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10-AMCP-0193 JUL 14 2010

Mr. D. A. Faulk, Program Manager
Office of Environmental Cleanup
Hanford Project Office
U.S. Environmental Protection Agency
309 Bradley Boulevard, Suite 115
Richland, Washington 99352

Dear Mr. Faulk:

PERFORMANCE MONITORING PLAN FOR THE 200-ZP-1 GROUNDWATER OPERABLE UNIT REMEDIAL ACTION, DOE/RL-2009-115, REVISION 0

This letter transmits the approved Performance Monitoring Plan (PMP) for the 200-ZP-1 Groundwater Operable Unit Remedial Action, DOE/RL-2009-115, Revision 0.

Comments received from the U.S. Environmental Protection Agency (EPA) on Draft A via e-mail on April 2, 2010, and letter dated April 28, 2010, have been incorporated. Revision 0 was signed by EPA on June 2, 2010, and the U.S. Department of Energy Richland Operations Office on June 10, 2010.

This PMP presents the types of data to be collected, the well networks to be monitored, the frequency of data collection, and the analysis of the data, to monitor the activities associated with the remedial action selected in the Record of Decision for the 200-ZP-1 Operable Unit.

If you have any questions, please contact me, or your staff may contact Briant Charboneau, of my staff, on (509) 373-6137.

Sincerely,

Matthew S. McCormick, Assistant Manager
for the Central Plateau

AMCP:ACT

Attachment

cc: See Page 2

JUL 14 2010

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DOE/RL-2009-115
Revision 0

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

U.S. DEPARTMENT OF ENERGY

Richland Operations Office

P.O. Box 550
Richland, Washington 99352

DOE/RL-2009-115
Revision 0

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

Date Published
May 2010

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

U.S. DEPARTMENT OF ENERGY Richland Operations Office

P.O. Box 550
Richland, Washington 99352

Release Approval 6/15/2010
Date

Concurrence Page

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

Concurrence: B. L. Charboneau
U.S. Department of Energy, Richland Operations Office

[signature] 6-10-2010
Signature Date

E. Laija
U.S. Environmental Protection Agency

[signature] 6/2/10
Signature Date

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Terms

amsl	above mean sea level
COC	contaminant of concern
DS	decision statement
gpm	gallons per minute
HEIS	Hanford Environmental Information System
MCL	maximum contaminant level
MNA	monitored natural attenuation
OU	operable unit
PMP	performance monitoring plan
RAO	remedial action objective
ROD	Record of Decision
TCE	trichloroethylene
WAC	*Washington Administrative Code*

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1 Introduction

This performance monitoring plan (PMP) has been prepared to guide groundwater monitoring data collection activities associated with implementation of the 200-ZP-1 Operable Unit (OU) remedial action. The selected remedy is described in the *Record of Decision, Hanford 200 Area, 200-ZP-1 Superfund Site, Benton County, Washington* (EPA et al. 2008), hereafter referred to as the 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. The PMP does not present the more specific aspects of data collection that are typically described in a sampling and analysis plan and/or a quality assurance project plan. In addition, the PMP is not designed to monitor the treatment process in 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.

This PMP is intended to be a "living document," which will be modified based on changing hydraulic and contaminant distribution conditions at the 200-ZP-1 OU. It is likely that significant improvements will be made over time to the site conceptual model, groundwater flow model, and three-dimensional contaminant distributions especially as results become available from ongoing drilling and sampling at the new extraction and injection well locations. It is also likely that wells included in the PMP monitoring networks will go dry as a result of the operation of the 200-ZP-1 remedial system. Therefore, frequent modifications to the monitoring well networks are likely, and it is important that this PMP is flexible enough and/or can be updated to specify a performance monitoring regime that makes sense for the current state of the site.

The 200-ZP-1 Groundwater OU underlies the northern portion of the Hanford Site's 200 West Area, as shown in Figure 1-1. The remedial investigation and feasibility study (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*, respectively) concluded that without remedial action, contaminants in 200-ZP-1 groundwater would exceed risk threshold values for future industrial workers and residents who might use the groundwater as a drinking water supply. The existing contaminant concentrations also exceed federal and state maximum contaminant levels (MCLs) and state groundwater cleanup standards for use of the groundwater as a source of drinking water. As stated in the ROD, the major contaminant of concern (COC) for the 200-ZP-1 OU is carbon tetrachloride. Other 200-ZP-1 COCs include total chromium, hexavalent chromium, nitrate, trichloroethylene (TCE), iodine-129, technetium-99, and tritium.

The ROD presents the selected remedial action for restoring the aquifer, as well as the cleanup levels for the COCs. The *200 West Area 200-ZP-1 Pump-and-Treat Remedial Design/Remedial Action Work Plan* (DOE/RL-2008-78) 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 are further described below.

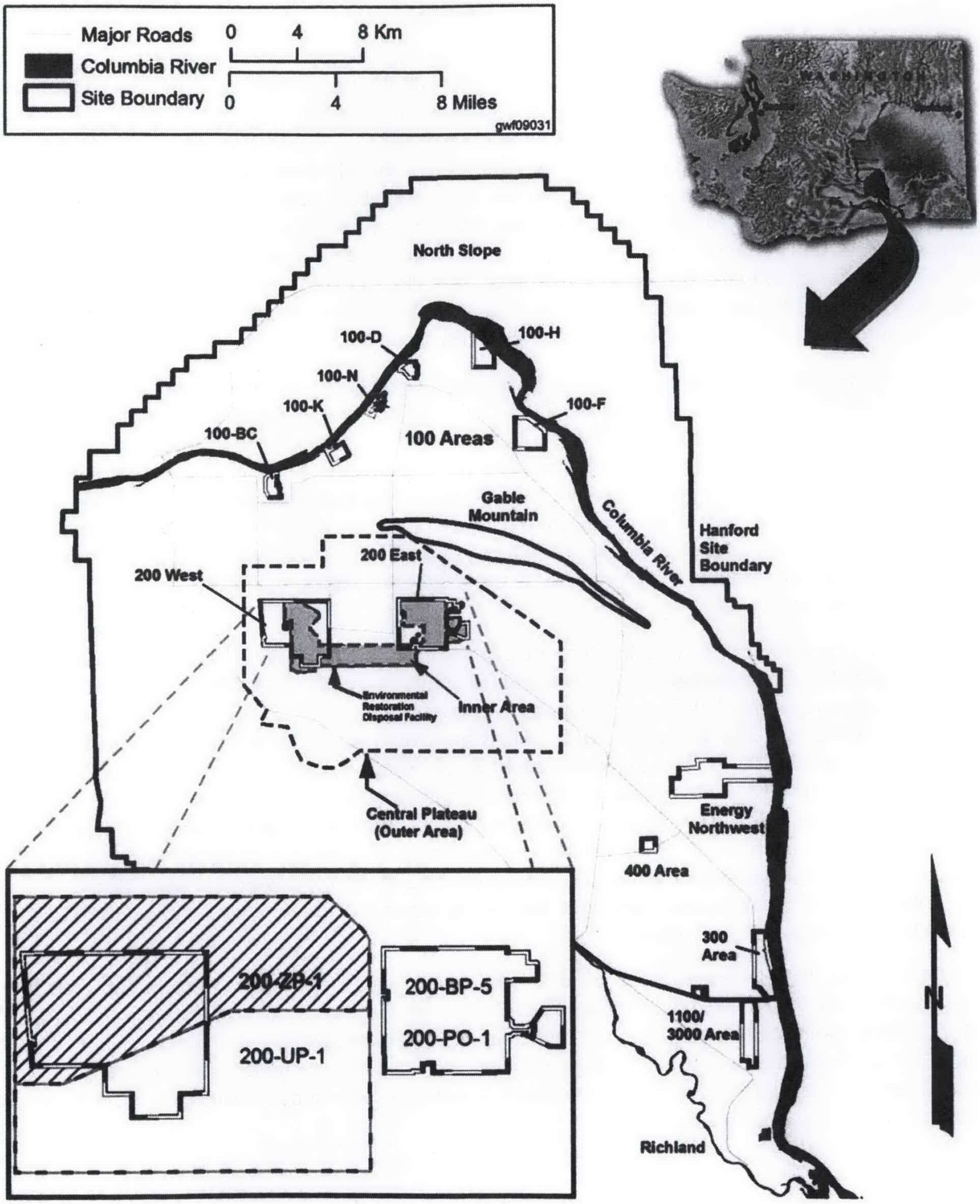

Figure 1-1. Site Location

1.1 Remedial Action Objectives

The state of Washington, through its groundwater protection program, has determined that the aquifer setting for the 200-ZP-1 OU meets the *Washington Administrative Code* (WAC) definition for potable groundwater and has been recognized by the state as a potential source of domestic drinking water. Consistent with the state's beneficial-use determination, the contaminated groundwater must be restored to a level that supports future use as a potential domestic drinking water supply. In accordance with this goal, the specific RAOs for remediation of the contaminated 200-ZP-1 OU groundwater listed below.

- RAO #1: Return the 200-ZP-1 OU groundwater to beneficial use (restore groundwater to achieve domestic drinking water levels) by achieving cleanup levels (Table 1-1). This objective is to be achieved within the entire 200-ZP-1 OU groundwater plumes. The estimated timeframe to achieve cleanup levels is within 125 years.
- RAO #2: Apply institutional controls to prevent the use of groundwater until cleanup levels (Table 1-1) have been achieved. Within the entire OU groundwater plumes, institutional controls must be maintained and enforced until the cleanup levels are achieved, which is estimated to be within 125 years.
- RAO #3: Protect the Columbia River and its ecological resources from degradation and unacceptable impact caused by contaminants originating from the 200-ZP-1 OU. This final objective is applicable to the entire 200-ZP-1 OU groundwater plumes. Protection of the Columbia River from impacts caused by 200-ZP-1 OU contaminants must continue until the cleanup levels are achieved, which is estimated to be within 125 years.

Table 1-1. Cleanup Levels for 200-ZP-1 Operable Unit 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
Trichloroethylene (TCE)	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 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.

COC = contaminant of concern

WAC = *Washington Administrative Code*

1.2 200-ZP-1 Operable Unit Selected Remedy

The selected remedy for the 200-ZP-1 OU consists of four components: (1) pump-and-treat, (2) monitored natural attenuation (MNA), (3) flow-path control, and (4) institutional controls. The first three components will require groundwater monitoring to assess the performance of the selected remedy and are addressed by this PMP. The fourth component does not require groundwater monitoring and is not addressed by this PMP. Descriptions of the first three components of the selected remedy are presented in the following sections.

1.2.1 Pump-and-Treat Component

The groundwater pump-and-treat system will be designed, installed, and operated to capture and treat contaminated groundwater to reduce the mass of carbon tetrachloride, total chromium, hexavalent chromium, nitrate, TCE, iodine-129, and technetium-99 throughout the 200-ZP-1 OU by a minimum of 95 percent within 25 years. The pump-and-treat component will be designed and implemented in combination with MNA to achieve the cleanup levels listed in Table 1-1 for all COCs within 125 years. Carbon tetrachloride concentrations in the groundwater 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 the mass of carbon tetrachloride by 95 percent within the expected timeframe is 7,570 L/min (2,000 gallons per minute [gpm]) using approximately 20 extraction wells and approximately 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 viable treatment technology to remove tritium from the groundwater. However, the half-life of tritium is sufficiently short, so the tritium will decay below the cleanup standard before it leaves the industrial land-use zone (Figure 1-1).

The remedial design will consider, as necessary, the need for treatment of other constituents (e.g., uranium) that may be captured by the 200-ZP-1 OU extraction wells. While not COCs for the 200-ZP-1 OU, such constituents may be encountered during restoration from sources related to the other adjacent groundwater OUs.

1.2.2 Monitored Natural Attenuation Component

Passive natural attenuation processes will be used along with the active pump-and-treat system to reduce COC concentrations to below the cleanup levels. Natural attenuation processes to be relied on as part of this component include abiotic degradation, volatilization (for TCE and carbon tetrachloride), dispersion, sorption, and natural radioactive decay (for tritium). As presented in the ROD, it is estimated that natural attenuation processes should reduce COC concentrations to acceptable levels in approximately 100 years, and the 200-ZP-1 OU plumes should remain on the Central Plateau geographic area during this timeframe. 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 of the groundwater contamination (Figure 1-2). Injecting the treated water in these locations will slow the natural eastward flow of most of the groundwater and, as a result, keep most of the COCs for the 200-ZP-1 OU within the hydraulic capture zone of the extraction wells. It will also increase the time available for natural attenuation processes to reduce the concentrations of contaminant concentrations not captured by the extraction wells.

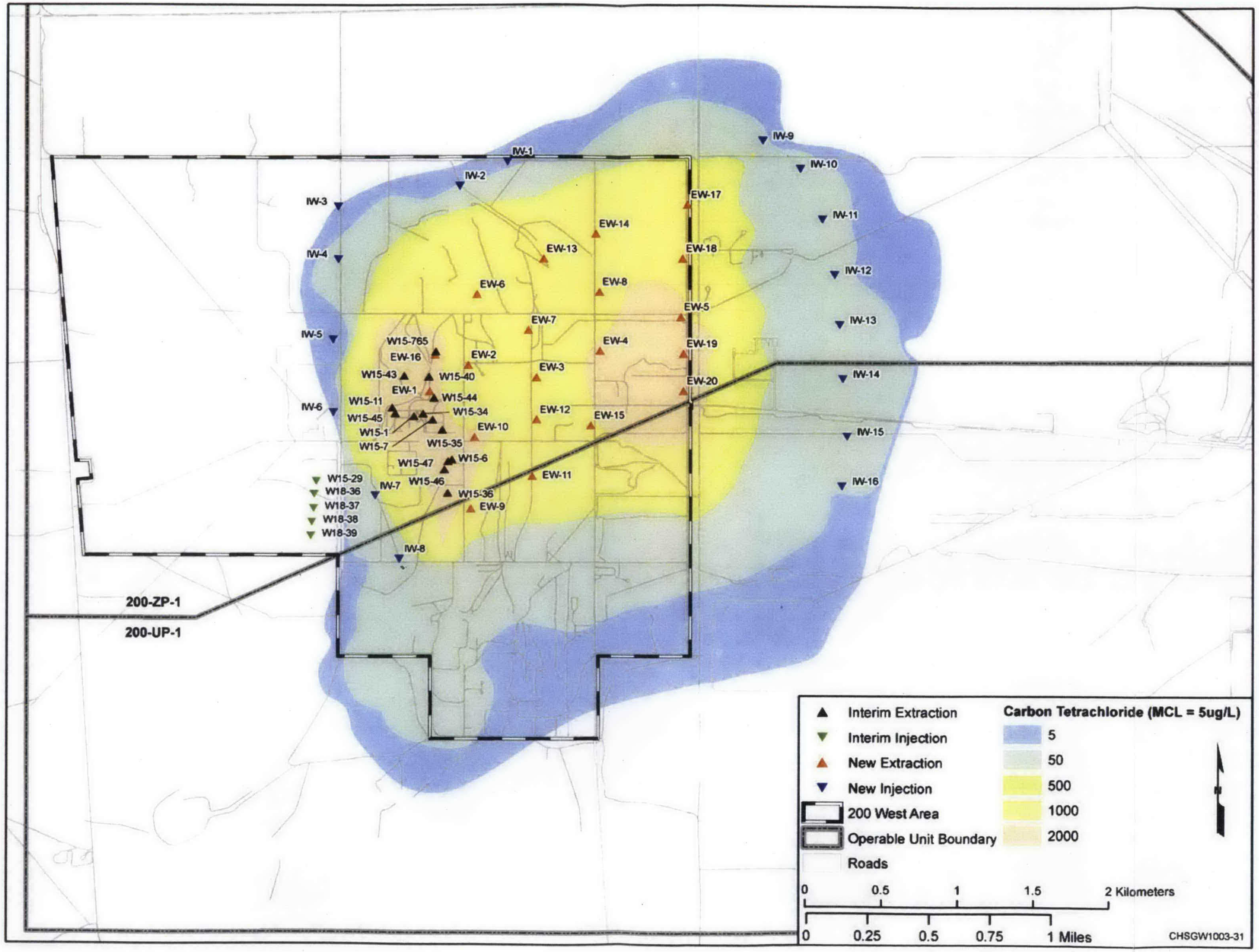

Figure 1-2. Proposed Pump-and-Treat System Well Field and Maximum Carbon Tetrachloride Concentrations

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Flow-path control will also be used to minimize the potential for groundwater in the northern portion of the aquifer to flow northward through Gable Gap and toward the Columbia River (Figure 1-1). Injection wells will be located to re-direct the groundwater flow to the east, which is the longest groundwater flow path to the river (about 26 km [16 mi]).

1.3 Implementation of the Selected Remedy

Since the ROD was prepared, the proposed pump-and-treat system has evolved into a multi-phased installation of approximately 20 new extraction wells and approximately 16 new injection wells, as well as the design and construction of a new treatment plant with a 7,571 L/min (2,000-gpm) total treatment capacity (Figure 1-2). The 200-ZP-1 interim pump-and-treat system will continue to operate while the first new extraction wells are drilled and installed, and while the new treatment plant is constructed. The design and construction period for the new treatment plant is estimated at approximately 3 years. The new treatment plant will begin operation at a capacity of approximately 3,785 L/min (1,000 gpm) while the remaining new extraction and injection wells are drilled and installed. Overall, the new treatment plant is expected to operate for a period of approximately 25 years.

