

# **FISCAL YEAR 2004 ANNUAL SUMMARY REPORT FOR 200-UP-1 AND 200-ZP-1 PUMP-AND- TREAT OPERATIONS**

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



**United States  
Department of Energy**  
P.O. Box 550  
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## TERMS

bgs	below ground surface
CFR	<i>Code of Federal Regulations</i>
DNAPL	dense nonaqueous phase liquid
DQO	data quality objectives
DOE	U.S. Department of Energy
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
ERDF	Environmental Restoration Disposal Facility
ETF	Effluent Treatment Facility
FH	Fluor Hanford, Inc.
FY	fiscal year
GAC	granular activated carbon
gpm	gallons per minute
HEIS	Hanford Environmental Information System
LERF	Liquid Effluent Retention Facility
MCL	maximum contaminant level
MSE	MSE Technology Applications, Inc.
MTCA	<i>Model Toxics Control Act</i>
N/A	not applicable
OU	operable unit
PFP	Plutonium Finishing Plant
RAO	remedial action objective
RI/FS	remedial investigation/feasibility study
RL	U.S. Department of Energy, Richland Operations Office
ROD	Record of Decision
RPD	relative percent difference
TCE	trichloroethene
WAC	<i>Washington Administrative Code</i>
WSCF	Waste Sampling and Characterization Facility

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**METRIC CONVERSION CHART**

<b>Into Metric Units</b>			<b>Out of Metric Units</b>		
<i>If You Know</i>	<i>Multiply By</i>	<i>To Get</i>	<i>If You Know</i>	<i>Multiply By</i>	<i>To Get</i>
<b>Length</b>			<b>Length</b>		
inches	25.4	millimeters	millimeters	0.039	inches
inches	2.54	centimeters	centimeters	0.394	inches
feet	0.305	meters	meters	3.281	feet
yards	0.914	meters	meters	1.094	yards
miles	1.609	kilometers	kilometers	0.621	miles
<b>Area</b>			<b>Area</b>		
sq. inches	6.452	sq. centimeters	sq. centimeters	0.155	sq. inches
sq. feet	0.093	sq. meters	sq. meters	10.76	sq. feet
sq. yards	0.836	sq. meters	sq. meters	1.196	sq. yards
sq. miles	2.6	sq. kilometers	sq. kilometers	0.4	sq. miles
acres	0.405	hectares	hectares	2.47	acres
<b>Mass (weight)</b>			<b>Mass (weight)</b>		
ounces	28.35	grams	grams	0.035	ounces
pounds	0.454	kilograms	kilograms	2.205	pounds
ton	0.907	metric ton	metric ton	1.102	ton
<b>Volume</b>			<b>Volume</b>		
teaspoons	5	milliliters	milliliters	0.033	fluid ounces
tablespoons	15	milliliters	liters	2.1	pints
fluid ounces	30	milliliters	liters	1.057	quarts
cups	0.24	liters	liters	0.264	gallons
pints	0.47	liters	cubic meters	35.315	cubic feet
quarts	0.95	liters	cubic meters	1.308	cubic yards
gallons	3.8	liters			
cubic feet	0.028	cubic meters			
cubic yards	0.765	cubic meters			
<b>Temperature</b>			<b>Temperature</b>		
Fahrenheit	subtract 32, then multiply by 5/9	Celsius	Celsius	multiply by 9/5, then add 32	Fahrenheit
<b>Radioactivity</b>			<b>Radioactivity</b>		
picocuries	37	millibecquerel	millibecquerels	0.027	picocuries

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## 1.0 INTRODUCTION

Five pump-and-treat systems are being operated by Fluor Hanford, Inc. (FH) at the Hanford Site under interim Records of Decision (RODs). Two of the systems, which are the subject of this fiscal year 2004 (FY04) annual report, are located in the 200 West Area (Figure 1-1). The 200-UP-1 Groundwater Operable Unit (OU) pump-and-treat system is removing primary contaminants uranium and technetium-99, and secondary contaminants carbon tetrachloride and nitrate. The 200-ZP-1 Groundwater OU pump-and-treat system removes primarily carbon tetrachloride and secondary contaminants chloroform and trichloroethene (TCE). Three other systems are operating at sites along the Columbia River. The 100-HR-3 OU is removing hexavalent chromium from groundwater at the 100-D and 100-H sites. Similarly, the 100-KR-4 OU is removing hexavalent chromium at the 100-K Area, and the 100-NR-2 OU is removing strontium-90 from groundwater at the 100-N Area.

Interim RODs were issued for the 200-UP-1 OU in 1997 (*Record of Decision for the 200-UP-1 Interim Remedial Measure* [EPA et al. 1997]) and the 200-ZP-1 OU in 1995 (*Declaration of the Interim Record of Decision for the 200-ZP-1 Operable Unit* [EPA et al. 1995]). Each of the interim RODs specified the action levels of contaminants and identified the plume concentrations and locations to be targeted by the pump-and-treat systems. The remedial action objectives (RAOs) that were identified for the 200-UP-1 OU include the following:

- Reducing 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) (*Washington Administrative Code* [WAC] 173-340) and 10 times the maximum contaminant level (MCL) for technetium-99.
- Reducing potential adverse human health risks through reduction of contaminant mass.
- Preventing further movement of these contaminants from the highest concentration area.
- Providing information that will lead to development and implementation of a final remedy that will be protective of human health and the environment.

The “Selected Remedy” section of the 200-UP-1 interim ROD identifies the area of highest concentration of uranium and technetium as corresponding to the area where concentrations are within the 480 µg/L and 9,000 pCi/L plume contours, respectively.

The RAOs for the 200-ZP-1 OU include the following:

- Reducing contamination in the area of highest concentrations of carbon tetrachloride.
- Preventing further movement of these contaminants from the highest concentration area.
- Providing information that will lead to development of a final remedy that will be protective of human health and the environment.

The “Selected Remedy” section of the 200-ZP-1 interim ROD identifies the area of highest concentration as corresponding to the area within the 2,000 to 3,000 parts per billion (µg/L) contour of carbon tetrachloride. The MCL for carbon tetrachloride is 5 µg/L.

