are active at the site. Biodegradation rate constants can be calculated from time-series data of the measured COC concentrations in conjunction with aquifer hydrogeologic parameters such as seepage velocity and dilution.
DS #4: Determine if the P&T system will remove at least 95 percent of the mass of COCs in 25 years or less, and thereby achieve remedy goals for the P&T phase of the remedy.	Groundwater contaminant sampling data, extraction and injection well flow rate data, and extraction well and combined treatment plant influent and effluent contaminant sampling data.	The groundwater contaminant transport model will be used to predict if the P&T system will remove at least 95 percent of the mass of COCs in 25 years or less. This analysis will use the three-dimensional contaminant plume shell for each COC as the starting concentration in the model and then transporting the contaminant plume forward in time for at least 25 years. Current and future anticipated extraction and injection well flow rates will be needed as input to the model. Using the simulated extraction well contaminant concentrations and flow rates, the contaminant mass removed by each extraction is calculated. The percentage mass removed for each COC will be calculated by summing the simulated mass removed by each extraction well and then dividing by the starting mass for each COC. Initial masses are provided in ECF-200ZP1-13-0006, <i>Description of Groundwater Modeling Calculations for the Calendar Year 2012 (CY2012) 200 Areas Pump-and-Treat Report</i> ; and DOE/RL-2013-14, <i>Calendar Year 2012 Annual Summary Report for the 200-ZP-1 and 200-UP-1 Operable Unit Pump-and-Treat Operations</i> . The combined treatment plant influent and effluent contaminant sampling data, extraction well contaminant sampling data, and extraction well and treatment plant influent flow rate data will be used to calculate the actual contaminant mass removed by the P&T system. Contaminant mass removal can be calculated by multiplying the difference in the treatment plant influent and effluent contaminant concentrations by the influent flow rate and the elapsed time at that concentration and flow rate. However, some COCs may not be detectable in the combined treatment plant influent samples but are detectable in samples collected from one or more of the extraction wells. In this case, a more accurate mass removal can be calculated using the individual extraction well contaminant sampling and flow rate data and summing the mass removed from the individual extraction wells to obtain the total mass removal for the COC.

Table B-3. DQO Step 3 and Step 5 – Information Inputs and Analytical Approach

DS #	Data Inputs*	Analytical Approach*
<p>DS #5: Determine if contamination is expanding downgradient, laterally or vertically after the P&T component has been turned off, thereby necessitating an evaluation of the predicted success of the remedial action.</p>	<p>Groundwater contaminant sampling data collected from the monitoring well network.</p>	<p>Groundwater sampling data will be evaluated to determine if contamination is expanding downgradient, laterally, or vertically after the P&T system has been shut down.</p> <p>The trends in measured concentrations for downgradient monitoring wells will be analyzed to draw conclusions about the expansion or migration of the COC plumes. Three-dimensional contaminant plume shells will be updated for each COC using the most current sampling data. Plume volume and contaminant mass statistics can be generated from the plume shells. The contaminant distributions and statistics can be compared to those from the previous plume shell versions to evaluate expansion or contraction of each COC plume.</p> <p>If evaluation of groundwater sampling data indicates that a COC plume may be expanding downgradient and the remedial system is still operating, several courses of action may be taken. Extraction and injection well flow rates or production intervals may be adjusted to improve the hydraulic capture of escaping contaminant mass or new extraction wells may be installed to capture escaped contaminant mass that is contributing to downgradient plume expansion.</p>
<p>DS #6: Determine if the current remedy design is predicted to achieve cleanup levels for all COCs within 125 years, and thereby achieve the overall remedial goal.</p>	<p>Groundwater contaminant sampling data, extraction and injection well flow rate data, and extraction well contaminant sampling data.</p>	<p>The groundwater contaminant transport model will be used to predict if the current remedy design will achieve cleanup levels for all COCs within 125 years. This analysis can be accomplished by using the three-dimensional contaminant plume shell for each COC as the starting concentration in the model and transporting the contaminant plume forward in time for at least 125 years. Current and future anticipated extraction and injection well flow rates can be supplied to the model as input. An animation can be made for each COC displaying the contaminant concentrations greater than or equal to the cleanup level as the plume contracts over time. If the simulated contaminant concentrations remain significantly above the cleanup level during the 125-year period, the remedy goal may not be achieved within the desired remedial time frame.</p>
<p>DS #7: Determine if remediation has been successfully completed and a recommendation can be made for no further action.</p>	<p>Groundwater contaminant sampling data.</p>	<p>Groundwater sampling data will be evaluated to determine if the remediation has been successfully completed. If contaminant concentrations in all monitoring wells, for all COCs, have decreased to below the cleanup levels for at least 5 years, then a recommendation should be made for no further action.</p>
<p>DS #8: Determine if certain areas of the contaminant plumes are not responding to P&T remediation as expected, and therefore require the evaluation of other technologies for a more focused or “hot spot” remedy.</p>	<p>Groundwater contaminant sampling data.</p>	<p>Groundwater sampling data will be evaluated on an annual basis to determine if any areas of the contaminant plumes are not responding to P&T remediation. If one or more areas are identified, options will be evaluated.</p>
<p>DS #9: Once 95 percent of the mass of COCs has been removed, determine if there is rebound in COC concentrations, which would require the P&T to be turned back on.</p>	<p>Groundwater contaminant sampling data.</p>	<p>Groundwater sampling data will be collected and analyzed for each of the COCs to determine if there is a rebound in COC concentrations.</p>

* A detailed explanation of the data included in this table is provided in the main text of this document.

COC = contaminant of concern

DS = decision statement

OU = operable unit

P&T = pump and treat

PMP = performance monitoring plan

Table B-4. DQO Step 6 – Typical Acceptance and Performance Criteria

Required Data	Acceptance/Performance Criteria
Groundwater level (depth to water, top of casing, northing and easting coordinates, well screen top and bottom elevations)	Depth to water should be specified to the nearest 0.61 cm (0.02 ft). Top of casing should be specified to the nearest 0.03 m (0.1 ft). Northings and eastings should be specified to the nearest 0.03 to 1.5 m (0.1 to 5 ft). Well screen top and bottom should be specified to the nearest 0.03 m (0.10 ft) (± 1.5 m [5 ft]).
Pumping rates	Pumping rates should be measured on a semicontinuous basis using in-line flow meters accurate to 5 percent of the flow rate.
Contaminant concentrations	Precision is ≤ 20 percent for most contaminants; $\leq 20\%$ for radionuclide contaminants. Analytical method must be able to provide data equal to or less than the cleanup levels.
Biogeochemical parameters	Precision is ≤ 20 percent. Errors in the measurement of these parameters have little impact on any significant decisions regarding natural attenuation processes.
Groundwater field parameters	Precision is ≤ 20 percent. Errors in the field measurement of these parameters have little impact on any significant decisions regarding natural attenuation processes.

1 The monitoring program obtains data from a network of monitoring wells that have been evaluated to
2 develop a constituent-specific set of analyses for each well. For each contaminant (excluding carbon
3 tetrachloride and trichloroethene), each well identified for monitoring was evaluated in the context of
4 geographic location relative to the plume in the 200-ZP-1 OU, depth of screen relative to depth of
5 contamination, and the data trends relative to the cleanup level (this evaluation included data collected
6 as part of the PMP efforts, as well as data from as far back as 1990). For VOCs such as carbon
7 tetrachloride and trichloroethene, the monitoring well network extends into the 200-UP-1 OU in order to
8 track the plume and mass removal and meet the performance metrics provided in the 200-ZP-1 OU ROD
9 (EPA et al., 2008). The contaminant-specific sampling will be augmented by sampling each well for all
10 COCs every 5 years to support the preparation of the CERCLA 5-year review. Sampling of the
11 monitoring well network for all COCs on a 5-year basis will generate sufficient data for quantitative
12 analysis to support addressing all nine DSs; however, annual sampling from the contaminant-specific well
13 list will provide data for assessing DSs #1, #2, and #5. This includes determining if there are any new
14 releases of COCs; evaluating concentration trends in high-concentration areas of the plumes;
15 and determining if contamination is expanding downgradient, laterally, or vertically. Therefore, while
16 the P&T system is operating, the list of plume and constituent-specific analyses will be evaluated
17 annually to determine if analyses will be added or dropped for the well. Additional vertical sampling will
18 be performed to support the assessment of the remedy against the RAOs (DS #5).

19 **B1.4.1 Existing Monitoring Wells**

20 The monitoring well network will change over time as remedy components reduce COC concentrations
21 and the plumes contract. Some areas within the aquifer will be cleaned up more quickly, and many of the
22 shallow monitoring wells may go dry in areas furthest from the injection wells. Therefore, while the P&T
23 system is operating, the contaminant monitoring well networks will be evaluated annually to determine if

1 monitoring wells will be dropped from the network or if other wells should be added to the network.
 2 These changes will be presented in an amended version of this SAP, subject to EPA review
 3 and concurrence.

4 **B1.4.2 Proposed New Monitoring Wells**

5 Several areas where existing monitoring well coverage may be inadequate are identified in Section 3.1.2
 6 in the main text to evaluate remedial action effectiveness. To address potential gaps in the monitoring
 7 well network, new monitoring wells may be installed (Table B-5). New wells will be installed using
 8 procedures described in DOE/RL-2010-72, *Sampling and Analysis Plan for Remedial Action Wells in the*
 9 *200-ZP-1 Groundwater Operable Unit*.

Table B-5. Proposed New Monitoring Wells

Well Priority	Temporary Well Name	Easting (m)	Northing (m)	Estimated Mid-Screen Elevation (m amsl)
1	MW7B	568900	135945	120
	MW7A	568900	135945	100
2	MW1A	568369	137743	90
	MW1B	568369	137743	110
3	MW3A	567578	136476	73
	MW3B	567578	136476	92
	MW3C	567578	136476	112
4	MW5A	567374	135941	70
	MW5B	567374	135941	110
5	MW2	567591	137577	111
6	MW4A	566638	136251	80
	MW4B	566638	136251	100
7	MW6A	566941	135175	80
	MW6B	566941	135175	106
8	MW8A	568670	136810	98
	MW8B	568670	136810	120

amsl = above mean sea level

10 **B1.5 Contaminants**

11 Specific contaminants for CERCLA groundwater monitoring are listed in Table B-6. The CERCLA
 12 COCs listed are those identified in the 200-ZP-1 OU ROD (EPA et al., 2008).

Table B-6. Analytes for 200-ZP-1 OU Groundwater Monitoring

Constituent	CAS Number	Data Use
Contaminants of Concern		
Carbon tetrachloride	56-23-5	Delineate carbon tetrachloride plume
Chromium (total)	7440-47-3	Delineate chromium plume
Chromium (hexavalent)	18540-29-9	Delineate chromium plume
Iodine-129	15046-84-1	Delineate iodine-129 plume
Nitrate-N	14797-55-8	Delineate nitrate plume
Technetium-99	14133-76-7	Delineate technetium-99 plume
Trichloroethene	79-01-6	Delineate trichloroethene plume
Tritium	10028-17-8	Delineate tritium plume
Other Potential Contaminants		
Uranium (from 200-UP-1 Operable Unit)	7440-61-1	Delineate uranium plume
Alkalinity	N/A	Evaluate natural attenuation
Carbonate content (bicarbonate and carbonate)	N/A	Evaluate natural attenuation
Chloroform	67-66-3	Evaluate carbon tetrachloride natural attenuation
Chloride	16887-00-6	Evaluate chlorinated solvent natural attenuation
Chloromethane	74-87-3	Evaluate carbon tetrachloride natural attenuation
cis-1,2-Dichloroethene	156-59-2	Evaluate trichloroethene natural attenuation
Dichloromethane	75-09-2	Evaluate carbon tetrachloride natural attenuation
Iron	7439-89-6	Evaluate nitrate natural attenuation
Manganese	7436-96-5	Evaluate nitrate natural attenuation
Nitrite-N	14797-65-0	Evaluate nitrate natural attenuation
Sulfate	14808-79-8	Evaluate nitrate natural attenuation
Sulfide	18496-25-8	Evaluate nitrate natural attenuation
Total dissolved solids	N/A	Evaluate nitrate natural attenuation, identify new releases
Total organic carbon	N/A	Evaluate nitrate natural attenuation
Vinyl chloride	75-01-4	Evaluate trichloroethene natural attenuation

Table B-6. Analytes for 200-ZP-1 OU Groundwater Monitoring

Constituent	CAS Number	Data Use
Field Measurements		
Depth to groundwater	N/A	Evaluate new releases
Dissolved oxygen	N/A	Evaluate natural attenuation
Oxidation-reduction potential	N/A	Evaluate natural attenuation
pH	N/A	Evaluate well purge for sampling
Specific conductance	N/A	Evaluate well purge for sampling
Temperature	N/A	Evaluate well purge for sampling
Turbidity	N/A	Evaluate well purge for sampling

CAS = Chemical Abstracts Service

N/A = not applicable

1 **B1.6 Project Schedule**

2 This SAP will direct CERCLA monitoring activities needed for 200-ZP-1 OU until 2137. The yearly
3 sampling schedule will be established by the Sample Management and Reporting (SMR) organization
4 through processes and software applications such as the Sample Management Integrated Lifecycle
5 Environment (SMILE), which optimizes the overall number of sampling trips and limits schedule
6 redundancy. The SMR organization tracks overlapping requirements so single sampling events can be
7 used to co-sample wells and optimize schedules.

8 **B2 Quality Assurance Project Plan**

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

1 This QAPjP is divided into the following four sections, which describe the quality requirements and
 2 controls applicable to Hanford Site OU groundwater monitoring activities:

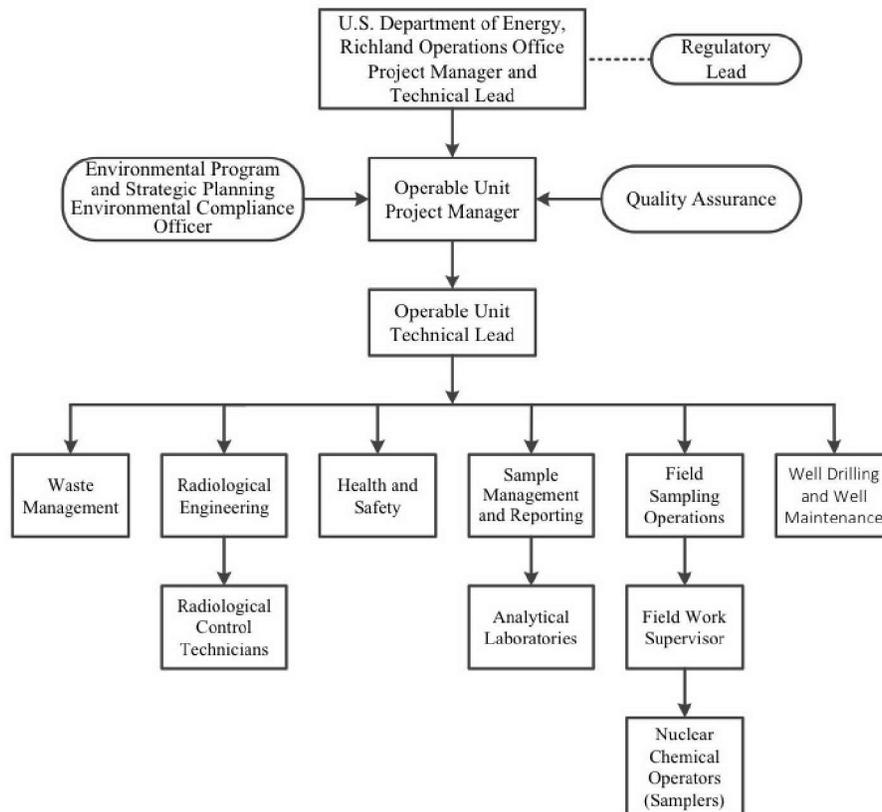
- 3 • Section B2.1, Project Management
- 4 • Section B2.2, Data Generation and Acquisition
- 5 • Section B2.3, Assessment and Oversight
- 6 • Section B2.4, Data Review and Usability

7 **B2.1 Project Management**

8 This section addresses project goals, the management approaches planned, and planned
 9 output documentation.

10 **B2.1.1 Project/Task Organization**

11 The contractor, or its approved subcontractor, is responsible for planning, coordinating, sampling, and
 12 shipping samples to the laboratory. The contractor is also responsible for preparing and maintaining
 13 configuration control of the SAP and assisting the U.S. Department of Energy, Richland Operations
 14 Office (DOE-RL) project manager in obtaining approval of the SAP and future proposed revisions.
 15 The project organization (regarding routine groundwater monitoring) is described in the following
 16 subsections and is illustrated in Figure B-6.



17
 18

Figure B-6. Project Organization

1 **B2.1.1.1 Regulatory Lead**

2 The lead regulatory agency is responsible for regulatory oversight of cleanup projects and activities.
3 The lead regulatory agency has SAP approval authority for the OUs that they manage. The lead
4 regulatory agency works with DOE-RL to resolve concerns regarding the work described in this SAP
5 in accordance with Ecology et al., 1989a, *Hanford Federal Facility Agreement and Consent Order*
6 (hereafter referred to as the Tri-Party Agreement).

7 **B2.1.1.2 DOE-RL Project Manager**

8 The DOE-RL project manager is responsible for the following:

- 9 • Monitoring the contractor's performance of activities under CERCLA, RCRA, the *Atomic Energy Act*
10 *of 1954*, and the Tri-Party Agreement (Ecology et al., 1989a) for the Hanford Site
- 11 • Obtaining lead regulatory agency approval of the SAP
- 12 • Authorizing field sampling activities
- 13 • Approving the SAP
- 14 • Functioning as primary interface with regulatory agencies

15 **B2.1.1.3 DOE-RL Technical Lead**

16 The DOE-RL technical lead is responsible for the following:

- 17 • Providing day-to-day oversight of the contractor's work scope performance
- 18 • Working with the contractor and the regulatory agencies to identify and resolve technical issues
- 19 • Providing technical input to the DOE-RL project manager

20 **B2.1.1.4 Operable Unit Project Manager**

21 The OU project manager (or designee) is responsible and accountable for the following:

- 22 • Project-related activities
- 23 • Coordinating with DOE-RL, the regulatory agencies, and contractor management in support of
24 sampling activities to ensure that work is performed safely and cost effectively
- 25 • Managing sampling documents and requirements, field activities, and subcontracted tasks; and
26 ensuring that the project file is properly maintained

27 **B2.1.1.5 Operable Unit Technical Lead**

28 The OU technical lead is responsible for the following:

- 29 • Developing specific sampling design, analytical requirements, and QC requirements, either
30 independently or as defined through a systematic planning process
- 31 • Ensuring that sampling and analysis activities, as delegated by OU project manager, are carried out in
32 accordance with the SAP
- 33 • Working closely with the environmental compliance officer (ECO), the QA and the Health and Safety
34 organizations, the field work supervisor (FWS), and the SMR organization to integrate these and
35 other technical disciplines in planning and implementing the work scope

1 **B2.1.1.6 Environmental Compliance Officer**

2 The ECO is responsible for the following:

- 3 • Providing technical oversight, direction, and acceptance of project and subcontracted
4 environmental work
- 5 • Developing appropriate mitigation measures to minimize adverse environmental impacts
- 6 • Reviewing plans, protocols, and technical documents to ensure that environmental requirements have
7 been addressed
- 8 • Identifying environmental issues affecting operations and developing cost-effective solutions
- 9 • Responding to environmental/regulatory issues or concerns
- 10 • Overseeing project implementation for compliance with applicable internal and external
11 environmental requirements

12 **B2.1.1.7 Quality Assurance**

13 The QA organization point of contact is responsible for the following:

- 14 • Addressing QA issues on the project
- 15 • Overseeing implementation of the project QA requirements
- 16 • Reviewing project documents (including DQO summary report, QAPjP, and SAP)
- 17 • Reviewing data validation reports from third-party data validation contractors, as appropriate
- 18 • Participating in QA assessments on sample collection and analysis activities, as appropriate

19 **B2.1.1.8 Health and Safety**

20 The Health and Safety organization is responsible for the following:

- 21 • Coordinating industrial safety and health support within the project in accordance with the
22 health and safety program, job hazard analyses, and other pertinent federal regulations
- 23 • Assisting project personnel in complying with the applicable health and safety program
- 24 • Coordinating with Radiological Engineering to determine personal protective equipment requirements

25 **B2.1.1.9 Radiological Engineering**

26 Radiological Engineering is responsible for the following:

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

1 **B2.1.1.10 Sample Management and Reporting Organization**

2 The SMR organization is responsible for the following activities:

- 3 • Interfacing between the OU technical lead, the Field Sampling Operations (FSO), the Well
4 Maintenance organization, and the analytical laboratories
- 5 • Generating field sampling documents, labels, and instructions for field sampling personnel
- 6 • Developing the sample authorization form (SAF), which provides information and instructions to the
7 analytical laboratories
- 8 • Providing instructions to the FSO nuclear chemical operators (NCOs) (i.e., samplers) on the
9 collection of samples as specified in the SAP
- 10 • Monitoring the entire sample and data process
- 11 • Coordinating laboratory analytical work and ensuring that the laboratories conform to Hanford Site
12 QA requirements (or their equivalent), as approved DOE, the U.S. Environmental Protection Agency
13 (EPA), and Ecology
- 14 • Resolving sample documentation deficiencies or issues associated with the FSO, laboratories, or
15 other entities to ensure that project needs are met
- 16 • Receiving analytical data from the laboratories
- 17 • Ensuring that data are uploaded into the Hanford Environmental Information System (HEIS) database
- 18 • Arranging for and overseeing data validation, as requested
- 19 • Informing the OU project manager and/or OU technical lead of any issues reported by the
20 analytical laboratories

21 **B2.1.1.11 Analytical Laboratories**

22 Analytical laboratories are responsible for the following:

- 23 • Analyzing samples in accordance with established methods
- 24 • Providing data packages containing analytical and QC results
- 25 • Providing explanations in response to resolution of analytical issues
- 26 • Meeting the requirements of this plan
- 27 • Being on the Mission Support Alliance evaluated suppliers list
- 28 • Being accredited by Ecology for the analyses performed for the Soil and Groundwater
29 Remediation Project

1 **B2.1.1.12 Waste Management**

2 Waste Management is responsible for the following:

- 3 • Communicating policies and protocols
- 4 • Ensuring compliance for waste storage, transportation, disposal, and tracking in a safe and
5 cost-effective manner
- 6 • Identifying waste management sampling/characterization requirements to ensure
7 regulatory compliance
- 8 • Interpreting data to determine waste designations and profiles
- 9 • Preparing and maintaining other documents to confirm compliance with waste acceptance criteria

10 **B2.1.1.13 Field Sampling Organization**

11 The FSO is responsible for the following:

- 12 • Planning, coordinating, and conducting field sampling activities
- 13 • The FWS directing the NCOs (samplers) and ensuring that the NCOs are appropriately trained
14 and available
- 15 • The FWS reviewing the SAP for field sample collection concerns, analytical requirements, and
16 special sampling requirements
- 17 • Ensuring that the sampling design is understood by the NCOs and can be performed as specified; this
18 is achieved by performing mock-ups and holding practice sessions with field personnel
- 19 • The NCOs collecting all salient samples in accordance with sampling documentation
- 20 • Completing field logbook entries, chain-of-custody forms and shipping paperwork; and ensuring
21 delivery of the samples to the analytical laboratory
- 22 • The FWS acting as a technical interface between the OU project manager and the field crew
23 supervisors (e.g., the drilling buyer's technical representative [BTR], and geologist BTR) and
24 ensuring that technical aspects of the field work are met in consultation with the OU project manager
25 and SMR, resolving issues regarding arising from translation of technical requirements to field
26 operations and coordinating resolution of sampling issues

27 **B2.1.1.14 Well Maintenance**

28 The Well Maintenance manager is responsible for the following:

- 29 • Coordinating well maintenance activities
- 30 • Coordinating with the OU technical lead to identify field constraints that could affect
31 groundwater sampling

32 **B2.1.2 Quality Objectives and Criteria**

33 The QA objective of this plan is to ensure the generation of analytical data of known and appropriate
34 quality that are acceptable and useful for decision-making purposes. In support of this objective, statistics
35 and data descriptors known as data quality indicators (DQIs) help determine the acceptability and utility

1 of data to the user. The principal DQIs are precision, accuracy, representativeness, comparability,
2 completeness, bias, and sensitivity. These are defined, for the purposes of this document, in Table B-7.

3 Data quality is defined by the degree of rigor in the acceptance criteria assigned to the DQIs.
4 The applicable QC guidelines, DQI acceptance criteria, and levels of effort for assessing data quality are
5 dictated by the intended use of the data and the requirements of the analytical method. DQIs are evaluated
6 during the data quality assessment (DQA) process (Section B2.4.3).

7 **B2.1.3 Special Training/Certification**

8 A graded approach is used to ensure that workers receive a level of training commensurate with their
9 responsibilities and compliant with applicable DOE orders and government regulations. The FWS, in
10 coordination with line management, will ensure that special training requirements for field personnel
11 are met.

12 In addition, pre-job briefings will be held in accordance with work management and work release
13 requirements document evaluation activities and associated hazards, including the following topics:

- 14 • Objective of the activities
- 15 • Individual tasks to be performed
- 16 • Hazards associated with the planned tasks
- 17 • Controls applied to mitigate the hazards
- 18 • Environment in which the job will be performed
- 19 • Facility where the job will be performed
- 20 • Equipment and material required

21 Training records are maintained for each employee in an electronic training record database.
22 The contractor's training organization maintains the training records system. Line management confirms
23 that an employee's training is appropriate and up-to-date prior to performing any field work.

24 **B2.1.4 Documents and Records**

25 The OU project manager (or designee) is responsible for ensuring that the current version of the SAP is
26 being used and for providing updates to field personnel. Version control is maintained by the
27 administrative document control process. Changes to the sampling document are handled in accordance
28 with HASQARD (DOE/RL-96-68) and the Tri-Party Agreement Action Plan (Ecology et al., 1989b).
29 The OU project manager is responsible for tracking all SAP changes, obtaining appropriate review, and
30 alerting DOE-RL of these changes. Appropriate documentation will follow in accordance with the
31 requirements for the particular type of change. Table B-8 summarizes the changes that may be made and
32 their documentation requirements.

33 The FWS, the SMR organization, and appropriate BTR are responsible for ensuring that field instructions
34 are maintained and aligned with any revisions or approved changes to the SAP. The SMR organization
35 will ensure that any deviations from the SAP are reflected in revised paperwork for the samplers and the
36 analytical laboratory. The FWS or appropriate BTR will ensure that deviations from the SAP or problems
37 encountered in the field are documented appropriately (e.g., in the field logbook) in accordance with
38 corrective action protocols.

Table B-7. Data Quality Indicators

DQI	Definition	Determination Methodologies	Corrective Actions
Precision	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: <ul style="list-style-type: none"> • Evaluate apparent cause (e.g., sample heterogeneity). • Request reanalysis or remeasurement. • Qualify the data before use.
Accuracy	Accuracy is the closeness of a measured result to an accepted reference value. Accuracy is usually measured as a percent recovery. Quality control analyses used to measure accuracy include standard recoveries, laboratory control samples, spiked samples, and surrogates.	Analyze a reference material or reanalyze a sample to which a material of known concentration or amount of pollutant has been added (a spiked sample).	If recovery does not meet objective: <ul style="list-style-type: none"> • Qualify the data before use. • Request reanalysis or remeasurement.
Representativeness	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 upon the proper design of the sampling program and will be satisfied by ensuring 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: <ul style="list-style-type: none"> • Identify the reason for the results not being representative. • Flag for further review. • Review data for usability. • If data are usable, qualify the data for limited use and define the portion of the system that the data represent. • If data are not usable, flag as appropriate. • Redefine sampling and measurement requirements and protocols. • Resample and reanalyze, as appropriate.