It is expected that the design of the new 200-ZP-1 OU extraction, injection, and monitoring well field will continue to evolve as data are collected and analyzed from the phased drilling, sampling, and testing of the new extraction, injection, and monitoring wells. If during drilling of new wells, sampling results indicate that contamination below Ringold Unit 8 (also known as the Ringold Lower Mud Unit) is higher than contaminant levels above Ringold Unit 8, changes to the well design and locations will be made to appropriately address the contamination in order to meet cleanup levels specified in the 200-ZP-1 ROD. These changes may include constructing the extraction well below Ringold Unit 8. Likewise, if high concentrations of contaminants are found below Ringold Unit 8, then changes may include injecting treated water below Ringold Unit 8 to provide a vertical gradient to prevent eastern migration of contaminants above the basalt and protect contamination from penetrating the basalt. If contamination is above levels that are being addressed through MNA in the interval below Ringold Unit 8, then this may warrant construction of extraction and injection wells below Ringold Unit 8 and the addition of drilling monitoring wells below Ringold Unit 8 to monitor the migration and containment of contaminants in that interval.

Aquifer testing to be conducted following well installation should provide data on the hydraulic performance for fully penetrating, large-diameter extraction wells in the 200-ZP-1 OU. Borehole logging, contaminant sampling, and sieve analysis data collected from the new extraction and injection well locations should also allow significant improvements to be made to the site conceptual model, groundwater flow model, and three-dimensional contaminant distributions. The data may be used in the 200 West Area groundwater flow model to further improve the design of the proposed well field.

For the current design of the 200-ZP-1 OU pump-and treat system, the extraction wells are located in areas of the carbon tetrachloride plume with concentrations greater than 100 μg/L (Figure 1-2). This design concept concentrates the active treatment portion of the selected remedy on the most contaminated groundwater in a relatively large groundwater plume. The eastern injection wells are located in areas of the carbon tetrachloride plume with concentrations less than 100 μg/L, but possibly greater than 5 μg/L (Figure 1-2). Any groundwater contaminated above cleanup levels that is located downgradient of the eastern injection well fence will be addressed by the passive treatment processes of natural attenuation. The western injection wells are generally located in groundwater with carbon tetrachloride concentrations below 5 μg/L.

Since the 200-ZP-1 OU pump-and-treat system will extract some groundwater and associated contaminants originating from the 200-UP-1 OU, the monitoring networks presented in this PMP extend into the 200-UP-1 OU. Groundwater contamination originating from both the 200-ZP-1 and 200-UP-1 OUs is somewhat commingled at this point in time, and the monitoring network is intended to delineate the entire extent of contamination. However, this PMP is not intended to monitor the performance of any 200-UP-1 remedial activities, as these will be specifically addressed once the 200-UP-1 feasibility study is completed and a separate ROD (or an amendment to the 200-ZP-1 ROD) is completed.

The carbon tetrachloride plume depicted in Figure 1-2 is from *Description of Modeling Analyses in Support of the 200-ZP-1 Remedial Design/Remedial Action Work Plan* (DOE/RL-2009-38). Figure 1-2 depicts the maximum projected carbon tetrachloride concentrations looking downward through the 200 West Area contaminant transport model layers in 2008. The carbon tetrachloride concentrations in the contaminant transport model were initialized using the 2008 three-dimensional carbon tetrachloride plume shell presented in the 200-ZP-1 modeling report (DOE/RL-2009-38).

2 Site Conceptual Model

This chapter briefly describes the local geology, hydrogeology, and groundwater in the 200 West Area. This information is summarized from the ROD and is included to provide a brief overview of the current understanding of the site conceptual model.

2.1 Local Geology

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

2.2 Local Hydrogeology

The sediment thickness above the water table (the vadose zone) in the 200 West Area 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, and the Hanford Formation. Erosion during cataclysmic flooding removed some of the Ringold Formation and Cold Creek unit. Perched water (water above the water table) has historically been documented above the Cold Creek unit at locations in the 200 West Area. However, since most liquid waste discharges to the area were stopped in 1995, perched water is infrequently encountered in the vadose zone.

Recharge to the unconfined aquifer in the 200 West Area is from artificial and natural sources. Any natural recharge originates from precipitation. Estimates of recharge from precipitation at the Hanford Site range from 0 to 10 cm/year (0 to 4 in./year) and are largely dependent on soil texture, as well as 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 were stopped in 1995. The artificial recharge in the Central Plateau that continues is largely limited 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. A small volume of uncontaminated water may be used for dust and contamination control during construction phases.

2.3 Groundwater

Groundwater beneath the Hanford Site is found in an upper primarily unconfined aquifer system and in deeper confined aquifers within the basalt. The Columbia River is the primary discharge area for both the unconfined and confined aquifers. The 200 West Area is located approximately 8 km (5 mi) south of the Columbia River. The unconfined aquifer in the 200-ZP-1 OU area of the Central Plateau 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, groundwater flow through the Central Plateau occurs in a predominantly easterly direction from the 200 West Area to the 200 East Area.

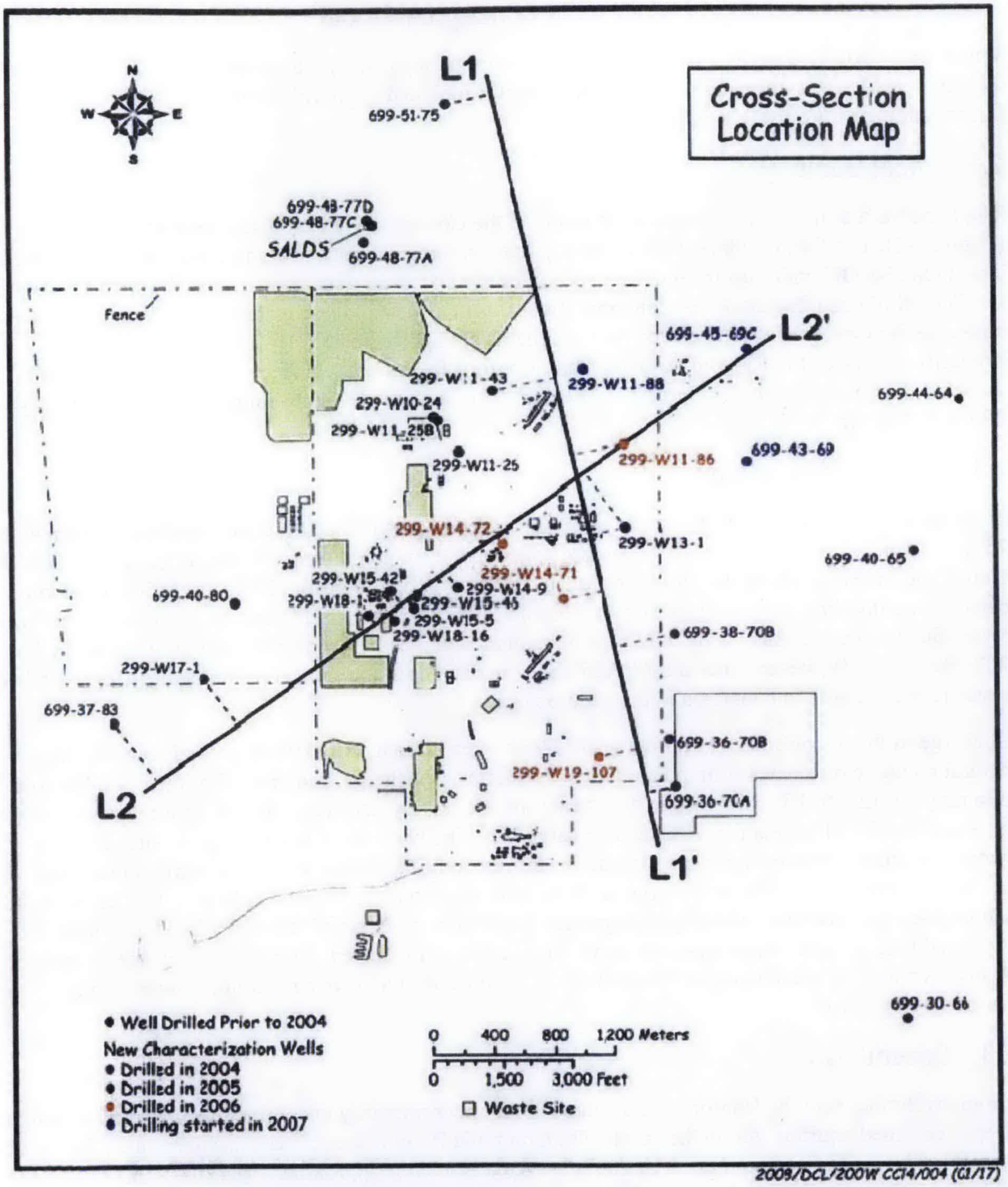
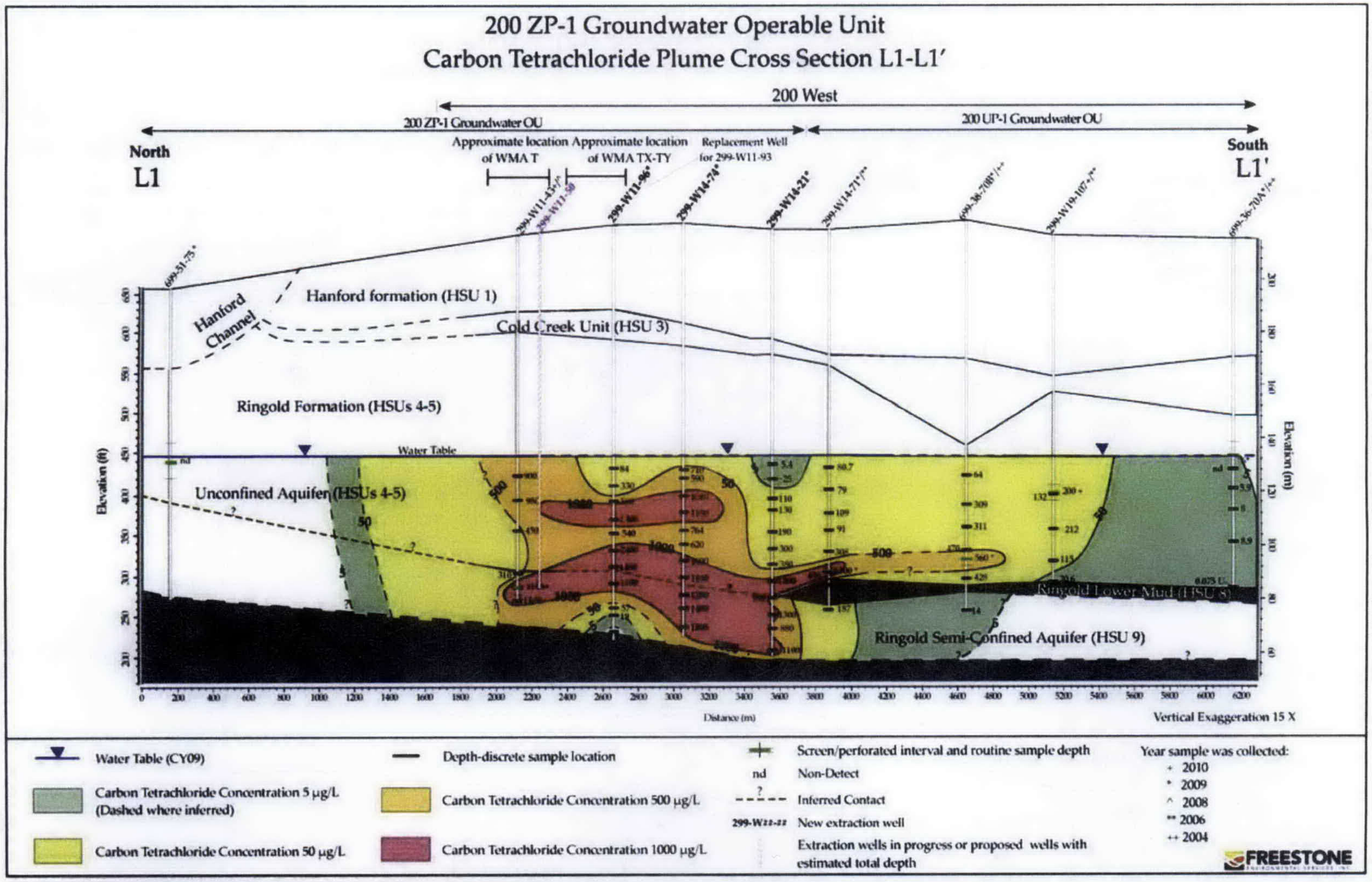
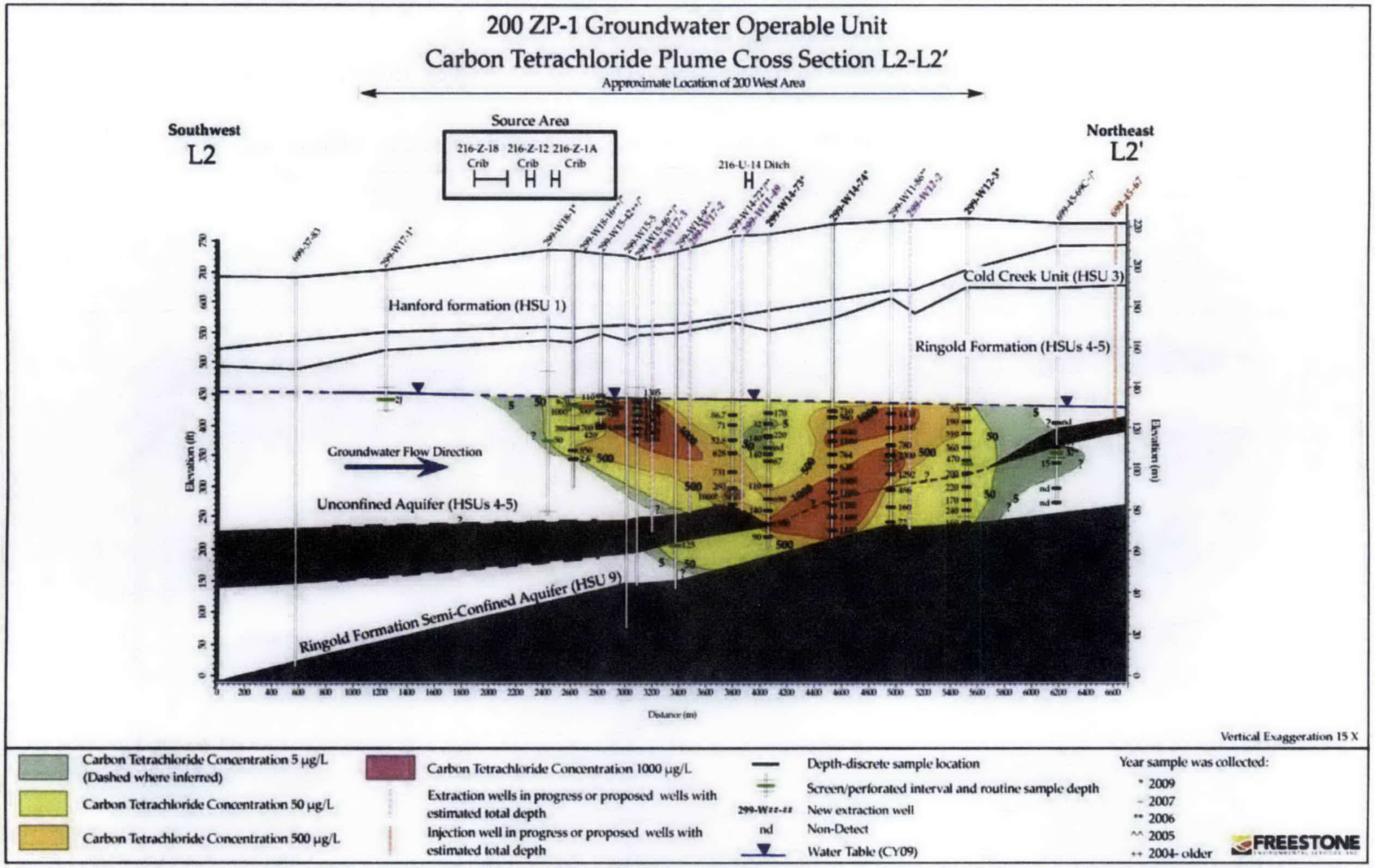


Figure 2-1. Location of Cross-Sections Including Wells Used for Interpretation



Note: 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')



Note: Modified from DOE/RL-2006-24, *Remedial Investigation Report for the 200-ZP-1 Groundwater Operable Unit*.

Figure 2-3. Hydrogeologic Cross-Section for Wells with Depth-Discrete Carbon Tetrachloride Concentration Data, Southwest to Northeast (L2 to L2')

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

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

2.4 Contaminant Distribution

Figures 2-1, 2-2, and 2-3 show cross-sections of the carbon tetrachloride concentrations in the 200-ZP-1 OU. The figures depict a carbon tetrachloride plume that is present at the water table in the source area and gradually dives in the aquifer as it migrates downgradient. The downward migration of the plume is stopped by the relatively fine-grained Ringold Unit 8, which acts as a hydraulic barrier to vertical groundwater flow. Ringold Unit 8, also known as the Ringold Lower Mud Unit, is discontinuous and/or relatively thin in places. This allows the carbon tetrachloride plume to migrate vertically downward to the basalt bedrock in those areas where Ringold Unit 8 is missing. The carbon tetrachloride plume does not extend downward into the basalt bedrock that defines the bottom of the alluvial aquifer system. Both the basalt bedrock and the Ringold Unit 8 rise to the northeast and force the carbon tetrachloride plume to gradually rise toward the surface as it migrates eastward and as the saturated thickness of the aquifer decreases.