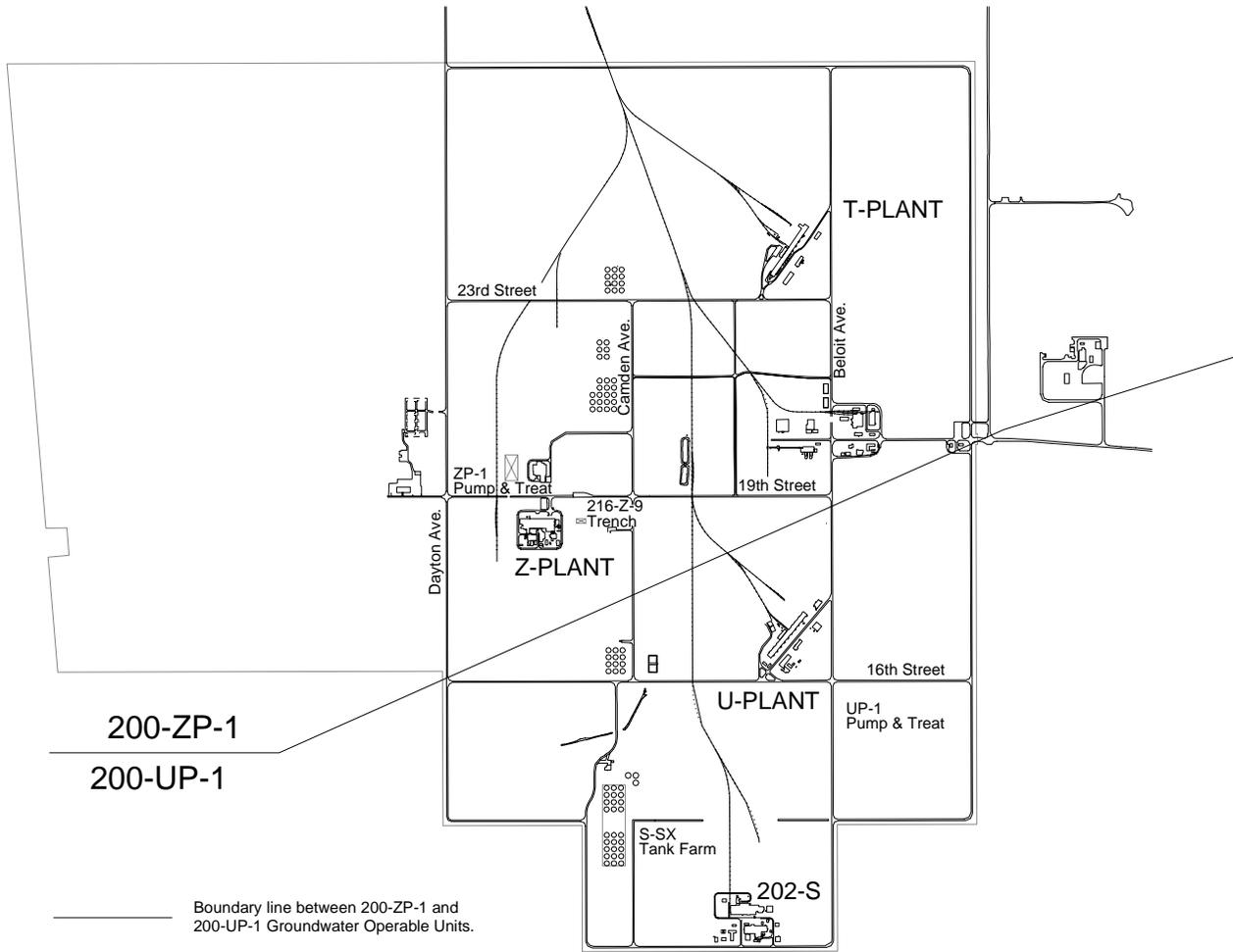
Extraction rates required for success were also identified for each primary contaminant at the two OUs and are discussed in the respective OU sections of this report.

A 5-year review, required by the U.S. Environmental Protection Agency (EPA) to assess remediation effectiveness, was first conducted in 2000 for all active pump-and-treat systems and was documented in the *USDOE Hanford Site First Five-Year Review Report* (EPA 2001). Virtually all of the actions identified in this 5-year review were closed out in FY02 (*Fiscal Year 2002 Annual Summary Report for 200-UP-1 and 200-ZP-1 Pump-and-Treat Operations* [DOE-RL 2003a]). One remaining action, to develop a geochemical model for uranium at the 200-UP-1 OU, was completed in FY04 and is summarized in this report. A second 5-year review is scheduled to begin in FY05.

The format of this report is similar to previous years' reports, but much of the supporting data has been moved to appendices included on a compact disc at the back of the document. The report contains two sections (Section 2.0 for the 200-UP-1 OU, and Section 3.0 for the 200-ZP-1 OU) that address each of the pump-and-treat systems, as well as a concluding discussion on respective treatment system costs (Section 4.0). For each OU section, subsections will discuss the following information:

- Description of modifications and changes to the pump-and-treat systems, new wells drilled, and other changes to the OU during FY04
- Summary of extraction well data
- Discussion of treatment system performance
- Discussion of contaminant trends at extraction and key monitoring wells
- Examination of groundwater and plume responses to both regional geohydrologic changes and groundwater extraction
- Discussion of quality assurance and quality control sampling results
- Conclusions and recommendations on pump-and-treat system effectiveness and plume monitoring system effectiveness.

Figure 1-1. Hanford Site 200 West Area.



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## 2.0 200-UP-1 OPERABLE UNIT PUMP-AND-TREAT SYSTEM

Measurable progress was made toward meeting the four RAOs for the 200-UP-1 OU pump-and-treat system in FY04. As required, further movement of contaminants from the high-concentration portion of the plume was prevented, health risks were reduced through reduction of contaminant mass, and information was collected that will support development of a final remedy. Based on all well data for FY04, technetium-99 concentrations remained below the RAO of >9,000 pCi/L and, at many wells, were approaching or below the MCL of 900 pCi/L. For uranium, all monitoring and extraction wells remained below the RAO of >480 µg/L during FY04 sampling.

During FY04, the pumping system was comprised of three extraction wells: 299-W19-36, 299-W19-39, and 299-W19-43 (Figure 2-1). Five monitoring wells were used to determine the boundaries of the plumes. An 11-km (6.8-mi) pipeline connects the extraction well heads to the Effluent Treatment Facility (ETF). The ETF removed the primary contaminants of concern (technetium-99 and uranium), as well as the secondary contaminants of concern (carbon tetrachloride and nitrate).

The entire 200-UP-1 Groundwater OU addresses the conditions and plumes beneath the southern third of the 200 West Area and adjacent portions of the surrounding 600 Area. Additional information on the 200-UP-1 pump-and-treat operational history and contaminant source background is presented in Appendix A.