Table B-7. Data Quality Indicators

DQI	Definition	Determination Methodologies	Corrective Actions
Comparability	Comparability expresses the degree of confidence with which one data set can be compared to another. It is dependent upon the proper design of the sampling program and will be satisfied by ensuring that the approved plans are followed and that proper sampling and analysis techniques are applied.	Use identical or similar sample collection and handling methods, sample preparation and analytical methods, holding times, and quality assurance protocols.	If data are not comparable to other data sets: <ul style="list-style-type: none"> • 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	Completeness is a measure of the amount of valid data collected compared to the amount planned. Measurements are considered to be valid if they are unqualified or qualified as estimated data during validation. Field completeness is a measure of the number of samples collected versus the number of samples planned. Laboratory completeness is a measure of the number of valid measurements compared to the total number of measurements planned.	Compare the number of valid measurements completed (samples collected or samples analyzed) with those established by the project's quality criteria (data quality objectives or performance/acceptance criteria).	If data set does not meet completeness objective: <ul style="list-style-type: none"> • 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	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: <ul style="list-style-type: none"> • Properly select and use sampling tools. • Institute correct sampling and subsampling procedures to limit preferential selection or loss of sample media. • Use sample handling procedures, including proper sample preservation, that limit the loss or gain of constituents to the sample media.

Table B-7. Data Quality Indicators

DQI	Definition	Determination Methodologies	Corrective Actions
			<p>Analytical data that are known to be affected by either sampling or analytical bias are flagged to indicate possible bias.</p> <p>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.</p>
Sensitivity	Sensitivity is an instrument's or method's minimum concentration that can be reliably measured (i.e., instrument detection limit or limit of quantitation).	<p>Determine the minimum concentration or attribute to be measured by an instrument (instrument detection limit) or by a laboratory (limit of quantitation).</p> <p>The lower limit of quantitation is the lowest level that can be routinely quantified and reported by a laboratory.</p>	<p>If detection limits do not meet objective:</p> <ul style="list-style-type: none"> • Request reanalysis or remeasurement using methods or analytical conditions that will meet required detection or limit of quantitation. • Qualify/reject the data before use.

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

Table B-8. Change Control for Sampling Projects			
Type of Change^a	Type of Change (Tri-Party Agreement Action Plan^b)	Action	Documentation
<p>Minor change: Change has no impact on the sample or field analytical result, and little or no impact on performance or cost. Further, the change does not affect the DQOs specified in the SAP.</p>	<p>Minor field change: Changes that have no adverse effect on the technical adequacy of the job or the work schedule.</p>	<p>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.</p>	<p>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.</p>
<p>Significant change: Change has a considerable effect on performance or cost, but still allow for meeting the DQOs specified in the SAP.</p>	<p>Minor change: Changes to approved plans that do not affect the overall intent of the plan or schedule.</p>	<p>The OU project manager will inform the DOE-RL project manager and the regulatory lead of the change and seek concurrence at a unit managers' meeting or comparable forum. The lead regulatory agency determines there is no need to revise the document.</p>	<p>Documentation of this change approval would be in the unit managers' meeting minutes or a comparable record, such as a change notice.^c</p>
<p>Fundamental change: Change has significant effect on the sample or the field analytical result, performance, or cost, and the change does not meet the requirements specified in the DQOs in the sampling document.</p>	<p>Revision necessary: Lead regulatory agency determines changes to approved plans require revision to document.</p>	<p>If it is anticipated that a fundamental change will require the approval of the regulatory lead, the applicable DOE-RL project manager will be notified by the OU project manager and will be involved in the decision prior to implementation of a fundamental change. The lead regulatory agency determines the change requires a revision to the document.</p>	<p>Formal revision of the sampling document.</p>

a. Consistent with DOE/RL-96-68, *Hanford Analytical Services Quality Assurance Requirements Document* (HASQARD).

b. Consistent with Sections 9.3 and 12.4 of Ecology et al., 1989b, *Hanford Federal Facility Agreement and Consent Order Action Plan* (Tri-Party Agreement Action Plan).

c. The Tri-Party Agreement Action Plan, Section 9.3, defines the minimum elements of a change notice.

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

DQO = data quality objective

OU = operable unit

SAP = sampling and analysis plan

1 The OU project manager, FWS, or designee, is responsible for communicating field corrective
2 action requirements and ensuring that immediate corrective actions are applied to field activities.
3 The OU project manager is also responsible for ensuring that a project files are maintained. The project
4 files will contain project records or references to their storage locations. Project files may include the
5 following information, as appropriate:

- 6 • Operational records and logbooks
- 7 • Data forms
- 8 • Global positioning system data (a copy will be provided to the SMR organization)
- 9 • Inspection or assessment reports and corrective action reports
- 10 • Field summary reports
- 11 • Interim progress reports
- 12 • Final reports
- 13 • Forms required by WAC 173-160, “Minimum Standards for Construction and Maintenance of
14 Wells,” and the master drilling contract

15 The following records are managed and maintained by SMR personnel:

- 16 • Field sampling logbooks
- 17 • Groundwater sample reports and field sample reports
- 18 • Chain-of-custody forms
- 19 • Sample receipt records
- 20 • Laboratory data packages
- 21 • Analytical data verification, and validation reports, if any
- 22 • Analytical data “case file purges” (i.e., raw data purged from laboratory files) provided by the offsite
23 analytical laboratories

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

- 25 • Analytical logbooks
- 26 • Raw data and QC sample records
- 27 • Standard reference material and/or proficiency test sample data
- 28 • Instrument calibration information

29 Records may be stored in either electronic or hardcopy format. Documentation and records, regardless
30 of medium or format, are controlled in accordance with work requirements and processes to ensure
31 that stored records are accurate and can be retrieved. Records required by the Tri-Party Agreement
32 (Ecology et al., 1989a) will be managed in accordance with the requirements therein.

1 B2.2 Data Generation and Acquisition

2 The following sections present the requirements for analytical methods, measurement and analysis, data
3 collection or generation, data handling, and field and laboratory QC. The requirements for instrument
4 calibration and maintenance, supply inspections, and data management are also addressed.

5 B2.2.1 Analytical Methods Requirements

6 Analytical method performance requirements for samples collected are presented in Table B-9.

7 In consultation with the laboratory and the OU project manager, the SMR organization can approve
8 changes to analytical methods as long as the new method is based upon a nationally recognized standard
9 method (e.g., EPA or ASTM [formerly American Society for Testing & Materials]) and the new method
10 delivers analytical data that are comparable to those provided by the old method. The new method must
11 achieve project DQOs as well or better than the replaced method and is required due to the nature of the
12 sample (e.g., high radioactivity). The laboratory using the new method must be accredited by Ecology to
13 perform that method. Issues that may affect analytical results are resolved by the SMR organization in
14 coordination with the OU project manager.

Table B-9. Performance Requirements for Groundwater Analysis					
CAS Number	Analyte	Survey or Analytical Method	Units	Action Level	Target Detection Limit
56-23-5	Carbon tetrachloride (LL) (COC)	SW-846, Method 8260	µg/L	3.4	1
67-66-3	Chloroform (TP)	SW-846, Method 8260	µg/L	7.17	5
75-09-2	Dichloromethane (TP)	SW-846, Method 8260	µg/L	5	5
74-87-3	Chloromethane (TP)	SW-846, Method 8260	µg/L	N/A	10
79-01-6	Trichloroethene (COC)	SW-846, Method 8260	µg/L	1	1
156-59-2	cis-1,2-Dichloroethene (TP)	SW-846, Method 8260	µg/L	70	5
75-01-4	Vinyl chloride (TP-LL)	SW-846, Method 8260	µg/L	2	2
7440-47-3	Chromium (total) (COC)	SW-846, SW6010/6020 or EPA 200.8	µg/L	100	10
18540-29-9	Hexavalent chromium (COC)	Method 7196	µg/L	48	10
14697-55-8	Nitrate-N (COC)	SW-846, EPA 300.0 or 9056	mg/L	10	0.25
14797-65-0	Nitrite-N (TP)	EPA 300.0 or 9056	mg/L	1	0.25
15046-84-1	Iodine-129 (COC)	Low-energy photon spectroscopy (LL)	pCi/L	1	1
14133-76-7	Technetium-99 (COC)	Liquid scintillation	pCi/L	900	50

CAS Number	Analyte	Survey or Analytical Method	Units	Action Level	Target Detection Limit
10098-97-2	Strontium-90	Gas proportional counting	pCi/L	8	2
10028-17-8	Tritium (COC)	Liquid scintillation	pCi/L	20,000	700
7440-61-1	Uranium (from the 200-UP-1 OU)	SW-846, SW6010/6020 or EPA 200.8	µg/L	30	1
N/A	Total organic carbon (NAP)	EPA 415.1	µg/L	N/A	1,000
N/A	Total dissolved solids	EPA 160.1	mg/L	500	10
14808-79-8	Sulfate (NAP)	EPA 300.0A or 9056	mg/L	250	0.55
18496-25-8	Sulfide (NAP)	EPA 376.1, 4500D, 9034, or 9030	mg/L	N/A	0.50
7439-89-6	Iron (NAP)	SW-846, SW6010/6020	µg/L	300	100
7439-96-5	Manganese (NAP)	SW-846, SW6010/6020	µg/L	50	15 / 5
N/A	Alkalinity (NAP)	EPA 310.1	mg/L	N/A	5
16887-00-6	Chloride	EPA 300.0 or 9056	mg/L	250	0.40

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

CAS = Chemical Abstracts Service

COC = contaminant of concern

EPA = U.S. Environmental Protection Agency

LL = low level

N/A = not applicable

NAP = natural attenuation evaluation parameter

OU = operable unit

TP = transformation product

1 **B2.2.2 Field Analytical Methods**

2 Chemical field screening and radiological field survey data used for site characteristics will be measured
3 in accordance with HASQARD (DOE/RL-96-68) requirements, as applicable. Field analytical methods
4 may also be performed in accordance with the manufacturers' manuals. Section B3 provides the
5 parameters identified for field survey analyses.

6 **B2.2.3 Quality Control**

7 The QC requirements specified in the SAP must be followed in the field and analytical laboratory to
8 ensure that reliable data are obtained. Field QC samples will be collected to evaluate the potential for
9 cross-contamination and provide information pertinent to sampling variability. Laboratory QC samples
10 estimate the precision, bias, and matrix effects of the analytical data. Field and laboratory QC sample
11 requirements are summarized in Table B-9. Acceptance criteria for field and laboratory QC are shown
12 in Table B-10. Data will be qualified and flagged in the HEIS database, as appropriate.

Table B-10. Project QC Requirements

Sample Type	Frequency	Characteristics Evaluated
Field QC		
Field duplicate	One in 20 well trips.	Precision, including sampling and analytical variability
Field split (SPLIT)	As needed. When needed, the minimum is one for every analytical method, for analyses performed where detection limit and precision and accuracy criteria have been defined in the analytical performance requirements table.	Precision, including sampling, analytical, and interlaboratory
Full trip blank (FTB)	One in 20 well trips.	Cross-contamination from containers or transportation
Field transfer blank (FXR)	One each day that volatile organic compounds are sampled.	Contamination from sampling site
Equipment blank (EB)	As needed. If only disposable equipment is used or equipment is dedicated to a particular well, then an EB is not required. Otherwise, one for every 20 samples. ^a	Adequacy of sampling equipment decontamination and contamination from nondedicated equipment
Analytical QC^b		
Laboratory duplicate	One per analytical batch. ^c	Laboratory reproducibility and precision
Matrix spike (MS)	One per analytical batch. ^c	Matrix effect/laboratory accuracy
Post-preparation spike	One per analytical batch. ^c	Matrix effect/laboratory accuracy
Matrix spike duplicate (MSD)	One per analytical batch. ^c	Laboratory accuracy and precision
Laboratory control sample (LCS)	One per analytical batch. ^c	Evaluate laboratory accuracy
Method blank (MB)	One per analytical batch. ^c	Laboratory contamination
Surrogate (SUR)	One per sample. ^c	Recovery/yield
Tracer	One per sample. ^c	Recovery/yield

a. For portable pumps, EBs are collected one for every 10 well trips. Whenever a new type of nondedicated equipment is used, an EB will be collected every time sampling occurs until it can be shown that less frequent collection of EBs is adequate to monitor the decontamination methods for the non-dedicated equipment.

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

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

QC = quality control

1

Table B-11. Field and Laboratory QC Elements and Acceptance Criteria

Analyte ^a	QC Element	Acceptance Criteria	Corrective Action
General Chemical Parameters			
Alkalinity	MB ^b	< MDL	Flagged with “C”
Conductivity		<5% sample concentration	
Hexavalent chromium	LCS	80 – 120% recovery ^c	Data reviewed ^d
pH	Laboratory duplicate or MS/MSD	≤20% RPD	Data reviewed ^d
Total dissolved solids	Post-preparation spike ^b	75 – 125% recovery ^c	Flagged with “N”
Total organic carbon	EB	<2 times MDL	Flagged with “Q”
Total organic halides	Field duplicate	≤20% RPD ^e	Flagged with “Q”
Ammonia, Anions, and Cyanide			
Ammonia	MB	< MDL	Flagged with “C”
Anions by IC		<5% sample concentration	
Cyanide	LCS	80 – 120% recovery ^c	Data reviewed ^d
	Laboratory duplicate or MS/MSD	≤20% RPD	Data reviewed ^d
	MS	75 – 125% recovery ^c	Flagged with “N”
	EB, FTB	<2 times MDL	Flagged with “Q”
	Field duplicate	≤20% RPD ^e	Flagged with “Q”
Metals			
ICP metals	MB	< MDL	Flagged with “C”
ICP/MS metals		<5% sample concentration	
Mercury	LCS	80 – 120% recovery ^c	Data reviewed ^d
	MS/MSD	75 – 125% recovery ^c	Flagged with “N”
	DUP/MSD	≤20% RPD	Data reviewed ^d
	EB, FTB	<2 times MDL	Flagged with “Q”
	Field duplicate	≤20% RPD ^e	Flagged with “Q”
Volatile Organic Compounds			
Volatiles by GC/MS	MB	< MDL ^f	Flagged with “B”
Total petroleum hydrocarbons by GC		<5% sample concentration	
	LCS	70 – 130%	Data reviewed ^d

Table B-11. Field and Laboratory QC Elements and Acceptance Criteria

Analyte ^a	QC Element	Acceptance Criteria	Corrective Action
	MS/MSD	70 – 130%	Flagged with “T”
	DUP/MSD	≤20%	Data reviewed ^d
	MS/MSD	70 – 30% recovery	Flagged with “T”
	SUR	70 – 130%	Data reviewed ^d
	EB, FTB, FXR	<2 times MDL ^f	Flagged with “Q”
	Field duplicate	≤20% RPD ^e	Flagged with “Q”
Semivolatile Organic Compounds			
Semivolatiles by GC/MS	MB	< MDL ^f <5% sample concentration	Flagged with “B”
	LCS	70 – 130%	Data reviewed ^d
	DUP/MSD	≤20% RPD	Data reviewed ^d
	MS/MSD	% recovery statistically derived ^e	Flagged with a “T”
	SUR	70 – 130%	Data reviewed ^d
	EB, FTB	<2 times MDL ^f	Flagged with “Q”
	Field duplicate	≤20% RPD ^e	Flagged with “Q”
Radiochemical Analyses			
Americium (isotopic) Carbon-14 Gamma scan Gross alpha Gross beta Iodine-129 Plutonium (isotopic) Strontium-89/90 Technetium-99 Tritium Tritium (low level) Uranium (isotopic) Uranium (total)	MB	< MDC <5% sample concentration	Flagged with “B”
	LCS	80 – 120% recovery	Data reviewed ^d
	Laboratory duplicate ^e	≤20% RPD	Data reviewed ^d
	MS ^g	75 – 125% recovery	Flagged with “N”
	Tracer (where applicable)	30 – 105% recovery	Data reviewed ^d
	Carrier (where applicable)	40 – 110% recovery	Data reviewed ^d
	EB, FTB	<2 times MDA	Flagged with “Q”
	Field duplicate	≤20% RPD ^e	Flagged with “Q”

Table B-11. Field and Laboratory QC Elements and Acceptance Criteria

Analyte ^a	QC Element	Acceptance Criteria	Corrective Action
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- a. Specific analytes and method for determination are available from the Sample Management and Reporting organization.
- b. Does not apply to pH, conductivity, total dissolved solids, or alkalinity.
- c. Determined by the laboratory based on historical data or statistically derived control limits. Limits are reported with the data. Where specific acceptance criteria are listed, those acceptance criteria may be used in place of statistically derived acceptance criteria.
- d. After review, corrective actions are determined on a case-by-case basis.
- e. Applies only in cases where one or both results are greater than 5 times the minimum detectable concentration.
- f. For common laboratory contaminants such as acetone, methylene chloride, 2-butanone, toluene, and phthalate esters, the acceptance criteria is <5 times the MDL.
- g. Applies only to isotopic carbon-14, technetium-99, total uranium by ICP/MS, and tritium.

DUP = duplicate	LCS = laboratory control sample
EB = equipment blank	MB = method blank
FEAD = format for electronic analytical data	MDA = minimum detectable activity
FTB = full trip blank	MDL = method detection limit
FXR = field transfer blank	MS = matrix spike
GC = gas chromatography	MSD = matrix spike duplicate
GC/MS = gas chromatography/mass spectrometry	QC = quality control
IC = ion chromatography	RPD = relative percent difference
ICP = inductively coupled plasma	SUR = surrogate
ICP/MS = inductively coupled plasma/mass spectrometry	

Data Flags:

- B (organics)/C (inorganics/wetchem) = analyte was detected in both the associated quality control blank and the sample)
- N = all except GC/MS (matrix spike outlier)
- T = volatile organic analytes and semivolatile organic analytes GC/MS (matrix spike outlier)
- Q = associated QC sample is out of limits

1 **B2.2.3.1 Field Quality Control Samples**

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

- 7 • **Field duplicates:** Independent samples collected as close as possible to the same time and same
 8 location as the scheduled sample and are intended to be identical. Field duplicates are placed in
 9 separate sample containers and analyzed independently. Field duplicates are used to determine
 10 precision for both sampling and laboratory measurements.
- 11 • **Field splits (SPLITS):** Two samples collected as close as possible to the same time and same location
 12 and are intended to be identical. SPLITS will be stored in separate containers and analyzed by
 13 different laboratories for the same analytes. SPLITS are interlaboratory comparison samples used to
 14 evaluate comparability between laboratories.

- 1 • **Full trip blanks (FTB):** Bottles prepared by the sampling team prior to traveling to the sampling site.
2 The preserved bottle set is either for volatile organic analysis (VOA) only or identical to the set that
3 will be collected in the field. It is filled with high-purity reagent water (or dead water from
4 well 699-S11-E12AP for low-level tritium FTBs¹), and the bottles are sealed and transported
5 (unopened) to the field in the same storage containers used for samples collected that day. Collected
6 FTBs are typically analyzed for the same constituents as the samples from the associated sampling
7 event. FTBs are used to evaluate potential contamination of the samples attributable to the sample
8 bottles, preservative, handling, storage, and transportation.
- 9 • **Field transfer blanks (FXR):** Preserved VOA sample vials filled with high-purity reagent water at
10 the sample collection site where VOC samples are collected. The samples will be prepared during
11 sampling to evaluate potential contamination attributable to field conditions. After collection, FXR
12 sample vials will be sealed and placed in the same storage containers with the samples collected the
13 same day for the associated sampling event. FXR samples will be analyzed for VOCs only.
- 14 • **Equipment blanks (EB):** Reagent water passed through or poured over the decontaminated sampling
15 equipment identical to the sample set collected and placed in sample containers, as identified on
16 the SAF. The EB sample bottles are placed in the same storage containers with the samples from the
17 associated sampling event. The EB samples will be analyzed for the same constituents as the samples
18 from the associated sampling event. The EBs are used to evaluate the effectiveness of the
19 decontamination process. EBs are not required for disposable sampling equipment.

20 **B2.2.3.2 Laboratory Quality Control Samples**

21 Internal QA/QC programs are maintained by the laboratories used by the project. Laboratory QA includes
22 a comprehensive QC program that includes the use of matrix spikes (MSs), matrix duplicates, matrix
23 spike duplicates (MSDs), laboratory control samples (LCSs), surrogates (SURs), tracers, and method
24 blanks (MBs). These samples are recommended in the guidance documents and are required by the EPA
25 protocol (e.g., EPA-600/4-79/20, *Methods for Chemical Analysis of Water and Wastes*) and will be run at
26 the frequency specified in the respective references unless superseded by agreement. QC checks outside
27 of control limits are documented in analytical laboratory reports during DQAs, if performed. Laboratory
28 QC and their typical frequencies are listed in Table B-10. Acceptance criteria are provided in Table B-11.
29 The various types of laboratory QC samples are defined as follows:

- 30 • **Laboratory duplicate:** An intralaboratory replicate sample that is used to evaluate the precision of
31 a method in a given sample matrix.
- 32 • **Matrix spike (MS):** An aliquot of a sample spiked with a known concentration of target analyte(s).
33 The MS is used to assess the bias of a method in a given sample matrix. Spiking occurs prior to
34 sample preparation and analysis.
- 35 • **Post-preparation spike:** The same as a MS; however, the spiking occurs after sample preparation.
- 36 • **Matrix spike duplicate (MSD):** A replicate spiked aliquot of a sample that is subjected to the entire
37 sample preparation and analytical process. The MSD results are used to determine the bias and
38 precision of a method in a given sample matrix.

¹ Because of the low detection levels achieved in the low-level tritium analysis, special low-level tritium water must be used. This low-level tritium water, known as “dead water,” is collected yearly, or as needed, from well 699-S11-E12AP or other approved source.

- 1 • **Laboratory control sample (LCS):** A control matrix (e.g., reagent water) spiked with analytes
2 representative of the target analytes or a certified reference material that is used to evaluate
3 laboratory accuracy.
- 4 • **Method blank (MB):** An analyte-free matrix to which all reagents are added in the same volumes or
5 proportions as used in the sample processing. The MB is carried through the complete sample
6 preparations and analytical procedure, and it is used to quantify contamination resulting from the
7 analytical process.
- 8 • **Surrogate (SUR):** A compound added to all samples in the analysis batch (field samples and QC
9 samples) prior to preparation. The SUR is typically similar in chemical composition to the analyte
10 being determined, yet it is not normally encountered. SURs are expected to respond to the preparation
11 and measurement systems in a manner similar to the analytes of interest. Because SURs are added to
12 all standards, samples, and QC samples, they are used to evaluate overall method performance in
13 a given matrix. SURs are used only in organic analyses.
- 14 • **Tracer:** A known quantity of radioactive isotope that is different from that of the isotope of interest
15 but is expected to behave similarly and is added to an aliquot of sample. Sample results are generally
16 corrected based on tracer recovery.

Table B-12. Preservation, Container, and Holding-Time Guidelines

Constituent or Parameter	Minimum Volume	Container Type ^a	Preservation ^b	Holding Time
Gravimetric Determinations				
Residue, filterable total dissolved solids	500 mL	Poly or glass	Store ≤6°C	7 days
Organic Analyses				
Volatile organics	4 × 40 mL	Amber glass VOA vial with Teflon®-lined septum lid	Store ≤6°C (if free Cl ₂ , add 4 drops of 10% sodium thiosulfate), adjust pH to <2 with HCl	14 days
Semivolatile organics	4 × 1 L	Amber glass with Teflon-lined lid	Store ≤6°C (if residual Cl ₂ , add 3 mL 10% sodium thiosulfate/gal of sample)	7 days before extraction 40 days after extraction
WTPH-D	4 × 1 L	Amber glass with Teflon-lined lid	Store ≤6°C pH to <2 with HCl	7 days before extraction (14 days if preserved) 40 days after extraction
WTPH-G	4 × 40 mL	Amber glass VOA vial with Teflon-lined septum lid	Store ≤6°C, adjust pH to <2 with HCl	14 days

Table B-12. Preservation, Container, and Holding-Time Guidelines

Constituent or Parameter	Minimum Volume	Container Type ^a	Preservation ^b	Holding Time
Total organic halides	1 L	Glass with Teflon-lined lid	Store $\leq 6^{\circ}\text{C}$, adjust pH to < 2 with H_2SO_4	28 days
Total organic carbon	250 mL	Amber glass with Teflon-lined lid	Store $\leq 6^{\circ}\text{C}$, adjust pH to < 2 with H_2SO_4 or HCl	28 days
Metals^c				
ICP/MS (with/without mercury)	250 mL	Poly or glass	Adjust pH to < 2 with nitric acid	28 days/6 months ^e
ICP/AES (with/without mercury)	250 mL	Poly or glass	Adjust pH to < 2 with nitric acid	28 days/6 months ^e
Dissolved metals (with/without mercury)	500 mL	Poly or glass	Filter prior to pH adjustment to < 2 with nitric acid	28 days/6 months ^e
Mercury	250 mL	Poly or glass	Adjust pH to < 2 with nitric acid	28 days
Miscellaneous Inorganic				
Alkalinity	500 mL	Poly or glass	Store $\leq 6^{\circ}\text{C}$	14 days
Cyanide	250 mL	Poly or glass	Store $\leq 6^{\circ}\text{C}$, adjust pH to > 12 with 50% NaOH ; if oxidizing agents present, add 5 mL 0.1 N NaAsO_2/L or 0.06 g ascorbic acid/L	14 days
Hexavalent chromium	60 mL	Poly or glass	Store $\leq 6^{\circ}\text{C}$	24 hours
pH	60 mL	Poly or glass	None required	Analyze immediately
Specific conductivity	150 mL	Poly or glass	Store $\leq 6^{\circ}\text{C}$	28 days
Inorganic Ions				
Ammonia	125 mL	Poly or glass	Store $\leq 6^{\circ}\text{C}$, adjust pH to < 2 with H_2SO_4	28 days
Bromide	125 mL	Poly or glass	Store $\leq 6^{\circ}\text{C}$	28 days
Chloride	125 mL	Poly or glass	Store $\leq 6^{\circ}\text{C}$	28 days
Fluoride	125 mL	Poly or glass	Store $\leq 6^{\circ}\text{C}$	28 days

Table B-12. Preservation, Container, and Holding-Time Guidelines

Constituent or Parameter	Minimum Volume	Container Type ^a	Preservation ^b	Holding Time
Nitrate	125 mL	Poly or glass	Store $\leq 6^{\circ}\text{C}$	48 hours
Nitrite	125 mL	Poly or glass	Store $\leq 6^{\circ}\text{C}$	48 hours
Phosphate	125 mL	Poly or glass	Store $\leq 6^{\circ}\text{C}$	48 hours
Sulfate	125 mL	Poly or glass	Store $\leq 6^{\circ}\text{C}$	28 days
Sulfide	250 mL	Wide-mouth poly or glass	Store $\leq 6^{\circ}\text{C}$, ZnAc+NaOH to pH >9	7 days
Radiochemical Analyses				
Gross alpha/beta (plate count)	500 mL	Poly or glass	Adjust pH to <2 with HNO_3	6 months
Americium/curium by AEA	1 L for all AEA	Poly or glass	Adjust pH to <2 with HNO_3	6 months
Carbon-14	2 \times 1 L	Poly or glass	None	6 months
Plutonium isotopic by AEA	1 L for all AEA	Poly or glass	Adjust pH to <2 with HNO_3	6 months
Uranium isotopic by AEA	1 L for all AEA	Poly or glass	Adjust pH to <2 with HNO_3	6 months
Gamma energy analysis	500 mL	Square poly	Adjust pH to <2 with HNO_3	6 months
Iodine-129	2 \times 4 L	Poly or glass	None	6 months
Neptunium-237	1 L	Poly or glass	Adjust pH to <2 with HNO_3	6 months
Strontium-90 (total beta radiostrontium)	2 \times 1 L	Poly or glass	Adjust pH to <2 with HNO_3	6 months
Technetium-99 by liquid scintillation	1 L	Poly or glass	Adjust pH to <2 with HCl	6 months
Tritium	1 L	Glass	None	6 months
Total uranium by kinetic phosphorescence analysis	250 mL	Poly or glass	Adjust pH to <2 with HNO_3	6 months

Table B-12. Preservation, Container, and Holding-Time Guidelines

Constituent or Parameter	Minimum Volume	Container Type ^a	Preservation ^b	Holding Time
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Notes:

Teflon® is a registered trademark of E.I. DuPont de Nemours and Company, Wilmington, Delaware.

