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Addressees:

CALENDAR YEAR 2011 ANNUAL SUMMARY REPORT FOR THE 200-ZP-1 AND 200-UP-1 OPERABLE UNIT PUMP-AND-TREAT OPERATIONS, DOE/RL-2012-03, REVISION 0 AND 200-ZP-1 INTERIM PUMP-AND-TREAT SYSTEM SUMMARY PERFORMANCE REPORT FOR CALENDAR 2012, DOE/RL-2012-36, REVISION 0

This letter transmits the Calendar Year 2011 Annual Summary Report for the 200-ZP-1 and 200-UP-1 Operable Unit Pump-and-Treat Operations, DOE/RL-2012-03, Revision 0 and the 200-ZP-1 Interim Pump-and-Treat System Summary Performance Report for Calendar Year 2012, DOE/RL-2012-36, Revision 0 to the U.S. Environmental Protection Agency and the State of Washington Department of Ecology.

The Calendar Year 2011 Annual Summary Report presents the annual pump-and-treat system performance evaluation for the 200-ZP-1 and 200-UP-1 Operable Units at the Hanford Site. Results are provided for Calendar Year 2011, which covers the period from January 1, 2011, through December 31, 2011. The Summary Performance Report for Calendar Year 2012 presents a summary of the lifecycle performance of the 200-ZP-1 interim status pump-and-treat system in the Hanford Site's 200-ZP-1 Operable Unit. The 200-ZP-1 pump-and-treat system operated during Calendar Year 2012 for the period of January 1, 2012, through May 2, 2012, at which time the system was shut down to transition to operation of the final status 200 West Area pump-and-treat system.

200·ZP·1, 200·UP·1

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

Sincerely,

FOR

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for the River and Plateau

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DOE/RL-2012-03
Revision 0

Calendar Year 2011 Annual Summary Report for the 200-ZP-1 and 200-UP-1 Operable Unit Pump-and-Treat Operations

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

Contractor for the U.S. Department of Energy
under Contract DE-AC06-08RL14788

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Assistant Secretary for Environmental Management

Contractor for the U.S. Department of Energy
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Executive Summary

This report presents the annual pump-and-treat (P&T) system performance evaluation for the 200-UP-1 and 200-ZP-1 Operable Units (OUs) at the Hanford Site. The results are provided for calendar year (CY) 2011.

The U Plant P&T system within the 200-UP-1 OU remediated the uranium and technetium-99 plumes originating from the 216-U-1/2 Cribs. During 2011, the U.S. Environmental Protection Agency and U.S. Department of Energy agreed to discontinue operation of this system due to low flow rates from the extraction wells and because the remedial action objectives (RAOs) were achieved. The system was shut down in March 2011. From January to March 2011, a total of 1.1 million L (0.3 million gal) of groundwater was extracted and discharged to the Liquid Effluent Retention Facility basin 43 for treatment at the Effluent Treatment Facility (ETF). Because U Plant P&T system operations were terminated in March 2011, the volume of water treated during 2011 was less than the 4.6 million L (1.2 million gal) treated in 2010. The volume of water removed from the aquifer since operations began in March 1994 is 887 million L (234 million gal).

In 2011, the 200-UP-1 P&T system removed 0.24 kg of uranium, 0.24 g (0.0041 Ci) of technetium-99, 0.2 kg of carbon tetrachloride, and 734 kg of nitrate. Since startup in March 1994, 220.5 kg of uranium, 127.4 g (2.17 Ci) of technetium-99, 41.4 kg of carbon tetrachloride, and 49,201 kg of nitrate have been removed. During 2011, the treated effluent concentrations from the ETF remained below regulatory limits.

During 2011, construction of the P&T system for the technetium-99 plumes in the vicinity of the S-SX Tank Farms was underway. The system is scheduled to begin operation in 2012 and consists of a three-well extraction system, aboveground pipelines, and a transfer building to pump extracted groundwater to the 200 West Area P&T facility for treatment and reinjection. By the end of 2011, the necessary piping was laid and the transfer station was constructed. Acceptance testing of the constructed system will be complete in early 2012.

This is the final report for the 200-UP-1 U Plant interim P&T system. Overall, the U Plant P&T system was successful in achieving the interim RAOs. Within the targeted remediation area, concentrations at all wells were below the 300 μg/L RAO for uranium

and below the 9,000 pCi/L RAO for technetium-99. Further remediation of the uranium and technetium-99 plumes, as needed, will be addressed in the final Record of Decision for the 200-UP-1 OU, which is scheduled to be issued by September 2012.

In 2011, the 200-ZP-1 P&T system sustained an average flow rate of 1,442 L/min (381 gallons per minute [gpm]). The extraction wells produced 758 million L (200.2 million gal) in 2011, which is a 33 percent increase beyond the 570.2 million L (150.6 million gal) of groundwater treated in 2010. This increase is primarily due to the addition of the new, high-capacity well 299-W15-225 to the extraction network in late 2010. Since 1996, the cumulative volume of groundwater extracted is 5.8 billion L (1.5 billion gal). 791.8 kg of carbon tetrachloride was removed in 2011, which is a 13 percent increase beyond the 700.7 kg of carbon tetrachloride removed in 2010.

Construction activities have been completed on the new 200 West Area P&T facility to implement the selected remedy in the 200-ZP-1 final ROD[1], issued in September 2008 to address remediation of the contamination plume extent within the 200-ZP-1 OU. Operation of this facility will begin in 2012. The annual P&T report for 2012 will address the startup and performance of the 200 West Area P&T facility and transition from the interim 200-ZP-1 P&T system.

[1] EPA, Ecology, and DOE, 2008, *Record of Decision Hanford 200 Area 200-ZP-1 Operable Unit Superfund Site, Benton County, Washington*, U.S. Environmental Protection Agency, Washington State Department of Ecology, and U.S. Department of Energy, Olympia, Washington.

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Terms

CHPRC	CH2M HILL Plateau Remediation Company
COC	contaminant of concern
CY	calendar year
DOE	U.S. Department of Energy
DWS	drinking water standard
EPA	U.S. Environmental Protection Agency
ETF	Effluent Treatment Facility
FY	fiscal year
gpm	gallons per minute
LERF	Liquid Effluent Retention Facility
MTCA	*Model Toxics Control Act*
NA	not available
OU	operable unit
P&T	pump-and-treat
PFP	Plutonium Finishing Plant
QA	quality assurance
QC	quality control
RAO	remedial action objective
REDOX	Reduction-Oxidation (Plant)
RL	U.S. Department of Energy, Richland Operations Office
ROD	Record of Decision
TCE	trichloroethene
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order*
VOC	volatile organic compound
WMA	waste management area

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1 Introduction

The purpose of this report is to present the calendar year (CY) 2011 operational results for three groundwater pump-and-treat (P&T) systems located in the 200 West Area (Figure 1-1) of the Hanford Site. These P&T systems addressed groundwater contamination in the 200-ZP-1 and 200-UP-1 Operable Units (OUs), as required under interim Records of Decision (RODs). The P&T systems are operated by CH2M HILL Plateau Remediation Company (CHPRC) for the U.S. Department of Energy (DOE).

The U Plant P&T system is located in the 200-UP-1 Groundwater OU. This system addresses the primary groundwater contaminants of concern (COCs), uranium and technetium-99, and the secondary COCs, carbon tetrachloride and nitrate, in the vicinity of U Plant. Groundwater from the extraction wells is transported by pipeline from the 200 West Area to the Liquid Effluent Retention Facility (LERF) in the 200 East Area for treatment at the Effluent Treatment Facility (ETF). In March 2011, the U.S. Environmental Protection Agency (EPA) and DOE agreed to suspend U Plant P&T operations due to poor extraction well performance and because the remedial action objectives (RAOs) were achieved.

Technetium-99 occurs as a groundwater contaminant downgradient of the SX Tank Farm in the southern portion of the 200 West Area. During quarterly sampling of well 299-W23-19 near the source of this plume within the tank farm, a minimum of 3,785 L (1,000 gal) is purged from the well as an interim remedy to remove technetium-99 from the aquifer.

Contaminated groundwater in the 200-ZP-1 OU is treated by two P&T systems. The main 200-ZP-1 P&T system is a stand-alone treatment plant removing carbon tetrachloride, as well as secondary COCs chloroform and trichloroethene (TCE). During 2011, the 200-ZP-1 P&T system operated with 14 extraction wells and 5 injection wells to treat a broad region of groundwater contamination. A second 200-ZP-1 OU groundwater extraction system removes technetium-99 contamination at two wells east of the T Tank Farm. Groundwater from these extraction wells is transported by pipeline to the LERF for removal of technetium-99 and other contaminants at the ETF.

The 200-UP-1 and 200-ZP-1 P&T systems are described in Chapters 2 and 3, respectively, including information on the following topics:

- Modifications made to the P&T systems (including newly drilled wells, test results, and other changes during 2011)
- Summary of extraction well data (including extraction flow rates and system availability)
- Treatment system performance (including mass removed, volume treated, and system availability)
- Trends for COCs in extraction and key monitoring wells
- Groundwater plume changes (e.g., changes in plume size)
- Conclusions and recommendations (including recommendations for changes to system configuration and operating parameters, as well as system maintenance)

Appendices A through D present background information, history of regulatory actions, process knowledge, contaminant sources, and ETF treatment information relevant to the 200-UP-1 and 200-ZP-1 P&T systems. These appendices are provided on a compact disc found at the back of the document.

Hanford Site Groundwater Monitoring for 2011 (DOE/RL-2011-118, in publication) presents additional information on the nature and extent of groundwater contamination. Appendix D of that document

provides a discussion of quality assurance (QA) and quality control (QC) as applied to groundwater sampling and analysis during 2011.

This report for 2011 is the final report for the "interim action 200-ZP-1 P&T system," as the remedial action is being changed to final remedy status. The *Record of Decision Hanford 200 Area 200-ZP-1 Operable Unit Superfund Site, Benton County, Washington* (EPA et al., 2008) was issued in September 2008. The selected remedy includes construction of new treatment facilities and additional injection and extraction wells to support the new system. When this system becomes operational in CY 2012, the new system will capture 95 percent of the carbon tetrachloride mass and nonradiological and radiological contaminants. The next annual P&T report will address the final months of operation of the interim system and the startup and performance of the 200 West Area P&T facility.

This is the final report for the 200-UP-1 U Plant interim P&T system. The extraction well system to capture groundwater contamination in the vicinity of the S-SX Tank Farms was under construction during 2011 and is scheduled to begin operation in 2012, using the treatment capacity of the new 200 West Area P&T Facility.

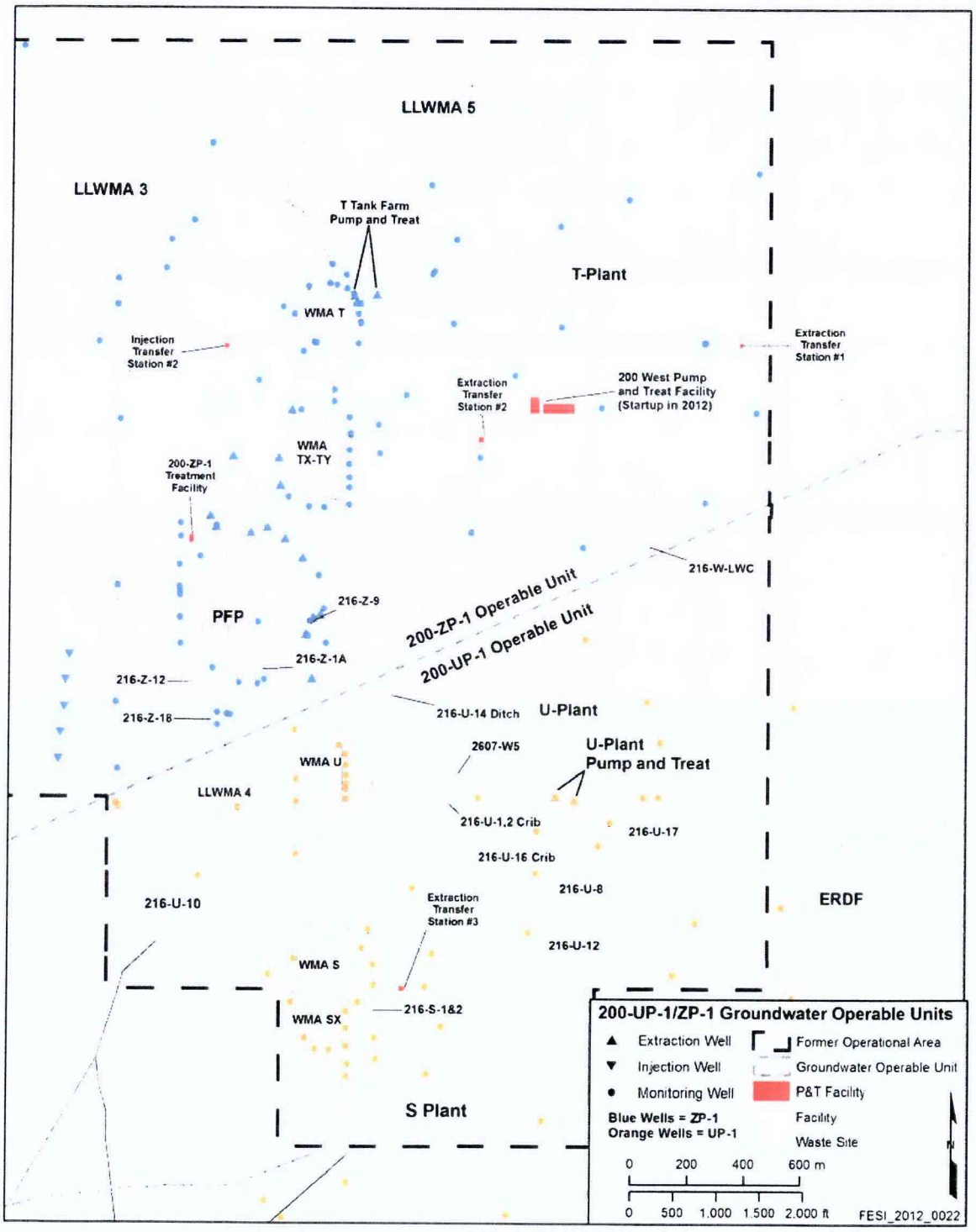

Figure 1-1. Hanford Site 200 West Area, Groundwater OUs, and Associated Waste Sites

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2 200-UP-1 Operable Unit Pump-and-Treat System

The 200-UP-1 OU addresses groundwater contaminant plumes beneath the southern third of the 200 West Area and adjacent portions of the surrounding 600 Area (Figure 2-1). A P&T system was constructed in the vicinity of U Plant and began operation in 1994 to remediate uranium and technetium-99 contamination originating from the 216-U-1/2 Cribs (a treatability test was conducted in 1994). This chapter describes the results of system operation during 2011 and summarizes the progress made in remediating the aquifer since P&T startup.

The *Record of Decision for the 200-UP-1 Operable Unit Interim Remedial Action, Hanford Site, Benton County, Washington* (EPA/541/R-97/048) was issued in 1997. The selected remedy consists of pumping the highest concentration zone of the contaminated groundwater plume downgradient from the 216-U-1/2 Cribs and treating the contamination using the existing ETF located in the 200 East Area. The primary COCs identified for the interim action are uranium and technetium-99, with carbon tetrachloride and nitrate as secondary COCs. The interim ROD presented the following four interim RAOs:

- **RAO #1:** Reduce contamination in the area of highest concentrations of uranium and technetium-99 to below 10 times the cleanup level under the *Model Toxics Control Act* (MTCA) (WAC 173-340, "Model Toxics Control Act – Cleanup") for uranium (later changed to 10 times the drinking water standard [DWS] for uranium) and 10 times the DWS for technetium-99.
- **RAO #2:** Reduce potential adverse human health risks through reduction of contaminant mass.
- **RAO #3:** Prevent further movement of these contaminants from the highest concentration area.
- **RAO #4:** Provide information that will lead to development and implementation of a final remedy that will be protective of human health and the environment.

The ROD identified the portions of the uranium and technetium-99 plumes targeted for remediation as the areas where concentrations exceeded 10 times the 48 μg/L MTCA cleanup level for uranium and 10 times the 900 pCi/L DWS for technetium-99. Because a DWS for uranium was not established in 1997, the 48 μg/L MTCA cleanup standard for total uranium was adopted and incorporated in the 200-UP-1 ROD. A DWS of 30 μg/L was established in 2004 by EPA and was adopted at the Hanford Site in 2008. Thus, the RAO for uranium was 480 μg/L until 2009 and then 300 μg/L thereafter (*Explanation of Significant Differences for the Interim Record of Decision for the 200-UP-1 Groundwater Operable Unit, Hanford Site, Washington* [EPA et al., 2009]). The RAO for technetium-99 is 9,000 pCi/L.

In July 2003, after 9 years of operation, the P&T system successfully achieved the then current RAOs for uranium and technetium-99. To determine if contaminant concentrations would remain below action levels with no further groundwater extraction, a year-long rebound study featuring frequent groundwater sampling was conducted between January 2005 and January 2006. Following completion of the rebound study, the U Plant P&T system remained in hot-standby status. Groundwater extraction from wells 299-W19-36 and 299-W19-43 resumed on April 19, 2007, at the direction of the DOE Richland Operations Office (RL) because the maximum uranium concentration was above the revised RAO of 300 μg/L.

Technetium-99 also occurs as a groundwater contaminant near the S and SX Tank Farms in the southern portion of the 200-UP-1 OU. Since October 1999, analytical results from one well within the SX Tank Farm, 299-W23-19, have shown technetium-99 concentrations ranging between 30,000 and 188,000 pCi/L. Several newer downgradient wells also have technetium-99 concentrations that exceed

9,000 pCi/L. A limited groundwater extraction operation was initiated in March 2003 at 299-W23-19, with a requirement for once-per-quarter extraction of at least 3,785 L (1,000 gal) of groundwater after sampling.

Substantial progress has been made toward a final ROD for the 200-UP-1 OU. The *Remedial Investigation/Feasibility Study for the 200-UP-1 Groundwater Operable Unit* (DOE/RL-2009-122, Draft A) and the related *Proposed Plan to Amend the 200-ZP-1 Groundwater Operable Unit Record of Decision to Include the Remedial Actions for the 200-UP-1 Groundwater Operable Unit* (DOE/RL-2010-05, Draft A) were both submitted to the regulatory agencies for review on September 24, 2010, meeting *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al., 1989) Milestone M-15-17A. The preferred alternative presented in the proposed plan includes a combination of groundwater P&T for uranium, technetium-99, nitrate, total chromium, and hexavalent chromium; hydraulic containment for iodine-129; and monitored natural attenuation for tritium. The draft documents are expected to be finalized later in fiscal year (FY) 2012. The proposed cleanup levels for each COC are the federal and state DWSs and the State of Washington MTCA Method B cleanup levels, where appropriate. The treated effluent from P&T operations will be injected back into the 200 West Area aquifer for flow-path control and hydraulic containment.

The activities, developments, and performance of the U Plant P&T system during 2011 are presented in Sections 2.1 through 2.7. Background information, P&T system operational data, and supporting information are presented in Appendix A and subsequent appendices. Groundwater sampling and extraction at well 299-W23-19 for 2011 are discussed in Section 2.8 and Appendix D. The P&T system being constructed to remediate the technetium-99 plumes at the S-SX Tank Farms is discussed in Section 2.8. Sections 2.9 and 2.10, respectively, provide conclusions and recommendations.

2.1 Calendar Year 2011 Activities and Developments

The U Plant P&T system operated until March 30, 2011. Flow rates from the extraction wells had decreased for several years due to reduced well efficiency and the declining regional water table. Attempts to rehabilitate the wells during 2010 were unsuccessful (DOE/RL-2011-01, *Hanford Site Groundwater Monitoring Report for 2010*). In addition, the pump in extraction well 299-W19-36 ceased operating on November 13, 2010, and was not replaced because of the long-term low flow rate experienced before the failure. The flow rate in 2011 from remaining extraction well 299-W19-43 averaged 9.4 L/min (2.5 gallons per minute [gpm]), which was much lower than 51 L/min (13.7 gpm) achieved when this well was first brought online in 2003 (DOE/RL-2003-58, *Fiscal Year 2003 Annual Summary Report for 200-UP-1 and 200-ZP-1 Pump-and-Treat Operations*). While not performed in 2011, a previous capture zone analysis indicated that the system is no longer effective in capturing the remaining uranium and technetium-99 plumes (DOE/RL-2011-01). EPA and DOE agreed to terminate P&T operations based on the diminished capacity of the extraction wells and because uranium and technetium-99 concentrations in both extraction wells have remained below the RAOs of 300 μg/L and 9,000 pCi/L, respectively.

2.2 Extraction System Performance

In 2011, a total of 1.1 million L (0.29 million gal) of groundwater was extracted by well 299-W19-43, before the system was shut down (Table 2-1). This volume is lower than the 4.6 million L (1.2 million gal) removed in 2010 because the system operated for a shorter duration at a lower capacity and extraction well 299-W19-36 was non-operational. The cumulative volume of water removed since startup in March 1994 is 887 million L (234 million gal). Production efficiency statistics were not calculated for the limited period of operation during 2011.

2.3 Treatment System Performance

During the 2011 operating period, the U Plant P&T system removed an estimated 0.24 kg of uranium, 0.24 g (0.0041 Ci) of technetium-99, 0.2 kg of carbon tetrachloride, and 734 kg of nitrate from groundwater beneath the 200-UP-1 OU (Table 2-1). Since startup in March 1994, 220.5 kg of uranium, 127.4 g (2.17 Ci) of technetium-99, 41.4 kg of carbon tetrachloride, and 49,201 kg of nitrate have been removed.

Treatment system performance refers to the treatment facility's effectiveness to reduce contaminant concentrations in the P&T system effluent prior to discharge back into the environment. Figure 2-2 shows the influent and effluent concentrations for the ETF from 1997 to the present. The concentrations since the fourth quarter of FY 2007 represent water from the U Plant P&T system and the P&T system at WMA T in the 200-ZP-1 OU combined. The water from both systems is pumped to the same basin at the LERF prior to treatment. The treated effluent concentrations for uranium, technetium-99, carbon tetrachloride, and nitrate were below regulatory limits during all of 2011, indicating that the treatment process is effective for removing contamination from the water.

2.4 Aquifer Response

Changes in groundwater levels are important in assessing P&T system effectiveness in capturing the contaminant plume. Water-level measurements are the basis for evaluating the impact of pumping on the aquifer and regional groundwater trends. The water level in each monitoring well is recorded before collecting a groundwater sample. In addition, water levels are collected manually once each year on the same day at designated wells to measure the regional (sitewide) water table. A third means of measuring water levels is by way of the automated water-level monitoring network/system, which consists of pressure transducers connected to data loggers at select wells (299-W19-18, 299-W19-35, 299-W19-46, and 299-W19-48 for the U Plant P&T system). Water-level data are transmitted directly to the office from these wells. These stations allow for hourly monitoring of the water table and are useful for identifying water-level changes associated with discrete events, such as atmospheric pressure fluctuations or drawdown near pumping wells.

Because the system only operated for 3 months during the year, a capture analysis was not performed for 2011. However, the previous analysis performed for 2010 (DOE/RL-2011-26, *Calendar Year 2010 Annual Summary Report for the 200-ZP-1 and 200-UP-1 Operable Unit Pump-and-Treat Operations*) indicated that the capture zone for the extraction wells was small due to the low flow rates. Figure 2-3 presents the March 2011 groundwater elevation contours at 200-UP-1. The withdrawal of groundwater at the operating extraction well (299-W19-43) had no discernible effect on the water table due to the low flow rate.

2.5 Contaminant Monitoring

This section presents contaminant monitoring results and trends for uranium, technetium-99, carbon tetrachloride, and nitrate in the vicinity of the P&T system. Figure 2-1 shows the locations of wells used to monitor groundwater contamination in the area of the pumping wells. Figures 2-4 through 2-7 show the sampling results from the groundwater monitoring network and the concentration trends for uranium, technetium-99, carbon tetrachloride, and nitrate from 2006 through December 31, 2011. This period includes the latter portion of the rebound study, the hot-standby period, restart of the extraction wells, and operation through the 2010 well rehabilitation and shutdown of the pumping wells in early 2011. The plume maps in this chapter are based on annual average sample results at the monitoring wells.

2.5.1 Uranium Monitoring Results

Uranium concentrations were below the RAO of 300 µg/L at all monitoring wells within the area targeted for remediation (Figures 2-4 and 2-8), but concentrations remain above the 30 µg/L DWS. The maximum sample result in this area during 2011 was 214 µg/L in well 299-W19-48. In 299-W19-18, located just downgradient from the 216-U-1/2 Cribs, the concentration was 374 µg/L. Although this is above the 300 µg/L RAO, this well is upgradient of the targeted remediation area.

Table 2-2 compares the average annual concentrations of uranium for 2010 and 2011. With the exception of 299-W19-49, uranium concentrations in the U Plant P&T system monitoring wells during 2011 either remained stable or decreased from the levels observed in 2010 (Figure 2-4 and Table 2-2). The concentration in 299-W19-49 increased from 51 µg/L in 2010 to 96 µg/L in 2011. These observations indicate that the uranium plume is no longer a growing contamination issue, as concentrations are mostly stable or declining, depending on the well. Further remediation of the uranium plume, including in the area of the source cribs (as needed) will be addressed as part of the final remedy for the 200-UP-1 OU.

2.5.2 Technetium-99 Monitoring Results

Groundwater technetium-99 concentrations during 2011 were below the 9,000 pCi/L RAO for all plume monitoring wells, and except for the extraction wells, all concentrations were below the 900 pCi/L DWS (Figures 2-5 and 2-9). The maximum sample result during 2011 was 330 pCi/L in 299-W19-35. The extraction wells were not sampled during 2011, but the maximum sample result during 2010 was 7,100 pCi/L in 299-W19-36.

Table 2-2 provides a comparison of annual average concentrations for technetium-99 for 2010 and 2011. Technetium-99 concentrations remained stable or decreased at most wells during 2011. The only increasing trend was noted at 299-W19-49, but the concentration in this well (170 pCi/L) was far below the DWS. The two extraction wells had slightly increased concentrations during CY 2010, but data were not available to evaluate the changes in 2011. These observations indicate that technetium-99 is no longer a growing contamination issue in this area and concentrations have been reduced substantially by the P&T system.

2.5.3 Carbon Tetrachloride Monitoring Results

Carbon tetrachloride concentrations in 2011 remained stable when compared to 2010 but exceeded the 5 µg/L DWS at all monitoring wells in the targeted remediation area (Figure 2-6 and Table 2-3). Wells 299-W19-36 and 699-38-70B have historically shown the highest concentrations and the greatest variability (Figure 2-6). Well 699-38-70B (located far downgradient and east of the targeted remediation area) is screened deeper in the unconfined aquifer.

Well 299-W19-43 has had increasing carbon tetrachloride concentrations since 2009 and through 2010. Analytical results were not available to determine trends in 2011. All other monitoring wells showed stable trends during 2011. A comparison between 2010 and 2011 average annual concentrations is provided in Table 2-3. The carbon tetrachloride plume is much larger than the area targeted for remediation by the U Plant P&T system. Thus, although 41.4 kg of carbon tetrachloride have been removed from the aquifer since startup in 1994, the overall effect of this system on the larger carbon tetrachloride plume has been very limited.

2.5.4 Nitrate Monitoring Results

All of the sampled wells showed stable nitrate concentration trends in 2011. For most wells, quarterly and annual average concentrations exceeded the 45 mg/L DWS (Figure 2-7 and Table 2-3). Average annual concentrations ranged from 17.6 to 110 mg/L. The concentration in 299-W19-49 and 299-W19-105

remained below the DWS during 2011. Similar to carbon tetrachloride, the nitrate plume is much larger than the area targeted for remediation by the U Plant P&T system. Even though 49.2 kg of nitrate have been removed from the aquifer, this is not enough to substantially affect the larger nitrate plume.

2.5.5 Deep Well Monitoring

Most wells in the 200-UP-1 uranium and technetium-99 plume areas are screened within the upper 12.2 m (40 ft) of the unconfined aquifer, where the majority of contaminant mass is present. Wells constructed with screened intervals located within the lower portion of the unconfined aquifer include 299-W19-34A and 299-W19-34B (located in the central portion of the uranium and technetium-99 plumes, downgradient from the 216-U-1/2 Cribs) and 699-38-70B (east of the 200 West Area) (Figure 2-1).

Well 299-W19-34B was not sampled during 2011; however, in 2010, the uranium concentration was 0.9 µg/L and technetium-99 was not detected in this well. For the remaining two deep wells, concentrations during 2011 were stable and ranged from 0.93 to 1.6 µg/L for uranium, 0 to 175 pCi/L for technetium-99, 175 to 755 µg/L for carbon tetrachloride, and 18.1 to 22.7 mg/L for nitrate (Table 2-4). These results are consistent with the current plume interpretations that uranium, technetium-99, and nitrate occur within the upper portion of the aquifer in the targeted remediation area, while the carbon tetrachloride plume extends deep into the aquifer.

2.6 Historical Plume Trends

Appendix C provides information on current conditions and historical changes in the uranium and technetium-99 plumes due to P&T operations for the past 15 years (FY 1995 through CY 2011). Beginning with the 2009 report (DOE/RL-2010-11, Rev. 1, *Hanford Site Groundwater Monitoring and Performance Report for 2009*), the reporting time period was changed to the calendar year (CY) to provide a consistent presentation of groundwater data and plume maps between various project reports.

2.6.1 Uranium

During 2011, the uranium plume configuration (Figure 2-8) changed little from 2010. The overall extent of the plume, at the 30 µg/L contour level, has changed little since the U Plant P&T system began operating in 1994 (see Figures C-1 through C-3 in Appendix C). Thus, while the P&T system has been successful in reducing uranium concentrations to below the 300 µg/L RAO, it has not reduced concentrations to below the 30 µg/L DWS (although this was not an objective of the P&T system).

The persistent uranium plume immediately downgradient of the 216-U-1/2 Cribs may be the result of residual drainage from the vadose zone or continuing releases from aquifer sediments. At present, only 299-W19-18 monitors the area immediately downgradient of the 216-U-1/2 Cribs (this well is 95 m [310 ft] downgradient from the cribs). The concentration trend for this well shows an overall decline (Figure 2-4), suggesting that the main mass of mobile uranium has already passed this location. There are no monitoring wells between 299-W19-18 and the next downgradient well, 299-W19-36 (a distance of 270 m [890 ft]). The high uranium concentrations observed prior to 2011 in extraction wells 299-W19-36 and 299-W19-43, along with the persistent levels measured in adjacent monitoring wells (e.g., 299-W19-48), indicate that uranium continues to be present in a large portion of the aquifer downgradient from the 216-U-1/2 Cribs. This is thought to be due to the lower mobility of uranium in the aquifer compared to other constituents and/or a continuing source of uranium to the aquifer water.

2.6.2 Technetium-99

While the technetium-99 plume (Figure 2-9) for 2011 is similar to the 2010 plume, the plume has decreased in size substantially since 1994 in response to P&T system operations (see Figures C-4 through C-6 in Appendix C). During 2010, the RAO of 9,000 pCi/L was achieved in all areas of the plume. Based

on the latest available data (from 2010) for the extraction wells, only 299-W19-36 and 299-W19-43 remain above the DWS of 900 pCi/L. Thus, the system has effectively achieved the RAO for technetium-99 and it has also been effective in reducing concentrations to below the 900 pCi/L DWS at most wells. This is attributed to the high mobility of technetium-99 in the aquifer (i.e., it does not sorb to sediment grains), and it also indicates that there is not a substantial continuing source of technetium-99 to the aquifer.

2.7 Quality Assurance/Quality Control

Discussions on QA and QC encompassing sampling and analysis of all applicable wells are provided in Appendix D in the *Hanford Site Groundwater Monitoring for 2011* (DOE/RL-2011-118, in publication). Appendix D of that document includes an overall view of the QA/QC issues that may affect interpretation of the groundwater data for the P&T OUs.

2.8 Technetium-99 at the S-SX Tank Farms

Two technetium-99 plumes are present in the vicinity of the S and SX Tank Farms (Figure 2-10). The largest (southern) plume is located south and east of the SX Tank Farm and originates from that tank farm. The northern plume is located east of the S Tank Farm and has been attributed to an overfill event at tank S-104. A P&T system to remediate these plumes is under construction, and three extraction wells were installed during 2011. Section 2.8.3 includes a discussion on the new system.

2.8.1 Technetium-99 Plume from the SX Tank Farm

The distribution of the technetium-99 plume from the SX-Tank Farm in 2011 is consistent with the 2010 depiction, although some evidence exists of downgradient migration. Sample results for wells 299-W22-83 and 299-W22-86 indicate that technetium-99 is migrating slowly to the east. Evidence for this is the annual average concentration observed at 299-W22-86, which exceeded the RAO for technetium-99 (9,000 pCi/L) for the first time in 2009.

The highest concentration of technetium-99 in this plume occurs in the southwestern corner of the SX Tank Farm at 299-W23-19. Technetium-99 concentrations in this well peaked in 2003 at 188,000 pCi/L and again in September 2005 at 137,000 pCi/L (Figure 2-11). For 2011, concentrations ranged between 40,000 and 51,000 pCi/L, which is slightly lower than concentrations observed in 2010, indicating that the mass flux of technetium-99 to the aquifer in the vicinity of this well has been decreasing in recent years. Additional information on the background and sampling history for 299-W23-19 is presented in Appendix D.

Wells 299-W22-80 and 299-W23-15 had technetium-99 concentrations at or just above laboratory detection limits. Both of these wells continue to have unexpectedly low technetium-99 concentrations, as both wells are located near the central portion of the greater than 9,000 pCi/L plume contour. An in-well tracer test at 299-W22-80 (to evaluate flow within the well under non-pumping conditions [PNNL-14113, *Results of Detailed Hydrologic Characterization Tests – FY 2001*]) and time-series sampling during extensive purging indicated that relatively clean water may be migrating into the bottom of the well, moving up the wellbore, and diluting concentrations in the upper portion of the plume (PNNL-15070, *Hanford Site Groundwater Monitoring for Fiscal Year 2004*). A similar process is assumed to be occurring at 299-W23-15.

During 2011, downgradient wells 299-W22-47 and 299-W22-83 exhibited technetium-99 concentrations in excess of 9,000 pCi/L (Figure 2-10). Well 299-W22-47, drilled in January 2005, has had technetium-99 concentrations ranging from 14,000 to 20,000 pCi/L and has shown a slight decreasing trend since 2008 (Figure 2-12). Well 299-W22-83, which is located downgradient of 299-W22-47 within the central

portion of the plume, has had stable concentrations since January 2008 (mostly between 17,000 and 18,000 pCi/L). Concentrations in this well previously increased from near 200 pCi/L when the well was installed in 2001 to a maximum of 19,000 pCi/L in 2008 (Figure 2-12). Well 299-W22-86 was installed in early 2006. Technetium-99 concentrations have steadily increased in this well from June 2006 (1,950 pCi/L) to the 10,000 pCi/L concentrations observed in August and December 2010, reflecting downgradient migration of the plume (Figure 2-12). These trends indicate that the plume has achieved a near steady-state condition at 299-W22-47 and 299-W22-83, and perhaps also at 299-W22-86, in which the downgradient migration of the plume is in balance with the reduction of contaminant concentrations by dispersion.

During 2011, new extraction wells 299-W22-91 and 299-W22-92 were installed within this plume near monitoring wells 299-W22-50 and 299-W22-86, respectively. Vertical profile samples of the aquifer were collected during drilling, and the results for technetium-99 are shown in Table 2-5. The plume is limited to the upper 20 m (65.6 ft) of the aquifer at both locations, which is similar to other vertical profile samples collected within this plume. The maximum concentration measured during drilling was 29,100 pCi/L in 299-W22-91 at 10.5 m (34.4 ft) below the water table.

Quarterly sampling at 299-W23-19 began in March 2000. Beginning in March 2003, sampling was accompanied with large-volume purging and disposal of at least 3,785 L (1,000 gal) of technetium-99-contaminated groundwater. The goal of this remedy is to remove some of the technetium-99 from the aquifer. This practice continued during 2011. Approximately 0.011 Ci (or 0.62 g) of technetium-99 has been removed from the aquifer at this location since startup in 2003. This remedy will be discontinued when the S-SX Tank Farms P&T system begins operating, which is scheduled for 2012.

2.8.2 Technetium-99 Plume from the S Tank Farm

The technetium-99 plume east of the S Tank Farm is more limited in extent but also shows downgradient migration. The technetium-99 plume is bounded by concentrations below the DWS in 299-W22-84, 299-W22-81, and 299-W22-69 (Figure 2-10). In 299-W22-44, which defines the core of the plume, the concentration exceeded the DWS of 900 pCi/L for the first time in 2004. Concentrations increased rapidly starting in 2006, reaching a maximum concentration of 20,000 pCi/L in December 2009 (Figure 2-13); however, concentrations have declined since then. This trend indicates that a pulse of contamination entered the aquifer beneath the S Tank Farm and is migrating past this well.

Well 299-W22-26, located east of 299-W22-44, is the furthest downgradient well within the plume. Concentrations have also increased in this well, from 1,130 pCi/L in December 2005 to 6,000 pCi/L in December 2010 (Figure 2-13). Concentrations declined during 2011. Based on the groundwater flow velocity (36 m/yr [118.1 ft/yr]), the travel time between 299-W22-44 and 299-W22-26 is estimated to be 7 years. Thus, the recent concentration peaks in these wells are attributed to separate pulses of contamination from the tank farm. Evidence for an earlier release from the tank farm can be seen in the trend for 299-W22-48, located within the southern portion of the plume (Figure 2-13). Technetium-99 concentrations increased rapidly in this well between 2000 and 2002, peaking at 4,670 pCi/L in September 2002.

During 2011, new extraction well 299-W22-90 was installed near 299-W22-44. Vertical profile sampling of the aquifer was performed during drilling, and the results are shown in Table 2-5. Prior to this sampling, information was not available on the depth distribution of this plume, but it was hypothesized that the plume was limited to the upper portion of the aquifer similar to the SX Tank Farm plume. The vertical profile sample results confirmed this interpretation. The maximum concentration was

5,520 pCi/L at 4.1 m (13.5 ft) below the water table, and the concentration declined to below the 900 pCi/L DWS at the next sample location 10.6 m (34.8 ft) below the water table.

2.8.3 S-SX Tank Farms Pump-and-Treat System

The implementation of a groundwater P&T system for the technetium-99 plumes at the S-SX Tank Farms is underway as required by the revised work plan (DOE/RL-97-36, Rev. 3, *200-UP-1 Groundwater Remedial Design/Remedial Action Work Plan*). The remedial design is complete and consists of a three-well extraction system, aboveground pipelines, and a transfer building to pump extracted groundwater to the 200 West Area P&T facility for treatment and reinjection (Figure 2-14). The targeted area for this interim action is the plume region bounded by the 9,000 pCi/L contour. Modeling of plume capture indicates that an average total pumping rate of 300 L/min (80 gpm) will meet remedy objectives. During 2011, three extraction wells (299-W22-90, 299-W22-91, and 299-W22-92) were drilled near existing monitoring wells 299-W22-44, 299-W22-50, and 299-W22-86, respectively. In addition, monitoring well 299-W22-96 was drilled north of the Reduction-Oxidation (REDOX) Plant. Installation of a second monitoring well, 299-W22-95, is planned for FY 2013 and will be located within the S Tank Farm plume. In addition, an automated water-level monitoring system was installed in existing wells 299-W22-44, 299-W22-50, 299-W22-69, 299-W22-80, 299-W22-83, 299-W22-84, 299-W22-85, and 299-W22-86. The new wells and the water-level monitoring network will be used during operation of the P&T system to evaluate plume capture. By the end of 2011, necessary piping was placed and the transfer station was constructed. Acceptance testing of the constructed system is expected to be completed in early 2012, and operations will start in the second half of 2012.

2.9 Conclusions

The 200-UP-1 U Plant P&T system operated from 1994 until the system was shut down in 2011. Flow rates from the extraction wells had declined to very low levels, and attempts to rehabilitate the wells in 2010 were not successful. Because of this, DOE and EPA agreed to no longer operate the system and it was shut down in March 2011. Overall, the system was successful in achieving its objectives. The specific interim RAOs are listed below, along with a summary of the progress made for each:

- **RAO #1:** Reduce contamination in the area of highest concentrations of uranium and technetium-99 to below 10 times the 30 µg/L DWS for uranium and below 10 times the 900 pCi/L DWS for technetium-99.

  Results: During its operational period, the U Plant P&T system substantially reduced concentrations of uranium and technetium-99 in the aquifer. Prior to system startup in 1994, the maximum concentrations within the targeted remediation area were 3,320 µg/L for uranium (299-W19-29, now decommissioned) and 20,500 pCi/L for technetium-99 (299-W19-24, now decommissioned). The interim RAO of 300 µg/L for uranium was achieved during 2009 and the interim RAO of 9,000 pCi/L for technetium-99 was achieved during 2005 (technetium-99 concentrations were briefly above the RAO in extraction well 299-W19-36 during 2007 when the system was restarted after the rebound study). In addition, the system also reduced the technetium-99 concentration to below the 900 pCi/L DWS at all wells within the targeted remediation area, except for the extraction wells. In the monitoring wells, the highest uranium sample result during 2011 was 219 µg/L (299-W19-48), and the highest technetium-99 result was 330 pCi/L (299-W19-35). The extraction wells were last sampled during 2010, and the maximum concentrations were 257 µg/L for uranium (299-W19-43) and 7,100 pCi/L for technetium-99 (299-W19-36). This constitutes a reduction in maximum concentrations since startup of 92 percent for uranium and 65 percent for technetium-99.

- **RAO #2:** Reduce potential adverse human health risks through reduction of contaminant mass.

  Results: The U Plant P&T system was successful in removing contaminant mass from the aquifer. The mass originally estimated to have been in the plumes was 130 kg for uranium and 160 kg (2.72 Ci) for technetium-99 (DOE/RL-97-36, Rev. 1). Throughout its operational period, the system removed from the aquifer a total of 220.5 kg of uranium and 127.4 g (2.17 Ci) of technetium-99, or 170 percent and 80 percent of the mass originally estimated to have been in the aquifer, respectively. The extra uranium removed could be due to an inaccurate original mass determination or the addition of uranium to the aquifer water either by leaching from the vadose zone beneath the source cribs or by desorption of this constituent from the aquifer sediments. With the reduction in contaminant mass and concentrations below RAOs, it is concluded that P&T operations have reduced the potential for adverse human health risks.

- **RAO #3:** Prevent further movement of uranium and technetium-99 from the highest concentration area.

  Results: Hydraulic containment of the contaminant plumes (at concentrations above the RAOs) was maintained during operation of the U Plant P&T system. This can be seen by examining the historical plume maps for uranium and technetium-99 presented in Appendix C. The portions of the plumes at concentrations greater than the RAOs of 300 µg/L for uranium and 9,000 pCi/L for technetium-99 remained within the area targeted for remediation and did not migrate beyond the boundary of the 200 West Area.

- **RAO #4:** Provide information that will lead to development and implementation of a final remedy that will be protective of human health and the environment.

  Results: Information collected during U Plant P&T operations pertinent to development and implementation of a final remedy is the response of the uranium and technetium-99 plumes to the P&T system. Because technetium-99 does not sorb to aquifer sediments and additional contaminant mass was apparently not added to the aquifer, this constituent responded very well to the P&T system. As described above, maximum plume concentrations were reduced by 65 percent and contaminant mass in the aquifer was reduced by 80 percent. Furthermore, the size of the plume above the 900 pCi/L DWS was substantially reduced (see the historical plume maps in Appendix C). These observations indicate that P&T is an effective remedy for technetium-99.

  The P&T system was effective in achieving the uranium RAOs, as evidenced by the 92 percent reduction in maximum plume concentrations and the removal of 170 percent of the contaminant mass estimated to have originally been in the aquifer. However, with regard to plume size above the DWS, this constituent did not respond as well as technetium-99 (see the historical plume maps in Appendix C). As described above, contaminant mass may have been added to the aquifer water by leaching from the vadose zone or desorption from the aquifer sediment. The sorption of uranium to sediment grains also means that the migration rate of this constituent in the aquifer is slower than technetium-99. All of these factors may explain why uranium concentrations persist above the DWS within the P&T area.

2.10 Recommendations

The following recommendations are made for the U Plant P&T area:

- Wells 299-W19-36 and 299-W19-43 should be reconfigured and equipped with low-flow pumps for groundwater monitoring. Although these wells are no longer useful as extraction wells due to their low flow rates, they will be useful as monitoring wells in support of a final remedy.

- The plume distribution between 299-W19-18 near the 216-U-1/2 Cribs and the P&T system monitoring wells southeast of U Plant is not well defined. Further characterization of the uranium plume in this area should be performed as an input to designing a final remedy.