### 2.1 FISCAL YEAR 2004 ACTIVITIES AND DEVELOPMENTS

Several important developments occurred at the 200-UP-1 Groundwater OU and pump-and-treat system in FY04, including the following:

- The 200-UP-1 baseline pump-and-treat system met its RAOs for the whole of FY04. This marks the 200-UP-1 pump-and-treat system as the most successful system at Hanford to date.
- The 200-UP-1 OU pump-and-treat system was configured with three extraction wells (299-W19-36, 299-W19-39, and 299-W19-43) operating full time. With all three of the extraction wells operating after scheduled system outages in the first quarter, the system was able to exceed the long-term production requirement of 189.3 L/min (50 gallons per minute [gpm]) by averaging 192.3 L/min (50.8 gpm).
- New monitoring wells 699-38-70B (well “P”), 699-38-70C (well “N”), and 699-40-65 (well “S”) were drilled between December 2003 and February 2004 as part of the larger 200-UP-1 groundwater monitoring network. The wells are aligned downgradient of and in an east-northeasterly direction from the pump-and-treat system. In part, these wells monitor downgradient technetium and uranium concentrations but were primarily intended to provide clearer definition of the greater 200-UP-1 contaminant distributions. During drilling, groundwater samples were taken at approximately 9-m (30-ft) intervals to establish a vertical profile of contaminant distribution in the unconfined aquifer. Quarterly sampling was conducted following development and acceptance of the new wells. Technetium-99 concentrations at well 699-38-70C were above the 900 pCi/L

MCL, and ranged between 970 and 1,600 pCi/L for the 27-m (89-ft) thickness of the aquifer sampled between the water table and the top of the Ringold Lower Mud Unit.

- Two of three planned wells (699-36-70B [well “P”] and 699-30-66 [well “R”]) (FH 2003) were drilled east and south of the pump-and-treat system. Drilling at the third well, well “K” (299-W19-48), was delayed into FY05.
- A revision to the 200-UP-1 remedial investigation/feasibility study (RI/FS) work plan (DOE/RL-92-76 [DOE-RL 2003b]) was made during FY04 and was submitted for review. The final document is scheduled for release in FY05.
- A semi-annual sampling and analysis program was implemented for FY04 at three extraction and four monitoring wells around the pump-and-treat baseline plume, replacing an annual sampling program in FY03. In addition, annual and biennial sampling was conducted at wells 299-W19-34A and 299-W19-34B, respectively. These two wells are screened at deeper intervals within the aquifer: 98.8 to 103.5 m (324 to 339.6 ft) and 125.5 to 128.5 m (411 to 421 ft) below ground surface (bgs), respectively.
- No wells were decommissioned around the 200-UP-1 pump-and-treat system. Well 299-W19-20 went dry, and groundwater levels in well 299-W19-40 dropped below the pump intake, thus requiring sampling with a bailer.
- Work was completed in FY04 on a geochemical model developed by MSE Technology Applications, Inc. (MSE) of Butte, Montana. This activity met a recommendation presented in the 5-year review (EPA 2001) to provide information for the 200-UP-1 RI/FS process. A summary report was issued in September 2004 (MSE 2004).
- With technetium-99 and uranium concentrations remaining below the respective RAOs of >9,000 pCi/L and >480 µg/L, a rebound study was prepared for implementation in calendar year 2005. The rebound study will start with shutdown of the 200-UP-1 extraction wells in January 2005 and will end in January 2006. As outlined in the study plan, extraction and monitoring wells will be sampled monthly for uranium and technetium, and quarterly for carbon tetrachloride and nitrate. Analytical results will be tracked during calendar year 2005 to see if contaminant concentrations increase to above-RAO concentrations. If primary contaminant concentrations remain below the RAOs during the rebound study, post-study monitoring in the plume will be performed in accordance with the 200-UP-1 RI/FS work plan.

## 2.2 EXTRACTION SYSTEM PERFORMANCE

The ETF reported processing nearly 93.8 million L (24,000,000 gal) of groundwater in FY04. Quarterly volumes of treated groundwater and removed contaminant mass are shown in Table 2-1 for the 200-UP-1 OU since initiation of pump-and-treat operations. Daily average production rates are shown in Figure 2-2 for each of the three extraction wells. The average production rates are summarized in the table below for FY04 and the period from January 23 through September 30, 2004. Production rates were lower during the first quarter of FY04 due to scheduled system outages. Reconfiguration of 299-W19-36 as an extraction well was completed during the first quarter of FY04, allowing all three extraction wells to operate continuously. After the system was optimized, the average production rate increased to approximately 192.3 L/min (50.8 gpm).

	Well 299-W19-39	Well 299-W19-36	Well 299-W19-43	Cumulative Avg. Extraction
Extraction rate (L/min), FY04, total	119.5	22.1	29.3	170.9 (45.1 gpm)
Extraction rate (L/min), FY04, since January 26, 2004	133.7	24.4	34.2	192.3 (50.8 gpm)

Total system operating time in FY04 was 8,073.5 hours out of 8,784 hours. As shown in Figure 2-3 and Appendix B, scheduled system outages (e.g., maintenance and leachate transfers) totaled 710.5 hours, including modifications in the first quarter. No unscheduled system outages (e.g., major extraction well shutdown) occurred in FY04. The resulting 91.9% extraction system availability in FY04 is lower than FY03, primarily due to the scheduled system outages during the first quarter of FY04.

Figure 2-3 depicts the monthly system availability. Unless extraction well 299-W19-39 is affected, other pump shutdowns are not considered as outages. A more detailed description of extraction system performance is provided in Appendix B.

### 2.3 TREATMENT SYSTEM PERFORMANCE

Operations in FY04 increased the cumulative volume of groundwater processed at 200-UP-1 to over 801.2 million L (211,689,986 gal) since pump-and-treat operations started in March 1994. The FY04 and cumulative removed quantities of uranium, technetium-99, carbon tetrachloride, and nitrate are presented in the table below:

Contaminant	FY04 Totals	Totals Since Startup, March 1994
Uranium (kg)	23.5	203
Technetium-99 (g [Ci])	12.1 (0.21 Ci)	114.1 (1.94 Ci)
Carbon tetrachloride (kg)	5.4	31.2
Nitrate (kg)	5,207	32,550

The ETF process generated a total of 471 – 208-L drums (55-gal drum size) of powder waste, shipped nine 208-L drums of sludge waste, and generated 643 ft<sup>3</sup> (18.2 m<sup>3</sup>) of contact waste. The ETF process efficiencies are reported at nearly 100% for uranium, technetium-99, carbon tetrachloride, and nitrate. Contaminant concentrations in the ETF influent and effluent are compared in Figure 2-4. Uranium, technetium-99, carbon tetrachloride, and most nitrate concentrations in the treated effluent were below laboratory detection levels. An estimated 9.1 kg of carbon tetrachloride were lost to the atmosphere in transport between the well heads and the treatment system. Carbon tetrachloride lost in transit between the 200-UP-1 well heads and the ETF is not reportable because it is a continuous release that is routine, anticipated, and incidental to normal operations and treatment processes (40 *Code of Federal Regulations* [CFR] 302).