The information in this table does not represent EPA requirements, but is instead intended solely as guidance. Selection of container, preservation techniques, and applicable holding times should be based on the stated project-specific data quality objectives.

a. Under the “Container” heading, the term “poly” stands for EPA clean polyethylene bottles.

b. For preservation identified as store at $\leq 6^{\circ}\text{C}$, the sample should be protected against freezing unless it is known that freezing will not impact the sample integrity.

c. For metals analysis, 28 days/6 months holding time defines 28 days for mercury, 6 months for all other metals.

AEA = alpha energy analysis

EPA = U.S. Environmental Protection Agency

ICP/AES = inductively coupled plasma/atomic emission spectroscopy

ICP/MS = inductively coupled plasma/mass spectrometry

VOA = volatile organic analyte

WTPH-D = Washington State Department of Ecology total petroleum hydrocarbons as diesel

WTPH-G = Washington State Department of Ecology total petroleum hydrocarbons as gasoline

1 Laboratories are required to analyze samples within the holding time specified in Table B-12. In some
 2 instances, constituents in the samples not analyzed within the holding times may be compromised by
 3 volatilizing, decomposing, or by other chemical changes. Data from samples analyzed outside the holding
 4 times are flagged in the HEIS database with an “H.”

5 **B2.2.4 Measurement Equipment**

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

12 **B2.2.5 Instrument and Equipment Testing, Inspection, and Maintenance**

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

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

1 **B2.2.6 Instrument and Equipment Calibration and Frequency**

2 Specific field equipment calibration information is provided in Section B3.5. Analytical laboratory
3 instruments are calibrated in accordance with the laboratory's QA plan and applicable Hanford
4 Site requirements.

5 **B2.2.7 Inspection and Acceptance of Supplies and Consumables**

6 Consumables, supplies, and reagents will be reviewed in accordance with the requirements of SW-846,
7 *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update V*,
8 as amended, and will be appropriate for their use. Supplies and consumables used in support of sampling
9 and analysis activities are procured in accordance with internal work requirements and processes.
10 Responsibilities and interfaces necessary to ensure that items procured/acquired for the contractor meet
11 the specific technical and quality requirements must be in place. The procurement system ensures that
12 purchased items comply with applicable procurement specifications. Supplies and consumables are
13 checked and accepted by users prior to use.

14 **B2.2.8 Nondirect Measurements**

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

18 **B2.2.9 Data Management**

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

22 Electronic data access, when appropriate, will be through a Hanford Site database (e.g., HEIS) or
23 a project-specific database, whichever is applicable for the data being stored. Where electronic data are
24 not available, hardcopies will be provided in accordance with Section 9.6 of the Tri-Party Agreement
25 Action Plan (Ecology et al., 1989b).

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

31 **B2.3 Assessment and Oversight**

32 The elements in assessment and oversight address the effectiveness of project implementation and
33 associated QA and QC activities. The purpose of assessment is to ensure that the QAPjP is implemented
34 as prescribed.

1 **B2.3.1 Assessments and Response Actions**

2 Random surveillances and assessments are used to verify compliance with the requirements outlined in
3 this SAP, project field instructions, the project quality management plan, methods, and regulatory
4 requirements. Deficiencies identified by these assessments will be reported in accordance with
5 existing programmatic requirements. The project's line management chain coordinates corrective
6 actions/deficiencies resolutions in accordance with the QA program, the corrective action management
7 program, and associated methods implementing these programs. When appropriate, corrective actions
8 will be taken by the OU project manager (or designee).

9 Oversight activities in the analytical laboratories, including corrective action management, are conducted
10 in accordance with the laboratory's QA plan. The contractor oversees offsite analytical laboratories and
11 verifies that the laboratories are qualified for performing Hanford Site analytical work.

12 **B2.3.2 Reports to Management**

13 Management will be made aware of deficiencies identified by self-assessments, corrective actions from
14 ECOs, and findings from QA assessments and surveillances. Issues reported by the laboratories are
15 communicated to the SMR organization, which then initiates a sample issue resolution form. This process
16 is used to document analytical or sample issues and to establish resolution with the OU project manager.

17 **B2.4 Data Review and Usability**

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

20 **B2.4.1 Data Review and Verification**

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

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

30 Errors identified by the laboratories are reported to the SMR organization's project coordinator, who
31 initiates a sample issue resolution form. This process is used to document analytical errors and to
32 establish resolution with the OU technical lead.

33 For analytical data in sample media, field screening results are of lesser importance in making inferences
34 regarding risk. Field QA/QC results will be reviewed to ensure that the data are usable.

35 Review by the OU technical lead data will help determine if observed changes reflect improved/degraded
36 groundwater quality or potential data errors and may result in submittal of a request for data review on
37 questionable data. The laboratory may be asked to check calculations or reanalyze the sample, or the well
38 may be resampled. Results of the request for data review process are used to flag the data appropriately in
39 the HEIS database and/or to add comments.

1 **B2.4.2 Data Validation**

2 Data validation activities will be performed at the discretion of the OU project manager and under the
3 direction of the SMR organization. If performed, data validation activities will be based on EPA
4 functional guidelines.

5 **B2.4.3 Reconciliation with User Requirements**

6 The DQA process compares completed field sampling activities to those proposed in corresponding
7 sampling documents and provides an evaluation of the resulting data. The purpose of the DQA is to
8 determine whether quantitative data are of the correct type and are of adequate quality and quantity to
9 meet the project DQOs. For routine groundwater monitoring performed under this SAP, the DQA is
10 captured in QC associated with the annual Hanford Site groundwater monitoring report, which evaluates
11 field and laboratory QC and the usability of data. Further DQAs will be performed at the discretion of
12 the OU project manager and documented in a report overseen by the SMR organization.

13 **B3 Field Sampling Plan**

14 This section identifies the groundwater wells to be monitored, the sampling frequency, and the
15 constituents to be analyzed.

16 **B3.1 Sampling Objectives**

17 The objectives of groundwater monitoring in the 200-ZP-1 OU are to define the extent, and track the
18 movement, of the groundwater contaminant plumes in the unconfined aquifer. These objectives are
19 accomplished in the field by sampling the groundwater at designated wells and analyzing the samples for
20 the identified COCs.

21 **B3.2 Sample Location, Frequency, and Constituents to be Monitored**

22 The sampling requirements and groundwater monitoring wells comprising the 200-ZP-1 OU network are
23 listed in Appendix A. Appendix F provides information on the hydrogeologic unit monitored by the wells.
24 Table B-13 lists the hydraulic monitoring wells. Table B-14 identifies the specific constituents to be
25 analyzed and the sampling frequency for those wells that have been selected for monitoring. Appendix A
26 provides the criteria used to identify the wells needed to address the decision statements identified during
27 the DQO process. Some wells are co-sampled with other monitoring programs (e.g., monitored to meet
28 RCRA requirements). Monitoring requirements for the other monitoring programs are described in
29 separate plans. The reported data from these networks is supplementary to the information gathered under
30 this SAP.

31 **B3.2.1 Monitoring Network**

32 This SAP organizes the wells within the 200-ZP-1 OU by constituents. Not all of the wells identified for
33 potential use in the monitoring network within the OU are needed to monitor each contaminant.
34 An analysis of the network to identify the wells needed for monitoring specific COC plumes is presented
35 in Chapter 3 in the main text. The groundwater monitoring well network is comprised of two well groups:
36 (1) monitoring wells for water-level measurements, and (2) monitoring wells for COC and MNA
37 sampling and analysis. The hydraulic monitoring well locations are shown in Figure B-7, the VOC
38 monitoring well locations are shown in Figure B-8, and the contaminant-specific monitoring well
39 locations are shown in Figures B-9 through B-14. General information for each of the hydraulic
40 monitoring wells is shown in Table B-13, and details of the current groundwater monitoring well
41 networks are provided in Appendix F. The sampling schedule for all analytes is provided in Table B-14.

Table B-13. 200 West Hydraulic Monitoring Well Network

Well Name	Easting (m)	Northing (m)	Surface Elevation (m)	Depth to Screen Top (m)	Depth to Screen Bottom (m)	Date Drilled	Transducer Equipment	Mid-Screen Elevation (m)
299-W10-1	566663	136735	207.5	57.91	82.3	08/07/1947	No	137.4
299-W10-27	566844	136442	205.6	67.36	78.02	03/23/2001	No	132.9
299-W10-30	566083	136739	211.6	73.86	84.53	03/14/2006	No	132.4
299-W10-31	566266	136968	210.4	73.13	83.82	04/20/2006	No	131.9
299-W10-33	566773	136610	206.0	118.87	124.96	06/15/2007	No	84.1
299-W11-13	567099	136424	211.9	66.45	143.86	07/31/1961	No	106.7
299-W11-18	567182	137161	216.5	69.19	89.916	03/01/1967	No	136.9
299-W11-33Q	567185	136844	217.2	74.41	91.17	09/09/1994	No	134.4
299-W11-43	567270	136971	217.5	129.44	134.01	05/23/2005	No	85.8
299-W11-45	566993	136776	213.6	85.73	90.18	09/02/2005	No	125.7
299-W11-47	566934	136681	210.4	83.58	92.89	01/06/2006	No	122.2
299-W11-48	566882	136846	209.7	84.56	112.01	11/29/2006	Yes	111.4
299-W11-87	568141	136609	223.6	116.36	120.94	03/01/2007	Yes	105.0
299-W11-88	567875	137113	221.9	135.66	147.85	10/03/2007	Yes	80.1
299-W13-1	568149	136049	223.5	119.15	129.81	02/10/2004	No	99.1
299-W14-11	566902	136288	205.1	79.77	82.81	04/26/2005	No	123.8
299-W14-14	566898	136181	205.4	66.13	76.81	11/12/1998	No	134.0
299-W14-17	567007	136218	205.9	67.64	78.32	10/24/2000	No	132.9
299-W14-71	567733	135568	219.4	125.17	129.74	07/27/2006	Yes	92.0
299-W14-72	567328	135941	216.3	126.18	130.76	08/15/2006	No	87.9
299-W15-1	566554	135943	207.0	57.91	82.3	05/02/1947	No	136.9
299-W15-11	566412	136001	208.3	55.78	90.53	03/08/1968	No	135.1
299-W15-152	566309	135550	209.9	71.94	82.61	09/15/2005	No	132.6
299-W15-17	566307	135719	209.8	128.77	131.82	10/28/1987	No	79.5
299-W15-3	566729	136371	205.4	60.96	71.93	09/30/1952	No	139.0
299-W15-30	566305	135749	210.2	66.47	78.63	05/05/1995	Yes	137.7
299-W15-31A	566377	135856	208.5	64.76	76.93	05/26/1995	No	137.7

Table B-13. 200 West Hydraulic Monitoring Well Network

Well Name	Easting (m)	Northing (m)	Surface Elevation (m)	Depth to Screen Top (m)	Depth to Screen Bottom (m)	Date Drilled	Transducer Equipment	Mid-Screen Elevation (m)
299-W15-37	566716	135248	203.0	64.74	77.98	05/16/1996	No	131.68
299-W15-42	566582	135627	207.4	69.50	84.74	02/26/2002	No	130.3
299-W15-46	566752	135587	204.2	63.86	88.23	10/03/2003	No	128.2
299-W15-49	566307	135973	209.1	71.86	82.52	11/01/2004	No	131.9
299-W15-50	566793	135791	203.2	74.19	84.85	02/28/2005	No	123.7
299-W15-7	566676	135920	204.2	55.47	106.68	03/30/1966	No	123.1
299-W17-1	565311	135039	199.2	58.99	69.67	12/17/2003	No	134.9
299-W18-1	566422	135465	209.1	59.44	111.89	01/12/1959	No	123.4
299-W18-15	566380	134733	202.2	51.82	74.07	04/25/1980	No	139.3
299-W18-16	566605	135426	208.5	71.47	82.13	10/20/2004	No	131.8
299-W18-22	566089	134990	204.9	126.94	136.39	09/25/1987	No	73.2
299-W18-40	566723	134996	203.4	66.53	77.20	09/28/2001	No	131.6
299-W19-107	567998	135206	217.4	94.65	99.22	03/31/2006	Yes	120.5
299-W19-18	567361	135012	214.0	67.06	109.12	12/12/1985	No	125.90
299-W19-34A	567674	135012	215.1	98.82	103.51	05/18/1994	No	113.9
299-W19-34B	567663	135011	215.5	125.46	128.41	12/12/1985	No	88.6
299-W19-35	567992	135015	213.6	73.13	82.3	04/20/1994	No	135.9
299-W19-4	567950	135351	219.0	77.72	135.03	02/15/1960	No	112.3
299-W19-41	566897	135005	206.5	67.07	77.76	09/23/1998	No	134.1
299-W19-6	567133	134694	210.3	115.82	125.27	12/13/1968	No	89.79
299-W21-2	568124	134574	214.9	79.29	89.96	11/22/2004	No	130.2
299-W22-24	567648	134411	212.2	67.06	163.07	09/08/1960	No	97.1
299-W22-47	566909	134076	206.3	69.70	80.37	01/19/2005	No	131.3
299-W23-20	566718	134446	203.8	65.68	76.35	08/21/2000	No	132.8
299-W26-14	566683	133539	205.4	68.08	78.75	04/03/2003	No	132.0
299-W27-2	566908	133670	207.4	123.79	126.87	12/18/1992	No	82.1
299-W6-3	567118	137299	214.4	124.82	127.95	10/15/1991	No	87.9

Table B-13. 200 West Hydraulic Monitoring Well Network

Well Name	Easting (m)	Northing (m)	Surface Elevation (m)	Depth to Screen Top (m)	Depth to Screen Bottom (m)	Date Drilled	Transducer Equipment	Mid-Screen Elevation (m)
299-W6-6	567319	137639	217.5	127.58	130.84	10/24/1991	No	88.3
299-W7-3	566292	137639	207.2	136.85	145.29	11/23/1987	No	66.1
699-25-70	568545	131172	193.0	53.34	134.11	08/31/1948	No	99.24
699-25-80	565676	131106	189.0	273.41	370.03	11/30/1948	No	321.3
699-30-66	569991	132739	210.5	117.35	120.4	10/13/2004	No	91.6
699-32-62	571010	133216	216.6	83.82	103.63	04/06/1960	No	122.9
699-32-62P	571010	133216	216.6	83.82	146.3	04/06/1960	No	101.5
699-32-70B	568462	133242	204.2	63.09	100.58	08/09/1957	No	122.37
699-32-72A	567943	133363	204.7	65.42	74.56	07/31/1957	No	134.7
699-32-72B	567935	133362	205.1	65.41	74.56	05/18/1994	No	135.1
699-34-88	563012	133950	194.0	146.0	127.02	12/20/1948	No	136.5
699-35-59	571956	134096	222.1	94.48	106.67	10/31/1985	No	121.5
699-35-66A	569858	134099	222.5	79.25	98.15	06/13/1957	No	133.76
699-35-78A	566064	134271	202.4	54.86	85.04	08/17/1950	Yes	132.02
699-36-70B	568428	134626	215.2	80.51	91.17	06/09/2004	No	129.4
699-38-61	571219	134997	228.2	101.83	107.92	11/16/1993	No	123.3
699-38-65	570090	135040	230.7	152.4	155.45	12/31/1959	No	76.8
699-38-68A	569180	134932	219.0	81.59	90.74	06/21/1994	No	132.8
699-38-70B	568469	135331	222.6	123.96	128.53	02/03/2004	No	96.3
699-38-70C	569084	135326	226.7	120.60	125.18	02/17/2004	No	103.8
699-39-79	565891	135412	206.5	54.44	73.152	09/07/1948	Yes	142.7
699-40-62	571164	135764	228.9	102.11	114.0	01/17/1949	No	120.8
699-40-65	570057	135881	231.0	100.0	111.5	02/03/2004	No	125.3
699-43-69	568967	136488	227.4	121.98	132.64	12/11/2007	No	100.1
699-43-89	562917	136620	197.7	43.28	60.35	01/16/1951	No	145.9
699-44-64	570391	136897	222.2	96.32	134.72	01/31/1960	No	106.67
699-45-69A	568729	137183	222.1	83.52	111.56	06/22/1948	No	124.6

Table B-13. 200 West Hydraulic Monitoring Well Network

Well Name	Easting (m)	Northing (m)	Surface Elevation (m)	Depth to Screen Top (m)	Depth to Screen Bottom (m)	Date Drilled	Transducer Equipment	Mid-Screen Elevation (m)
699-45-69C	568947	137234	222.6	111.86	116.43	07/13/2007	Yes	108.4
699-47-60	571474	137969	199.6	71.63	84.43	07/20/1948	No	121.6
699-47-80AP	565562	137693	218.26	198.12	204.83	11/30/1983	No	16.8
699-47-80AQ	565562	137693	218.26	153.31	156.36	11/30/1983	No	63.4
699-48-71	568388	138057	210.9	138	156.36	09/26/1956	No	63.7
699-48-77C	566469	138087	206.6	88.39	94.49	04/01/1994	No	115.42
699-49-79	565771	138271	211.1	65.58	80.77	07/03/1948	No	137.9
699-50-74	567360	138647	201.4	68.07	78.74	07/12/2005	No	128.0
699-51-63	570664	139148	175.3	47.85	55.78	11/06/1956	No	123.49
699-51-75	566978	138906	196.6	57.91	68.58	10/31/1957	No	133.4
699-55-76	566723	140226	178.7	42.98	67.36	01/18/1959	No	123.5

1 Monitoring locations for each contaminant were selected based on detection and data trends. The data for
2 each constituent were assembled to show the number of samples collected within the 1990 through 2012
3 time frame, with sub-data categories for the number of nondetected samples, the number of nondetected
4 samples greater than the cleanup level, the number of detections, the number of detections greater than the
5 cleanup level with the associated year(s), the first year sampled, the latest year sampled, and data trends
6 in the context of the cleanup level. Each constituent and well was then individually evaluated against the
7 appropriate plume map to determine whether a reduction in frequency of analysis for that constituent was
8 appropriate. This evaluation considered the geographic location of the well with respect to the plume and
9 the trend in the data. Wells that were within the plume, were above the cleanup level, had increasing
10 trends, were recently above the cleanup level (therefore warranting further monitoring), or were the first
11 well downgradient were not considered for reduction. In some cases, the first well downgradient, or the
12 sentinel well, may be an extraction well. Extraction wells are currently on a quarterly monitoring
13 schedule. The wells considered for reduction did not have detections above the cleanup level and were
14 stable or downward trending below the cleanup level. An annual sampling frequency was selected for the
15 VOA and contaminant-specific well networks.

16 **B3.2.2 Water-Level Measurements**

17 Figure B-7 depicts the current hydraulic monitoring network. Table B-13 lists the current wells with
18 pressure transducers installed. Water-level measurements are collected during each groundwater
19 monitoring event. Periodic water-level data recorded by the pressure transducers are downloaded on
20 a quarterly to an annual basis, depending on the measurement frequency.

1 Water-level measurements may also be collected during nonroutine events when a significant change
2 in P&T operation occurs (e.g., during a system-wide shutdown), when a group of wells is temporarily
3 or permanently idle for a period of 7 days or more, or when pumping rates are simultaneously altered at
4 three or more wells for a period of 7 days or more. The CHPRC project manager will have the discretion
5 to determine if a nonroutine water-level measurement event is warranted.

6 **B3.2.3 Groundwater Quality Sampling**

7 Groundwater sampling has been performed on an annual basis from the contaminant monitoring wells
8 in the 200 West Area since 2011. Beginning in 2014, a contaminant-specific set of wells (Figures B-8
9 through B-14) were identified for annual sampling based on a review of the wells and the data trends
10 relative to the plumes (DOE/RL-2013-22, *Hanford Site Groundwater Monitoring Report for 2012*). All of
11 the 200-ZP-1 OU wells will be sampled in the year prior to and in preparation for the next CERCLA
12 5-year review.

13 **B3.2.4 Groundwater Extraction Well Pumping Rates**

14 Instantaneous pumping rates and total flow for extraction wells are measured by inline flow meters, and
15 the data are saved to onsite and remote servers. The data servers can be queried as needed to obtain daily,
16 weekly, or monthly average flow rates, as well as total monthly flows.

17 **B3.3 Sampling Methods**

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

- 19 • Field screening measurements
- 20 • Radiological screening
- 21 • Groundwater sampling
- 22 • Water-level measurements

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

- 25 • **pH:** Two consecutive measurements agree within 0.2 pH units.
- 26 • **Temperature:** Two consecutive measurements agree within 0.2°C (32.4°F).
- 27 • **Conductivity:** Two consecutive measurements agree within 10 percent of each other.
- 28 • **Turbidity:** Less than 5 nephelometric turbidity units prior to sampling (or project scientist's
29 recommendation).

30 The field parameters for dissolved oxygen and reduction-oxidation potential may be specified by the
31 project.

32 For certain types of samples, preservatives are required. While the preservative may be added to the
33 collection bottles before their use in the field, it is allowable to add the preservative at the sampling
34 vehicle immediately after collection. Samples may require filtering in the field, as noted on the
35 chain-of-custody forms.

36 To ensure sample and data usability, the sampling associated with this SAP will be performed in
37 accordance with HASQARD (DOE/RL-96-68) regarding sample collection, collection equipment, and
38 sample handling.

Table B-14. Sampling and Analysis Schedule for 200-ZP-1 Groundwater OU Well Network

Well ID	Well Number	Co-Sample	Hydro-geologic Unit	WAC Compliant	Carbon Tetrachloride	Chromium (Total and Hexavalent)	Iodine-129	Nitrate	Technetium-99	Trichloroethene	Tritium	Uranium	Chloroform	Dichloromethane	Chloromethane	cis-1,2-Dichloroethene	Vinyl Chloride	Chloride	Nitrite	Total Organic Carbon	Total Dissolved Solids	Sulfate	Sulfide	Iron	Manganese	Alkalinity	Carbonate Content	Field Parameters
A7136	299-W10-1	RCRA, WMA T	U	N/1947	A	A	5	A	5	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A
A4891	299-W10-14	—	LU	N/1987	A	5	5	A	5	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A
C3125	299-W10-27	RCRA, WMA TX-TY	TU	C/2001	A	A	A	A	A	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A
C4989	299-W10-30	AEA and RCRA, LLWMA-3	TU	C/2006	A	5	5	A	5	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A
C5194	299-W10-31	AEA and RCRA, LLWMA-3	TU	C/2006	A	5	5	A	5	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A
C5855	299-W10-33	—	LU	C/2007	A	A	5	A	A	A	A	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A
A5465	299-W11-13	—	U	N/1961	A	A	A	A	A	A	A	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A
A7284	299-W11-18	—	TU	N/1967	A	A	A	A	5	A	A	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A
B2402	299-W11-33Q	—	TU	N/1994	A	A	A	A	A	A	A	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A
A4694	299-W11-43	—	LU	C/2005	A	A	A	A	A	A	A	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A
C4948	299-W11-45	RCRA, WMA T	UU	C/2005	A	A	A	A	A	A	A	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A
C4990	299-W11-47	RCRA, WMA T	U	C/2006	A	A	A	A	A	A	A	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A
C5243	299-W11-48	—	LU	C/2006	A	A	A	A	A	A	A	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A
C5407	299-W11-87	—	LU	C/2007	A	A	5	A	5	A	A	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A
C5572	299-W11-88	AEA, Ringold confined	LU	C/2007	A	A	A	A	5	A	A	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A
C4238	299-W13-1	—	MU	C/2004	A	5	5	A	5	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A
C9440	299-W13-2	—	LU	C/2015	A	A	A	A	A	A	A	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A
C4668	299-W14-11	RCRA, WMA TX-TY	UU	C/2005	A	A	A	A	A	A	A	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A

Table B-14. Sampling and Analysis Schedule for 200-ZP-1 Groundwater OU Well Network

Well ID	Well Number	Co-Sample	Hydro-geologic Unit	WAC Compliant	Carbon Tetrachloride	Chromium (Total and Hexavalent)	Iodine-129	Nitrate	Technetium-99	Trichloroethene	Tritium	Uranium	Chloroform	Dichloromethane	Chloromethane	cis-1,2-Dichloroethene	Vinyl Chloride	Chloride	Nitrite	Total Organic Carbon	Total Dissolved Solids	Sulfate	Sulfide	Iron	Manganese	Alkalinity	Carbonate Content	Field Parameters	
B8549	299-W14-13	DOH and RCRA, WMA TX-TY	TU	C/1998	A	A	A	A	A	A	A	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	5	A
B8547	299-W14-14	RCRA, WMA TX-TY	TU	C/1998	A	A	A	A	A	A	A	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	5	A
C5103	299-W14-72	—	LU	C/2006	A	5	5	A	5	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	5	A
A5474	299-W15-11	—	TU	N/1968	A	5	5	A	A	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	5	A
C4685	299-W15-152	AEA and RCRA, LLWMA-4	TU	C/2005	A	5	5	A	5	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	5	A
A4921	299-W15-17	AEA and RCRA, LLWMA-4	LU	C/1987	A	5	5	A	5	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	5	A
B2643	299-W15-33	—	UU	C/1995	A	5	5	A	A	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	5	A
C3803	299-W15-42	—	UU	C/2002	A	5	A	A	A	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	5	A
C3426	299-W15-46	—	UU	C/2003	A	5	5	A	A	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	5	A
C4301	299-W15-49	—	UU	C/2004	A	5	5	A	A	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	5	A
C4302	299-W15-50	—	MU	C/2005	A	5	5	A	A	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	5	A
A5476	299-W15-7	—	TU	N/1966	A	5	5	A	5	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	5	A
C3339	299-W15-763	RCRA, WMA TX-TY	TU	C/2001	A	5	5	A	A	A	A	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	5	A
C3397	299-W15-765	RCRA, WMA TX-TY	TU	C/2001	A	A	5	A	A	A	A	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	5	A
C4683	299-W15-83	AEA and RCRA, LLWMA-4	TU	C/2005	A	5	5	A	5	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	5	A
C4684	299-W15-94	AEA and RCRA, LLWMA-4	TU	C/2005	A	5	5	A	5	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	5	A

Table B-14. Sampling and Analysis Schedule for 200-ZP-1 Groundwater OU Well Network

Well ID	Well Number	Co-Sample	Hydro-geologic Unit	WAC Compliant	Carbon Tetrachloride	Chromium (Total and Hexavalent)	Iodine-129	Nitrate	Technetium-99	Trichloroethene	Tritium	Uranium	Chloroform	Dichloromethane	Chloromethane	cis-1,2-Dichloroethene	Vinyl Chloride	Chloride	Nitrite	Total Organic Carbon	Total Dissolved Solids	Sulfate	Sulfide	Iron	Manganese	Alkalinity	Carbonate Content	Field Parameters
A5481	299-W18-1	—	U	N/1959	A	5	A	A	A	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A
C4303	299-W18-16	—	TU	C/2004	A	5	5	A	A	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A
C9439	299-W5-2	—	LU	C/2015	A	A	A	A	A	A	A	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A
A4998	299-W6-3	—	LU	N/1991	A	5	5	A	A	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A
A5001	299-W6-6	AEA, Ringold confined, SALDS	LU	N/1991	A	5	5	A	A	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A
A5009	299-W7-3	AEA, Ringold confined, SALDS	LU	N/1987	A	5	5	A	5	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A
C5573	699-43-69	AEA, Ringold confined	CR	C/2007	A	A	5	A	5	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A
A5188	699-44-64	—	TU	N/1960	A	5	5	A	A	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A
A5196	699-45-69A	—	TU	N/1948	A	5	5	A	5	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A
C5574	699-45-69C	AEA, Ringold confined	MU	C/2007	A	5	5	A	5	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A
A5202	699-47-60	200-BP-5, AEA, Ringold confined	TU	N/1948	A	5	5	A	5	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A
A5214	699-48-71	SALDS	TU	N/1956	A	A	A	A	A	A	A	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A
C4697	699-50-74	—	TU	C/2005	A	5	5	A	5	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A
A5231	699-51-63	—	TU	N/1956	A	5	5	A	5	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A
C5102	299-W14-71	—	LU	C/2006	A	—	—	—	—	A	—	—	A	A	A	A	A	—	—	—	—	—	—	—	—	—	—	A
B2753	299-W15-37	200-UP-1	UU	C/1996	A	—	—	—	—	A	—	—	A	A	A	A	A	—	—	—	—	—	—	—	—	—	—	A
A4932	299-W18-15	200-UP-1	TU	N/1980	A	—	—	—	—	A	—	—	A	A	A	A	A	—	—	—	—	—	—	—	—	—	—	A