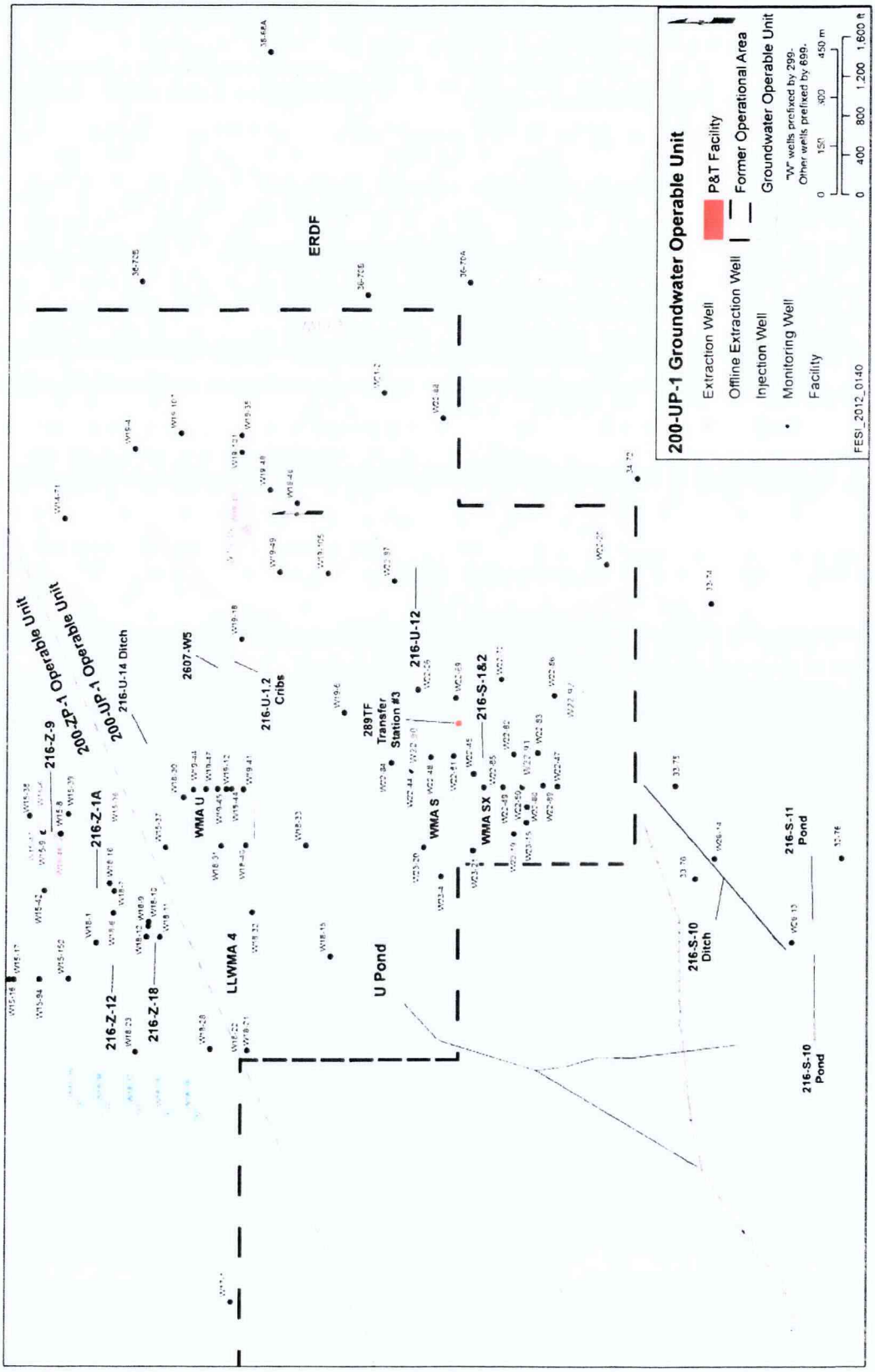


Figure 2-1. U Plant P&T System Monitoring Wells Location Map, CY 2011

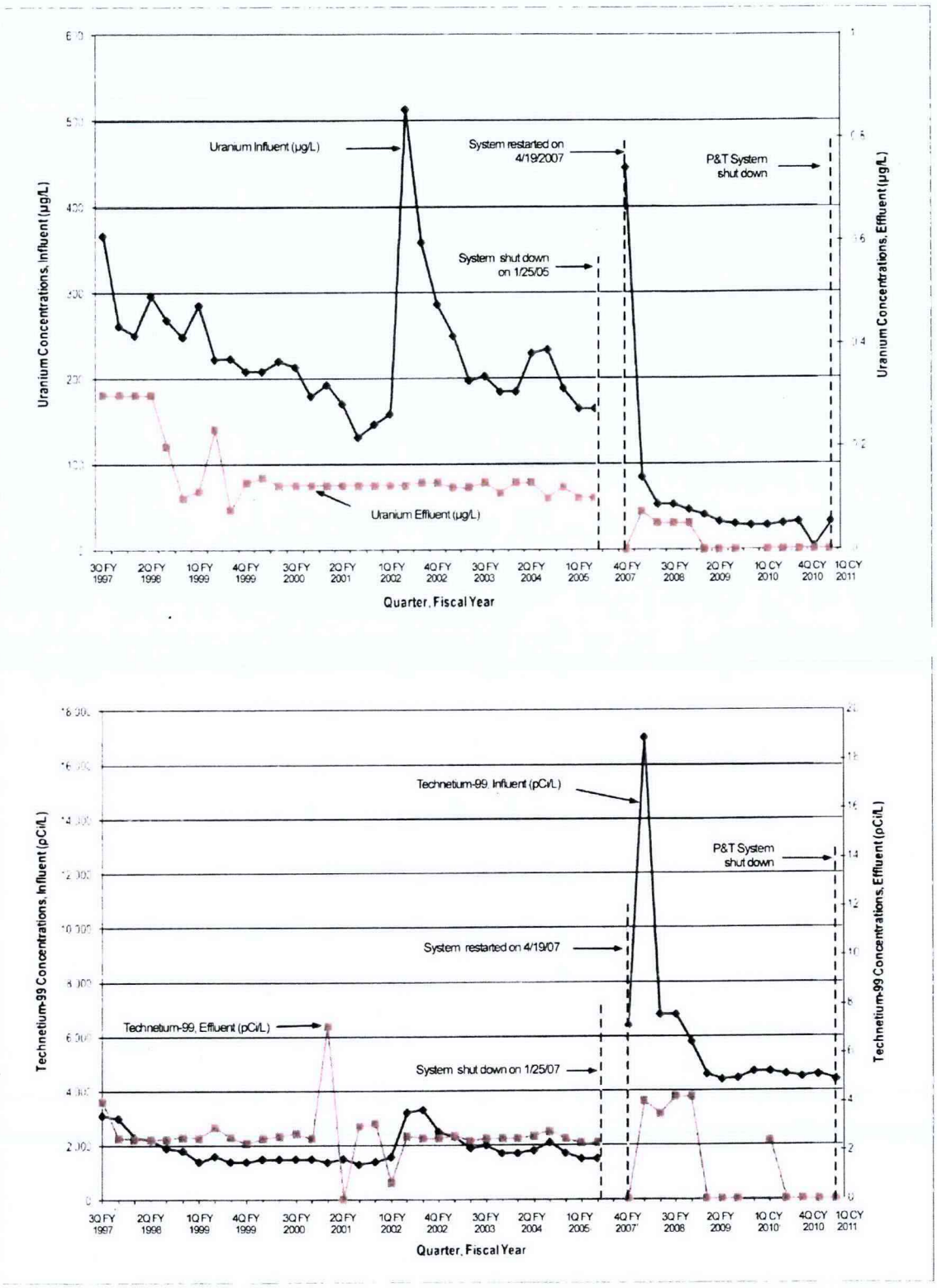


Figure 2-2. 200-UP-1 Contaminant Concentrations as Measured by the ETF

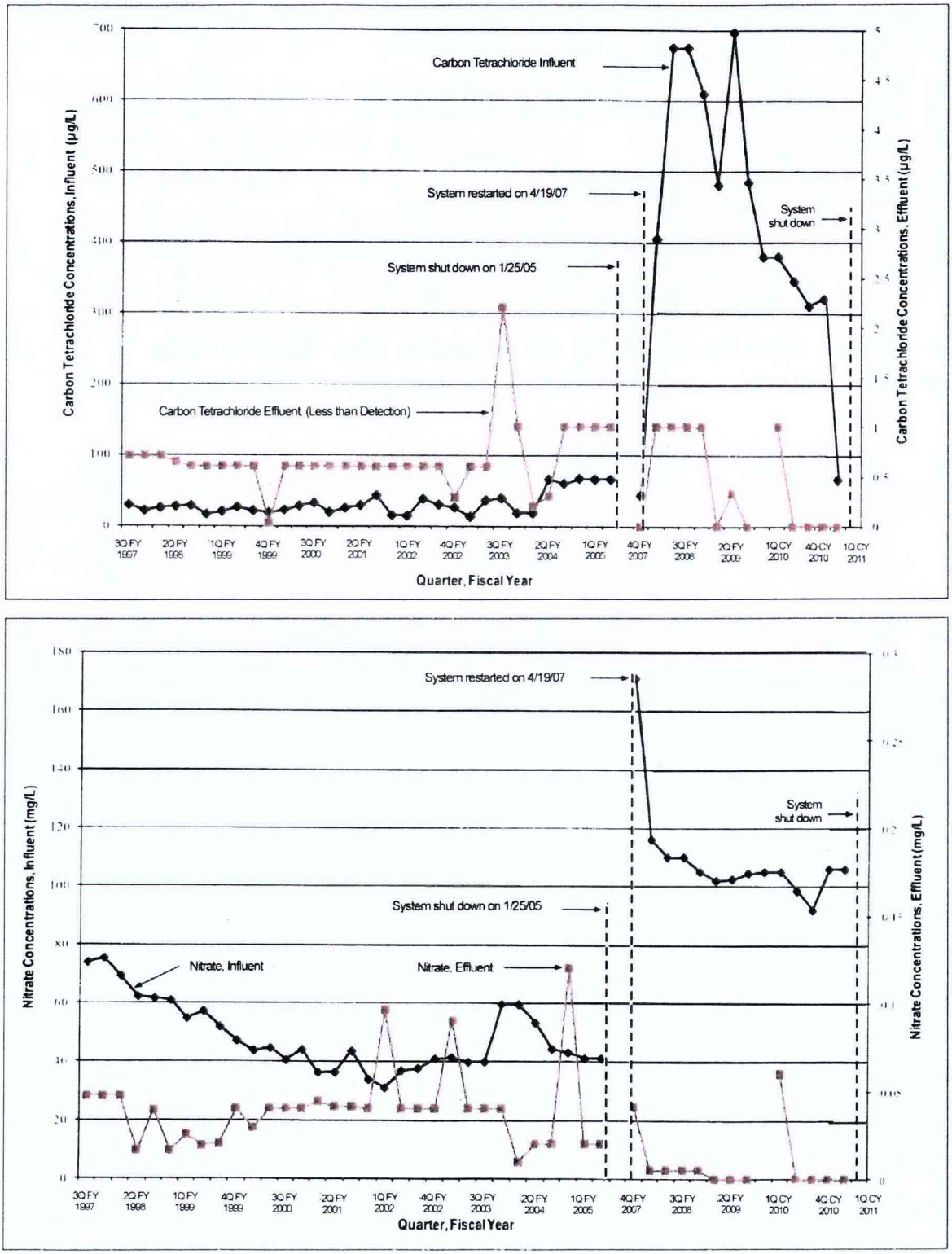


Figure 2-2. 200-UP-1 Contaminant Concentrations as Measured by the ETF (cont'd)

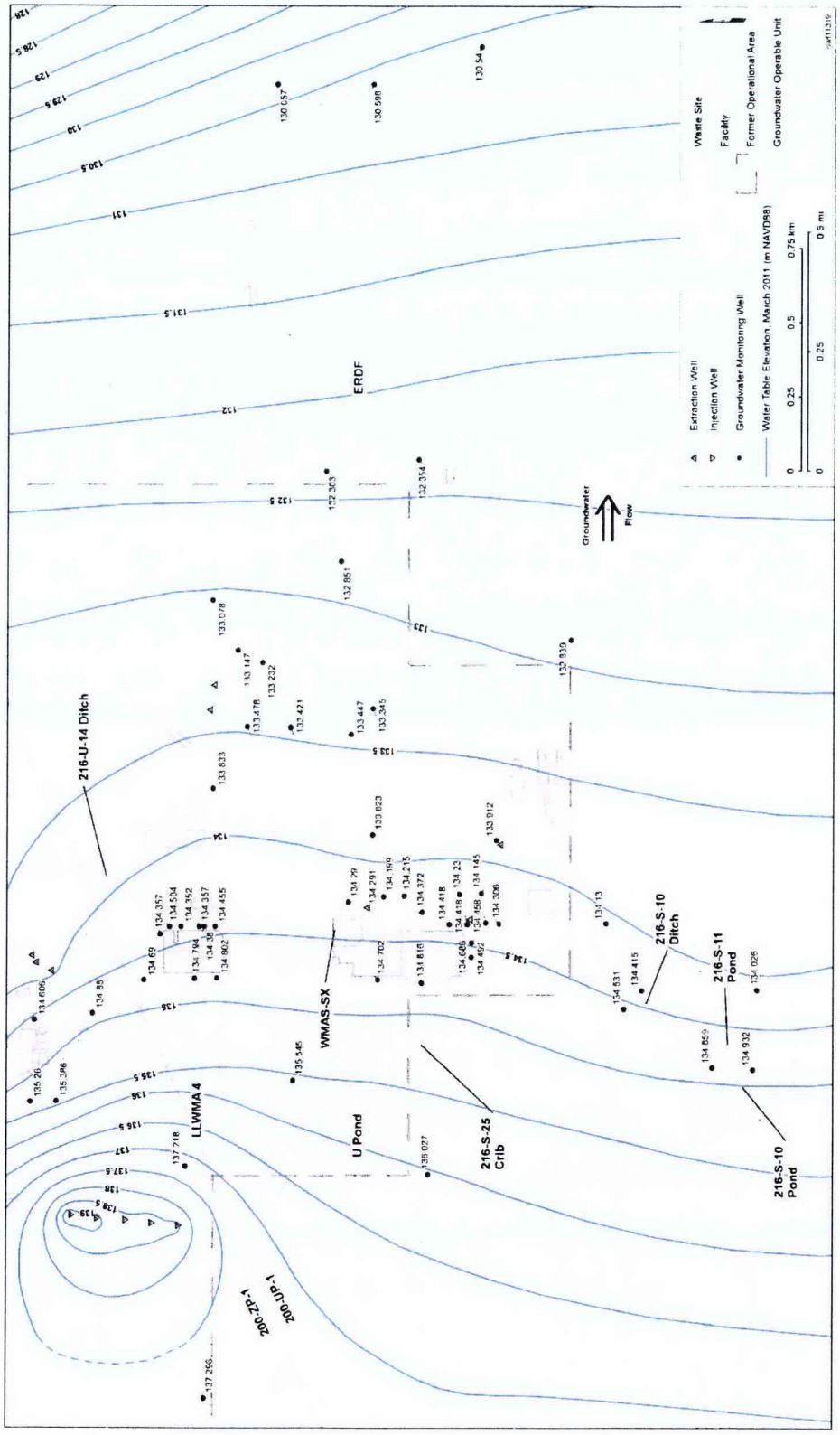


Figure 2-3. Groundwater Elevation Contours at 200-UP-1, March 2011

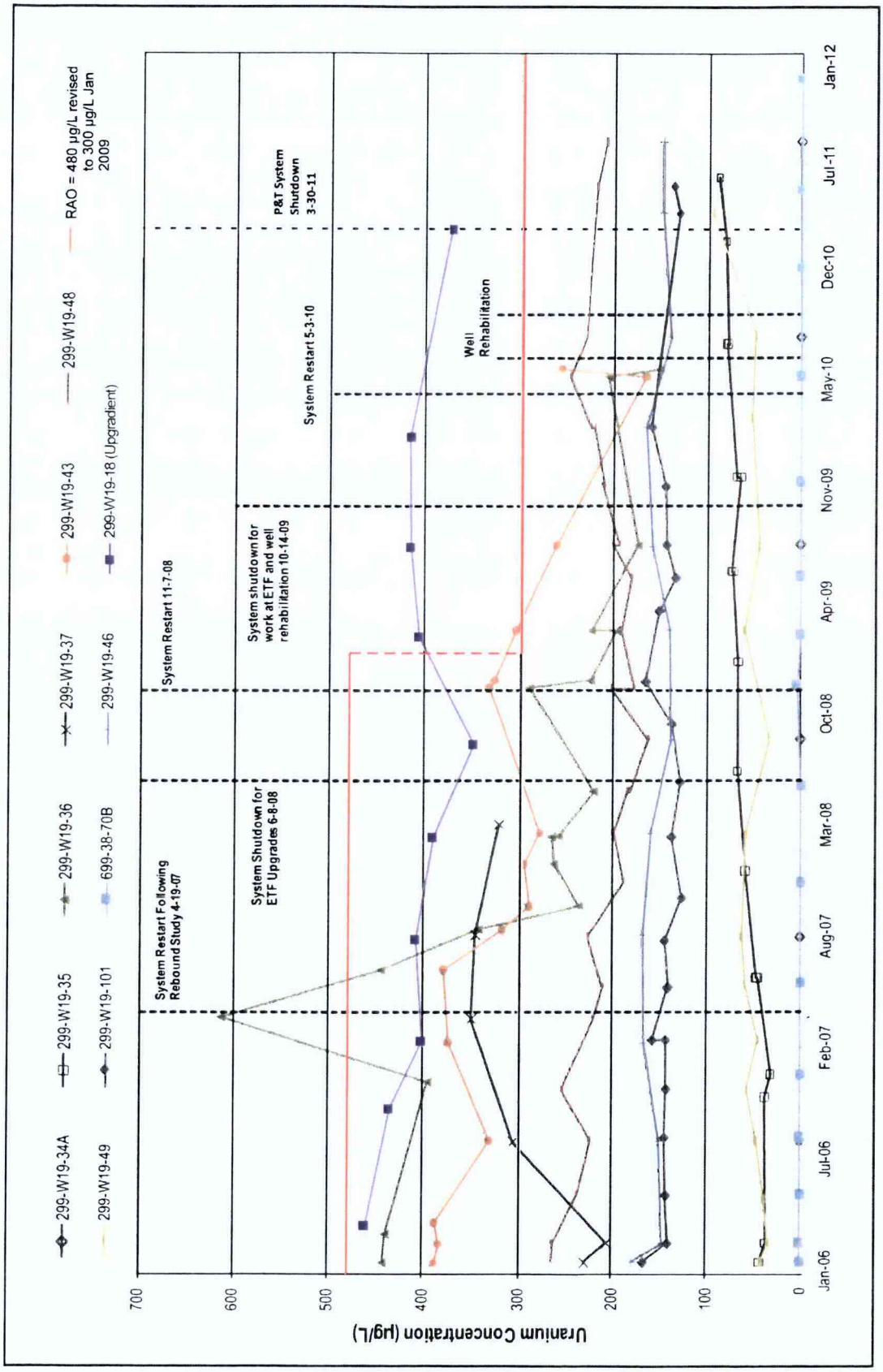


Figure 2-4. 200-UP-1 Monitoring Wells, Uranium Trend Plots (with System Timeline)

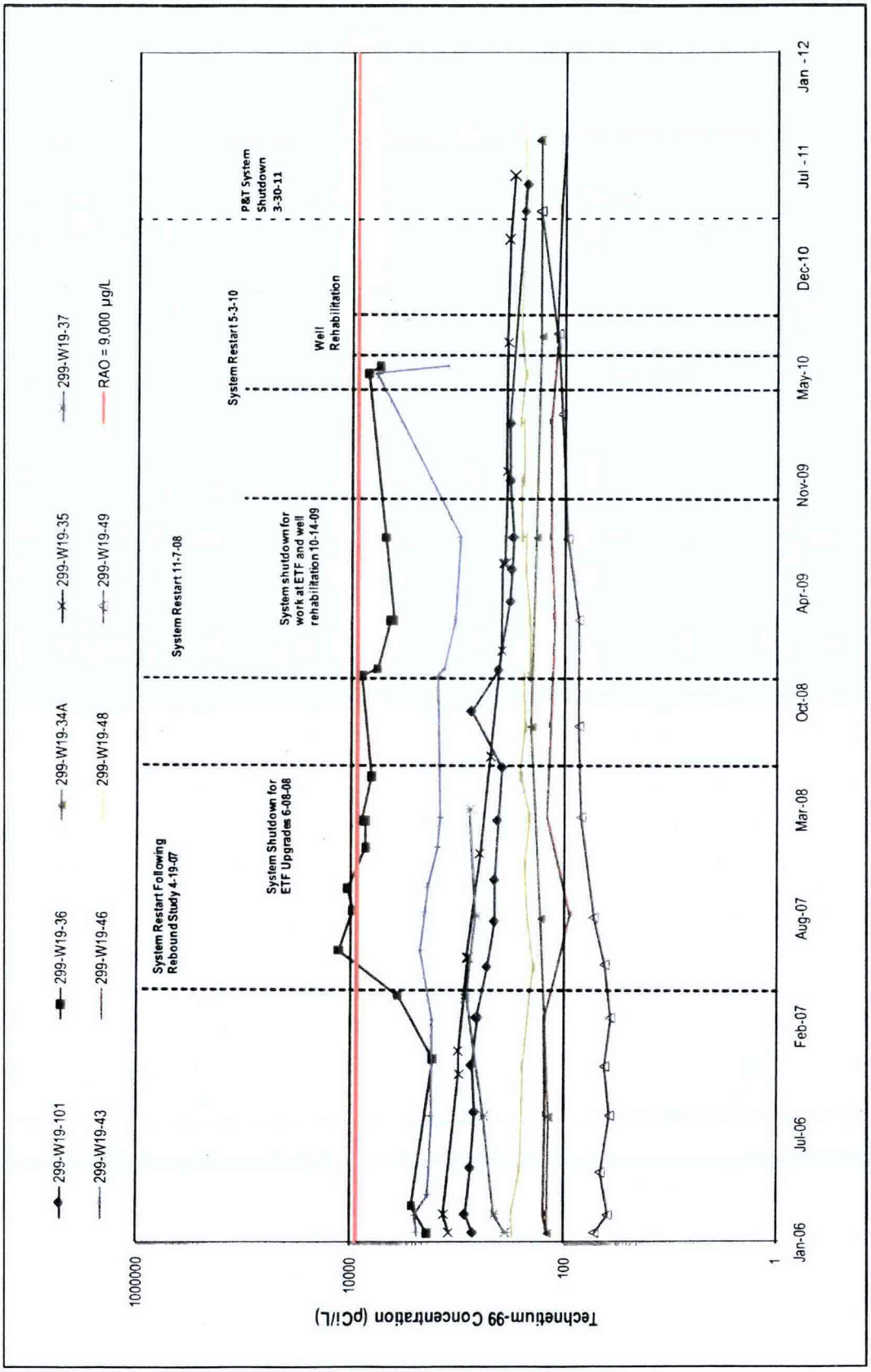


Figure 2-5. 200-UP-1 Monitoring Wells, Technetium-99 Trend Plots

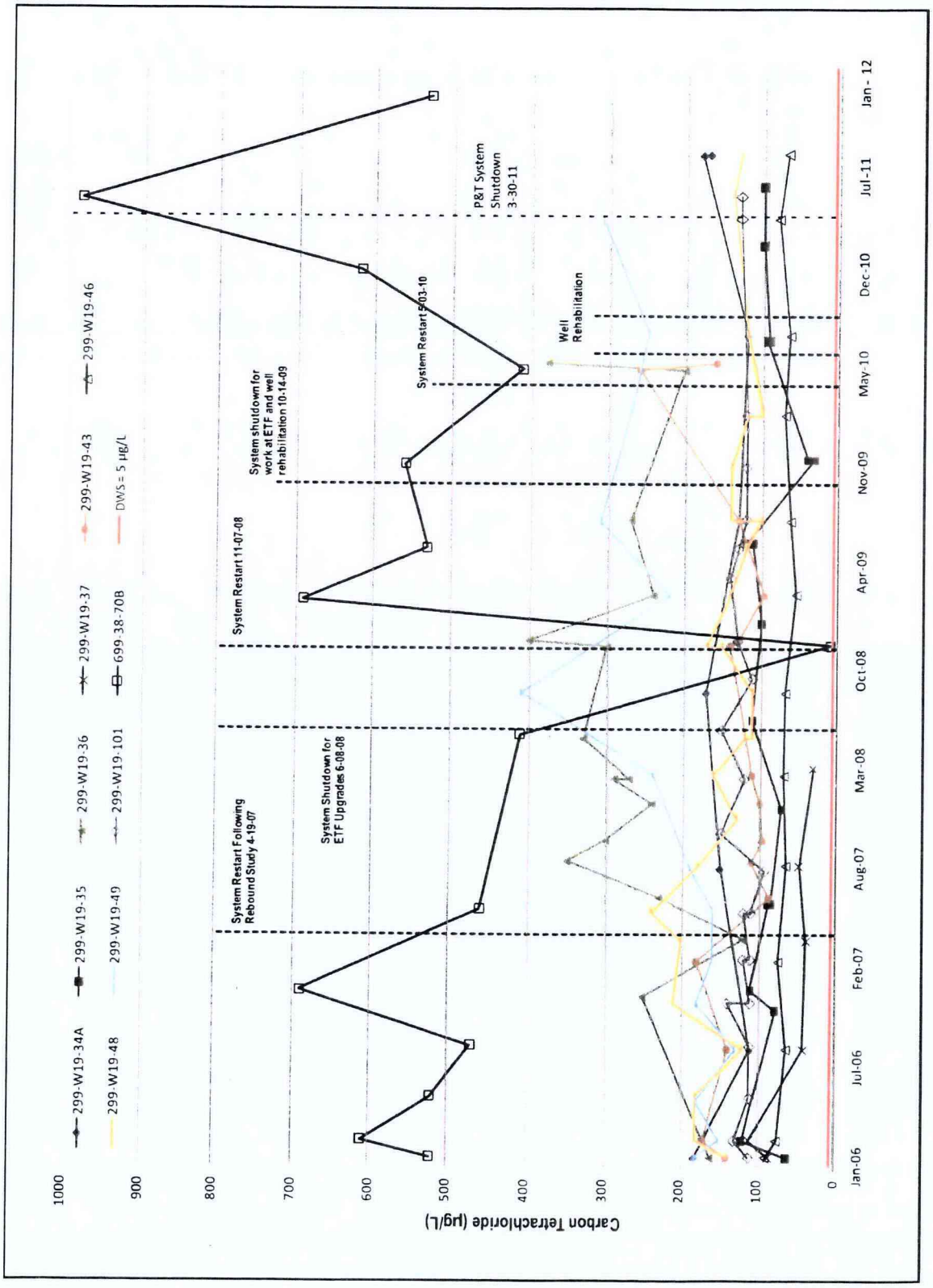


Figure 2-6. 200-UP-1 Monitoring Wells, Carbon Tetrachloride Trend Plots

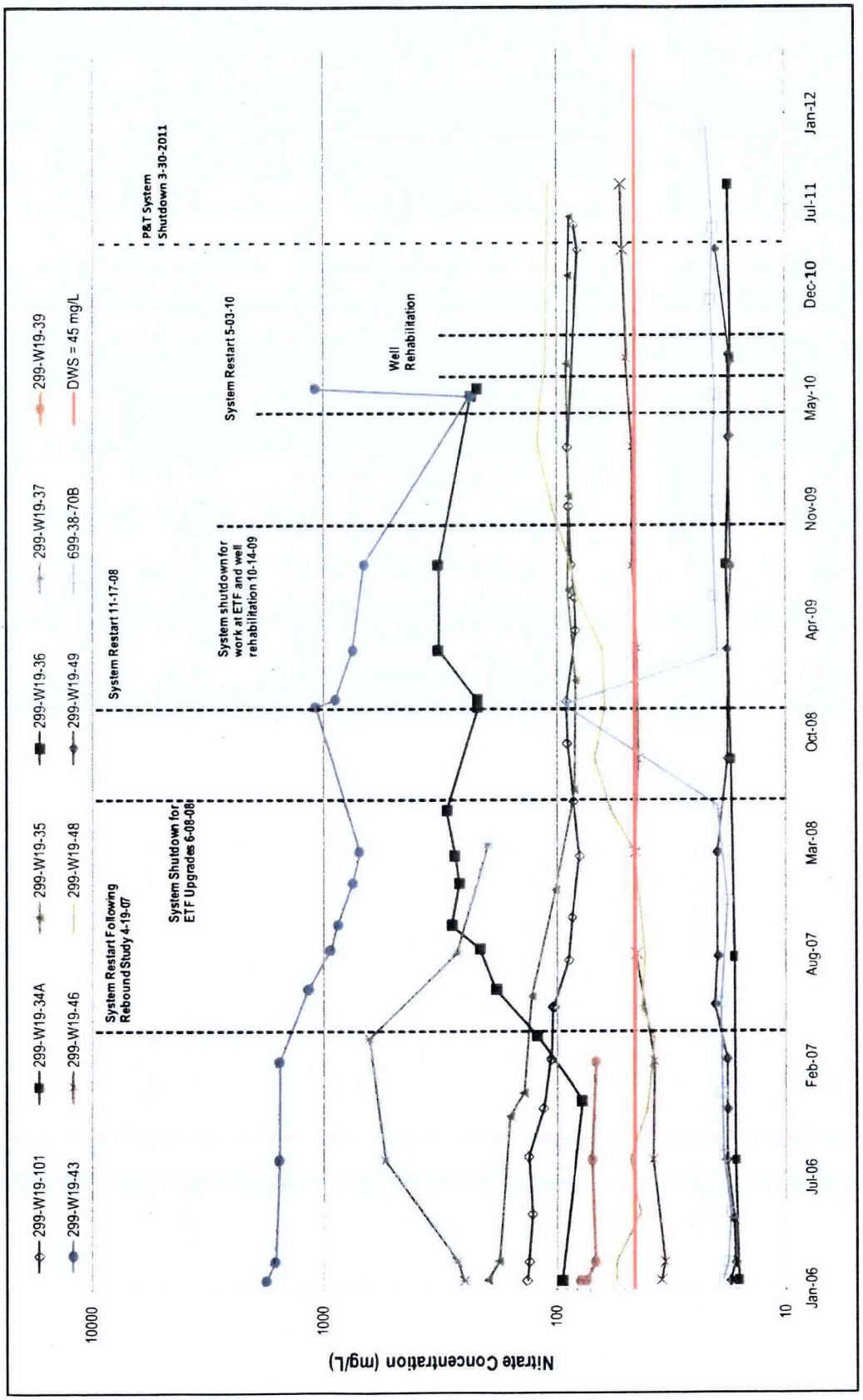


Figure 2-7. 200-UP-1 Monitoring Wells, Nitrate Trend Plots

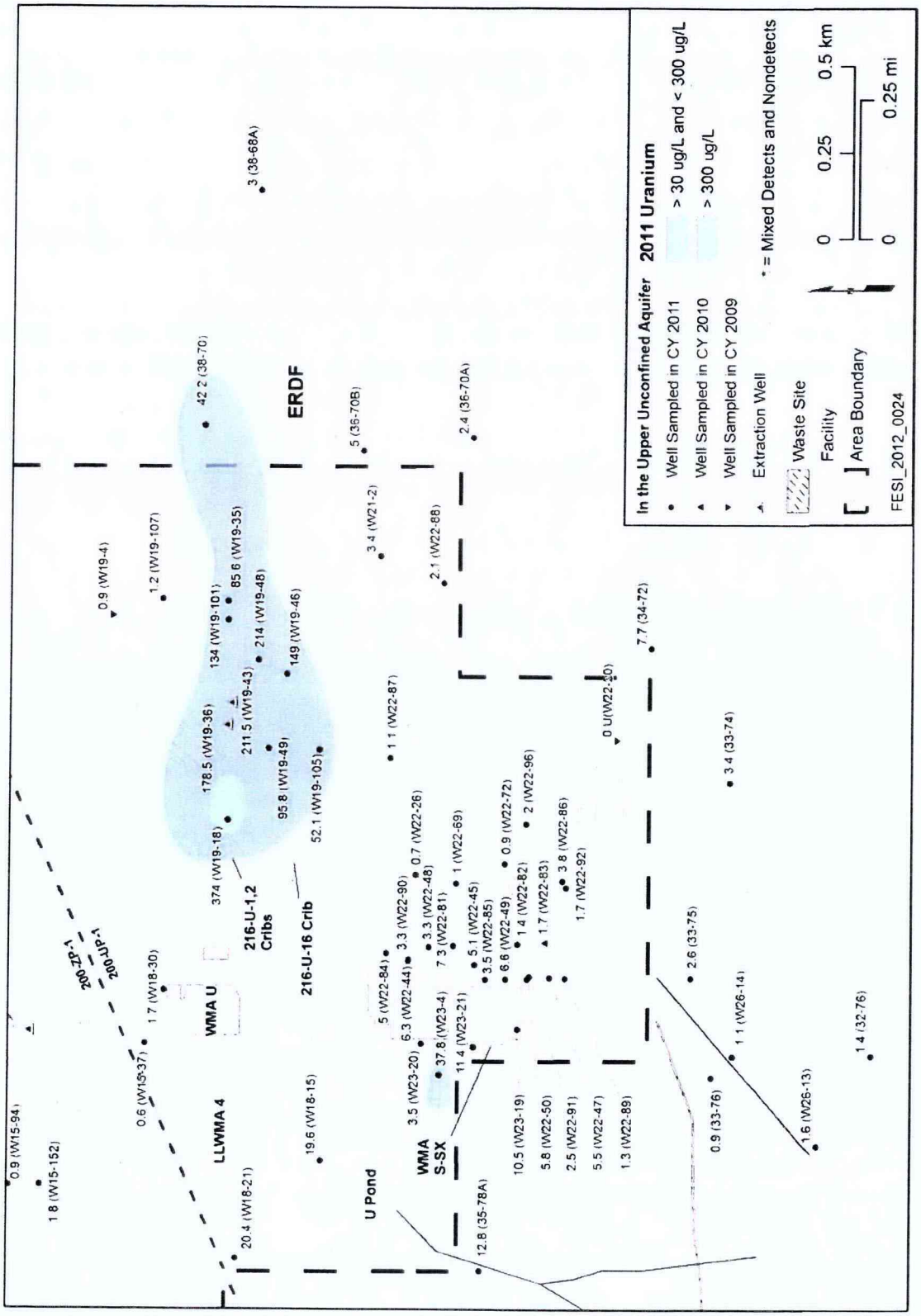


Figure 2-8. 200-UP-1 Uranium Contaminant Plume in 2011

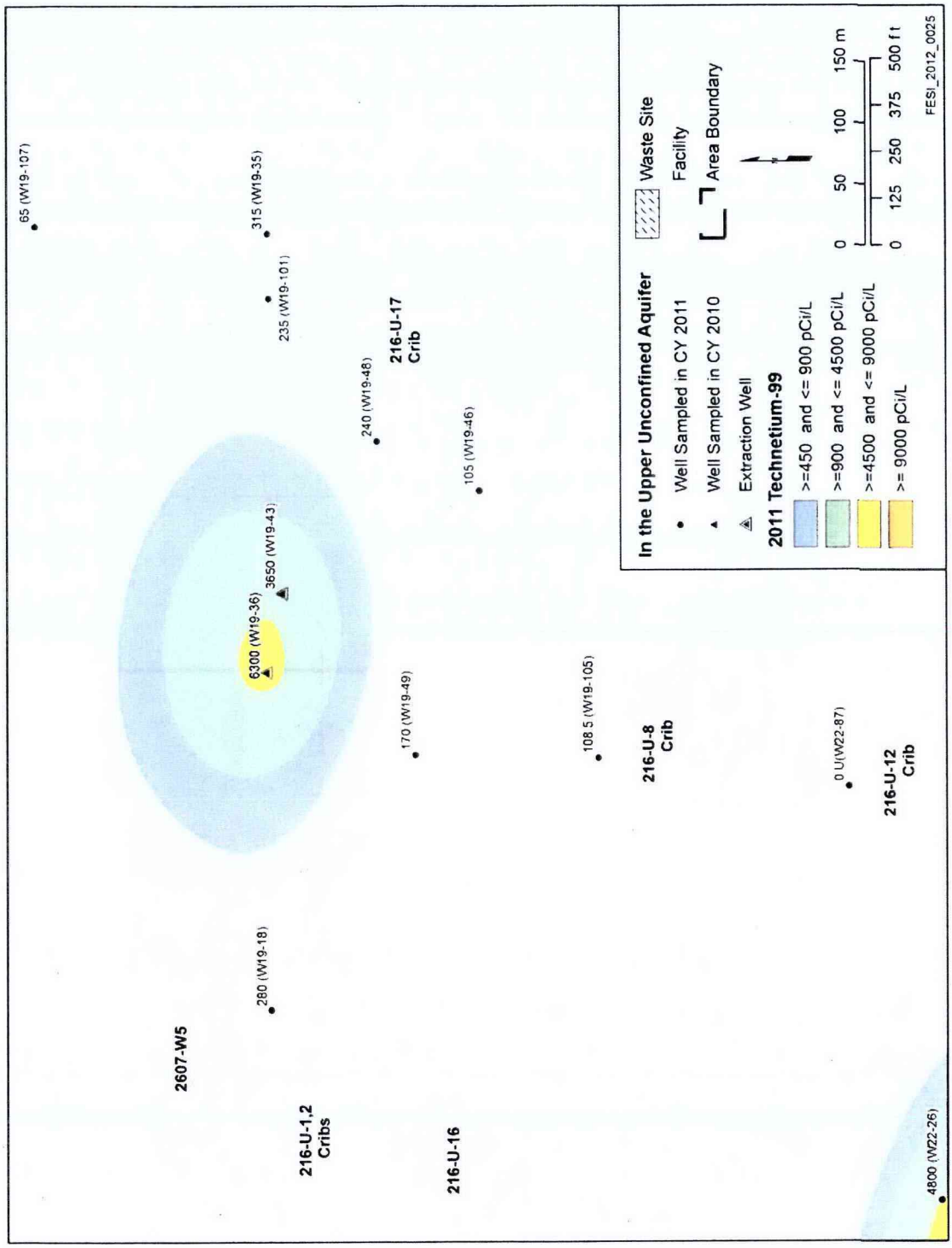


Figure 2-9. 200-UP-1 Technetium-99 Contaminant Plume in 2011

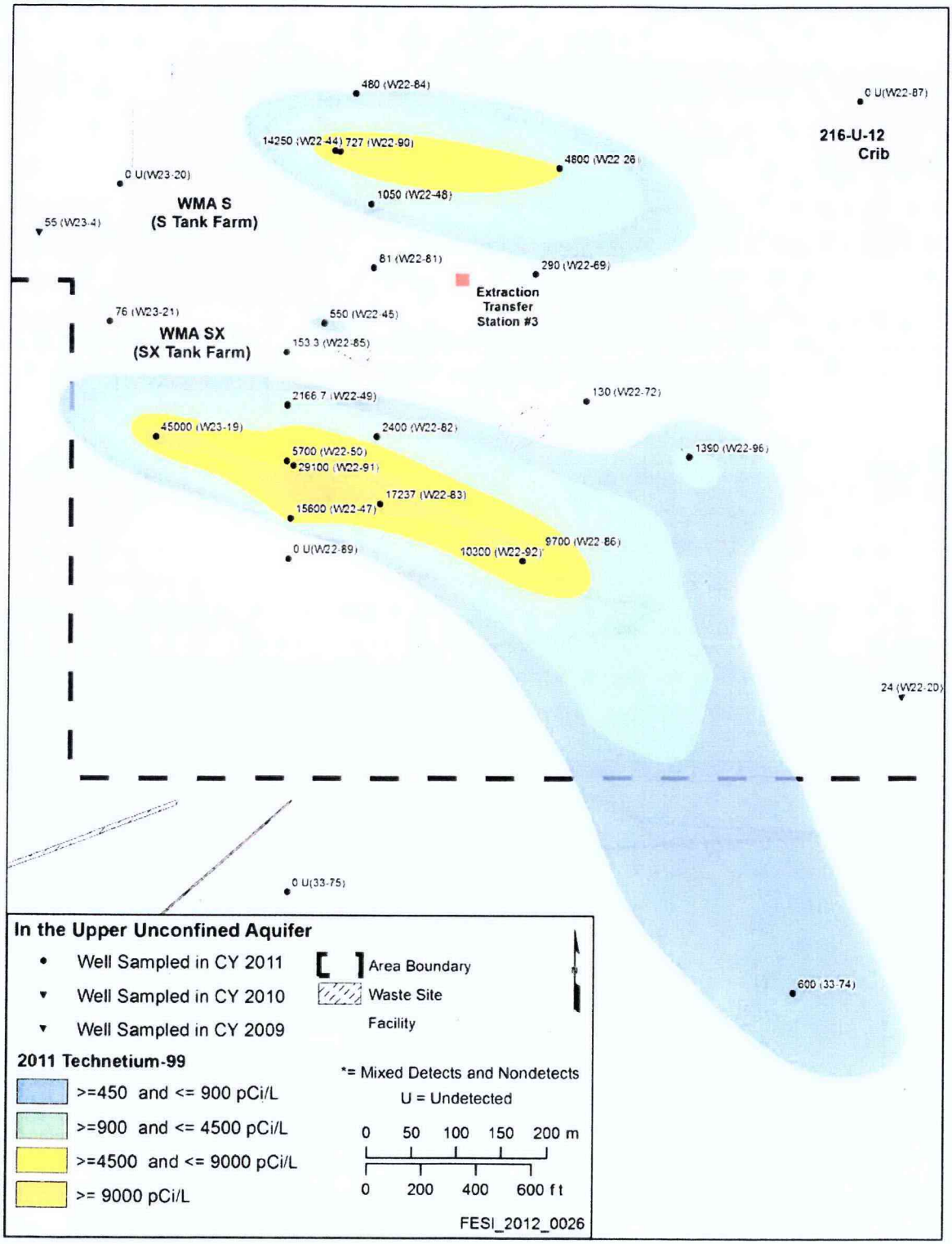


Figure 2-10. 200-UP-1 Technetium-99 Plume South of SX Tank Farm in 2011

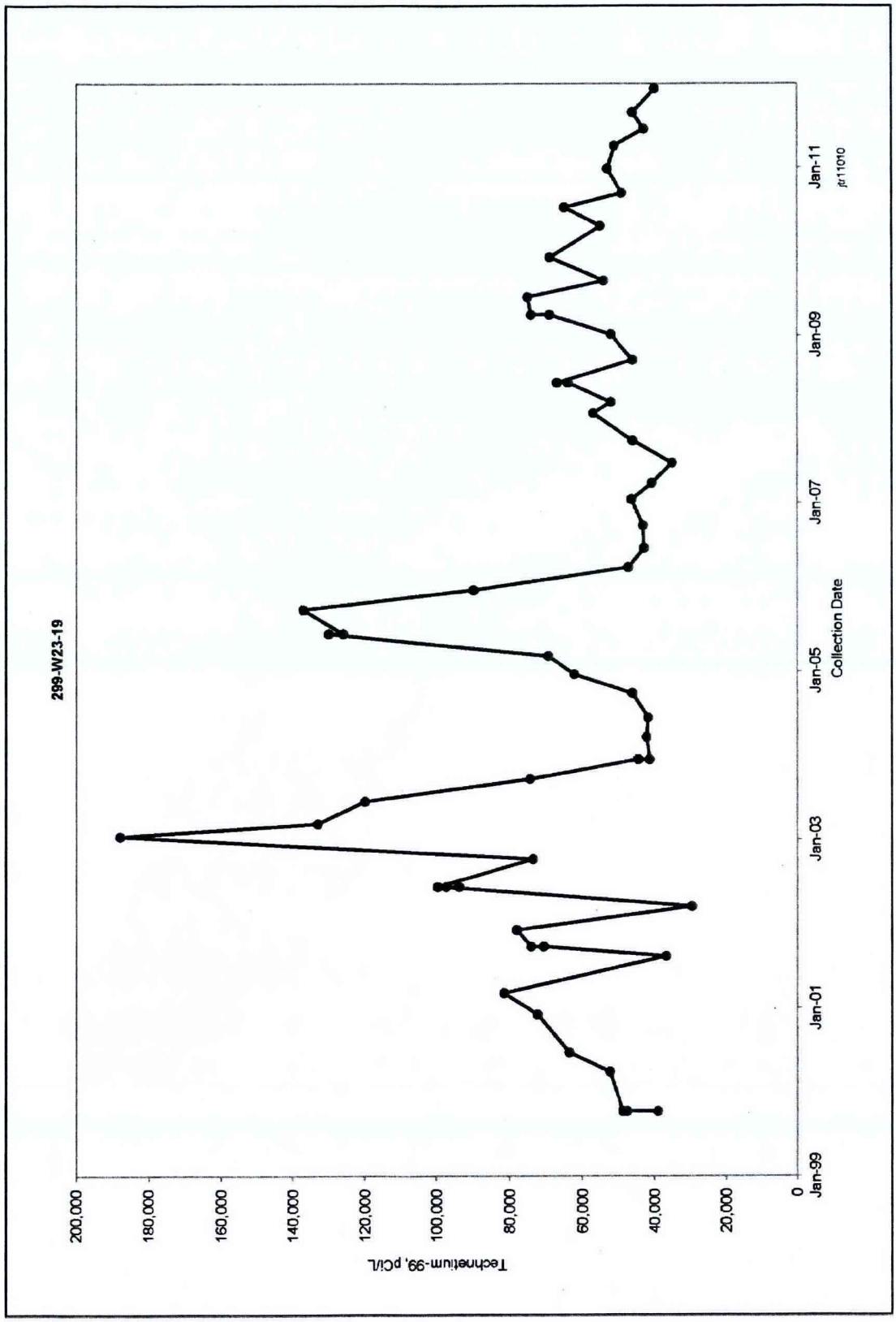


Figure 2-11. Technetium-99 Trend Plot at Well 299-W23-19

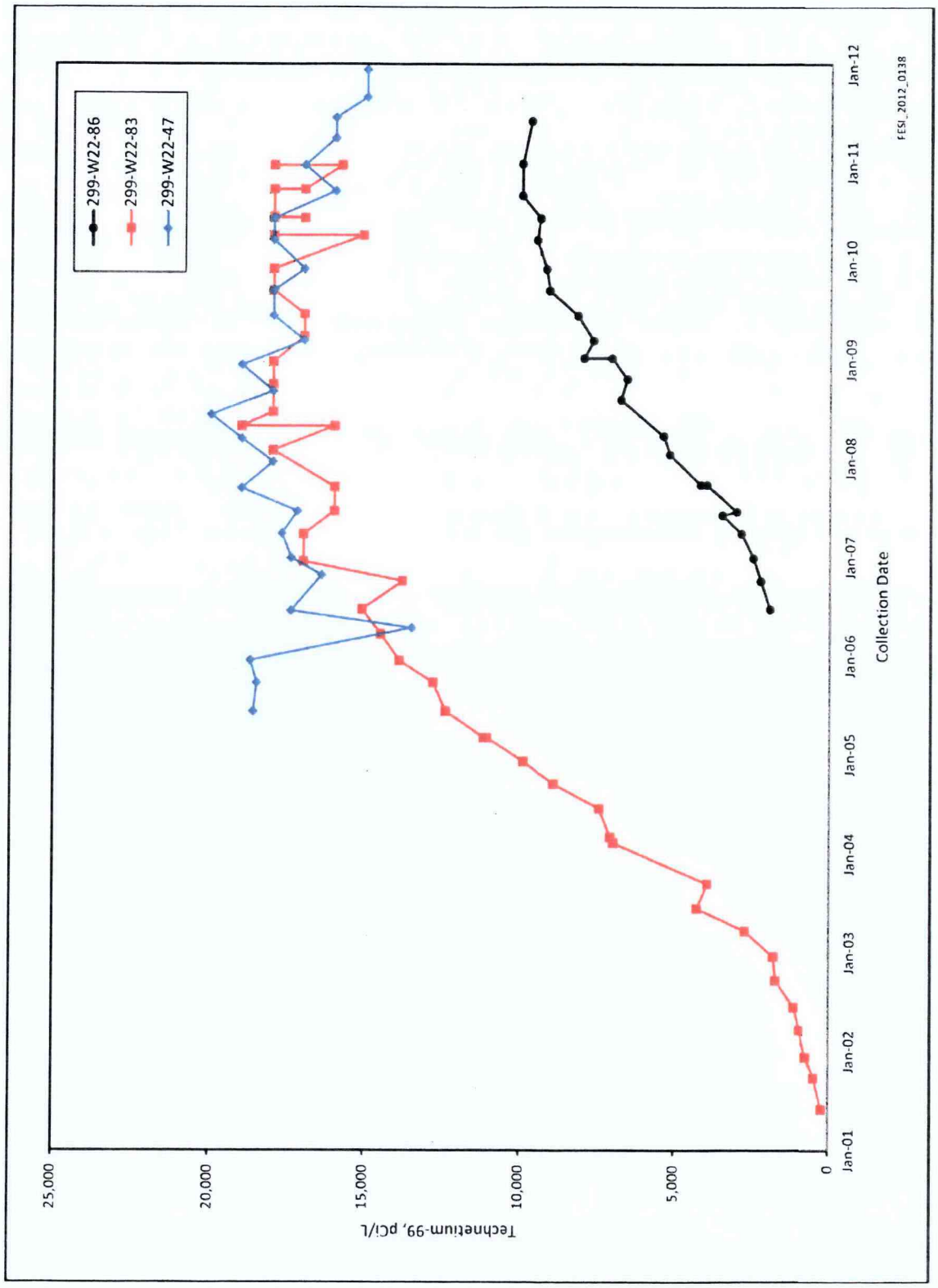


Figure 2-12. Technetium-99 Trend Plots for Wells 299-W22-47, 299-W22-83, and 299-W22-86 (SX Tank Farm Area)

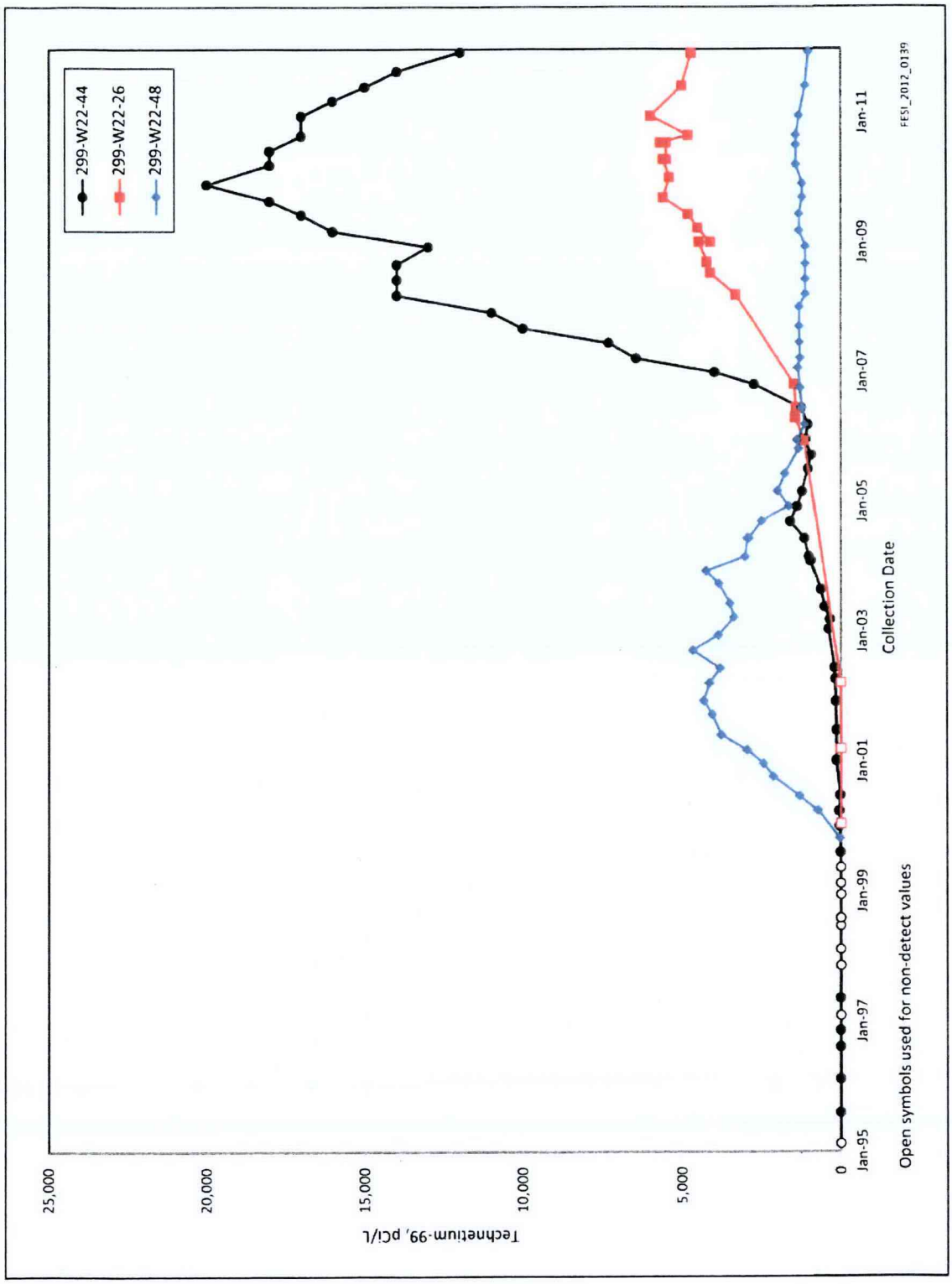


Figure 2-13. Technetium-99 Trend Plots for Wells 299-W22-44, 299-W22-26, and 299-W22-48 (S Tank Farm Area)

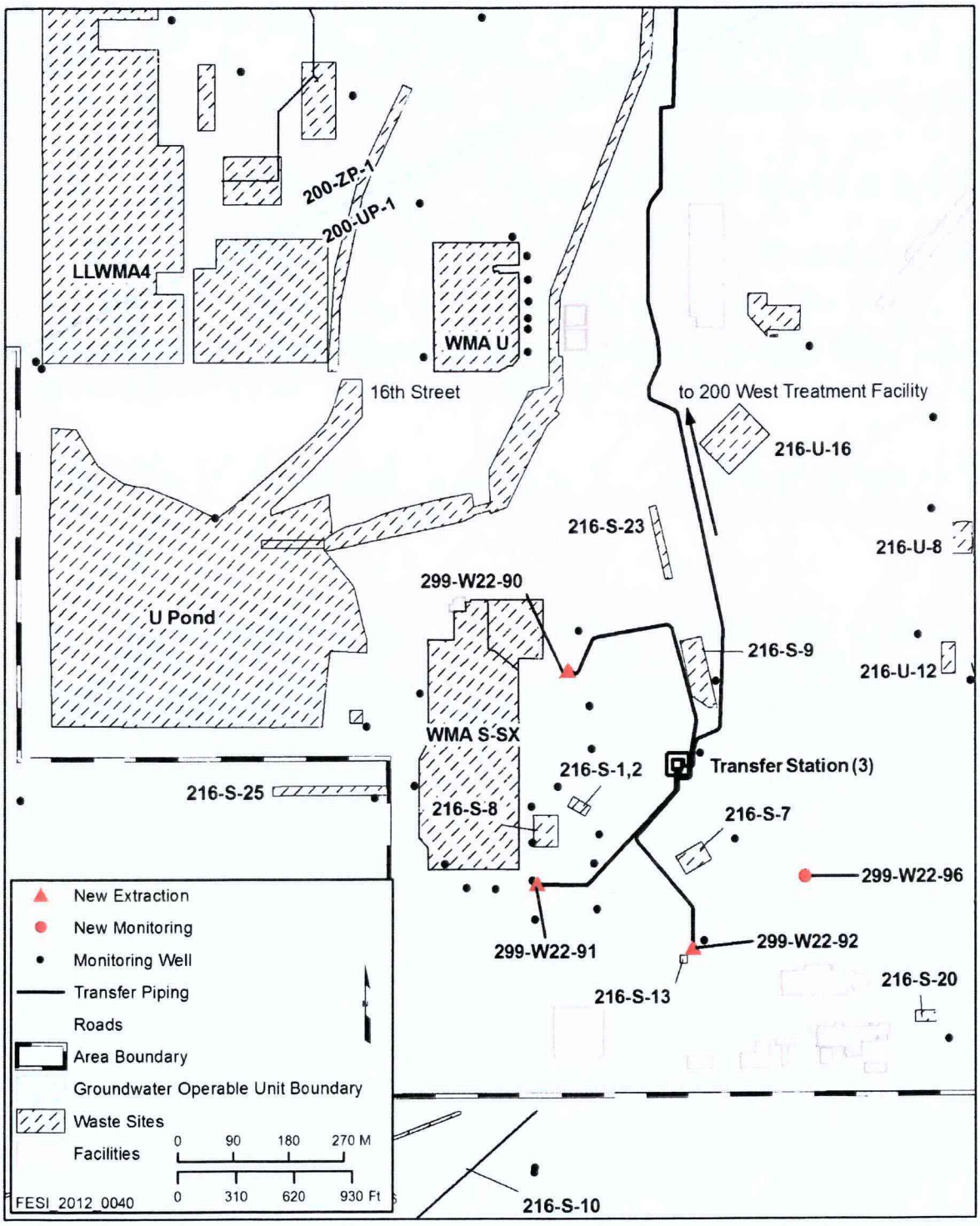


Figure 2-14. S-SX Tank Farms P&T System Location Map

Table 2-1. Groundwater Extraction and Contaminant Mass Removal

Total groundwater processed	
Total groundwater processed in 2011 (L)	1,113,994
Total groundwater processed since startup (March 1994) (L)	886,583,062
Operational efficiency for 2011 (as reported by ETF)	
Removal efficiency % by mass for uranium, average for year – [(influent – effluent) ÷ (influent)] x 100	100%

Contaminant	Total for 2010[a]	Total for 2011[a]	Total Since Startup, March 1994
Uranium (kg)	0.8	0.24	220.5
Technetium-99 (g [Ci])[b]	1.0 (0.017)	0.24 (0.0041)	127.4 (2.17)
Carbon tetrachloride (kg)	0.9	0.2	41.4
Nitrate (kg)	914	734	49,201

a. Mass removed is calculated from volume extracted.

b. For technetium-99, grams convert to curies at a ratio of 58.7 g/Ci.