2.5 Site Conceptual Model Uncertainties

Several potential uncertainties are associated with the current site conceptual model that could impact the success of the 200-ZP-1 OU remedial action. These uncertainties include (1) the effectiveness of the Ringold Unit 8 as a barrier to vertical contaminant migration, (2) the continuity of Ringold Unit 8, and (3) the thickness of the contaminant plume near the source areas. Near the contaminant source areas, Figures 2-1, 2-2, and 2-3 depict approximately 60 m (196.9 ft) of saturated aquifer above the confining unit, Ringold Unit 8. Below the confining unit is approximately 15 m (49.2 ft) of saturated aquifer, above the basalt bedrock. The continuity of the confining unit and its effectiveness as a hydraulic barrier to the downward migration of contaminants are important to the design of the new extraction well field. If the confining unit is fairly effective as a hydraulic barrier and contaminants have not migrated below the unit, then the extraction wells should only be completed above the confining unit. If the confining unit is not an effective hydraulic barrier, is more discontinuous than previously believed, or contamination has migrated below it, then the extraction wells may need to extract groundwater from both above and below the confining unit. If contamination has migrated below the confining unit, the possibility of the carbon tetrachloride plume extending into the basalt bedrock may need to be further evaluated.

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

3 Design of the Performance Monitoring Program

This chapter presents the required program for groundwater monitoring data collection activities associated with implementation of 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 shall be used to monitor and evaluate the success of the selected remedial action. Appendix A presents the results from the data quality objectives process that were used to develop the sampling approaches identified in this chapter.

3.1 Contaminant Monitoring

Contaminant monitoring data will be collected over the life of the remedial action to evaluate performance and optimize effectiveness. The selection of the contaminant monitoring well network, sampling frequency, and analytical parameters are discussed in the following sections.

3.1.1 Contaminant Monitoring Network

Both a proposed full and a reduced contaminant monitoring well network are presented in this PMP. Because sampling the full well network is costly, a reduced well network may be sampled every other sampling event, at least while the remedial system is operating. Sampling of the full well network will generate sufficient data for quantitative analysis in support of addressing each of the seven decision statements (DSs). This analysis includes plume shell development 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 of the reduced well network will generate sufficient data for more qualitative analysis in support of addressing DSs #1, #2, and #5. This includes determining if any new COC releases COCs have occurred; evaluating concentration trends in high-concentration areas of the plumes; and determining if contamination is expanding downgradient, laterally, or vertically.

The contaminant monitoring networks shown in Figures 3-1 and 3-2 are expected to evolve over time as the active pump-and-treat and passive natural attenuation remediation processes result in changes in contaminant concentrations and plume sizes. Some areas of the plumes will cleanup more quickly than other areas, and the extraction wells will most likely be shut down in a staged manner as they become increasingly inefficient to operate. Additionally, many of the shallow monitoring wells may go dry in areas farthest removed from the east and west injection well fences. Therefore, while the pump-and-treat system is operating, the contaminant monitoring well networks shall be evaluated on an annual basis to determine if monitoring wells shall be dropped from the networks or if other wells shall be added to the networks.

After the pump-and-treat system has been shut down, the contaminant monitoring well networks shall be evaluated on a less frequent basis as the plumes change more slowly, except for when a rebound study is being performed. During a rebound study, samples shall be collected on an annual or more frequent basis. At a minimum, the contaminant monitoring networks should be evaluated every 5 years in accordance with the 5-year review requirement described in the ROD.

3.1.1.1 Proposed Full Contaminant Monitoring Well Network

The proposed full contaminant monitoring well network, which includes 125 wells, is presented in Figure 3-1, and the available well construction details for the network are presented in Appendix B. The proposed full contaminant monitoring well network was derived as outlined in the following discussion.

A master list of available monitoring wells was queried from the Hanford Environmental Information System (HEIS) database for the 200-ZP-1 and 200-UP-1 OUs. This query included data such as well coordinates, well construction information, and historical purpose of the wells. Many of the wells included in the query results had missing information, especially for the older historic wells.

The master list of monitoring wells was then reduced by determining if the well was missing crucial information, was indicated as being dry, or was located outside the area of interest for performance monitoring. Many wells identified from the HEIS database query were missing top and bottom screen elevation data; however, this information was present in the 2008 carbon tetrachloride plume shell data set. For these wells, the mid-screen elevation was supplied (in Appendix B) from the plume shell data set. This suggests that the information is located in other Hanford databases and/or data sources, and the information should be added to the HEIS database.

The remaining potential monitoring wells were then imported into the latest carbon tetrachloride plume shell grid and were compared to the three-dimensional carbon tetrachloride distribution to qualitatively evaluate their redundancy. At this stage of the evaluation, there was a relatively dense (i.e., well separation ranging from approximately 40 to 260 m [131.2 to 853.0 ft]) network of shallow monitoring wells in the tank farm areas and a much more widely spaced (i.e., well separation ranges from approximately 500 to 1,900 m [1640.4 to 6233.6 ft]) network of monitoring wells further to the east and/or deeper in the aquifer. Closely spaced monitoring wells were thinned out by considering their three-dimensional spatial proximity to other monitoring wells and their carbon tetrachloride concentrations. Monitoring wells that defined the high- and low-concentration areas were kept, and the wells that provided little added definition of the three-dimensional carbon tetrachloride distribution were discarded. The goal of this evaluation was to improve future carbon tetrachloride plume shell development by providing a more spatially consistent and complete network of monitoring wells that monitor elevations from the basalt bedrock to the water table and can provide a more appropriate density of carbon tetrachloride data relative to the large scale of the plume.

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

3.1.1.2 Proposed Reduced Contaminant Monitoring Well Network

The 67 wells proposed for the reduced contaminant monitoring well network are presented in Figure 3-2, and the available well construction details for the network are presented in Appendix B. The proposed reduced contaminant monitoring well network was derived as described in the following discussion.

The plume shell data sets for each of the COCs were sorted to find the 20 most contaminated wells for each COC. This list of wells was then compared to the full monitoring well network list of wells, and those wells not included in the full well network were eliminated.

The downgradient "sentry" wells included in the full well network, which are useful for monitoring plume expansion, were then added to the reduced well network. The resulting reduced well network only includes monitoring wells that are also included in the full well network to provide continuity to COC concentration trends.

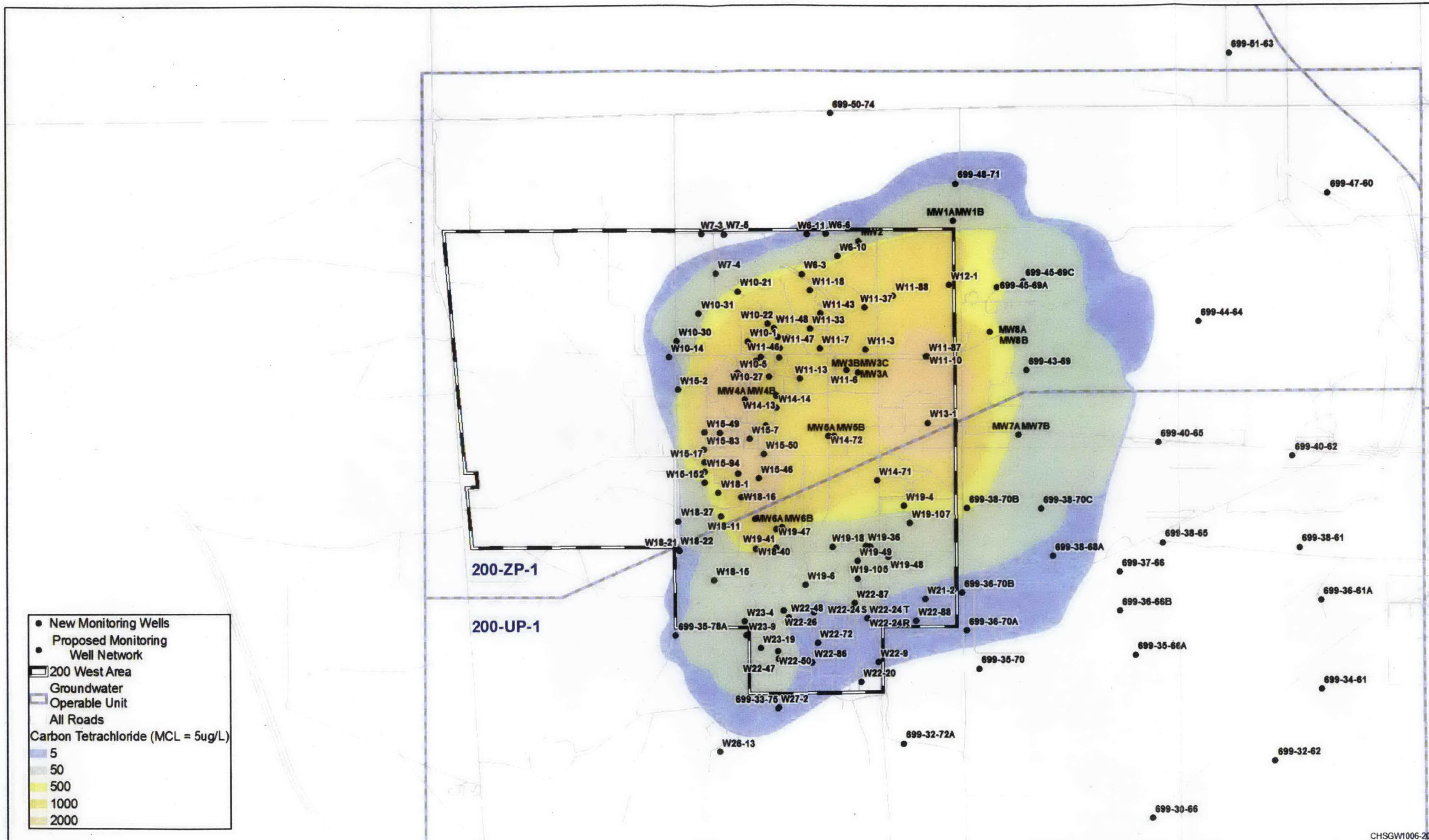


Figure 3-1. Proposed Contaminant Monitoring Well Network (Full)

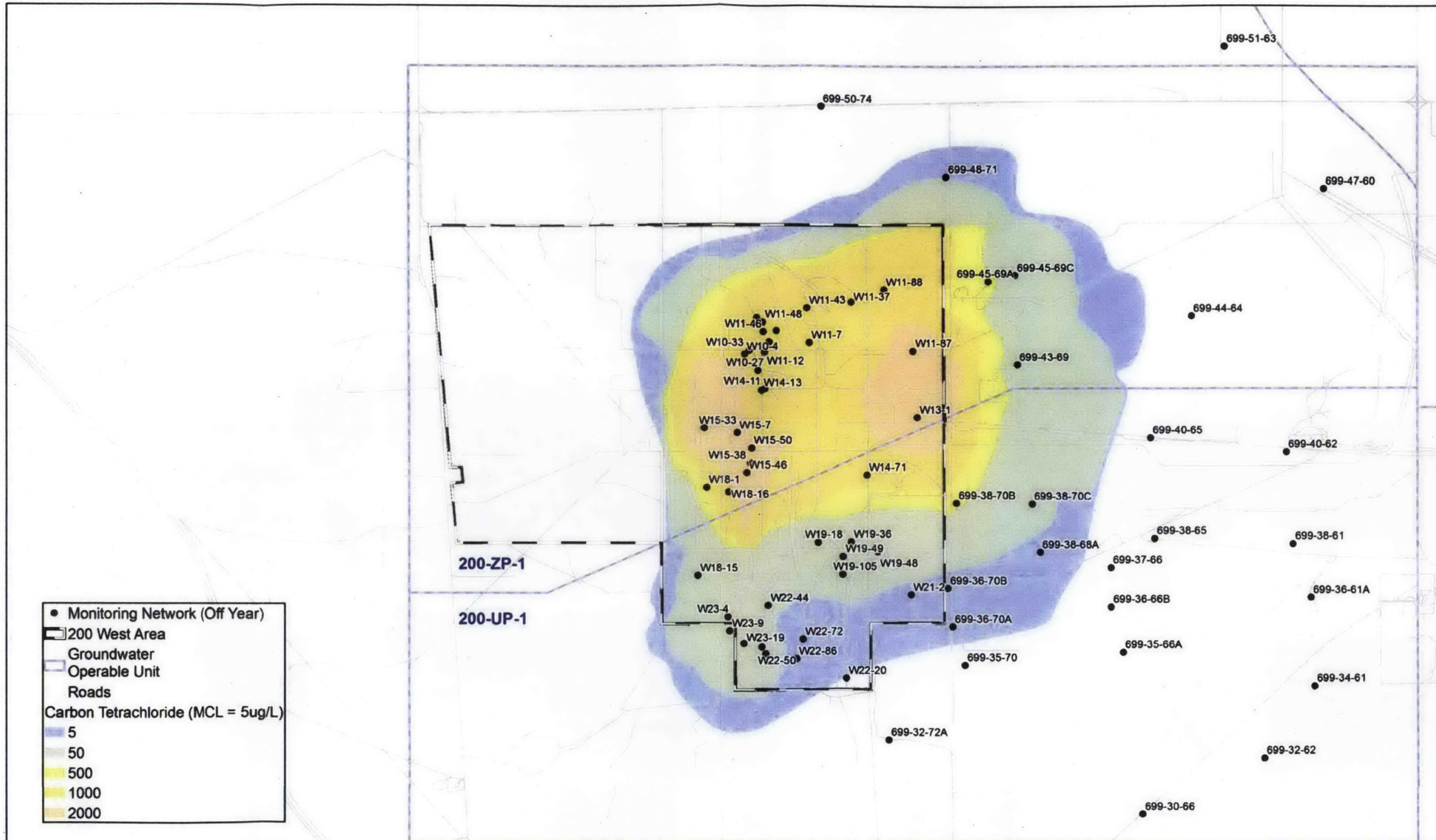


Figure 3-2. Proposed Contaminant Monitoring Well Network (Reduced)

3.1.2 Data Gap in Monitoring Well Coverage

The process of comparing the available monitoring well coverage to the latest three-dimensional carbon tetrachloride plume shell revealed several areas of significance that lack monitoring well coverage. These data gap areas resulted in areas of relatively large uncertainty in the carbon tetrachloride plume shell. In support of the data gap investigation, maps of kriged carbon tetrachloride error variance were also produced for several elevation intervals in the aquifer. These maps, which are presented in Appendix C, reveal the areas in the kriged three-dimensional carbon tetrachloride plume shell with the greatest error variance or relative uncertainty. While these maps provide visual information concerning uncertainty in the distribution of data, the maps are dependent on the kriging parameters used to generate them.

In order to reduce some of the more significant uncertainty in the carbon tetrachloride plume delineation, several new monitoring wells are proposed, as shown in Figure 3-3. Figure 3-3 also shows the data point locations used to construct the latest carbon tetrachloride plume shell (not all wells are labeled, and the 299- and 699- well name prefixes are not shown on the figure to save space). Table 3-1 lists the locations and estimated mid-screen elevations of proposed new monitoring wells that, if constructed and routinely sampled, could significantly reduce this uncertainty. Priority ranking (highest priority is ranked 1, lowest priority is ranked 14) was also assigned to each well based on the well's potential to reduce the uncertainty in the carbon tetrachloride distribution. While some of these data gaps may be temporarily filled by one-time sampling data collected during drilling of the proposed new extraction wells, 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 pump-and-treat system optimization.

Proposed new monitoring wells MW1A, MW1B, and MW2 are intended to help delineate the northern and northeastern boundaries of the carbon tetrachloride plume. Sampling at location 299-W11-88 has carbon tetrachloride concentrations of 1,700 µg/L at 103 m (337.9 ft) above mean sea level (amsl) and 850 µg/L at 94 m (308.4 ft) amsl. Currently, there are no available monitoring wells screened at appropriate elevations to delineate the northern and northeastern extent of these high concentrations. These proposed new monitoring wells are also positioned in locations between the western and eastern injection well fences, within the area of groundwater extraction.

Proposed new monitoring wells MW3A, MW3B, and MW3C are intended to fill in a gap in the monitoring well network between upgradient monitoring wells (e.g., 299-W10-33 and 299-W14-11) and downgradient monitoring wells (e.g., 299-W11-86 and 299-W11-87). This data gap is approximately 1,325 m (4,347.1 ft) in the middle of the new pump-and-treat extraction well field with significant carbon tetrachloride concentrations (greater than 1,000 µg/L), both upgradient and downgradient. 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 shall be completed above Ringold Unit 8.

Proposed new monitoring wells MW4A and MW4B are intended to provide deep monitoring coverage near the source areas just west of the TX/TY Tank Farms, as this area has little deep monitoring coverage. The proposed new monitoring wells are also intended to provide deep monitoring coverage close to the first new pump-and-treat extraction well to be installed during Phase 1 of the remedial action. Well screens A and B shall both be completed above Ringold Unit 8.

Proposed new monitoring wells MW5A and MW5B are intended to provide monitoring coverage above and below the existing monitoring well screen at 299-W14-72 (mid-screen elevation of 88 m [288.7 ft] amsl). As with proposed new monitoring wells MW3A, B, and C, these proposed new monitoring wells are located in the middle of the new pump-and-treat extraction well field, upgradient of sampling location 299-W13-1 that monitors carbon tetrachloride concentrations greater than 500 μg/L deep in the aquifer. Screen A is intended to be completed below Ringold Unit 8, and screen B shall be completed above Ringold Unit 8.

Proposed new monitoring wells MW6A and MW6B are intended to provide deep (mid-screen elevations of 80 and 106 m [262.5 and 347.8 ft] amsl) monitoring coverage just northeast of the U Tank Farm in the vicinity of the carbon tetrachloride source areas. These wells shall help delineate the southern boundary of the high-concentration area of the carbon tetrachloride plume under the source areas. Well screen A shall be completed below Ringold Unit 8, and well screen B shall be completed above Ringold Unit 8.