Table B-14. Sampling and Analysis Schedule for 200-ZP-1 Groundwater OU Well Network

Well ID	Well Number	Co-Sample	Hydro-geologic Unit	WAC Compliant	Carbon Tetrachloride	Chromium (Total and Hexavalent)	Iodine-129	Nitrate	Technetium-99	Trichloroethene	Tritium	Uranium	Chloroform	Dichloromethane	Chloromethane	cis-1,2-Dichloroethene	Vinyl Chloride	Chloride	Nitrite	Total Organic Carbon	Total Dissolved Solids	Sulfate	Sulfide	Iron	Manganese	Alkalinity	Carbonate Content	Field Parameters
A4933	299-W18-21	AEA and RCRA, LLWMA-4, 200-UP-1	TU	C/1987	A	—	—	—	—	A	—	—	A	A	A	A	A	—	—	—	—	—	—	—	—	—	—	A
A4934	299-W18-22	AEA and RCRA, LLWMA-4, 200-UP-1	LU	C/1987	A	—	—	—	—	A	—	—	A	A	A	A	A	—	—	—	—	—	—	—	—	—	—	A
C3395	299-W18-40	AEA and RCRA, WMA U	TU	C/2001	A	—	—	—	—	A	—	—	A	A	A	A	A	—	—	—	—	—	—	—	—	—	—	A
C4968	299-W19-105	200-UP-1	TU	C/2005	A	—	—	—	—	A	—	—	A	A	A	A	A	—	—	—	—	—	—	—	—	—	—	A
C5193	299-W19-107	200-UP-1	UU	C/2006	A	—	—	—	—	A	—	—	A	A	A	A	A	—	—	—	—	—	—	—	—	—	—	A
A7743	299-W19-18	200-UP-1	TU	N/1985	A	—	—	—	—	A	—	—	A	A	A	A	A	—	—	—	—	—	—	—	—	—	—	A
A9517	299-W19-34A	200-UP-1	MU	C/1994	A	—	—	—	—	A	—	—	A	A	A	A	A	—	—	—	—	—	—	—	—	—	—	A
A9513	299-W19-34B	—	MU	C/1994	A	—	—	—	—	A	—	—	A	A	A	A	A	—	—	—	—	—	—	—	—	—	—	A
B2461	299-W19-36	200-UP-1	UU	C/1995	A	—	—	—	—	A	—	—	A	A	A	A	A	—	—	—	—	—	—	—	—	—	—	A
A4958	299-W19-4	200-UP-1	U	N/1960	A	—	—	—	—	A	—	—	A	A	A	A	A	—	—	—	—	—	—	—	—	—	—	A
B8551	299-W19-41	AEA and RCRA, WMA U	TU	C/1998	A	—	—	—	—	A	—	—	A	A	A	A	A	—	—	—	—	—	—	—	—	—	—	A
C4258	299-W19-47	AEA and RCRA, WMA U	TU	C/2004	A	—	—	—	—	A	—	—	A	A	A	A	A	—	—	—	—	—	—	—	—	—	—	A
C4300	299-W19-48	200-UP-1	UU	C/2004	A	—	—	—	—	A	—	—	A	A	A	A	A	—	—	—	—	—	—	—	—	—	—	A
C4695	299-W19-49	200-UP-1	TU	C/2005	A	—	—	—	—	A	—	—	A	A	A	A	A	—	—	—	—	—	—	—	—	—	—	A
A4959	299-W19-6	—	MU	N/1968	A	—	—	—	—	A	—	—	A	A	A	A	A	—	—	—	—	—	—	—	—	—	—	A
C4639	299-W21-2	200-UP-1	TU	C/2004	A	—	—	—	—	A	—	—	A	A	A	A	A	—	—	—	—	—	—	—	—	—	—	A

Table B-14. Sampling and Analysis Schedule for 200-ZP-1 Groundwater OU Well Network

Well ID	Well Number	Co-Sample	Hydro-geologic Unit	WAC Compliant	Carbon Tetrachloride	Chromium (Total and Hexavalent)	Iodine-129	Nitrate	Technetium-99	Trichloroethene	Tritium	Uranium	Chloroform	Dichloromethane	Chloromethane	cis-1,2-Dichloroethene	Vinyl Chloride	Chloride	Nitrite	Total Organic Carbon	Total Dissolved Solids	Sulfate	Sulfide	Iron	Manganese	Alkalinity	Carbonate Content	Field Parameters
C4667	299-W22-47	AEA, WMA S-SX	UU	C/2005	A	—	—	—	—	A	—	—	A	A	A	A	A	—	—	—	—	—	—	—	—	—	—	A
C4970	299-W22-72	AEA, WMA S-SX, 200-UP-1	TU	C/2006	A	—	—	—	—	A	—	—	A	A	A	A	A	—	—	—	—	—	—	—	—	—	—	A
C4971	299-W22-86	AEA, WMA S-SX, 200-UP-1	TU	C/2006	A	—	—	—	—	A	—	—	A	A	A	A	A	—	—	—	—	—	—	—	—	—	—	A
C4977	299-W22-87	200-UP-1	TU	C/2005	A	—	—	—	—	A	—	—	A	A	A	A	A	—	—	—	—	—	—	—	—	—	—	A
C4978	299-W22-88	200-UP-1	TU	C/2008	A	—	—	—	—	A	—	—	A	A	A	A	A	—	—	—	—	—	—	—	—	—	—	A
B8809	299-W23-19	AEA, WMA S-SX	TU	C/1999	A	—	—	—	—	A	—	—	A	A	A	A	A	—	—	—	—	—	—	—	—	—	—	A
A4987	299-W23-4	200-UP-1	U	N/1957	A	—	—	—	—	A	—	—	A	A	A	A	A	—	—	—	—	—	—	—	—	—	—	A
B8817	299-W26-13	RCRA, S-10, 200-UP-1	TU	C/1999	A	—	—	—	—	A	—	—	A	A	A	A	A	—	—	—	—	—	—	—	—	—	—	A
A5410	299-W27-2	RCRA, S-10	LU	C/1992	A	—	—	—	—	A	—	—	A	A	A	A	A	—	—	—	—	—	—	—	—	—	—	A
C4298	699-30-66	200-UP-1	LU	C/2004	A	—	—	—	—	A	—	—	A	A	A	A	A	—	—	—	—	—	—	—	—	—	—	A
A5128	699-32-62	200-UP-1	TU	N/1960	A	—	—	—	—	A	—	—	A	A	A	A	A	—	—	—	—	—	—	—	—	—	—	A
A5130	699-32-72A	200-UP-1	U	N/1957	A	—	—	—	—	A	—	—	A	A	A	A	A	—	—	—	—	—	—	—	—	—	—	A
C4974	699-33-75	RCRA, S-10, 200-UP-1	TU	C/2008	A	—	—	—	—	A	—	—	A	A	A	A	A	—	—	—	—	—	—	—	—	—	—	A
A5463	699-34-61	200-UP-1	TU	C/1993	A	—	—	—	—	A	—	—	A	A	A	A	A	—	—	—	—	—	—	—	—	—	—	A
A5139	699-35-66A	200-UP-1, ERDF	TU	N/1957	A	—	—	—	—	A	—	—	A	A	A	A	A	—	—	—	—	—	—	—	—	—	—	A
A5141	699-35-78A	200-UP-1	TU	N/1950	A	—	—	—	—	A	—	—	A	A	A	A	A	—	—	—	—	—	—	—	—	—	—	A
A5144	699-36-61A	—	TU	N/1948	A	—	—	—	—	A	—	—	A	A	A	A	A	—	—	—	—	—	—	—	—	—	—	A
C6219	699-36-66B	ERDF, 200-UP-1	TU	C/2007	A	—	—	—	—	A	—	—	A	A	A	A	A	—	—	—	—	—	—	—	—	—	—	A

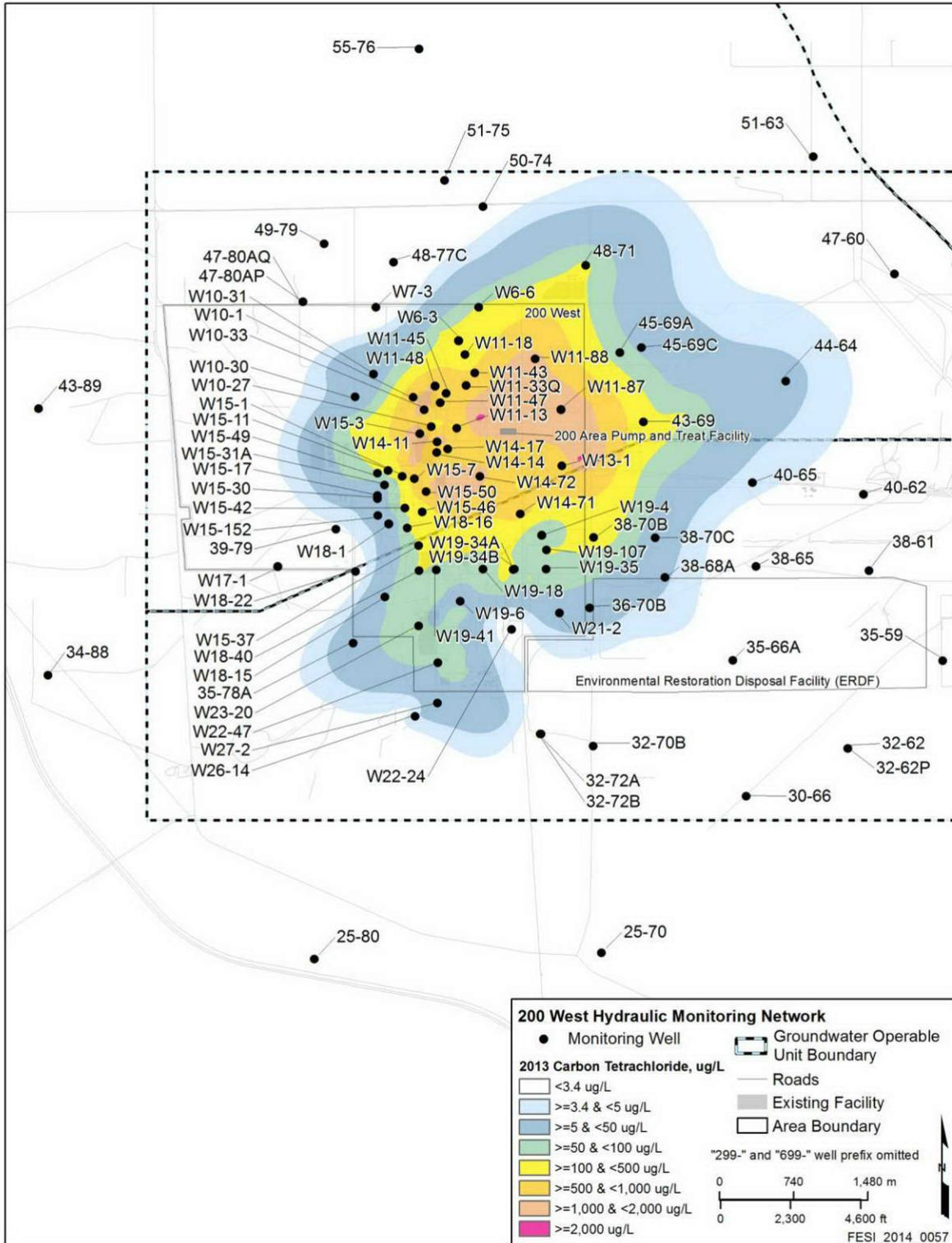
Table B-14. Sampling and Analysis Schedule for 200-ZP-1 Groundwater OU Well Network

Well ID	Well Number	Co-Sample	Hydro-geologic Unit	WAC Compliant	Carbon Tetrachloride	Chromium (Total and Hexavalent)	Iodine-129	Nitrate	Technetium-99	Trichloroethene	Tritium	Uranium	Chloroform	Dichloromethane	Chloromethane	cis-1,2-Dichloroethene	Vinyl Chloride	Chloride	Nitrite	Total Organic Carbon	Total Dissolved Solids	Sulfate	Sulfide	Iron	Manganese	Alkalinity	Carbonate Content	Field Parameters
A9901	699-36-70A	ERDF, DOH, 200-UP-1	TU	C/1994	A	—	—	—	—	A	—	—	A	A	A	A	A	—	—	—	—	—	—	—	—	—	—	A
C4299	699-36-70B	200-UP-1	TU	C/2004	A	—	—	—	—	A	—	—	A	A	A	A	A	—	—	—	—	—	—	—	—	—	—	A
C5704	699-37-66	ERDF, 200-UP-1	TU	C/2007	A	—	—	—	—	A	—	—	A	A	A	A	A	—	—	—	—	—	—	—	—	—	—	A
A5464	699-38-61	200-UP-1	TU	C/1993	A	—	—	—	—	A	—	—	A	A	A	A	A	—	—	—	—	—	—	—	—	—	—	A
A5148	699-38-65	200-UP-1	TU	N/1959	A	—	—	—	—	A	—	—	A	A	A	A	A	—	—	—	—	—	—	—	—	—	—	A
A9516	699-38-68A	200-UP-1	TU	C/1994	A	—	—	—	—	A	—	—	A	A	A	A	A	—	—	—	—	—	—	—	—	—	—	A
C4236	699-38-70B	200-UP-1	MU	C/2004	A	—	—	—	—	A	—	—	A	A	A	A	A	—	—	—	—	—	—	—	—	—	—	A
C4256	699-38-70C	200-UP-1	LU	C/2004	A	—	—	—	—	A	—	—	A	A	A	A	A	—	—	—	—	—	—	—	—	—	—	A
A5158	699-40-62	200-UP-1	TU	N/1949	A	—	—	—	—	A	—	—	A	A	A	A	A	—	—	—	—	—	—	—	—	—	—	A
C4235	699-40-65	200-UP-1	TU	C/2004	A	—	—	—	—	A	—	—	A	A	A	A	A	—	—	—	—	—	—	—	—	—	—	A

Note: Field parameters include temperature, dissolved oxygen, pH, turbidity, and oxidation-reduction measurements.

- A = sample annually
- AEA = alpha energy analysis
- 5 = sample every 5 years to coincide with preparation of the next *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* 5-year review
- = not sampled
- C = well construction is compliant with resource protection requirements of WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells"
- DOH = Department of Health
- ERDF = Environmental Restoration Disposal Facility
- ID = identification

- LLWMA = low-level waste management area
- LU = lower unconfined aquifer
- MU = middle unconfined aquifer
- N = well construction is not compliant with WAC 173-160
- RCRA = *Resource Conservation and Recovery Act of 1976*
- SALDS = State-Approved Land Disposal Site
- TU = top of unconfined aquifer
- U = unconfined aquifer
- UU = upper unconfined aquifer
- WMA = waste management area



1
 2

Figure B-7. Hydraulic Monitoring Network

1 Suggested sample container, preservation, and holding-time requirements are specified in Table B-12
2 for groundwater samples. These requirements are in accordance with the analytical methods
3 specified in Table B-9. The final container types and volumes will be identified on the SAF and
4 chain-of-custody form. This SAP defines a “sample” as a filled sample bottle for starting the clock for
5 holding-time restrictions.

6 Holding time is the elapsed time period between sample collection and analysis. Exceeding required
7 holding times could result in changes in constituent concentrations due to volatilization, decomposition,
8 or other chemical alterations. Required holding times depend on the analytical method, as specified in
9 appropriate EPA methods (e.g., EPA-600/4-79-020 or SW-846).

10 **B3.3.1 Decontamination of Sampling Equipment**

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

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

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

21 **B3.3.2 Radiological Field Data**

22 Alpha and beta/gamma data collection in the field will be used as needed to support sampling and
23 analysis efforts. Radiological screening will be performed by the RCT or other qualified personnel.
24 The RCT will record field measurements, noting the depth of the sample and the instrument reading.
25 Measurements will be relayed to the field geologist (for wells) for daily inclusion in the field logbook or
26 operational records, as applicable.

27 The following information will be distributed to personnel performing work in support of this SAP:

- 28 • Instructions to RCTs on the methods required to measure sample activity and media for gamma,
29 alpha, and/or beta emissions, as appropriate.
- 30 • Information regarding the portable radiological field instrumentation, including the following:
31 a physical description of the instruments, radiation and energy response characteristics,
32 calibration/maintenance and performance testing descriptions, and the application/operation of
33 the instrument. These instruments are commonly used on the Hanford Site to obtain measurements
34 of removable surface contamination measurements and direct measurements of the total
35 surface contamination.
- 36 • Instructions regarding the minimum requirements for documenting radiological controls information
37 in accordance with 10 CFR 835, “Occupational Radiation Protection.”
- 38 • Instructions for managing the identification, creation, review, approval, storage, transfer, and
39 retrieval of radiological information.

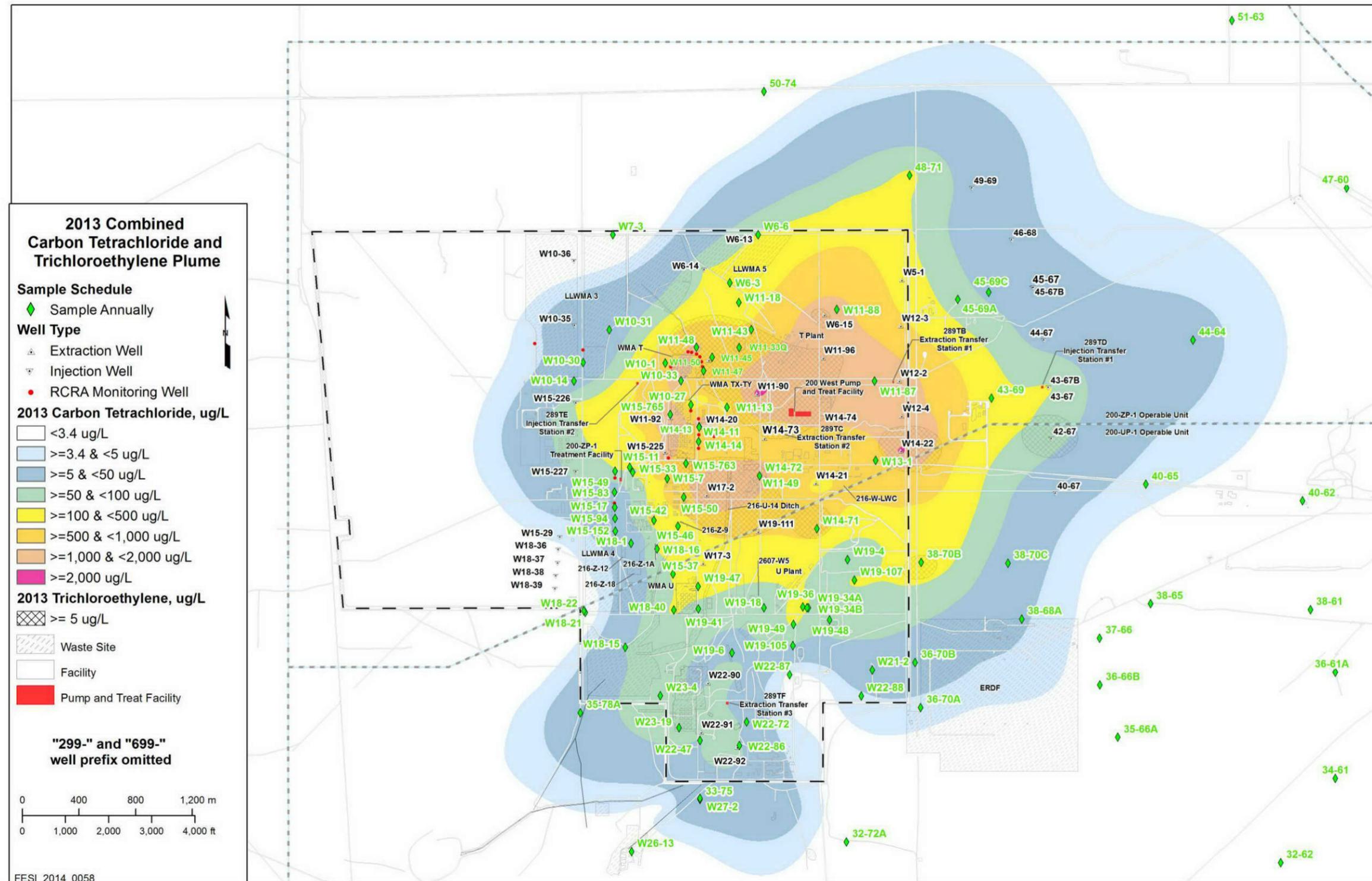


Figure B-8. Contaminant Monitoring Well Network (VOCs)

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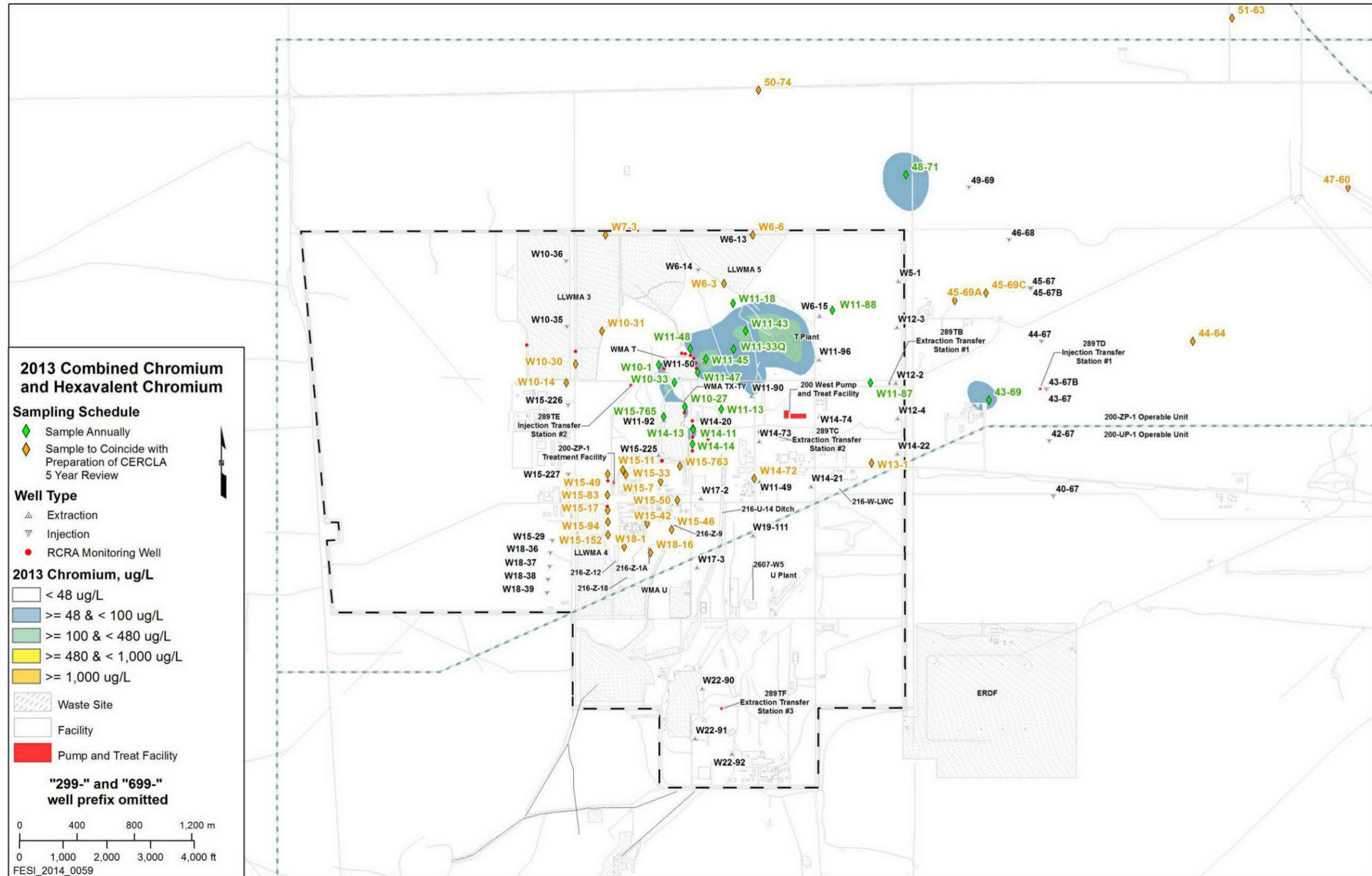


Figure B-9. Contaminant-Specific Monitoring Well Network (Chromium)

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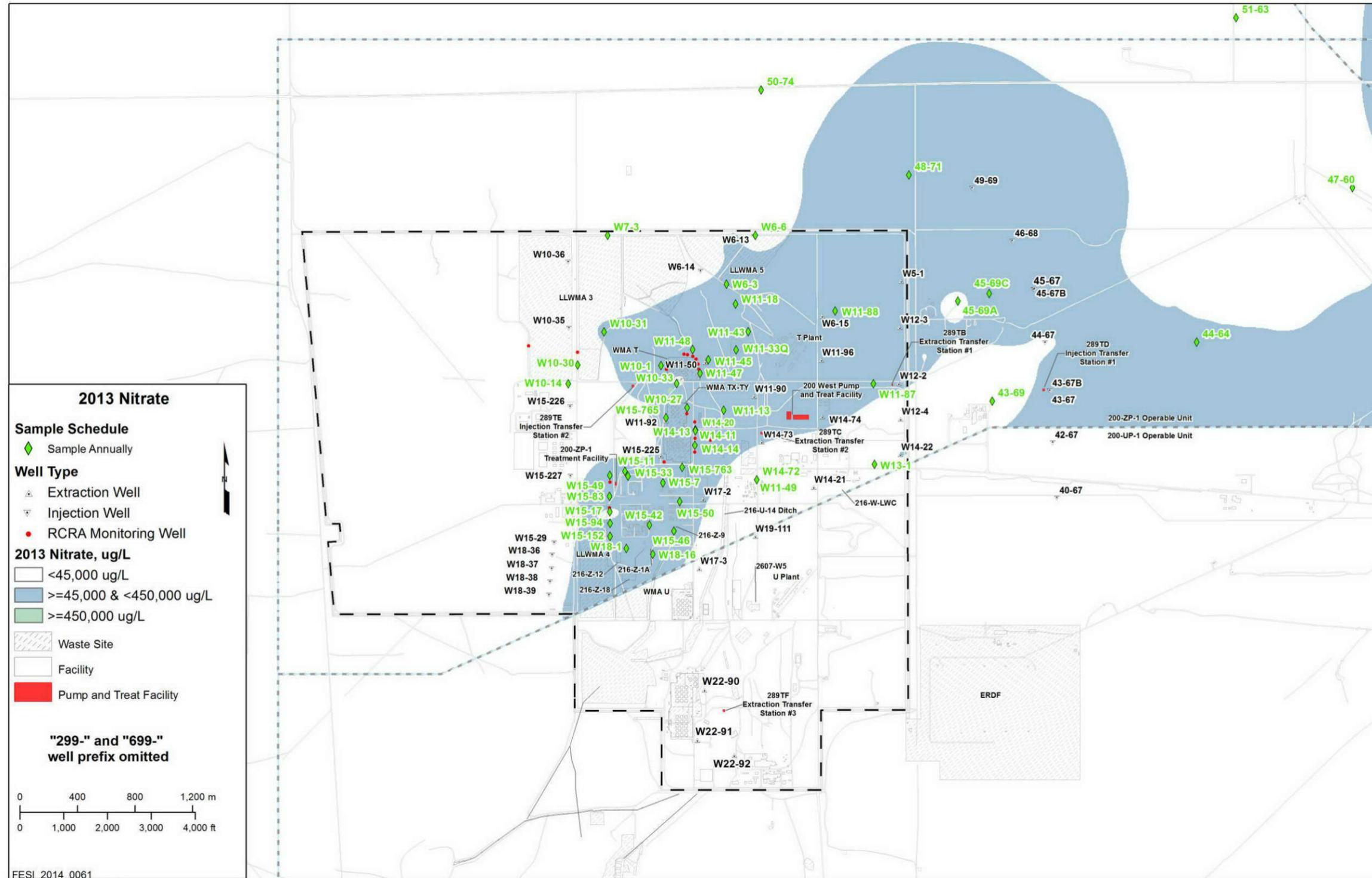