Table 2-2. Comparison of Annual Average Concentrations for Uranium and Technetium

Well	2010 Avg.	2011 Avg.	Annual Comparison*	1st Qtr. Avg. for 2011	2nd Qtr. Avg. for 2011	3rd Qtr. Avg. for 2011	4th Qtr. Avg. for 2011
Uranium (µg/L), RAO = 300 µg/L							
299-W19-18	417	374	Stable	374	--	--	--
299-W19-107	1.4	1.17	Stable	--	1.23	1.11	--
299-W19-105	76	52.1	Decreasing	50.4	--	53.8	--
299-W19-101	160	135.5	Stable	134	137	--	--
299-W19-35	79	85.6	Stable	81.7	89.5	--	--
299-W19-36	179	NA	NA	--	--	--	--
299-W19-43	212	NA	NA	--	--	--	--
299-W19-46	153	149	Stable	--	149	149	--
299-W19-48	230	214	Stable	--	219	209	--
299-W19-49	51	95.8	Increasing	--	95.8	--	--
Technetium-99 (pCi/L), RAO = 9,000 pCi/L							
299-W19-18	240	280	Stable	280	--	--	--
299-W19-107	73	65	Stable	--	68	62	--
299-W19-105	150	108.5	Decreasing	120	97	--	--
299-W19-101	330	235	Decreasing	240	230	--	--
299-W19-35	350	315	Stable	330	300	--	--
299-W19-36	6,300	NA	NA	--	--	--	--
299-W19-43	3,650	NA	NA	--	--	--	--
299-W19-46	130	105	Stable	--	110	100	--
299-W19-48	255	240	Stable	--	240	240	--
299-W19-49	115	170	Increasing	--	170	--	--

* Annual comparison is the percent difference between 2011 and 2010 data and is calculated by the following equation: ([CY 2011 – CY 2010] ÷ CY 2010) x 100%. Wells are considered stable if there is a less than 20% change in concentration from 2010 to 2011.

NA = not applicable

Table 2-3. Comparison of Annual Average Concentrations for Carbon Tetrachloride and Nitrate

Well	2010 Avg.	2011 Avg.	Annual Comparison*	1st Qtr. Avg. for 2011	2nd Qtr. Avg. for 2011	3rd Qtr. Avg. for 2011	4th Qtr. Avg. for 2011
Carbon Tetrachloride (µg/L), DWS = 5µg/L							
299-W19-18	63	61	Stable	61	--	--	--
299-W19-107	190	210	Stable	--	240	180	--
299-W19-105	133	145	Stable	170	120	--	--
299-W19-101	120	130	Stable	130	130	--	--
299-W19-35	93	100	Stable	100	100	--	--
299-W19-36	290	NA	NA	--	--	--	--
299-W19-43	210	NA	NA	--	--	--	--
299-W19-46	67	74	Stable	--	80	68	--
299-W19-48	112.5	135	Stable	--	140	130	--
299-W19-49	260	310	Stable	--	310	--	--
Nitrate (mg/L), DWS = 45 mg/L							
299-W19-18	55.3	54.9	Stable	54.9	--	--	--
299-W19-107	68.8	73.4	Stable	--	73.9	73.0	--
299-W19-105	19.5	17.6	Stable	17.8	--	17.3	--
299-W19-101	89.5	82.2	Stable	80.6	83.7	--	--
299-W19-35	90.7	88.8	Stable	89.4	88.1	--	--
299-W19-36	227	NA	NA	--	--	--	--
299-W19-43	659	NA	NA	--	--	--	--
299-W19-46	45.0	52.2	Stable	--	51.8	52.7	--
299-W19-48	116	110	Stable	--	110	109	--
299-W19-49	17.8	20.5	Stable	--	20.5	--	--

* Annual comparison is the percent difference between 2011 and 2010 data and is calculated by the following equation: ([CY 2011 – CY 2010] ÷ CY 2010) x 100%. Wells are considered stable if there is a less than 20% change in concentration from 2010 to 2011.

NA = not applicable

Table 2-4. Comparison of Annual Average Concentrations for Uranium, Technetium-99, Carbon Tetrachloride, and Nitrate in Deep Wells

Well	2010 Avg.	2011 Avg.	Annual Comparison*	1st Qtr. Avg. for 2011	2nd Qtr. Avg. for 2011	3rd Qtr. Avg. for 2011	4th Qtr. Avg. for 2011
Uranium (µg/L), DWS = 30 µg/L							
699-38-70B	1.023	0.926	Stable	--	0.929	--	0.923
299-W19-34A	1.35	1.6	Stable	--	--	1.6	--
299-W19-34B	0.90	NA	NA	--	--	--	--
Technetium-99 (pCi/L), DWS = 900 pCi/L							
699-38-70B	0	-3.85	Stable	--	-5.9	--	-1.8
299-W19-34A	170	175	Stable	--	--	175	--
299-W19-34B	13.5	NA	NA	--	--	--	--
Carbon Tetrachloride (µg/L), DWS = 5 µg/L							
699-38-70B	515	755	Increasing	--	980	--	530
299-W19-34A	120	175	Increasing	--	--	175	--
299-W19-34B	190	NA	NA	--	--	--	--
Nitrate (mg/L), DWS = 45 mg/L							
699-38-70B	21.0	22.0	Stable	--	21.2	--	22.7
299-W19-34A	17.3	18.2	Stable	--	--	18.2	--
299-W19-34B	12.1	NA	NA	--	--	--	--

* Annual comparison is the percent difference between 2011 and 2010 data and is calculated by the following equation: ([CY 2011 – CY 2010] ÷ CY 2010) x 100%. Wells are considered stable if there is a less than 20% change in concentration from 2010 to 2011.

NA = not applicable

Table 2-5. Results of Aquifer Vertical Profile Sampling During 2011

299-W22-90		299-W22-91		299-W22-92		299-W22-96	
Depth Below Water Table (m)	Tc-99 (pCi/L)	Depth Below Water Table (m)	Tc-99 (pCi/L)	Depth Below Water Table (m)	Tc-99 (pCi/L)	Depth Below Water Table (m)	Tc-99 (pCi/L)
4.1	5,520	4.4	4,280	2.9	5,300	3.4	1,390
10.6	727	10.5	29,100	9.1	10,300	8.5	17.1 (U)
16.7	13.7	16.4	1,690	14.9	2,220	--	--
22.6	1.75 (U)	22.4	17.1 (U)	21.3	257	--	--

U = undetected

3 200-ZP-1 Operable Unit Pump-and-Treat System

The interim 200-ZP-1 P&T system was installed to remediate groundwater concentrations of carbon tetrachloride exceeding 2,000 µg/L in the 200-ZP-1 OU (Figure 3-1). Secondary COCs also targeted by the system include chloroform and TCE. Sources of the carbon tetrachloride contamination were discharges to three waste sites located south and east of the Plutonium Finishing Plant (PFP), including the 216-Z-9 Trench, 216-Z-1A Tile Field, and 216-Z-18 Crib. The carbon tetrachloride plume currently extends north of the PFP and is centered around a high-concentration region west of the Waste Management Area (WMA) TX-TY Tank Farms. An interim ROD issued in 1995 (EPA/ROD/R10-95/114, *Record of Decision for the USDOE Hanford 200-ZP-1 Operable Unit, 200 Area NPL Site Interim Remedial Measure*) provided the regulatory framework for the interim P&T remediation.

The interim P&T system consists of a treatment system, 14 extraction wells, and 5 injection wells. The treatment system uses an air-stripper column to remove carbon tetrachloride, chloroform, TCE, and other volatile organic compounds (VOCs) from the groundwater by volatilizing the VOCs into a vapor phase. The VOCs are then adsorbed on granular activated carbon in canisters that are sent offsite for regeneration following breakthrough. Treated groundwater is returned to the aquifer through injection wells located south-southwest of the treatment facility (Figure 3-1).

Based on recommendations in *The Second CERCLA Five-Year Review Report for the Hanford Site* (DOE/RL-2006-20), two extraction wells (299-W11-45 and 299-W11-46) downgradient of the WMA T Tank Farm were brought online in 2007 to address technetium-99 contamination in groundwater beneath and adjacent to the WMA T Tank Farm. Groundwater from these two wells is transferred via pipeline to the LERF basins in the 200 East Area; treated at the ETF to remove technetium-99, metals, nitrate, and VOCs; and discharged at the State-Approved Land Disposal Site north of 200 West Area. Section 3.6 discusses the 2011 activities and concentration data related to technetium-99 groundwater contamination. Technetium-99 removal will be regulated under the 200-ZP-1 final ROD (EPA et al., 2008) when the new 200 West Area P&T facility becomes operational in 2012.

In September 2008, a final ROD was issued (EPA et al., 2008) selecting a remedy that, in addition to remediation of carbon tetrachloride, addresses remediation of other chemical and radioactive contaminants throughout the 200-ZP-1 OU: TCE, iodine-129, nitrate, chromium (trivalent and hexavalent), tritium, and technetium-99. As a component of the selected remedy, the 200 West Area P&T facility was designed and constructed to capture 95 percent of carbon tetrachloride mass and the expanded list of contaminants. Construction activities on the 200 West Area P&T facility and new extraction and injection wells supporting the system were completed in 2011. Operation of the new system will begin in 2012.

The 200-ZP-1 interim action remedy is still in effect until the 200 West Area P&T facility is brought online. This section describes the annual performance during CY 2011, as required by the 200-ZP-1 interim ROD (EPA/ROD/R10-95/114). Appendix A presents the history of the P&T system and provides a synopsis of the waste site operations and contaminant sources. This is the last report for the "interim action 200-ZP-1 P&T system," as the remedial action is being changed to final remedy status. The next annual P&T report will address the startup and performance of the 200 West Area P&T facility and transition from the interim action 200-ZP-1 P&T system.

3.1 Calendar Year 2011 Activities and Developments

During 2011, numerous activities were performed at 200-ZP-1 to improve system operation, prepare for operation of the 200 West Area P&T facility, and provide a better understanding of contaminant distribution and movement. A summary of these activities and developments is as follows:

- Interim action P&T operations continued.
- Construction of the radiological process facility and biological treatment facility as part of the 200 West Area P&T facility was completed in December 2011.
- Phase I operation of the new 200 West Area P&T facility was completed in December 2011 in accordance with the *200 West Area 200-ZP-1 Pump-and-Treat Remedial Design/Remedial Action Work Plan* (DOE/RL-2008-78), meeting Tri-Party Agreement Milestone M-016-122.
- Six injection wells were drilled and three were completed in 2011 for the 200 West Area P&T facility.

In addition to construction activities, several documents relevant to interim or final P&T operations were completed, including the following:

- *ZP-1 Pump-and-Treat Facility Layup Plan* (SGW-49761) describes the strategy and basis for shutdown of the interim 200-ZP-1 P&T system.
- *200 West Area Pump and Treat Startup Plan* (SGW-49168) provides a general description of the 200 West Area P&T facility startup process.
- *Transition Plan from the Interim 200-ZP-1 Pump-and-Treat System to the Commissioning of the 200 West Groundwater Treatment Facility* (DOE/RL-2011-75) documents the general approach for terminating operations at the interim P&T system and the startup and operation of the new 200 West Area P&T facility.
- *Mitigation Action Plan for the 200 West Groundwater Remediation Project* (SGW-48726) describes the mitigation process and documents the ecological and cultural surveys conducted to assess potential impact to the environment by the project.
- *Predicted Impact of Future Water-Level Declines on Groundwater Well Longevity within the 200 West Area, Hanford Site* (SGW-50907) provides information on 200 West Area monitoring wells currently in use that are expected to become dry within the next 10 years due to declining water levels.

3.2 Extraction System Performance

This section describes the volume of water removed by the interim extraction wells, extraction system availability throughout the year, and changes to the well network during the year. The average combined flow rate for the extraction wells was 1,442 L/min (381 gpm). The extraction system produced 758 million L (200.2 million gal) of water in 2011, a 33 percent increase over the 570.1 million L (150.6 million gal) produced in 2010. Online availability in 2011 was 97 percent compared to 87 percent in 2010 as a result of improved system management and maintenance. Since startup in 1996, 5.8 billion L (1.5 billion gal) of groundwater have been extracted for treatment.

In 2010, 299-W15-44 was removed from the extraction network and designated as a monitoring well. At the same time, new 200 West Area extraction well 299-W15-225 (about 51 m [167 ft] away) was

temporarily added to the well network, thereby maintaining 14 extraction wells at the P&T system. All of the previous extraction wells for the 200-ZP-1 P&T system were completed in the upper 15 m (50 ft) of the unconfined aquifer. The new extraction well (which will be connected to the new system when it becomes operational) was completed over a longer interval, with the 45.7 m (150 ft) of screen extending from 75 to 123 m (245 to 405 ft) below ground surface. Extraction well 299-W15-225 has much higher production rates, averaging 946 L/min (250 gpm) and accounting for 66 percent of the water extracted by the entire extraction well field. Additional injection and extraction wells installed during 2011 and in previous years in support of the 200 West Area P&T facility are not explicitly discussed in this report because they are not part of the interim P&T system.

During 2011, four extraction wells were taken offline due to low water levels that prevented sustainable operation: 299-W15-6, 299-W15-36, 299-W15-40, and 299-W15-765. Extraction well 299-W15-47 was taken offline due to a failed pump. In 2011, injection well 299-W18-37 was taken offline because condensation built up between the inner and outer pipeline, triggering the leak detector alarm and shutting the well down. Maintenance (scheduled for spring 2012) to seal the outer pipeline needs to be completed prior to bringing the injection well back online.

Figure 3-2 summarizes pumping rates during 2011 for the interim 200-ZP-1 P&T remedy. The average total system extraction rate decreased slightly over the year, from approximately 1,703 L/min (450 gpm) in the first quarter to about 1,514 L/min (400 gpm) in the fourth quarter. Most extraction wells operated at a rate of 189 L/min (50 gpm) or less, with the exception of 299-W15-225, which had an average extraction rate of about 946 L/min (250 gpm) for most of the year. Flow rates in 2011 for each of the 200-ZP-1 extraction and injection wells are shown in Figure 3-3.

3.3 Treatment System Performance

Treatment system performance describes the contaminant mass removed at the interim P&T facility, treatment facility processes, and operational efficiencies (including plant shutdown).

During 2011, the system operated a total of 357 days. A total of 758 million L (200.2 million gal) of water was processed through the treatment system in 2011, which is a 33 percent increase over the 570.1 million L (150.6 million gal) processed in 2010. Online availability in 2011 was 97 percent compared to 87 percent in 2010. The better performance for 2011 largely relates to improved system management and improved system maintenance.

Contaminant concentrations measured in the treatment system's influent tank T-01 represent a composite of all extracted groundwater entering the system. Average carbon tetrachloride, chloroform, and TCE concentrations for 2011 were 1,038 µg/L, 8.1 µg/L, and 2.7 µg/L, respectively. The total amount of carbon tetrachloride removed in 2011 was 791.8 kg, which is a 13 percent increase in mass removed compared to the 700.7 kg of carbon tetrachloride removed in 2010. The increase in mass removed is a direct result of the increase in treated volume and concentrations in 2011 from extraction well 299-W15-225.

Figure 3-4 provides a historical trend of carbon tetrachloride removed in relation to the amount of groundwater extracted. As observed in the trend, since 2004, the amount of carbon tetrachloride removed has decreased in relation to the amount of groundwater extracted. This change reflects overall decreases in the concentration of carbon tetrachloride in the aquifer. Figure 3-5 illustrates the decline in carbon tetrachloride concentrations in 41 monitoring and extraction wells across the 200-ZP-1 OU. The decline represents an average 65 percent decrease in carbon tetrachloride concentration in the aquifer since the interim system began operations in 1996. In 1996, the estimated mass of dissolved carbon tetrachloride contained in the groundwater plume was 4,400 kg. To date, 13,503 kg have been removed by the

interim P&T system, and the areal extent of the greater than 2,000 µg/L plume has been reduced from 0.53 km^2 to 0.24 km^2 (0.2 mi^2 to 0.09 mi^2).

Table 3-1 lists the interim P&T performance parameters for 2011 and since startup in 1996. Appendix B presents additional system performance information. Table 3-2 provides average annual concentrations of carbon tetrachloride in groundwater pumped from each extraction well for 2011 compared to averages in 2010. Figure 3-6 provides a graphical representation of the carbon tetrachloride removal efficiency calculated by influent and effluent concentrations at the process facility. During 2011, the interim P&T system's removal efficiency was 99.9 percent.

3.4 Aquifer Response

Water-level changes are important in assessing 200-ZP-1 P&T system effectiveness and provide the basis for assessing hydraulic control that pumping exerts over groundwater and plume migration. Groundwater levels are measured throughout the 200 West Area hourly at some wells using pressure transducers and annually at other wells using manual (depth-to-water) measurements. These measurements are useful for identifying water-level changes associated with discrete events, such as atmospheric pressure fluctuations or drawdown near pumping wells. Groundwater elevations indicate that flow is generally from west to east throughout the 200 West Area, but flow directions are locally affected by pumping at the interim 200-ZP-1 P&T extraction wells, at the WMA T Tank Farm extraction wells, and by injection of treated water at the interim P&T system injection wells (Note that during 2011, pumping at the 200-UP-1 remedy ceased and is not included in the assessment presented here). Figure 3-7 illustrates groundwater elevation contours throughout the 200 West Area.

3.4.1 Groundwater Elevation Mapping

The groundwater elevation map presented in this section was prepared using an interpolation technique that is an alternative to using a numerical model for estimating capture. The technique is detailed in *Collection and Mapping of Water Levels to Assist in the Evaluation of Groundwater Pump-and-Treat Remedy Performance* (SGW-42305).

The water-level map is prepared using universal kriging (*Geostatistics: Modeling Spatial Uncertainty* [Chiles and Delfiner, 1999]; "On the Use of a Main Trend for the Kriging Technique in Hydrology" [Volpi and Gambolati, 1978]), which enables a deterministic trend to be included in the map. When mapping water levels in the vicinity of 200 West Area extraction and injection wells, the deterministic form of the trend comprises the summation of a plane with terms describing the effects of pumping. Using superposition to sum the effects of multiple pumped wells, pumping effects can be combined with the planar trend to give the following estimate of the water level, H, at any location (x,y) (Equation 3-1):

$$H(x,y) = A + Bx + Cy + D\sum_{1}^{n} Q_i \log_{10}(r_i) + \varepsilon(x,y) \qquad \textbf{(Equation 3-1)}$$

where:

A	=	regression coefficient
B	=	regression coefficient
C	=	regression coefficient
D	=	regression coefficient
n	=	number of pumped wells
$Q_i \log_{10}(r_i)$	=	effect of pumping at well i
$\varepsilon(x,y)$	=	the residual from the trend

The trend term describing pumping effects can be derived from the Thiem or the Cooper-Jacob equation (SGW-42305). Using Equation 3-1 to prepare a water-level map results in a more realistic map than other methods that incorporate the effect of pumping in the interpolation algorithm.

Figure 3-7 presents a water-level contour map for the 200 West Area during 2011. Weekly averaged water levels and corresponding pumping rates were used to generate 52 maps similar to that depicted in Figure 3-7, as described in the previous section. Each of these 52 maps presents a picture similar to that illustrated in Figure 3-7 (i.e., a pattern of groundwater flow from west to east) with several local areas of concentric contours that indicate (1) convergent gradients toward extraction wells, or (2) divergent gradients away from injection wells. The largest single area of focused drawdown is centered on 299-W15-225, with approximately 66 percent of the extraction of the current 200-ZP-1 groundwater remedy.

Figure 3-8 depicts the groundwater elevation contours from Figure 3-7, as well as contours depicting the extent of groundwater contaminated by carbon tetrachloride in 2011.

3.4.2 Hydraulic Analyses Results

As indicated in Figure 3-3, more than half of the overall extraction in the system occurs at high-capacity well 299-W15-225. As a result, groundwater flows focus on 299-W15-225, a long-screened well that intercepts a greater fraction of the unconfined aquifer than the other wells in the current system. A shift in focus of extraction from water table wells to wells screened throughout the thickness of the aquifer results in a narrower and deeper capture zone ("Hydrodynamic of the Capture Zone of Partially Penetrating Pumping Well in an Unconfined Aquifer" [Faybishenko et al., 1995]; "Variations in Capture-Zone Geometry of a Partially Penetrating Pumping Well in an Unconfined Aquifer" [Bair and Lahm, 1996]). Furthermore, hydrographs at monitoring wells in the 200 West Area suggest that extraction at 299-W15-225 leads to a large area of declining groundwater levels, which is reflected in reduced capacity at several of the water table extraction wells.

Although capture zone analysis was not performed this year, the capture zone analysis performed for 2010 is still representative for 2011 because extraction and injection rates did not change substantially (DOE/RL-2011-26). The capture zone analysis figure presented in 2010 and the figures presented here suggest that the patterns of groundwater flow established by the current 200-ZP-1 remedy result in convergent groundwater gradients (and by inference, hydraulic containment) throughout part of the area that shows the highest concentrations of carbon tetrachloride in the 200 West Area. However, these figures also identify that hydraulic containment is insufficient in much of the center and eastern portions of the 200 West Area. These areas are targets for the operation of long-screened groundwater extraction (and injection) wells that will begin operation during 2012 as part of the final 200-ZP-1 groundwater remedy.

3.5 Contaminant Monitoring

The carbon tetrachloride, chloroform, and TCE plumes (Figures 3-9, 3-10, and 3-11, respectively) are defined by analytical data, including results from a network of more than 40 groundwater monitoring wells and 14 extraction wells penetrating the upper aquifer. The carbon tetrachloride plume was generated using additional data from 15 new extraction wells, 11 new injection wells, and 9 deep monitoring wells screened near the bottom of the unconfined aquifer in the plume area (i.e., within the extent of the 5 μg/L plume). These data provide the primary means to determine the effectiveness of the 200-ZP-1 P&T system on cleanup, to evaluate progress in achieving RAOs, and to support delineating the current plume. Prior to and during system operations in the years preceding 2011, as many as 40 wells (23 monitoring wells and 17 extraction wells) exceeded the interim RAO of 2,000 μg/L carbon tetrachloride. During

2011, only nine wells (four monitoring wells and five extraction wells) were at or exceeded 2,000 µg/L (Figure 3-5).

Section 3.5.1 presents the results for the 18 active monitoring wells and 14 extraction wells within the interim remedy (i.e., originally targeted, greater than 2,000 µg/L) plume area. Trend plots for carbon tetrachloride concentrations at wells with significant changes (±20 percent) during the period of 2006 through 2011 are presented in Figure 3-12 for extraction wells and in Figure 3-13 for monitoring wells. In addition, Tables 3-2 through 3-6 show the 2011 averages (if more than one sample was collected) and compare the 2011 and 2010 annual concentration averages for carbon tetrachloride, chloroform and TCE concentrations in 200-ZP-1 wells.

Field studies conducted in 2006 and 2007 (DOE/RL-2006-58, *Carbon Tetrachloride Dense Non-Aqueous Phase Liquid [DNAPL] Source Term Interim Characterization Report*; DOE/RL-2007-22, *Carbon Tetrachloride Dense Non-Aqueous Phase Liquid [DNAPL] Source Term Characterization Report Addendum*) investigated whether carbon tetrachloride was present as a free-phase, dense nonaqueous-phase liquid product. In both studies, only the water-soluble component was detected. Therefore, it was concluded that carbon tetrachloride no longer (or minimally) exists in free-phase, dense nonaqueous-phase form in groundwater at the former disposal sites. Consequently, any current downward migration of this contaminant is thought to be the result of lithologic controls and/or a vertical hydraulic gradient induced by past liquid waste disposal operations.

3.5.1 Carbon Tetrachloride, Chloroform, and Trichloroethene Monitoring Results

The 2011 contaminant monitoring results in the 200-ZP-1 OU are summarized below:

- **Plume trends:** The high-concentration portion of the carbon tetrachloride plume (greater than 2,000 µg/L) covered a smaller, more fragmented area in 2011 (0.24 km^2 [0.09 mi^2]) than in 2010 (0.53 km^2 [0.2 mi^2]) (Figure 3-9). Nine wells had carbon tetrachloride samples greater than 2,000 µg/L during at least one sampling event in 2011 compared to seven wells that exceeded 2,000 µg/L during at least one sampling event in 2010. Wells 299-W15-34, 299-W15-35, 299-W15-40, 299-W15-50, and 299-W15-765 were above 2,000 µg/L for both 2011 and 2010. During 2011, carbon tetrachloride concentrations in wells 299-W10-28, 299-W11-34P, 299-W11-87, and 299-W15-6 also exceeded 2,000 µg/L.

  The area enclosed by the 1,000 µg/L contour for carbon tetrachloride was much larger in 2011 (2.09 km^2 [0.81 mi^2]) compared to 2010 (0.43 km^2 [0.17 mi^2]) due to the inclusion of data from deep within the aquifer. Alternatively, the greater than 1,000 µg/L carbon tetrachloride plume contour within the upper 15 m (50 ft) of the aquifer decreased in area from 0.43 km^2 (0.17 mi^2) in 2010 to 0.42 km^2 (0.16 mi^2) in 2011. However, data from wells screened deeper in the aquifer provide a more accurate depiction of the full three-dimensional extent of contamination.

  Likewise, the area enclosed by the greater than 5 µg/L contour for carbon tetrachloride was much larger in 2011 (13.96 km^2 [5.39 mi^2]) compared to 2010 (10.77 km^2 [4.16 mi^2]) because the maximum analytical values from all wells were used in contouring, including new downgradient wells.

  Figure 3-10 shows the 2011 chloroform sample results for the 200-ZP-1 wells. Chloroform levels have not exceeded the 80 µg/L DWS in any extraction or monitoring well since August 1996. In 2011, average chloroform concentrations in 200-ZP-1 wells ranged from less than detection to 24 µg/L. The highest chloroform concentration observed in 2011 was 50 µg/L in 299-W15-225. Figure 3-14 depicts trends for extraction wells, Figure 3-16 depicts trends for monitoring wells, and Figure 3-19 depicts trends for deep monitoring wells with significant changes (±20 percent) in

chloroform concentration. The source of chloroform is from the degradation of carbon tetrachloride (DOE/RL-2007-22).

During 2011, the TCE plume was very similar to the plume observed in 2010 (Figure 3-11). In 2011, average TCE concentrations in 200-ZP-1 baseline monitoring wells ranged from 0 to 6.6 μg/L. Only two monitoring wells (299-W11-34P and 299-W15-44) exceeded a concentration of 10 μg/L (both at 11 μg/L).

- **Extraction wells:** During 2011, with three exceptions, carbon tetrachloride concentrations in extraction wells showed stable or decreasing trends compared to 2010 data (Table 3-2, Figure 3-12). Extraction wells 299-W15-40, 299-W15-225, and 299-W15-1 in the PFP source areas displayed an increasing concentration trend in comparison to 2010 (Table 3-2). Sampling results for extraction wells exceeded 3,000 μg/L carbon tetrachloride only in 299-W15-40, which had the highest 2011 carbon tetrachloride concentration of 3,700 μg/L. Although the maximum carbon tetrachloride concentration exceeded 2,000 μg/L in five extraction wells, average annual concentrations exceeded 2,000 μg/L only at extraction wells 299-W15-40 (3,700 μg/L) and 299-W15-765 (2,233 μg/L). Average annual values for all extraction wells ranged from 346 to 3,700 μg/L (Table 3-2).

  The southernmost extraction well operated in 2011 was 299-W15-45, near the 216-Z-9 Crib. The carbon tetrachloride concentration in this well declined during 2011, with an average of 346 μg/L compared to 546 μg/L in 2010. This well had concentrations as high as 1,700 μg/L in April 2006.

  Well 299-W15-6, located north of 299-W15-45, is screened in the lower unconfined aquifer near the 216-Z-9 Crib and historically had carbon tetrachloride concentrations ranging from 1,500 to 2,000 μg/L. The average 2011 concentration was similar at 1,493 μg/L, with a maximum value of 2,000 μg/L reported in January 2011.

  During 2011, TCE concentrations showed decreasing trends at all extraction wells compared to 2010 values. Figure 3-15 depicts trends for extraction wells with significant change in TCE concentration (±20 percent). Maximum TCE concentrations in 2011 exceeded the 5 μg/L DWS in only one extraction well, 299-W15-765, with 6 μg/L.

- **Monitoring wells:** Carbon tetrachloride concentrations in the monitoring wells continued to decline or remained stable in 2011, indicating that pumping during the interim action has been effective in remediating groundwater (Table 3-3, Figure 3-13). Monitoring wells within the plume had average carbon tetrachloride concentrations well below the 2,000 μg/L interim action RAO (except 299-W15-50 at 3,250 μg/L and 299-W11-87 at 2,350 μg/L). At monitoring well 299-W10-28, located west of WMA T, the carbon tetrachloride concentration increased from 1,000 μg/L in 2010 to 2,300 μg/L in 2011, exceeding the RAO. This well is located between an area of high carbon tetrachloride concentration and the two downgradient WMA T extraction wells. Consequently, 299-W10-28 is in the flow path of upgradient contaminated groundwater that is being drawn toward the extraction wells, accounting for the increase in carbon tetrachloride in this well.

  Table 3-4 presents the 2011 baseline plume monitoring results for chloroform. In addition, Table 3-4 shows the comparison between 2011 and 2010 sampling results with the percent difference between 2010 and 2011 data calculated. One well, 299-W15-1, increased slightly in chloroform concentration, from 2.9 μg/L in 2010 to 3.8 μg/L in 2011. The TCE concentrations exceeded the DWS of 5 μg/L at 14 of 21 monitoring locations. Figure 3-17 depicts trends for wells with significant changes (±20 percent) in TCE. For 2011, the average annual TCE concentration measured in the monitoring wells ranged from less than detection to 6.6 μg/L (Table 3-5). The maximum TCE value measured in 2011 was 11 μg/L in monitoring wells 299-W11-34P and 299-W15-44. None of the southern monitoring wells had detectable concentrations of TCE during 2011. Wells in the high-concentration

portion of the carbon tetrachloride plume showed decreasing or stable TCE values compared to 2010 data.

- **Deep monitoring wells:** Carbon tetrachloride concentrations above the RAO were observed in only one monitoring well (299-W11-87) screened deep in the unconfined aquifer, just above the Ringold lower mud semi-confining layer. Average concentrations for carbon tetrachloride in nine deep monitoring wells located within or east of the plume ranged from less than detection to 2,350 μg/L at 299-W11-87, which is northeast of WMA TX-TY (Table 3-6). Figure 3-18 depicts trends for deep monitoring wells with significant (±20 percent) changes in carbon tetrachloride concentration.

  Chloroform concentrations at the nine deep wells varied: five wells had stable concentrations, one well had decreasing concentrations, and three wells had increasing average concentrations compared to 2010 data (Table 3-6). Average chloroform levels remained well below the DWS of 80 μg/L, ranging from less than detection to 24 μg/L. Figure 3-19 depicts trends for deep monitoring wells with significant (±20 percent) changes in chloroform concentration.

  Maximum TCE concentrations measured in the nine deep monitoring wells ranged from less than detection to 6.7 μg/L. Table 3-6 presents average annual concentrations for deep monitoring wells. Two wells exceeded the 5 μg/L DWS for TCE: 299-W14-71 (8.8 μg/L) and 299-W13-1 (5.6 μg/L). Figure 3-20 depicts trends for deep monitoring wells with significant (±20 percent) changes in TCE concentration.

3.5.2 Historical Plume Trends

During 2011, the 200-ZP-1 interim P&T system controlled the high-concentration area of carbon tetrachloride. In 2011, no extraction or monitoring wells exceeded 4,000 μg/L carbon tetrachloride, and only nine wells were at or exceeded 2,000 μg/L (Figure 3-5). Appendix E shows changes in plume configuration due to the interim P&T operations from FY 1995 through 2011. The historical carbon tetrachloride plume maps shown in Appendix E depict the gradual elimination (between 1995 and 2004) of the greater than 4,000 μg/L area around the PFP. The plume maps also depict the northeastward migration of the plume outside of the capture zone of the extraction wells.

Continued investigations during drilling of new groundwater monitoring, extraction, and injection wells in support of the 200 West Area P&T facility revealed carbon tetrachloride concentrations greater than 1,000 μg/L throughout the entire thickness of the aquifer rather than just the upper 15 m (50 ft). Figure 3-9 shows the carbon tetrachloride distribution throughout the unconfined aquifer, which includes depth-discrete sample results during installation of recent wells. The plume map shows carbon tetrachloride extending to the east from the source areas. As a result of using sample data throughout the entire thickness of the aquifer, the carbon tetrachloride plume above the 5 μg/L DWS has increased in size from 10.77 km^2 to 13.96 km^2 (4.16 to 5.39 mi^2). The 200 West Area P&T well system is designed to capture and contain contamination throughout the unconfined aquifer (Figure 3-9).

3.6 Technetium-99 Plume Trend and Remediation at WMA T Tank Farm

Technetium-99 is most commonly found in the 200 West Area in groundwater downgradient of tank farms or liquid disposal waste sites associated with tank farm or evaporator processes (Figure 3-21). Potential sources for technetium-99 include the 216-T-21 through 216-T-25 Cribs, the 216-T-26 through 216-T-28 Cribs, the 242-T evaporator, and the WMA T and WMA TX-TY Tank Farms. This section addresses the 2011 activities in regard to technetium-99 groundwater contamination at the 200-ZP-1 OU.

Technetium-99 is found at levels significantly above the DWS of 900 pCi/L on the eastern (downgradient) side of WMA T and in two areas near WMA TX-TY. One plume, centered on the

northern portion of WMA TX-TY, is elongated toward the southeast (Figure 3-21). For this plume, the 2011 maximum concentration of 6,300 pCi/L was found at 299-W15-765, which is located on the west side of WMA TX-TY. Technetium-99 concentrations in this well increased from a maximum concentration of 5,600 pCi/L in 2010.

Another smaller plume, located at the southern end of WMA TX-TY, is slightly elongated in an east-west direction. This plume had a maximum concentration of 1,790 pCi/L observed at 299–W15-763, which is a decrease from the 2010 maximum of 2,100 pCi/L. Technetium–99 concentrations in the plumes associated with WMA TX-TY fluctuated but remained stable during 2011 compared to 2010.

Two extraction wells, 299-W11-45 and 299-W11-46, operate as part of the WMA T P&T system to capture technetium-99 in groundwater beneath and adjacent to WMA T. Both wells are located near the northeast corner of the WMA. The highest annual maximum concentration of 7,600 pCi/L occurred at performance monitoring well 299-W11-41. This was one of six wells located near WMA T with a maximum concentration exceeding the DWS (Figure 3-22). During 2011, data from the other five wells ranged from 1,200 to 7,200 pCi/L. That portion of the plume near WMA T falling outside the capture zone continues to migrate toward the northeast.

In 2011, the WMA T extraction wells produced 58.2 million L (15.4 million gal) of groundwater at a combined average annual rate of 110.7 L/min (29.2 gpm). During 2011, the online availability for 299-W11-45 was 90 percent and 299-W11-46 was 81 percent (Table 3-7). Target analytes include technetium-99, carbon tetrachloride, nitrate, TCE, and chromium. Treatment in 2011 at the ETF resulted in removal of 13.3 g of technetium-99; 57.9 kg of carbon tetrachloride; 23,023 kg of nitrate; 405.2 g of TCE; and 6.9 kg of chromium. Table 3-7 summarizes the 2011 production data for the WMA T extraction well system.

Concentrations along the eastern margin of WMA T continue to decrease due to pumping at 299-W11-45 and 299-W11-46. Prior to remediation startup in late 2007, technetium-99 concentrations at 299-W11-45 and 299-W11-46 were 19,100 and 113,000 pCi/L, respectively. The maximum technetium-99 concentrations recorded in 2011 are 2,500 pCi/L in 299-W11-45 and 5,120 pCi/L in 299-W11-46. Figure 3-22 illustrates the decline in technetium-99 concentration in 200-ZP-1 wells prior to and during 2011, which demonstrates the effectiveness of the WMA T P&T system.

3.7 Quality Assurance/Quality Control

Discussions on QA and QC encompassing sampling and analysis of all applicable wells are provided in Appendix D in the *Hanford Site Groundwater Monitoring for 2011* (DOE/RL-2011-118, in publication). Appendix D of that document includes an overall view of the QA/QC issues that may affect interpretation of the groundwater data for the P&T OUs.

3.8 Conclusions

The interim ROD RAOs are site-specific goals that define the extent of cleanup necessary to achieve the specific level of remediation at the site. Measurable progress was made during the reporting period to meet specific interim RAOs. The results for each RAO are as follows:

- **RAO #1:** Prevent further movement of contaminants from the highest concentration area of the baseline carbon tetrachloride plume.

  Results: The shallow portion of the aquifer (upper 15 m [50 ft]) in the baseline carbon tetrachloride plume continues to be captured by the interim 200-ZP-1 P&T system. The interim P&T system was designed specifically to hydraulically contain and remove carbon tetrachloride mass in the

high-concentration area (greater than 2,000 μg/L) of the PFP plume. Since remediation efforts began in 1996, the area with carbon tetrachloride concentrations greater than 2,000 μg/L decreased in size from 0.53 km^2 to 0.24 km^2 (0.2 mi^2 to 0.09 mi^2).

- **RAO #2:** Reduce contamination in the areas of highest concentration of carbon tetrachloride.

  Results: During 2011, 792 kg of carbon tetrachloride were removed from 758 million L (200 million gal) of groundwater. Since startup of P&T operations, 13,503 kg of carbon tetrachloride have been removed from 5.8 billion L (1.5 billion gal) of groundwater. The volume of water treated in 2011 was 30 percent more than in 2010. Reduction in carbon tetrachloride contamination within the highest concentration portion of the contaminant plume by the interim P&T system has been demonstrated by the contaminant removal volumes, a decrease in concentration in both extraction and monitoring wells (Figure 3-5), and a decrease in the extent of the targeted contamination area over the last 15 years.

  Operations at the WMA T P&T system removed 58.2 million L (15.4 million gal) of contaminated groundwater. Contaminant mass removed in 2011 included 13.3 g of technetium-99; 57.9 kg of carbon tetrachloride; 23,023 kg of nitrate; 405.2 g of TCE; and 6.9 kg of chromium. A reduction in technetium-99 near WMA T by the WMA T P&T system has been demonstrated by the decrease in concentration in both extraction and monitoring wells in the 200-ZP-1 OU (Figure 3-22).

- **RAO #3:** Provide information that will lead to development of a final remedy that will be protective of human health and the environment.

  Results: Data collected over the previous 15 years of P&T system operation were used to develop the final ROD (EPA et al., 2008). The remedial design/remedial action work plan (DOE/RL-2008-78) was issued in 2009, and the *200 West Area Groundwater Pump-and-Treat Remedial Design Report* (DOE/RL-2010-13) was issued in 2010. The selected remedy for the 200-ZP-1 OU combines P&T, monitored natural attenuation, flow-path control, and institutional controls. Three sampling and analysis plans were issued to support the final remedy:

  - DOE/RL-2008-57, *Sampling and Analysis Plan for the First Set of Remedial Action Wells in the 200-ZP-1 Groundwater Operable Unit*
  - DOE/RL-2009-95, *Sampling Analysis Plan for Eleven ARRA Wells to Support the 200 West Groundwater Treatment System in Fiscal Year 2010*
  - DOE/RL-2010-72, *Sampling and Analysis Plan for Eight Remediation Wells in the 200-ZP-1 Operable Unit in Fiscal Year 2011*

3.9 Recommendations

Recommendations for the 200-ZP-1 OU include the following:

- During drilling of future wells in the 200-ZP-1 OU, collect depth-discrete groundwater samples to define the vertical distribution of contamination, appropriate length of well screens, and proper positioning of the screens within the aquifer.
- Apply modeling tools to assess the effectiveness of the P&T well configuration to continue to support plume capture and assess efficiency of sampling frequency for the monitoring well network.
- Evaluate all extraction and injection wells to detect degradation in well efficiency. If well performance is found to have declined, well evaluation and well rehabilitation should be performed.

- Review the current performance monitoring well network to determine if sufficient coverage exists to verify plume extent and movement. Many wells in the monitoring well network went dry due to the regionally declining water table, and additional wells will go dry over the next 10 years. Large-scale pumping from the new extraction wells will accelerate this effect in some areas. As the number of available wells decreases, the ability to effectively monitor remediation, contaminant concentrations, and changes in the plume configuration will be significantly impaired.
- Evaluate the current groundwater-level monitoring network to determine how many additional wells need automated water-level monitoring equipment installed to support hydraulic monitoring of the 200 West Area P&T facility.