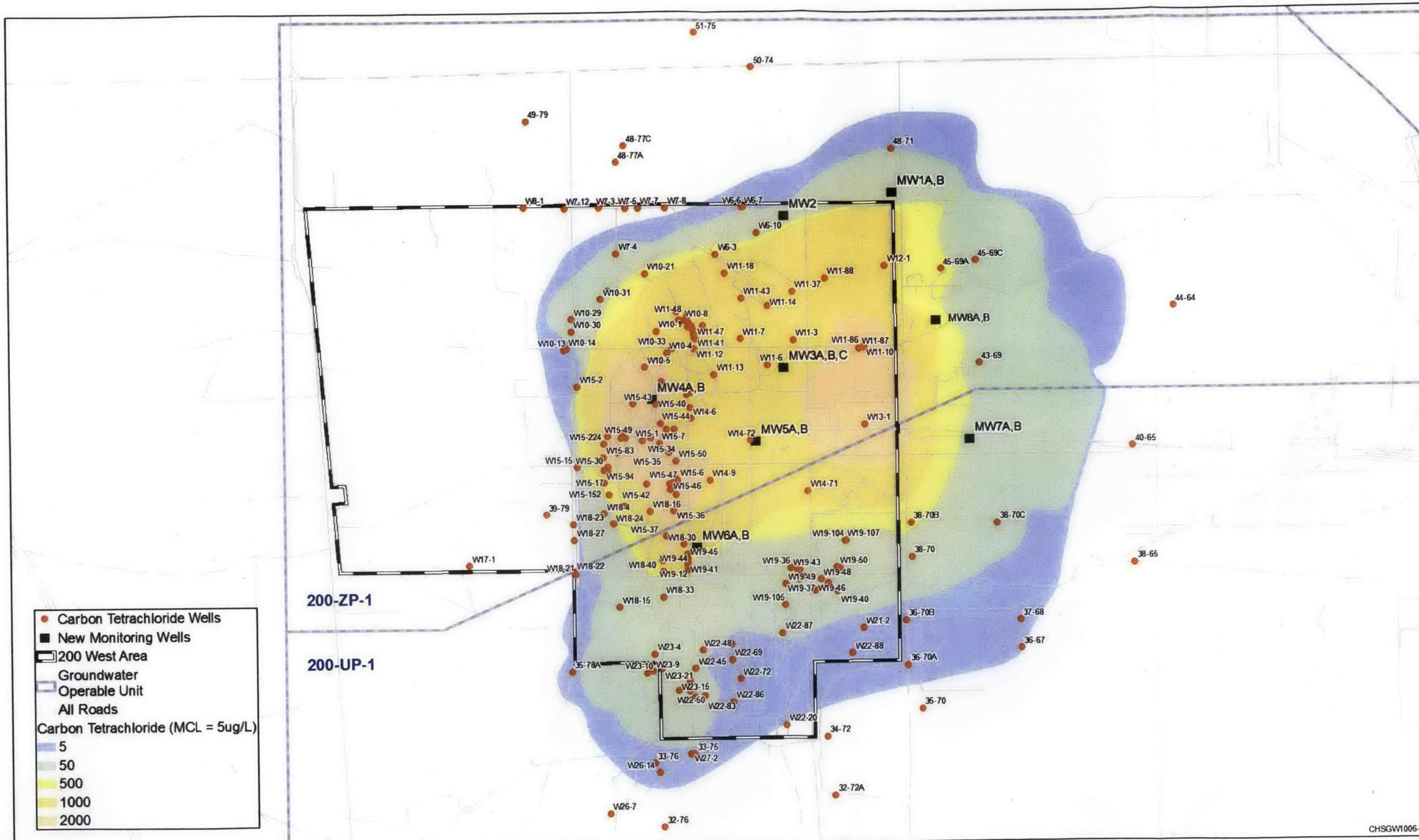
Proposed new monitoring wells MW7A and MW7B shall help delineate the downgradient extent of the contamination found at sampling location 299-W13-1 and to fill in the gap in monitoring coverage between monitoring wells 299-W13-1 and 699-40-65. Proposed new monitoring wells MW8A and MW8B shall help delineate the downgradient extent of the contamination found at sampling location 299-W11-87 and help fill in the gap in monitoring coverage between monitoring wells 299-W11-87 and 699-44-64. This is a gap in coverage of approximately 1,880 m (6,168.0 ft). Well screen B shall be completed above Ringold Unit 8 (if there is sufficient saturated thickness). Well screen A shall be completed below Ringold Unit 8. The proposed new monitoring wells are located upgradient of the new pump-and-treat system's eastern injection well fence and downgradient of the new extraction wells.

3.1.3 Contaminant Monitoring Frequency

An initial baseline sampling round will be conducted using the full monitoring well network before the pump-and-treat system is activated. The data collected from this sampling event, in addition to the data collected from the drilling and sampling of the new extraction and injection wells, will be used to construct baseline three-dimensional contaminant plume shells for each COC. The data set will be the most comprehensive set of sampling data available and will generate the most accurate starting contaminant masses and plume volumes for each COC. These initial contaminant masses will be used to calculate the mass removal statistics for each COC over the life of the remedial system operation in support of DS #4.

During the early operation of the pump-and-treat system, groundwater samples will be collected from the contaminant monitoring well network on an annual basis. The reduced well network may be used every other sampling event; however, the first sampling event conducted after the first year of system operation will use the full well network. As stated previously, the groundwater flow velocities typically range from 0.0001 to 0.5 m/day (0.00033 to 1.64 ft/day) across the 200-ZP-1 OU. The upper-bound value of 0.5 m/day (1.64 ft/day) corresponds to a maximum groundwater flow rate of approximately 180 m/year (590.6 ft/year). For the relatively closely spaced, shallow monitoring wells in the tank farm areas (with well separation ranging from approximately 40 to 260 m [131.2 to 853.0 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 (with well separation ranging from approximately 500 to 1,900 m [1,640.4 to 6,233.6 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 likely appropriate given the size of the plumes, the groundwater flow velocities, and the well spacing of the available monitoring well network.

In later pump-and-treat system operations, when contaminant concentrations change less rapidly, the frequency of monitoring well sampling shall be evaluated. The sampling frequency may be reduced to biannually, at least for some monitoring wells.



Note: Not all wells are labeled, and the 299- and 699- well name prefixes are not shown on this figure to save space.

Figure 3-3. Carbon Tetrachloride Plume Shell Monitoring Well Locations

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Table 3-1. Proposed New Monitoring Wells

Well No.	Well Name	Easting (m)	Northing (m)	Estimated Mid-Screen Elevation (m amsl)	Priority
1	MW1A	568369	137743	90	3
2	MW1B	568369	137743	110	4
3	MW2	567591	137577	111	10
4	MW3A	567578	136476	73	5
5	MW3B	567578	136476	92	6
6	MW3C	567578	136476	112	7
7	MW4A	566638	136251	80	11
8	MW4B	566638	136251	100	12
9	MW5A	567374	135941	70	8
10	MW5B	567374	135941	110	9
11	MW6A	566941	135175	80	13
12	MW6B	566941	135175	106	14
13	MW7A	568900	135945	100	2
14	MW7B	568900	135945	120	1
15	MW8A MW8B	568670	136810	98 120	

amsl = above mean sea level

After the pump-and-treat system is shut down, the frequency of contaminant monitoring shall be evaluated based on the observed rate of change of the contaminant plumes. The contaminant monitoring frequency for those monitor wells near the last extraction wells to be shut down should be adequate to monitor for possible rebound of contaminant concentrations in the early years after the wells are shut down. At a minimum, contaminant monitoring samples will be collected every 5 years in accordance with the 5-year review requirement described in the ROD.

Each extraction well will be sampled on a monthly basis during the first few years of pump-and-treat system operation. The sampling data collected from each extraction well 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 generally advisable 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, in order to maximize the mass removed per gallon of produced groundwater. The sampling data are also needed to help track contaminant mass removal during the remedial action. Some COCs may be detectable above the cleanup levels in samples collected from individual extraction wells but may not be detectable in the combined treatment plant influent samples. Therefore, without the extraction well sampling results, the mass removal for such COCs could not be tracked by using only the combined treatment plant influent samples.

After several years of pump-and-treat system operation, when contaminant distributions and system operation have stabilized, the extraction well sampling frequency will be evaluated and potentially changed to a quarterly basis.

Treatment plant influent and effluent sampling will be performed on a monthly basis until the treatment plant has been shut down.

3.1.4 Contaminant Monitoring Analytical Parameters

During early operation of the pump-and-treat system, contaminant monitoring samples collected from the monitoring wells will be analyzed for the COCs and other potential contaminants listed in Table A-1, as well as the biogeochemical and field screening parameters in Table A-2 (see Appendix A). As part of the 5-year review process, the constituents monitored at each monitoring well will be reviewed and a list of selected constituents will be developed for each monitoring well. However, the analytical parameters analyzed for in each monitoring well will be sufficient to delineate each contaminant plume in three-dimensional, with sub-cleanup level concentrations surrounding each contaminant plume to define their boundaries.

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

3.2 Hydraulic Monitoring

Hydraulic monitoring data will be collected over the life of the remedial action to evaluate performance and optimize effectiveness. The selection of the monitoring well network and measurement frequency are described in the following sections.

3.2.1 Hydraulic Monitoring Network

The proposed hydraulic monitoring well network is shown in Figure 3-4, and the available well construction details are listed in Appendix D. Hydraulic monitoring will be conducted for the duration of pump-and-treat system operation. The hydraulic monitoring well network was derived using a procedure similar to that used for selecting contaminant monitoring locations. The starting point used the same master list of available monitoring wells previously described for the contaminant monitoring network. The list was then reduced to provide a more consistently spaced network of well screens, covering elevations ranging from the basalt bedrock to the water table interface. Since hydraulic stresses are more homogeneous than contaminant concentrations, this monitoring well network is less dense and more regularly spaced than the contaminant monitoring network. A few monitoring wells located in close proximity to proposed new pump-and-treat extraction wells were then added to the network to provide monitoring points in close proximity to several of the extraction wells. The monitoring wells cover a spatial area that exceeds the boundaries of the plumes and the proposed pump-and-treat system so the hydraulic monitoring data can provide useful model calibration data sets.

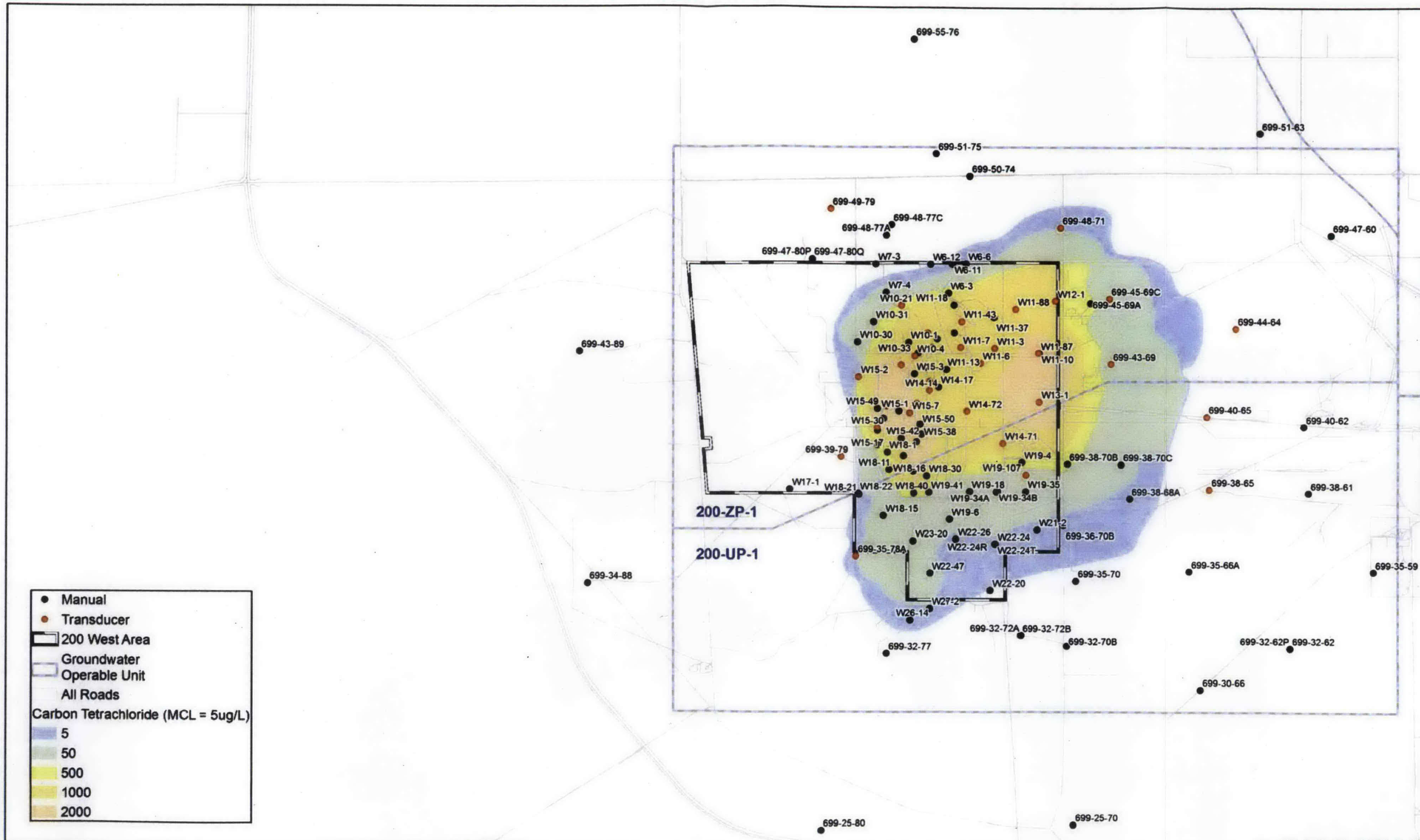

Figure 3-4. Proposed Hydraulic Monitoring Well Network

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Many of the hydraulic monitoring wells are proposed to be instrumented with transducers and data loggers to measure semicontinuous groundwater elevations. These wells are shown on Figure 3-4 and are listed in Appendix D. The hydraulic monitoring wells were chosen for the following reasons.

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

After shutting down the pump-and-treat system operation, the hydraulic monitoring network will be evaluated. The density of the monitoring well network will be reduced to reflect the return of hydraulic gradients to a more regional groundwater flow pattern.

3.2.2 Hydraulic Monitoring Frequency

While the pump-and-treat system is operational, a synoptic set of hydraulic monitoring data will be collected from the hydraulic monitoring well network on an annual basis. Also, a pre-system startup set of hydraulic monitoring data will be collected from the hydraulic monitoring well network to provide a baseline set of hydraulic data. Changing remedial system groundwater extraction and injection rates will result in changes to the three-dimensional groundwater head field, which can affect extraction well performance and plume capture. Currently, the 200-ZP-1 OU water table continues to decline at a rate of approximately 0.21 m/year (0.69 ft/year) due to the elimination of the large influx of artificial recharge that created the elevated water table. Therefore, annual hydraulic monitoring is likely prudent to ensure that the remedial system is operating with optimal performance.

While the pump-and-treat system is operating, the need for semicontinuously measured groundwater elevations from transducer-equipped hydraulic monitoring wells will be evaluated and the wells equipped as needed. 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 will 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.

While the pump-and-treat system is operational, flow rates will be measured in each extraction and injection well, and for the combined treatment plant influent, on a semicontinuous basis.

After the pump-and-treat system has been shut down, the frequency of hydraulic monitoring in monitoring wells will be evaluated based on how rapidly the water table stabilizes. At a minimum, a synoptic set of hydraulic monitoring data will be collected from the hydraulic monitoring well network every 5 years in accordance with the 5-year review requirement described in the ROD.

3.3 Performance Monitoring Analysis and Reporting

Each performance monitoring event will be analyzed and reported. A suggested performance monitoring report outline, which is applicable during the early years of the remedy, is shown below. It should be noted; however, that not all of the report elements included in the suggested outline may be applicable to each performance period.

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 Site Conceptual 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
gpm	gallons per minute
OU	operable unit
PMP	performance monitoring plan
RAM	residual analysis method
ROD	Record of Decision
WAC	*Washington Administrative Code*

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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), 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).

- <u>DS #1</u>: 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.
- <u>DS #2</u>: 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 impractability 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 begin to 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 will be collected are summarized as follows.

- Contaminant sampling data for the groundwater monitoring network: Contaminant sampling for the monitoring well network will be 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 will be analyzed for the COCs listed in Table 1-1 (see main text). Analytical method detection limits will be equal to or less than the cleanup levels listed in Table 1-1. Groundwater samples will also be 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	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 (TCE)	1[a]	µg/L	Delineate TCE 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 TCE) so the excess lifetime cancer risk does not exceed $1x10^{-5}$ 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 (total and dissolved)	EPA 6010B	µg/L	Evaluate natural attenuation
Manganese (total and dissolved)	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

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"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 will spatially cover an area larger than the area covered by the pump-and-treat extraction and injection wells. The spatial density of monitoring wells will be the greatest in the area bounded by the proposed east and west injection well fences (shown in Figure 1-2 [see main text]). The monitoring wells will have sufficient vertical coverage to monitor elevations ranging from the basalt bedrock up to the water table interface. Operating extraction wells will not be included in the groundwater elevation monitoring well network. The hydraulic monitoring data will include 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 semicontinuously. Measured groundwater elevations will be accurate to the nearest 0.61 cm (0.02 ft).
- Remedial system monitoring data: Extraction and injection well flow rates will be measured at each well on a semicontinuous basis using in-line flow meters accurate to 5 percent of the pumping rate. Combined influent and effluent contaminant monitoring samples will be collected from the treatment plant influent and effluent sampling ports while the extraction wells are pumping, preferably at design rates. The samples will be analyzed for the COCs listed in Table 1-1 (see main text), and the analytical method detection limits will be equal to or less than the cleanup levels listed in Table 1-1 (main text). Extraction well contaminant monitoring samples will be collected from the sampling port at each individual extraction well while the well is pumping, preferably at the design rate. The samples will be analyzed for the COCs listed in Table 1-1, and the analytical method detection limits will be 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 will be necessary to determine if new releases of COCs occur. The sampling data will be 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 will be 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 will be 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 will be needed for model input. The contaminant transport model will 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, will be needed to initialize the contaminant concentrations in the model. Extraction well contaminant sampling data will be 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 will be 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 that will be 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 will 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 will be 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 will be 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 will be 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 will be 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, 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. A starting mass for each COC will be 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 will be re-evaluated after completing drilling and sampling at the new extraction and injection well locations. 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 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 will be 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 will be 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 will be 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 will be 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 proposed 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 below.