Figure B-11. Contaminant-Specific Monitoring Well Network (Nitrate)

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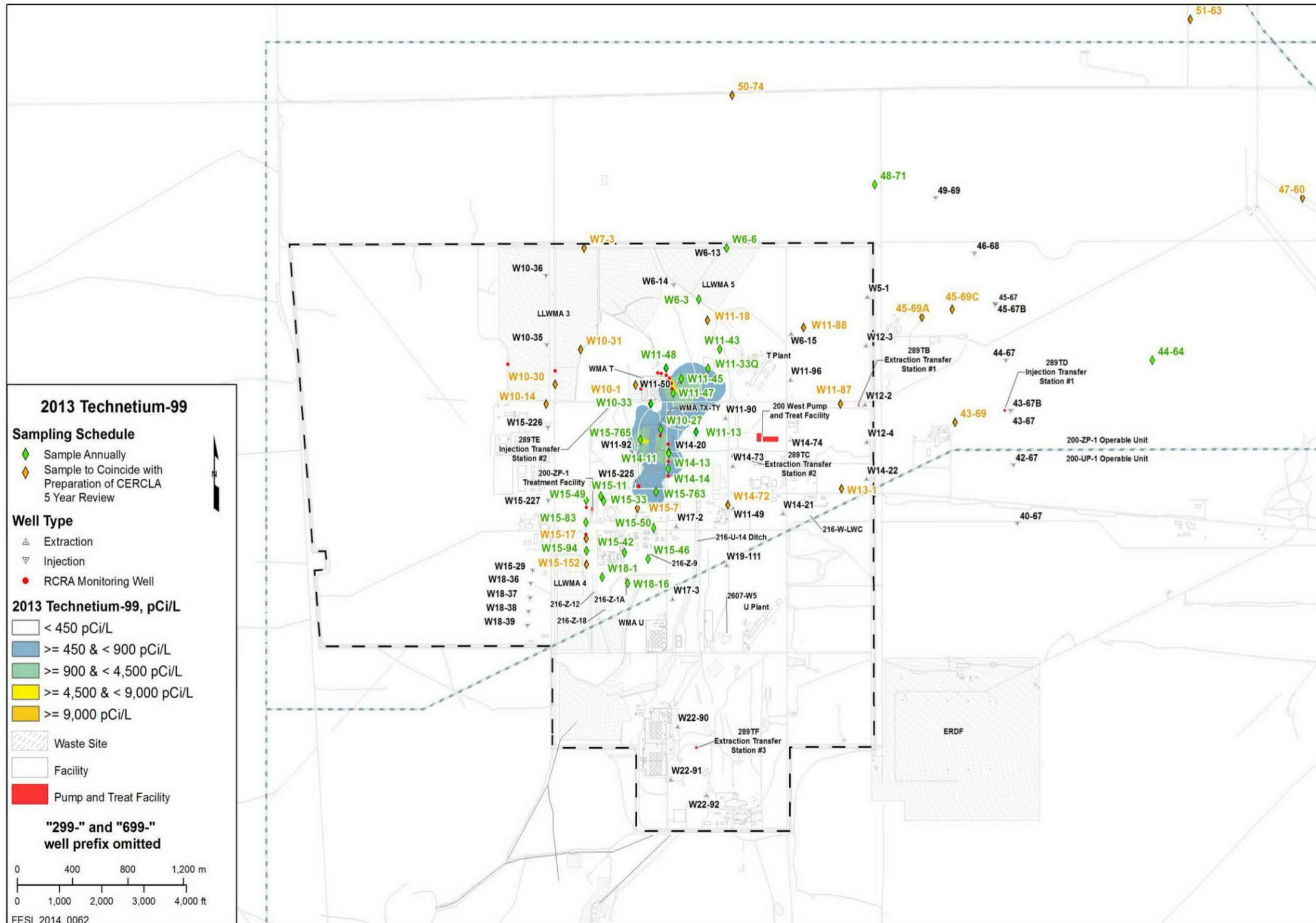


Figure B-12. Contaminant-Specific Monitoring Well Network (Technetium-99)

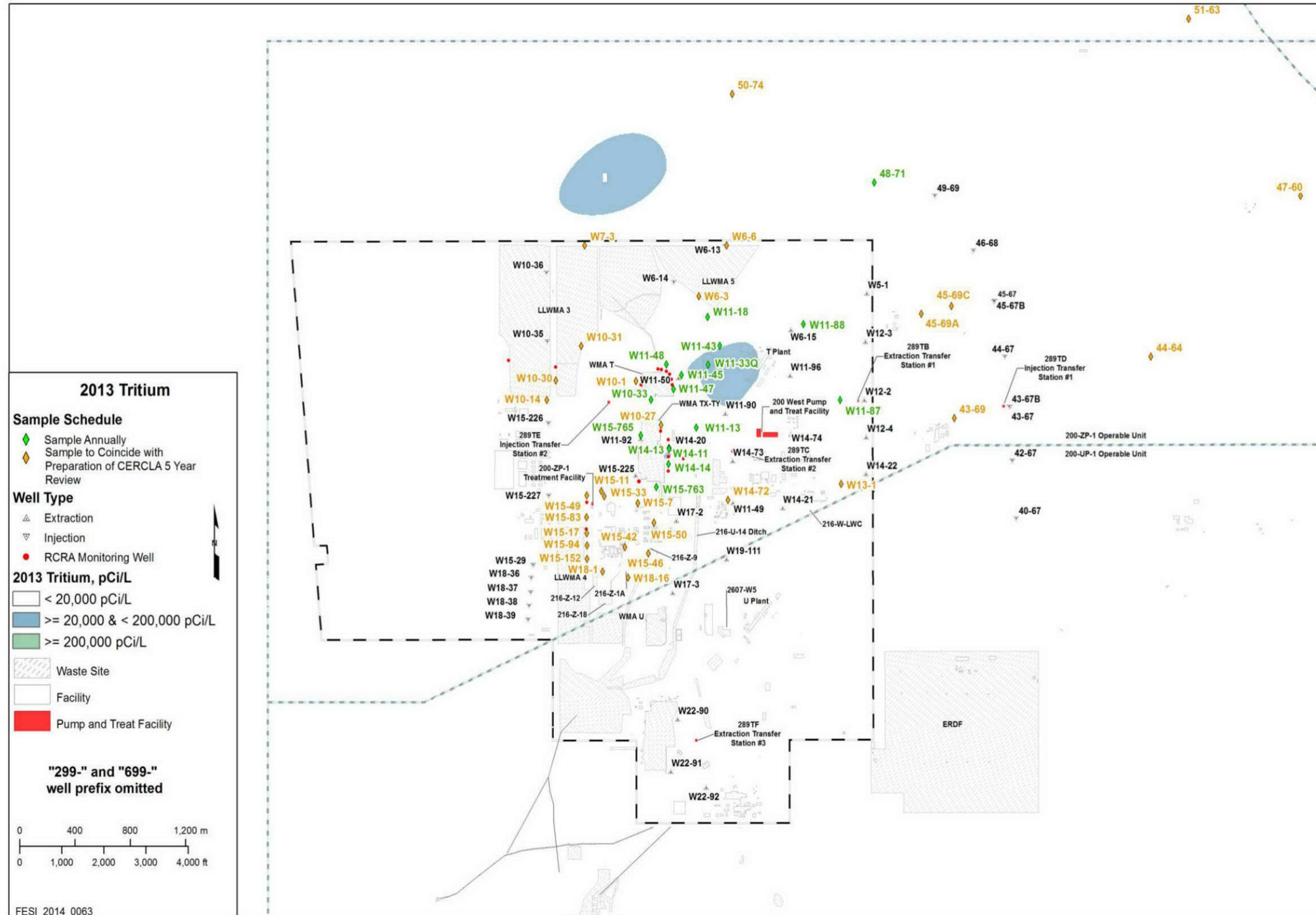


Figure B-13. Contaminant-Specific Monitoring Well Network (Tritium)

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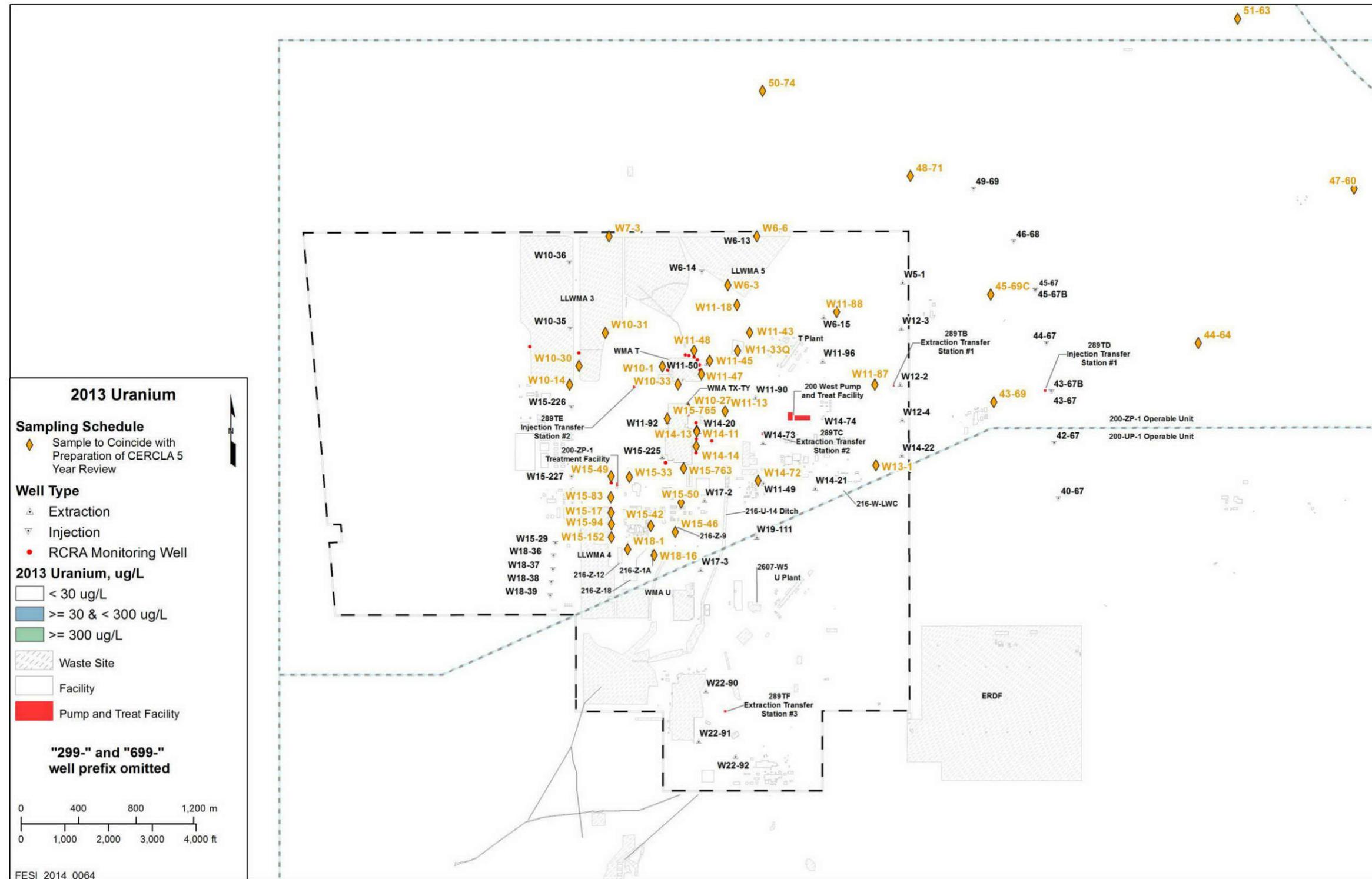


Figure B-14. Contaminant-Specific Monitoring Well Network (Uranium)

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- 1 • The minimum standards and practices necessary for preparing, performing, and retaining
2 radiological-related information.
- 3 • The requirements associated with preparing and transporting regulated material.
- 4 • Daily reports of radiological surveys and measurements collected during conduct of field
5 investigation activities. Data will be cross-referenced between laboratory analytical data and
6 radiation measurements to facilitate interpreting the investigation results.

7 **B3.3.3 Water Levels**

8 Groundwater levels are measured annually across the Hanford Site to construct water table maps that are
9 used to determine the direction and rate of groundwater flow in the unconfined aquifer (SGW-38815,
10 *Water-Level Monitoring Plan for the Hanford Site Soil and Groundwater Remediation Project*). Water
11 levels are also measured in wells that are screened in confined or partially confined aquifers to help
12 determine horizontal and vertical hydraulic gradients.

13 A measurement of depth to water is also recorded in each well prior to sampling using calibrated depth
14 measurement tapes. Two consecutive measurements are taken that agree within 6 mm (0.02 ft), and these
15 are recorded along with the date, time, and measuring tape number. The depth to groundwater is
16 subtracted from the elevation of a reference point (usually the top of casing) to obtain the water-level
17 elevation. The top of casing is a known elevation reference point because it has been surveyed to local
18 reference data.

19 **B3.4 Documentation of Field Activities**

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

28 Data forms may be used to collect field information; however, the information recorded on data forms
29 must follow the same requirements as those for logbooks. The data forms must be referenced in
30 the logbooks. A summary of information to be recorded on data forms or in logbooks is as follows:

- 31 • Purpose of activity
- 32 • Day, date, time, and weather conditions
- 33 • Names, titles, and organizations of personnel present
- 34 • Deviations from the QAPjP
- 35 • All site activities, including field tests
- 36 • Materials quality documentation (e.g., certifications)
- 37 • Details of samples collected (e.g., preparation, SPLITS, DUPs, MS, and EBs)
- 38 • Location and types of samples

- 1 • Chain-of-custody details and variances relating to the chain-of-custody
- 2 • Field measurements
- 3 • Field calibrations testing, inspections, maintenance and surveys, and equipment identification
- 4 numbers, as applicable
- 5 • Equipment decontaminated, number of decontaminations, and variations to decontamination methods
- 6 • Equipment failures or breakdowns and descriptions of any corrective actions
- 7 • Telephone calls relating to field activities

8 **B3.4.1 Corrective Actions and Deviations for Sampling Activities**

9 The OU project manager, FWS, appropriate BTR (or designee), and SMR personnel must document
10 deviations from protocols, problems pertaining to sample collection, chain-of-custody forms, target
11 analytes, contaminants, sample transport, or noncompliant monitoring. Examples of deviations include
12 samples not collected because of field conditions, changes in sample locations because of physical
13 obstructions, or additions of sample depth(s).

14 As appropriate, such deviations or problems will be documented (e.g., in the field logbook) in accordance
15 with internal corrective action methods. The OU project manager, FWS, appropriate BTR (or designee),
16 or SMR personnel will be responsible for communicating field corrective action requirements and for
17 ensuring immediate corrective actions are applied to field activities.

18 Changes in sample activities that require notification, approval, and documentation will be performed as
19 specified in Table B-8.

20 **B3.5 Calibration of Field Equipment**

21 Construction management, the appropriate BTR, or the FWS is responsible for ensuring that field
22 equipment is calibrated appropriately. Onsite environmental instruments are calibrated in accordance
23 with manufacturers' operating instructions, internal work requirements and processes, and/or field
24 instructions that provide direction for equipment calibration or verification of accuracy by analytical
25 methods. The results from all instrument calibration activities are recorded in accordance
26 with HASQARD (DOE/RL-96-68).

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

- 28 • Prior to initial use of a field analytical measurement system
- 29 • At the frequency recommended by the manufacturer or methods, or as required by regulations
- 30 • Upon failure to meet specified QC criteria

31 Calibration of radiological field instruments on the Hanford Site is performed by the Mission Support
32 Alliance prime contractor, as specified by their calibration program.

33 Daily calibration checks will be performed and documented for each instrument used to characterize areas
34 under investigation. These checks will be made on standard materials sufficiently like the matrix under
35 consideration for direct comparison of data. Analysis times will be sufficient to establish detection
36 efficiency and resolution.

1 Standards used for calibration will be traceable to nationally recognized standard agency source or
2 measurement system.

3 **B3.6 Sample Handling**

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

8 A sampling and data tracking database is used to track the samples from the point of collection through
9 the laboratory analysis process.

10 **B3.6.1 Containers**

11 Pre-cleaned sample containers with certificates of analysis denoting compliance with EPA specifications
12 (EPA 540/R-93/051, *Specifications and Guidance for Contaminant-Free Sample Containers*) for the
13 intended analyses will be used for samples collected for chemical analysis. Container sizes may vary
14 depending upon laboratory-specific volumes/requirements for meeting analytical detection limits.
15 The Radiological Engineering organization will measure the contamination levels and dose rates
16 associated with the filled sample containers. This information, along with other data, will be used to select
17 proper packaging, marking, labeling, and shipping paperwork and to verify that the sample can be
18 received by the analytical laboratory in accordance with the laboratory's radioactivity acceptance criteria.
19 If the dose rate on the outside of a sample container or the curie content exceeds levels acceptable by
20 an offsite laboratory, the FWS (in consultation with the SMR organization), can send smaller volumes to
21 the laboratory. Container types and sample amounts or volumes are identified in Table B-12.

22 **B3.6.2 Container Labeling**

23 Each sample container will be labeled with the following information on firmly affixed,
24 water-resistant labels:

- 25 • SAF
- 26 • HEIS number
- 27 • Sample collection date and time
- 28 • Analysis required
- 29 • Preservation method (if applicable)
- 30 • Chain-of-custody number
- 31 • Bottle type and size
- 32 • Laboratory performing the analyses
- 33 • Sample location

34 In addition, sample records must include the following information:

- 35 • Analysis required
- 36 • Source of sample
- 37 • Matrix (water)
- 38 • Field data (pH, temperature, turbidity, and conductivity)
- 39 • Radiological readings

1 **B3.6.3 Sample Custody**

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

7 Shipping requirements will determine how sample shipping containers are prepared for shipment.
8 The analyses requested for each sample will be indicated on the accompanying chain-of-custody form.
9 Each time the responsibility for the custody of the sample changes, the new and previous custodians will
10 sign the record and note the date and time. The sampler will make a copy of the signed record before
11 sample shipment and will transmit the copy to the SMR organization within 48 hours of shipping.

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

- 13 • Project name
- 14 • Signature of sampler
- 15 • Unique sample number
- 16 • Date and time of collection
- 17 • Matrix
- 18 • Preservatives
- 19 • Signatures of individual involved in sample transfer
- 20 • Requested analyses (or reference thereto)

21 Samplers should note any anomalies with the samples that would prevent batching. If anomalies are
22 found, the samplers should inform the SMR organization before adding any information regarding
23 batching on the chain-of-custody form.

24 **B3.6.4 Sample Transportation**

25 All packaging and transportation instructions shall be in compliance with applicable transportation
26 regulations and DOE requirements. Regulations for classifying, describing, packaging, marking, labeling,
27 and transporting hazardous materials, hazardous substances, and hazardous wastes are enforced by the
28 U.S. Department of Transportation (DOT) as described in 49 CFR 171, “Transportation,” “General
29 Information, Regulations, and Definitions,” through 177, “Carriage by Public Highway.” Carrier specific
30 requirements defined in the International Air Transportation Association’s *Dangerous Goods Regulations*
31 (IATA, 2013) shall also be used when preparing sample shipments conveyed by air freight providers.

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

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

1 Prior to shipping radioactive samples to the laboratory, the organization responsible for shipping
2 shall notify the laboratory of the approximate number and radiological levels of the samples.
3 This notification is conducted through the SMR organization's project coordinator. The laboratory is
4 responsible for ensuring that the applicable license limits are not exceeded. The laboratory shall provide
5 the SMR organization with written acceptance for samples with elevated radioactive contamination
6 or dose.

7 **B4 Management of Waste**

8 Waste materials are generated during sample collection, processing, and sub-sampling activities.
9 Waste will be managed in accordance with Appendix B of DOE/RL-2009-124, *200 West Pump and*
10 *Treat Operations and Maintenance Plan*.

11 Offsite analytical laboratories are responsible for the disposal of unused sample quantities. Pursuant to
12 40 CFR 300.440, "National Oil and Hazardous Substances Pollution Contingency Plan," "Procedures for
13 Planning and Implementing Off-Site Response Actions," approval from the DOE remedial project
14 manager is required before returning unused samples or waste from offsite laboratories.

15 **B5 Health and Safety**

16 The hazardous waste operations safety and health program was established to ensure the safety and health
17 of workers involved in hazardous waste site activities. The program was developed to comply with the
18 requirements of 29 CFR 1910.120, "Occupational Safety and Health Standards," "Hazardous Waste
19 Operations and Emergency Response," and 10 CFR 835. The health and safety program defines the
20 chemical, radiological, and physical hazards and specifies the controls and requirements for day-to-day
21 work activities on the Hanford Site. Personal training, control of industrial safety and radiological
22 hazards, personal protective equipment, site control, and general emergency response to spills, fire,
23 accidents, injury, site visitors, and incident reporting are governed by the health and safety program.

24 **B6 References**

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27 [idx?SID=ad0c92c54c54be8ce01de5ecce952fda&mc=true&node=pt10.4.835&rgn=div5](http://www.ecfr.gov/cgi-bin/text-idx?SID=ad0c92c54c54be8ce01de5ecce952fda&mc=true&node=pt10.4.835&rgn=div5).

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31 [idx?SID=ad0c92c54c54be8ce01de5ecce952fda&mc=true&node=pt29.5.1910&rgn=div5#se29.5.](http://www.ecfr.gov/cgi-bin/text-idx?SID=ad0c92c54c54be8ce01de5ecce952fda&mc=true&node=pt29.5.1910&rgn=div5#se29.5.1910_1120)
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36 [idx?SID=19ced5634bd68b173b0730bd8e5472eb&mc=true&node=pt40.28.300&rgn=div5#se40.](http://www.ecfr.gov/cgi-bin/text-idx?SID=19ced5634bd68b173b0730bd8e5472eb&mc=true&node=pt40.28.300&rgn=div5#se40.28.300_1440)
37 [28.300_1440](http://www.ecfr.gov/cgi-bin/text-idx?SID=19ced5634bd68b173b0730bd8e5472eb&mc=true&node=pt40.28.300&rgn=div5#se40.28.300_1440).

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- 3 49 CFR 171, “General Information, Regulations, and Definitions.”
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Appendix C
200-ZP-1 Operable Unit
Contaminant Monitoring Well Network

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C1 200-ZP-1 Operable Unit Contaminant Monitoring Well Network

Table C-1 provides details on the 200-ZP-1 Operable Unit (OU) contaminant monitoring well network for volatile organics, and Table C-2 provides details of the monitoring network for the other contaminants of concern (COCs), which are a subset of the volatile organics network. Table C-3 provides the details of the contaminant-specific well networks and their sampling schedules.