## 2.4 CONTAMINANT MONITORING

The technetium-99 and uranium plumes are defined by sample results from wells around the baseline plume location. As secondary contaminants of concern, carbon tetrachloride and nitrate plumes are more extensive and cover most of the 200 West Area. Reductions to the secondary contaminants' plume sizes and mass reductions from treatment at the 200-UP-1 OU are beneficial but are of minor impact to the larger 200 West Area plumes. The 200-UP-1 contaminant trend plots for influent as measured at extraction wells 299-W19-36, 299-W19-39, and 299-W19-43 are shown in Figure 2-5.

### 2.4.1 Technetium-99 and Uranium Monitoring Results

FY04 marks the first full year that any Hanford Site pump-and-treat system has met RAOs. All concentrations of uranium and technetium-99 were below their respective target concentrations of 480 µg/L and 9,000 pCi/L at all baseline monitoring and extraction wells.

Seven monitoring and extraction wells at the 200-UP-1 OU were each sampled during two separate events in the second and fourth quarters of FY04 (wells 299-W19-35, 299-W19-36, 299-W19-37, 299-W19-39, 299-W19-40, 299-W19-43, and 299-W19-46). The resulting concentrations of uranium and technetium-99 are shown in the table below for FY03, FY04, and the second and fourth quarters of FY04:

Well Name	FY03 Avg. Concentration	FY04 Avg. Concentration	Annual Comparison <sup>b</sup>	Second Quarter 2004	Fourth Quarter 2004
<i>Uranium (µg/L)</i>					
299-W19-34A	1.0 <sup>d</sup>	1.0	Stable	--	1.0
299-W19-34B	1.18 <sup>d</sup>	0.88	Stable	--	0.88
299-W19-35	43	39.7	Stable	37.4 <sup>a</sup>	42
299-W19-36	453	388	Stable	438	407; 319
299-W19-37	267	205	Decreasing	208	201
299-W19-39	223	103	Decreasing	102	103
299-W19-40	127	94	Decreasing	NA	94
299-W19-43	835	259	Decreasing	285	232
299-W19-46	142	151	Stable	163	139

Well Name	FY03 Avg. Concentration	FY04 Avg. Concentration	Annual Comparison <sup>b</sup>	Second Quarter 2004	Fourth Quarter 2004
<i>Technetium-99 (pCi/L)</i>					
299-W19-34A	136 <sup>d</sup>	130	Stable	--	130 <sup>a</sup>
299-W19-34B	16.7 <sup>d</sup>	17.8	Stable	--	17.8
299-W19-35	795	1,395	Increasing	1,460 <sup>a</sup>	1,330
299-W19-36	4,600	5,087	Stable	5,910	4,140; 5,210
299-W19-37	622	402	Decreasing	340	464
299-W19-39	952	883	Stable	886	880
299-W19-40	170	234	Increasing	NA	234
299-W19-43	10,795	836	Decreasing	22 <sup>c</sup>	836
299-W19-46	158	140	Stable	143	137

<sup>a</sup> Values averaged.

<sup>b</sup> Comparison is the percent difference between FY04 and FY03 and is calculated by the following equation:  $[(FY04 - FY03) / FY03] \times 100\%$ . Wells are considered stable if there is less than a 20% change in concentration from FY03 to FY04.

<sup>c</sup> Suspect data "Y" qualifier for review; insufficient evidence to show result valid or invalid.

<sup>d</sup> Last data point in August 2002.

NA = not available

Analytical data from the fourth quarter 2004 sampling event were below the technetium-99 RAO of >9,000 pCi/L for the seven sampled wells in the 200-UP-1 OU system. Average technetium-99 concentrations increased in two monitoring wells (299-W19-35 and 299-W19-40) that are associated with an eastern downgradient area where concentrations exceed 900 pCi/L. However, the technetium-99 average concentration remained stable (i.e., less than a 20% change from FY03 to FY04) in extraction well 299-W19-39, which is located in the same area.

At extraction well 299-W19-36, the average technetium-99 concentration increased from 4,600 pCi/L in FY03 to 5,910 pCi/L before declining to 4,140 and 5,210 pCi/L later in FY04. Well 299-W19-36 is located within the historically more contaminated, western portion of the baseline plume area where concentrations exceeded 9,000 pCi/L in FY03. Well 299-W19-36 was converted back to an extraction well during the first quarter of FY04.

During the same period, the average technetium-99 concentrations decreased in monitoring well 299-W19-37 and extraction well 299-W19-43, which are located downgradient of well 299-W19-36. The lower technetium-99 concentrations in wells 299-W19-37 and 299-W19-43 occurred after well 299-W19-43 was converted from a monitoring well to an extraction well in May 2003. The average technetium-99 concentration in well 299-W19-43 decreased from 22,400 pCi/L in FY02, to 10,795 pCi/L in FY03, and to 836 pCi/L in FY04.

Trend plots for all wells associated with the 200-UP-1 OU are presented in Appendix D. The current technetium-99 and uranium plumes, based on the fourth quarter FY04 sampling, are shown in Figures 2-6 and 2-7.

Analytical data from the fourth quarter 2004 sampling event were below the uranium RAO of >480 µg/L for the seven wells sampled in the 200-UP-1 OU system. The FY04 uranium concentrations either decreased or remained stable in these seven wells. The average uranium concentration in 299-W19-43 continued a steady decline from 1,560 µg/L in FY02 to 259 µg/L in FY04.

Deeper zones of the aquifer at the 200-UP-1 pump-and-treat system are monitored annually at well 299-W19-34A (98.8 to 103.5 m [324.1 to 339.6 ft]) and biennially at well 299-W19-34B (125.5 to 128.5 m [411.7 to 421.6 ft]). In FY04, technetium-99 and uranium concentrations in both wells were in line with trends reported since at least January 2001. Uranium concentrations at both wells averaged approximately 1.0 µg/L. A greater depth-dependent spread of technetium-99 concentrations was found between wells 299-W19-34A (130 µg/L) and 299-W19-34B (17.8 pCi/L).

Some monitoring wells in the 200-UP-1 baseline plume exhibited rapid increases to peak concentrations followed by rapid declines since groundwater extraction began in 1994. As discussed in detail in the *Fiscal Year 2002 Annual Summary Report for the 200-UP-1 and 200-ZP-1 Pump-and-Treat Operations* (DOE-RL 2003a), the peak-and-decline behavior could be attributed to a variety of causes (e.g., remobilization of contaminants from the vadose zone). A rebound study is planned for the second quarter of FY05 to evaluate the stability of contaminant concentrations in groundwater.