A6.1 Approach to Resolve Decision Statement #1

Groundwater contaminant sampling data will be evaluated to determine if any new releases of COCs have occurred. Contaminant monitoring well sampling concentration trends 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 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 will be 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 will be 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 will be 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 will be 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 will be 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 200-ZP-1 OU remedial investigation report (DOE/RL-2006-24, *Remedial Investigation Report for the 200-ZP-1 Groundwater Operable Unit*) and the feasibility study report (DOE/RL-2007-28, *Feasibility Study for the 200-ZP-1 Groundwater Operable Unit*) 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 ROD should likely be amended to reflect this determination. Also, this PMP should be modified to include the applicable transformation products as COCs.

A6.3 Approach to Resolve Decision Statement #3

Groundwater elevation data will be 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 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.

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 will be 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 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 will be 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 will use 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 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 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 will be 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 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 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 more 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 usually 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 semicontinuous 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 µg/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 µg/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 that shall be 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 of this PMP.

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Appendix B

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

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B1 200-ZP-1 Operable Unit Proposed Contaminant Monitoring Well Network

Table B-1 provides details on the full proposed contaminant monitoring well network for the 200-ZP-1 Operable Unit, and Table B-2 provides details on the reduced proposed contaminant monitoring well network.

Table B-1. 200-ZP-1 Operable Unit Proposed Contaminant Monitoring Well Network (Full)

Well No.	Well Name	Easting (m)	Northing (m)	Surface Elevation (m)	Depth to Screen Top (m)	Depth to Screen Bottom (m)	Date Drilled	Mid-Screen Elevation* (m)
1	299-W10-1	566663	136735	207.5	149.5	125.2	8/7/47	137.4
2	299-W10-14	566017	136609	214.3	84.1	78.0	11/18/87	81.1
3	299-W10-21	566584	137155	206.5	142.7	136.6	8/27/93	139.7
4	299-W10-22	566833	136883	209.0	143.3	134.1	10/2/94	138.7
5	299-W10-30	566083	136739	211.6	137.8	127.1	3/14/06	132.4
6	299-W10-31	566266	136968	210.4	137.3	126.6	4/20/06	131.9
7	299-W10-33	566773	136610	206.0	87.1	81.0	6/15/07	84.1
8	299-W10-4	566735	136578	205.5	147.6	130.8	11/10/52	139.0
9	299-W10-5	566579	136475	206.0	152.6	138.9	5/18/54	145.8
10	299-W11-10	568148	136610	223.2	145.2	130.5	4/16/56	137.8
11	299-W11-12	566927	136604	208.2	147.2	132.0	12/21/53	139.6
12	299-W11-13	567099	136424	211.9	145.5	68.4	7/31/61	106.9
13	299-W11-18	567182	137161	216.5	147.3	126.6	3/1/67	137.0
14	299-W11-3	567642	136664	220.0	142.6	122.5	8/29/56	132.5
15	299-W11-37	567635	137018	221.6	142.3	132.8	7/7/94	136.6
16	299-W11-43	567270	136971	217.5	88.1	83.5	5/23/05	85.8
17	299-W11-45	566993	136776	213.6	127.9	123.4	9/2/05	125.7
18	299-W11-46	566915	136773	210.9	130.7	124.6	7/26/05	127.6
19	299-W11-47	566934	136681	210.4	126.8	117.5	1/6/06	122.2
20	299-W11-48	566882	136846	209.7	125.1	97.7	11/29/06	111.4
21	299-W11-6	567482	136493	219.8	139.9	124.7	7/5/51	132.3
22	299-W11-7	567261	136675	217.1	142.4	128.7	9/17/51	135.6
23	299-W11-87	568141	136609	223.6	107.3	102.7	3/1/07	105.0
24	299-W11-88	567875	137113	221.9	86.2	74.0	10/3/07	80.1

Table B-1. 200-ZP-1 Operable Unit Proposed Contaminant Monitoring Well Network (Full)

Well No.	Well Name	Easting (m)	Northing (m)	Surface Elevation (m)	Depth to Screen Top (m)	Depth to Screen Bottom (m)	Date Drilled	Mid-Screen Elevation* (m)
25	299-W12-1	568331	137206	222.4	138.9	128.3	5/9/56	133.6
26	299-W13-1	568149	136049	223.5	104.4	93.7	2/10/04	99.1
27	299-W14-11	566902	136288	205.1	125.3	122.3	4/26/05	123.1
28	299-W14-13	566902	136282	205.1	138.7	128.7	8/31/98	133.7
29	299-W14-14	566898	136181	205.4	139.3	128.6	11/12/98	134.0
30	299-W14-71	567733	135568	219.4	94.2	89.7	7/27/06	92.0
31	299-W14-72	567328	135941	216.4	90.2	85.6	8/15/06	87.9
32	299-W15-152	566309	135550	209.9	137.9	127.3	9/15/05	132.6
33	299-W15-17	566307	135719	209.8	81.0	78.0	10/28/87	79.5
34	299-W15-2	566094	136336	212.4	146.0	133.8	8/12/54	139.9
35	299-W15-33	566433	135967	206.8	142.4	127.9	12/31/95	135.2
36	299-W15-37	566716	135248	203.0	140.3	125.1	5/16/96	132.7
37	299-W15-38	566813	135673	203.7	141.2	135.1	5/17/96	137.3
38	299-W15-42	566582	135627	207.4	137.9	122.7	2/26/02	130.3
39	299-W15-46	566752	135587	204.2	140.4	116.0	10/3/03	128.2
40	299-W15-49	566307	135973	209.1	137.3	126.6	11/1/04	131.9
41	299-W15-50	566793	135791	203.2	129.0	118.4	2/28/05	123.7
42	299-W15-7	566676	135920	204.2	148.8	97.6	3/30/66	123.2
43	299-W15-763	566809	136029	202.9	138.4	127.7	1/17/01	133.1
44	299-W15-83	566305	135826	209.3	137.7	127.0	8/9/05	132.4
45	299-W15-94	566308	135640	209.9	137.9	127.2	9/19/05	132.6
46	299-W18-1	566422	135465	209.1	149.6	79.5	1/12/59	113.8
47	299-W18-15	566380	134733	202.2	142.8	118.7	4/25/80	130.7
48	299-W18-16	566605	135426	208.6	137.1	126.4	10/20/04	131.8
49	299-W18-21	566098	134979	204.9	145.3	136.2	7/29/87	140.7
50	299-W18-22	566089	134990	204.9	77.9	68.5	9/25/87	73.2
51	299-W18-27	566090	135227	211.4	145.3	139.1	5/7/91	142.2
52	299-W18-40	566723	134996	203.4	136.9	126.2	9/28/01	131.6
53	299-W19-105	567565	134745	213.0	135.2	124.5	12/13/05	129.8
54	299-W19-107	567998	135206	217.4	122.8	118.2	3/31/06	120.5
55	299-W19-34A	567674	135012	215.3	116.5	111.8	5/18/94	113.3

Table B-1. 200-ZP-1 Operable Unit Proposed Contaminant Monitoring Well Network (Full)

Well No.	Well Name	Easting (m)	Northing (m)	Surface Elevation (m)	Depth to Screen Top (m)	Depth to Screen Bottom (m)	Date Drilled	Mid-Screen Elevation* (m)
56	299-W19-36	567635	135017	215.4	140.8	127.1	9/1/95	133.9
57	299-W19-40	567974	134847	210.8	140.5	134.4	8/21/95	137.5
58	299-W19-41	566897	135005	206.5	139.5	128.8	9/23/98	134.1
59	299-W19-48	567823	134926	212.9	133.0	122.3	10/5/04	127.6
60	299-W19-49	567568	134894	214.2	135.1	124.5	8/30/05	129.8
61	299-W21-2	568124	134574	214.9	135.6	124.9	11/22/04	130.2
62	299-W22-20	567593	133879	207.1	144.6	116.0	6/19/57	130.3
63	299-W22-26	567205	134465	208.4	147.4	117.5	12/31/63	132.5
64	299-W22-47	566909	134076	206.3	136.6	125.9	1/19/05	131.2
65	299-W22-48	566997	134425	207.9	138.9	134.4	11/8/99	136.7
66	299-W22-50	566904	134140	205.0	138.6	134.0	1/28/00	136.3
67	299-W22-72	567237	134207	208.0	135.8	125.1	2/22/06	130.5
68	299-W22-86	567187	134041	206.4	135.9	125.2	3/10/06	130.5
69	299-W22-87	567542	134540	212.0	135.7	125.1	12/14/05	130.4
70	299-W22-88	568046	134391	213.9	134.3	123.7	2/6/08	129.0
71	299-W23-4	566628	134392	203.0	148.1	111.6	6/18/57	129.9
72	299-W23-9	566642	134275	203.7	153.7	133.6	8/11/72	142.7
73	299-W26-13	566424	133294	199.8	138.2	127.5	12/28/99	132.8
74	299-W27-2	566908	133670	207.4	83.6	80.5	12/18/92	82.1
75	299-W6-10	567413	137453	218.2	141.7	135.5	2/13/92	138.6
76	299-W6-3	567118	137299	214.4	89.5	86.4	10/15/91	88.0
77	299-W6-6	567319	137639	217.5	89.9	86.6	10/24/91	88.3
78	299-W7-3	566292	137639	207.2	70.3	61.9	11/23/87	66.1
79	299-W7-4	566409	137308	205.8	144.0	134.8	11/19/87	139.4
80	299-W7-5	566476	137636	206.2	143.1	136.8	11/19/87	140.0
81	699-32-72A	567943	133363	204.7	76.7	56.8	7/31/57	66.7
82	699-33-75	566908	133662	207.4	135.7	125.1	1/8/08	130.4
83	699-35-70	568566	133988	212.3	141.3	135.2	9/8/48	138.3
84	699-35-78A	566064	134271	202.4	147.5	117.3	8/17/50	132.0
85	699-36-70A	568467	134309	216.0	137.6	128.4	12/10/94	132.2
86	699-36-70B	568428	134626	215.2	134.7	124.1	6/9/04	129.4

Table B-1. 200-ZP-1 Operable Unit Proposed Contaminant Monitoring Well Network (Full)

Well No.	Well Name	Easting (m)	Northing (m)	Surface Elevation (m)	Depth to Screen Top (m)	Depth to Screen Bottom (m)	Date Drilled	Mid-Screen Elevation* (m)
87	699-38-65	570090	135040	230.7	163.7	72.2	12/31/59	117.9
88	699-38-70B	568469	135331	222.6	98.6	94.0	2/3/04	96.3
89	699-38-70C	569084	135326	226.7	106.1	101.5	2/17/04	103.8
90	699-40-65	570057	135881	231.0	130.2	119.5	2/3/04	124.1
91	699-43-69	568967	136488	227.4	105.4	94.7	12/11/07	100.1
92	699-44-64	570391	136897	222.2	125.9	87.5	1/31/60	106.7
93	699-45-69A	568729	137183	222.1	138.6	110.6	6/22/48	124.6
94	699-45-69C	568947	137234	222.6	110.7	106.1	7/13/07	108.4
95	699-48-71	568388	138057	210.9	138.0	118.8	9/26/56	128.4
96	699-50-74	567360	138647	201.4	133.3	122.7	7/12/05	128.0
97	299-W10-27	566844	136442	205.6	138.3	127.6	3/23/01	132.9
98	299-W11-33	567185	136844	217.2	142.8	126.1	9/9/94	134.4
99	299-W18-11	566440	135266	209.5	151.6	142.4	1/4/69	147.0
100	299-W19-18	567361	135012	214.0	146.9	104.9	12/12/85	125.9
101	299-W19-34B	567663	135011	215.5	90.0	87.1	NA	87.6
102	299-W19-4	567950	135351	219.0	141.3	56.0	2/15/60	98.3
103	299-W19-47	566895	135162	206.3	137.1	126.4	6/1/04	131.7
104	299-W19-6	567133	134694	210.3	94.5	85.1	12/13/68	89.8
105	299-W22-24P	567648	134411	212.2	48.6	39.4	9/8/60	44.0
106	299-W22-24Q	567648	134411	212.2	67.4	60.7	9/8/60	64.1
107	299-W22-24R	567648	134411	212.2	86.7	79.0	9/8/60	82.8
108	299-W22-24S	567648	134411	212.2	104.9	97.3	9/8/60	101.1
109	299-W22-24T	567648	134411	212.2	123.2	115.6	9/8/60	119.4
110	299-W22-44	566956	134484	207.8	145.2	134.0	11/26/91	139.6
111	299-W22-9	567740	134043	207.5	140.5	116.4	5/4/56	128.4
112	299-W23-19	566759	134167	202.5	139.5	136.4	11/17/99	137.9
113	299-W6-11	567163	137635	215.2	138.8	132.7	5/21/92	135.7
114	699-30-66	569991	132739	210.5	93.1	90.1	10/13/04	91.6
115	699-32-62	571010	133216	216.6	132.7	64.2	4/6/60	98.5
116	699-34-61	571396	133810	221.8	129.4	123.3	11/29/93	126.3
117	699-35-66A	569858	134099	222.5	143.2	124.3	6/13/57	133.8

Table B-1. 200-ZP-1 Operable Unit Proposed Contaminant Monitoring Well Network (Full)

Well No.	Well Name	Easting (m)	Northing (m)	Surface Elevation (m)	Depth to Screen Top (m)	Depth to Screen Bottom (m)	Date Drilled	Mid-Screen Elevation* (m)
118	699-36-61A	571395	134557	229.0	128.4	110.5	8/12/48	119.5
119	699-36-66B	569731	134469	221.3	131.7	121.0	12/20/07	126.4
120	699-37-66	569730	134797	222.0	131.3	120.6	11/28/07	126.0
121	699-38-61	571219	134997	228.2	126.3	120.2	11/16/93	123.3
122	699-38-68A	569180	134932	218.9	137.3	128.2	6/21/94	132.0
123	699-40-62	571164	135764	228.9	126.8	115.0	1/17/49	120.9
124	699-47-60	571474	137969	199.6	123.4	115.1	7/20/48	118.5
125	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 and are included in this table because the top and bottom screen elevation were not available. Top and bottom screen elevations are not available from the Hanford Environmental Information System database but are likely available from other data sources and/or databases because they were available to construct the plume shell data set.

NA = not available

Table B-2. 200-ZP-1 Operable Unit Proposed Contaminant Monitoring Well Network (Reduced)

Well No.	Well Name	Easting (m)	Northing (m)	Surface Elevation (m)	Depth to Screen Top (m)	Depth to Screen Bottom (m)	Date Drilled	Mid-Screen Elevation* (m)
1	299-W10-22	566833	136883	209.0	143.3	134.1	10/02/94	138.7
2	299-W10-27	566844	136442	205.6	138.3	127.6	03/23/01	132.9
3	299-W10-33	566773	136610	206.0	87.1	81.0	06/15/07	84.1
4	299-W10-4	566735	136578	205.5	147.6	130.8	11/10/52	139.0
5	299-W11-12	566898	136597	208.2	147.2	132.0	12/21/53	139.6
6	299-W11-37	567606	137011	221.6	142.3	132.8	07/07/94	136.6
7	299-W11-43	567241	136964	217.5	88.1	83.5	05/23/05	85.8
8	299-W11-45	566993	136776	213.6	127.9	123.4	09/02/05	125.7
9	299-W11-46	566886	136766	210.9	130.7	124.6	07/26/05	127.6
10	299-W11-47	566934	136681	210.4	126.8	117.5	01/06/06	122.2
11	299-W11-48	566882	136846	209.7	125.1	97.7	11/29/06	111.4
12	299-W11-7	567261	136675	217.1	142.4	128.7	09/17/51	135.6
13	299-W11-87	568113	136602	223.6	107.3	102.7	03/01/07	105.0

Table B-2. 200-ZP-1 Operable Unit Proposed Contaminant Monitoring Well Network (Reduced)