Table C-1. 200-ZP-1 OU Contaminant Monitoring Well Network for Volatile Organics

Well Name	Easting (m)	Northing (m)	Surface Elevation (m)	Screen Top Elevation (m)	Screen Bottom Elevation (m)	Date Drilled	Mid-Screen Elevation ^a (m)
299-W10-1	566663	136735	207.5	149.5	125.2	8/7/47	137.4
299-W10-14	566017	136609	214.3	84.1	78.0	11/18/87	81.1
299-W10-27	566844	136442	205.6	138.3	127.6	3/23/01	132.9
299-W10-30	566083	136739	211.6	137.8	127.1	3/14/06	132.4
299-W10-31	566266	136968	210.4	137.3	126.6	4/20/06	131.9
299-W10-33	566773	136610	206.0	87.1	81.0	6/15/07	84.1
299-W11-13	567099	136424	211.9	145.5	68.4	7/31/61	106.9
299-W11-18	567182	137161	216.5	147.3	126.6	3/1/67	137.0
299-W11-33Q	567185	136844	217.2	142.8	126.1	9/9/94	134.4
299-W11-43	567270	136971	217.5	88.1	83.5	5/23/05	85.8
299-W11-45	566993	136776	213.6	127.9	123.4	9/2/05	125.7
299-W11-47	566934	136681	210.4	126.8	117.5	1/6/06	122.2
299-W11-48	566882	136846	209.7	125.1	97.7	11/29/06	111.4
299-W11-87	568141	136609	223.6	107.3	102.7	3/1/07	105.0
299-W11-88	567875	137113	221.9	86.2	74.0	10/3/07	80.1
299-W13-1	568149	136049	223.5	104.4	93.7	2/10/04	99.1
299-W13-2	568833	135819	225.3	128.4	104.3	3/21/2016	116.4
299-W14-11	566902	136288	205.1	125.3	122.3	4/26/05	123.1
299-W14-13	566902	136282	205.1	138.7	128.7	8/31/98	133.7
299-W14-14	566898	136181	205.4	139.3	128.6	11/12/98	134.0
299-W14-71	567733	135568	219.4	94.2	89.7	7/27/06	92.0
299-W14-72	567328	135941	216.4	90.2	85.6	8/15/06	87.9
299-W15-11	566412	136001	208.3	152.5	117.8	3/18/68	135.2
299-W15-152	566309	135550	209.9	137.9	127.3	9/15/05	132.6
299-W15-17	566307	135719	209.8	81.0	78.0	10/28/87	79.5

Table C-1. 200-ZP-1 OU Contaminant Monitoring Well Network for Volatile Organics

Well Name	Easting (m)	Northing (m)	Surface Elevation (m)	Screen Top Elevation (m)	Screen Bottom Elevation (m)	Date Drilled	Mid-Screen Elevation^a (m)
299-W15-33	566433	135967	206.8	142.4	127.9	12/31/95	135.2
299-W15-37	566716	135248	203.0	140.3	125.1	5/16/96	132.7
299-W15-42	566582	135627	207.4	137.9	122.7	2/26/02	130.3
299-W15-46	566752	135587	204.2	140.4	116.0	10/3/03	128.2
299-W15-49	566307	135973	209.1	137.3	126.6	11/1/04	131.9
299-W15-50	566793	135791	203.2	129.0	118.4	2/28/05	123.7
299-W15-7	566676	135920	204.2	148.8	97.6	3/30/66	123.2
299-W15-763	566809	136029	202.9	138.4	127.7	1/17/01	133.1
299-W15-765	566697	136373	205.3	138.2	127.6	10/4/01	132.9
299-W15-83	566305	135826	209.3	137.7	127.0	8/9/05	132.4
299-W15-94	566308	135640	209.9	137.9	127.2	9/19/05	132.6
299-W18-1	566422	135465	209.1	149.6	79.5	1/12/59	113.8
299-W18-15	566380	134733	202.2	142.8	118.7	4/25/80	130.7
299-W18-16	566605	135426	208.6	137.1	126.4	10/20/04	131.8
299-W18-21	566098	134979	204.9	145.3	136.2	7/29/87	140.7
299-W18-22	566089	134990	204.9	77.9	68.5	9/25/87	73.2
299-W18-40	566723	134996	203.4	136.9	126.2	9/28/01	131.6
299-W19-105	567565	134745	213.0	135.2	124.5	12/13/05	129.8
299-W19-107	567998	135206	217.4	122.8	118.2	3/31/06	120.5
299-W19-18	567361	135012	214.0	146.9	104.9	12/12/85	125.9
299-W19-34A	567674	135012	215.3	116.5	111.8	5/18/94	113.3
299-W19-34B	567663	135011	215.5	90.0	87.1	11/9/94	87.6
299-W19-36	567635	135017	215.4	140.8	127.1	9/1/95	133.9
299-W19-4	567950	135351	219.0	141.3	56.0	2/15/60	98.3
299-W19-41	566897	135005	206.5	139.5	128.8	9/23/98	134.1
299-W19-47	566895	135162	206.3	137.1	126.4	6/1/04	131.7
299-W19-48	567823	134926	212.9	133.0	122.3	10/5/04	127.6
299-W19-49	567568	134894	214.2	135.1	124.5	8/30/05	129.8
299-W19-6	567133	134694	210.3	94.5	85.1	12/13/68	89.8
299-W21-2	568124	134574	214.9	135.6	124.9	11/22/04	130.2
299-W22-47	566909	134076	206.3	136.6	125.9	1/19/05	131.2

Table C-1. 200-ZP-1 OU Contaminant Monitoring Well Network for Volatile Organics

Well Name	Easting (m)	Northing (m)	Surface Elevation (m)	Screen Top Elevation (m)	Screen Bottom Elevation (m)	Date Drilled	Mid-Screen Elevation ^a (m)
299-W22-72	567237	134207	208.0	135.8	125.1	2/22/06	130.5
299-W22-86	567187	134041	206.4	135.9	125.2	3/10/06	130.5
299-W22-87	567542	134540	212.0	135.7	125.1	12/14/05	130.4
299-W22-88	568046	134391	213.9	134.3	123.7	2/6/08	129.0
299-W23-19	566759	134167	202.5	139.5	136.4	11/17/99	137.9
299-W23-4	566628	134392	203.0	148.1	111.6	6/18/57	129.9
299-W26-13	566424	133294	199.8	138.2	127.5	12/28/99	132.8
299-W27-2	566908	133670	207.4	83.6	80.5	12/18/92	82.1
299-W5-2	568175	137621	216.9	111.7	87.4	12/1/2015	99.5
299-W6-3	567118	137299	214.4	89.5	86.4	10/15/91	88.0
299-W6-6	567319	137639	217.5	89.9	86.6	10/24/91	88.3
299-W7-3	566292	137639	207.2	70.3	61.9	11/23/87	66.1
699-30-66	569991	132739	210.5	93.1	90.1	10/13/04	91.6
699-32-62	571010	133216	216.6	132.7	64.2	4/6/60	98.5
699-32-72A	567943	133363	204.7	76.7	56.8	7/31/57	66.7
699-33-75	566908	133662	207.4	135.7	125.1	1/8/08	130.4
699-34-61	571396	133810	221.8	129.4	123.3	11/29/93	126.3
699-35-66A	569858	134099	222.5	143.2	124.3	6/13/57	133.8
699-35-78A	566064	134271	202.4	147.5	117.3	8/17/50	132.0
699-36-61A	571395	134557	229.0	128.4	110.5	8/12/48	119.5
699-36-66B	569731	134469	221.3	131.7	121.0	12/20/07	126.4
699-36-70A	568467	134309	216.0	137.6	128.4	12/10/94	132.2
699-36-70B	568428	134626	215.2	134.7	124.1	6/9/04	129.4
699-37-66	569730	134797	222.0	131.3	120.6	11/28/07	126.0
699-38-61	571219	134997	228.2	126.3	120.2	11/16/93	123.3
699-38-65	570090	135040	230.7	163.7	72.2	12/31/59	117.9
699-38-68A	569180	134932	218.9	137.3	128.2	6/21/94	132.0
699-38-70B	568469	135331	222.6	98.6	94.0	2/3/04	96.3
699-38-70C	569084	135326	226.7	106.1	101.5	2/17/04	103.8
699-40-62	571164	135764	228.9	126.8	115.0	1/17/49	120.9
699-40-65	570057	135881	231.0	130.2	119.5	2/3/04	124.1

Table C-1. 200-ZP-1 OU Contaminant Monitoring Well Network for Volatile Organics

Well Name	Easting (m)	Northing (m)	Surface Elevation (m)	Screen Top Elevation (m)	Screen Bottom Elevation (m)	Date Drilled	Mid-Screen Elevation ^a (m)
699-43-69	568967	136488	227.4	105.4	94.7	12/11/07	100.1
699-44-64	570391	136897	222.2	125.9	87.5	1/31/60	106.7
699-45-69A	568729	137183	222.1	138.6	110.6	6/22/48	124.6
699-45-69C	568947	137234	222.6	110.7	106.1	7/13/07	108.4
699-47-60	571474	137969	199.6	123.4	115.1	7/20/48	118.5
699-48-71	568388	138057	210.9	138.0	118.8	9/26/56	128.4
699-50-74	567360	138647	201.4	133.3	122.7	7/12/05	128.0
699-51-63	570664	139148	175.3	127.4	119.5	11/6/56	123.5

a. Mid-screen elevations were obtained from the 2008 carbon tetrachloride plume shell data set.

b. Require maintenance prior to sampling.

OU = Operable Unit

1
2

Table C-2. 200-ZP-1 OU Contaminant Monitoring Well Network

Well Name	Easting (m)	Northing (m)	Surface Elevation (m)	Screen Top Elevation (m)	Screen Bottom Elevation (m)	Date Drilled	Mid-Screen Elevation* (m)
299-W10-1	566663	136735	207.5	149.5	125.2	8/7/47	137.4
299-W10-14	566017	136609	214.3	84.1	78.0	11/18/87	81.1
299-W10-27	566844	136442	205.6	138.3	127.6	3/23/01	132.9
299-W10-30	566083	136739	211.6	137.8	127.1	3/14/06	132.4
299-W10-31	566266	136968	210.4	137.3	126.6	4/20/06	131.9
299-W10-33	566773	136610	206.0	87.1	81.0	6/15/07	84.1
299-W11-13	567099	136424	211.9	145.5	68.4	7/31/61	106.9
299-W11-18	567182	137161	216.5	147.3	126.6	3/1/67	137.0
299-W11-33Q	567185	136844	217.2	142.8	126.1	9/9/94	134.4
299-W11-43	567270	136971	217.5	88.1	83.5	5/23/05	85.8
299-W11-45	566993	136776	213.6	127.9	123.4	9/2/05	125.7
299-W11-47	566934	136681	210.4	126.8	117.5	1/6/06	122.2
299-W11-48	566882	136846	209.7	125.1	97.7	11/29/06	111.4
299-W11-87	568141	136609	223.6	107.3	102.7	3/1/07	105.0
299-W11-88	567875	137113	221.9	86.2	74.0	10/3/07	80.1
299-W13-1	568149	136049	223.5	104.4	93.7	2/10/04	99.1
299-W13-2	568833	135819	225.3	128.4	104.3	3/21/2016	116.4
299-W14-11	566902	136288	205.1	125.3	122.3	4/26/05	123.1
299-W14-13	566902	136282	205.1	138.7	128.7	8/31/98	133.7
299-W14-14	566898	136181	205.4	139.3	128.6	11/12/98	134.0
299-W14-72	567328	135941	216.4	90.2	85.6	8/15/06	87.9
299-W15-11	566412	136001	208.3	152.5	117.8	3/18/68	135.2
299-W15-152	566309	135550	209.9	137.9	127.3	9/15/05	132.6
299-W15-17	566307	135719	209.8	81.0	78.0	10/28/87	79.5
299-W15-33	566433	135967	206.8	142.4	127.9	12/31/95	135.2
299-W15-42	566582	135627	207.4	137.9	122.7	2/26/02	130.3
299-W15-46	566752	135587	204.2	140.4	116.0	10/3/03	128.2
299-W15-49	566307	135973	209.1	137.3	126.6	11/1/04	131.9
299-W15-50	566793	135791	203.2	129.0	118.4	2/28/05	123.7
299-W15-7	566676	135920	204.2	148.8	97.6	3/30/66	123.2
299-W15-763	566809	136029	202.9	138.4	127.7	1/17/01	133.1

Table C-2. 200-ZP-1 OU Contaminant Monitoring Well Network

Well Name	Easting (m)	Northing (m)	Surface Elevation (m)	Screen Top Elevation (m)	Screen Bottom Elevation (m)	Date Drilled	Mid-Screen Elevation* (m)
299-W15-765	566697	136373	205.3	138.2	127.6	10/4/01	132.9
299-W15-83	566305	135826	209.3	137.7	127.0	8/9/05	132.4
299-W15-94	566308	135640	209.9	137.9	127.2	9/19/05	132.6
299-W18-1	566422	135465	209.1	149.6	79.5	1/12/59	113.8
299-W18-16	566605	135426	208.6	137.1	126.4	10/20/04	131.8
299-W5-2	568175	137621	216.9	111.7	87.4	12/1/2015	99.5
299-W6-3	567118	137299	214.4	89.5	86.4	10/15/91	88.0
299-W6-6	567319	137639	217.5	89.9	86.6	10/24/91	88.3
299-W7-3	566292	137639	207.2	70.3	61.9	11/23/87	66.1
699-43-69	568967	136488	227.4	105.4	94.7	12/11/07	100.1
699-44-64	570391	136897	222.2	125.9	87.5	1/31/60	106.7
699-45-69A	568729	137183	222.1	138.6	110.6	6/22/48	124.6
699-45-69C	568947	137234	222.6	110.7	106.1	7/13/07	108.4
699-47-60	571474	137969	199.6	123.4	115.1	7/20/48	118.5
699-48-71	568388	138057	210.9	138.0	118.8	9/26/56	128.4
699-50-74	567360	138647	201.4	133.3	122.7	7/12/05	128.0
699-51-63	570664	139148	175.3	127.4	119.5	11/6/56	123.5

* Mid-screen elevations were obtained from the 2008 carbon tetrachloride plume shell data set.
 OU = Operable Unit

Table C-3. 200-ZP-1 Monitoring Well Schedule for Analyses

Well	Carbon Tetrachloride	Total and Hexavalent Chromium	Iodine-129	Nitrate	Technetium-99	Trichloroethylene	Tritium	Uranium	Chloroform	Dichloromethane	Chloromethane	cis-1,2-Dichloroethene	Vinyl Chloride	Chloride	Nitrite	Total Organic Carbon	Total Dissolved Solids	Sulfate	Sulfide	Iron	Manganese	Alkalinity	Carbonate content	Temperature	pH	Specific Conductance	Turbidity	Dissolved Oxygen	Redox Potential
299-W10-1	A	A	5	A	5	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A	A	A	A	A	A
299-W10-14	A	5	5	A	5	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A	A	A	A	A	A
299-W10-27	A	A	A	A	A	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A	A	A	A	A	A
299-W10-30	A	5	5	A	5	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A	A	A	A	A	A
299-W10-31	A	5	5	A	5	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A	A	A	A	A	A
299-W10-33	A	A	5	A	A	A	A	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A	A	A	A	A	A
299-W11-13	A	A	A	A	A	A	A	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A	A	A	A	A	A
299-W11-18	A	A	A	A	5	A	A	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A	A	A	A	A	A
299-W11-33Q	A	A	A	A	A	A	A	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A	A	A	A	A	A
299-W11-43	A	A	A	A	A	A	A	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A	A	A	A	A	A
299-W11-45	A	A	A	A	A	A	A	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A	A	A	A	A	A
299-W11-47	A	A	A	A	A	A	A	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A	A	A	A	A	A
299-W11-48	A	A	A	A	A	A	A	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A	A	A	A	A	A
299-W11-87	A	A	5	A	5	A	A	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A	A	A	A	A	A
299-W11-88	A	A	A	A	5	A	A	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A	A	A	A	A	A
299-W13-1	A	5	5	A	5	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A	A	A	A	A	A
299-W13-2	A	A	A	A	A	A	A	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A	A	A	A	A	A
299-W14-11	A	A	A	A	A	A	A	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A	A	A	A	A	A
299-W14-13	A	A	A	A	A	A	A	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A	A	A	A	A	A
299-W14-14	A	A	A	A	A	A	A	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A	A	A	A	A	A
299-W14-72	A	5	5	A	5	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A	A	A	A	A	A
299-W15-11	A	5	5	A	A	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A	A	A	A	A	A
299-W15-152	A	5	5	A	5	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A	A	A	A	A	A
299-W15-17	A	5	5	A	5	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A	A	A	A	A	A
299-W15-33	A	5	5	A	5	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A	A	A	A	A	A
299-W15-42	A	5	A	A	A	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A	A	A	A	A	A
299-W15-46	A	5	5	A	A	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A	A	A	A	A	A
299-W15-49	A	5	5	A	A	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A	A	A	A	A	A

Table C-3. 200-ZP-1 Monitoring Well Schedule for Analyses

Well	Carbon Tetrachloride	Total and Hexavalent Chromium	Iodine-129	Nitrate	Technetium-99	Trichloroethylene	Tritium	Uranium	Chloroform	Dichloromethane	Chloromethane	cis-1,2-Dichloroethene	Vinyl Chloride	Chloride	Nitrite	Total Organic Carbon	Total Dissolved Solids	Sulfate	Sulfide	Iron	Manganese	Alkalinity	Carbonate content	Temperature	pH	Specific Conductance	Turbidity	Dissolved Oxygen	Redox Potential	
299-W15-50	A	5	5	A	A	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A	A	A	A	A	A	A
299-W15-7	A	5	5	A	5	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A	A	A	A	A	A	A
299-W15-763	A	5	5	A	A	A	A	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A	A	A	A	A	A	A
299-W15-765	A	A	5	A	A	A	A	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A	A	A	A	A	A	A
299-W15-83	A	5	5	A	5	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A	A	A	A	A	A	A
299-W15-94	A	5	5	A	5	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A	A	A	A	A	A	A
299-W18-1	A	5	A	A	A	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A	A	A	A	A	A	A
299-W18-16	A	5	5	A	A	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A	A	A	A	A	A	A
299-W5-2	A	A	A	A	A	A	A	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A	A	A	A	A	A	A
299-W6-3	A	5	5	A	A	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A	A	A	A	A	A	A
299-W6-6	A	5	5	A	A	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A	A	A	A	A	A	A
299-W7-3	A	5	5	A	5	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A	A	A	A	A	A	A
699-43-69	A	A	5	A	5	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A	A	A	A	A	A	A
699-44-64	A	5	5	A	A	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A	A	A	A	A	A	A
699-45-69A	A	5	5	A	5	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A	A	A	A	A	A	A
699-45-69C	A	5	5	A	5	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A	A	A	A	A	A	A
699-47-60	A	5	5	A	5	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A	A	A	A	A	A	A
699-48-71	A	A	A	A	A	A	A	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A	A	A	A	A	A	A
699-50-74	A	5	5	A	5	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A	A	A	A	A	A	A
699-51-63	A	5	5	A	5	A	5	5	A	A	A	A	A	A	A	5	5	A	5	5	5	5	5	A	A	A	A	A	A	A
VOC Wells in 200-UP-1																														
299-W14-71	A	-	-	-	-	A	-	-	A	A	A	A	A	-	-	-	-	-	-	-	-	-	-	A	A	A	A	A	A	A
299-W15-37	A	-	-	-	-	A	-	-	A	A	A	A	A	-	-	-	-	-	-	-	-	-	-	A	A	A	A	A	A	A
299-W18-15	A	-	-	-	-	A	-	-	A	A	A	A	A	-	-	-	-	-	-	-	-	-	-	A	A	A	A	A	A	A
299-W18-21	A	-	-	-	-	A	-	-	A	A	A	A	A	-	-	-	-	-	-	-	-	-	-	A	A	A	A	A	A	A
299-W18-22	A	-	-	-	-	A	-	-	A	A	A	A	A	-	-	-	-	-	-	-	-	-	-	A	A	A	A	A	A	A
299-W18-40	A	-	-	-	-	A	-	-	A	A	A	A	A	-	-	-	-	-	-	-	-	-	-	A	A	A	A	A	A	A
299-W19-105	A	-	-	-	-	A	-	-	A	A	A	A	A	-	-	-	-	-	-	-	-	-	-	A	A	A	A	A	A	A

Table C-3. 200-ZP-1 Monitoring Well Schedule for Analyses

Well	Carbon Tetrachloride	Total and Hexavalent Chromium	Iodine-129	Nitrate	Technetium-99	Trichloroethylene	Tritium	Uranium	Chloroform	Dichloromethane	Chloromethane	cis-1,2-Dichloroethene	Vinyl Chloride	Chloride	Nitrite	Total Organic Carbon	Total Dissolved Solids	Sulfate	Sulfide	Iron	Manganese	Alkalinity	Carbonate content	Temperature	pH	Specific Conductance	Turbidity	Dissolved Oxygen	Redox Potential
299-W19-107	A	-	-	-	-	A	-	-	A	A	A	A	A	-	-	-	-	-	-	-	-	-	-	A	A	A	A	A	A
299-W19-118	A	-	-	-	-	A	-	-	A	A	A	A	A	-	-	-	-	-	-	-	-	-	-	A	A	A	A	A	A
299-W19-34A	A	-	-	-	-	A	-	-	A	A	A	A	A	-	-	-	-	-	-	-	-	-	-	A	A	A	A	A	A
299-W19-34B	A	-	-	-	-	A	-	-	A	A	A	A	A	-	-	-	-	-	-	-	-	-	-	A	A	A	A	A	A
299-W19-36	A	-	-	-	-	A	-	-	A	A	A	A	A	-	-	-	-	-	-	-	-	-	-	A	A	A	A	A	A
299-W19-4	A	-	-	-	-	A	-	-	A	A	A	A	A	-	-	-	-	-	-	-	-	-	-	A	A	A	A	A	A
299-W19-41	A	-	-	-	-	A	-	-	A	A	A	A	A	-	-	-	-	-	-	-	-	-	-	A	A	A	A	A	A
299-W19-47	A	-	-	-	-	A	-	-	A	A	A	A	A	-	-	-	-	-	-	-	-	-	-	A	A	A	A	A	A
299-W19-48	A	-	-	-	-	A	-	-	A	A	A	A	A	-	-	-	-	-	-	-	-	-	-	A	A	A	A	A	A
299-W19-49	A	-	-	-	-	A	-	-	A	A	A	A	A	-	-	-	-	-	-	-	-	-	-	A	A	A	A	A	A
299-W19-6	A	-	-	-	-	A	-	-	A	A	A	A	A	-	-	-	-	-	-	-	-	-	-	A	A	A	A	A	A
299-W21-2	A	-	-	-	-	A	-	-	A	A	A	A	A	-	-	-	-	-	-	-	-	-	-	A	A	A	A	A	A
299-W22-47	A	-	-	-	-	A	-	-	A	A	A	A	A	-	-	-	-	-	-	-	-	-	-	A	A	A	A	A	A
299-W22-72	A	-	-	-	-	A	-	-	A	A	A	A	A	-	-	-	-	-	-	-	-	-	-	A	A	A	A	A	A
299-W22-86	A	-	-	-	-	A	-	-	A	A	A	A	A	-	-	-	-	-	-	-	-	-	-	A	A	A	A	A	A
299-W22-87	A	-	-	-	-	A	-	-	A	A	A	A	A	-	-	-	-	-	-	-	-	-	-	A	A	A	A	A	A
299-W22-88	A	-	-	-	-	A	-	-	A	A	A	A	A	-	-	-	-	-	-	-	-	-	-	A	A	A	A	A	A
299-W23-19	A	-	-	-	-	A	-	-	A	A	A	A	A	-	-	-	-	-	-	-	-	-	-	A	A	A	A	A	A
299-W23-4	A	-	-	-	-	A	-	-	A	A	A	A	A	-	-	-	-	-	-	-	-	-	-	A	A	A	A	A	A
299-W26-13	A	-	-	-	-	A	-	-	A	A	A	A	A	-	-	-	-	-	-	-	-	-	-	A	A	A	A	A	A
299-W27-2	A	-	-	-	-	A	-	-	A	A	A	A	A	-	-	-	-	-	-	-	-	-	-	A	A	A	A	A	A
699-30-66	A	-	-	-	-	A	-	-	A	A	A	A	A	-	-	-	-	-	-	-	-	-	-	A	A	A	A	A	A
699-32-62	A	-	-	-	-	A	-	-	A	A	A	A	A	-	-	-	-	-	-	-	-	-	-	A	A	A	A	A	A
699-32-72A	A	-	-	-	-	A	-	-	A	A	A	A	A	-	-	-	-	-	-	-	-	-	-	A	A	A	A	A	A
699-33-75	A	-	-	-	-	A	-	-	A	A	A	A	A	-	-	-	-	-	-	-	-	-	-	A	A	A	A	A	A
699-34-61	A	-	-	-	-	A	-	-	A	A	A	A	A	-	-	-	-	-	-	-	-	-	-	A	A	A	A	A	A
699-35-66A	A	-	-	-	-	A	-	-	A	A	A	A	A	-	-	-	-	-	-	-	-	-	-	A	A	A	A	A	A
699-35-78A	A	-	-	-	-	A	-	-	A	A	A	A	A	-	-	-	-	-	-	-	-	-	-	A	A	A	A	A	A

Table C-3. 200-ZP-1 Monitoring Well Schedule for Analyses

Well	Carbon Tetrachloride	Total and Hexavalent Chromium	Iodine-129	Nitrate	Technetium-99	Trichloroethylene	Tritium	Uranium	Chloroform	Dichloromethane	Chloromethane	cis-1,2-Dichloroethene	Vinyl Chloride	Chloride	Nitrite	Total Organic Carbon	Total Dissolved Solids	Sulfate	Sulfide	Iron	Manganese	Alkalinity	Carbonate content	Temperature	pH	Specific Conductance	Turbidity	Dissolved Oxygen	Redox Potential
699-36-61A	A	-	-	-	-	A	-	-	A	A	A	A	A	-	-	-	-	-	-	-	-	-	-	A	A	A	A	A	A
699-36-66B	A	-	-	-	-	A	-	-	A	A	A	A	A	-	-	-	-	-	-	-	-	-	-	A	A	A	A	A	A
699-36-70A	A	-	-	-	-	A	-	-	A	A	A	A	A	-	-	-	-	-	-	-	-	-	-	A	A	A	A	A	A
699-36-70B	A	-	-	-	-	A	-	-	A	A	A	A	A	-	-	-	-	-	-	-	-	-	-	A	A	A	A	A	A
699-37-66	A	-	-	-	-	A	-	-	A	A	A	A	A	-	-	-	-	-	-	-	-	-	-	A	A	A	A	A	A
699-38-61	A	-	-	-	-	A	-	-	A	A	A	A	A	-	-	-	-	-	-	-	-	-	-	A	A	A	A	A	A
699-38-65	A	-	-	-	-	A	-	-	A	A	A	A	A	-	-	-	-	-	-	-	-	-	-	A	A	A	A	A	A
699-38-68A	A	-	-	-	-	A	-	-	A	A	A	A	A	-	-	-	-	-	-	-	-	-	-	A	A	A	A	A	A
699-38-70B	A	-	-	-	-	A	-	-	A	A	A	A	A	-	-	-	-	-	-	-	-	-	-	A	A	A	A	A	A
699-38-70C	A	-	-	-	-	A	-	-	A	A	A	A	A	-	-	-	-	-	-	-	-	-	-	A	A	A	A	A	A
699-40-62	A	-	-	-	-	A	-	-	A	A	A	A	A	-	-	-	-	-	-	-	-	-	-	A	A	A	A	A	A
699-40-65	A	-	-	-	-	A	-	-	A	A	A	A	A	-	-	-	-	-	-	-	-	-	-	A	A	A	A	A	A

A = sample annually

5 = sample every 5 years to coincide with preparation of the next *Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) 5-year review*

- = not sampled

VOC = volatile organic compounds

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References

Comprehensive Environmental Response, Compensation, and Liability Act of 1980, 42 USC 9601, et seq.,
Pub. L. 107-377, December 31, 2002. Available at: <http://epw.senate.gov/cercla.pdf>.

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Appendix D
200-ZP-1 Operable Unit Kriged Carbon Tetrachloride
Error Variance Maps

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Figure D-2. Kriged Carbon Tetrachloride Error Variance from 128.5 to 131.5 m Above Mean
Sea Level D-3

Figure D-3. Kriged Carbon Tetrachloride Error Variance from 122.5 to 125.5 m Above Mean
Sea Level D-4

Figure D-4. Kriged Carbon Tetrachloride Error Variance from 110.5 to 113.5 m Above Mean
Sea Level D-5

Figure D-5. Kriged Carbon Tetrachloride Error Variance from 98.5 to 101.5 m Above Mean
Sea Level D-6

Figure D-6. Kriged Carbon Tetrachloride Error Variance from 85.5 to 88.5 m Above Mean
Sea Level D-7

Figure D-7. Kriged Carbon Tetrachloride Error Variance from 73.5 to 76.5 m Above Mean
Sea Level D-8

Figure D-8. Kriged Carbon Tetrachloride Error Variance from 67.5 to 70.5 m Above Mean
Sea Level D-9

Figure D-9. Kriged Carbon Tetrachloride Error Variance from 61.5 to 64.5 m Above Mean
Sea Level D-10

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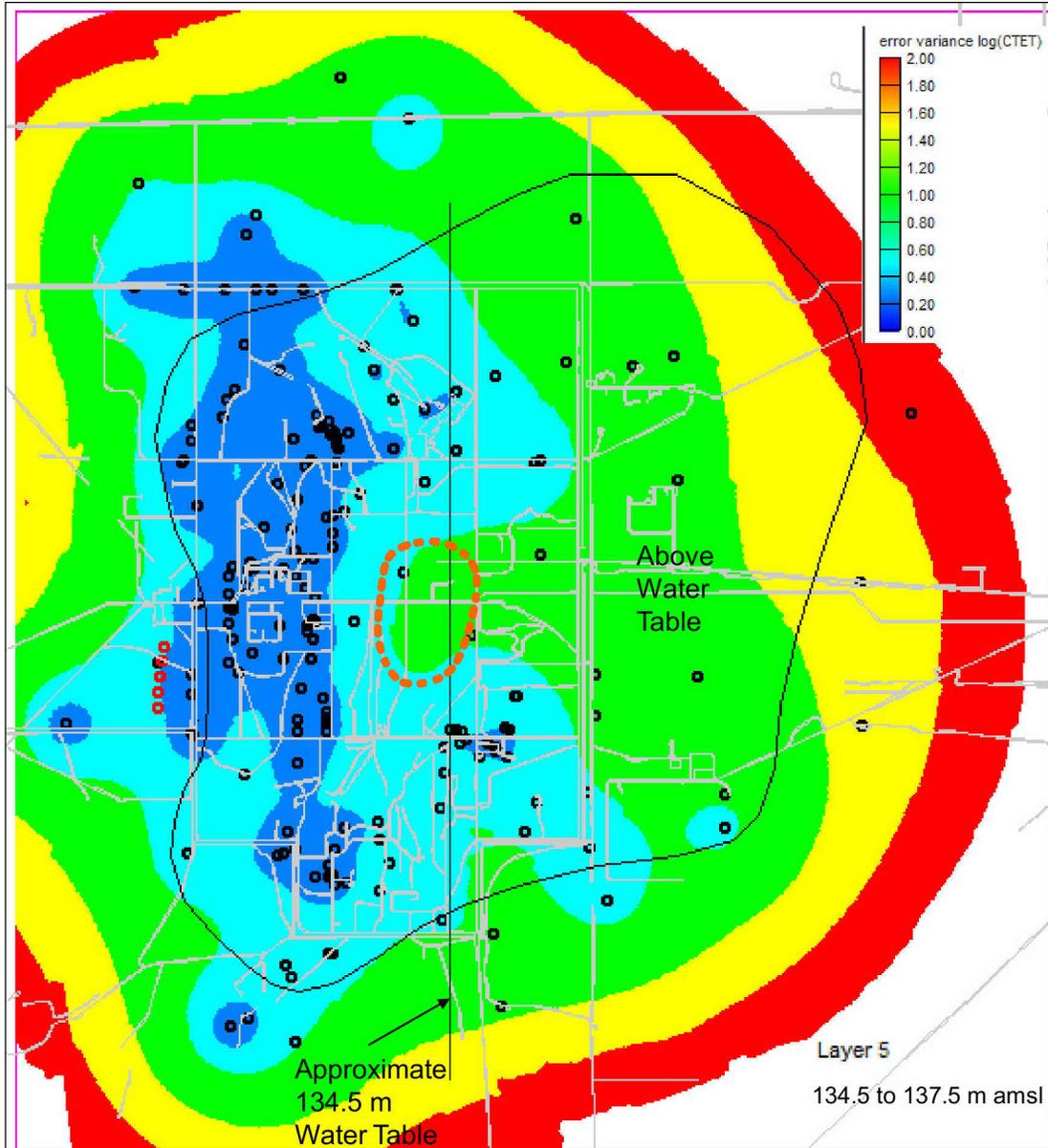
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1 **D1 200-ZP-1 Operable Unit Kriged Carbon Tetrachloride**
2 **Error Variance Maps**

3 The maps provided in this appendix reveal the areas in the kriged three-dimensional carbon tetrachloride
4 plume shell of the 200-ZP-1 Operable Unit that have the greatest error variance or relative uncertainty.
5 While these maps provide visual information concerning uncertainty in the distribution of data, they are
6 dependent on the kriging parameters used to generate them.