#### 2.4.2 Secondary Contaminant Monitoring Results

The same seven monitoring and extraction wells sampled for technetium-99 and uranium at the 200-UP-1 OU were also sampled for nitrate and carbon tetrachloride during three separate events in the second, third, and fourth quarters of FY04. The resulting nitrate and carbon tetrachloride concentrations and annual comparisons are shown in the table below:

Well Name	FY03 Avg. Concentration	FY04 Avg. Concentration	Annual Comparison <sup>b</sup>	Second Quarter 2004	Third Quarter 2004	Fourth Quarter 2004
<i>Carbon Tetrachloride (µg/L)</i>						
299-W19-35	94	84	Stable	94 <sup>a</sup>	--	74
299-W19-36	270	463	Increasing	--	490	650; 250
299-W19-37	73	140	Increasing	160		120
299-W19-39	72	50	Decreasing	--	48	52
299-W19-40	24	12	Decreasing	--	--	12
299-W19-43	80	114	Increasing	190	--	37
299-W19-46	81	46	Decreasing	32	--	59

Well Name	FY03 Avg. Concentration	FY04 Avg. Concentration	Annual Comparison <sup>b</sup>	Second Quarter 2004	Third Quarter 2004	Fourth Quarter 2004
<i>Nitrate (µg/L)</i>						
299-W19-35	233,000	241,500	Stable	257,000	--	226,000
299-W19-36	413,000	256,750	Decreasing	--	265,000	265,000; 232,000
299-W19-37	255,000	61,300	Decreasing	54,900	--	67,700
299-W19-39	144,000	133,000	Stable	--	135,000	131,000
299-W19-40	38,100	39,000	Stable	--	--	39,000
299-W19-43	135,700	484,500	Increasing	522,000	--	447,000
299-W19-46	49,900	31,200	Decreasing	32,300	--	30,100

<sup>a</sup> Values averaged.

<sup>b</sup> Comparison is the percent difference between FY04 and FY03 and is calculated by the following equation:  $[(FY04 - FY03) / FY03] \times 100\%$ . Wells are considered stable if there is less than a 20% change in concentration from FY03 to FY04.

Nitrate is present in the 200 West Area as two large plumes that exceed the 45 mg/L MCL. The plume within the 200-UP-1 OU is derived from wastes sites 216-U-1 and 216-U-2, which are located west of the 200-UP-1 pump-and-treat system. Average nitrate concentrations either decreased or remained stable during FY04 in six of the seven wells sampled. The highest nitrate concentration was found in well 299-W19-43, which was the only well with increased nitrate concentrations in FY04. Well 299-W19-43 was initially sampled for nitrate in FY03.

Carbon tetrachloride is primarily derived from past Z Plant discharges to waste sites 216-Z-1A, 216-Z-9, and 216-Z-18 in the 200-ZP-1 Groundwater OU, and has since spread beneath most of the 200 West Area. Carbon tetrachloride concentrations in the vicinity of the 200-UP-1 baseline plume are much less than the >2,000 µg/L RAO values that are applied for 200-ZP-1 remediation, but are consistently above the 5 µg/L MCL. The highest carbon tetrachloride concentration occurred in well 299-W19-36 during FY03 (270 µg/L) and again in FY04 (650 µg/L). During FY04, the carbon tetrachloride concentration increased in three of the seven wells sampled: 299-W19-36, 299-W19-37, and 299-W19-43. Insufficient data are available to determine if contaminant variability is due to local aquifer heterogeneity or broader movement of carbon tetrachloride through the aquifer. The three wells are located near an upgradient portion of the baseline plume area, which has had historically high concentrations of all analytes.

At well 299-W19-34A, carbon tetrachloride concentrations declined to 125 µg/L in August 2004 from 139 µg/L in FY02. Carbon tetrachloride concentrations at well 299-W19-34B dropped by 50%, from an average of 173 µg/L in FY02 to 85 µg/L in August 2004. Nitrate concentrations at the two wells continued to slowly decline in FY04, reaching average annual values of 13,950 and 8,850 pCi/L, respectively.

## 2.5 AQUIFER RESPONSE

Aquifer response is an important component in assessing the effectiveness of the pump-and-treat system. Water-level measurements provide the basis for assessing the control that pumping exerts over the flow around the plumes. Coupled with the knowledge of aquifer properties, aquifer response also helps to predict the capture zone of the pumping system, and rate of groundwater flow.

### 2.5.1 Hydraulic Monitoring

Groundwater flow in the 200-UP-1 OU is generally west to east, with a hydraulic gradient of 0.0013 m/m. As shown in Figure 2-8, the current flow pattern indicates a slow change from the west-northwest/east-southeast flow regime active in the 1995 baseline. Impacts from discharges to liquid waste sites are diminishing as the present flow direction more closely approximates the regional flow in the 200 West Area and the western portion of the Hanford Site. Small impacts of extraction well pumping on monitoring well water levels were observed during the year.

Groundwater elevation data collected during FY04 at locations away from the extraction wells, but near the 200-UP-1 pump-and-treat system, indicated that the groundwater surface declined at an average of 0.36 m/year (1.18 ft/year). This is essentially the same rate of decline as observed in FY03 and FY02 (0.38 and 0.36 m/year, respectively) but is significantly less than the 0.66 m/year (2.16 ft/year) reported for FY98. The decline began with cessation of discharges to the 216-U-10 Pond in 1985 and accelerated when a Sitewide disposal of low-level liquid waste streams to the soil column was halted in 1995. Declining groundwater levels are hindering the ability to maintain the 189.3 L/min (50 gpm) extraction rate specified in the interim ROD (EPA et al. 1997).

Minor discharges to the soil column continue at sanitary tile fields (2607-W5) and through leaking water lines. A pipeline leak in March 2003 released unknown but relatively small quantities of water to the soil column at a location approximately 70 m (230 ft) west of the 216-U-1/U-2 Cribs. Concentrations of nitrate and carbon tetrachloride have increased between January 2003 and August 2004 at well 299-W19-9, which is the nearest well. It is uncertain if either source is responsible for the increase in concentrations. Additional discussion of hydraulic monitoring is presented in Appendix C. Discharges to the 2607-W5 tile field are to be halted by March 2005.

### 2.5.2 Numerical Modeling

Numerical modeling has been used to calculate capture zones around the extraction wells, as shown in Figure 2-9. Appendix E provides additional information regarding groundwater modeling. Modeling results indicate that the extraction wells are capturing contaminants in the baseline plume area. The streamlines and 90-day travel markers for the capture zones around the three extraction wells represent the approximate location of a water particle at 90-day intervals for the past year. Although Figure 2-9 may suggest that the pump-and-treat system may not be treating all of the baseline plume, it continues to build on the treatment achieved in previous years. The streamlines are more qualitative than absolute, and they show the width of the capture zone for each of the three wells.