Well No.	Well Name	Easting (m)	Northing (m)	Surface Elevation (m)	Depth to Screen Top (m)	Depth to Screen Bottom (m)	Date Drilled	Mid-Screen Elevation* (m)
14	299-W11-88	567875	137113	221.9	86.2	74.0	10/03/07	80.1
15	299-W13-1	568149	136049	223.5	104.4	93.7	02/10/04	99.1
16	299-W14-11	566902	136288	205.1	125.3	122.3	04/26/05	123.1
17	299-W14-13	566873	136275	205.1	138.7	128.7	08/31/98	133.7
18	299-W14-71	567733	135568	219.4	94.2	89.7	07/27/06	92.0
19	299-W15-33	566405	135960	206.8	142.4	127.9	12/31/95	135.2
20	299-W15-38	566784	135666	203.7	141.2	135.1	05/17/96	137.3
21	299-W15-46	566752	135587	204.2	140.4	116.0	10/03/03	128.2
22	299-W15-50	566794	135791	203.2	129.0	118.4	02/28/05	123.7
23	299-W15-7	566676	135920	204.2	148.8	97.6	03/30/66	123.2
24	299-W18-1	566422	135465	209.1	149.6	79.5	01/12/59	113.8
25	299-W18-15	566351	134727	202.2	142.8	118.7	04/25/80	130.7
26	299-W18-16	566605	135426	208.6	137.1	126.4	10/20/04	131.8
27	299-W19-105	567536	134739	213.0	135.2	124.5	12/13/05	129.8
28	299-W19-18	567332	135005	214.0	146.9	104.9	12/12/85	125.9
29	299-W19-36	567606	135010	215.4	140.8	127.1	09/01/95	133.9
30	299-W19-48	567823	134926	212.9	133.0	122.3	10/05/04	127.6
31	299-W19-49	567539	134888	214.2	135.1	124.5	08/30/05	129.8
32	299-W21-2	568096	134567	214.9	135.6	124.9	11/22/04	130.2
33	299-W22-20	567564	133872	207.1	144.6	116.0	06/19/57	130.3
34	299-W22-44	566927	134478	207.8	145.2	134.0	11/26/91	139.6
35	299-W22-47	566909	134076	206.3	136.6	125.9	01/19/05	131.2
36	299-W22-50	566875	134133	205.0	138.6	134.0	01/28/00	136.3
37	299-W22-72	567210	134201	208.0	135.8	125.1	02/22/06	130.5
38	299-W22-86	567159	134035	206.4	135.9	125.2	03/10/06	130.5
39	299-W23-19	566730	134160	202.5	139.5	136.4	11/17/99	137.9
40	299-W23-4	566599	134385	203.0	148.1	111.6	06/18/57	129.9
41	299-W23-9	566613	134268	203.7	153.7	133.6	08/11/72	142.7
42	699-30-66	569991	132739	210.5	93.1	90.1	10/13/04	91.6
43	699-32-62	570981	133209	216.6	132.7	64.2	04/06/60	98.5
44	699-32-72A	567914	133356	204.7	76.7	56.8	07/31/57	66.7

Table B-2. 200-ZP-1 Operable Unit Proposed Contaminant Monitoring Well Network (Reduced)

Well No.	Well Name	Easting (m)	Northing (m)	Surface Elevation (m)	Depth to Screen Top (m)	Depth to Screen Bottom (m)	Date Drilled	Mid-Screen Elevation* (m)
45	699-34-61	571396	133810	221.8	129.4	123.3	11/29/93	126.3
46	699-35-66A	569829	134092	222.5	143.2	124.3	06/13/57	133.8
47	699-35-70	568538	133981	212.3	141.3	135.2	09/08/48	138.3
48	699-36-61A	571366	134550	229.0	128.4	110.5	08/12/48	119.5
49	699-36-66B	569731	134469	221.3	131.7	121.0	12/20/07	126.4
50	699-36-70A	568438	134302	216.0	137.6	128.4	12/10/94	132.2
51	699-36-70B	568399	134619	215.2	134.7	124.1	06/09/04	129.4
52	699-37-66	569730	134797	222.0	131.3	120.6	11/28/07	126.0
53	699-38-61	571219	134997	228.2	126.3	120.2	11/16/93	123.3
54	699-38-65	570090	135040	230.7	163.7	72.2	12/31/59	117.9
55	699-38-68A	569151	134925	218.9	137.3	128.2	06/21/94	132.0
56	699-38-70B	568469	135331	222.6	98.6	94.0	02/03/04	96.3
57	699-38-70C	569084	135326	226.7	106.1	101.5	02/17/04	103.8
58	699-40-62	571164	135764	228.9	126.8	115.0	01/17/49	120.9
59	699-40-65	570057	135881	231.0	130.2	119.5	02/03/04	124.1
60	699-43-69	568967	136488	227.4	105.4	94.7	12/11/07	100.1
61	699-44-64	570391	136897	222.2	125.9	87.5	01/31/60	106.7
62	699-45-69A	568729	137183	222.1	138.6	110.6	06/22/48	124.6
63	699-45-69C	568947	137234	222.6	110.7	106.1	07/13/07	108.4
64	699-47-60	571474	137969	199.6	123.4	115.1	07/20/48	118.5
65	699-48-71	568388	138057	210.9	138.0	118.8	09/26/56	128.4
66	699-50-74	567360	138647	201.4	133.3	122.7	07/12/05	128.0
67	699-51-63	570664	139148	175.3	127.4	119.5	11/06/56	123.5

* Mid-screen elevations were obtained from the 2008 carbon tetrachloride plume shell data set and are included in this table because the top and bottom screen elevation were not available. Top and bottom screen elevations are not available from the Hanford Environmental Information System database but are likely available from other data sources and/or databases because they were available to construct the plume shell data set.

N/A = not available

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Appendix C

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

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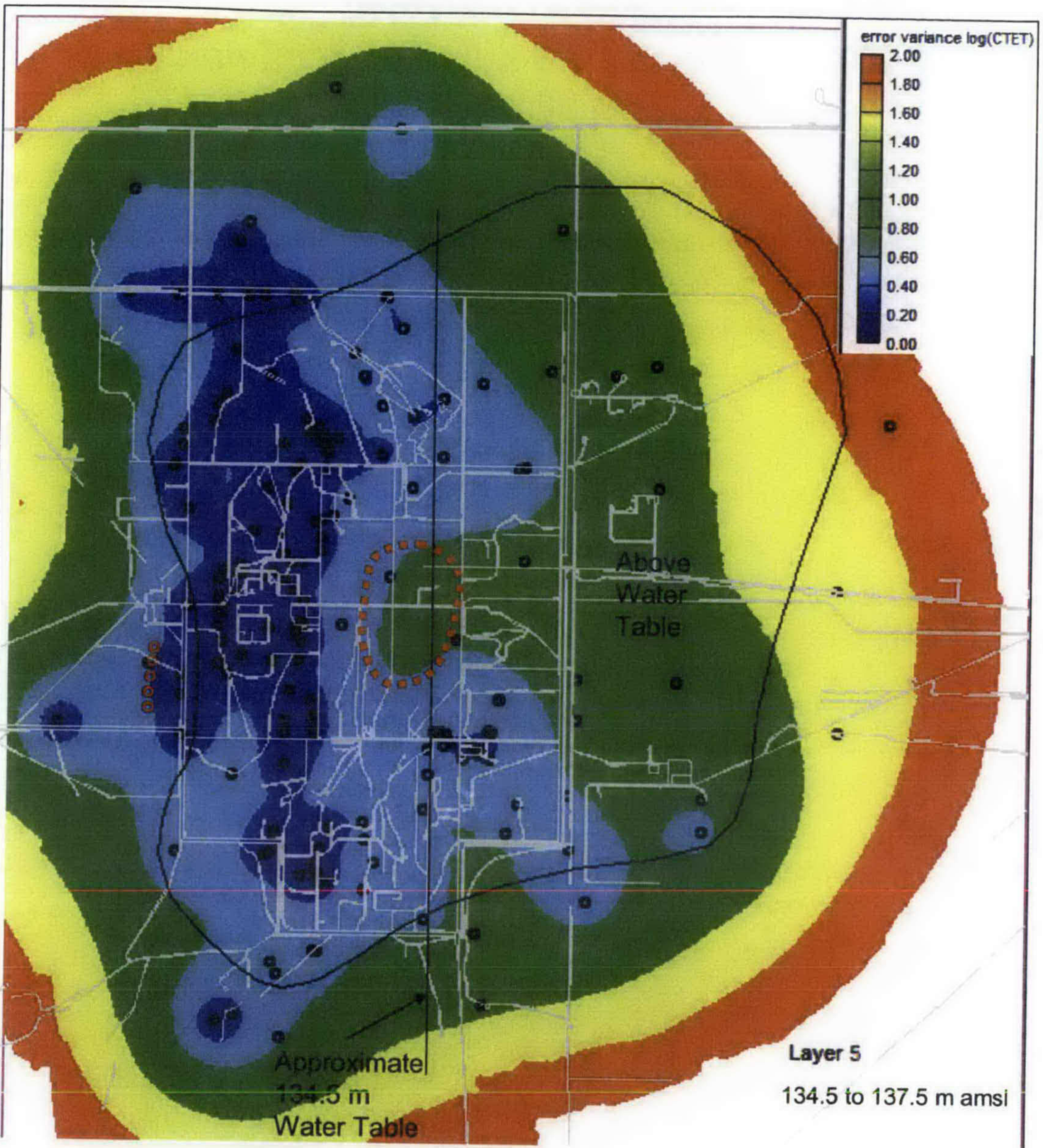
C1 200-ZP-1 Operable Unit Kriged Carbon Tetrachloride Error Variance Maps

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



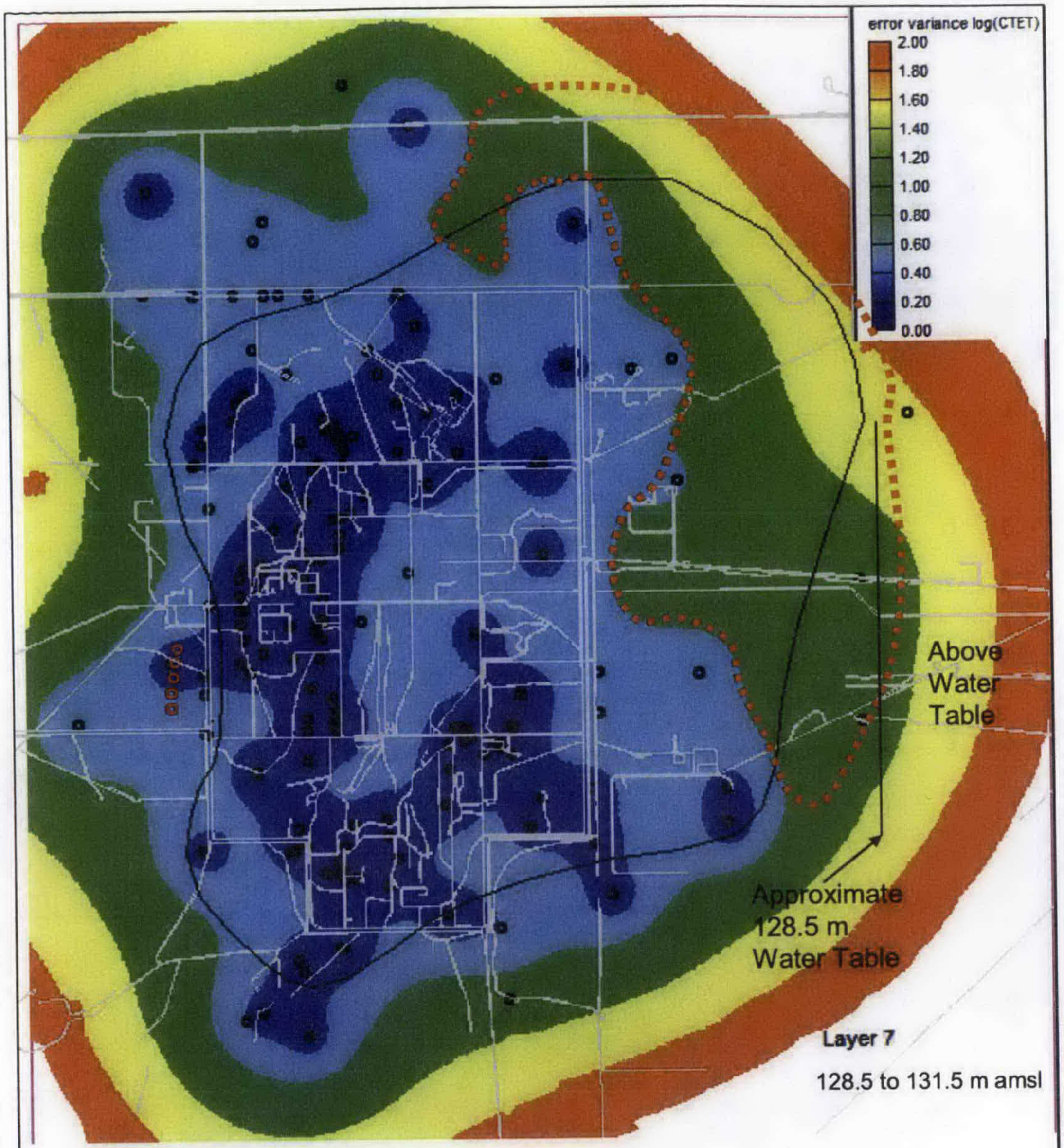
Map of Kriged Carbon Tetrachloride Error Variance

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 is area of relative uncertainty

amsl = above mean sea level
CTET = carbon tetrachloride

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



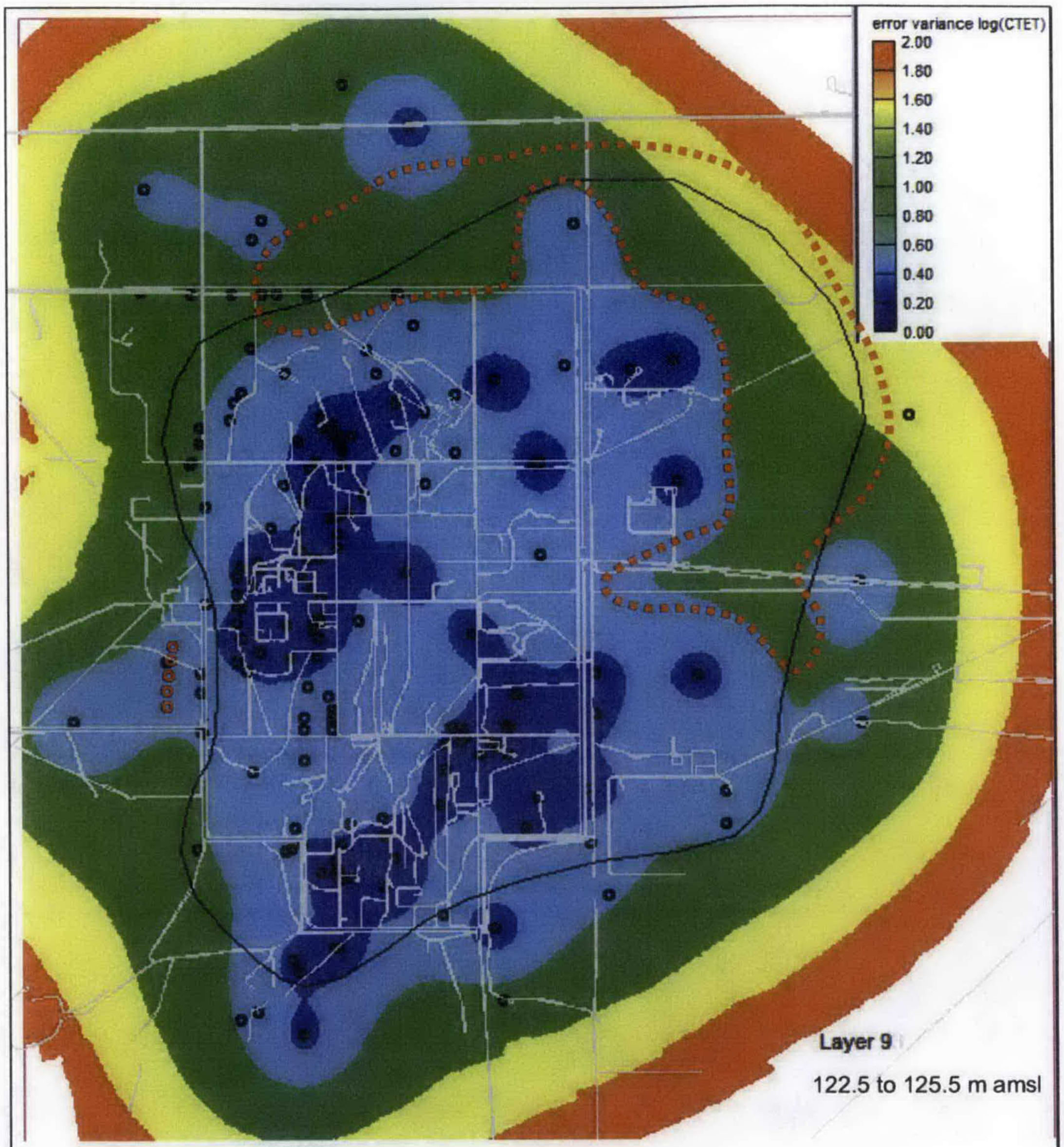
Map of Kriged Carbon Tetrachloride Error Variance