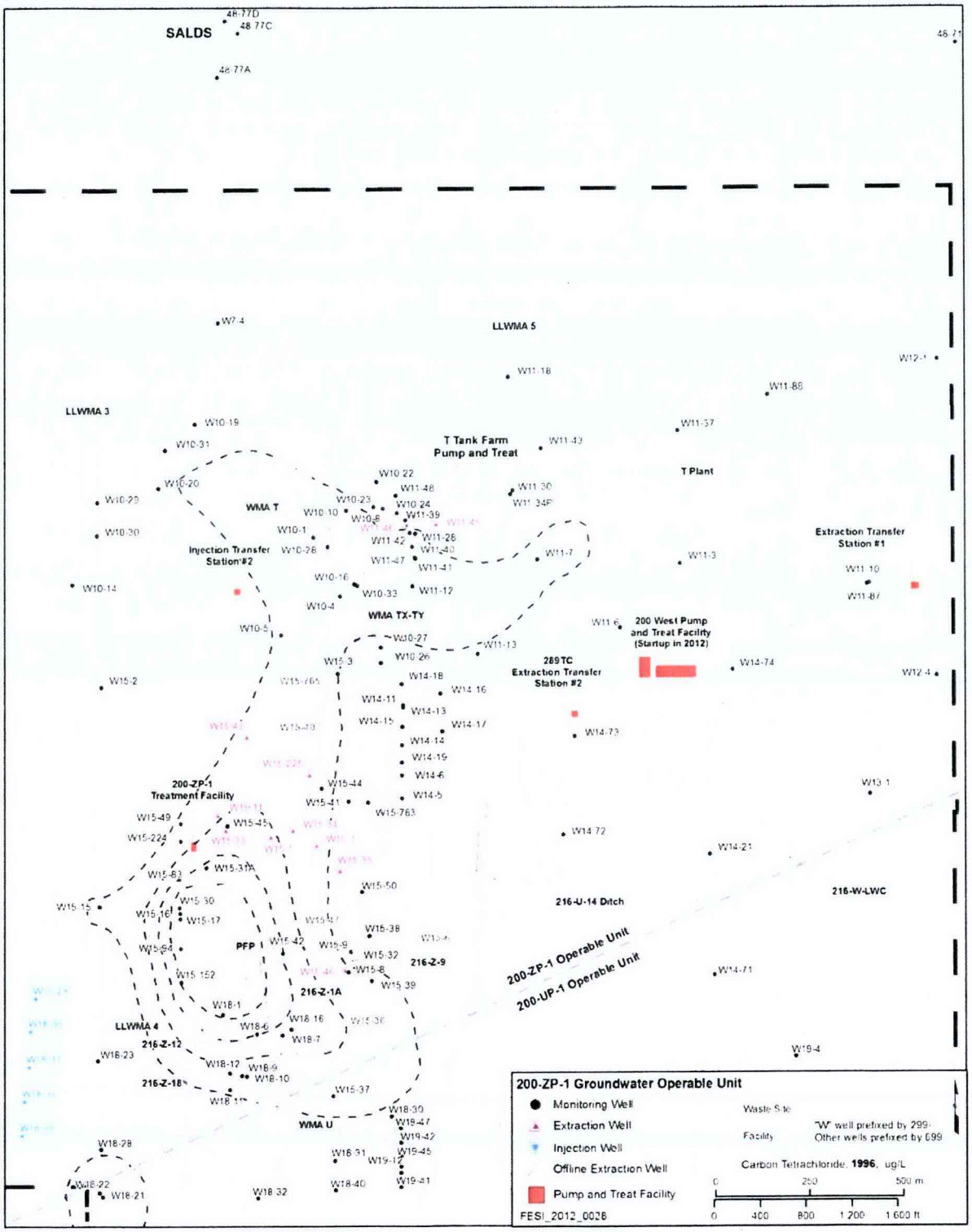


Figure 3-1. 200-ZP-1 Groundwater Well Network and Other Monitoring Wells

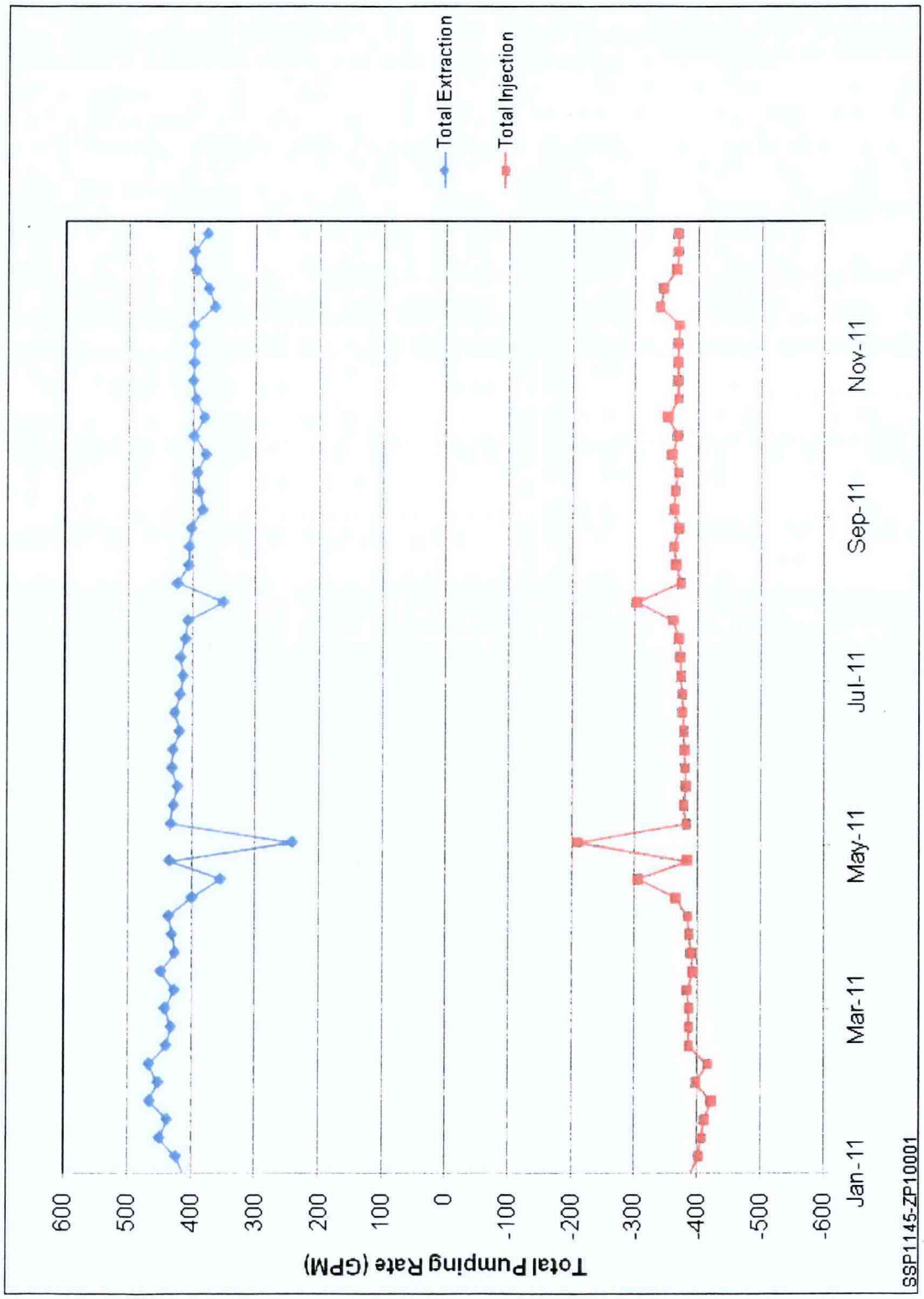


Figure 3-2. Pumping Rate for the 200-ZP-1 Remedy During 2011

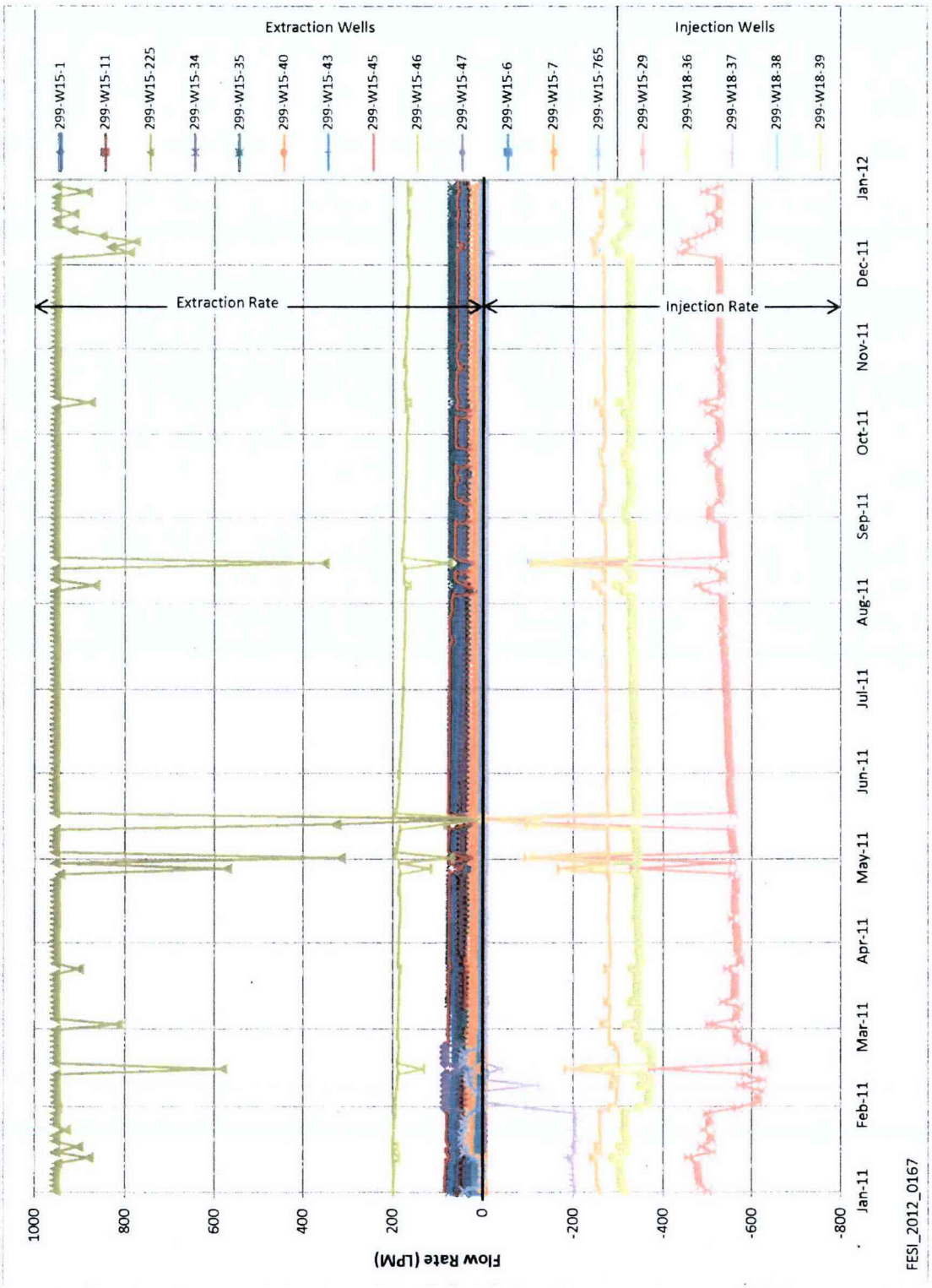


Figure 3-3. Pumping Rates for Injection and Extraction Wells in the 200-ZP-1 Remedy During 2011

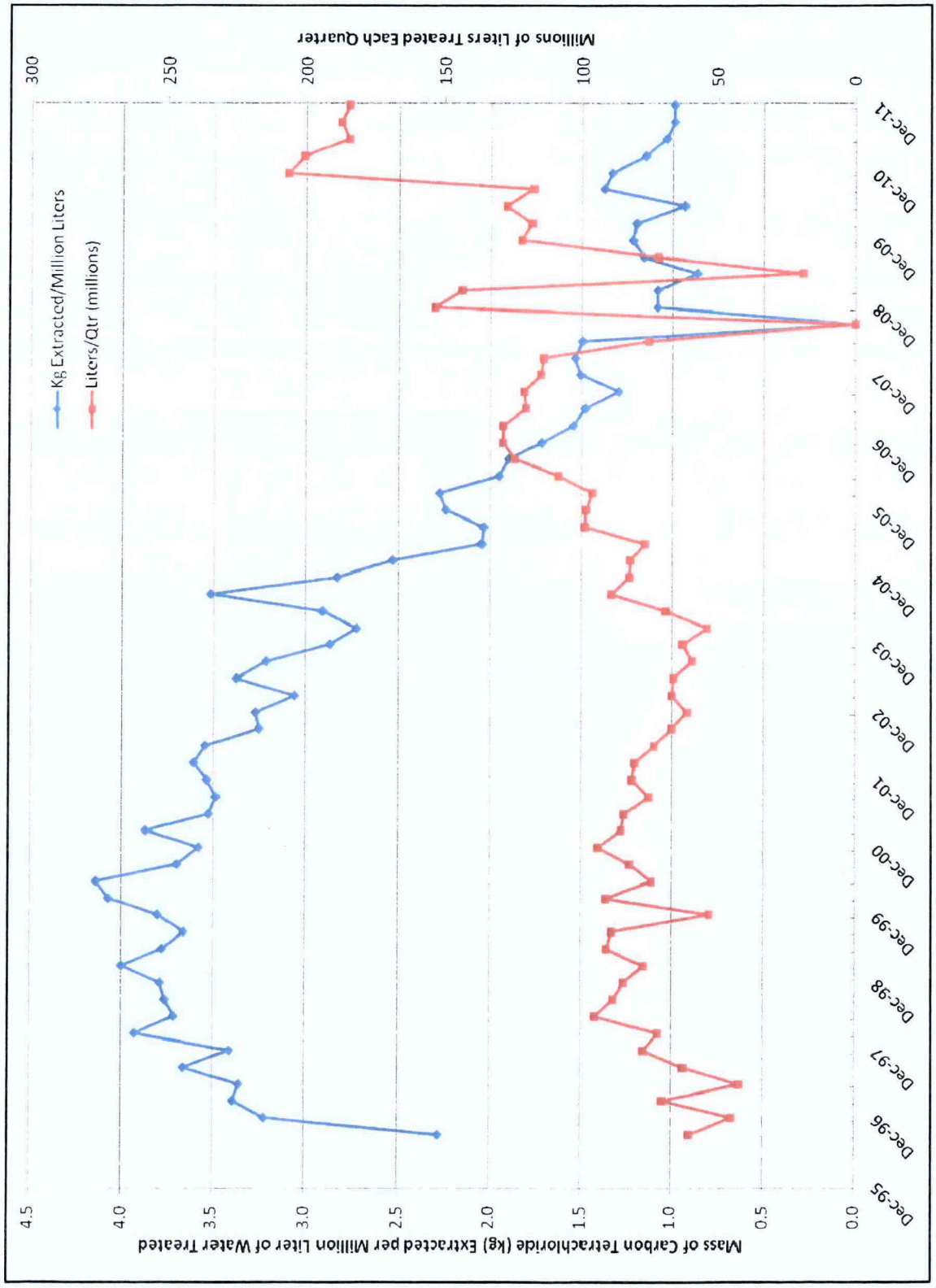
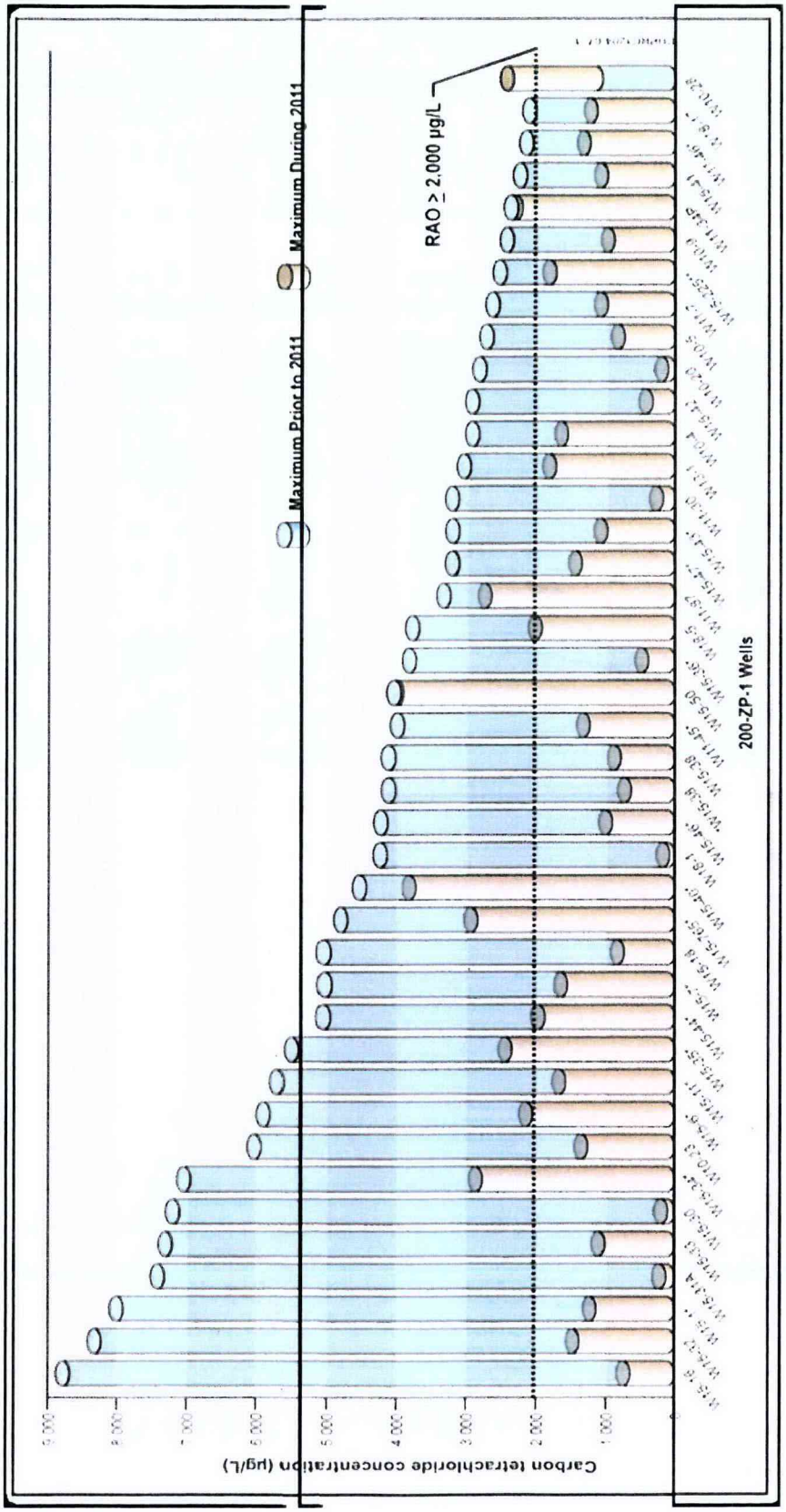


Figure 3-4. Historical Trend Between Carbon Tetrachloride Removed and Volume of Groundwater Extracted/Treated



Notes: Wells with concentrations at or exceeding the interim ROD RAO of 2,000 µg/L are shown above the black line.

* Extraction wells.

** 200 West Area extraction well temporarily connected to the interim system.

Figure 3-5. Maximum Carbon Tetrachloride Concentration in 200-ZP-1 Groundwater Wells Before and During 2011

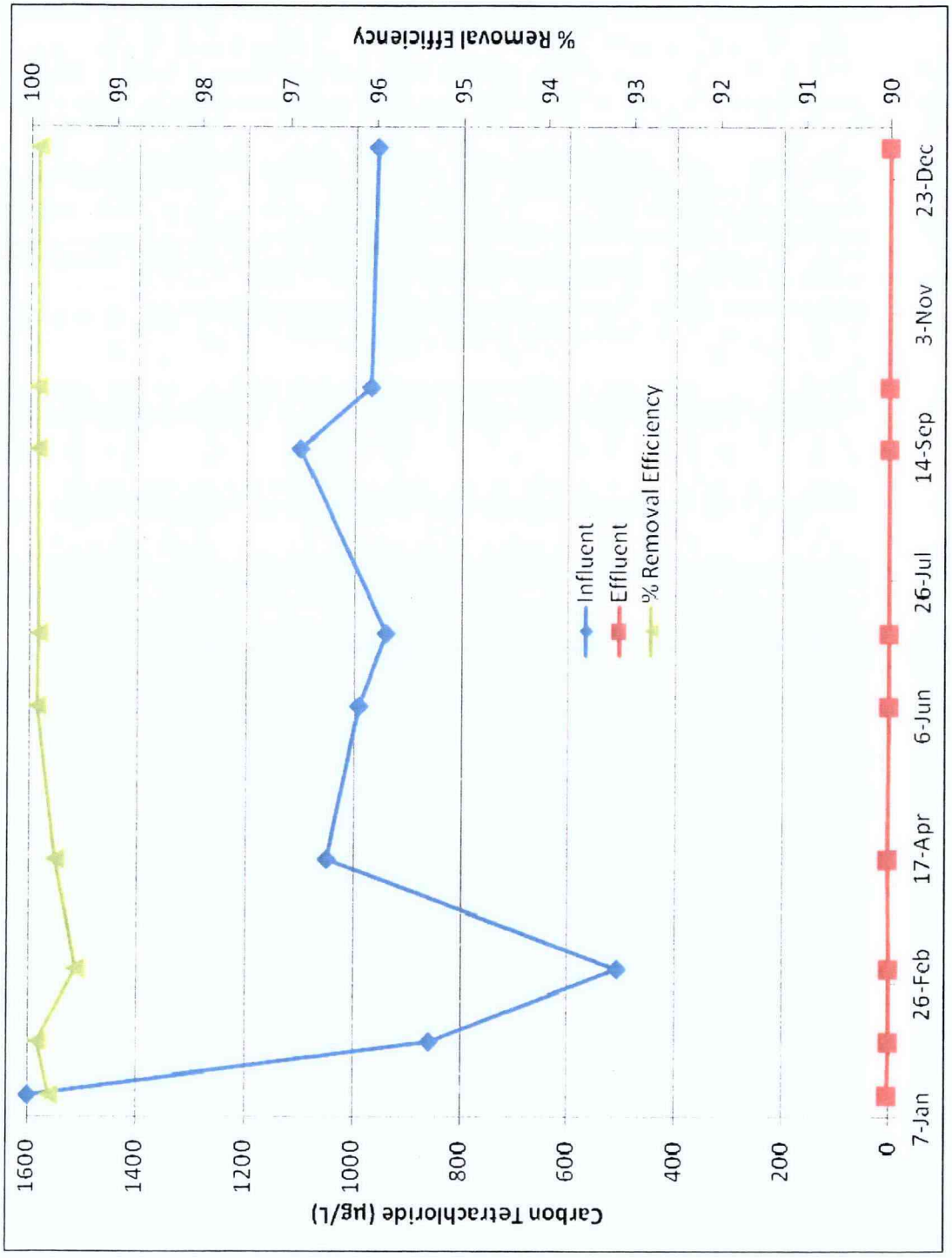


Figure 3-6. 200-ZP-1 Carbon Tetrachloride Concentrations at Influent Tank T-01 and Effluent Tank T-02 (with Removal Efficiencies) for 2011

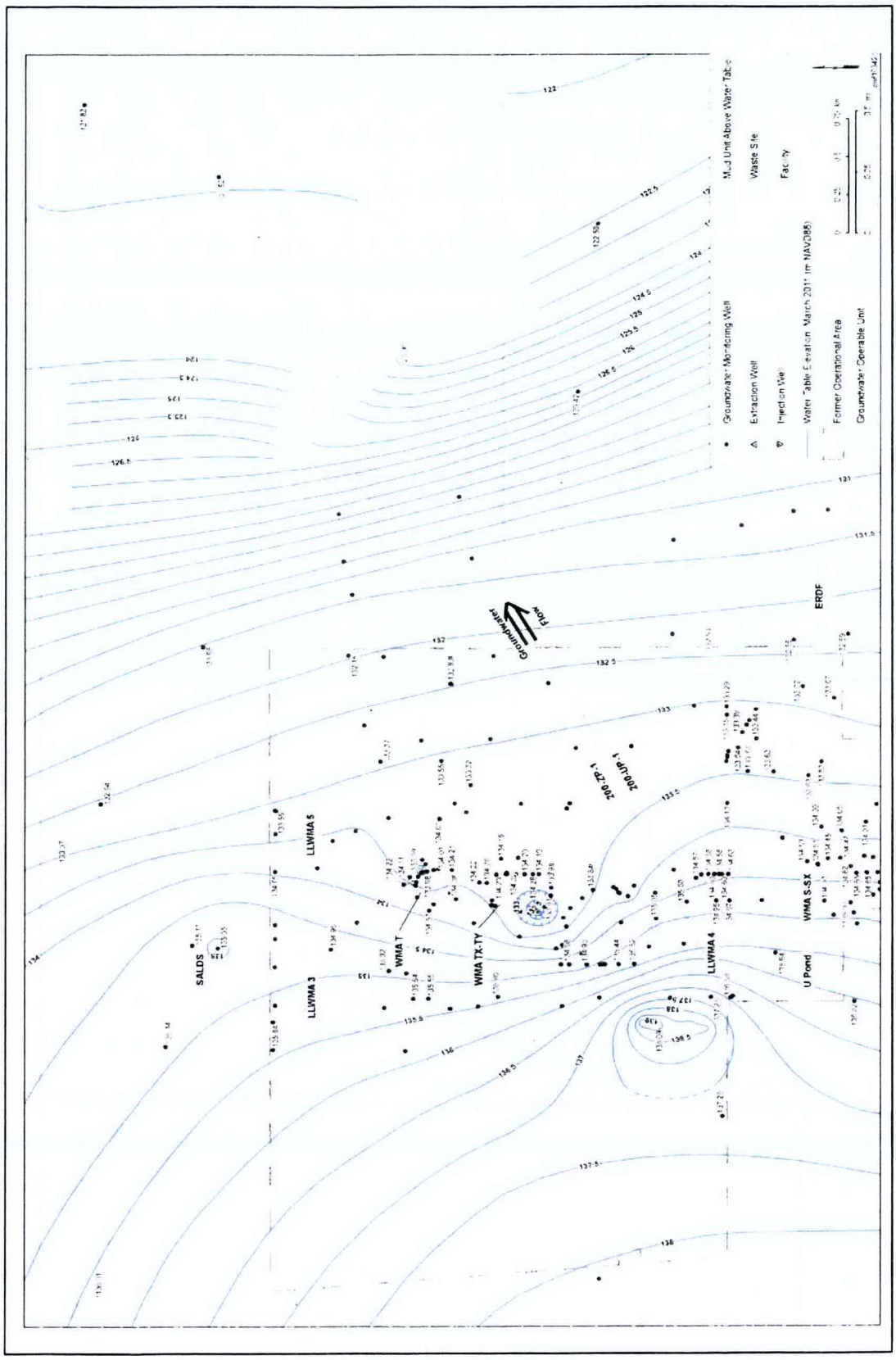


Figure 3-7. Groundwater Elevation Contours Throughout 200 West Area

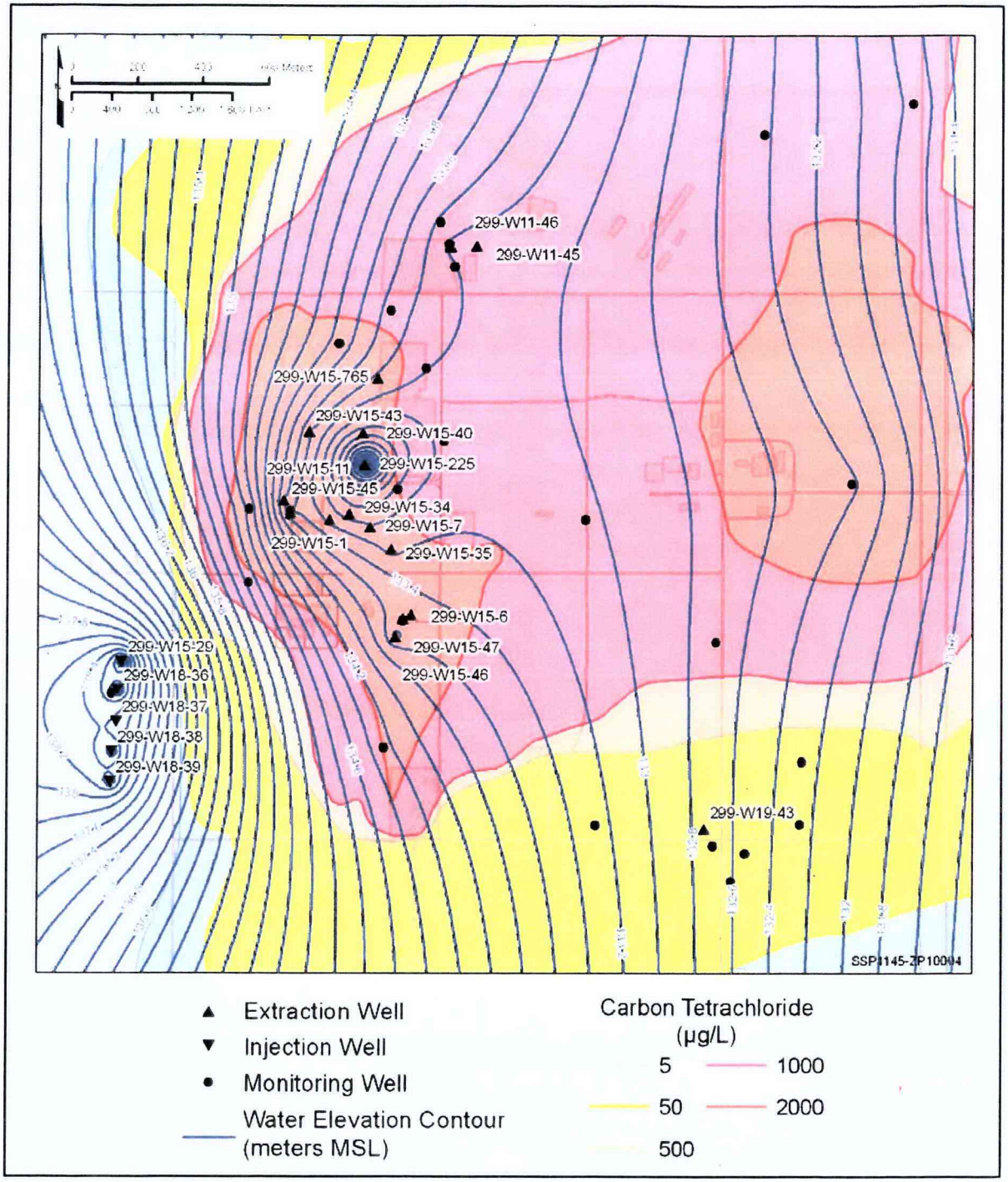


Figure 3-8. Groundwater Elevation Contours Throughout the 200 West Area During 2011, Overlain with Contoured Extent of Carbon Tetrachloride in 2011

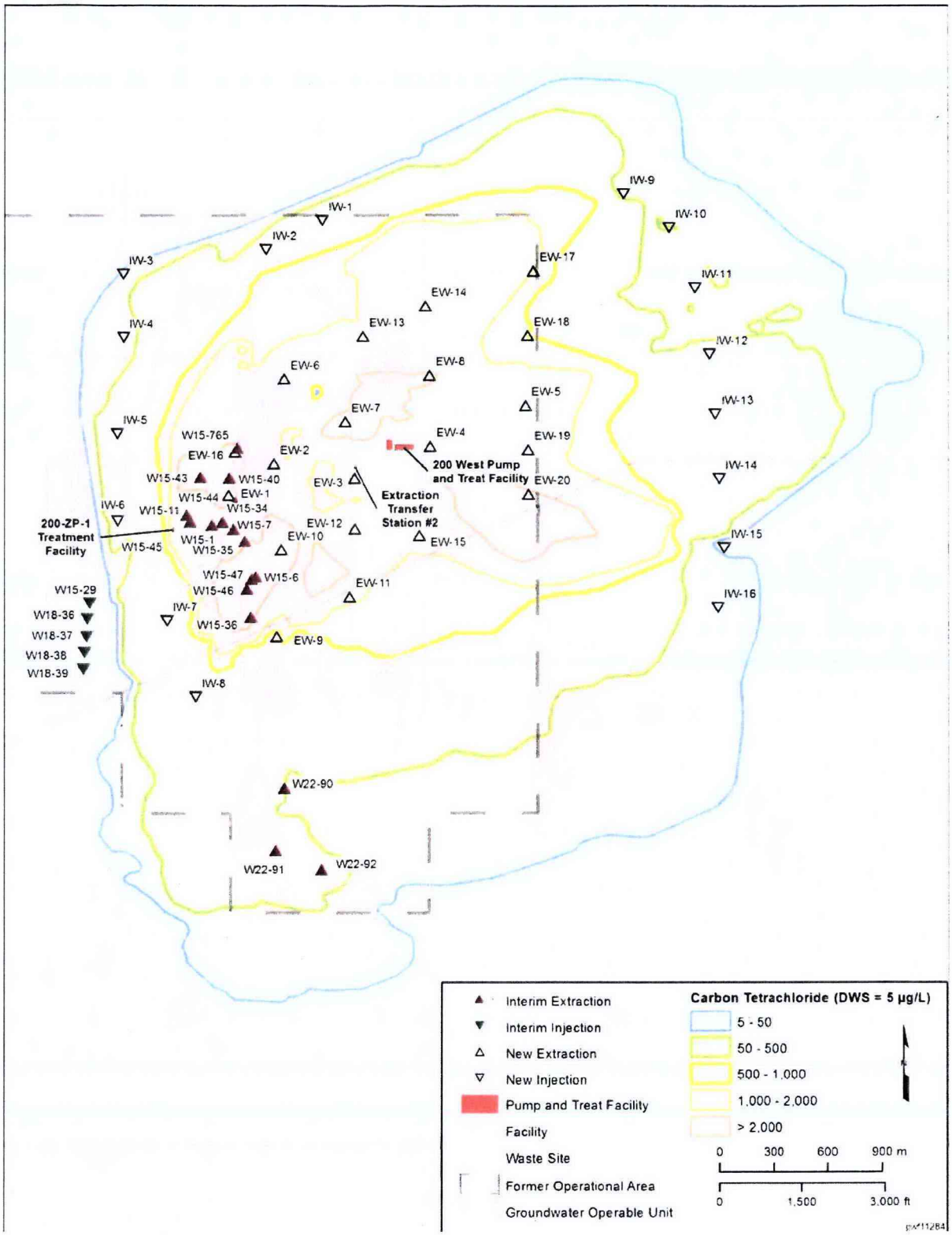


Figure 3-9. 200-ZP-1 Carbon Tetrachloride Contaminant Plume for 2011

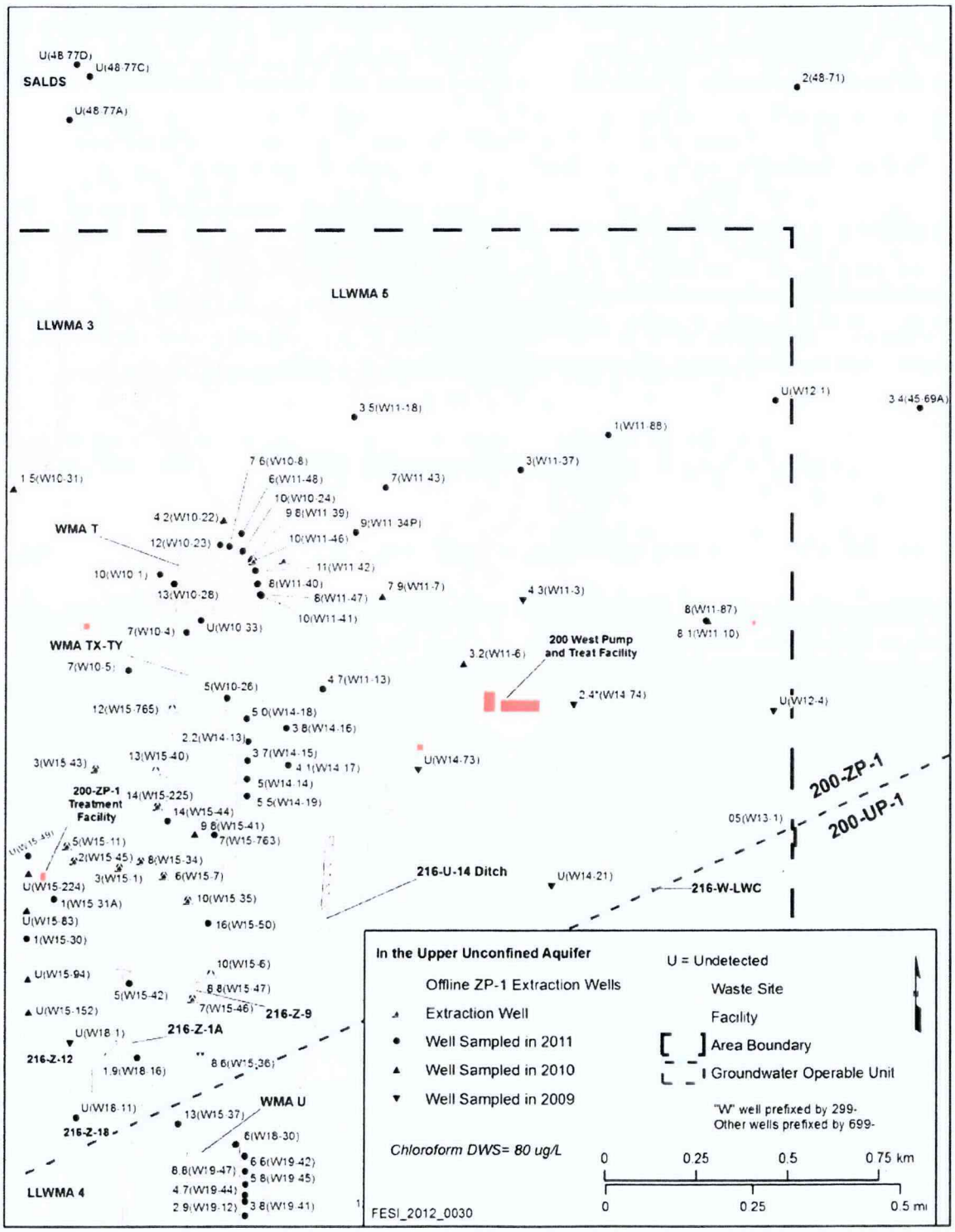


Figure 3-10. 200-ZP-1 Chloroform Concentration at 200-ZP-1 Wells for 2011

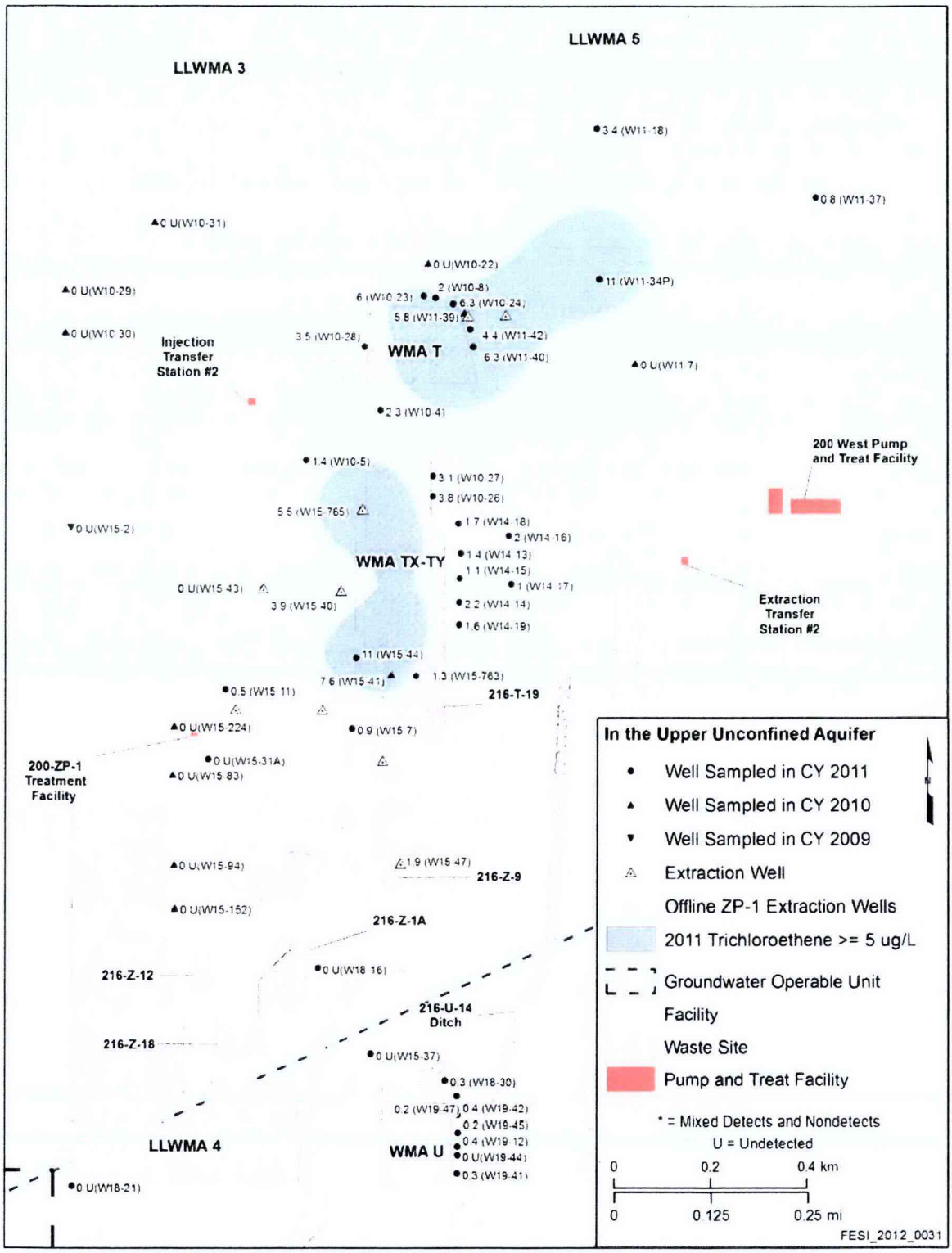


Figure 3-11. 200-ZP-1 TCE Contaminant Plume for 2011

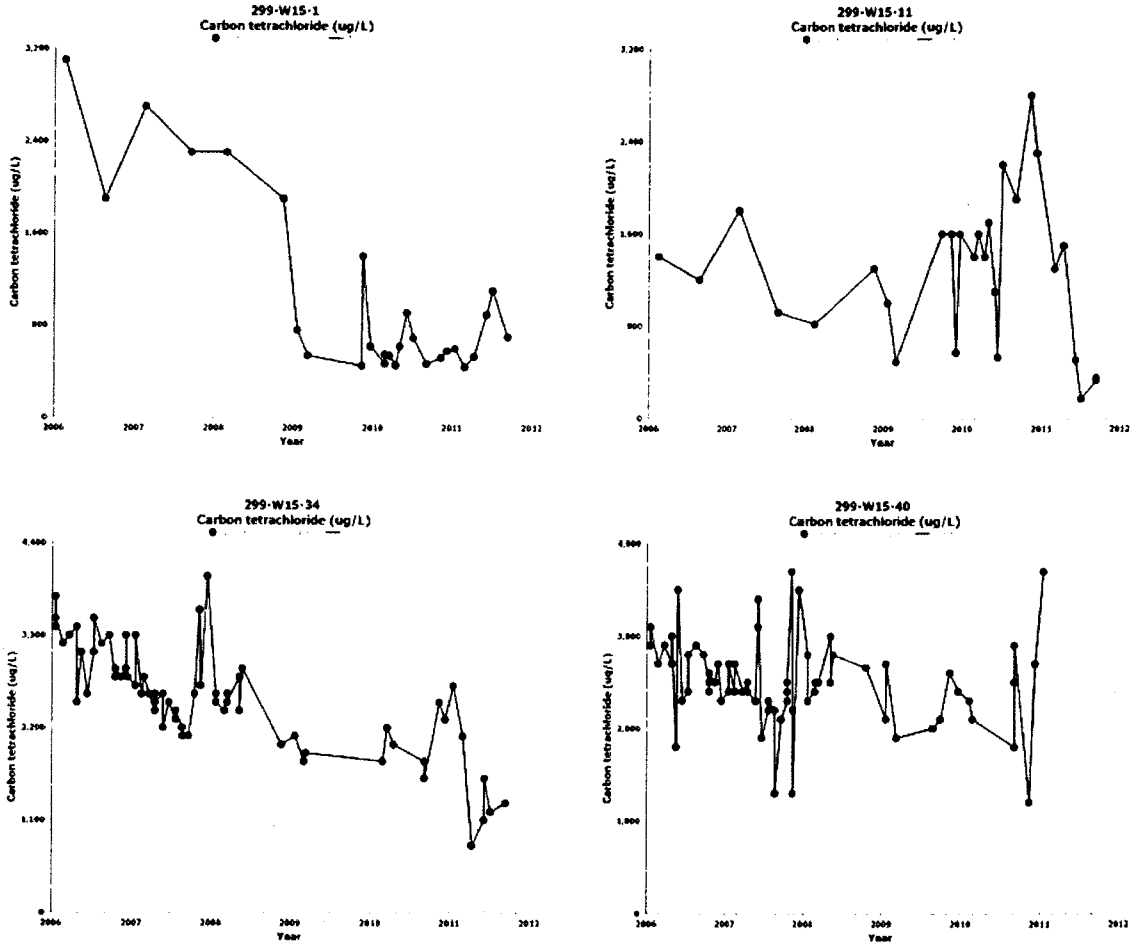


Figure 3-12. Extraction Well Carbon Tetrachloride Trend Plots

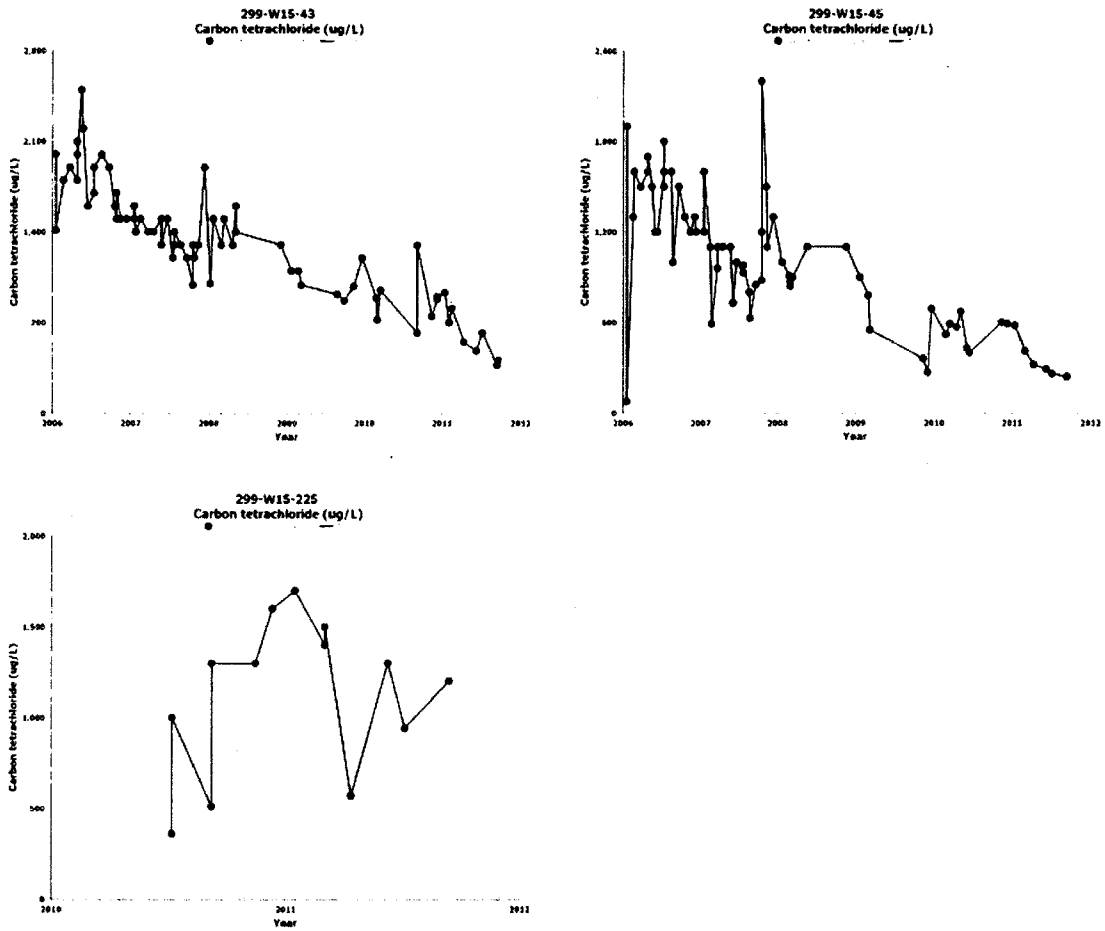


Figure 3-12. Extraction Well Carbon Tetrachloride Trend Plots (cont'd)