Additional proof of plume capture is evident by long-term, below-RAO contaminant concentrations at wells 299-W19-35, 299-W19-40, and at 299-W19-37. Well 299-W19-46, located adjacent to decommissioned well 299-W19-38, also provided an additional check by monitoring technetium-99 and uranium concentrations along the southern edge of the plume previously tracked by the older well. Well 299-W19-38 went dry in January 2000, with concentrations of technetium-99 at 750 pCi/L and uranium at 213 µg/L. With the startup of monitoring at well 299-W19-46, technetium-99 and uranium concentrations have not exceeded 175 pCi/L and 170 µg/L, respectively.

The FY98 annual report (DOE-RL 1999) contained a calculation of the time period that the extraction well pump at 299-W19-39 could be shut down before high-concentration contaminants would move from the well to beyond the downgradient capture zone. This calculation has been reproduced (Appendix E) to update for lower gradients and flow velocities. Using an assumed groundwater flow velocity of 0.22 m/day (0.72 ft/day), it was concluded that the pump could be shut down for up to 340 days before technetium-99 (with no retardation) exited the capture zone, and much longer for uranium (because retardation affects its transport).

## 2.6 RESULTS OF MSE URANIUM MODELING ACTIVITIES

Beginning in FY01, MSE was funded by U.S. Department of Energy (DOE)-Headquarters to develop a conceptual model of uranium movement in the 200-UP-1 OU. This work was completed at the end of FY04. The primary task associated with this project was a geochemical modeling effort, with the goal of producing an acceptable correlation between predicted and observed concentrations of uranium in the groundwater. The scope of the project included the following tasks:

- Sampling the soil and porewater for analysis of chemical and physical properties to develop a surface complexation model describing uranium partitioning between the soil and the groundwater for the site.
- Using the surface complexation model to investigate the partitioning relationships that may exist for potential contaminant transport paths at the site.
- Simulating uranium transport for potential transport paths at the site, including its source.
- Updating the conceptual model of uranium transport at the site with the model, providing the best fit of the simulated results with observed data.

The computer model used was “PHREEQCI” (Parkhurst and Appelo 1999), which is a public-domain equilibrium geochemical modeling program developed and supported by the U.S. Geological Survey. The modeling efforts focused on the processes (i.e., aqueous speciation, surface complexation, and precipitation) that may have controlled uranium mobility beneath the 216-U-1/U-2 Cribs. The key modeling elements included simulating one-dimensional advective transport of the 216-U-1/U-2 Crib wastes to the aquifer, mixing of contaminated water from the unsaturated zone with the aquifer water, and advective transport of atmospheric water through the contaminated sediments. Several scenarios were considered for the potential pathways of the 216-U-1/U-2 waste to the aquifer. The scenarios were also modeled using a range of parameter values (e.g., unsaturated soil column volume, water saturation ratio, waste pore volumes, mixing ratios, etc.). Each model predicted uranium concentrations at the water table interface and in the

aquifer that could be compared to measured, historical concentrations or used to predict future concentrations.

Results indicate that uranium contamination reached the groundwater through a “window” in the Cold Creek unit underlying the 216-U-1/U-2 Cribs. This is in agreement with the current conceptual model. Uranium is likely sorbed on the vadose zone sediments and did not precipitate to form a solid-phase uranium source (e.g., sodium autunite precipitate). These modeling results are in agreement with historical data of uranium contamination in the groundwater.

## 2.7 QUALITY ASSURANCE/QUALITY CONTROL

Replicate (duplicate) laboratory analyses were performed on 5% of groundwater samples collected across the 200-UP-1 Groundwater OU in FY04, although none of the wells were within the baseline plume area. The duplicate samples are compared for precision using the relative percent difference (RPD) calculation for each sample pair (Appendix G). The EPA’s guidelines (EPA 1988) indicate that an RPD of 20% or less is a satisfactory indicator of analytical precision. The results of the RPD calculation for the 200-UP-1 OU are summarized in the table below:

Type of Quality Control Sample	Number of Pairs	Number of Calculated RPD Values	Number of Pairs <20% RPD	Calculate Sample Pairs with RPD<20%
Laboratory replicates, uranium	9	9	9	100%
Laboratory replicates, technetium-99	8	6	6	100%
Laboratory splits, technetium-99	1	0	0	N/A
Laboratory replicates, carbon tetrachloride	7	3	3	100%
Laboratory splits, carbon tetrachloride	1	1	0	0%

Laboratory analyses of all uranium and technetium-99 replicate and split samples for which an RPD was calculated were within the 20% precision guideline. One split sample for carbon tetrachloride analysis exceeded the 20% RPD guideline.

## 2.8 TECHNETIUM-99 AT WELL 299-W23-19

Groundwater containing high concentrations of technetium-99 is being collected at well 299-W23-19 in the 241-SX Tank Farms and is then treated at the ETF (Appendix F). Effective March 12, 2003, in accordance with an agreement between DOE and the Washington State Department of Ecology (Ecology), quarterly sampling at this well was accompanied by the capture and treatment of large volumes (>3,785 L [>1,000 gal]) of contaminated groundwater. The groundwater was taken to the ETF by truck and combined with water received from the 200-UP-1 extraction wells. During FY04, well 299-W23-19 was sampled four times. The trend plot for technetium-99 concentrations is presented in Figure 2-10, showing a peak in January 2003 at 188,000 pCi/L, followed by a substantial decline to 46,100 pCi/L in September 2004.

The following table presents data on the accumulated volume of purgewater and the concentration of the initial sample. From this information, the technetium-99 curie content was calculated and converted to a mass value using the specific activity value of 0.017 Ci/g. As the table indicates, a total of approximately 0.0019 Ci of technetium-99 (or 0.11 g) have been recovered. The declining concentrations suggest that the plume, or a higher concentration pulse, has moved downgradient from the well's capture zone.

Date of Sampling	Groundwater Pumped, L (gal)	Technetium-99 Concentration (pCi/L)	Curies of Technetium-99 <sup>a</sup>	Mass of Technetium-99 (g)
March 12, 2003	2,722 (719)	133,000	0.00036	0.021
June 18, 2003	4,028 (1,064)	120,000	0.00048	0.028
September 23, 2003	4,013 (1,060)	74,300	0.00030	0.018
December 16, 2003	3,944 (1,042)	42,950	0.00017	0.010
March 22, 2004	4,845 (1,280)	42,200	0.00020	0.012
June 16, 2004	3,986 (1,053)	41,800	0.00017	0.010
September 29, 2004	4,111 (1,086)	46,100	0.00019	0.011
<b>Total through FY04</b>	<b>27,649 (7,304)</b>	<b>--</b>	<b>0.00187</b>	<b>0.11</b>

<sup>a</sup> Specific activity of technetium-99 is 0.017 Ci/g, or 58.7 g/Ci.