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 is area of relative uncertainty

amsl = above mean sea level
CTET = carbon tetrachloride

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



Map of Kriged Carbon Tetrachloride Error Variance

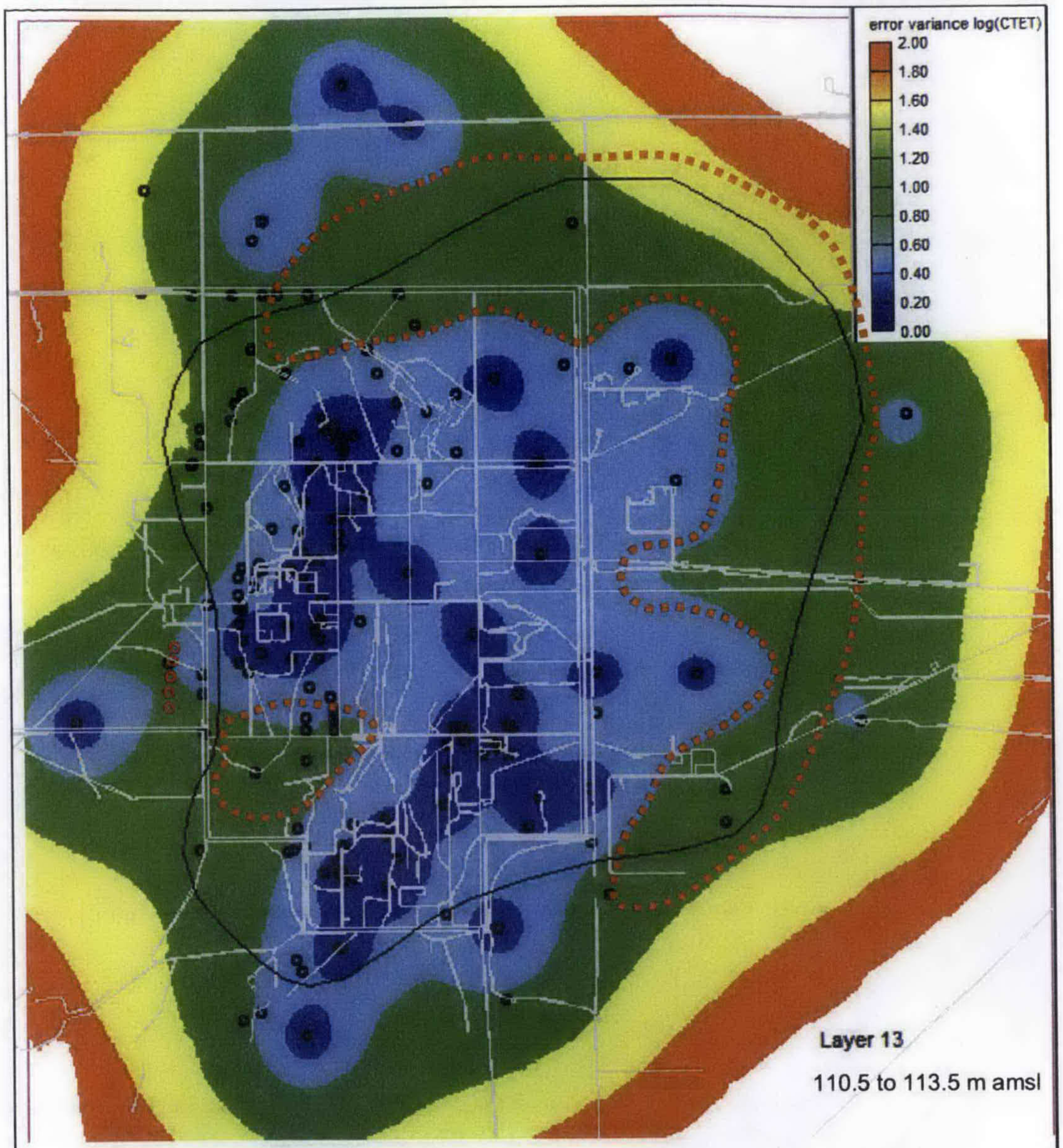
Legend

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 is area of relative uncertainty

amsl = above mean sea level

CTET = carbon tetrachloride

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



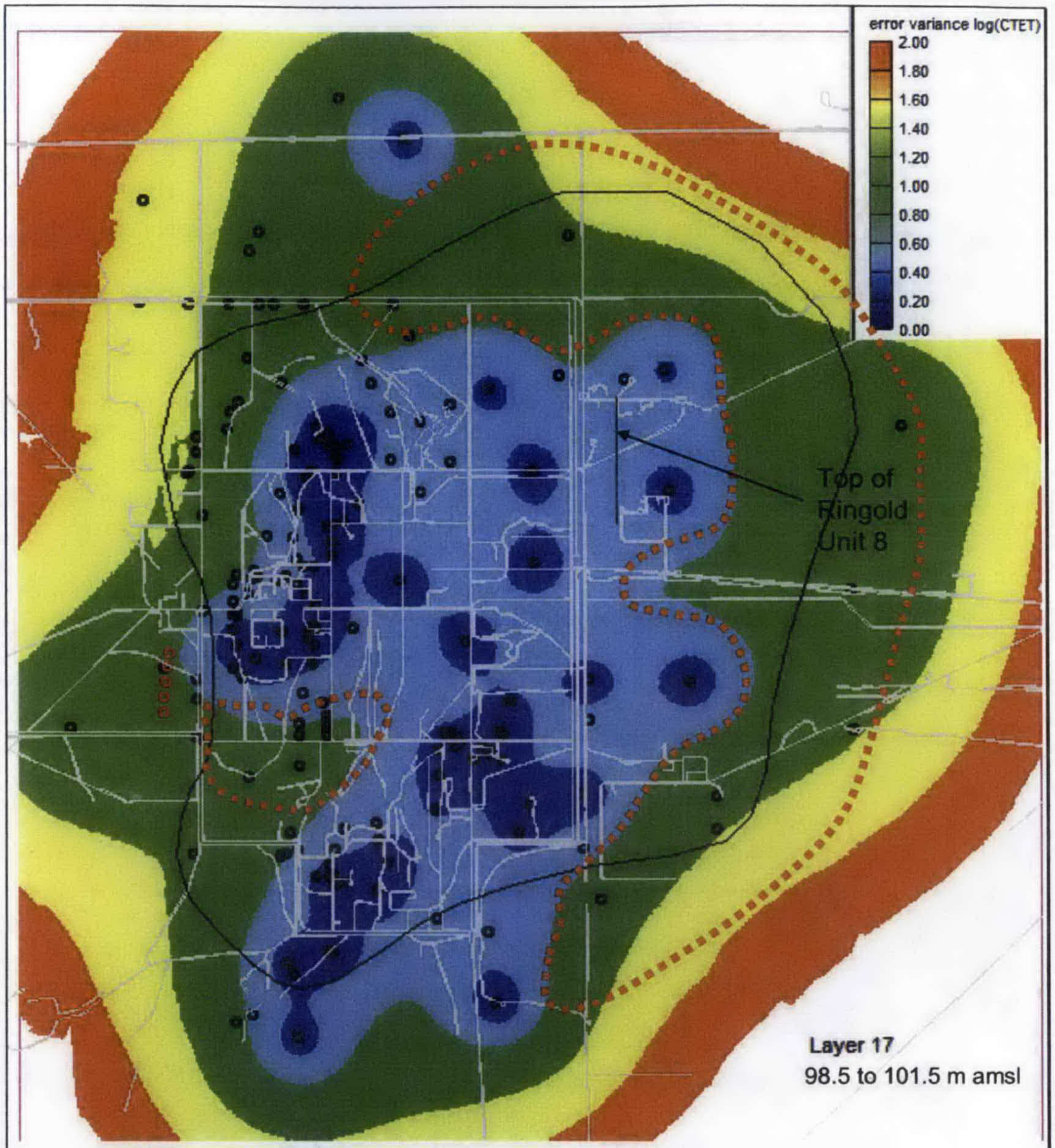
Map of Kriged Carbon Tetrachloride Error Variance

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 is area of relative uncertainty

amsl = above mean sea level
CTET = carbon tetrachloride

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



Map of Kriged Carbon Tetrachloride Error Variance

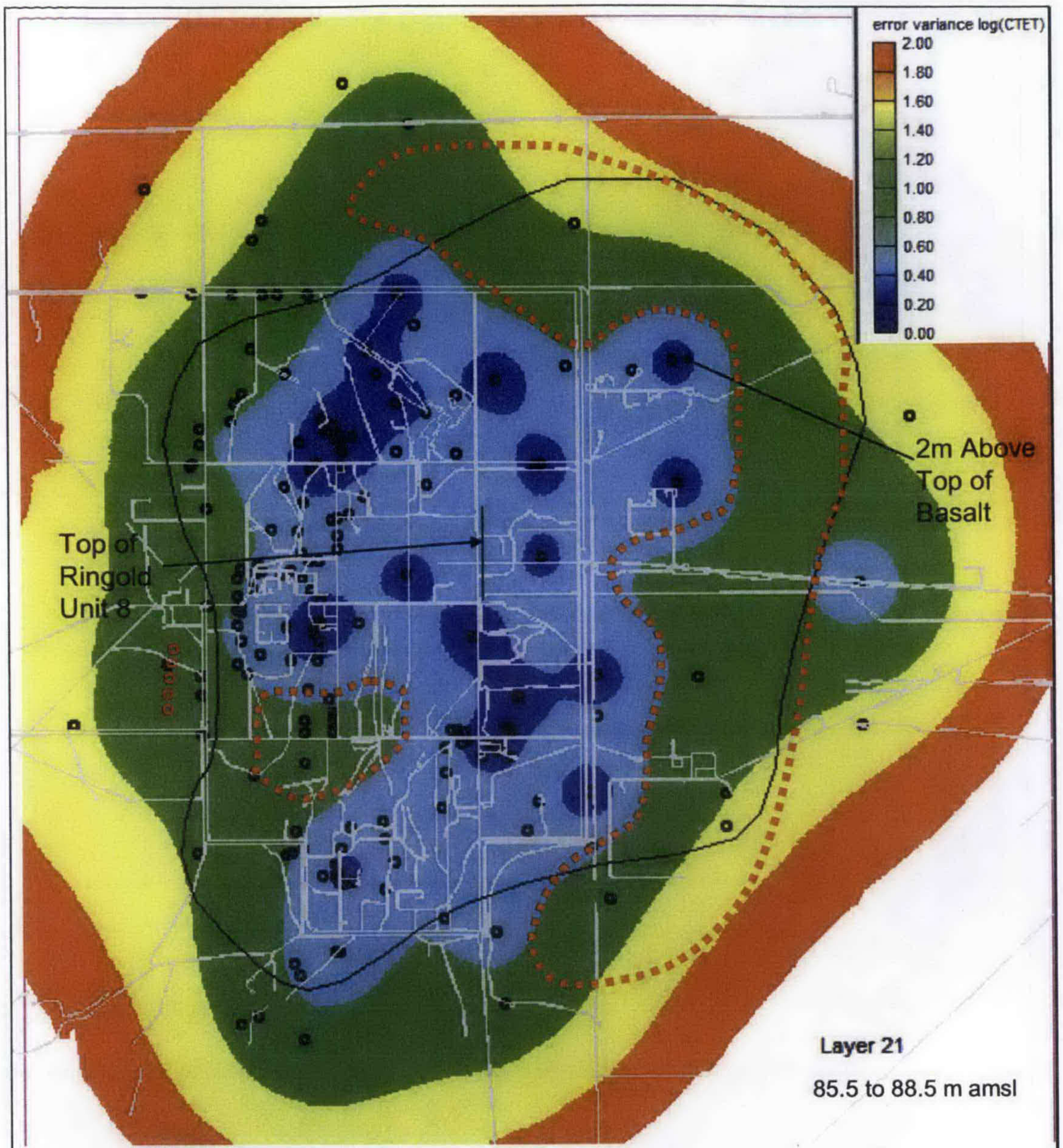
Legend

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 is area of relative uncertainty

amsl = above mean sea level

CTET = carbon tetrachloride

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



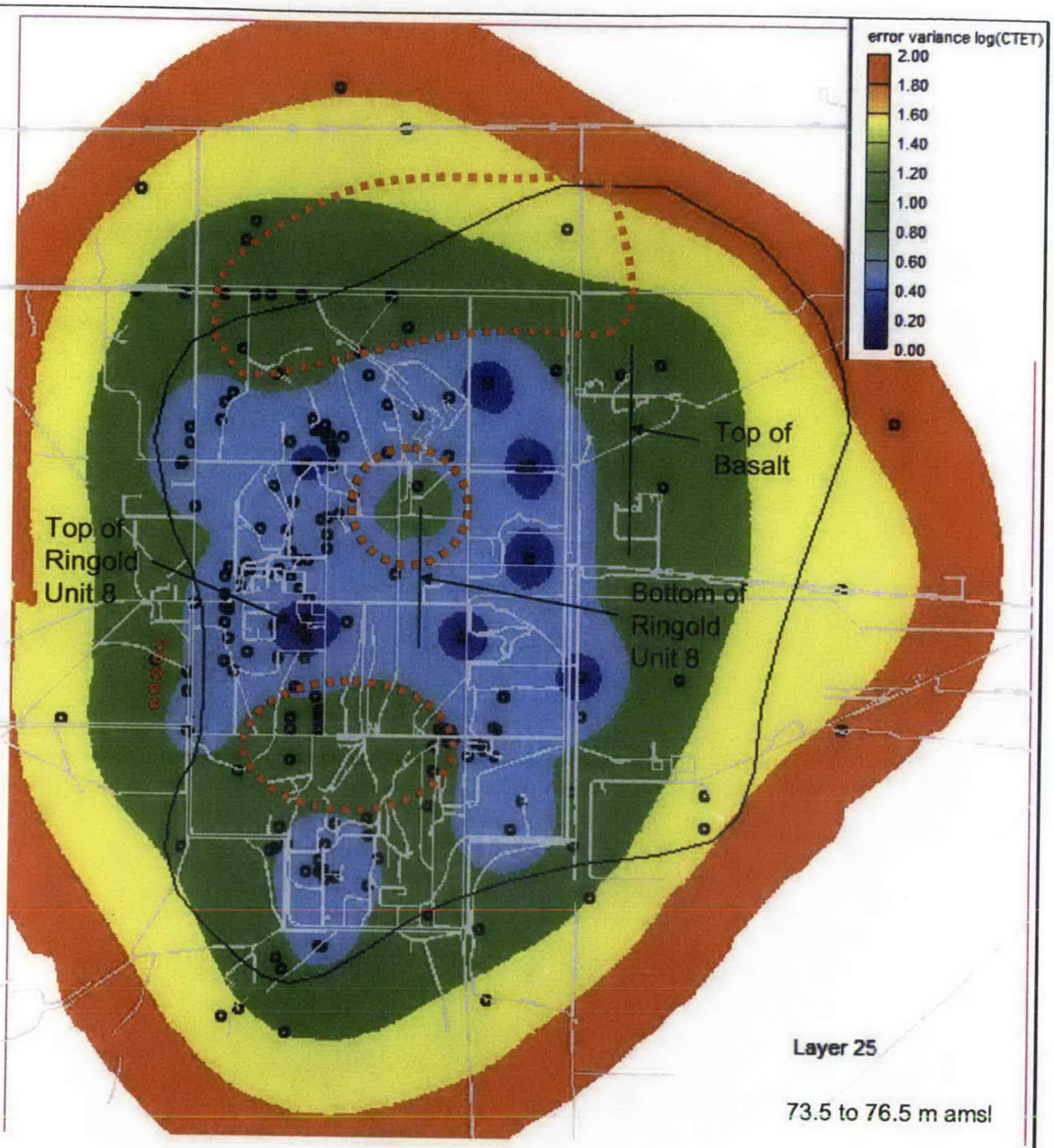
Map of Kriged Carbon Tetrachloride Error Variance

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 is area of relative uncertainty

amsl = above mean sea level
CTET = carbon tetrachloride

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



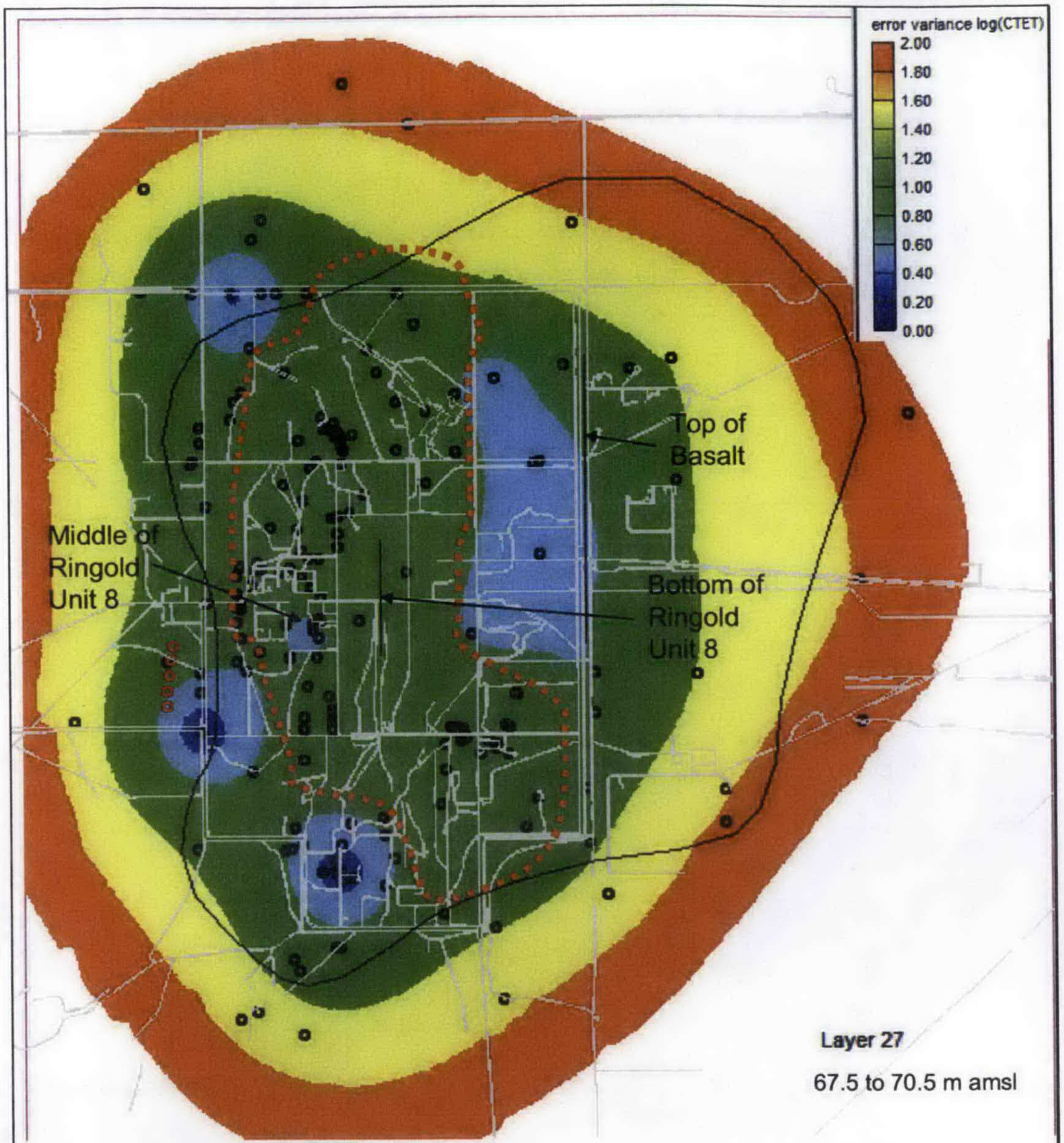
Map of Kriged Carbon Tetrachloride Error Variance