7



Map of Kriged Carbon Tetrachloride Error Variance

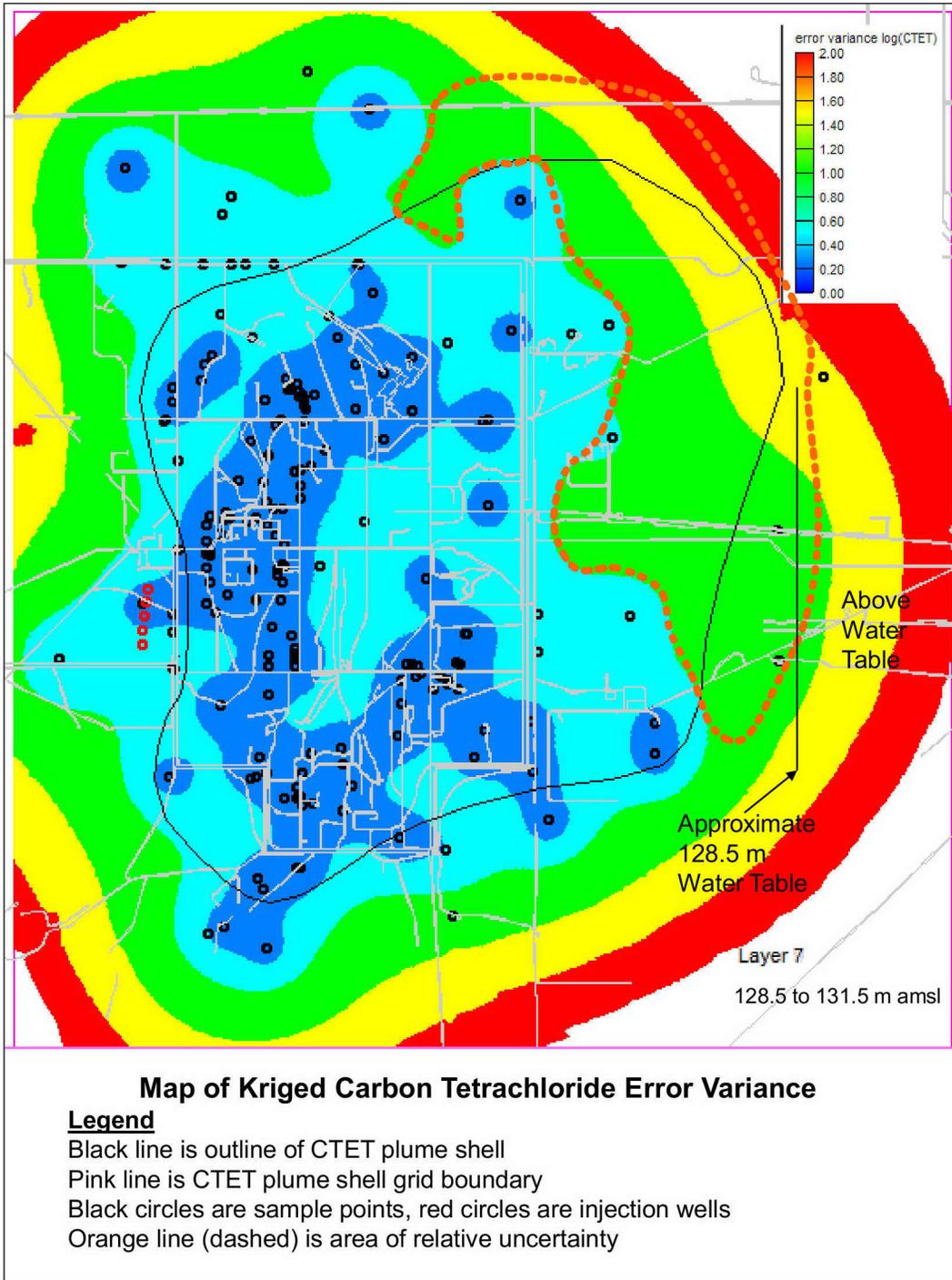
Legend

- Black line is outline of CTET plume shell
- Pink line is CTET plume shell grid boundary
- Black circles are sample points, red circles are injection wells
- Orange line (dashed) is area of relative uncertainty

- 1
- 2 amsl = above mean sea level
- 3 CTET = carbon tetrachloride

4 **Figure D-1. Kriged Carbon Tetrachloride Error Variance from 134.5 to 137.5 m Above Mean Sea Level**

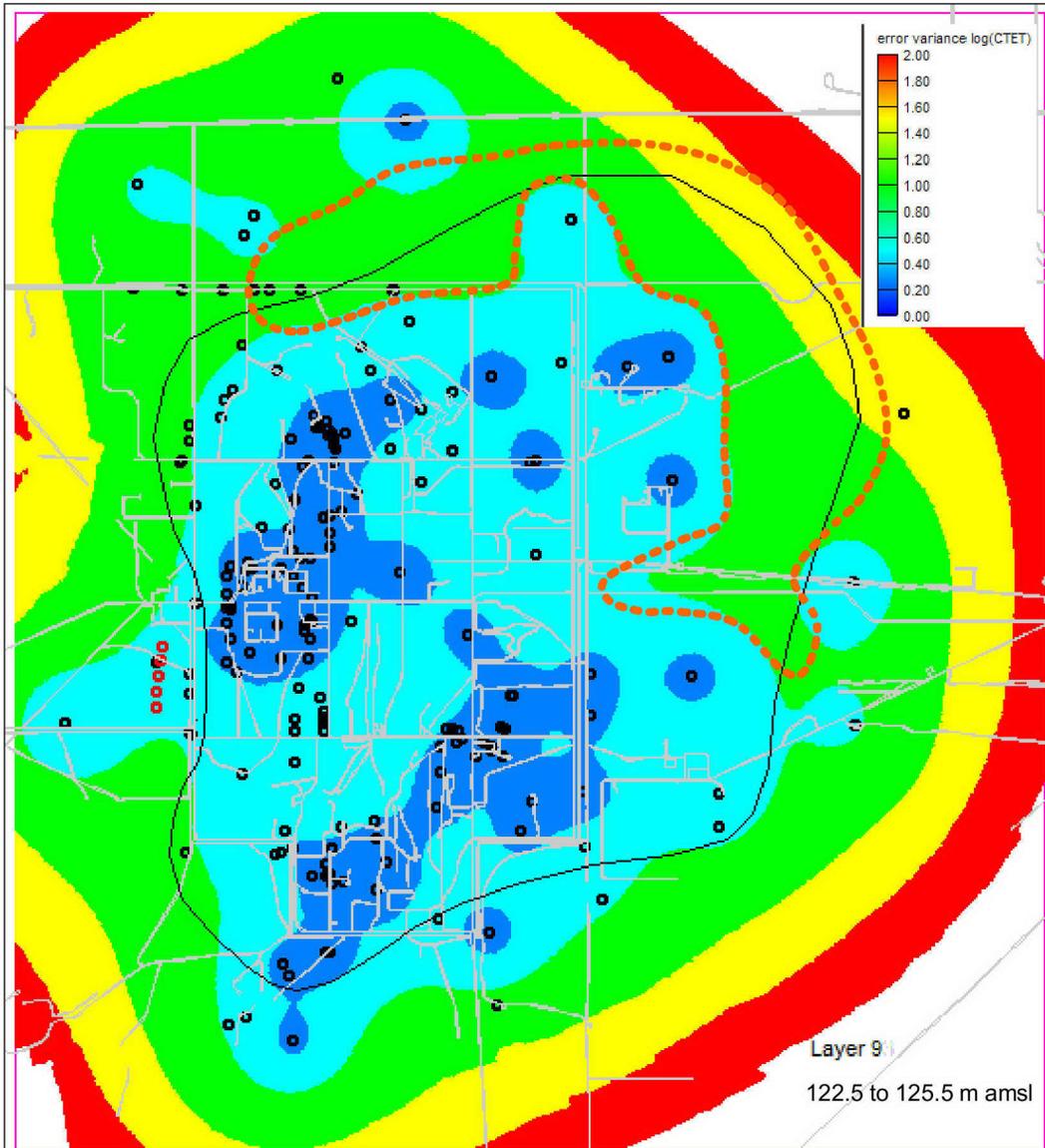
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- 1
- 2 amsl = above mean sea level
- 3 CTET = carbon tetrachloride

4 **Figure D-2. Kriged Carbon Tetrachloride Error Variance from 128.5 to 131.5 m Above Mean Sea Level**

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Map of Kriged Carbon Tetrachloride Error Variance

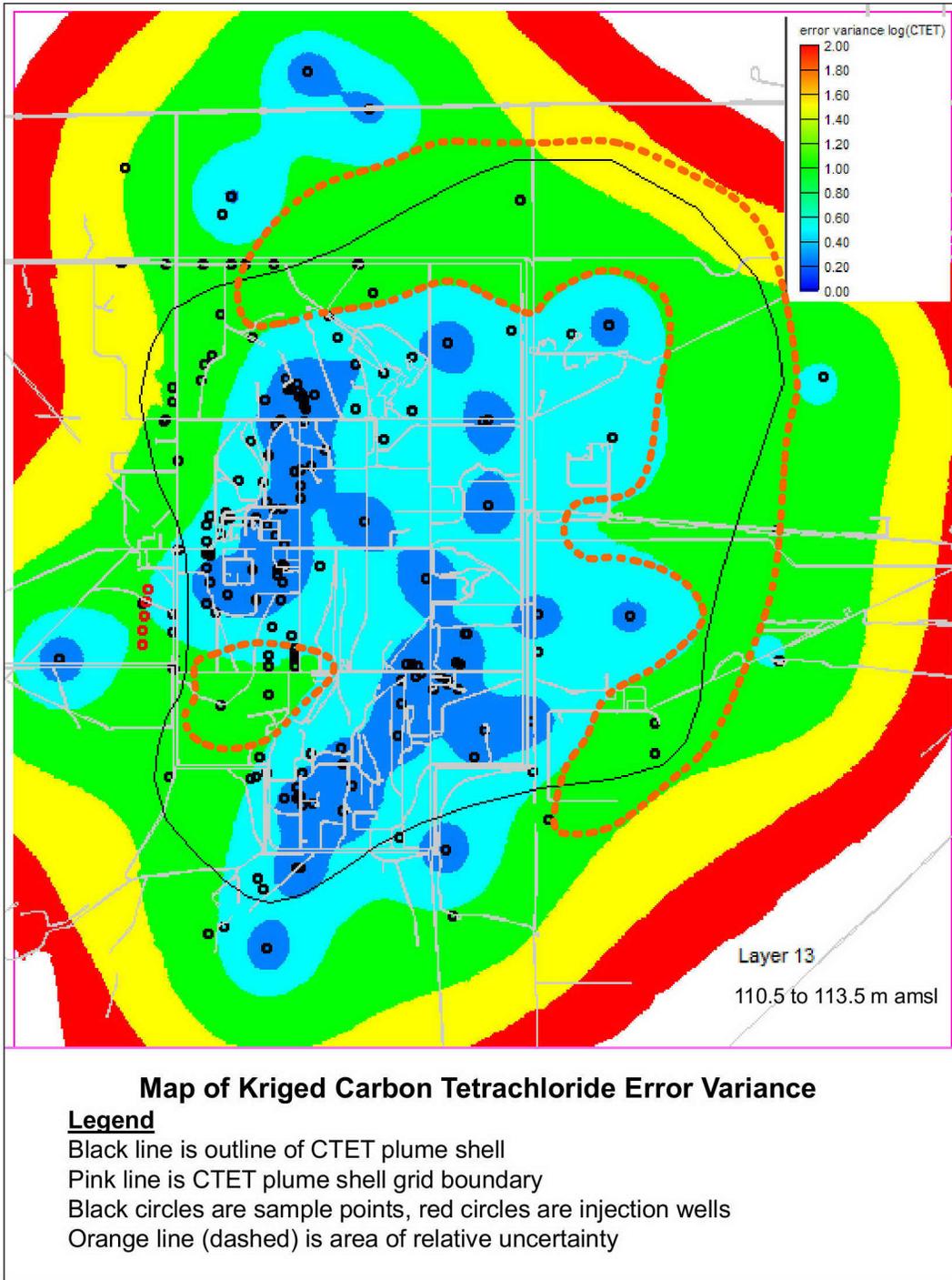
Legend

- Black line is outline of CTET plume shell
- Pink line is CTET plume shell grid boundary
- Black circles are sample points, red circles are injection wells
- Orange line (dashed) is area of relative uncertainty

- 1
- 2 amsl = above mean sea level
- 3 CTET = carbon tetrachloride

4 **Figure D-3. Kriged Carbon Tetrachloride Error Variance from 122.5 to 125.5 m Above Mean Sea Level**

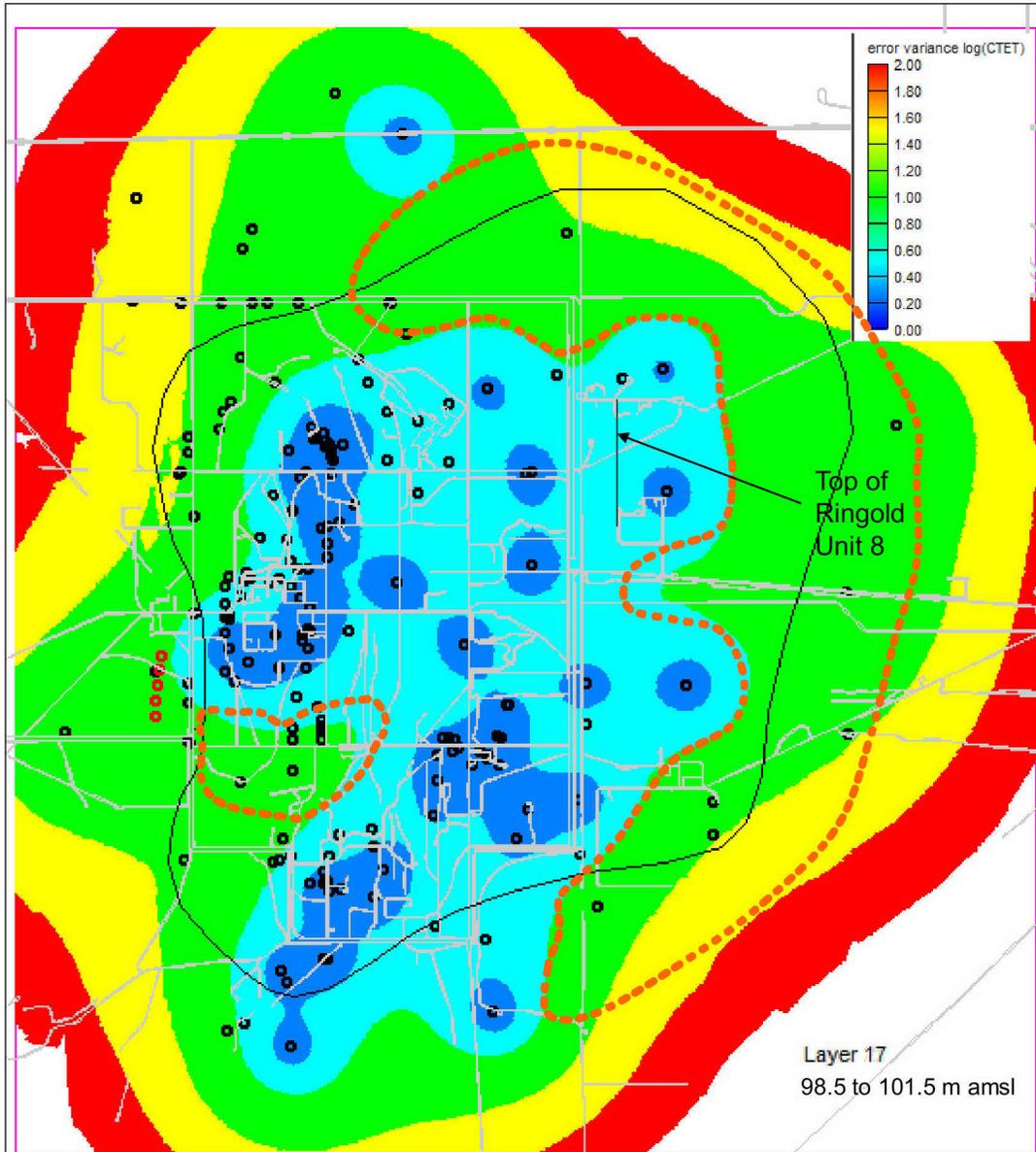
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- 1
- 2 amsl = above mean sea level
- 3 CTET = carbon tetrachloride

4 **Figure D-4. Kriged Carbon Tetrachloride Error Variance from 110.5 to 113.5 m Above Mean Sea Level**

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Map of Kriged Carbon Tetrachloride Error Variance

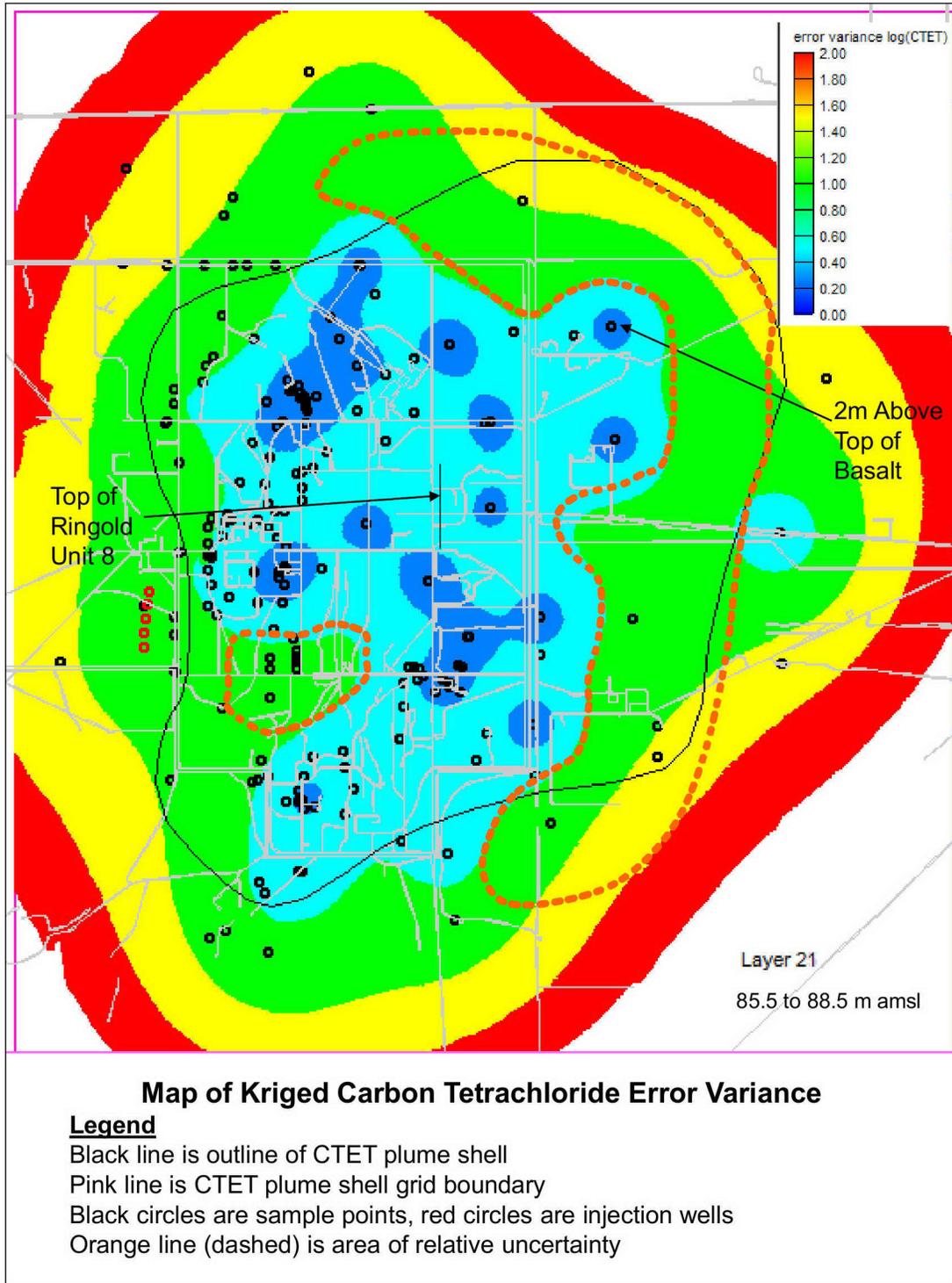
Legend

- Black line is outline of CTET plume shell
- Pink line is CTET plume shell grid boundary
- Black circles are sample points, red circles are injection wells
- Orange line (dashed) is area of relative uncertainty

- 1
- 2 amsl = above mean sea level
- 3 CTET = carbon tetrachloride

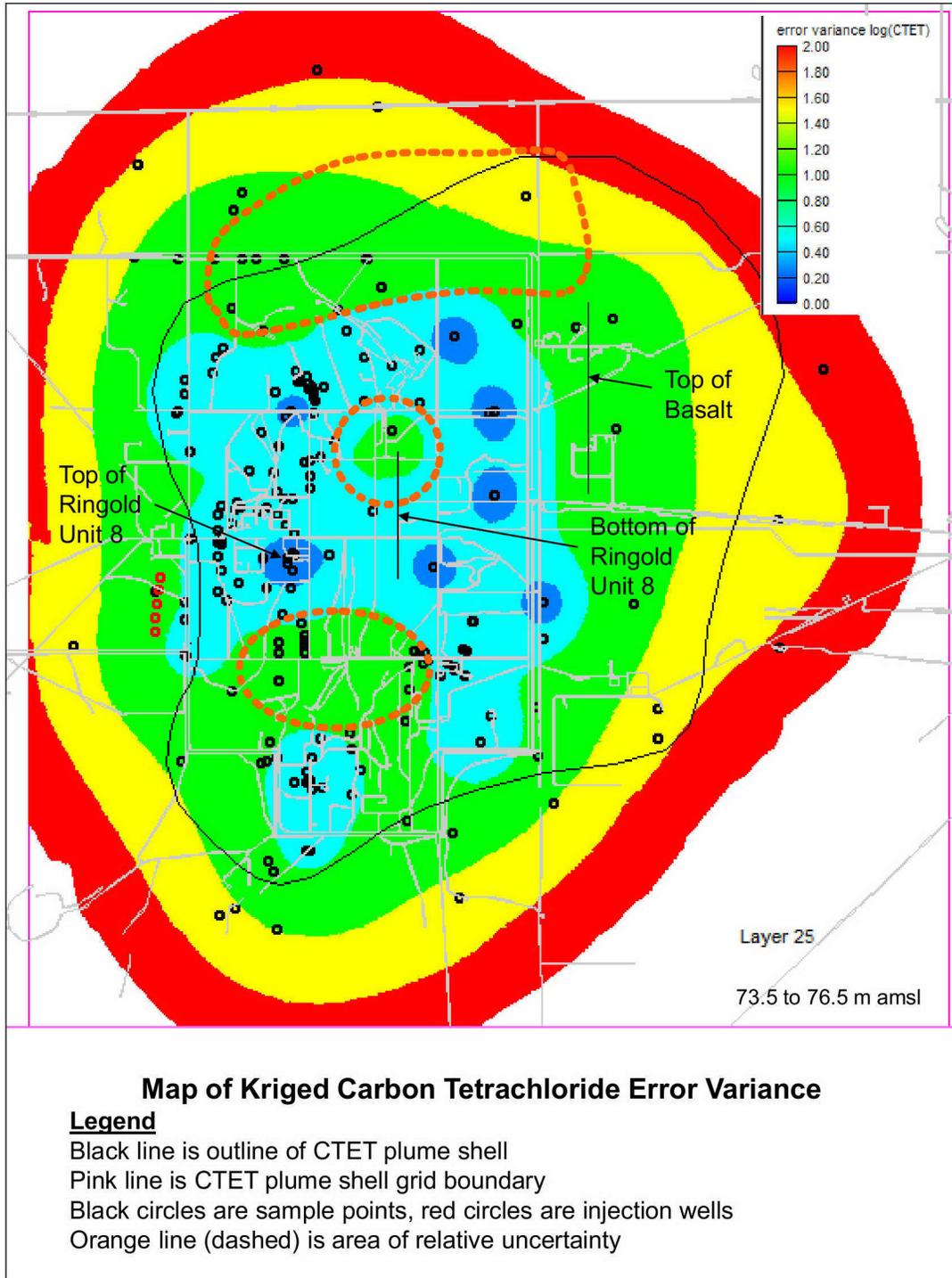
4 **Figure D-5. Kriged Carbon Tetrachloride Error Variance from 98.5 to 101.5 m Above Mean Sea Level**