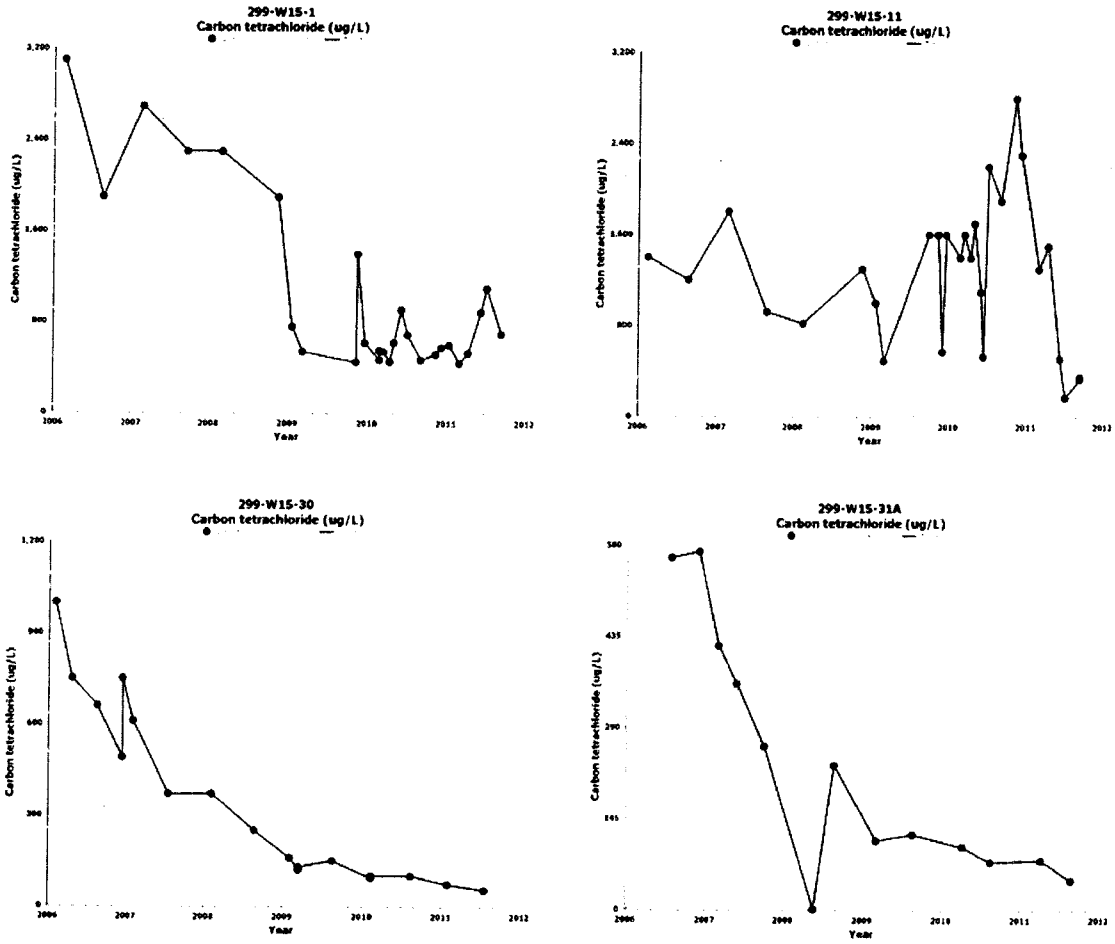


Figure 3-13. Monitoring Wells Carbon Tetrachloride Trend Plots

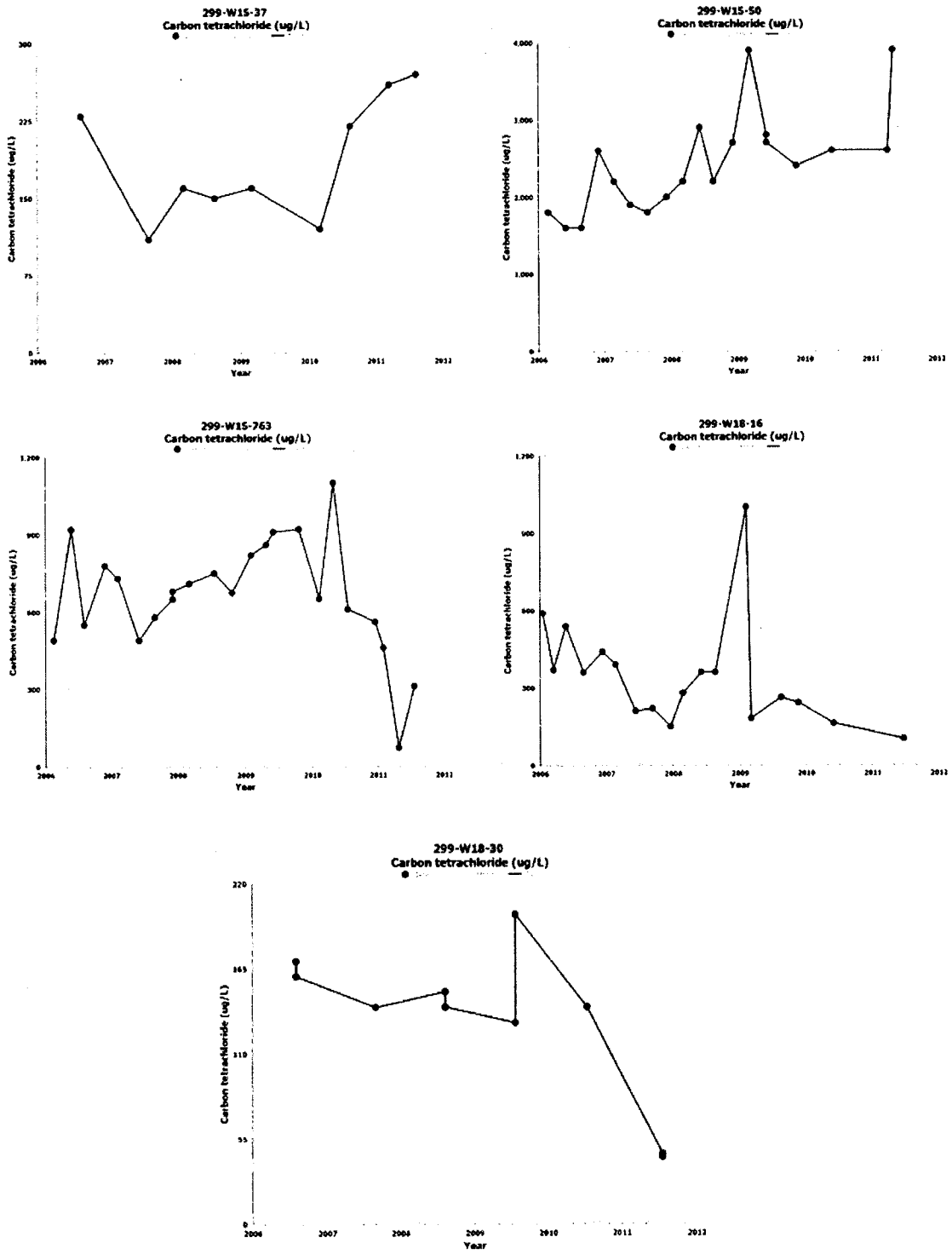


Figure 3-13. Monitoring Wells Carbon Tetrachloride Trend Plots (cont'd)

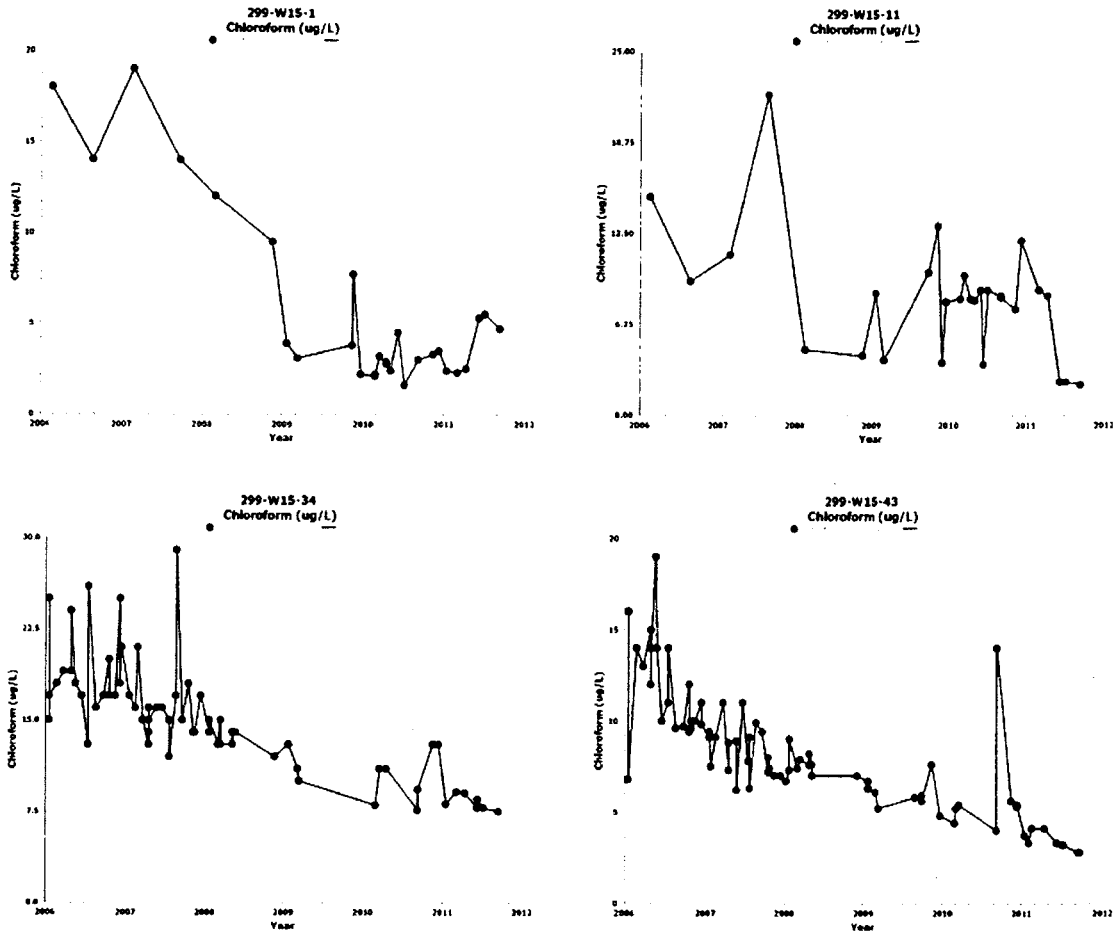


Figure 3-14. Extraction Wells Chloroform Trend Plots

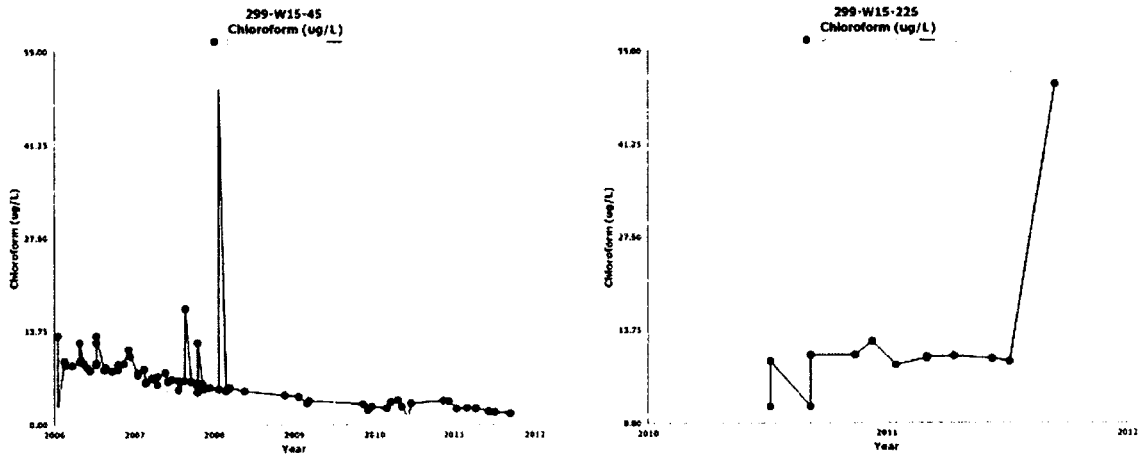


Figure 3-14. Extraction Wells Chloroform Trend Plots (cont'd)

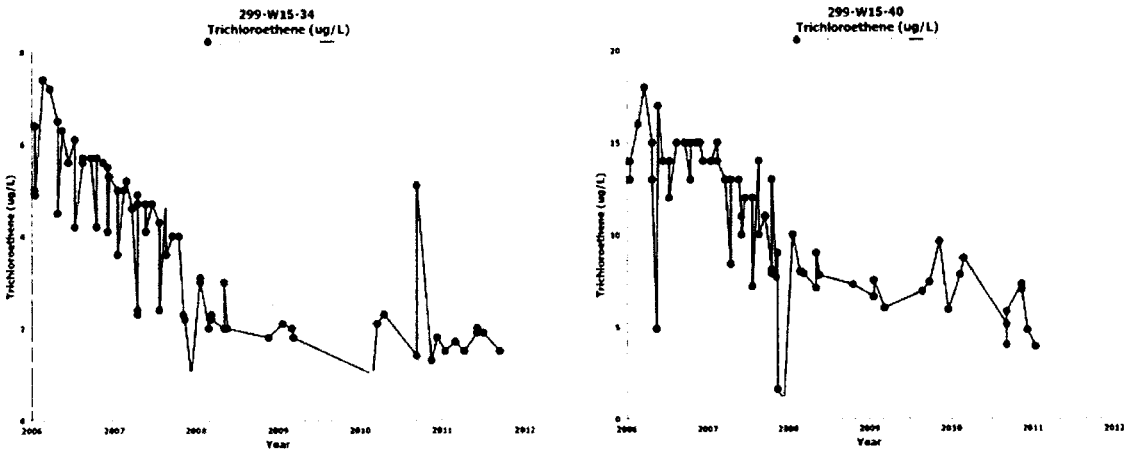


Figure 3-15. Extraction Wells TCE Trend Plots

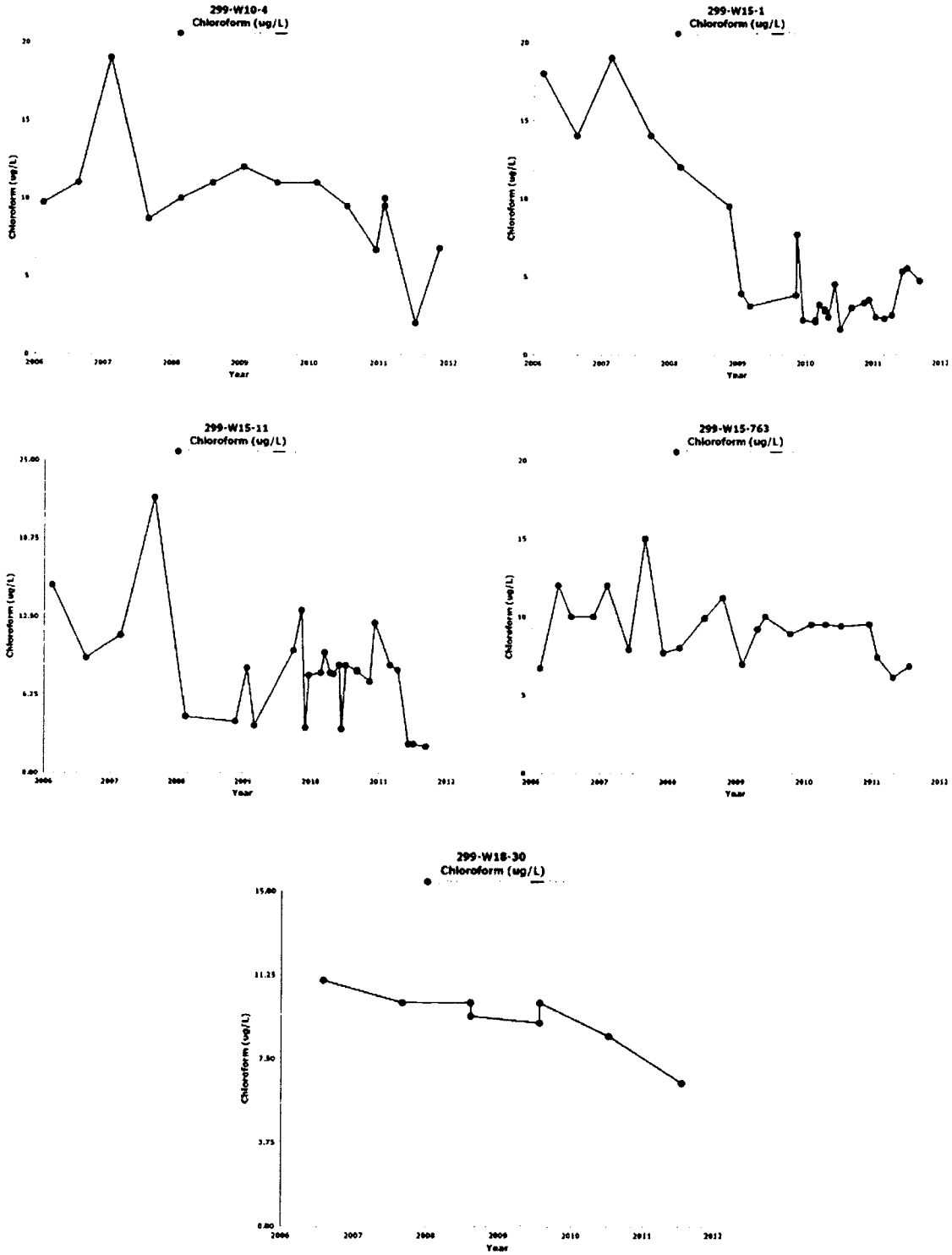


Figure 3-16. Monitoring Wells Chloroform Trend Plots

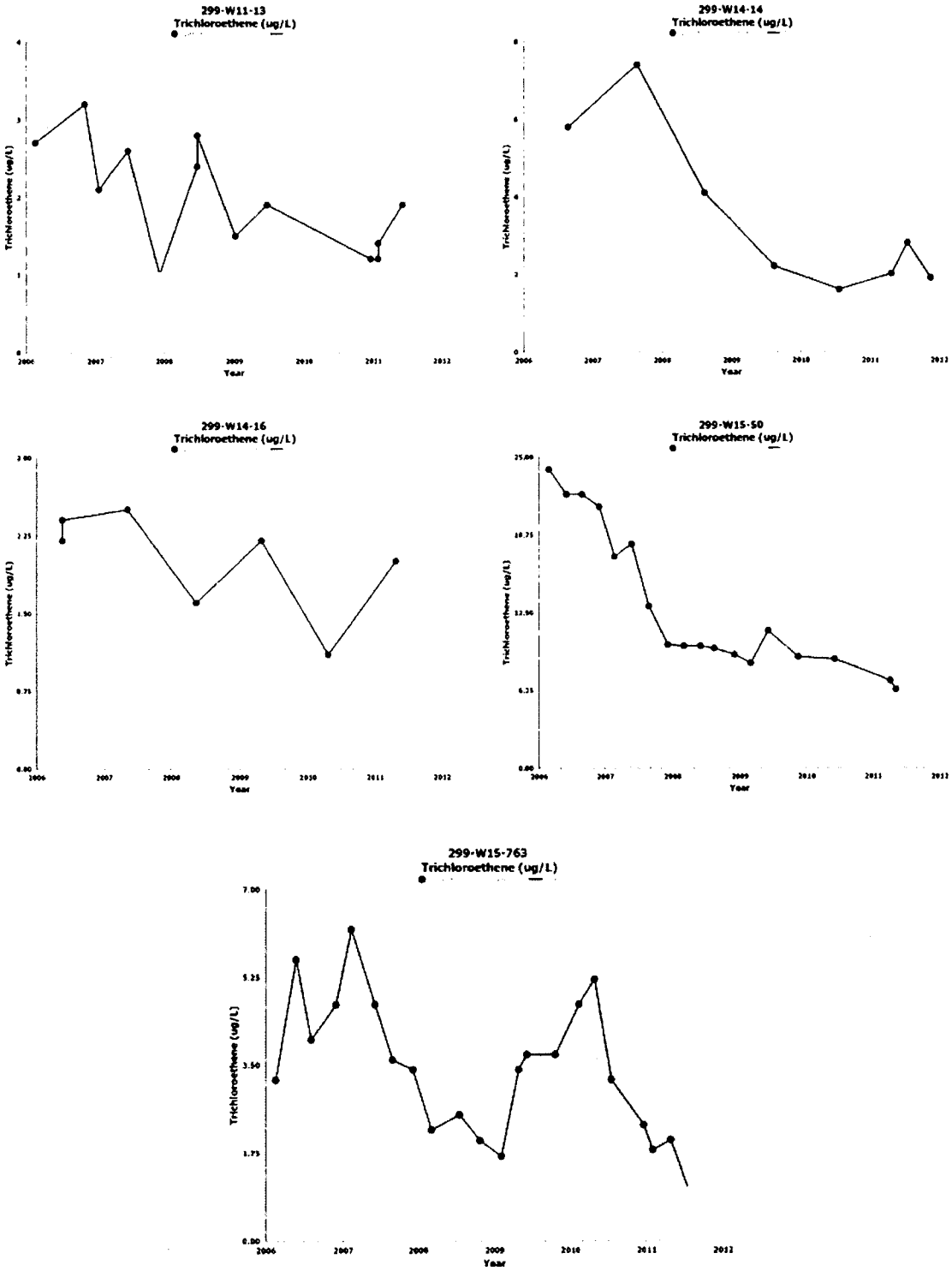


Figure 3-17. Monitoring Wells TCE Trend Plots

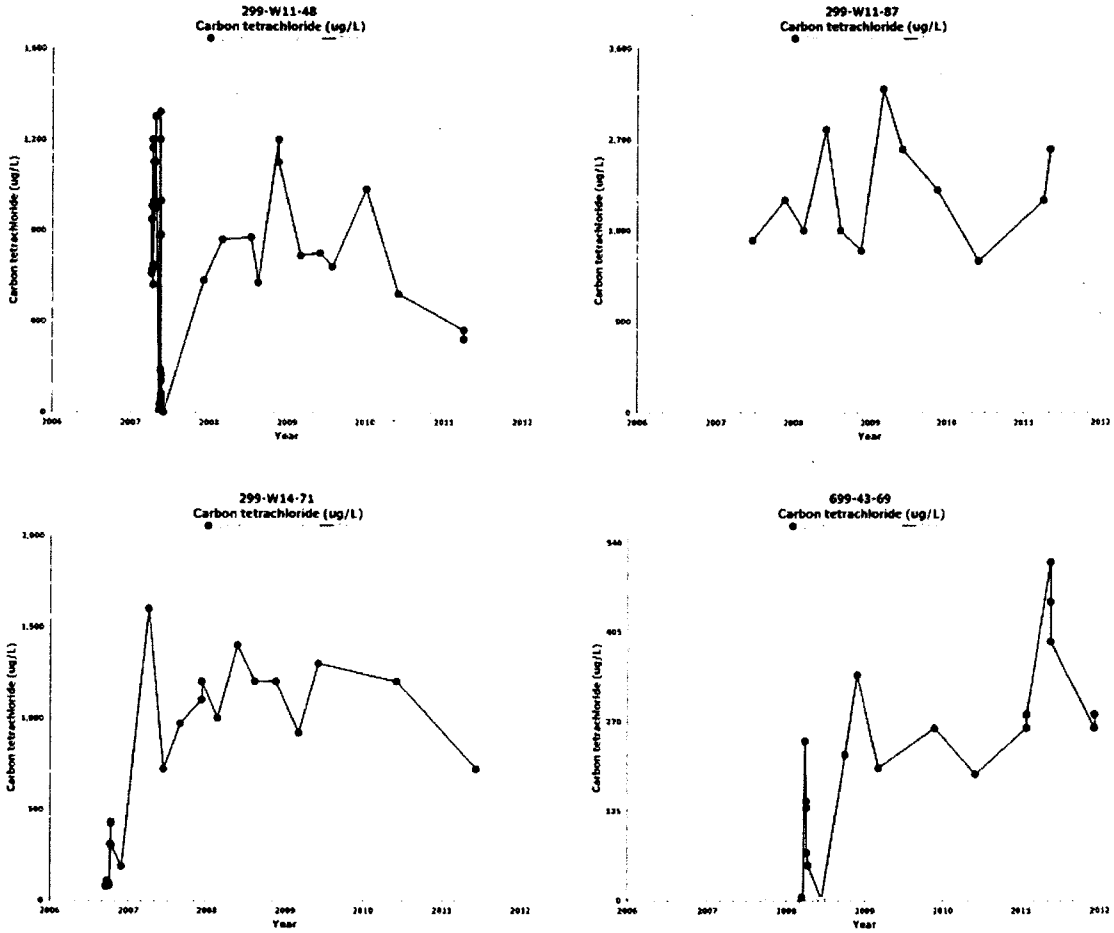


Figure 3-18. Deep Monitoring Wells Carbon Tetrachloride Trend Plots

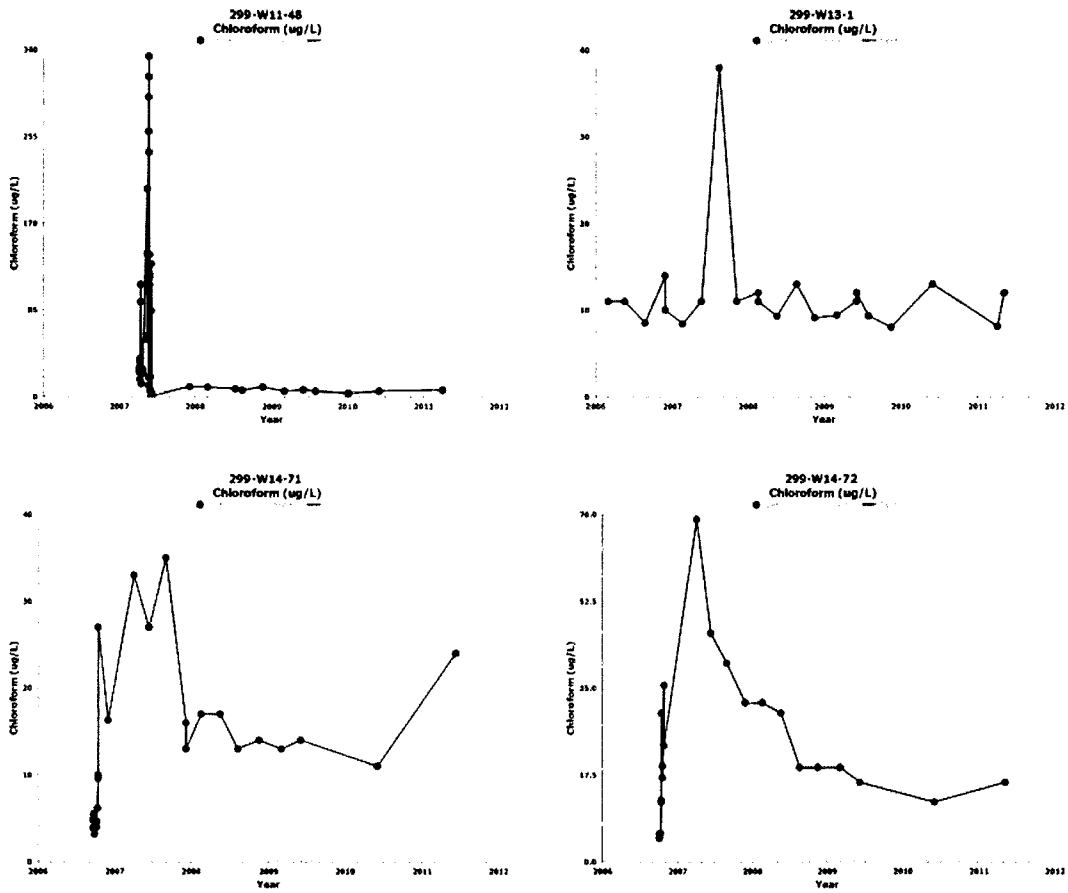


Figure 3-19. Deep Monitoring Wells Chloroform Trend Plots

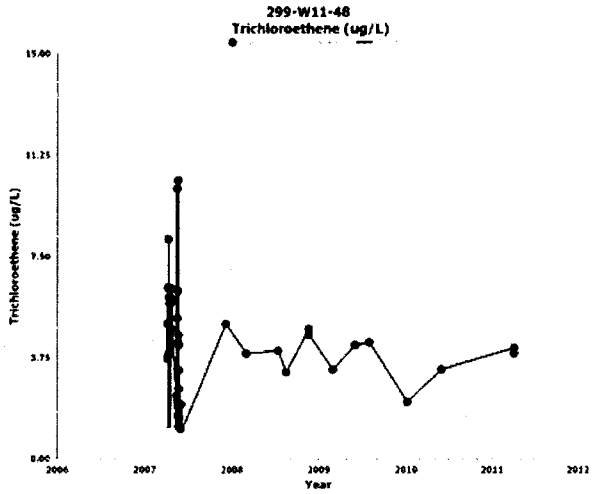


Figure 3-20. Deep Monitoring Wells TCE Trend Plots

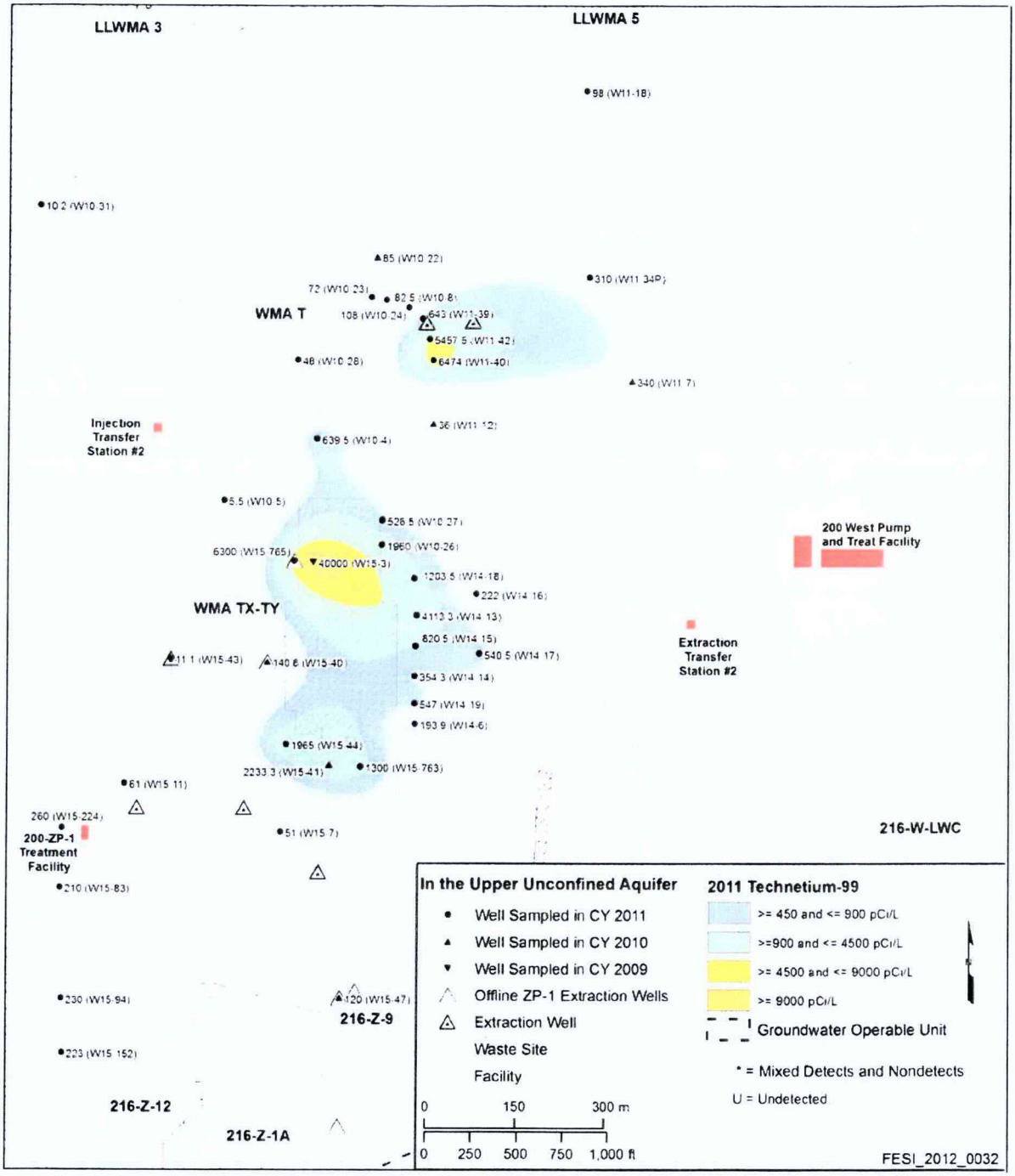
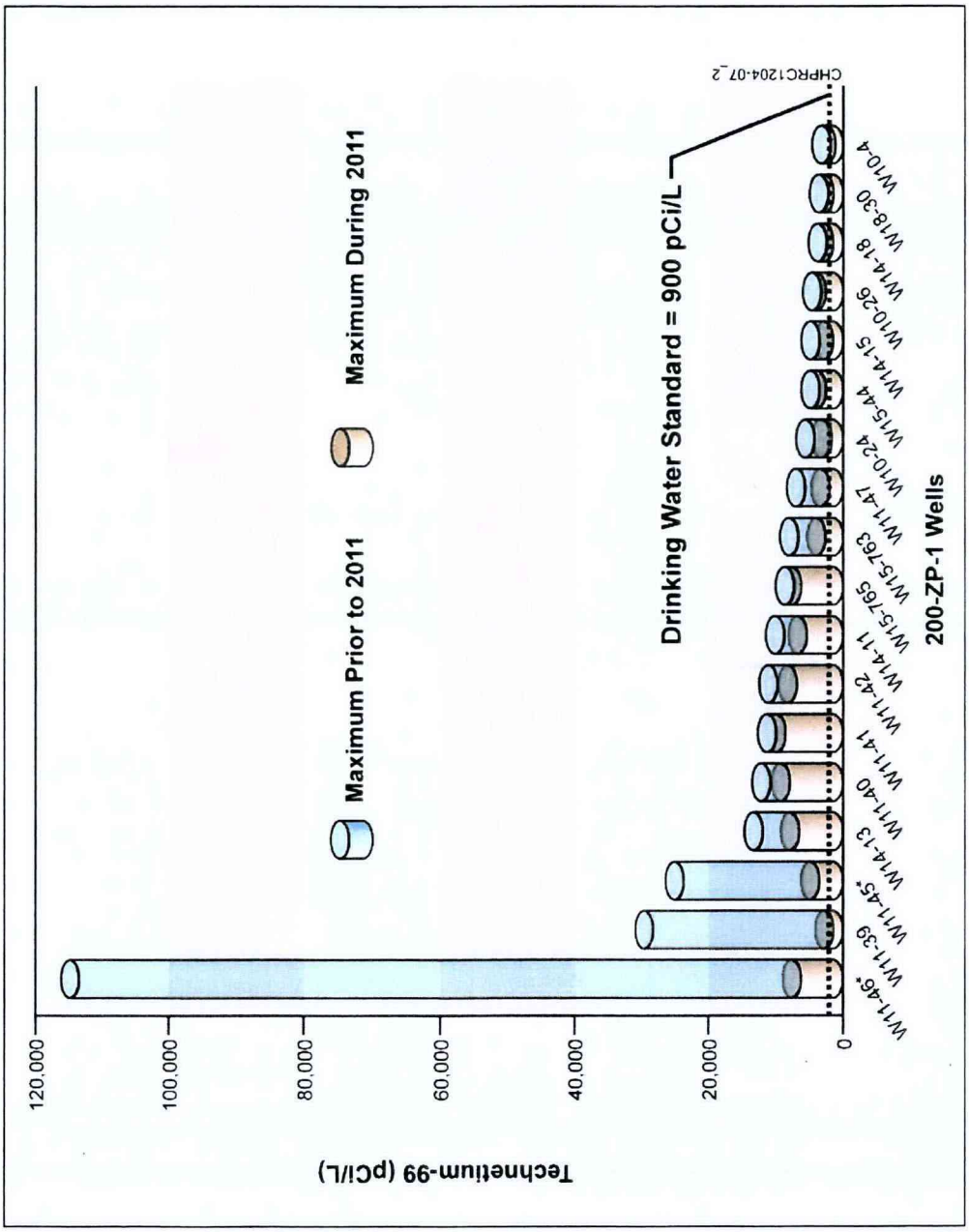


Figure 3-21. 200-ZP-1 Technetium-99 Contaminant Plume for 2011



Notes: An asterisk (*) indicates extraction well.

Figure 3-22. Maximum Technetium-99 Concentration in 200-ZP-1 Groundwater Wells Before and During 2011

Table 3-1. 200-ZP-1 Interim P&T System Performance in 2011 and Since System Startup in 1996

Performance	2011	Since 1996
Total groundwater processed (L)	758 million	5.8 billion
Total mass of carbon tetrachloride removed (kg)	791.8	13,503
Average mass removal efficiency [(influent – effluent) ÷ (influent)] x 100	99.9%	99%
System online availability	97%	95.5%
Plume area at 2,000 μg/L (km^2)	0.24	0.53

Table 3-2. 200-ZP-1 Average Annual Concentrations for Carbon Tetrachloride from Extraction Wells and Influent and Effluent Tanks

Well	2010 Avg. Concentration (µg/L)	2011 Avg. Concentration (µg/L)	Annual Comparison[a] (%)
299-W15-765[b]	2,400	2,233	Stable (-7)
299-W15-40[b]	2,087	3,700	Increasing (77)
299-W15-43[b]	876	609	Decreasing (-30)
299-W15-225	1,012	1,230	Increasing (22)
299-W15-45[c]	546	346	Decreasing (-37)
299-W15-11	1,712	693	Decreasing (-59)
299-W15-34	2,029	1,543	Decreasing (-24)
299-W15-1	569	710	Increasing (25)
299-W15-7	1,012	1,093	Stable (8)
299-W15-35	1,768	1,580	Stable (-11)
299-W15-6[d]	1,725	1,493	Stable (-13)
299-W15-47[e]	1,034	--	N/A
299-W15-46	700	612	Stable (-12)
299-W15-36	Offline	Offline	NA
Influent tank (T-01)	1,216	1,033	Stable (-18)
Effluent tank (T-02)	2.3	1.8	Decreasing (-28)

a. Annual comparison is the percent difference between 2010 and 2011 data and is calculated by the following equation: ([2011 - 2010] ÷ 2010) x 100%. Values are considered stable if there is a <20 % change in concentration from 2010 to 2011.

b. Existing monitoring wells converted to extraction wells in July 2005.

c. Replaced well 299-W15-33 on April 26, 2004.

d. Converted to an extraction well on September 28, 2006, pumping from lower portion of the aquifer. Used as a monitoring well in 2005 and 2006.

e. Replaced well 299-W15-32 on April 28, 2004.

N/A = not applicable

Table 3-3. 200-ZP-1 Baseline Plume Monitoring Well Results for Carbon Tetrachloride

Well	2010 Avg. Concentration (µg/L)	2011 Avg. Concentration (µg/L)	Annual Comparison[a] (%)
299-W10-4	1,010	927	Stable (-8)
299-W15-1	569	710	Increasing (25)
299-W15-11	1,712	693	Decreasing (-59)
299-W15-152	30	--	N/A
299-W15-30	98	63	Decreasing (-35)
299-W15-31A	88	63	Decreasing (-28)
299-W15-37	170	265	Increasing (56)
299-W15-41	940	--	N/A
299-W15-42	323	300	Stable (-7)
299-W15-44	1,650	1,800	Stable (9)
299-W15-46	700	612	Stable (-12)
299-W15-49	150	130	Stable (13)
299-W15-50[b]	2,600	3,250	Increasing (25)
299-W15-83	27	--	N/A
299-W15-94	75	--	N/A
299-W15-763	730	281	Decreasing (-62)
299-W18-16	160	100	Decreasing (-37)
299-W18-30	140	44	Decreasing (-69)

a. Annual comparison is the percent difference between 2010 and 2011 data and is calculated by the following equation: ([2011 - 2010] ÷ 2010) x 100%. Wells are considered stable if there is a <20 % change in concentration from 2010 to 2011.

b. Well is screened deeper in aquifer.

N/A = not applicable

Table 3-4. 200-ZP-1 Baseline Plume Monitoring Well Results for Chloroform

Well	2010 Avg. Concentration (µg/L)	2011 Avg. Concentration (µg/L)	Annual Comparison[a] (%)
299-W10-4	9.1	7.1	Decreasing (-22)
299-W15-1	2.9	3.8	Increasing (32)
299-W15-11	8.2	4.3	Decreasing (-48)
299-W15-152	0 (U)	--	N/A
299-W15-30	0.8	0 (U)	Stable
299-W15-31A	1.1	1.2	Stable (9)
299-W15-37	11	13	Stable (18)
299-W15-41	9.8	--	N/A
299-W15-42	4.8	4.8	Stable
299-W15-46	8.1	7.4	Stable (-9)
299-W15-49	0 (U)	0 (U)	Stable
299-W15-50[b]	14	16	Stable (14)
299-W15-83	0 (U)	--	N/A
299-W15-94	0 (U)	--	N/A
299-W15-763	9.5	6.8	Decreasing (-29)
299-W18-16	0 (U)	1.9	Stable
299-W18-30	8.5	6.4	Decreasing (-25)

a. Annual comparison is the percent difference between 2010 and 2011 data and is calculated by the following equation: ([2011 - 2010] ÷ 2010) x 100%. Wells are considered stable if there is a <20 % change in concentration from 2010 to 2011.

b. Well is screened deeper in aquifer.

N/A = not applicable

Table 3-5. 200-ZP-1 Baseline Plume Monitoring Well Results for TCE

Well	2010 Avg. Concentration (µg/L)	2011 Avg. Concentration (µg/L)	Annual Comparison[a] (%)
299-W10-4	2.1	2.2	Stable (6)
299-W10-5	--	1.4	N/A
299-W11-13	1.2	1.5	Increasing (25)
299-W14-14	1.6	2.2	Increasing (39)
299-W14-16	1.1	2.0	Increasing (82)
299-W15-1	0 (U)	1.0	Stable
299-W15-11	1.5	1.6	Stable (7)
299-W15-152	0 (U)	--	N/A
299-W15-30	0.1	0 (U)	Stable
299-W15-31A	0 (U)	0 (U)	Stable
299-W15-37	0 (U)	0 (U)	Stable
299-W15-41	7.6	--	N/A
299-W15-42	0 (U)	0 (U)	Stable
299-W15-46	1.4	1.2	Stable (-10)
299-W15-49	0 (U)	0 (U)	Stable
299-W15-50[b]	8.7	6.6	Decreasing (-24)
299-W15-83	0 (U)	--	N/A
299-W15-94	0 (U)	--	N/A
299-W15-763	3.8	1.9	Decreasing (-51)
299-W18-16	0 (U)	0 (U)	Stable
299-W18-30	0 (U)	0.29	Stable

a. Annual comparison is the percent difference between 2010 and 2011 data and is calculated by the following equation: ([2011 - 2010] ÷ 2010) x 100%. Wells are considered stable if there is a <20 % change in concentration from 2010 to 2011.

b. Well is screened deeper in aquifer.

N/A = not applicable

Table 3-6. Deep Monitoring Well Contaminant Results

Well	2010 Avg. Concentration (µg/L)	2011 Avg. Concentration (µg/L)	Annual Comparison[a] (%)
Carbon Tetrachloride (µg/L), RAO = 2,000 µg/L			
299-W10-33	0 (U)	0 (U)	Stable
299-W11-48	750	340	Decreasing (-55)
299-W11-87	1,500	2,350	Increasing (57)
299-W11-88	1.2	1.2	Stable
299-W13-1	1,500	1,700	Stable (13)
299-W14-71	1,200	720	Decreasing (-40)
299-W14-72	1,100	1,300	Stable (18)
299-W15-17	4.4	--	N/A
299-W18-22	0 (U)	0 (U)	Stable
699-43-69	190	347	Increasing (83)
699-45-69C	--	35	N/A
Chloroform (µg/L), DWS = 80 µg/L			
299-W10-33	0 (U)	0 (U)	Stable
299-W11-48	4.3	6.4	Increasing (49)
299-W11-87	6.9	7.7	Stable (12)
299-W11-88	0 (U)	0 (U)	Stable
299-W13-1	13	10	Decreasing (-23)
299-W14-71	11	24	Increasing (118)
299-W14-72	12	16	Increasing (33)
299-W15-17	0.76	--	N/A
299-W18-22	0 (U)	0 (U)	Stable
699-43-69	4.8	5.6	Stable (17)
699-45-69C	--	1.1	N/A
TCE (µg/L), DWS = 5 µg/L			
299-W10-33	0 (U)	0 (U)	Stable
299-W11-48	2.7	4	Increasing (48)
299-W11-87	0 (U)	3.4	Stable
299-W11-88	0 (U)	0 (U)	Stable

Table 3-6. Deep Monitoring Well Contaminant Results

Well	2010 Avg. Concentration (µg/L)	2011 Avg. Concentration (µg/L)	Annual Comparison* (%)
299-W13-1	6.7	5.6	Stable (-16)
299-W14-71	8.8	8.8	Stable
299-W14-72	4.2	3.7	Stable (-12)
299-W15-17	0 (U)	--	N/A
299-W18-22	0 (U)	0 (U)	Stable
699-43-69	0 (U)	2.1	Stable
699-45-69C	--	0 (U)	N/A

* Annual comparison is the percent difference between 2010 and 2011 data and is calculated by the following equation: ([2011 - 2010] ÷ 2010) x 100%. Wells are considered stable if there is a <20 % change in concentration from 2010 to 2011.

N/A = not applicable

Table 3-7. WMA T Extraction Well Performance for 2011

Performance	299-W11-45	299-W11-46	Total
Total groundwater processed (L)	18.8 million	39.4 million	58.2 million
Mass of carbon tetrachloride removed (kg)	22.4	35.5	57.9
Mass of chromium removed (kg)	2.5	4.4	6.9
Mass of nitrate removed (kg)	6,815	16,209	23,024
Mass of technetium-99 removed (g)[Ci]	2.5 [0.044]	10.8 [0.187]	13.3 [0.231]
Mass of TCE removed (g)	175.3	229.9	405.2
System availability	89.9%	80.7%	85.3% average
Average mass removal efficiency [(influent – effluent) ÷ (influent)] x 100	99%	99%	99%

a. Mass removed is calculated from volume extracted, not volume treated.

b. Technetium-99 converted from Ci to grams by activity 58.7 g/Ci.

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4 Pump-and-Treat Systems Cost Data

This chapter presents the actual cost breakdown for 200-UP-1 U Plant and 200-ZP-1 OU P&T system operations for 2011, and the cost per unit mass is calculated for specific COCs. Costs are also included for the design and construction of the S-SX Tank Farms P&T system. The costs are separated into specific activities that can be categorized as either operational or capital expenses. Tables 4-1, 4-2, and 4-3 provide comparisons of the costs for the 200-UP-1 U Plant, 200-UP-1 S-SX Tank Farms, and 200-ZP-1 P&T systems, respectively, from FY 1997 through 2011. Specific activities are described below:

- **Design:** Includes initial design activities to support P&T system construction, permitting, aquifer response modeling, peer reviews, quality assurance, and all other design documentation. It also includes the design of system upgrades and modifications.
- **Treatment system capital construction:** Includes fees paid to the construction subcontractor for capital equipment, initial construction/construction of new wells, redevelopment of existing wells, and modifications to the P&T system. Includes all Environmental Restoration Contractor and CHPRC labor required for oversight and support of initial well installation. It is not applicable in the current discussion of costs and is included to provide historical perspective.
- **Project support:** Includes activities related to project coordination and technical consultation as required during the course of the facility design, construction, acceptance testing, and operation. Adjustments are made to reported numbers to represent the actual amount that project support accrued from program/project management and project controls.
- **Operations and maintenance:** Includes facility supplies, labor, and craft supervision costs associated with operating and maintaining the facility. It also includes costs associated with routine field screening and engineering support as required during the course of the P&T operations and periodic maintenance.
- **Performance monitoring:** Includes system and groundwater sampling and sample analysis as required in accordance with the *200-ZP-1 IRM Remedial Design Report* (DOE/RL-96-07) and the *200-UP-1 Groundwater Remedial Design/Remedial Action Work Plan* (DOE/RL-97-36). It also includes preparation of the annual performance evaluation report and subsequent reports, as required by the interim action work plans.
- **Waste management:** This is the estimated cost for the management of granular activated carbon at the 200-ZP-1 OU in accordance with applicable laws for suspect hazardous, toxic, and regulated wastes. Waste designation sampling and analysis is included. There are no charges to the 200-UP-1 OU project for groundwater treatment costs from the ETF.
- **Construction capital:** For the 200-ZP-1 OU in 2011, this includes the cost for treatment system upgrades, reconfiguration of existing monitoring wells into extraction wells, and the connection of wells to the treatment system. In 2011, this category for the S-SX Tank Farms includes the expense funded cost to build and equip the S-SX Tank Farms P&T transfer station, the connection of the new wells to the treatment system, and instrumenting the water-level monitoring system.
- **Well installation:** This includes costs for the installation of new *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* monitoring and extraction wells at the 200-UP-1 and 200-ZP-1 OUs. During 2011, four extraction and monitoring wells were completed to support the new S-SX Tank Farms P&T system in the 200-UP-1 OU.

4.1 200-UP-1 Pump-and-Treat System Costs

The cost breakdown for the 200-UP-1 U Plant P&T system is presented in Table 4-1. Total operation costs for this system during CY 2011 were lower than for 2010 because the system only operated during the first quarter of the year. The cost breakdown for design and construction of the 200-UP-1 S-SX Tank Farms P&T system is presented in Table 4-2.

The cost per liter of groundwater extracted and the unit cost of the contaminants captured was not calculated for the 200-UP-1 U-Plant P&T system due to the limited duration of operation and the low volume of groundwater extracted during 2011.

4.2 200-ZP-1 Pump-and-Treat System Costs

Total construction and operation costs for 2011 are lower than for 2010, despite significant capital expenditures in 2011. The lower costs are attributed to significantly reduced operations and maintenance costs relative to 2010. The cost breakdown for the 200-ZP-1 P&T system is presented in Table 4-3. The majority of the costs in 2011 reflect well installation (39.5 percent), operations and maintenance (33.0 percent), and treatment system capital (15.7 percent).

The cost to treat the groundwater decreased from 1.13¢/L in 2010 to 0.95¢/L in 2011, based on the 2011 annual groundwater production of 758.0 million L (200.2 million gal). Given the 2011 net recovery of 791.8 kg of carbon tetrachloride, the cost of recovery was $9,056.50/kg.