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 is area of relative uncertainty

amsl = above mean sea level
CTET = carbon tetrachloride

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



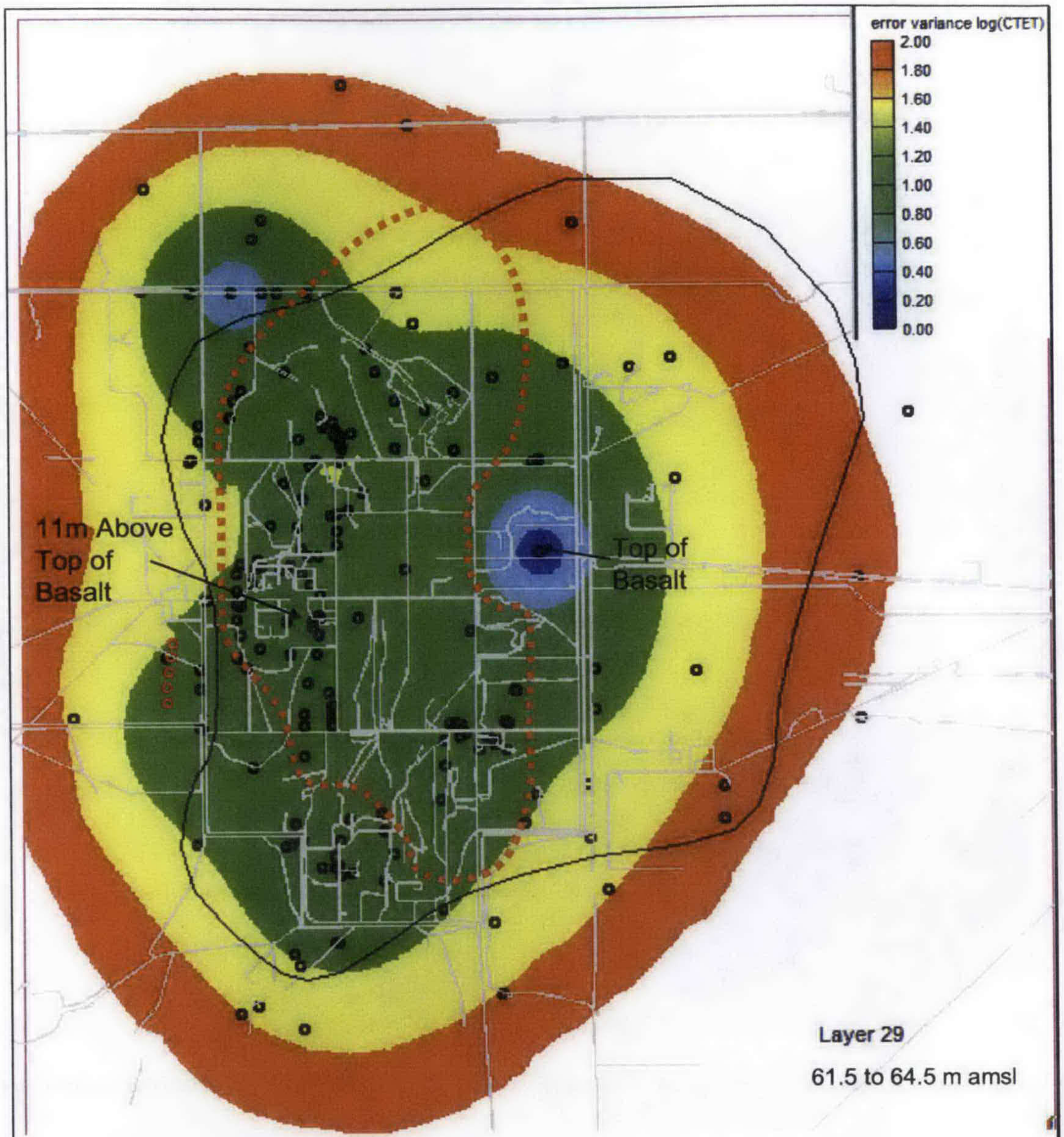
Map of Kriged Carbon Tetrachloride Error Variance

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 is area of relative uncertainty

amsl = above mean sea level
CTET = carbon tetrachloride

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



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 is area of relative uncertainty

amsl = above mean sea level
CTET = carbon tetrachloride

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

Appendix D

200-ZP-1 Operable Unit Proposed Hydraulic Monitoring Well Network

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D1 200-ZP-1 Operable Unit Proposed Hydraulic Monitoring Well Network

Table D-1 provides details for the 200-ZP-1 Operable Unit proposed hydraulic monitoring well network.

Table D-1. 200-ZP-1 Proposed Hydraulic Monitoring Well Network

Well No.	Well Name	Easting (m)	Northing (m)	Surface Elevation (m amsl)	Depth to Screen Top (m)	Depth to Screen Bottom (m)	Date Drilled	Transducer Equipment	Mid-Screen Elevation* (m)
1	299-W10-1	566663	136735	207.459	NA	NA	08/07/47	No	137.36
2	299-W10-21	566584	137155	206.49	63.78	69.87	08/27/93	Yes	--
3	299-W10-27	566844	136442	205.624	67.36	78.02	03/23/01	No	--
4	299-W10-30	566083	136739	211.647	73.86	84.53	03/14/06	No	--
5	299-W10-31	566266	136968	210.384	73.13	83.82	04/20/06	No	--
6	299-W10-33	566773	136610	205.986	118.87	124.96	06/15/07	No	--
7	299-W10-4	566735	136578	205.524	NA	NA	11/10/52	Yes	138.96
8	299-W10-5	566579	136475	205.962	NA	NA	05/18/54	Yes	145.76
9	299-W11-10	568148	136610	223.187	NA	NA	04/16/56	No	137.84
10	299-W11-13	567099	136424	211.935	NA	NA	07/31/61	No	106.93
11	299-W11-18	567182	137161	216.537	NA	NA	03/01/67	No	136.98
12	299-W11-3	567642	136664	220.019	NA	NA	08/29/56	Yes	132.54
13	299-W11-33	567185	136844	217.237	74.41	91.17	09/09/94	No	--
14	299-W11-37	567635	137018	221.609	NA	NA	07/07/94	No	136.64
15	299-W11-43	567270	136971	217.528	129.44	134.01	05/23/05	Yes	--
16	299-W11-45	566993	136776	213.614	85.73	90.18	09/02/05	No	--
17	299-W11-47	566934	136681	210.403	83.58	92.89	01/06/06	Yes	--
18	299-W11-48	566882	136846	209.7	84.56	112.01	11/29/06	Yes	--
19	299-W11-6	567482	136493	219.772	NA	NA	07/05/51	Yes	132.29
20	299-W11-7	567261	136675	217.108	NA	NA	09/17/51	Yes	135.57
21	299-W11-87	568141	136609	223.642	116.36	120.94	03/01/07	Yes	--
22	299-W11-88	567875	137113	221.9	135.66	147.85	10/03/07	Yes	--
23	299-W12-1	568331	137206	222.444	NA	NA	05/09/56	Yes	133.59
24	299-W13-1	568149	136049	223.54	119.15	129.81	02/10/04	Yes	--
25	299-W14-11	566902	136288	205.092	NA	NA	04/26/05	No	123.10

Table D-1. 200-ZP-1 Proposed Hydraulic Monitoring Well Network

Well No.	Well Name	Easting (m)	Northing (m)	Surface Elevation (m amsl)	Depth to Screen Top (m)	Depth to Screen Bottom (m)	Date Drilled	Transducer Equipment	Mid-Screen Elevation* (m)
26	299-W14-14	566898	136181	205.432	66.13	76.81	11/12/98	Yes	--
27	299-W14-17	567007	136218	205.853	67.64	78.32	10/24/00	No	--
28	299-W14-71	567733	135568	219.41	125.17	129.74	07/27/06	Yes	--
29	299-W14-72	567328	135941	216.387	126.18	130.76	08/15/06	Yes	--
30	299-W15-1	566554	135943	206.993	NA	NA	05/02/47	No	NA
31	299-W15-11	566412	136001	208.261	NA	NA	03/08/68	Yes	NA
32	299-W15-152	566309	135550	209.869	71.94	82.61	09/15/05	No	--
33	299-W15-17	566307	135719	209.783	128.77	131.82	10/28/87	No	--
34	299-W15-2	566094	136336	212.411	NA	NA	08/12/54	Yes	139.87
35	299-W15-3	566729	136371	205.385	NA	NA	09/30/52	No	NA
36	299-W15-30	566305	135749	210.126	66.47	78.63	05/05/95	Yes	--
37	299-W15-31A	566377	135856	208.48	64.76	76.93	05/26/95	No	--
38	299-W15-37	566716	135248	203.028	NA	NA	05/16/96	No	132.68
39	299-W15-38	566813	135673	203.691	NA	NA	05/17/96	No	137.31
40	299-W15-41	566758	136032	203.484	65.81	70.39	01/17/00	Yes	--
41	299-W15-42	566582	135627	207.391	69.50	84.74	02/26/02	No	--
42	299-W15-46	566752	135587	204.222	63.86	88.23	10/03/03	No	--
43	299-W15-49	566307	135973	209.127	71.86	82.52	11/01/04	No	--
44	299-W15-50	566793	135791	203.236	74.19	84.85	02/28/05	No	--
45	299-W15-7	566676	135920	204.249	NA	NA	03/30/66	Yes	123.17
46	299-W17-1	565311	135039	199.174	NA	NA	12/17/03	No	NA
47	299-W18-1	566422	135465	209.058	NA	NA	01/12/59	No	113.77
48	299-W18-11	566440	135266	209.468	57.91	67.05	01/04/69	No	--
49	299-W18-15	566380	134733	202.219	NA	NA	04/25/80	No	130.74
50	299-W18-16	566605	135426	208.58	71.47	82.13	10/20/04	No	--
51	299-W18-21	566098	134979	204.9	59.59	68.73	07/29/87	No	--
52	299-W18-22	566089	134990	204.857	126.94	136.39	09/25/87	No	--
53	299-W18-30	566871	135194	206.117	60.20	71.23	11/14/91	No	--
54	299-W18-40	566723	134996	203.413	66.53	77.20	09/28/01	No	--
55	299-W19-107	567998	135206	217.419	94.65	99.22	03/31/06	Yes	--

Table D-1. 200-ZP-1 Proposed Hydraulic Monitoring Well Network

Well No.	Well Name	Easting (m)	Northing (m)	Surface Elevation (m amsl)	Depth to Screen Top (m)	Depth to Screen Bottom (m)	Date Drilled	Transducer Equipment	Mid-Screen Elevation* (m)
56	299-W19-18	567361	135012	213.983	NA	NA	12/12/85	No	125.90
57	299-W19-34A	567674	135012	215.331	NA	NA	05/18/94	No	113.34
58	299-W19-34B	567663	135011	215.475	NA	NA	NA	No	87.57
59	299-W19-35	567992	135015	213.63	NA	NA	04/20/94	No	135.18
60	299-W19-4	567950	135351	219.023	NA	NA	02/15/60	No	98.30
61	299-W19-41	566897	135005	206.531	67.07	77.76	09/23/98	No	--
62	299-W19-6	567133	134694	210.341	NA	NA	12/13/68	No	89.79
63	299-W21-2	568124	134574	214.85	79.29	89.96	11/22/04	No	--
64	299-W22-20	567593	133879	207.091	NA	NA	06/19/57	No	130.28
65	299-W22-24	567648	134411	212.16	NA	NA	09/08/60	No	93.29
66	299-W22-24P	567648	134411	212.224	NA	NA	09/08/60	No	43.98
67	299-W22-24R	567648	134411	212.224	NA	NA	09/08/60	No	82.84
68	299-W22-24T	567648	134411	212.218	NA	NA	09/08/60	No	119.41
69	299-W22-26	567205	134465	208.379	NA	NA	12/31/63	No	132.48
70	299-W22-47	566909	134076	206.275	69.70	80.37	01/19/05	No	--
71	299-W23-20	566718	134446	203.795	65.68	76.35	08/21/00	No	--
72	299-W26-14	566683	133539	205.43	68.08	78.75	04/03/03	No	--
73	299-W27-2	566908	133670	207.404	123.79	126.87	12/18/92	No	--
74	299-W6-11	567163	137635	215.248	76.47	82.60	05/21/92	No	--
75	299-W6-12	566916	137635	212.091	73.83	78.45	04/14/92	No	--
76	299-W6-3	567118	137299	214.373	124.82	127.95	10/15/91	No	--
77	299-W6-6	567319	137639	217.469	127.58	130.84	10/24/91	No	--
78	299-W7-3	566292	137639	207.185	136.85	145.29	11/23/87	No	--
79	299-W7-4	566409	137308	205.833	61.87	71.01	11/19/87	No	--
80	699-25-70	568545	131172	192.966	NA	NA	08/31/48	No	99.24
81	699-25-80	565676	131106	188.994	NA	NA	11/30/48	No	122.28
82	699-30-66	569991	132739	210.481	117.34	120.39	10/13/04	No	--
83	699-32-62	571010	133216	216.562	NA	NA	04/06/60	No	98.46
84	699-32-62P	571010	133216	216.585	NA	NA	04/06/60	No	65.72
85	699-32-70B	568462	133242	204.204	NA	NA	08/09/57	No	122.37

Table D-1. 200-ZP-1 Proposed Hydraulic Monitoring Well Network

Well No.	Well Name	Easting (m)	Northing (m)	Surface Elevation (m amsl)	Depth to Screen Top (m)	Depth to Screen Bottom (m)	Date Drilled	Transducer Equipment	Mid-Screen Elevation* (m)
86	699-32-72A	567943	133363	204.661	NA	NA	07/31/57	No	66.74
87	699-32-72B	567935	133362	205.118	65.41	74.56	05/18/94	No	--
88	699-32-77	566417	133152	200.341	NA	NA	05/15/51	No	129.48
89	699-34-88	563012	133950	194.039	NA	NA	12/20/48	No	78.06
90	699-35-59	571956	134096	222.116	94.48	106.67	10/31/85	No	--
91	699-35-66A	569858	134099	222.452	NA	NA	06/13/57	No	133.76
92	699-35-70	568566	133988	212.326	71.01	77.11	09/08/48	No	--
93	699-35-78A	566064	134271	202.383	NA	NA	08/17/50	Yes	132.02
94	699-36-70B	568428	134626	215.24	80.51	91.17	06/09/04	No	--
95	699-38-61	571219	134997	228.167	101.83	107.92	11/16/93	No	--
96	699-38-65	570090	135040	230.709	NA	NA	12/31/59	Yes	117.93
97	699-38-68A	569180	134932	218.899	NA	NA	06/21/94	No	132.05
98	699-38-70B	568469	135331	222.559	123.96	128.53	02/03/04	No	--
99	699-38-70C	569084	135326	226.67	120.60	125.18	02/17/04	No	--
100	699-39-79	565891	135412	206.45	NA	NA	09/07/48	Yes	NA
101	699-40-62	571164	135764	228.943	NA	NA	01/17/49	No	120.88
102	699-40-65	570057	135881	231.028	NA	NA	02/03/04	Yes	124.14
103	699-43-69	568967	136488	227.362	121.98	132.64	12/11/07	Yes	--
104	699-43-89	562917	136620	197.72	NA	NA	01/16/51	No	133.41
105	699-44-64	570391	136897	222.203	NA	NA	01/31/60	Yes	106.67
106	699-45-69A	568729	137183	222.138	NA	NA	06/22/48	No	124.60
107	699-45-69C	568947	137234	222.569	111.86	116.43	07/13/07	Yes	--
108	699-47-60	571474	137969	199.578	NA	NA	07/20/48	No	118.50
109	699-47-80AP	565562	137693	NA	NA	NA	11/30/83	No	7.35
110	699-47-80AQ	565562	137693	NA	NA	NA	11/30/83	No	62.77
111	699-48-71	568388	138057	210.864	NA	NA	09/26/56	Yes	128.42
112	699-48-77A	566413	137969	206.674	64.74	70.83	05/04/92	No	--
113	699-48-77C	566469	138087	206.585	NA	NA	04/01/94	No	114.42
114	699-49-79	565771	138271	211.077	NA	NA	07/03/48	Yes	136.07
115	699-50-74	567360	138647	201.409	68.07	78.74	07/12/05	No	--

Table D-1. 200-ZP-1 Proposed Hydraulic Monitoring Well Network

Well No.	Well Name	Easting (m)	Northing (m)	Surface Elevation (m amsl)	Depth to Screen Top (m)	Depth to Screen Bottom (m)	Date Drilled	Transducer Equipment	Mid-Screen Elevation* (m)
116	699-51-63	570664	139148	175.302	NA	NA	11/06/56	No	123.49
117	699-51-75	566978	138906	196.561	NA	NA	10/31/57	No	NA
118	699-55-76	566723	140226	178.727	NA	NA	01/18/59	No	123.56

* Mid-screen elevations were obtained from the 2008 carbon tetrachloride plume shell data set and are included in this table because the top and bottom screen elevation were not available. Top and bottom screen elevations are not available from the Hanford Environmental Information System database but are likely available from other data sources and/or databases because they were available to construct the plume shell data set.

amsl = above mean sea level

NA = not available

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Distribution

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