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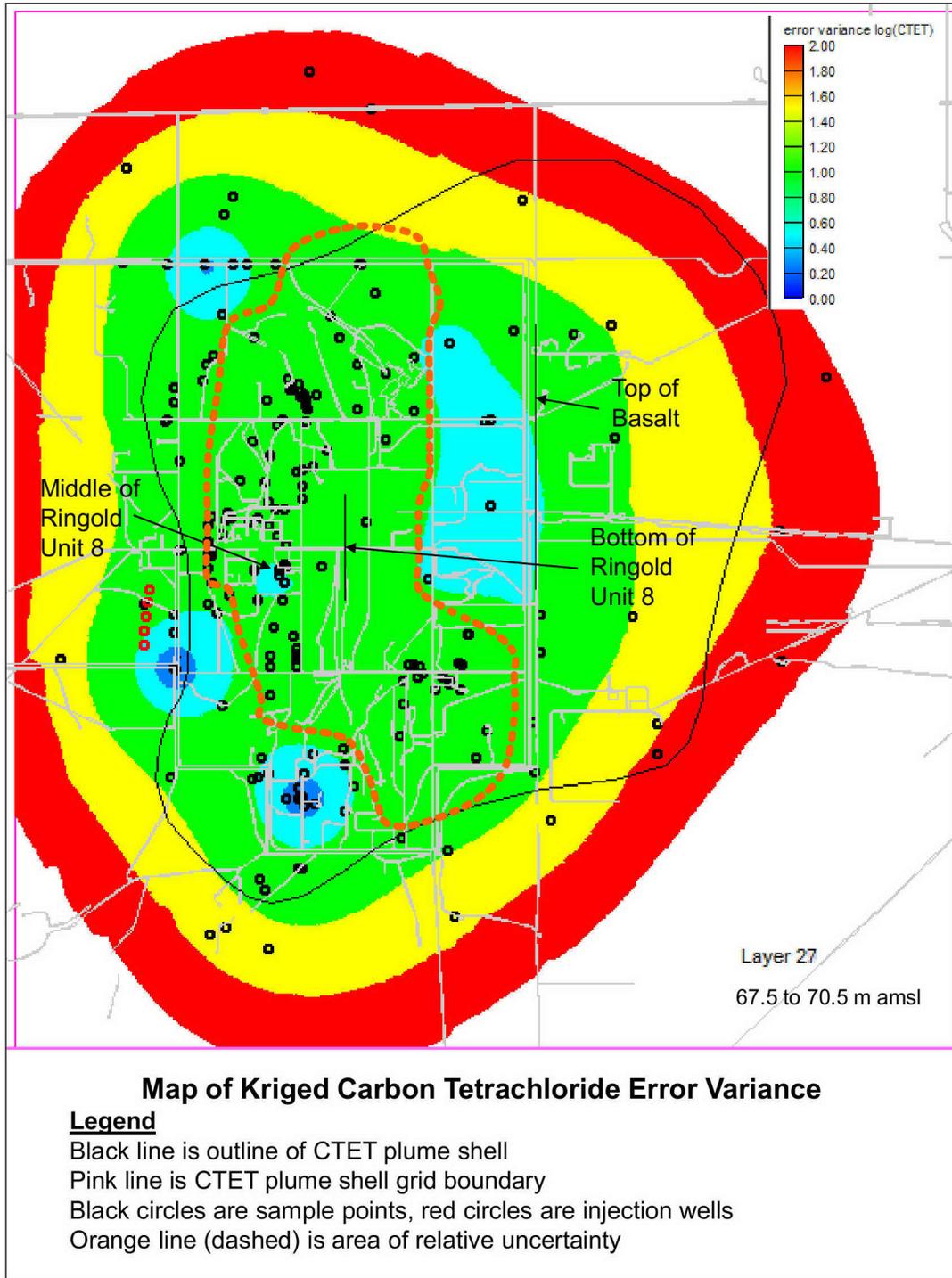
Figure D-6. Kriged Carbon Tetrachloride Error Variance from 85.5 to 88.5 m Above Mean Sea Level



- 1
- 2 amsl = above mean sea level
- 3 CTET = carbon tetrachloride

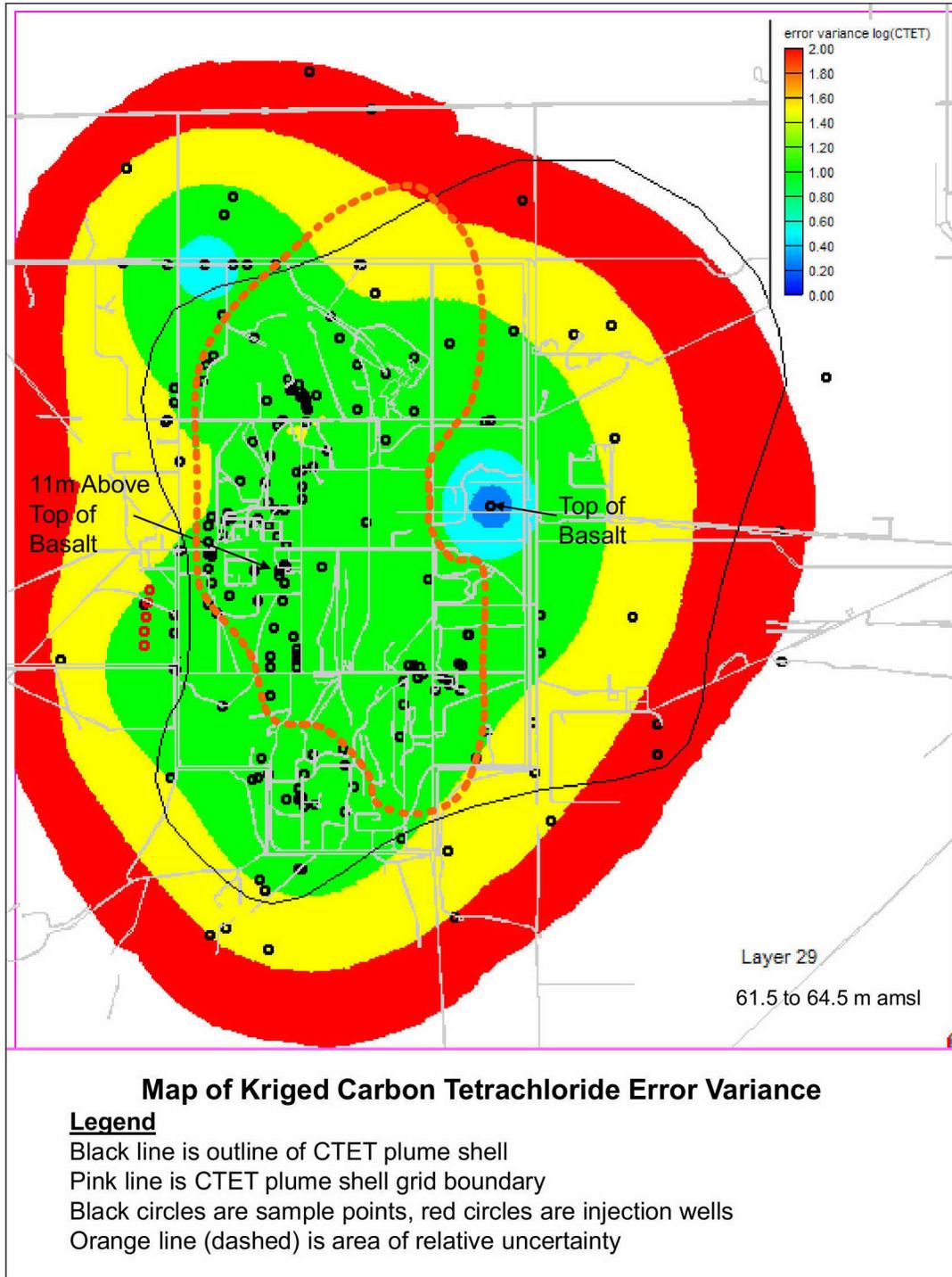
4 **Figure D-7. Kriged Carbon Tetrachloride Error Variance from 73.5 to 76.5 m Above Mean Sea Level**

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Figure D-8. Kriged Carbon Tetrachloride Error Variance from 67.5 to 70.5 m Above Mean Sea Level



- 1
- 2 amsl = above mean sea level
- 3 CTET = carbon tetrachloride

4 **Figure D-9. Kriged Carbon Tetrachloride Error Variance from 61.5 to 64.5 m Above Mean Sea Level**

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Appendix E
200-ZP-1 Operable Unit
Hydraulic Monitoring Well Network

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Tables

Table E-1. 200-ZP-1 OU Hydraulic Monitoring Well Network E-1

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1 **E1 200-ZP-1 OU Hydraulic Monitoring Well Network**

2 Table E-1 provides details for the 200-ZP-1 Operable Unit (OU) hydraulic monitoring well network.

Table E-1. 200-ZP-1 OU Hydraulic Monitoring Well Network

Well Name	Easting (m)	Northing (m)	Surface Elevation (m)	Depth to Screen Top (m)	Depth to Screen Bottom (m)	Date Drilled	Transducer Equipment	Mid-Screen Elevation (m)
299-W10-1	566663	136735	207.5	57.91	82.3	08/07/47	No	137.4
299-W10-27	566844	136442	205.6	67.36	78.02	03/23/01	No	132.9
299-W10-30	566083	136739	211.6	73.86	84.53	03/14/06	No	132.4
299-W10-31	566266	136968	210.4	73.13	83.82	04/20/06	No	131.9
299-W10-33	566773	136610	206.0	118.87	124.96	06/15/07	No	84.1
299-W11-13	567099	136424	211.9	66.45	143.86	07/31/61	No	106.7
299-W11-18	567182	137161	216.5	69.19	89.916	03/01/67	No	136.9
299-W11-33Q	567185	136844	217.2	74.41	91.17	09/09/94	No	134.4
299-W11-43	567270	136971	217.5	129.44	134.01	05/23/05	Yes	85.8
299-W11-45	566993	136776	213.6	85.73	90.18	09/02/05	No	125.7
299-W11-47	566934	136681	210.4	83.58	92.89	01/06/06	Yes	122.2
299-W11-48	566882	136846	209.7	84.56	112.01	11/29/06	Yes	111.4
299-W11-87	568141	136609	223.6	116.36	120.94	03/01/07	Yes	105.0
299-W11-88	567875	137113	221.9	135.66	147.85	10/03/07	Yes	80.1
299-W13-1	568149	136049	223.5	119.15	129.81	02/10/04	Yes	99.1
299-W14-11	566902	136288	205.1	79.77	82.81	04/26/05	No	123.8
299-W14-14	566898	136181	205.4	66.13	76.81	11/12/98	Yes	134.0
299-W14-17	567007	136218	205.9	67.64	78.32	10/24/00	No	132.9
299-W14-71	567733	135568	219.4	125.17	129.74	07/27/06	Yes	92.0
299-W14-72	567328	135941	216.3	126.18	130.76	08/15/06	Yes	87.9
299-W15-1	566554	135943	207.0	57.91	82.3	05/02/47	No	136.9
299-W15-11	566412	136001	208.3	55.78	90.53	03/08/68	Yes	135.1
299-W15-152	566309	135550	209.9	71.94	82.61	09/15/05	No	132.6
299-W15-17	566307	135719	209.8	128.77	131.82	10/28/87	No	79.5
299-W15-3	566729	136371	205.4	60.96	71.93	09/30/52	No	139.0
299-W15-30	566305	135749	210.2	66.47	78.63	05/05/95	Yes	137.7

Table E-1. 200-ZP-1 OU Hydraulic Monitoring Well Network

Well Name	Easting (m)	Northing (m)	Surface Elevation (m)	Depth to Screen Top (m)	Depth to Screen Bottom (m)	Date Drilled	Transducer Equipment	Mid-Screen Elevation (m)
299-W15-31A	566377	135856	208.5	64.76	76.93	05/26/95	No	137.7
299-W15-37	566716	135248	203.0	64.74	77.98	05/16/96	No	131.68
299-W15-42	566582	135627	207.4	69.50	84.74	02/26/02	No	130.3
299-W15-46	566752	135587	204.2	63.86	88.23	10/03/03	No	128.2
299-W15-49	566307	135973	209.1	71.86	82.52	11/01/04	No	131.9
299-W15-50	566793	135791	203.2	74.19	84.85	02/28/05	No	123.7
299-W15-7	566676	135920	204.2	55.47	106.68	03/30/66	Yes	123.1
299-W17-1	565311	135039	199.2	58.99	69.67	12/17/03	No	134.9
299-W18-1	566422	135465	209.1	59.44	111.89	01/12/59	No	123.4
299-W18-15	566380	134733	202.2	51.82	74.07	04/25/80	No	139.3
299-W18-16	566605	135426	208.5	71.47	82.13	10/20/04	No	131.8
299-W18-22	566089	134990	204.9	126.94	136.39	09/25/87	No	73.2
299-W18-40	566723	134996	203.4	66.53	77.20	09/28/01	No	131.6
299-W19-107	567998	135206	217.4	94.65	99.22	03/31/06	Yes	120.5
299-W19-18	567361	135012	214.0	67.06	109.12	12/12/85	No	125.90
299-W19-34A	567674	135012	215.1	98.82	103.51	05/18/94	No	113.9
299-W19-34B	567663	135011	215.5	125.46	128.41	12/12/85	No	88.6
299-W19-35	567992	135015	213.6	73.13	82.3	04/20/94	No	135.9
299-W19-4	567950	135351	219.0	77.72	135.03	02/15/60	No	112.3
299-W19-41	566897	135005	206.5	67.07	77.76	09/23/98	No	134.1
299-W19-6	567133	134694	210.3	115.82	125.27	12/13/68	No	89.79
299-W21-2	568124	134574	214.9	79.29	89.96	11/22/04	No	130.2
299-W22-47	566909	134076	206.3	69.70	80.37	01/19/05	No	131.3
299-W23-20	566718	134446	203.8	65.68	76.35	08/21/00	No	132.8
299-W26-14	566683	133539	205.4	68.08	78.75	04/03/03	No	132.0
299-W27-2	566908	133670	207.4	123.79	126.87	12/18/92	No	82.1
299-W6-3	567118	137299	214.4	124.82	127.95	10/15/91	No	87.9
299-W6-6	567319	137639	217.5	127.58	130.84	10/24/91	No	88.3
299-W7-3	566292	137639	207.2	136.85	145.29	11/23/87	No	66.1
699-25-70	568545	131172	193.0	53.34	134.11	08/31/48	No	99.24

Table E-1. 200-ZP-1 OU Hydraulic Monitoring Well Network

Well Name	Easting (m)	Northing (m)	Surface Elevation (m)	Depth to Screen Top (m)	Depth to Screen Bottom (m)	Date Drilled	Transducer Equipment	Mid-Screen Elevation (m)
699-25-80	565676	131106	189.0	273.41	370.03	11/30/48	No	-132.7
699-30-66	569991	132739	210.5	117.35	120.4	10/13/04	No	91.6
699-32-62	571010	133216	216.6	83.82	103.63	04/06/60	No	122.9
699-32-62P	571010	133216	216.6	83.82	146.3	04/06/60	No	101.5
699-32-70B	568462	133242	204.2	63.09	100.58	08/09/57	No	122.37
699-32-72A	567943	133363	204.7	65.42	74.56	07/31/57	No	134.7
699-32-72B	567935	133362	205.1	65.41	74.56	05/18/94	No	135.1
699-34-88	563012	133950	194.0	146.0	127.02	12/20/48	No	136.5
699-35-59	571956	134096	222.1	94.48	106.67	10/31/85	No	121.5
699-35-66A	569858	134099	222.5	79.25	98.15	06/13/57	No	133.76
699-35-78A	566064	134271	202.4	54.86	85.04	08/17/50	Yes	132.02
699-36-70B	568428	134626	215.2	80.51	91.17	06/09/04	No	129.4
699-38-61	571219	134997	228.2	101.83	107.92	11/16/93	No	123.3
699-38-65	570090	135040	230.7	152.4	155.45	12/31/59	Yes	76.8
699-38-68A	569180	134932	219.0	81.59	90.74	06/21/94	No	132.8
699-38-70B	568469	135331	222.6	123.96	128.53	02/03/04	No	96.3
699-38-70C	569084	135326	226.7	120.60	125.18	02/17/04	No	103.8
699-39-79	565891	135412	206.5	54.44	73.152	09/07/48	Yes	142.7
699-40-62	571164	135764	228.9	102.11	114.0	01/17/49	No	120.8
699-40-65	570057	135881	231.0	100.0	111.5	02/03/04	Yes	125.3
699-43-69	568967	136488	227.4	121.98	132.64	12/11/07	Yes	100.1
699-43-89	562917	136620	197.7	43.28	60.35	01/16/51	No	145.9
699-44-64	570391	136897	222.2	96.32	134.72	01/31/60	Yes	106.67
699-45-69A	568729	137183	222.1	83.52	111.56	06/22/48	No	124.6
699-45-69C	568947	137234	222.6	111.86	116.43	07/13/07	Yes	108.4
699-47-60	571474	137969	199.6	71.63	84.43	07/20/48	No	121.6
699-47-80AP	565562	137693	218.26	198.12	204.83	11/30/83	No	16.8
699-47-80AQ	565562	137693	218.26	153.31	156.36	11/30/83	No	63.4
699-48-71	568388	138057	210.9	138	156.36	09/26/56	Yes	63.7
699-48-77C	566469	138087	206.6	88.39	94.49	04/01/94	No	115.42

Table E-1. 200-ZP-1 OU Hydraulic Monitoring Well Network

Well Name	Easting (m)	Northing (m)	Surface Elevation (m)	Depth to Screen Top (m)	Depth to Screen Bottom (m)	Date Drilled	Transducer Equipment	Mid-Screen Elevation (m)
699-49-79	565771	138271	211.1	65.58	80.77	07/03/48	Yes	137.9
699-50-74	567360	138647	201.4	68.07	78.74	07/12/05	No	128.0
699-51-63	570664	139148	175.3	47.85	55.78	11/06/56	No	123.49
699-51-75	566978	138906	196.6	57.91	68.58	10/31/57	No	133.4
699-55-76	566723	140226	178.7	42.98	67.36	01/18/59	No	123.5

amsl = above mean sea level

NA = not available

OU = operable unit

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Appendix F
Sampling Interval Depth Information for 200-ZP-1
Groundwater Operable Unit Wells

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F1 Introduction

This appendix provides the following information for the 200-ZP-1 Groundwater Operable Unit (OU) wells.

- Well name
- Hydrogeologic Unit to be monitored – the portion of the aquifer that is located at the well screen or perforated casing (Table F-1)
- Sampling interval depth information for wells within the 200-ZP-1 Groundwater OU Area is shown in Table F-2 and includes:
 - Elevation at top of the screen or perforated interval
 - Elevation at the bottom of the screen or perforated interval
 - Open Interval Length, i.e., difference between elevations of top and bottom of the screen or perforated interval
 - Water Level Elevation, i.e., most recent water level elevation in the well
 - Water Level Date, i.e., date of most recent water level elevation measured in the well

Table F-1. Hydrogeologic Monitoring Unit Classification Scheme

Unit	Description
CR	Confined Ringold. Wells for which the open interval does not extend more than a approximately 3 m (10 ft) below the top of basalt. Typically open to the lower mud (unit 8) and basal gravel (unit 9) of the Ringold Formation. This classification is not used for wells completed in the Ringold Upper Mud (RUM).
LU	Lower Unconfined. Open interval begins at greater than 15.2 m (50 ft) below the water table and below the middle coarse hydrogeologic unit or within 15.2 m (50 ft) of the top of basalt and does not extend more than 3 m (10 ft) below the top of basalt.
MU	Middle Unconfined. Open interval begins at greater than 15.2 m (50 ft) below the water table and does not extend below the middle coarse hydrogeologic unit or to within 15.2 m (50 ft) of the top of basalt.
TU	Top of Unconfined. Screened across the water table or the top of the open interval is within 1.5 m (5 ft) of the water table, and the bottom of the open interval is no more than 10.7 m (35 ft) below the water table.
U	Undifferentiated unconfined. Open to more than 15.2 m (50 ft) of the unconfined aquifer system, or the open/monitoring interval depth is not documented but is known to be within the unconfined aquifer system.
UU	Upper unconfined. The top of the open interval is more than 1.5 m (5 ft) below the water table and the bottom of the open interval is no more than 15.2 m (50 ft) below the water table.

Table F-2. Hydrogeologic Monitoring Unit Classification and Well Network Details

Well Name	Hydrogeologic Unit Monitored	Elevation Top of Open Interval (m NAVD88)	Elevation Bottom of Open Interval (m NAVD88)	Open Interval Length (m)	Water Level Elevation (m NAVD88)	Water Level Date
299-W10-1	U	149.5	125.2	14.3	133.19	11/12/2014
299-W10-14	LU	84.1	78.0	6.1	137.40	11/14/2014
299-W10-27	TU	138.3	127.6	10.7	131.12	11/5/2014
299-W10-30	TU	137.8	127.1	10.7	136.91	9/5/2014
299-W10-31	TU	137.3	126.6	10.7	135.45	9/5/2014
299-W10-33	LU	87.1	81.0	6.1	132.91	9/2/2014
299-W11-13	U	145.5	68.4	77.1	130.88	3/14/2014
299-W11-18	TU	147.3	126.6	20.7	132.96	3/14/2014
299-W11-33Q	TU	142.8	126.1	16.5	131.43	12/16/2014
299-W11-43	LU	88.1	83.5	4.6	131.40	3/14/2014
299-W11-45	UU	127.9	123.4	4.5	130.78	3/24/2015
299-W11-47	U	126.8	117.5	9.3	131.20	11/7/2014
299-W11-48	LU	125.1	97.7	27.4	132.30	2/6/2014
299-W11-87	LU	107.3	102.7	4.6	128.42	3/14/2014
299-W11-88	LU	86.2	74.0	12.2	130.02	3/14/2014
299-W13-1	MU	104.4	93.7	10.7	129.39	3/14/2014
299-W13-2	LU	128.4	104.3	12.2	128.80	1/5/2016
299-W14-11	UU	125.3	122.3	3.0	129.67	11/11/2014
299-W14-13	TU	138.7	128.7	10.0	129.40	11/11/2014
299-W14-14	TU	139.3	128.6	10.7	130.57	11/18/2014
299-W14-71	LU	94.2	89.7	4.5	129.91	8/15/2014
299-W14-72	LU	90.2	85.6	4.6	129.53	3/14/2014
299-W15-11	TU	152.5	117.8	34.7	135.06	12/30/2013
299-W15-152	TU	137.9	127.3	10.6	133.17	7/22/2014
299-W15-17	LU	81.0	78.0	3.0	135.07	11/14/2014
299-W15-33	UU	142.4	127.9	14.5	134.27	11/14/2014
299-W15-37	UU	140.3	125.1	15.2	133.46	12/10/2014

Table F-2. Hydrogeologic Monitoring Unit Classification and Well Network Details

Well Name	Hydrogeologic Unit Monitored	Elevation Top of Open Interval (m NAVD88)	Elevation Bottom of Open Interval (m NAVD88)	Open Interval Length (m)	Water Level Elevation (m NAVD88)	Water Level Date
299-W15-42	UU	137.9	122.7	15.2	133.90	11/14/2014
299-W15-46	UU	140.4	116.0	24.4	133.20	1/20/2014
299-W15-49	UU	137.3	126.6	10.7	136.08	3/14/2014
299-W15-50	MU	129.0	118.4	10.6	132.71	3/14/2014
299-W15-7	TU	148.8	97.6	51.2	133.06	5/6/2014
299-W15-763	TU	138.4	127.7	10.7	132.12	5/20/2014
299-W15-765	TU	138.2	127.6	10.6	131.20	11/7/2014
299-W15-83	TU	137.7	127.0	10.7	135.51	7/9/2014
299-W15-94	TU	137.9	127.2	10.7	135.33	7/9/2014
299-W18-1	U	149.6	79.5	70.1	209.07	11/14/2014
299-W18-15	TU	142.8	118.7	24.1	135.07	2/7/2014
299-W18-16	TU	137.1	126.4	10.7	134.49	3/14/2014
299-W18-21	TU	145.3	136.2	9.1	136.29	11/18/2014
299-W18-22	LU	77.9	68.5	9.4	135.81	11/18/2014
299-W18-40	TU	136.9	126.2	10.7	134.31	12/10/2014
299-W19-105	TU	135.2	124.5	10.7	131.83	9/5/2014
299-W19-107	UU	122.8	118.2	4.6	130.95	3/14/2014
299-W19-18	TU	146.9	104.9	42.0	132.25	7/18/2014
299-W19-34A	MU	116.5	111.8	4.7	131.64	7/18/2014
299-W19-34B	MU	90.0	87.1	2.9	131.85	3/14/2014
299-W19-36	UU	140.8	127.1	13.7	131.86	8/4/2014
299-W19-4	U	141.3	56.0	85.3	131.25	1/2/2014
299-W19-41	TU	139.5	128.8	10.7	132.90	12/10/2014
299-W19-47	TU	137.1	126.4	10.7	136.78	12/10/2014
299-W19-48	UU	133.0	122.3	10.7	131.60	8/12/2014
299-W19-49	TU	135.1	124.5	10.6	131.92	8/12/2014
299-W19-6	MU	94.5	85.1	9.4	132.86	1/20/2014

Table F-2. Hydrogeologic Monitoring Unit Classification and Well Network Details

Well Name	Hydrogeologic Unit Monitored	Elevation Top of Open Interval (m NAVD88)	Elevation Bottom of Open Interval (m NAVD88)	Open Interval Length (m)	Water Level Elevation (m NAVD88)	Water Level Date
299-W21-2	TU	135.6	124.9	10.7	131.61	6/19/2014
299-W22-47	UU	136.6	125.9	10.7	132.98	12/10/2014
299-W22-72	TU	135.8	125.1	10.7	132.37	12/19/2014
299-W22-86	TU	135.9	125.2	10.7	132.22	12/19/2014
299-W22-87	TU	135.7	125.1	10.6	132.26	3/14/2014
299-W22-88	TU	134.3	123.7	10.6	131.96	11/4/2014
299-W23-19	TU	139.5	136.4	3.1	Not Available	Not Available
299-W23-4	U	148.1	111.6	36.5	134.30	2/7/2014
299-W26-13	TU	138.2	127.5	10.7	134.10	11/4/2014
299-W27-2	LU	83.6	80.5	3.1	133.29	5/20/2014
299-W5-2	LU	111.7	87.4	12.2	129.50	12/1/2015
299-W6-3	LU	89.5	86.4	3.1	133.99	3/14/2014
299-W6-6	LU	89.9	86.6	3.3	135.01	3/14/2014
299-W7-3	LU	70.3	61.9	8.4	135.23	3/14/2014
699-30-66	LU	93.1	90.1	3.0	130.07	11/3/2014
699-32-62	TU	132.7	64.2	68.5	128.02	3/18/2014
699-32-72A	U	76.7	56.8	19.9	131.97	4/11/2014
699-33-75	TU	135.7	125.1	10.6	133.06	11/3/2014
699-34-61	TU	129.4	123.3	6.1	125.94	3/24/2014
699-35-66A	TU	143.2	124.3	8.9	129.89	9/8/2014
699-35-78A	TU	147.5	117.3	30.2	135.26	11/18/2014
699-36-61A	TU	128.4	110.5	17.9	123.65	6/23/2014
699-36-66B	TU	131.7	121.0	10.7	129.93	9/8/2014
699-36-70A	TU	137.6	128.4	9.2	131.19	9/9/2014
699-36-70B	TU	134.7	124.1	10.6	131.45	2/14/2014
699-37-66	TU	131.3	120.6	10.7	129.40	9/8/2014
699-38-61	TU	126.3	120.2	6.1	123.18	2/10/2014

Table F-2. Hydrogeologic Monitoring Unit Classification and Well Network Details

Well Name	Hydrogeologic Unit Monitored	Elevation Top of Open Interval (m NAVD88)	Elevation Bottom of Open Interval (m NAVD88)	Open Interval Length (m)	Water Level Elevation (m NAVD88)	Water Level Date
699-38-65	TU	163.7	72.2	91.5	128.16	6/23/2014
699-38-68A	TU	137.3	128.2	9.1	130.66	2/4/2014
699-38-70B	MU	98.6	94.0	4.6	130.26	5/12/2014
699-38-70C	LU	106.1	101.5	4.6	130.27	5/12/2014
699-40-62	TU	126.8	115.0	11.8	122.44	3/21/2014
699-40-65	TU	130.2	119.5	10.7	126.33	5/13/2014
699-43-69	CR	105.4	94.7	10.7	129.51	3/21/2014
699-44-64	TU	125.9	87.5	38.4	123.03	11/12/2014
699-45-69A	TU	138.6	110.6	28.0	129.58	4/2/2014
699-45-69C	MU	110.7	106.1	4.6	129.57	4/16/2014
699-47-60	TU	123.4	115.1	8.3	121.86	7/21/2014
699-48-71	TU	138.0	118.8	19.2	130.53	8/27/2014
699-50-74	TU	133.3	122.7	10.6	132.33	6/23/2014
699-51-63	TU	127.4	119.5	7.9	122.59	11/14/2014

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F2 Reference

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