The *Hanford Site Groundwater Annual Report for Fiscal Year 2004* (PNNL 2005) presents a more detailed discussion of technetium-99 monitoring at this well.

## 2.9 CONCLUSIONS

The specific RAOs for the 200-UP-1 OU pump-and-treat interim remedial measure operation were met for the entirety of FY04. The results for each are discussed below:

- **RAO #1: Reduce contamination in the areas of highest concentrations of uranium and technetium-99 to below 10 times the cleanup level under MTCA for uranium and 10 times the MCL for technetium-99.**

**Results:** The RAO for technetium-99 and uranium has been met for one full year of operations. This is the first time that a Hanford Site pump-and-treat system has met RAOs. The highest concentration of technetium-99 was 5,910 pCi/L at well 299-W19-36. Similarly, uranium concentrations were the highest at this well, averaging 388 µg/L for FY04. A rebound study planned for calendar year 2005 is warranted.

- **Technetium-99 plume:** Extraction operations during FY04 continued to remove technetium-99 from the 200-UP-1 OU. The FY04 average concentrations were below the >9,000 pCi/L RAO for all seven monitoring and extraction wells sampled. The average concentration in well 299-W19-43 continued to decline (from 10,795 pCi/L in FY03 to 836 pCi/L in FY04) after it was converted from a monitoring well to an extraction well in FY03. Average concentrations remained either stable or decreased in most wells, except at 299-W19-36, which exhibited a small overall increase. Similarly, the technetium-99 concentrations in well 299-W19-35, located

downgradient along the northern portion of the plume, have increased from 379 pCi/L in early 1999, to 795 pCi/L in FY03, and to an average of 1,395 pCi/L in FY04.

- **Uranium plume:** Continued progress was made in remediating the baseline uranium plume during FY04. Average concentrations were below the RAO of >480 µg/L in all seven wells sampled and showed stable or declining trends. The average uranium concentration in well 299-W19-35 (42 µg/L) remained below the baseline MCL concentration of 48 µg/L. Average concentrations in all seven sampled wells either declined or remained stable during FY04.

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

**Results:** The remaining contaminant mass in groundwater was reduced during FY04. The ETF system treated more than 93 million L (24 million gal) of groundwater in FY04. The following contaminant mass was removed during FY04, and from system startup in March 1994:

<u>Contaminant</u>	<u>FY04</u>	<u>Total Since March 1994</u>
Technetium-99	12.1 g	114.13 g
Uranium	23.5 kg	203 kg
Carbon tetrachloride	5.4 kg	31.2 kg
Nitrate	5,207 kg	32,550 kg

An estimated 6.2 kg of carbon tetrachloride were lost to the atmosphere while pumping groundwater from the extraction wells to the Liquid Effluent Retention Facility (LERF). The ETF's treatment efficiencies were greater than 99.9% for all contaminants. No unscheduled downtime for the extraction wells occurred during FY04.

- ***RAO #3: Prevent further movement of these contaminants from the highest concentration area.***

**Results:** The highest concentration portion of the FY04 technetium-99 (>900 pCi/L) and uranium (>48 µg/L) plumes appear to be hydraulically contained based on data from downgradient wells 299-W19-37 and 299-W19-40. The upgradient plume boundaries are less certain due to fewer monitoring wells. The increasing technetium-99 concentration in well 299-W19-35 in the last several years will continue to be monitored.

- ***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:** FH continued to collect operational and groundwater monitoring data to support development and implementation of a final remedy. Three new monitoring wells (699-38-70B, 699-38-70C, and 699-40-65) were installed east and northeast of the 200-UP-1 extraction system to monitor downgradient contaminant concentrations and to establish a vertical contaminant profile distribution in the unconfined aquifer. Two other wells (699-30-60 and 299-W21-2) were installed in FY04 and monitor groundwater south and southeast of the 200-UP-1 pump-and-treat system.

MSE completed development of a geochemical model for uranium transport in unsaturated sediments and groundwater. A final report has been prepared.

A year-long rebound study is planned to begin in January 2005 to test whether contaminant concentrations will increase above RAO limits after the extraction system is shut down. Extraction and monitoring wells will be sampled monthly for uranium and technetium-99 during the system shutdown. Quarterly sampling at all wells will be conducted to detect carbon tetrachloride and nitrate concentrations.

## **2.10 RECOMMENDATIONS**

The following recommendation is made for the 200-UP-1 OU:

- Revise/revisit existing groundwater monitoring data quality objectives (DQOs) for the 200 West Area.

The DQO process for 200 West Area groundwater monitoring (BHI 2002) should be reopened to examine the impact of new groundwater data on conceptual models and to assess the additional work that is needed to update 200-UP-1 groundwater sampling described in the 200-UP-1 RI/FS work plan. Revisiting the existing monitoring well DQOs for both 200-UP-1 and 200-ZP-1 is recommended to establish realistic requirements and goals for what needs to be done to address unknowns within the 200-UP-1 OU.

Figure 2-1. 200-UP-1 Site Location Map and Monitoring Wells.