Table 4-1. Cost Breakdown for 200-UP-1 U Plant P&T Operations

Description	Actual Costs (in Thousands)														
	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Design	--	--	--	--	--	--	--	--	$7.3	$45.4	$8.0	--	$35.1	$55.2	[a]
Project support	$101.0	$86.0	$31.3	$39.6	$0.3	$140.1	$89.1	$124.9	$181.0	$45.7	$130.0	$228.7	$18.9	$8.4	$3.6
Operations and maintenance	$707.0	$400.8	$127.8	$418.8	$52.0	$78.4	$171.0	$287.7	$26.6	$42.4	$41.3	$190.6	$98.2	$112.1	$41.7
Performance monitoring	--	--	--	$32.2	$35.9	$33.1	$84.3	$175.4	$560.7	$77.8	$142.6	$88.6	$131.6	$89.3	$77.3
Waste management	--	--	--	$10.0	$21.3	$8.2	$33.3	$19.6	$12.8	$21.5	$7.0	$10.6	$1.5	$8.4	[a]
Construction capital	--	--	--	--	$71.7	$149.5	$48.1	$34.5	--	--	$30.7	--	--	--	--
Well installation	--	--	--	--	$198.5	$34.1	$145.9	$0.0	$487.3	--	$0.0	$18.5	--	--	--
Totals	**$808.0**	**$486.8**	**$159.1**	**$500.6**	**$379.7**	**$443.4**	**$571.7**	**$642.1**	**$1,275.7**	**$232.8**	**$359.6**	**$537.0**	**$285.3**	**$273.4**	**$122.6**

a. For 2011, costs were not incurred for waste management or design.

b. For 2011, no capital construction costs, as is expense funded.

Table 4-2. Cost Breakdown for 200-UP-1 S-SX Tank Farms P&T Design and Construction

Description	Actual Costs (in Thousands)														
	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Design	--	--	--	--	--	--	--	--	--	--	--	--	--	$250.0	[a]
Project support	--	--	--	--	--	--	--	--	--	--	--	--	--	$7.6	$155.4
Operations and maintenance	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Performance monitoring	--	--	--	--	--	--	--	--	--	--	--	--	--	--	$17.3
Waste management	--	--	--	--	--	--	--	--	--	--	--	--	--	--	[a]
Construction capital	--	--	--	--	--	--	--	--	--	--	--	--	--	1,378.9[b]	3,952.5[b]
Well installation	--	--	--	--	--	--	--	--	--	--	--	--	--	--	$1,177.4
Totals	--	--	--	--	--	--	--	--	--	--	--	--	--	**$1,636.5**	**5,302.6**

a. For 2011, costs were not incurred for waste management or design.

b. For 2010 and 2011, no capital construction costs, as is expense funded.

Table 4-3. Cost Breakdown for 200-ZP-1 P&T Operations

Description	Actual Costs (in Thousands)														
	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Design	--	--	--	--	--	--	--	--	64.3	104.8	210.2	2,065.2	210.6	193.5	--
Treatment system capital	--	--	--	--	--	--	--	92.3	762.5	178.4	--	--	--	4.3	1,122.5
Project support	444.0	183.8	158.9	115.1	30.9	141.6	171.1	249.9	248.8	197.6	713.7	1,229.0	368.5	568.0	227.9
Operations and maintenance	2320.0	626.2	704.5	701.3	550.8	478.4	724.8	703.4	766.2	756.8	1,356.4	2,169.8	1,735.1	4,798.3	2,363.9
Performance monitoring	--	--	--	256.9	177.0	146.1	127.6	265.3	990.5	306.7	873.8	206.6	434.3	482.3	378.6
Waste management	--	--	--	45.3	52.6	922.0	167.2	85.1	29.2	26.7	20.6	62.8	154.5	372.1	184.6
Regeneration subcontract	--	--	--	--	142.6	--	--	--	--	--	--	--	--	--	64.5
Well installation	--	--	--	--	68.0	1,071.5	397.9	241.8	556.3	658.4	2,562.4	1,470.0	--	--	2,829.3
Totals	**$2,764.0**	**$810.0**	**$863.4**	**$1,118.6**	**$1,021.9**	**$2,759.6**	**$1,588.6**	**$1,637.8**	**$3,417.8**	**$2,229.4**	**$5,737.1**	**$7,203.4**	**$2,903.0**	**$6,418.5**	**$7,171.3**

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Appendix A

Waste Site, Operable Unit, and Pump-and-Treat Operational History

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A Waste Site, Operable Unit, and Pump-and-Treat Operational History

This appendix describes the evolution of the 200-UP-1 and 200-ZP-1 pump-and-treat (P&T) systems in terms of waste site operations and discusses their programmatic and regulatory histories.

A1 200-UP-1 Operational History

A1.1 Waste Disposal

The 216-U-1/2 Cribs, as well as the 241-U-361 tank, comprised a waste disposal system that received significant volumes of liquids from uranium recovery processes. An injection well (299-W19-9, which was decommissioned in August 2005) was also part of the system but was not used for waste disposal. The cribs are constructed of wood and are 3.7 m by 3.7 m by 1.2 m (12 ft by 12 ft by 4 ft) open structures; the cribs rest at the bottom of 6.1 m (20 ft)-deep excavations. The two cribs were connected in series, and a T-fitting directed wastewater into the 216-U-1/2 Cribs. With this design, more waste is thought to have reached the 216-U-1 Crib than the 216-U-2 Crib.

Waste was derived from a variety of processes associated with uranium recovery and uranium-trioxide production. The Uranium Recovery Project (URP) operated between 1951 and 1957, and the process retrieved uranium from bismuth phosphate process metal wastes stored in the B, C, T, and U Tank Farms. The chemical separations process recovered uranium using a tributyl phosphate-based, solvent-extraction process conducted at the 221-U and 224-U Buildings. A related step in a separate part of the 224-U Plant (U Plant) converted batches of dilute uranyl nitrate hexahydrate into concentrated uranyl nitrate hexahydrate. The concentrated uranyl nitrate hexahydrate was then converted into uranium trioxide by calcining (i.e., heating) the uranyl nitrate hexahydrate in furnaces. Concentrated uranyl nitrate hexahydrate from the 202-S Reduction-Oxidation (REDOX) Plant was also calcined at U Plant, as was uranyl nitrate hexahydrate that was trucked in from the 202-A Plutonium-Uranium (PUREX) Plant. Additions and modifications to the uranium trioxide process were made with the addition of the 224-UA and other supporting facilities, which permitted continuous calcining operations. The uranium trioxide process was active until 1972, and then again from 1984 until 1989. A final cleanout run in 1992 processed the residual materials from the final cleanout run at the PUREX Plant.

The nature of waste-generating activities at these facilities is not well documented. Most of the waste sent to the 216-U-1/2 Cribs was received from the 221-U Building's 5-6 tanks between 1951 and 1957. The 5-6 tanks collected residual process vessel and pipeline drainage. Pipes in the U Plant were decontaminated from 1966 to 1967 with acid washes, which were then discharged to the 216-U-1/2 Cribs.

The uncertainty of waste-generating activities has led to a range of estimates of primary and secondary contaminants discharged to the soil column and in the groundwater. The Waste Information Data System (WIDS) database reports that the 216-U-1/2 Cribs received 4.62×10^7 L (1.22×10^7 gal) of process wastes from the URP and multiple uranium trioxide processes through 1967. The liquid wastes included trace to minor concentrations of uranium, which accumulated to 4,040 kg of uranium at the waste site (WHC-EP-0133, *U1/U2 Uranium Plume Characterization, Remedial Action Review and Recommendations for Future Action*). *Radionuclide Inventories of Liquid Waste Disposal Sites on the Hanford Site* (HNF-1744) lists an inventory of 0.701 Ci (2,096 kg) of total uranium, 6.82×10^{-4} Ci (0.012 g) of technetium-99, 1.7 Ci (0.017 g) of strontium-90, and 3.53 Ci (0.036 g) of cesium-137 (all values decayed through December 31, 1998). *Inventories for Low-Level Waste Tank Waste*

(WHC-SD-WM-RPT-164) used data from the Oak Ridge Isotope Generation and Depletion Code (ORIGEN2) model to estimate the amount of fission products generated at Hanford reactors. From that data, WHC-SD-WM-RPT-164 estimated that up to 11 Ci of technetium-99 had been disposed at the 216-U-1/2 and 216-U-8 Cribs. Finally, the *Hanford Soil Inventory Model, Rev. 1* (RPP-26744) reported 3,955 kg of uranium and 7.3 Ci of technetium-99 discharged to the two cribs. Estimates of contaminant mass remaining in the aquifer were provided in the *200-UP-1 Operable Unit Rebound Study Report* (WMP-30847)

Other waste sites were used for the plant's waste streams, primarily at the following cribs: 216-U-8 (1952 to 1960), 216-U-12 (1960 to 1988), and 216-U-17 (1988 to 1994). The 216-U-8 Crib received URP waste concentrator condensate and also U Plant uranyl nitrate hexahydrate–uranium trioxide condensates. With the completion of URP activities in 1957, only U Plant waste was discharged to the 216-U-8/U-12/U-17 Cribs.

A pipeline connecting U Plant to the 216-U-8/U-12 Cribs was constructed with vitrified clay pipe in 1951 and was active until 1988. The pipe leaked at the joints and contaminated the soil. This location was designated as a waste site following detection of radionuclides in plant matter along the pipeline right-of-way. The site was designated as unplanned release (UPR) 200-W-42 and was excavated in 2006.

An associated underground tank, 270-W, was used to neutralize the acidic waste stream and is suspected of leaking. This tank is located just upstream of the start of the vitrified clay pipe. During operations, the tank was filled with limestone, which neutralized the waste passing through the system from 1952 to 1957. It is uncertain if the limestone charge was maintained, and the bottom of this tank is thought to have suffered acid attack and may have leaked waste to the soil column. The wastes generated at U Plant were less acidic and neutralization was not known to be required.

Groundwater contamination was discovered at the 216-U-1/2 Cribs in January 1985, when samples from two nearby wells (299-W19-3 and 299-W19-11) revealed unusually high concentrations of uranium (up to 85,000 pCi/L) (WHC-EP-0133; RHO-RE-SA-116, *Characterization and Anion Removal of Uranium from Hanford Ground Water*) compared to much lower results from several weeks earlier. The contamination was attributed to startup of the 216-U-16 Crib, located 200 m (656.2 ft) south of the 216-U-1/2 Cribs. The 216-U-16 Crib received large volumes of cooling water from U Plant between July 1984 and 1987. The wastewater migrated north along a caliche layer and mobilized technetium-99 and uranium in the vadose zone soil column beneath the 216-U-1/2 Cribs, which added contaminant mass to the groundwater plume (WHC-EP-0133, PNL-8073, *Hanford Site Ground-Water Monitoring for 1990*). Boreholes were drilled to characterize the 216-U-1/2 sites, and an ion-exchange (IX) system based at the 242-S evaporator was set up. The IX system treated approximately 30 million L (8 million gal) of groundwater, recovering 687 kg of uranium between June and November 1985. Waste streams from the 242-S evaporator were sent to the 216-U-14 Ditch (cooling water) and the 216-S-25 Crib (process condensate). The WIDS database notes that an additional 830 kg of uranium were thought to remain in the groundwater after P&T operations.

Well 299-W19-11, drilled approximately 10 m (32.8 ft) east of the 216-U-1 Crib in 1983, was sampled and logged before startup of the 216-U-16 Crib (RHO-RE-SA-116). Data from 1983 revealed the presence of significant quantities of uranium, up to 36,000 parts per million (ppm) at 10.8 m (35.4 ft) below ground surface (bgs), which was spread across the upper 8 m (26.2 ft) of soil column directly below the 6 m (19.7 ft)-deep crib. Uranium concentrations then generally decreased with depth before increasing to 100 ppm at 50 m (164.1 ft) bgs near the Plio-Pleistocene caliche unit. Uranium concentrations then declined to 0.01 ppm near the groundwater table. Gross gamma geophysical logging conducted in 1985 (after the groundwater uranium increase) indicated that activities in sediments at

50 m (164.1 ft) were greater than activities in surrounding sediments. Geophysical logging also indicated that activity levels at the water table were higher than levels from the sediment layers above.

Detailed chemical analyses were performed on the 1983 soil samples (RHO-RE-SA-116). For the samples at 10.8 m (35.4 ft), the sediment was found to be acidic from the wastes previously discharged. The samples contained 0.3 percent phosphorous (by weight), plus 9 pCi/L of cesium-137 and 900 pCi/L of strontium-90. Uranium was detected by x-ray diffraction in association with phosphates derived from the original waste stream entering the URP. Uranium was also present in other forms in this sample.

The characterization activities in the 1980s at the 216-U-1/2 Cribs included drilling four boreholes (299-W19-15 through 299-W19-18), performing sediment sampling and analysis, and installing groundwater wells to monitor plume behavior. The water table was detected at approximately 67 m (219.8 ft) bgs, and a discontinuous, 3.7 m (12 ft)-thick caliche layer was found at 51 m (167.3 ft). A perched water table from 216-U-16 discharges was reported to be 23 m (75.5 ft), 21 m (68.9 ft), and 8 m (26.2 ft) thick for wells 299-W19-15, 299-W19-16, and 299-W19-17 (respectively) adjacent to the cribs, and the water was found to be contaminated with uranium. RHO-RE-SA-116 assumed that access to the aquifer was by holes in the caliche layer or by migration along well casings penetrating the caliche.

More recently, a number of cribs have been characterized to prepare for remediation at the 200-UW-1 Operable Unit (OU). This OU addresses the waste sites associated with the 221-U/U Plant system and related facilities. As discussed in the *Proposed Plan for the 200-UW-1 Operable Unit* (DOE/RL-2003-24), several waste sites have been identified for capping or covers based on risk assessment modeling. Modeling revealed that an initial spike would occur within the first 100 years, resulting from drainage of deep contamination within the vadose zone. Within 1,000 years and without caps, sharper spikes in mobile contaminants were shown to reach groundwater as follows: 216-U-1/U-2 for technetium-99, 216-U-8 for uranium and nitrate, and 216-U-12 for nitrate. With caps/covers, the larger spike in contaminants would not reach the groundwater. In support of crib cover designs, a series of shallow boreholes were drilled to locate the margins and volume of subsurface contamination at these cribs. The sampling and analysis programs have focused on uranium, nitrate, and technetium-99 concentrations in the uppermost 12.2 to 18.3 m (40 to 60 ft) of soil around the cribs. Contamination levels have been relatively low around the cribs.

A1.2 Remediation Activities

As stated above, a small IX plant operated in 1985 to capture uranium within what is now recognized as the 200-UP-1 OU. The current P&T program began in 1994 following a recommendation in the *200 West Groundwater Aggregate Area Management Study Report* (DOE/RL-92-16) that uranium, technetium-99, and nitrate plumes should be remediated under an interim remedial measure. This recommendation was implemented in an agreement between the U.S. Department of Energy (DOE), U.S. Environmental Protection Agency (EPA), and Washington State Department of Ecology (Ecology) as *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al., 1989) Milestone 13-93-03. The agreement specified an IX P&T system as a pilot-scale treatability test and identified uranium and technetium-99 as the primary contaminants of concern (COCs). The *Remedial Investigation/Feasibility Study Work Plan for the 200-UP-1 Groundwater Operable Unit* (DOE/RL-92-76) and the *Pilot-Scale Treatability Test Plan for the 200-UP-1 Groundwater Operable Unit* (DOE/RL-93-105) were prepared to guide development of the IX system. Carbon tetrachloride was added as a secondary COC, but nitrate was dropped as a target constituent for the treatability test.

The pilot-scale treatability test was conducted between March 1994 and September 1995 (DOE/RL-95-02, *Treatability Report for the 200-UP-1 Operable Unit – Hanford Site*). The treatability test consisted of an onsite P&T system constructed adjacent to the 216-U-17 Crib, plus single extraction

(299-W19-24) and injection (299-W19-25) wells. Well 299-W19-23 was added as a backup extraction well and was brought online when pumping rates at well 299-W19-24 declined. Additionally, wells 299-W19-20, 299-W19-23, 299-W19-26, 299-W19-28, 299-W19-29, and 299-W19-30 (originally installed between 1986 and 1990 to monitor 216-U-17 Crib performance) were used to track plume behavior. Groundwater was extracted at a rate of 57 L/min (15 gallons per minute [gpm]).
The IX technology was used to remove technetium and uranium, while granular activated carbon (GAC) was used for the secondary removal of carbon tetrachloride. The treatability test demonstrated that the IX and GAC technologies were effective for removing uranium/technetium-99 and carbon tetrachloride, respectively, from groundwater.

Following completion of the pilot test, P&T operations continued. A drilling program from 1994 to 1995 installed eight new wells (299-W19-34A through 299-W19-40, 299-W19-34A, and 299-W19-34B monitored deeper groundwater conditions) to better define and monitor the plume. Phase I P&T operations commenced September 25 1995, and continued until February 7, 1997, using the onsite plant and single new extraction (299-W19-39) and injection (299-W19-36) wells. Groundwater was treated at a rate of 189.3 L/min (50 gpm). During this period, operations continued in anticipation of the release of the *Interim Remedial Measure Proposed Plan for the 200-UP-1 Operable Unit, Hanford, Washington* (DOE/RL-95-26) and issuance of the *Record of Decision for the 200-UP-1 Operable Unit Interim Remedial Action, Hanford Site, Benton County, Washington* (EPA/541/R-97/048).

On February 25, 1997, the interim Record of Decision (ROD) (EPA/541/R-97/048) was issued for 200-UP-1 P&T operations. The *200-UP-1 Groundwater Remedial Design/Remedial Action Work Plan* (DOE/RL-97-36) was prepared to describe the detailed design of the treatment system. The selected remedy consisted of pumping from the highest concentration zone of the uranium and technetium-99 groundwater plumes and routing the groundwater to the Effluent Treatment Facility (ETF) in the 200 East Area for treatment. System operations were shut down from February 8 to March 30, 1997, to connect the extraction well to a 6 in. pipeline conveying groundwater to the ETF.

The selected remedy section of the 200-UP-1 interim action ROD (EPA/541/R-97/048) established the high-concentration zone for technetium-99 as the area contained within the 9,000 pCi/L contour, equal to 10 times the 900 pCi/L drinking water standard (DWS). For uranium, the selected remedy's high-concentration zone was a contour set at 480 µg/L, or 10 times the *Model Toxics Control Act* (MTCA) (WAC 173-340) standard of 48 µg/L. Since then, the MTCA standard has been lowered twice: first to 40 µg/L, and then to 30 µg/L(federal DWS) in fiscal year (FY) 2004. The P&T system is now evaluated against the selected remedy value of 10 times the 30 µg/L DWS (300 µg/L).

Phase II operations were initiated on March 31, 1997, and continued until calendar year (CY) 2011. During this time, contaminated groundwater was transported 11 km (7 mi) through a pipeline from extraction wells in the 200 West Area to the ETF for treatment. Prior to treatment, waste is stored in Liquid Effluent Retention Facility (LERF) basin 43, which started as a 24,605,000 L (6,500,000 gal) storage facility. A May 22, 1998, revision to the LERF *Resource Conservation and Recovery Act of 1976* (RCRA) Permit increased the capacity to 29,526,000 L (7,800,000 gal) by reducing the freeboard requirements for the basins. Wastewater enters the basin continually and is extracted in batches of 2,536,200 L (approximately 670,000 gal) to the ETF influent holding tank for treatment. The batch is run through the ETF and collected in an effluent holding tank. Samples are taken in each holding tank to determine the mass removed and to ensure that the treated water meets discharge requirements. After treatment, the process wastewater is discharged to the State-Approved Land Disposal Site, located north of the 200 West Area.

Over time, declines in water table elevation at the 200-UP-1 OU reduced the volume of water pumped at extraction well 299-W19-39. As a result, well 299-W19-36 was used as an extraction well between December 27, 2001, and May 15, 2003, and then again from November 21, 2003, to January 26, 2005. Well 299-W19-43 was converted to an extraction well and started in this role on May 22, 2003. On January 26, 2005, per agreement with Ecology and following one year of optimized pumping designed to keep extraction rates at or above 189.3 L/min (50 gpm), the 200-UP-1 P&T system was shut down for one year to conduct a rebound study. The rebound study measured the effectiveness of P&T operations determining contaminant concentrations in an unstressed aquifer. Primary and secondary contaminants had an opportunity to equilibrate with the regional groundwater flow and reach groundwater concentrations that more accurately reflect contaminant concentrations in the sediments.

During the rebound study, monthly sampling for the primary contaminants (i.e., technetium-99 and uranium) was scheduled for the last Wednesday of each month for one year at 10 wells within and adjacent to the baseline plume area. Quarterly analyses for secondary contaminants carbon tetrachloride and nitrate were also performed. In addition, samples were taken in the first 2 weeks following cessation of pumping and at DOE's request in early March 2005.

The rebound study was completed on January 25, 2006, and the rebound study report (WMP-30847) was released. Following a briefing and a comment period for the report, Ecology began revising the interim ROD by preparing an explanation of significant differences (ESD). Issue 18 identified in *The Second CERCLA Five-Year Review Report for the Hanford Site* (DOE/RL-2006-20) identified the change in EPA DWS for uranium to 30 µg/L and recommended preparing an ESD to incorporate this change into the interim ROD. The *Explanation of Significant Differences for the Interim Action Record of Decision for the 200-UP-1 Groundwater Operable Unit, Hanford Site, Benton County, Washington* [EPA et al., 2009]) was finalized in February 2009.

During and after the rebound study, the extraction well system was maintained in a hot-standby mode, able to restart with limited maintenance actions. At the end of P&T activities for FY 2005, the current P&T system had removed 212 kg of uranium and 118.9 g (2.02 Ci) of technetium-99. Including the 1985 P&T action, an estimated 899 kg of uranium had been removed from parts of the uranium plume. The 200-UP-1 P&T system was restarted on April 19, 2007, at the request of the DOE Richland Operations Office. The restart focused on the two existing extraction wells (299-W19-36 and 299-W19-43) where uranium concentrations remained greater than 300 µg/L. The system operated for the remainder of FY 2007, extracting at an average of 43.2 L/min (11.4 gpm), and continued operation in FY 2008, extracting a total of 13.5 million L (3.6 million gal) of groundwater. Due to a pump failure in late April 2008, extraction well 299-W19-43 was taken offline and remained nonoperational until late July 2008. Both wells operated until August 8, 2008, at which time they were shut down for the remainder of the FY 2008 to support equipment upgrades at the ETF.

Six new wells were drilled in FY 2006 within the larger area of the 200-UP-1 OU as part of the remedial investigation/feasibility study work plan (DOE/RL-92-76). Two of the boreholes (299-W19-105 and 299-W19-107) were drilled in areas around the P&T system but beyond the system's impact to contaminant plumes. Well 299-W22-69 was installed east of the S Tank Farm, wells 299-W22-72 and 299-W22-86 were installed east of the SX Tank Farm, and well 299-W22-87 was installed just west of the 216-U-12 Crib.

Six additional groundwater monitoring wells were installed in 2008 in the 200-UP-1 OU to fulfill the need for additional spatially distributed groundwater data to successfully complete the remedial investigation. Depth and monitoring requirements are identified in the remedial investigation/feasibility study work plan (DOE/RL-92-76). The wells were installed beginning in February 2008, with the last

well sample-ready in May 2008. The well identification numbers are 299-W22-88, 699-33-76, 699-33-74, 699-34-72, 699-33-75, and 699-32-76. Groundwater samples were collected at depth-discrete intervals (approximately 9.1 m [30 ft]) in each well during drilling and were analyzed for technetium-99 and volatile organics. Only limited contamination was found at depth in any of the wells, and subsequently the well screens were constructed at the top of the aquifer and were approximately 10.7 m (35 ft) in length. Two of the six new wells were drilled to the top of the Ringold Formation lower mud unit, and the remaining wells were drilled to 36.6 m (120 ft) below the water table.

Extraction well rehabilitation was initiated in 2010 to address reduced production from the P&T system from that of previous years. The first round of rehabilitation consisted of acid wash to remove calcium carbonate scale from wells 299-W19-43 and 299-W19-36. Rehabilitation was initiated in March 2010 and the wells came online in May. In June, a second rehabilitation of the wells was performed using the airburst method. The wells were restarted again in August and operated for the remainder of the year. Production from the wells was not appreciably improved after rehabilitation was completed.

At the start of 2011, well 299-W19-43 was operational, but the low output recognized earlier continued. The extraction pump in well 299-W19-36 ceased operating on November 13, 2010, and did not operate during 2011. EPA and DOE agreed to terminate the 200-UP-1 P&T operation due to the cost of repairs/replacement of inoperable well 299-W19-36, low production from well 299-W19-43, and the resulting ineffective capture zone. The system was shut down as of March 30, 2011.

For additional site characterization and background information on 200-UP-1 OU and P&T activities, refer to the following documents:

- BHI-00187, *Engineering Evaluation/Conceptual Plan for the 200-UP-1 Groundwater Operable Unit Interim Remedial Measure*
- DOE/RL-92-76, *Remedial Investigation/Feasibility Study Work Plan for the 200-UP-1 Groundwater Operable Unit*
- DOE/RL-97-36, *200-UP-1 Groundwater Remedial Design/Remedial Action Work Plan*

Information regarding the progress of 200-UP-1 P&T operations is provided in the following documents:

- BHI-00951, *200-UP-1 Groundwater P&T Phase I Annual Report, FY 1996*
- BHI-01126, *Fiscal Year 1997 Annual Report for the 100-NR-2, 200-UP-1, and 200-ZP-1 Pump-and-Treat Operations and Operable Units*
- DOE/RL-99-02, *Fiscal Year 1998 Annual Summary Report for the 200-UP-1, 200-ZP-1, and 100-NR-2 Pump-and-Treat Operations and Operable Units*
- DOE/RL-99-79, *Fiscal Year 1999 Annual Summary Report for the 200-UP-1, 200-ZP-1, and 100-NR-2 Pump-and-Treat Operations and Operable Units*
- DOE/RL-2000-71, *Fiscal Year 2000 Annual Summary Report for the 200-UP-1 and 200-ZP-1 Pump-and-Treat Operations*
- DOE/RL-2001-53, *Fiscal Year 2001 Annual Summary Report for the 200-UP-1 and 200-ZP-1 Pump-and-Treat Operations*
- DOE/RL-2002-67, *Fiscal Year 2002 Annual Summary Report for 200-UP-1 and 200-ZP-1 Pump-and-Treat Operations*

- DOE/RL-2003-58, *Fiscal Year 2003 Annual Summary Report for 200-UP-1 and 200-ZP-1 Pump-and-Treat Operations*
- DOE/RL-2004-72, *Fiscal Year 2004 Annual Summary Report for 200-UP-1 and 200-ZP-1 Pump-and-Treat Operations*
- DOE/RL-2005-91, *Fiscal Year 2005 Annual Summary Report for 200-UP-1 and 200-ZP-1 Pump-and-Treat Operations*
- DOE/RL-2006-73, *Fiscal Year 2006 Annual Summary Report for 200-UP-1 and 200-ZP-1 Pump-and-Treat Operations*
- DOE/RL-2008-02, *200-UP-1 and 200-ZP-1 Operable Units Pump and Treat Annual Report for FY07*
- DOE/RL-2008-77, *200-UP-1 and 200-ZP-1 Operable Units Pump-and-Treat System Annual Report for Fiscal Year 2008*
- DOE/RL-2010-11, *Hanford Site Groundwater Monitoring and Performance Report for 2009: Volumes 1 & 2*
- DOE/RL-2011-26, *Calendar Year 2010 Annual Summary Report for the 200-ZP-1 and 200-UP-1 Operable Unit Pump-and-Treat Operations*
- WMP-30847, *200-UP-1 Operable Unit Rebound Study Report*

A2 200-ZP-1 Operable Unit

A2.1 Waste Site Operational History

The 216-Z-9 Trench received organic and aqueous waste from the Reclamation of Uranium and Plutonium by Extraction (RECUPLEX) process at the Plutonium Finishing Plant (PFP) between 1955 and 1962. The RECUPLEX process used solvent extraction to recover plutonium from plutonium metal and compound scraps. Tributyl phosphate, mixed 15 to 20 percent by volume with carbon tetrachloride, removed plutonium in the exchange process from inorganic acid feed (HNF-EP-0924, *History and Stabilization of the Plutonium Finishing Plant [PFP] Complex, Hanford Site*). The plutonium was then removed from the tributyl phosphate/carbon tetrachloride organic solution and converted to plutonium nitrate, which became part of the feed for the refining process at PFP. The tributyl phosphate/carbon tetrachloride solution was treated and then discharged to the soil column at the 216-Z-9 Trench.

Scrap reprocessing was next performed at the 236-Z Plutonium Reclamation Facility between 1964 and 1987 (HNF-EP-0924). Wastes were sent to the soil column at the 216-Z-1A tile field between 1964 and 1969 and to the 216-Z-18 Crib between 1969 and 1973. After 1973, organic mixtures containing carbon tetrachloride wastes were used but were no longer discharged to the soil column.

In addition to the above, the 242-Z Waste Treatment Facility (operating between 1963 and 1976) was involved with the recovery of americium-241 and plutonium in an IX batch process using 30 percent dibutyl butyl phosphonate and 70 percent carbon tetrachloride between 1964 and 1970. Wastes from this process were also discharged to the disposal sites receiving Plutonium Reclamation Facility waste.

From the above sources, carbon tetrachloride was discharged to the ground during operations at PFP between 1955 and 1973. Estimated quantities of carbon tetrachloride discharged to the waste sites vary between 363,000 to 580,000 L (95,900 to 153,200 gal, or 577,000 to 922,000 kg) of liquid carbon tetrachloride. The waste was discharged primarily to three sites: 216-Z-1A (268,000 kg/168,600 L),

216-Z-9 (471,000 kg/296,300 L), and 216-Z-18 (173,800 kg/109,300 L) between 1955 and 1973 (DOE/RL-96-81, *Waste Site Grouping for 200 Areas Soil Investigations*). Three other sites (216-T-19 Crib, 216-Z-12 Crib, and 216-Z-19 Ditch) are known or suspected to have received lesser quantities of carbon tetrachloride and were active between 1959 and 1981.

Over 2,700,000 kg of nitrate were also discharged to the six sites. A nitrate plume has formed roughly coincident with that part of the carbon tetrachloride plume north of the waste sites.

Chloroform, a secondary COC for the interim remedial measure, may be a degradation product of carbon tetrachloride (PNNL-13560, *Assessment of Carbon Tetrachloride Groundwater Transport in Support of the Hanford Carbon Tetrachloride Innovative Technology Demonstration Program*). Chloroform (80 µg/L DWS) is also associated with septic waste disposal. The 2607-Z septic system and drain field (active from 1949 to 1999) are located east of the 234-5Z Building and may have been the source of high chloroform detections (up to 680 µg/L) during vertical profile sampling at well 299-W15-42. The WIDS database reports an estimated discharge in 1992 of 23,000 L/day (6,000 gal/day). The 1996 baseline chloroform plume generally mimicked the outline of the high-concentration baseline carbon tetrachloride plume but at much lower concentrations. In FY 2005, chloroform was detected at wells 299-W15-46 and 299-W15-50 at concentrations above the DWS. Vertical profile sampling at well 299-W15-46 reached 1,100 µg/L, while sampling at well 299-W15-50 encountered chloroform at 119 µg/L.

The origin of trichloroethene (TCE) in waste streams is unknown, but it is thought to have been used as a degreaser. A baseline TCE (5 µg/L DWS) plume was not prepared in 1996 because of low TCE concentrations at carbon tetrachloride monitoring wells. Since 1996, the TCE plume has been detected as extending from around the 234-5 Z Plant, north to the T Tank Farm. Previously, the TCE plume was centered around wells 299-W15-34 and 299-W15-35. In FY 2006, the plume was the most concentrated around wells 299-W15-50 and 299-W15-40. A southern extension (to well 299-W15-50) was also indicated in FY 2006, which is halfway between the 216-Z-9 Trench and 216-T-19 Cribs.

A2.2 Remediation Treatment Activities

Carbon tetrachloride was first detected in groundwater samples from several wells in 1986 (PNL-6120, *Environmental Monitoring at Hanford for 1986*) and was recognized as a broad plume beneath the 200 West Area in 1987. The characterization activities led to a request by the regulatory agencies that DOE assess carbon tetrachloride in the vadose zone (200-ZP-2, currently 200-PW-1) and evaluate alternatives to treat the contaminant. Subsequently, the *Expedited Response Action Proposal (EE/CA & EA) for 200 West Carbon Tetrachloride Plume* (DOE/RL-91-32) was prepared. Soil vapor extraction (SVE) was implemented at the 216-Z-9 Trench, 216-Z-1A tile field, and 216-Z-18 Crib. Initially, one system was built and operated for each of the three waste sites. Currently, operations are conducted between March 1 and October 31 each year. Also, passive SVE systems have been installed at eight boreholes around the 216-Z-18 Crib. The *Performance Evaluation Report for Soil Vapor Extraction Operations at the 200-PW-1 Carbon Tetrachloride Site, Fiscal Year 2005* (WMP-30426) provides information on SVE site operations and vadose zone conditions.

The *200 West Area Groundwater Aggregate Area Management Study Report* (DOE/RL-92-16) discussed the groundwater carbon tetrachloride plume and recommended it for expedited response action. This was implemented when the regulators requested that DOE assess groundwater contamination and evaluate alternatives for carbon tetrachloride contamination in the 200 West Area. The *Treatability Test Plan for the 200-ZP-1 Operable Unit* (DOE/RL-94-12) proposed and implemented a P&T system, which later became Phase I for the 200-ZP-1 OU.

The 200-ZP-1 P&T system was implemented in a three-phased approach. Phase I operations consisted of a pilot-scale treatability test between August 29, 1994, and July 19, 1996, around the 216-Z-12 Crib. During this phase, contaminated groundwater was removed through a single extraction well (299-W18-1) at a rate of approximately 151 L/min (40 gpm), treated using GAC, and then returned to the aquifer through an injection well (299-W18-4). For more detailed information about operations during the treatability test, refer to the *200-ZP-1 Operable Unit Treatability Test Report* (DOE/RL-95-30).

Concurrent with Phase I operations, the *Record of Decision for the USDOE Hanford 200-ZP-1 Operable Unit, 200 Area NPL Site Interim Remedial Measure* (EPA/ROD/R10-95/114) was issued in June 1995. The selected remedy was to use groundwater P&T technology to minimize further migration of carbon tetrachloride, chloroform, and TCE in the groundwater and remove mass.

Phase II operations commenced August 5, 1996, in accordance with the interim action ROD (EPA/ROD/R10-95/114) and Tri-Party Agreement Milestone M-16-04A. The 1996 groundwater plume was the basis for the interim action ROD. The well field configuration during Phase II operations consisted of three extraction wells (299-W15-33, 299-W15-34, and 299-W15-35) pumping at a combined rate of approximately 570 L/min (150 gpm) and a single injection well (299-W15-29). Groundwater was treated using an air stripper to release carbon tetrachloride into a vapor phase, and GAC was used to collect the vapor. For a detailed description of the treatment system setup and operation, refer to the *200-ZP-1 Interim Remedial Measure Quarterly Report: October – December 1996* (BHI-00952-02). Phase II operations were terminated on August 8, 1997, in preparation for Phase III operations.

Phase III operations began on August 29, 1997, satisfying Tri-Party Agreement Milestone M-16-04B. The well field for Phase III operations was expanded to include six extraction wells (existing, plus new wells 299-W15-32, 299-W15-36, and 299-W15-37) and five injection wells (existing, plus 299-W18-36, 299-W18-37, 299-W18-38, and 299-W18-39). The total pumping rate was increased to more than 800 L/min (200 gpm) versus a total treatment system capacity of 1,900 L/min (500 gpm). The treatment process for the Phase III system uses the same air-stripping and GAC systems for remediating contaminated groundwater. Extraction wells were installed to contain the high-concentration portion of the carbon tetrachloride plume located near the PFP, as required by the interim action ROD (EPA/ROD/R10-95/114). The southernmost extraction well, 299-W15-37, was converted to a monitoring well in January 2001 because of its limited impact on hydraulic capture of the high-concentration portion of the plume (DOE/RL-2001-53).

In late July 2005, four monitoring wells were converted to extraction wells and connected to the 200-ZP-1 P&T system. These four wells (299-W15-765, 299-W15-40, 299-W15-43, and 299-W15-44) improved hydraulic control over a lobe of the carbon tetrachloride plume extending west of the TX-TY Tank Farms and north of the baseline plume. Carbon tetrachloride concentrations at these wells ranged from 1,400 to 3,800 µg/L during the previous 2 to 3 years. Extraction rates averaged approximately 42 L/min (11 gpm) at wells 299-W15-40 and 299-W15-44 and between 150 to 210 L/min (40 to 55 gpm) at wells 299-W15-43 and 299-W15-765 in FY 2005. For FY 2006, extraction rates generally declined. Modifications were made in-plant to improve overall treatment rates, and the system's throughput was increased to 1,320 L/min (350 gpm).

A major characterization effort was started in FY 2004 to determine if a dense nonaqueous phase liquid (DNAPL) mass was present in the aquifer. The DOE solicited proposals and awarded a contract to Vista Engineering Technologies, LLC, to perform a series of studies to assess the distribution of carbon tetrachloride in the aquifer and vadose zone. Aquifer tests and a series of surface, shallow, and deep sediment tests were conducted during FY 2006. The *Carbon Tetrachloride Dense Non-Aqueous Phase*

Liquid (DNAPL) Source Term Interim Characterization Report (DOE/RL-2006-58) was released in September 2006 and amended in April 2007 (DOE/RL-2007-22, *Carbon Tetrachloride Dense Non-Aqueous Phase Liquid [DNAPL] Source Term Characterization Report Addendum*). In FY 2006, as part of the project scope, well 299-W15-6 was connected to the P&T system and pumping started on September 28, 2006. The well operated for 3 months to determine if high concentrations of carbon tetrachloride were present deep in the unconfined aquifer.

Borehole 299-W15-46 was drilled at the southern edge of the 216-Z-9 Trench to evaluate carbon tetrachloride distribution within the vadose and saturated zones. A significant mass of the contaminant was encountered throughout the vadose zone, down to the top of the Cold Creek unit (caliche zone). Smaller concentrations of carbon tetrachloride were found from below the caliche zone to the water table. The concentration of carbon tetrachloride within the unconfined aquifer was as great as 3,800 µg/L, but none was detected in the lower 14 m (46 ft) of sediments above the basalt. The *Borehole Summary Report for Well 299-W15-46 (C3426) Drilled at the 216-Z-9 Trench* (WMP-26264) was prepared for this well.

Elevated technetium-99 concentrations were found in wells 299-W15-44 and 299-W15-765 in the fourth quarter of FY 2005 and increased throughout FY 2006. In addition, a major increase was observed at well 216-W15-763. In FY 2007, technetium-99 concentrations peaked at both wells in the first quarter. Concentrations then declined noticeably at well 299-W15-765 and stabilized at approximately 2,100 pCi/L at well 299-W15-44. Minor increases were also observed at wells 299-W15-40 and 299-W10-26.

An IX system was installed at the well heads for 299-W15-44 and 299-W15-765 in April 2007. The system used a Purolite® resin to extract technetium-99 from the groundwater from these wells. The system was designed to reach breakthrough within several months of operations. Failure of a fitting at well 299-W15-765 in May 2007 led to a 7-week shutdown at that well and a 4-week shutdown at well 299-W15-44. Once resolved, the systems operated as expected. Breakthrough was not observed until October 2007. This system was shut down in December 2007 after completion of testing.

The RCRA actions were initiated around the T Tank Farm in FY 2005 following an increasing technetium-99 trend at well 299-W11-39. Although an interim ROD value was not established for the 200-ZP-1 OU, the trend triggered a response to investigate the site. A series of boreholes drilled between 2005 and 2007 characterized and located a low-concentration technetium-99 plume extending northeast of the T Tank Farm. Based on recommendations in DOE/RL-2006-20, actions were taken to control this plume. Two wells with the most elevated technetium-99 concentrations (299-W11-45 and 299-W11-46) were connected to a pipeline feeding to the ETF. The system was installed and operational by mid-September 2007, extracting groundwater at an estimated rate of approximately 102 L/m (27 gpm). Flow meters were added in early October 2007, and the extraction rate was increased to approximately 182 L/min (48 gpm).

In mid-May 2008, four monitoring wells (299-W15-1, 299-W15-7, 299-W15-11, and 299-W15-46) were converted to extraction wells to expand the 200-ZP-1 P&T throughput. The conversion and tie-in were completed in August 2008. Testing was initiated in August and completed in September 2008, demonstrating that the 200-ZP-1 treatment facility and control room were successfully upgraded to accommodate a flow capacity of 1,900 L/min (500 gpm). During the demonstration, three of the four new extraction wells achieved maximum sustainable flow rates. Following the demonstration, the system was temporarily shut down and two of the new extraction well discharge lines were re-routed directly to the 200-ZP-1 process building, allowing for maximum sustainable flow rates from all four extraction wells.

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In 2010, well 299-W15-44 was removed from the extraction network and was designated as a monitoring well. At the same time, new 200 West Area extraction well 299-W15-225 (about 51 m [167 ft] away) was added to the well network, thereby maintaining 14 extraction wells at the P&T system.

During 2011, wells 299-W15-47, 299-W15-36, 299-W15-40, 299-W15-6, and 299-W15-765 were taken offline from the extraction well network due to low water levels and/or failed pumps.

By the end of 2011, the 200-ZP-1 P&T system removed a total of 13,503 kg of carbon tetrachloride from groundwater, 792 kg of which was recovered during 2011.

For additional site characterization and background information on the 200-ZP-1 OU and the P&T activities, refer to the following documents:

- BHI-00110, *Engineering Evaluation/Conceptual Plan for the 200-ZP-1 Operable Unit Interim Remedial Measure*
- BHI-01311, *Hydrogeologic Conceptual Model for the Carbon Tetrachloride and Uranium/ Technetium Plumes in the 200 West Area: 1994 Through 1999 Update*
- DOE/RL-96-07, *200-ZP-1 IRM Phase II and III Remedial Design Report*

Information regarding the progress of 200-ZP-1 P&T operations is provided in the following documents:

- BHI-01126, *Fiscal Year 1997 Annual Report for the 100-NR-2, 200-UP-1, and 200-ZP-1 Pump-and-Treat Operations and Operable Units*
- DOE/RL-95-30, *200-ZP-1 Operable Unit Treatability Test Report*
- DOE/RL-99-02, *Fiscal Year 1998 Annual Summary Report for the 200-UP-1, 200-ZP-1, and 100-NR-2 Pump-and-Treat Operations and Operable Units*
- DOE/RL-99-79, *Fiscal Year 1999 Annual Summary Report for the 200-UP-1 and 200-ZP-1 Pump-and-Treat Operations and Operable Units*
- DOE/RL-2000-71, *Fiscal Year 2000 Annual Summary Report for the 200-UP-1 and 200-ZP-1 Pump-and-Treat Operations*
- DOE/RL-2001-53, *Fiscal Year 2001 Annual Summary Report for the 200-UP-1 and 200-ZP-1 Pump-and-Treat Operations*
- DOE/RL-2002-67, *Fiscal Year 2002 Annual Summary Report for 200-UP-1 and 200-ZP-1 Pump-and-Treat Operations*
- DOE/RL-2003-58, *Fiscal Year 2003 Annual Summary Report for 200-UP-1 and 200-ZP-1 Pump-and-Treat Operations*
- DOE/RL-2004-72, *Fiscal Year 2004 Annual Summary Report for 200-UP-1 and 200-ZP-1 Pump-and-Treat Operations*
- DOE/RL-2005-91, *Fiscal Year 2005 Annual Summary Report for 200-UP-1 and 200-ZP-1 Pump-and-Treat Operations*
- DOE/RL-2006-73, *Fiscal Year 2006 Annual Summary Report for 200-UP-1 and 200-ZP-1 Pump-and-Treat Operations*

- DOE/RL-2008-02, *200-UP-1 and 200-ZP-1 Operable Units Pump and Treat Annual Report for FY07*
- DOE/RL-2008-77, *200-UP-1 and 200-ZP-1 Operable Units Pump-and-Treat System Annual Report for Fiscal Year 2008*
- DOE/RL-2010-11, *Hanford Site Groundwater Monitoring and Performance Report for 2009: Volumes 1 & 2*
- DOE/RL-2011-26, *Calendar Year 2010 Annual Summary Report for the 200-ZP-1 and 200-UP-1 Operable Unit Pump-and-Treat Operations*

A3 Calculation of 200-UP-1 and T Tank Farm Groundwater Extraction Well Production and Contaminant Removal

Extracted groundwater from both the T Tank Farm wells and the 200-UP-1 P&T system (when it was operational) is sent to LERF basin 43 prior to treatment at the ETF. Water from LERF basin 43 is then pumped to an influent tank at the ETF in batches and sampled. Following treatment, the processed water is pumped to an effluent tank and sampled. Following analytical verification that all release standards have been met, the treated water is discharged to the ground at the State-Approved Land Disposal Site. Comparison of influent and effluent tank concentrations determines the mass of contaminants removed, undifferentiated with respect to the source of the contaminants. The influent concentrations for the retention basin and the effluent concentrations after treatment at the ETF indicate that a majority of uranium, technetium-99, carbon tetrachloride, and nitrate is removed by the treatment system.

To calculate the amounts of groundwater pumped and contaminants removed, operators manually record the flow totalizer values and the time of each reading for each well on a daily basis on a standard form in accordance with accepted operating procedures. The totalizer data are used to calculate the total flow from each well for the reporting period.

The extraction wells (299-W19-36 and 299-W19-43 at 200-UP-1 when the system operated, and 299-W11-45 and 299-W11-46 at the T Tank Farm) are sampled each quarter, to provide a defensible data set. The analytical results are entered into the Hanford Environmental Information System database.

The average concentrations for each extraction well and the total volume of groundwater pumped during each period are used to calculate the mass of the contaminants removed and are reported in either Table 2-1 or Table 3-2 in the main text discussion of this report.

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Appendix B

Treatment System Performance

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B Treatment System Performance

This appendix presents supplementary data to support the discussion in Chapters 2 and 3 for this calendar year (CY) 2011 annual report. The figures and tables in this appendix compare and summarize trends in the 200-UP-1 and 200-ZP-1 Operable Unit (OU) pump-and-treat (P&T) systems for 2011 versus previous years.

B1 200-UP-1 U Plant Pump-and-Treat System Performance

Figures B-1 through B-3 compare the mass of uranium, technetium-99, carbon tetrachloride, and nitrate removed to the volume of groundwater extracted since startup of the 200-UP-1 P&T system in 1994 through the termination of the operation on March 30, 2011.

Table B-1 presents a summary by year of the volume of groundwater treated and the mass of the primary and secondary contaminants removed by the extraction wells. The analytical results for uranium, technetium-99, carbon tetrachloride, and nitrate from extraction and baseline monitoring wells at the 200-UP-1 P&T system are provided in Chapter 2 of the main text.

The volume of water extracted and mass of contaminants removed from the aquifer, as listed in Table B-1 and shown in Figures B-1 through B-3, are different for fiscal year (FY) 2009, October 2009 to December 2009, and CY 2010 from the data presented in Appendix B of the previous annual report, *Calendar Year 2010 Annual Summary Report for the 200-ZP-1 and 200-UP-1 Operable Unit Pump-and-Treat Operations* (DOE/RL-2011-26). In the previous report, the volume of water listed as extracted by the U Plant P&T system also included the volume extracted by the system at Waste Management Area (WMA) T within the 200-ZP-1 OU. The water from both systems is pumped to the same basin at the Liquid Effluent Retention Facility, and the total volume from WMA T was not omitted when the U Plant system totals were determined. This situation only affects the data presented in Appendix B of DOE/RL-2011-26; the data listed in the main text were correct.

B2 200-ZP-1 Pump-and-Treat System Performance

Figure B-4 presents the cumulative volume in extracted groundwater versus the cumulative mass recovered of carbon tetrachloride for the 200-ZP-1 P&T system. Table B-2 presents a comparison of treatment volumes and carbon tetrachloride mass removed through 2011.

B3 Reference

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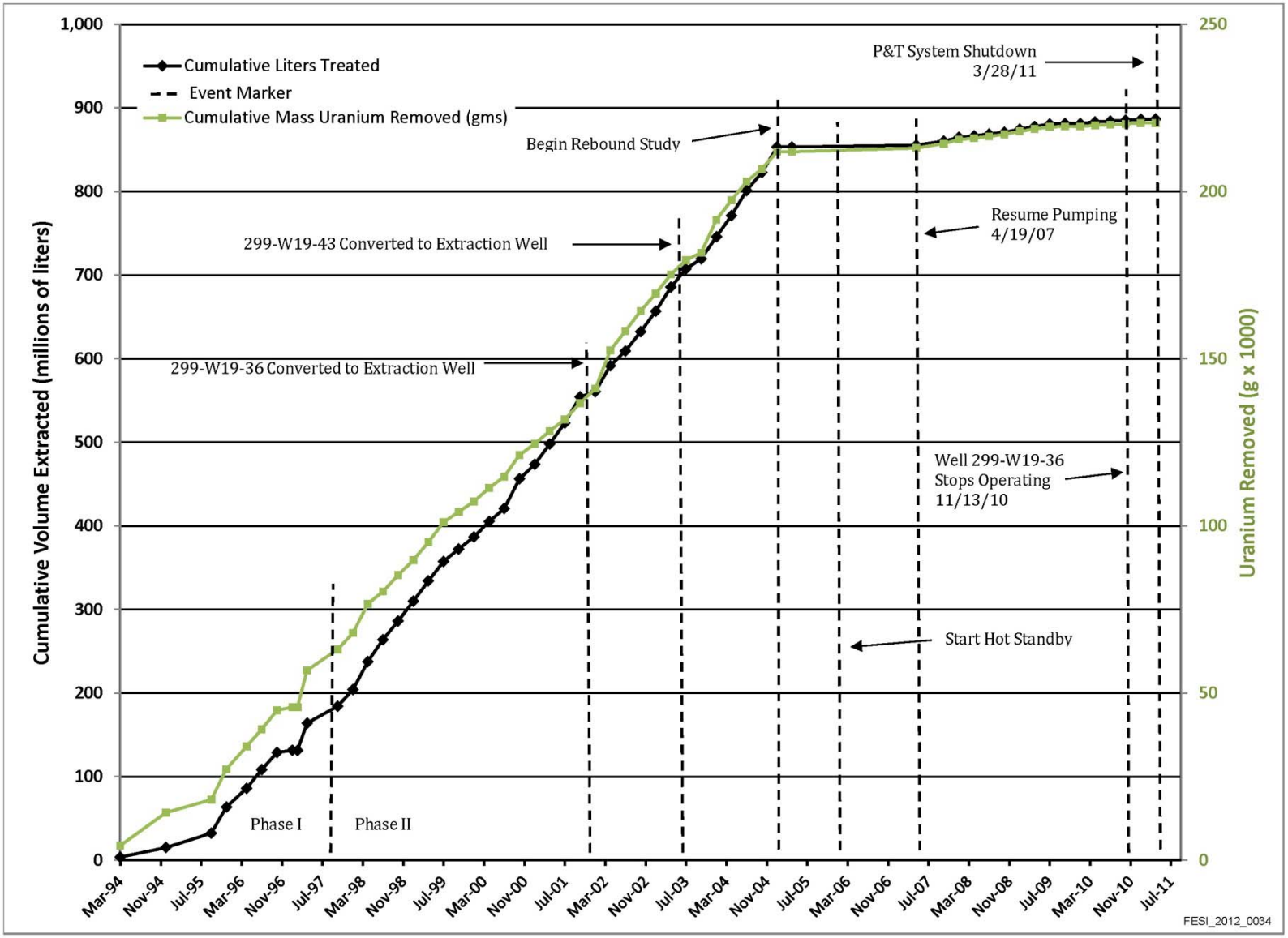

Figure B-1. 200-UP-1 P&T System Cumulative Groundwater Treated Versus Uranium Extracted in 2011

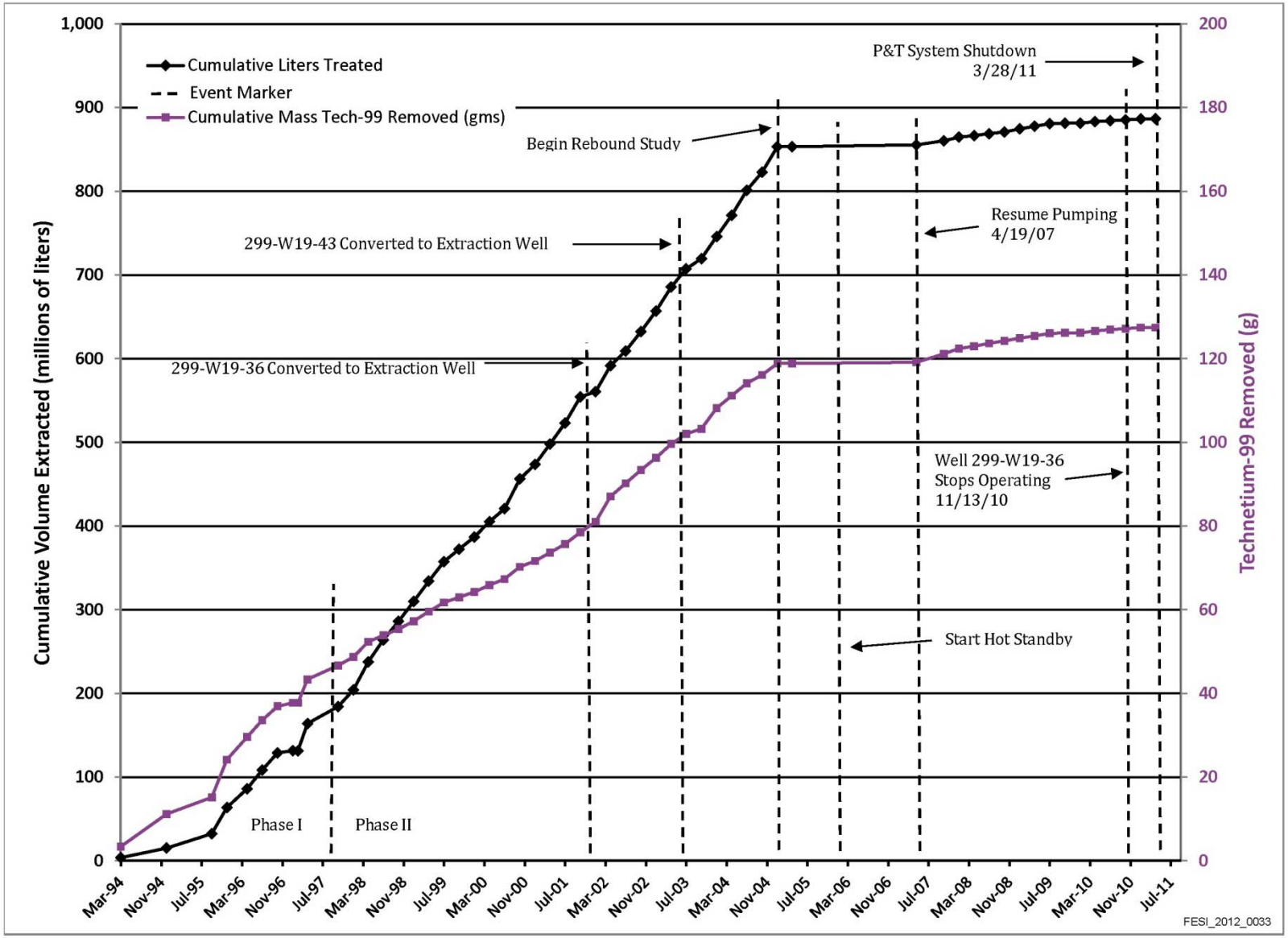

Figure B-2. 200-UP-1 P&T System Cumulative Groundwater Treated Versus Technetium-99 Extracted in 2011

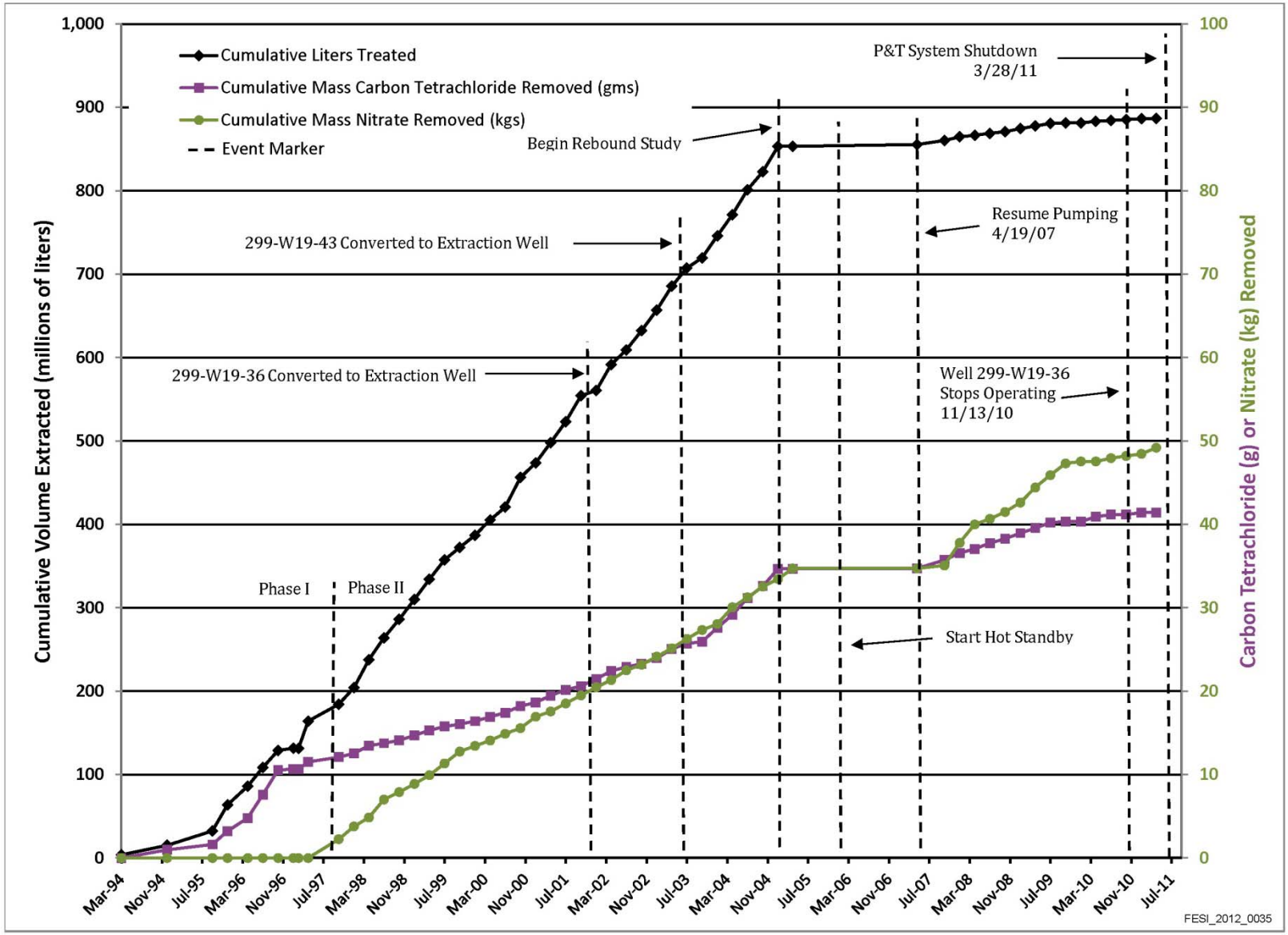

Figure B-3. 200-UP-1 P&T System Cumulative Groundwater Treated Versus Carbon Tetrachloride and Nitrate Extracted in 2011

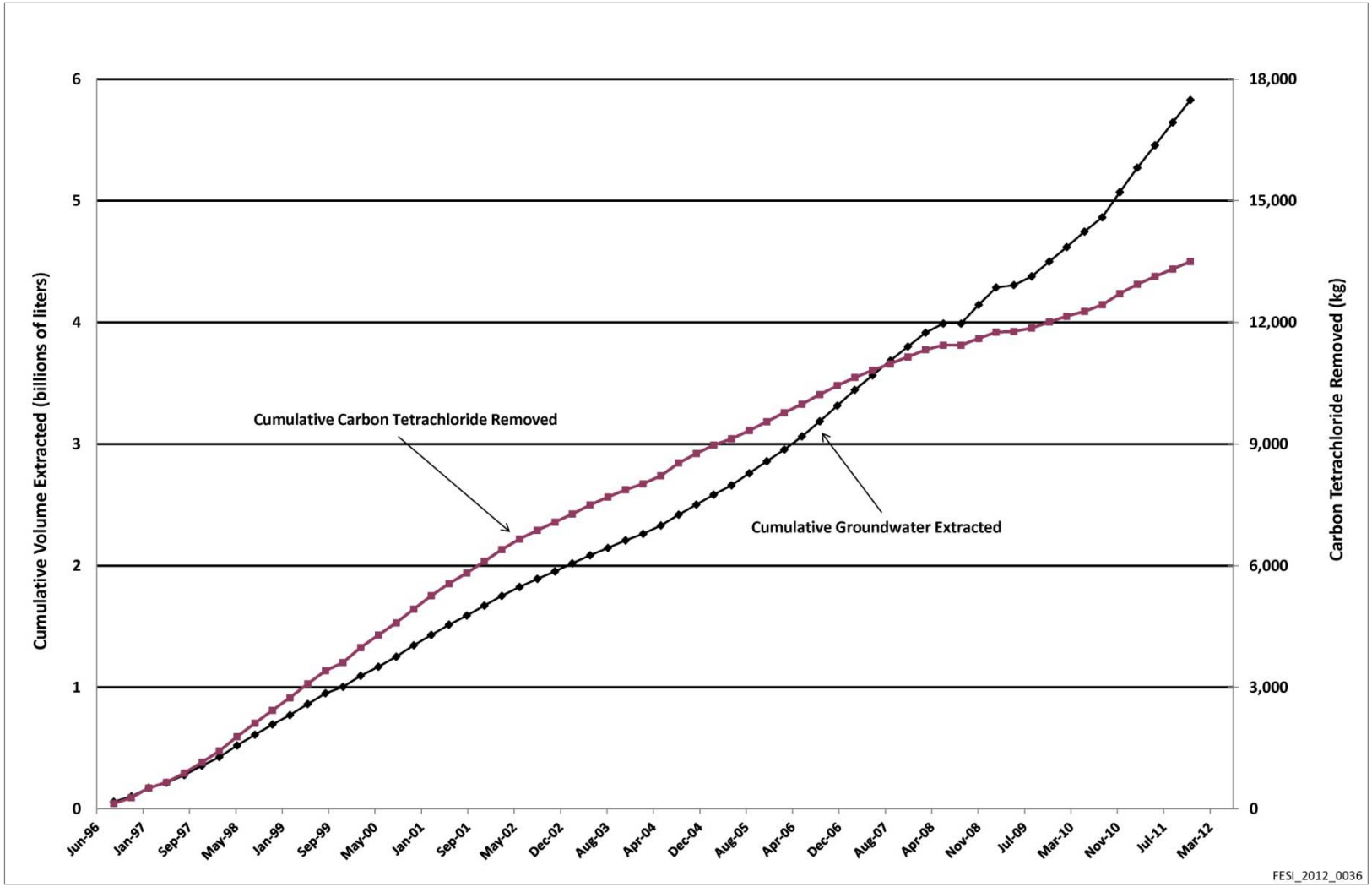

Figure B-4. 200-ZP-1 P&T System Cumulative Groundwater Treated Versus Carbon Tetrachloride Extracted in 2011

Table B-1. Quantity of Treated Groundwater and Contaminant Mass Removed Since Startup of 200-UP-1 P&T Operations

Reporting Period	Volume Treated (L)	Total Uranium Removed (g)	Tc-99 Removed (g)	Carbon Tetrachloride Removed (g)	Nitrate Removed (kg)
March 1994 – September 1996	108,629,387	39,232	33.6	7,590	0
FY 1997	55,382,081	17,570	9.8	3,941	2,260
FY 1998	100,067,035	23,630	10.5	2,235	5,650
FY 1999	93,471,260	20,700	7.8	2,002	4,859
FY 2000	63,229,380	13,640	5.6	1,659	2,807
FY 2001	102,475,318	17,128	8.4	2,744	3,924
FY 2002	85,886,445	26,420	14.5	2,747	3,686
FY 2003	98,343,000	21,175	11.8	2,799	4,157
FY 2004	93,764,659	23,540	12.1	5,447	5,207
FY 2005	52,125,123	8,877	4.8	3,504	2,166
FY 2006	0	0	0	0	0
FY 2007	2,064,214	1,129	0.27	53	359
FY 2008	13,463,380	3,470	4.5	3,024	6,415
FY 2009	11,909,007	2,861	2.4	2,481	5,825
October 2009 – December 2009	550,960	118	0.10	102	238
CY 2010	4,107,809	773	1.0	852	914
CY 2011	1,113,994	236	0.24	234	734
Totals	**886,583,062**	**220,499**	**127.4**	**41,414**	**49,201**

Table B-2. Quantity of Treated Groundwater and Contaminant Mass Removed Since Startup of 200-ZP-1 P&T Operations

Reporting Period	Volume Treated (L)	Mass of Carbon Tetrachloride Removed (kg)
August 1994 – July 1996	26,676,000	75.9
August 1996 – September 1996	33,232,327	61
FY 1997	218,800,017	750
FY 1998	336,162,100	1,212
FY 1999	340,781,036	1,287
FY 2000	300,403,641	1,183
FY 2001	338,846,428	1,226
FY 2002	301,282,482	1,053
FY 2003	253,601,656	819
FY 2004	274,504,266	840
FY 2005	340,004,371	800
FY 2006	427,714,208	890
FY 2007	498,749,476	758
FY 2008	304,512,329	462
FY 2009	340,616,835	370
October 2009 – December 2009	121,814,077	149
CY 2010	570,220,144	701
CY 2011	757,988,496	792
Totals	**5,785,909,889**	**13,503**

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Appendix C

Historic Plume Maps for the 200-UP-1 Operable Unit U Plant Pump-and-Treat System

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Figure C-5. 200-UP-1 Historical Technetium-99 Plume, 2002 to 2007 ..... C-7

Figure C-6. 200-UP-1 Historical Technetium-99 Plume, 2008 to 2011 ..... C-8

C Historic Plume Maps for the 200-UP-1 Operable Unit U Plant Pump-and-Treat System

C1 Summary

This appendix presents supplementary data to support the discussion presented in Chapter 2 in the main text for this calendar year (CY) 2011 annual report.

Changes in the uranium and technetium-99 plumes due to operation of the 200-UP-1 Operable Unit (OU) U Plant pump-and-treat (P&T) system for 16 of the past 17 years (fiscal year [FY] 1995 through CY 2011) are presented in Figures C-1 through C-6; the FY 1997 plume map has been omitted to conserve space since it is similar to the FY 1995 plume. The input for these plume maps was taken from *200-UP-1 Groundwater Pump-and-Treat Phase I Annual Report, FY 1996* (BHI-00951) and subsequent annual summary reports from 1996 through present. The plumes depicted from the earlier annual reports have not been reinterpreted. As additional wells are added each year, refinement of the plume configuration was possible in subsequent years. The plume configurations and the changes shown for the time period presented have been influenced by a number of factors, including interpretations by individual authors preparing each report and the data available at the time of report preparation. In earlier years, concentration data used to define the plume configuration each year were based on fourth quarter sampling results. After CY 2010, average annual concentration values were used to delineate the uranium and technetium-99 plumes.

Overall, the figures in this appendix demonstrate reduction of uranium and technetium-99 concentrations within the plumes and the reduction in the size of the technetium-99 plume since 1995.

C2 Reference

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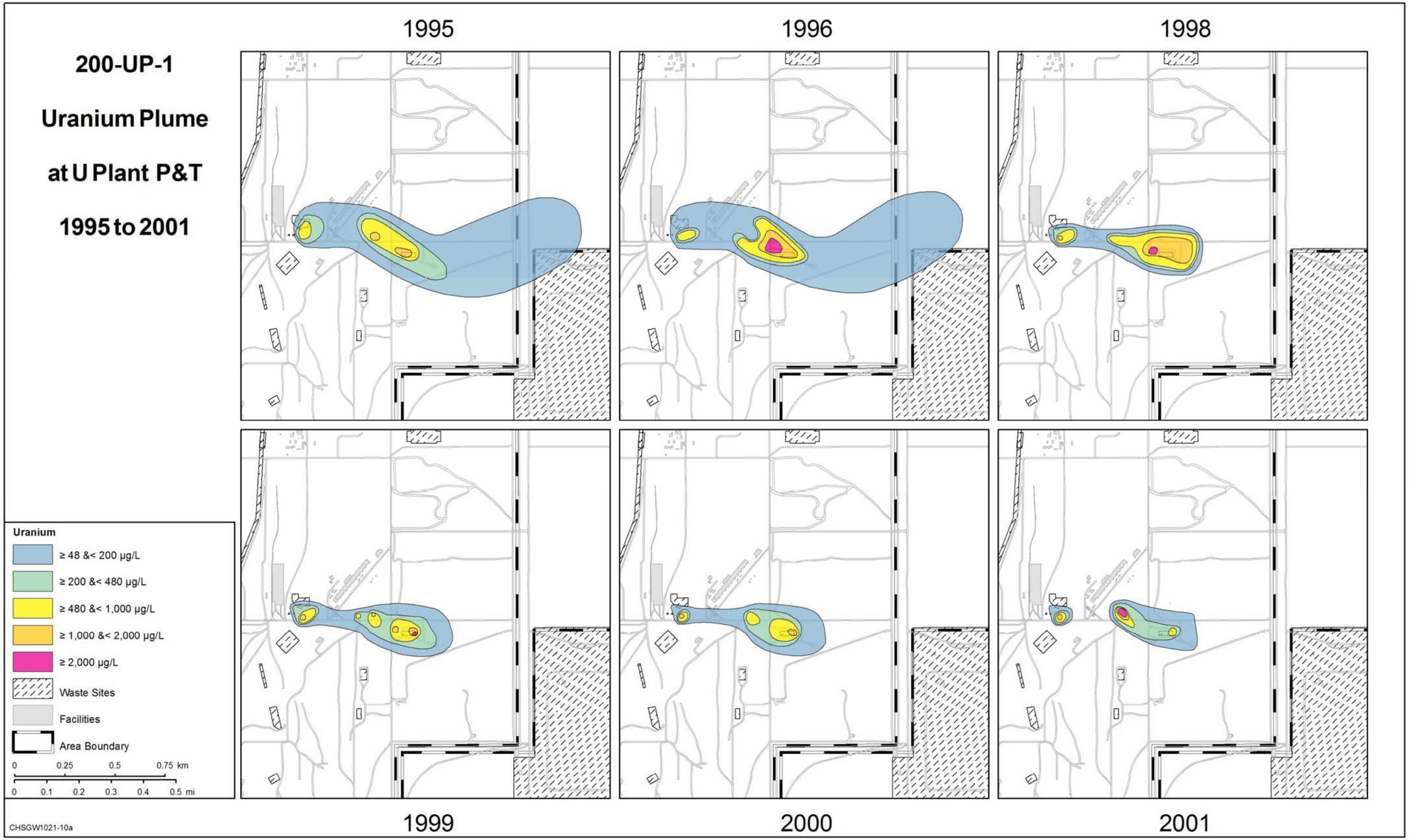

Figure C-1. 200-UP-1 Historical Uranium Plume, 1995 to 2001

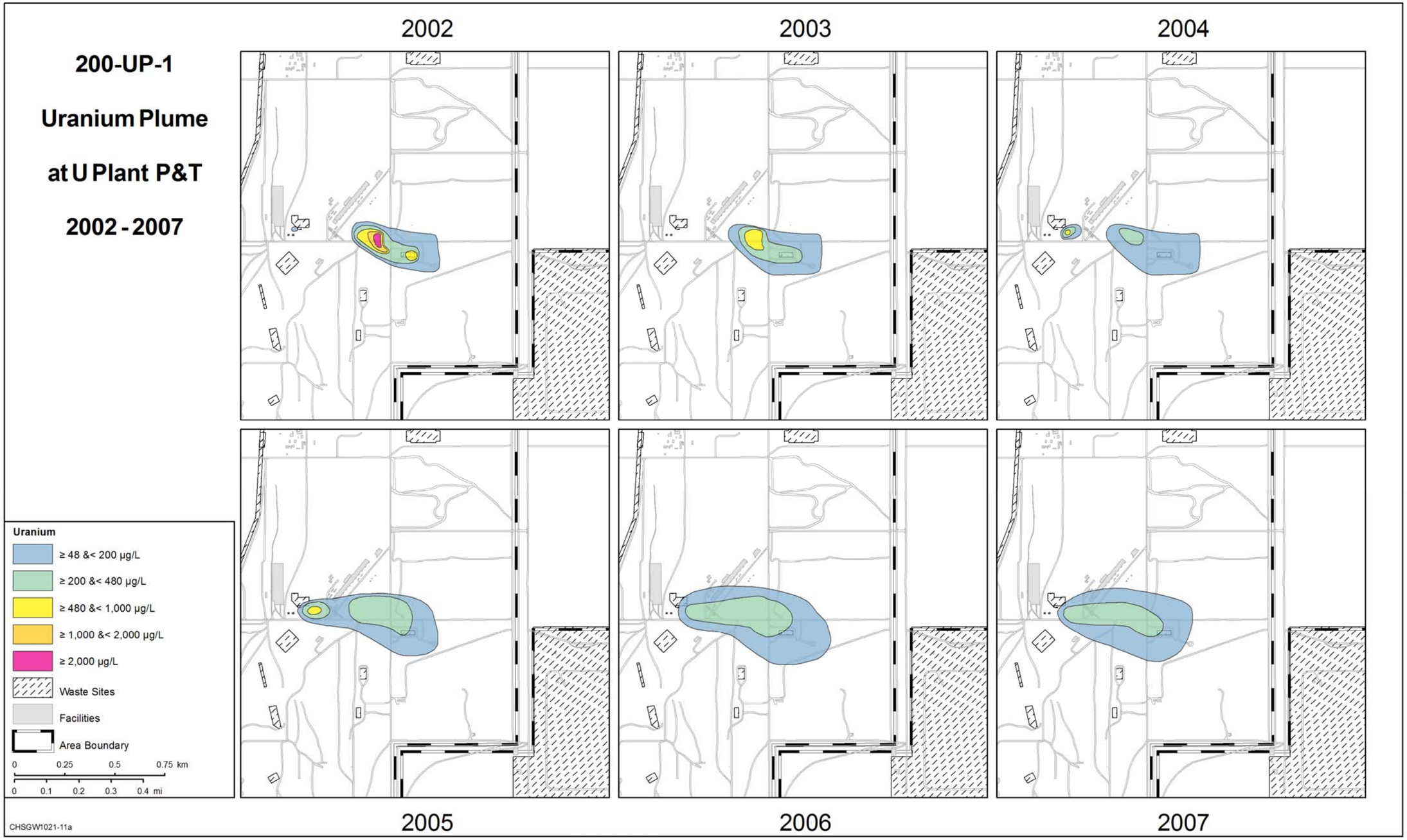

Figure C-2. 200-UP-1 Historical Uranium Plume, 2002 to 2007

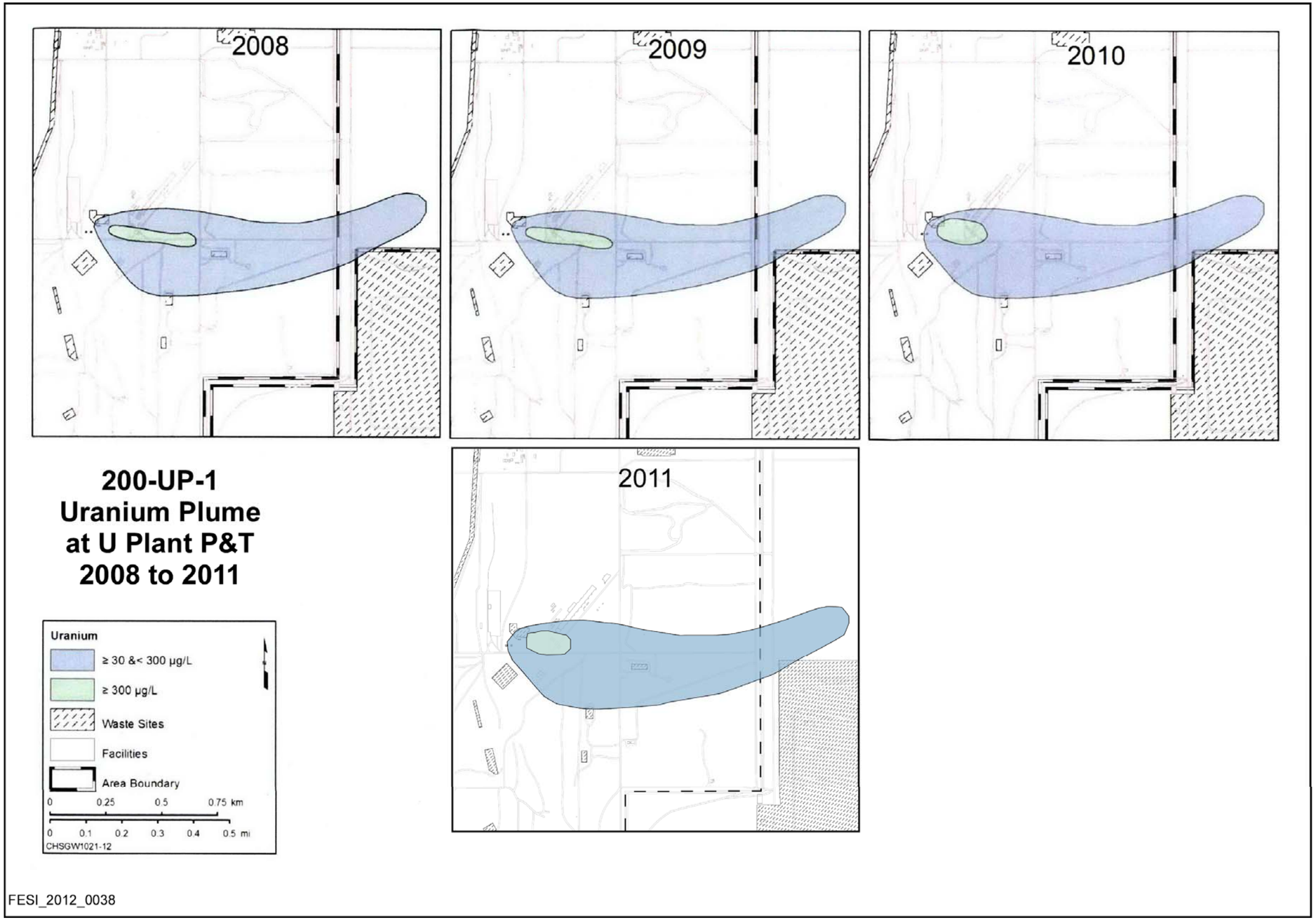

Figure C-3. 200-UP-1 Historical Uranium Plume, 2008 to 2011

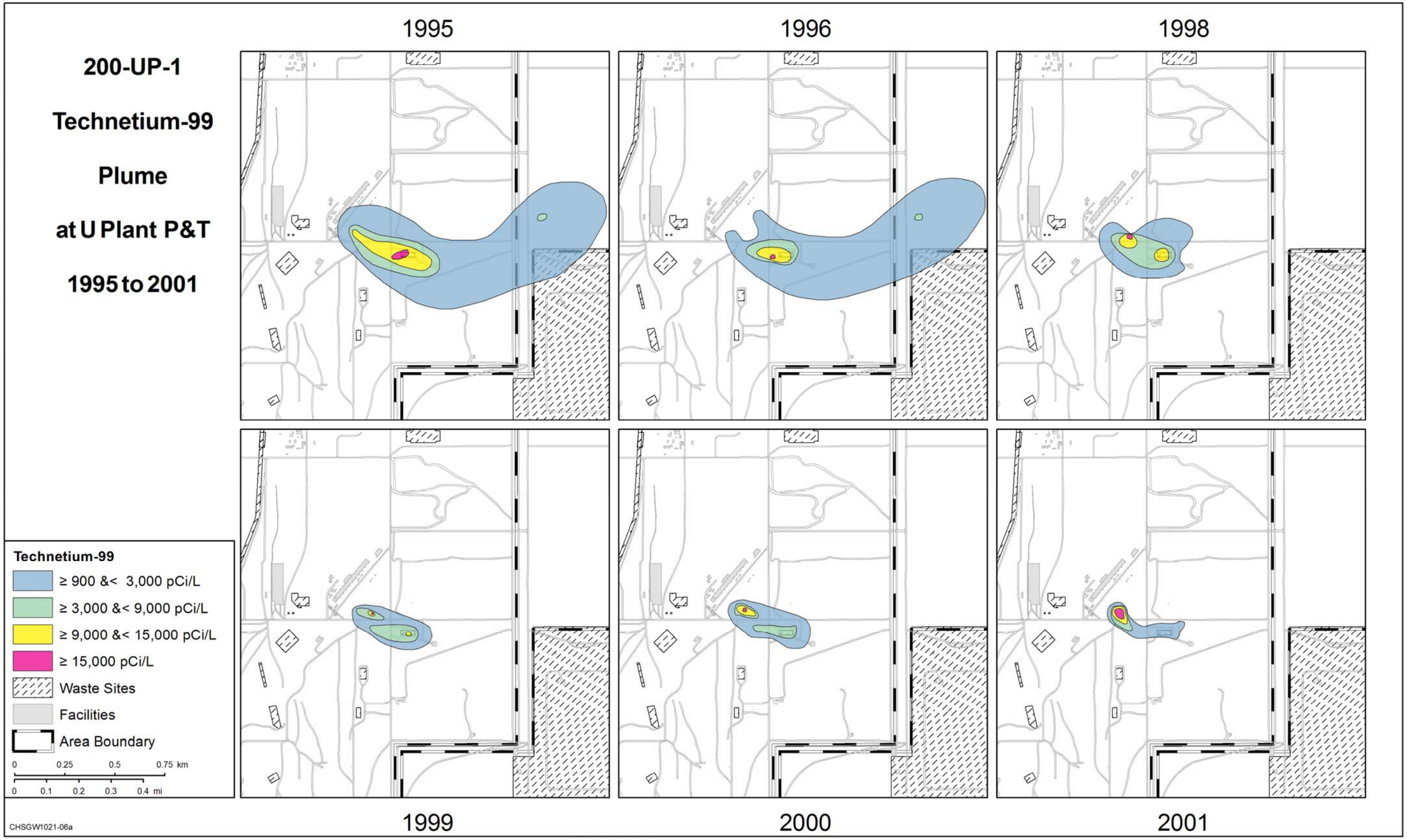

Figure C-4. 200-UP-1 Historical Technetium-99 Plume, 1995 to 2001

Figure C-5. 200-UP-1 Historical Technetium-99 Plume, 2002 to 2007

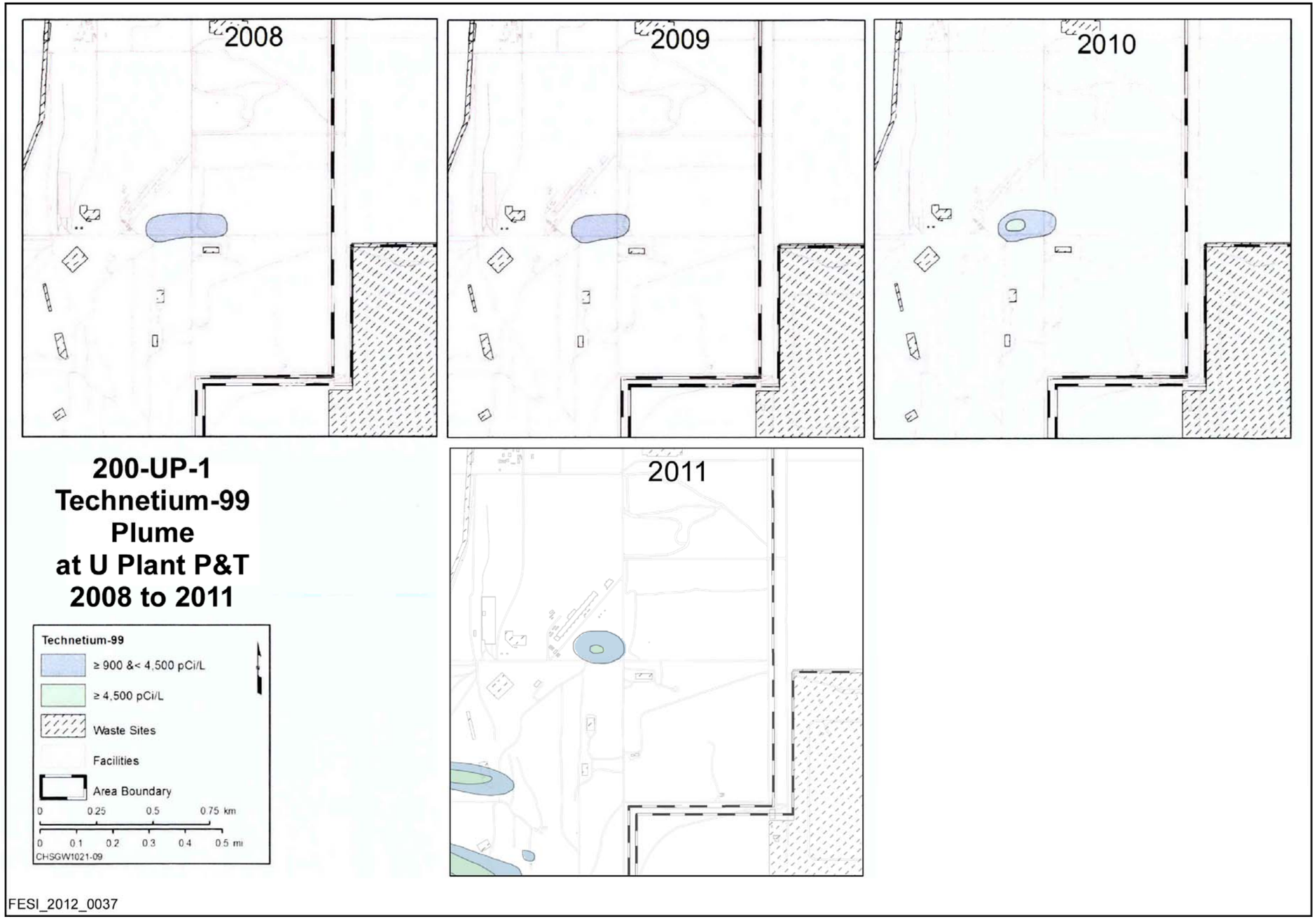

Figure C-6. 200-UP-1 Historical Technetium-99 Plume, 2008 to 2011

Appendix D

Technetium-99 at Well 299-W23-19

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D Technetium-99 at Well 299-W23-19

This appendix presents a discussion of the interim remedy for technetium-99 being performed at well 299-W23-19, including the history of the project and the activities that occurred during calendar year (CY) 2011.

D1 Project History

Groundwater monitoring well 299-W23-19 was drilled near the southwest corner of the SX Tank Farm in the 200-UP-1 Groundwater Operable Unit (OU) during August and September 1999. The boring was originally intended only for vadose zone characterization, but when high concentrations of technetium-99 were found in groundwater grab samples, a decision was made to use this well for long-term groundwater monitoring. Well 299-W23-19 was completed in November 1999, and the first analytical results for technetium-99 averaged 45,000 pCi/L.

In a letter dated May 31, 2001, to the U.S. Department of Energy (DOE), the Washington State Department of Ecology (Ecology) noted the elevated concentrations and requested an evaluation of interim measures for the groundwater ("Washington State Department of Ecology Directs Office of River Protection to Evaluate Interim Measures to Remediate High Level of Technetium-99 in Groundwater Associated with SX Waste Management Area Well 299-W23-19" [Uziemblo, 2001]). The DOE authorized CH2M HILL Hanford Group, Inc., to evaluate three options for groundwater treatment:

- **Option 1:** Using a skid-mounted pump-and-treat (P&T) system with reinjection of treated water.
- **Option 2:** Hauling pumped groundwater in tanker trucks to the Effluent Treatment Facility (ETF) for treatment.
- **Option 3:** Constructing a pipeline from the SX Tank Farm to the 200-UP-1 U Plant P&T site where the pipe could be tied into the existing pipeline for conveyance to the ETF.

The study estimated the cost of construction and operations and also identified regulatory issues associated with each of the three options. The technical feasibility of the three approaches was predicated based on an unknown but low sustainable groundwater extraction rate from well 299-W23-19, at approximately 11.4 L/min (3 gallons per minute [gpm]). Administrative feasibility issues varied with individual options and included the following:

- Permitting reinjection of groundwater for option 1
- Determining if waste streams and facilities in options 2 and 3 were regulated under the *Resource Conservation and Recovery Act of 1976* or the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
- Determining if groundwater sent to the ETF and/or the 200-UP-1 OU pipeline could be combined for use with existing groundwater streams
- Determining whether the ETF could handle a sustained flow of 208 to 227 L/min (55 to 60 gpm)

A geohydrologic analysis of the technetium-99 plume at well 299-W23-19 was conducted, which included performing a pumping test and numerical modeling of changes in plume configuration in response to pumping. The pumping test was conducted December 13-20, 2001, and the results are reported in *Technetium-99 in Groundwater at Hanford Well 299-W23-19: Options Analysis and*

Recommended Action Report (RPP-10757). The data indicated that a sustainable extraction rate of only 11 to 13 L/min (3 to 3.5 gpm) was possible from the well despite it being screened over an 8.2 m (27 ft)-thick interval. Sampling of groundwater from the well during the 72-hour pumping test, combined with specific conductance meter readings, indicated a fairly uniform distribution of technetium-99 around the well.

Numerical modeling was conducted in 2002 to quantify the effects of extraction on the aquifer and the contaminant plume and to evaluate the possible application of a P&T interim remedial measure (RPP-10757). Many of the aquifer properties were calculated with data based on the pumping test, while other properties were gathered from previous testing at nearby wells. Numerical modeling based on data from the 72-hour pumping test indicated a capture zone extending approximately 30 m (100 ft) around the well.

Due to the expected low sustainable pumping rate from well 299-W23-19, it was determined not to be feasible to convert the well into an extraction well. To perform some remediation of technetium-99, the practice of extended purging during sampling at well 299-W23-19 was agreed to by DOE and Ecology and began in 2003. This agreement was formalized in the *Explanation of Significant Differences for the Interim Action Record of Decision for the 200-UP-1 Groundwater Operable Unit Hanford Site Benton County, Washington* (EPA et al., 2009). After samples are collected from this well each quarter, well purging is continued at a higher flow rate until a minimum of 3,785 L (1,000 gal) of water are removed from the aquifer. The water is then transferred to the ETF for treatment and disposal. The objective of this practice is to reduce the technetium-99 concentration in the aquifer. This was to continue until four consecutive quarterly sample results are less than 9,000 pCi/L or until another remedy is implemented.

Following the initial 45,000 pCi/L average concentration in 1999, technetium-99 concentrations at 299-W23-19 varied between 29,500 and 99,700 pCi/L through fiscal year (FY) 2002. Technetium-99 concentrations spiked to 188,000 pCi/L in FY 2003 and 128,000 pCi/L in FY 2005. Concentrations have been relatively stable since 2006, fluctuating between 35,100 and 75,000 pCi/L. Figure 2-12 in the main text discussion presents a trend plot of technetium-99 in this well.

D2 Calendar Year 2011

During 2011, well 299-W23-19 was sampled four times, and each sampling event included pumping at least 3,785 L (1,000 gal) from the well. The volume extracted was recorded on the groundwater sample reports. The technetium-99 sample results ranged between 40,000 and 51,000 pCi/L, and these results were used to calculate the activity/mass of technetium-99 extracted from groundwater. During 2011, a total of 0.0009 Ci (0.054 g) of technetium-99 was removed from the aquifer, along with 20,310 L (5,366 gal) of groundwater. The total amount of groundwater removed since startup of purging activities is 176,510 L (46,636 gal), and the amount of technetium-99 removed is 0.0105 Ci (0.62 g).

Extended purging of well 299-W23-19 is not an effective method of removing technetium-99 from the aquifer, as evidenced by the low amount of technetium-99 recovered to date. This practice will be discontinued when the S-SX Tank Farms pump-and-treat system begins operating, which is scheduled for 2012.

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Appendix E

Historic Plume Maps for the 200-ZP-1 Operable Unit

Figures

Figure E-1. 200-ZP-1 Historical Carbon Tetrachloride Plume, 1996 to 2001 ..... E-3
Figure E-2. 200-ZP-1 Historical Carbon Tetrachloride Plume, 2002 to 2007 ..... E-4
Figure E-3. 200-ZP-1 Historical Carbon Tetrachloride Plume, 2008 to 2011 ..... E-5

E Historic Plume Maps for the 200-ZP-1 Operable Unit

This appendix presents supplementary data to support the discussion in Chapter 3 of the main text for this calendar year (CY) 2011 annual report.

For the 200-ZP-1 Operable Unit, changes in the carbon tetrachloride plume due to pump-and-treat (P&T) operations for the previous years of operation (fiscal year [FY] 1995 through 2011) are summarized in Figures E-1 through E-3. The FY 1997 plume map, which is similar to the FY 1998 plume, is not shown in the figure to conserve space. The historical plume maps were taken from annual summary reports between 1995 and 2011. The original baseline plumes depicted in the annual reports have not been reinterpreted, but changes such as standardizing the contour intervals in the plume depiction were made for consistency of presentation. In addition, only analytical results from wells in use during the FY for each plume map year were used, so as additional wells are added each year, refinement of the plume configuration was possible in subsequent years. The configuration of the plumes and the changes shown for the time period presented have been influenced by a number of factors, including interpretations by individual authors involved with each report and the data available at the time of report preparation.

Overall, Figures E-1 through E-3 demonstrate the positive impact of the 200-ZP-1 P&T system for plume reduction and contaminant mass removal since 1995. Concentration data used to define the plume configuration each year were previously based on fourth quarter sampling results. After 2010, average annual concentration values were used for delineation of the carbon tetrachloride plume.

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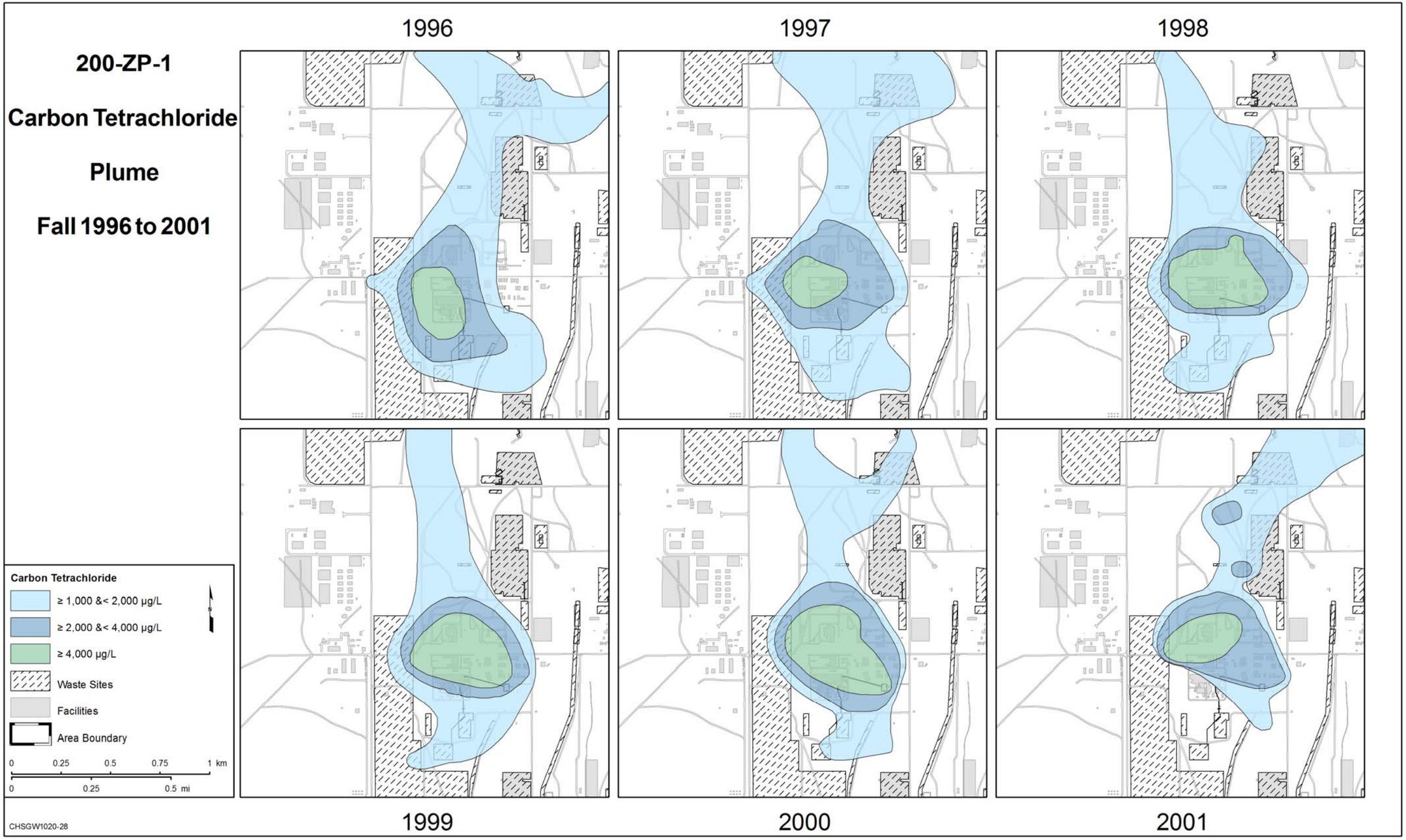

Figure E-1. 200-ZP-1 Historical Carbon Tetrachloride Plume, 1996 to 2001

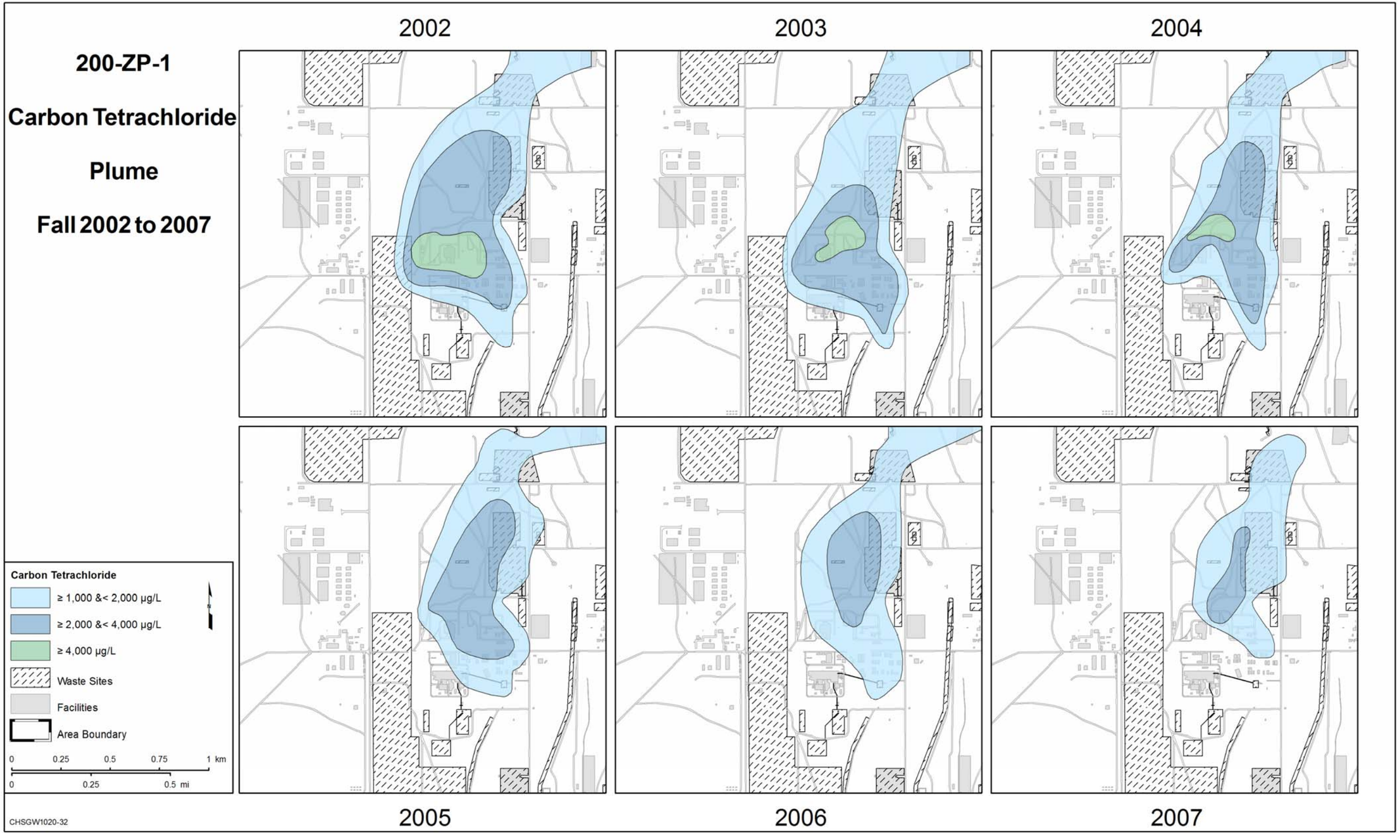

Figure E-2. 200-ZP-1 Historical Carbon Tetrachloride Plume, 2002 to 2007

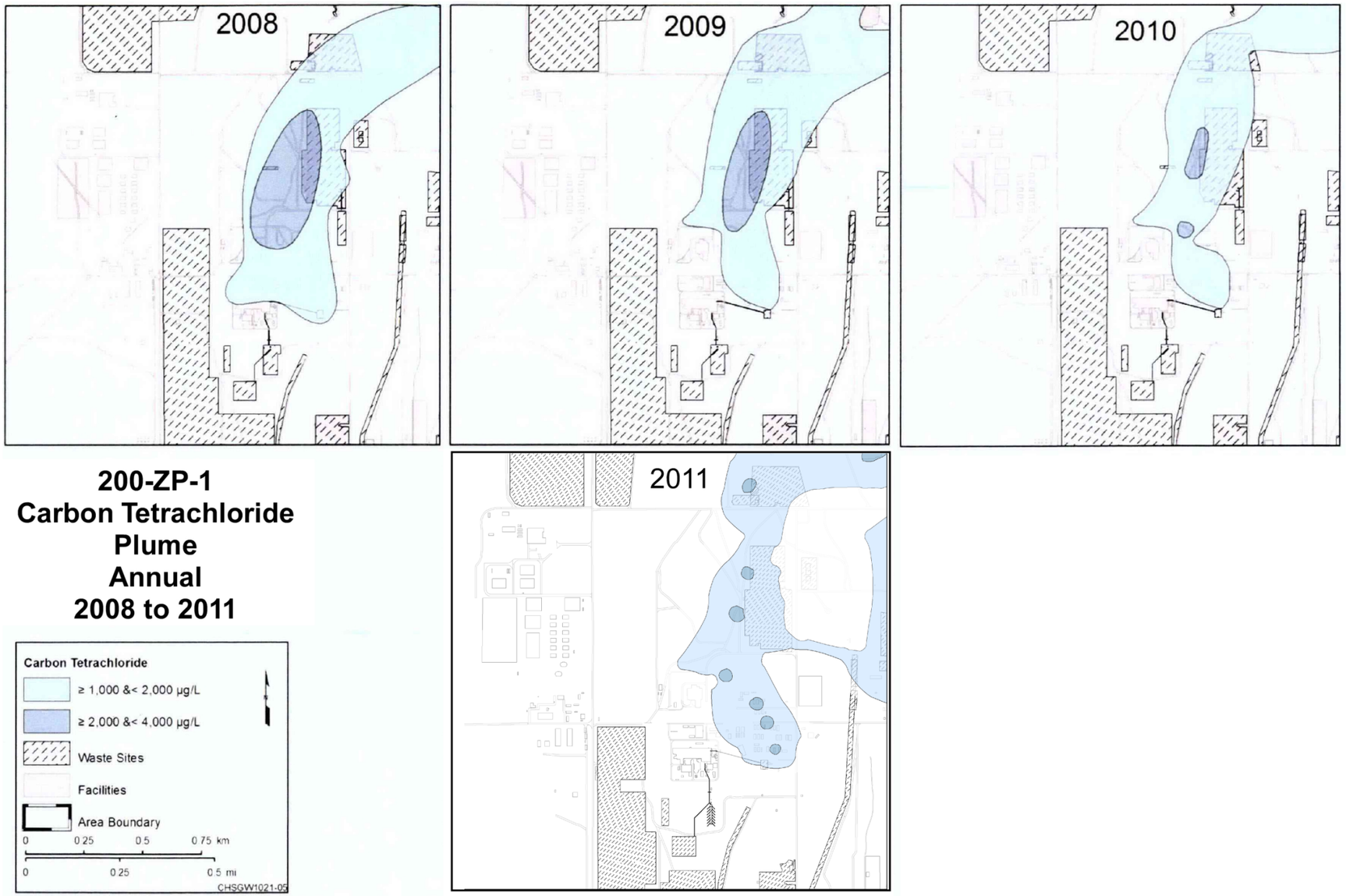

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Figure E-3. 200-ZP-1 Historical Carbon Tetrachloride Plume, 2008 to 2011

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200-ZP-1 Interim Pump-and-Treat System Summary Performance Report for Calendar Year 2012

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

Contractor for the U.S. Department of Energy
under Contract DE-AC06-08RL14788

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Executive Summary

This report presents a summary of the lifecycle performance of the 200-ZP-1 interim status pump-and-treat (P&T) system in the Hanford Site's 200-ZP-1 Operable Unit (OU). The 200-ZP-1 P&T system operated during calendar year (CY) 2012 for the period of January 1through May 2, 2012, at which time the system was shut down to transition to operation of the final status 200 West Area P&T system.

During recent operation, the 200-ZP-1 P&T system sustained a flow rate of 1,442 L/min (381 gallons per minute [gpm]). In CY 2012, the extraction wells produced 219 million L (57.8 million gal) and the treatment system removed 215 kg of carbon tetrachloride. Since 1996, the cumulative volume of groundwater treated is 6.0 billion L (1.6 billion gal), and a cumulative total of 13,718 kg of carbon tetrachloride was removed.

A second groundwater extraction system operated in the 200-ZP-1 OU under the interim Record of Decision (ROD)[1] to address technetium-99 contamination east of the T Tank Farm. During CY 2012 operation, 12.3 million L (3.3 million gal) of groundwater were removed and transported by pipeline to the Liquid Effluent Retention Facility for removal of 5.5 g of technetium-99, as well as other contaminants at the Effluent Treatment Facility.

This report for 2012 is the final report for the "interim action 200-ZP-1 P&T system," as the remedial action is being advanced to final remedy status. Construction has been completed and startup activities continue at the new 200 West Area P&T system to meet the requirements of the 200-ZP-1 OU final ROD.[2] The next annual P&T report for the 200-ZP-1 OU will address the startup and performance of the new 200 West Area P&T system and the transition from the interim 200-ZP-1 P&T system.

[1] EPA/ROD/R10-95/114, 1995, *Record of Decision for the USDOE Hanford 200-ZP-1 Operable Unit, 200 Area NPL Site Interim Remedial Measure*, U.S. Environmental Protection Agency, Washington State Department of Ecology, and U.S. Department of Energy, Olympia, Washington.

[2] EPA, Ecology, and DOE, 2008, *Record of Decision Hanford 200 Area 200-ZP-1 Operable Unit Superfund Site, Benton County, Washington*, U.S. Environmental Protection Agency, Washington State Department of Ecology, and U.S. Department of Energy, Olympia, Washington.

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List of Terms

CY	calendar year
gpm	gallons per minute
OU	operable unit
P&T	pump-and-treat
RAO	remedial action objective
ROD	Record of Decision
TCE	trichloroethene
WMA	waste management area

1 Introduction

The purpose of this report is to present a summary of the calendar year (CY) 2012 operational results for the interim 200-ZP-1 groundwater pump-and-treat (P&T) system located in the 200 West Area (Figure 1) of the Hanford Site. This P&T system addressed groundwater contamination in the 200-ZP-1 Operable Unit (OU), as required under the interim Record of Decision (ROD) (EPA/ROD/R10-95/114, *Record of Decision for the USDOE Hanford 200-ZP-1 Operable Unit, 200 Area NPL Site Interim Remedial Measure*), and was operated for the U.S. Department of Energy by CH2M HILL Plateau Remediation Company. The interim 200-ZP-1 P&T system operated until May 2, 2012, when the system was shut down to allow tie-ins to the new 200 West Area P&T system.

This report follows the format of the preceding 200-ZP-1 P&T annual reports, most recently the *Calendar Year 2011 Annual Summary Report for the 200-ZP-1 and 200-UP-1 Operable Unit Pump-and-Treat Operations* (DOE/RL-2012-03, in publication). DOE/RL-2012-03 and *Hanford Site Groundwater Monitoring for 2011* (DOE/RL-2011-118, in publication) present detailed background information on the nature and extent of 200-ZP-1 OU groundwater contamination that will not be repeated in this report. DOE/RL-2012-03 also provides discussions of the waste site operations and contaminant sources, regulatory decisions involved, and history of the P&T system. The appendices of DOE/RL-2012-03 present background information, history of regulatory actions, process knowledge, and contaminant sources relevant to the 200-ZP-1 P&T system.

This report for 2012 is the final report for the "interim action 200-ZP-1 P&T system," as the remedial action is being advanced to final remedy status. The *Record of Decision Hanford 200 Area 200-ZP-1 Operable Unit Superfund Site, Benton County, Washington* (EPA et al., 2008) was issued in September 2008 and presents the selected remedy regarding construction of new treatment facilities and the additional injection and extraction wells to support the new system. The next annual P&T report will address the transition from the interim action 200-ZP-1 P&T system, startup and performance of the 200 West Area P&T system, and its effect on the groundwater contamination.

2 Calendar Year 2012 Activities and Developments

In addition to supporting operation of the 200-ZP-1 interim action P&T system, the P&T project supported startup of the new 200 West Area P&T system. A summary of these activities includes the following:

- Operation of 200-ZP-1 interim action P&T system through May 2, 2012
- Installation of new water-level monitoring stations
- Support for startup of the new 200 West Area P&T system
- Integrated acceptance testing of the 200 West Area P&T system
- Readiness evaluation of the 200 West Area P&T system
- Preparation of documentation to support sampling of the 200 West Area wells, process system, and waste stream
- Initiation and completion of layup activities for the 200-ZP-1 interim P&T system

3 Extraction System Performance

During 2012 operations, the 200-ZP-1 P&T system had 14 designated extraction wells to remove contaminated groundwater from the unconfined aquifer. During that time, four extraction wells were offline due to low water levels that prevented sustainable operation: 299-W15-6, 299-W15-36, 299-W15-40, and 299-W15-765 (Table 1). Extraction well 299-W15-47 was offline due to a failed pump. Only one of the interim extraction wells will be included in the new 200 West Area P&T system, 299-W15-225, which was the first well drilled to support the new system.

Figure 2 presents the flow rates for each of the 200-ZP-1 extraction and injection wells during 2012. Most extraction wells operated at a rate of 189 L/min (50 gallons per minute [gpm]) or less, with the exception of 299-W15-225, which had an average extraction rate of about 950 L/min (251 gpm) during operation.

During recent system operation, the average combined flow rate for the extraction wells was 1,442 L/min (381 gpm). The extraction system produced 219 million L (57.8 million gal) of groundwater during operation in 2012 (Table 2).

4 Treatment System Performance

Contaminant concentrations measured in the treatment system's influent tank T-01 represent a composite of all extracted groundwater entering the treatment system. During 2012 operation, the average carbon tetrachloride concentration was 980 µg/L. Carbon tetrachloride concentration at effluent tank T-02 was 1 µg/L. During 2012, the interim P&T system's removal efficiency was 99.9 percent.

During 2012, the interim treatment system processed 219 million L (57.8 million gal) of contaminated groundwater. The calculated total amount of carbon tetrachloride removed in 2012 was 214.9 kg. Six billion L (1.6 billion gal) of groundwater have been treated since the system began operation, with a total of 13,718 kg of carbon tetrachloride removed from the aquifer (Table 2). Figure 3 illustrates the historical trend of carbon tetrachloride removed in relation to the amount of groundwater extracted. Figure 4 depicts the cumulative groundwater extracted versus the mass of carbon tetrachloride extracted.

5 Carbon Tetrachloride Contaminant Monitoring Results

During 2012, carbon tetrachloride concentrations in extraction wells showed stable or decreasing trends compared to 2011 data (Table 1). Sampling results for extraction wells exceeded 1,000 µg/L carbon tetrachloride at only 299-W15-225 and 299-W15-35 (Figure 5). In 2011, average carbon tetrachloride concentrations exceeded 1,000 µg/L in eight extraction wells, three of which were offline due to low water levels during 2012. Average values for individual extraction wells during 2012 ranged from 170 to 1,250 µg/L (Table 1).

6 Technetium-99 Remediation and Plume Trend at WMA T Tank Farm

Technetium-99 is found at levels significantly above the drinking water standard of 900 pCi/L on the eastern (downgradient) side of Waste Management Area (WMA) T and in two areas near WMA TX-TY at the 200-ZP-1 OU (Figure 1).

Two extraction wells, 299-W11-45 and 299-W11-46, were operated at the WMA T P&T system to capture technetium-99 in groundwater beneath and adjacent to the WMA. Both wells are located near the northeast corner of WMA T. In 2012, the WMA T extraction wells produced 12.3 million L (3.3 million gal) of groundwater at a combined average rate of 82.5 L/min (21.8 gpm). Target analytes

include technetium-99, carbon tetrachloride, nitrate, trichloroethene (TCE), and chromium. Treatment during 2012 at the Effluent Treatment Facility resulted in removal of 5.5 g of technetium-99; 11.6 kg of carbon tetrachloride; 4,717 kg of nitrate; 81.7 g of TCE; and 1.3 kg of chromium. Table 3 summarizes the 2012 production data for the WMA T extraction well system.

7 200-ZP-1 Pump-and-Treat System Costs

The cost breakdown for the interim 200-ZP-1 P&T system operations is presented in Table 4. The costs are separated into specific activities categorized as either operational or capital expenses. The majority of the costs in 2011 reflect operations and maintenance (76.6 percent) and project support (9.8 percent).

The cost per unit mass recovered was calculated for carbon tetrachloride. The cost for groundwater treatment decreased from 0.95¢/L in 2011 to 0.46¢/L in 2012, based on the 2012 annual groundwater production of 219 million L (57.8 million gal). This significant cost reduction is due to no capital well installation and treatment system improvements during the report period. Given the 2012 net recovery of 214.9 kg of carbon tetrachloride, the cost for recovery was $4,705/kg.

8 Conclusions

The interim ROD remedial action objectives (RAOs) are site-specific goals that define the extent of cleanup necessary to achieve the specific level of remediation at the site. Measurable progress was made during the reporting period to meet specific interim RAOs. The results for each RAO are as follows:

- **RAO #1:** Prevent further movement of contaminants from the highest concentration area of the baseline carbon tetrachloride plume.

  Results: Contaminated groundwater in the shallow portion of the aquifer (upper 15 m [50 ft]) in the baseline carbon tetrachloride plume was captured by the interim 200-ZP-1 P&T system. The interim P&T system was designed specifically to hydraulically contain and remove carbon tetrachloride mass in the high-concentration area (greater than 2,000 µg/L) of the Plutonium Finishing Plant plume. Figure 6 provides graphic evidence of the efficacy of system operations using the most recent plume configuration.

- **RAO #2:** Reduce contamination in the areas of highest concentration of carbon tetrachloride.

  Results: During 2012, 214.9 kg of carbon tetrachloride were removed from 219 million L (57.8 million gal) of groundwater. Since startup of P&T operations, 13,718 kg of carbon tetrachloride have been removed from 6.0 billion L (1.6 billion gal) of groundwater. Reduction in carbon tetrachloride contamination within the highest concentration portion of the contaminant plume by the interim P&T system has been demonstrated by the amount of contaminant removed, a decrease in concentration in the extraction and monitoring wells (Figure 5), and a decrease in the extent of the targeted contamination area over the last 15 years (Figure 6).

  Operations at the WMA T P&T system removed 12.3 million L (3.3 million gal) of contaminated groundwater. Contaminant mass removed in 2012 included 5.5 g of technetium-99.

- **RAO #3:** Provide information that will lead to development of a final remedy that will be protective of human health and the environment.

  Results: Data collected over the previous 15 years of P&T system operation were used to develop the final ROD (EPA et al., 2008), the *200 West Area 200-ZP-1 Pump-and-Treat Remedial Design/Remedial Action Work Plan* (DOE/RL-2008-78), and the *200 West Area Groundwater Pump-and-Treat Remedial Design Report* (DOE/RL-2010-13). The selected remedy for the

200-ZP-1 OU combines enlarged P&T operations (which will commence in the summer of 2012), monitored natural attenuation, flow-path control, and institutional controls.

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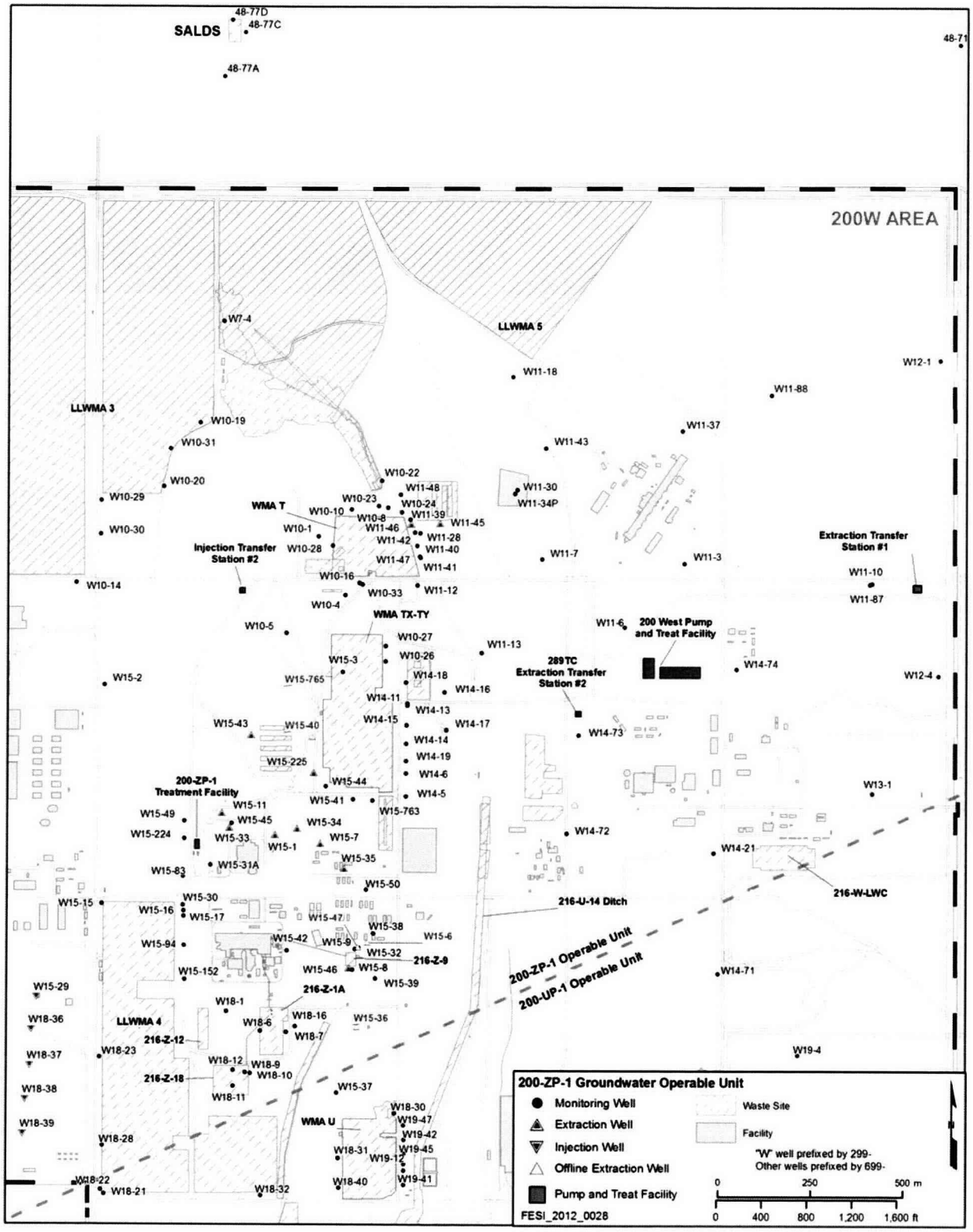

Figure 1. 200-ZP-1 OU Location Map and Well Network

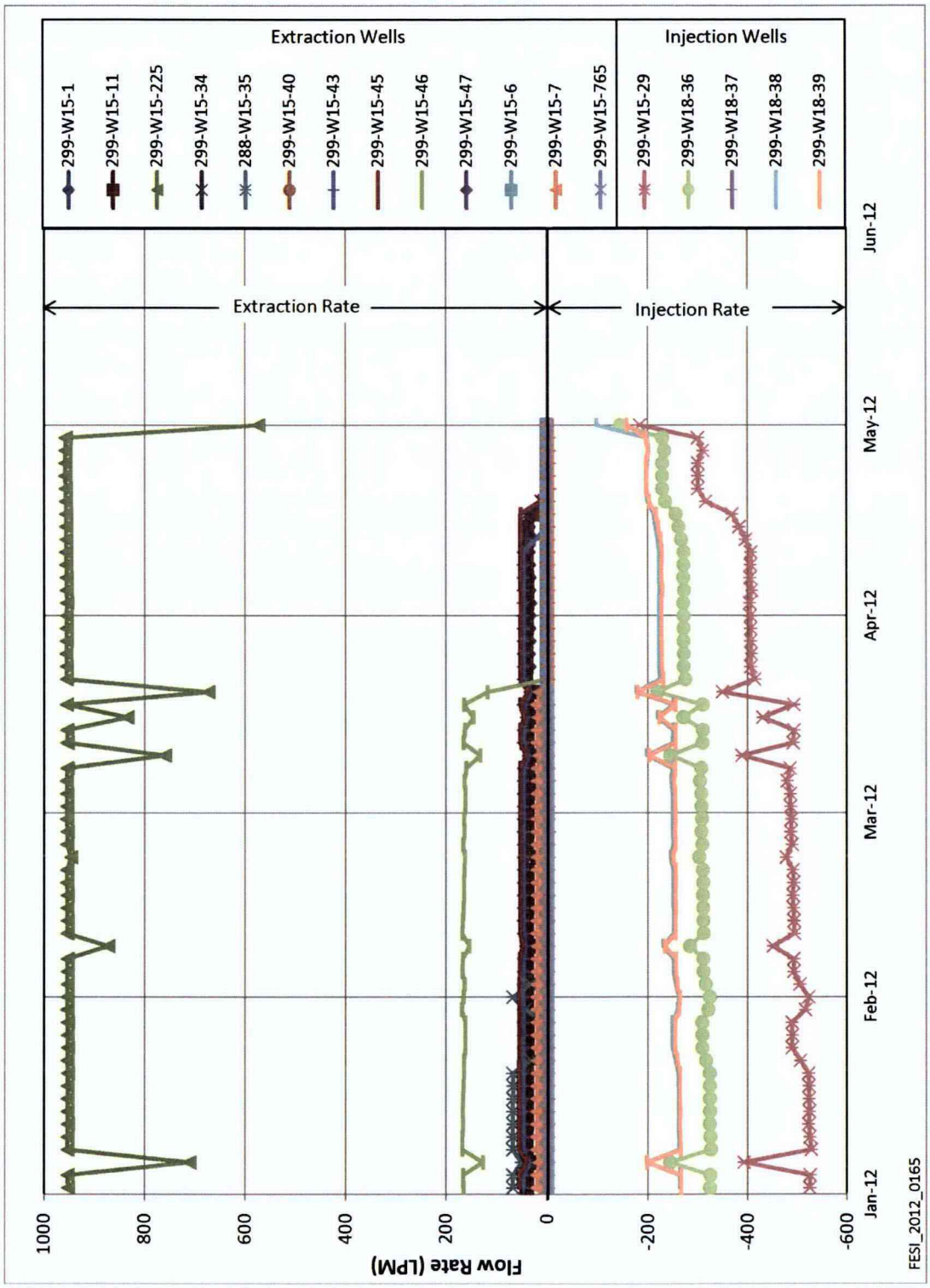

Figure 2. Flow Rates for Extraction and Injection Wells in the 200-ZP-1 P&T System During 2012

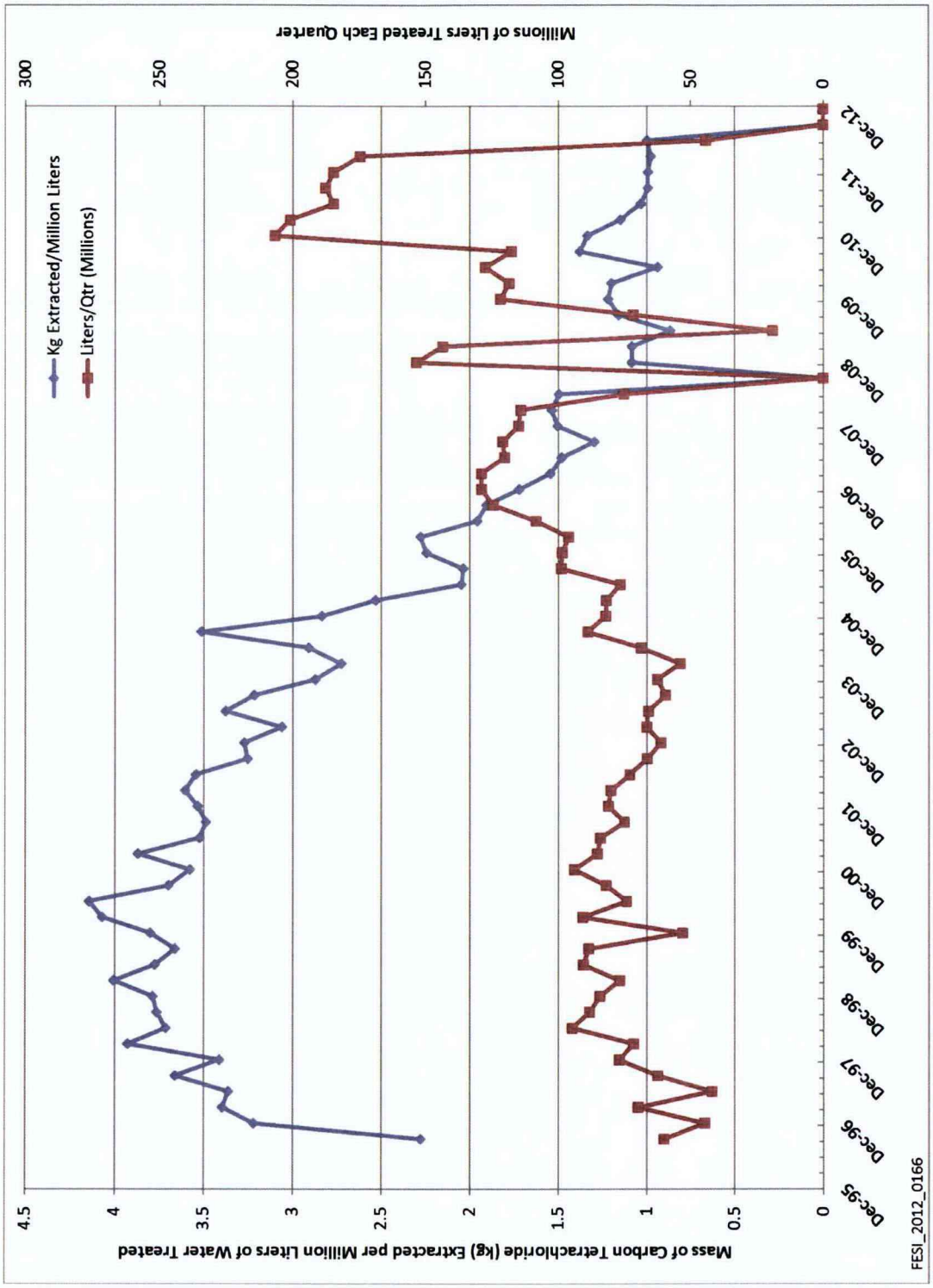

Figure 3. Groundwater Extracted/Treated and Carbon Tetrachloride Removed at the 200-ZP-1 P&T System

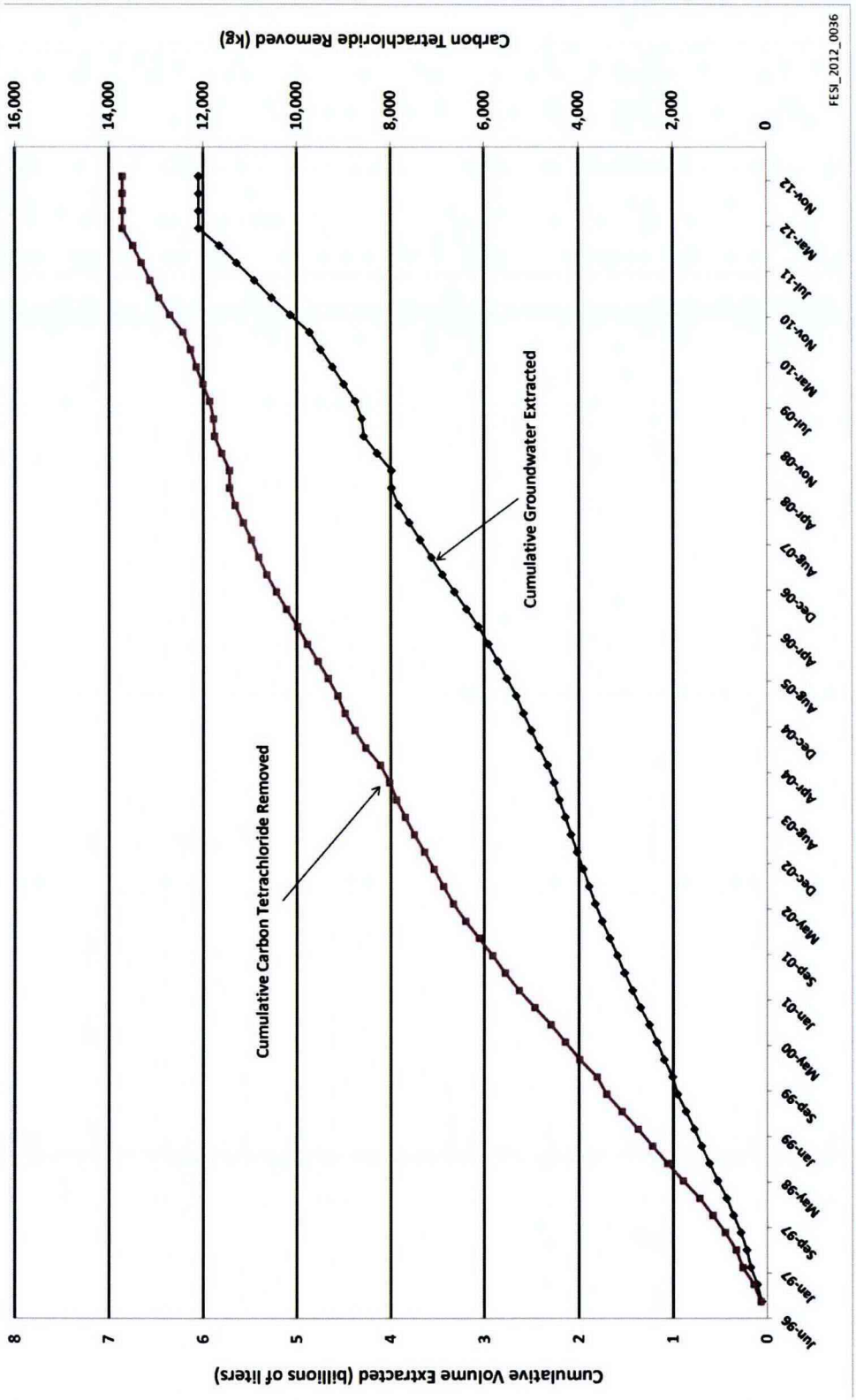

Figure 4. 200-ZP-1 P&T System Cumulative Groundwater Treated Versus Carbon Tetrachloride Extracted

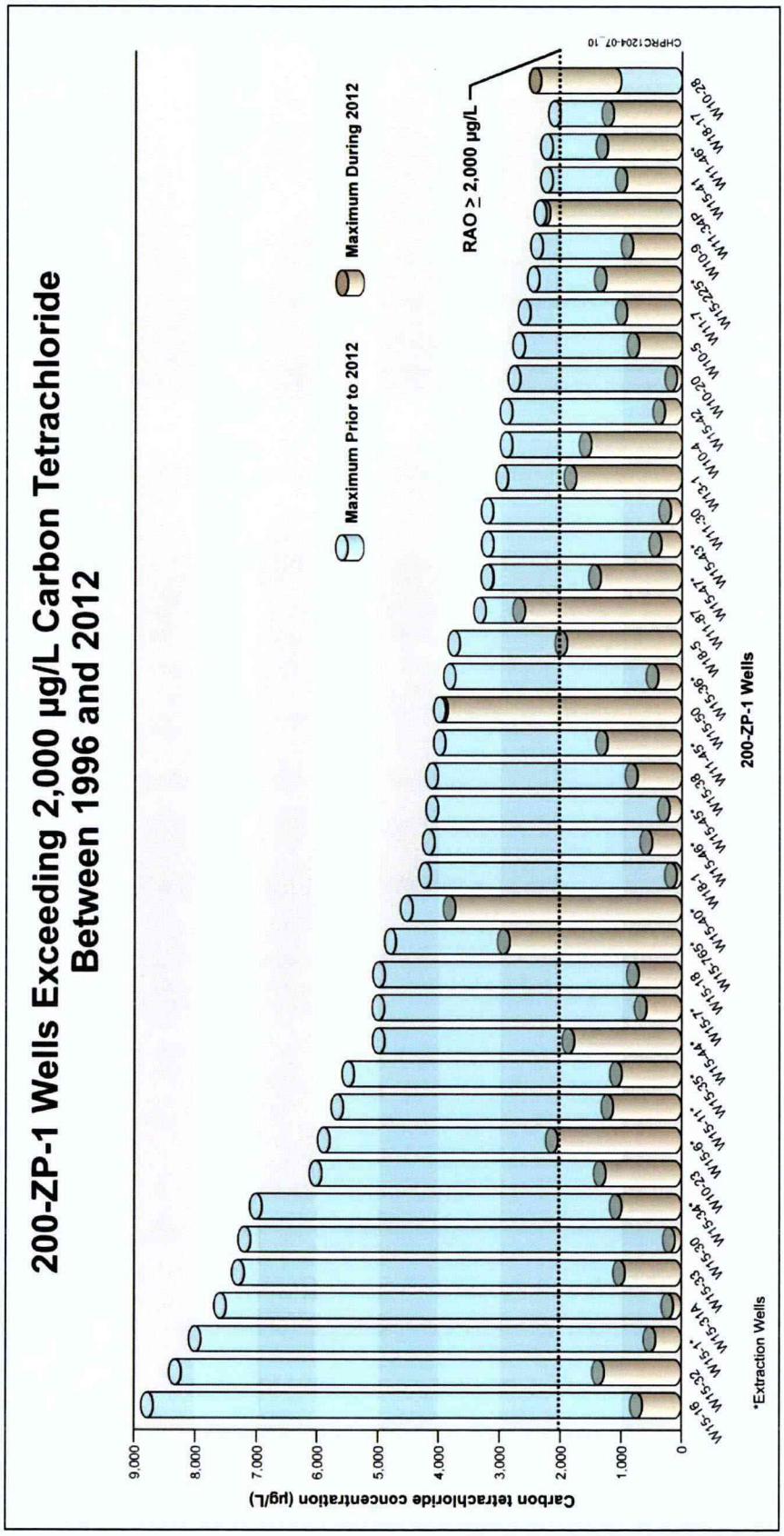

Figure 5. 200-ZP-1 Extraction Well Carbon Tetrachloride Maximum Concentration Values Prior to 2012 and During 2012

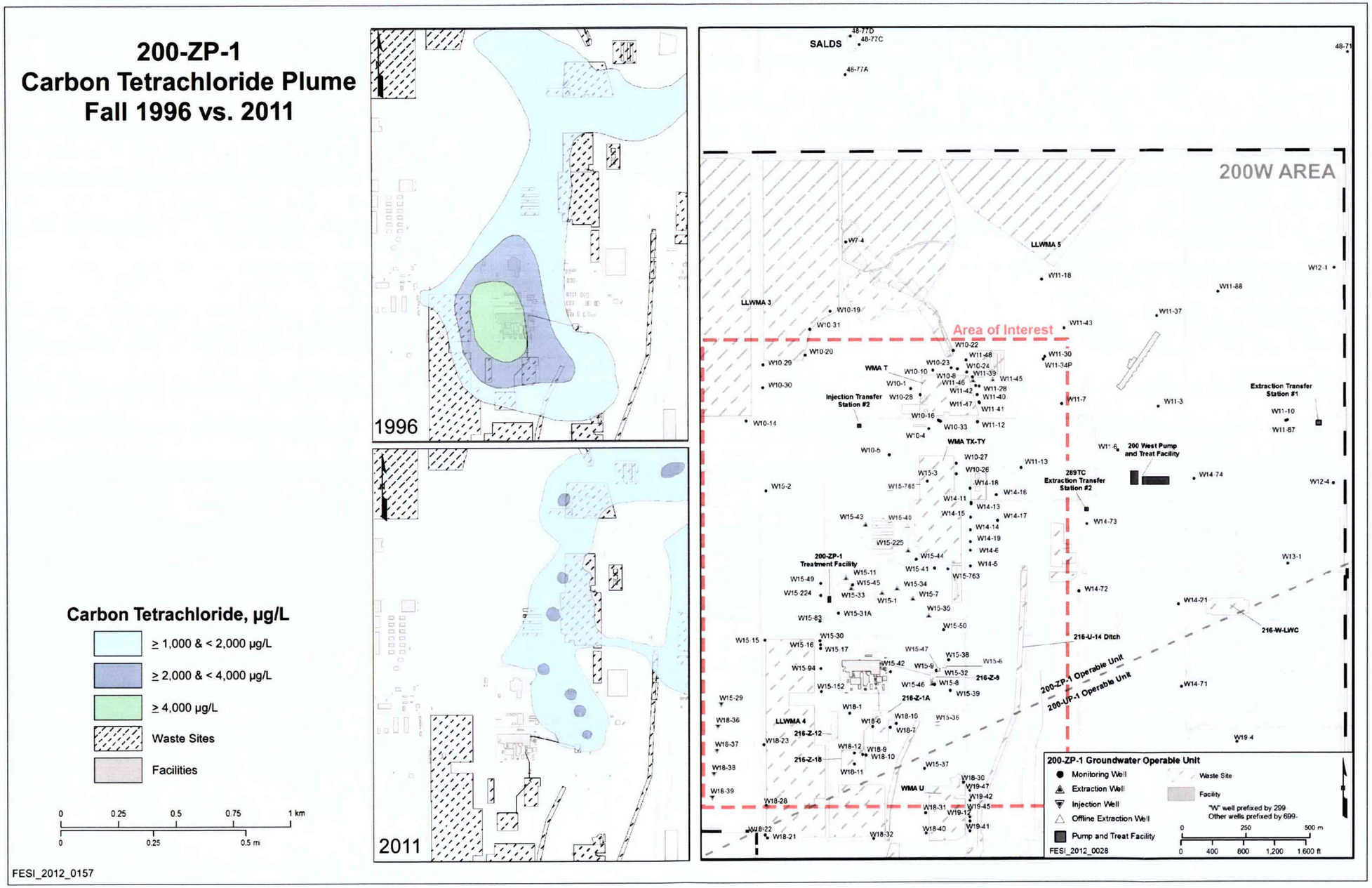

Figure 6. 200-ZP-1 Carbon Tetrachloride Plume, Fall 1996 Versus 2011

Table 1. 200-ZP-1 Average Annual Carbon Tetrachloride Concentrations from Extraction Wells and Influent and Effluent Tanks

Well	2011 Avg. Concentration (µg/L)	2012 Avg. Concentration (µg/L)	Annual Comparison* (%)
299-W15-765	2,233	Offline	N/A
299-W15-40	3,700	Offline	N/A
299-W15-43	609	330	Decreasing (-46)
299-W15-225	1,230	1,250	Stable (2)
299-W15-45	346	170	Decreasing (-51)
299-W15-11	693	670	Stable (-3)
299-W15-34	1,543	955	Decreasing (-38)
299-W15-1	710	430	Decreasing (-39)
299-W15-7	1,093	840	Decreasing (-23)
299-W15-35	1,580	1,000	Decreasing (-37)
299-W15-6[b]	1,493	Offline	N/A
299-W15-47	--	Offline	N/A
299-W15-46	612	495	Stable (-19)
299-W15-36	Offline	Offline	N/A
Influent tank (T-01)	1,033	980	Stable (-5)
Effluent tank (T-02)	1.8	1	Decreasing (-64)

* Annual comparison is the percent difference between 2011 and 2012 data and is calculated by the following equation: ([2012 - 2011] ÷ 2011) x 100%. Values are considered stable if there is a <20% change in concentration from 2011 to 2012.

N/A = not applicable

Table 2. 200-ZP-1 Interim P&T System Performance in 2012 and Since System Startup in 1996

Performance	2012	Since 1996
Total groundwater processed (L)	219 million	6.0 billion
Total mass of carbon tetrachloride removed (kg)	214.9	13,718
Average mass removal efficiency [(influent – effluent) ÷ (influent)] x 100	99.9%	99%
System online availability	97%	95.5%

Table 3. WMA T Extraction Well Performance for 2012

Performance	299-W11-45	299-W11-46	Total
Total groundwater processed (L)	2.5 million	9.8 million	12.3 million
Mass of carbon tetrachloride removed (kg)	3.0	8.6	11.6
Mass of chromium removed (kg)	0.3	1.0	1.3
Mass of nitrate removed (kg)	887	3,830	4,717
Mass of technetium-99 removed (g)[Ci]	0.5 [0.001]	5.0 [0.009]	5.5 [0.01]
Mass of TCE removed (g)	23.6	58.1	81.7
Average mass removal efficiency [(influent – effluent) ÷ (influent)] x 100	99%	99%	99%

a. Mass removed is calculated from volume extracted, not volume treated.

b. Technetium-99 converted from Ci to grams by activity 58.7 g/Ci.

Table 4. Cost Breakdown for 200-ZP-1 P&T Operations

Description	Actual Costs (in Thousands)															
	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Design	--	--	--	--	--	--	--	--	64.3	104.8	210.2	2,065.2	210.6	193.5	--	--
Treatment system capital	--	--	--	--	--	--	--	92.3	762.5	178.4	--	--	--	4.3	1,122.5	--
Project support	444.0	183.8	158.9	115.1	30.9	141.6	171.1	249.9	248.8	197.6	713.7	1,229.0	368.5	568.0	227.9	99.1
Operations and maintenance	2320.0	626.2	704.5	701.3	550.8	478.4	724.8	703.4	766.2	756.8	1,356.4	2,169.8	1,735.1	4,798.3	2,363.9	774.4
Performance monitoring	--	--	--	256.9	177.0	146.1	127.6	265.3	990.5	306.7	873.8	206.6	434.3	482.3	378.6	49.6
Waste management	--	--	--	45.3	52.6	922.0	167.2	85.1	29.2	26.7	20.6	62.8	154.5	372.1	184.6	44.8
Regeneration subcontract	--	--	--	--	142.6	--	--	--	--	--	--	--	--	--	64.5	43.1*
Well installation	--	--	--	--	68.0	1,071.5	397.9	241.8	556.3	658.4	2,562.4	1,470.0	--	--	2,829.3	--
Totals	**$2,764.0**	**$810.0**	**$863.4**	**$1,118.6**	**$1,021.9**	**$2,759.6**	**$1,588.6**	**$1,637.8**	**$3,417.8**	**$2,229.4**	**$5,737.1**	**$7,203.4**	**$2,903.0**	**$6,418.5**	**$7,171.3**	**$1,011.0**

Notes:

Design: Includes initial design activities to support P&T system construction, permitting, aquifer response modeling, peer reviews, quality assurance, and all other design documentation. It also includes the design of system upgrades and modifications.

Treatment system capital: Includes fees paid to the construction subcontractor for capital equipment, initial construction/construction of new wells, redevelopment of existing wells, and modifications to the P&T system. Includes all Environmental Restoration Contractor and CH2M HILL Plateau Remediation Company labor required for oversight and support of initial well installation.

Project support: Includes activities related to project coordination and technical consultation as required during the course of the facility design, construction, acceptance testing, and operation. Adjustments are made to reported numbers to represent the actual amount that project support accrued from program/project management and project controls.

Operations and maintenance: Includes facility supplies, labor, and craft supervision costs associated with operating and maintaining the facility. It also includes costs associated with routine field screening and engineering support as required during the course of the P&T operations and periodic maintenance.

Performance monitoring: Includes system and groundwater sampling and sample analysis as required in accordance with the *200-ZP-1 IRM Remedial Design Report* (DOE/RL-96-07). It also includes preparation of the annual performance evaluation report and subsequent reports, as required by the interim action work plans.

Waste management: This is the estimated cost for the management of granular activated carbon at the 200-ZP-1 OU in accordance with applicable laws for suspect hazardous, toxic, and regulated wastes. Waste designation sampling and analysis is included.

Regeneration subcontract: This included the costs of transportation and regeneration of the granular activated carbon canisters.

Well installation: This includes costs for the installation of new *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* monitoring and extraction wells at the 200-ZP-1 OU. During 2012, no new wells were completed to support the 200-ZP-1 OU groundwater remediation activities.

* The $43.1K for regeneration is estimated based on one lot ready to be shipped and a second lot to be shipped after laydown activities are completed.

Distribution

	MS	Quantity
U.S. Department of Energy, Richland Operations Office		
N.M. Bland	A5-11	1
B.L. Charboneau	A6-33	1
J.G. Morse	A6-38	3
DOE Public Reading Room	H2-53	1
CH2M HILL Plateau Remediation Company– Electronic Distribution		
M.W. Bowman	S5-31	
M.E. Byrnes	R3-50	
D.E. Dooley	R3-50	
J.P. McDonald	R3-50	
R.W. Oldham	R3-60	
J.G. Riddelle	R3-20	
V.J. Rohay	R3-50	
S.A. Simmons	R3-50	
Freestone Environmental Services, Inc. – Electronic Distribution		
G.L. Kasza gregkasza@gofreestone.com		
Administrative Record	H6-08	1
Document Clearance	H6-08	1

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