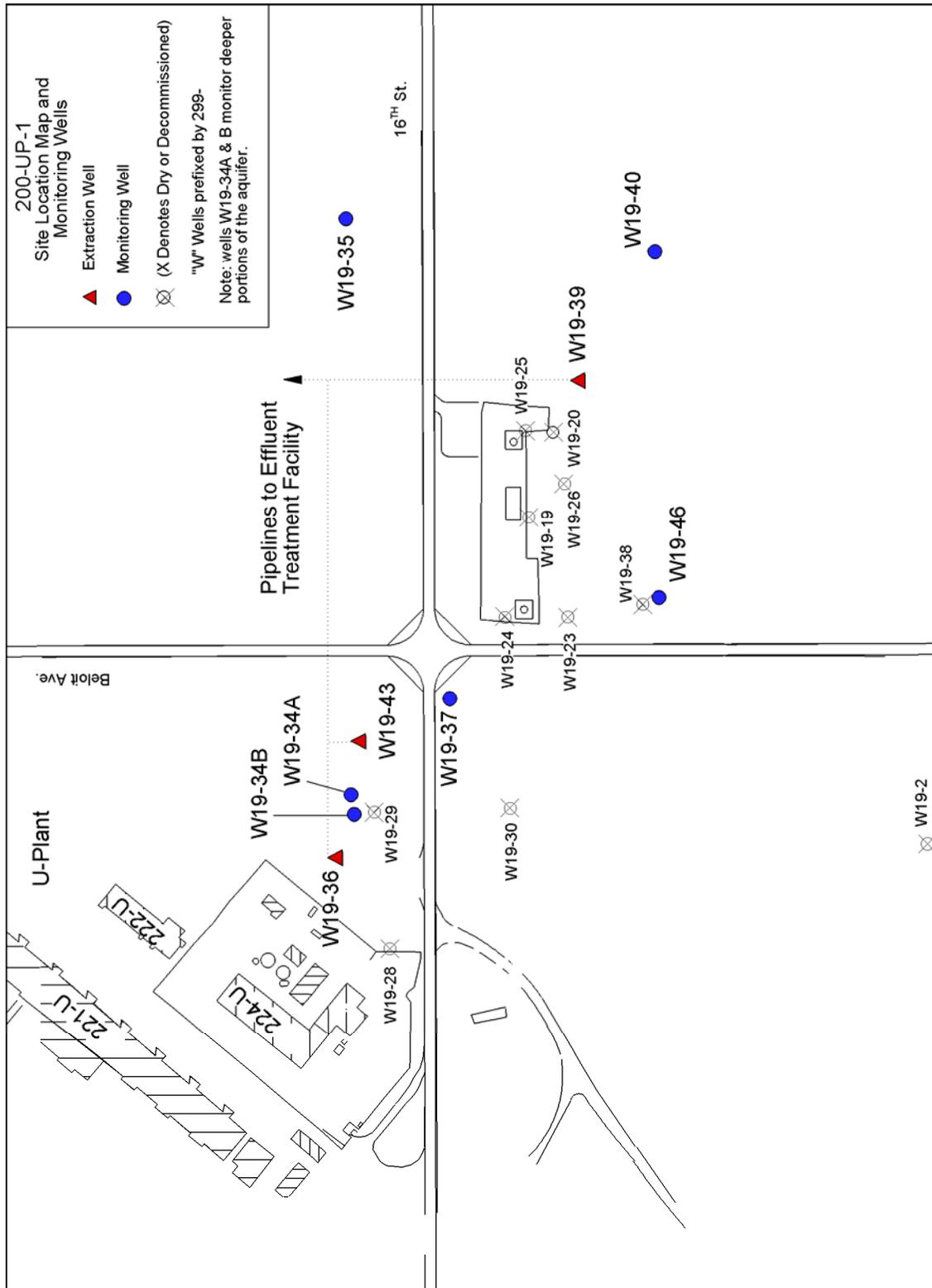


Figure 2-2. Extraction Rate Averages at 200-UP-1 Operable Unit.

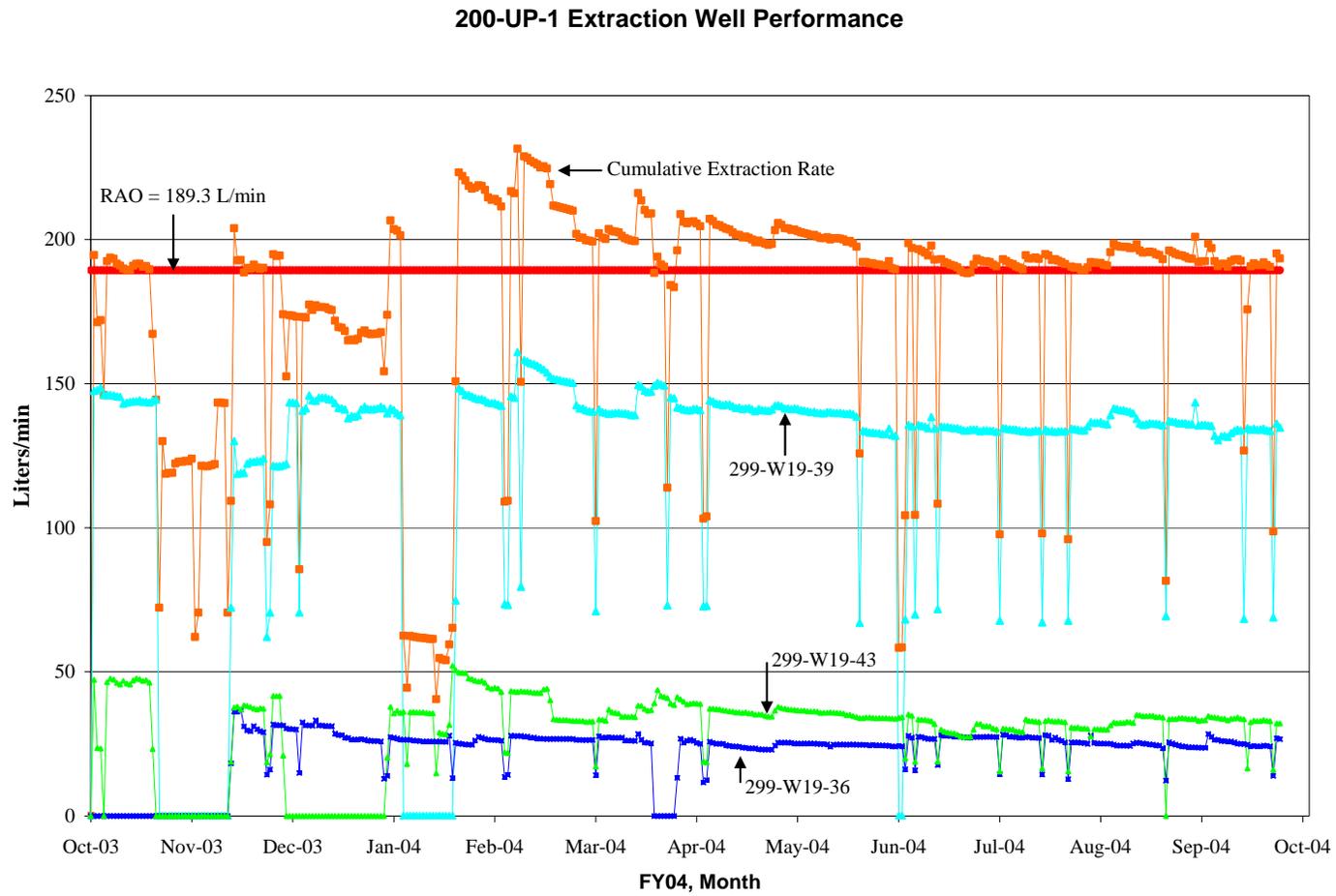
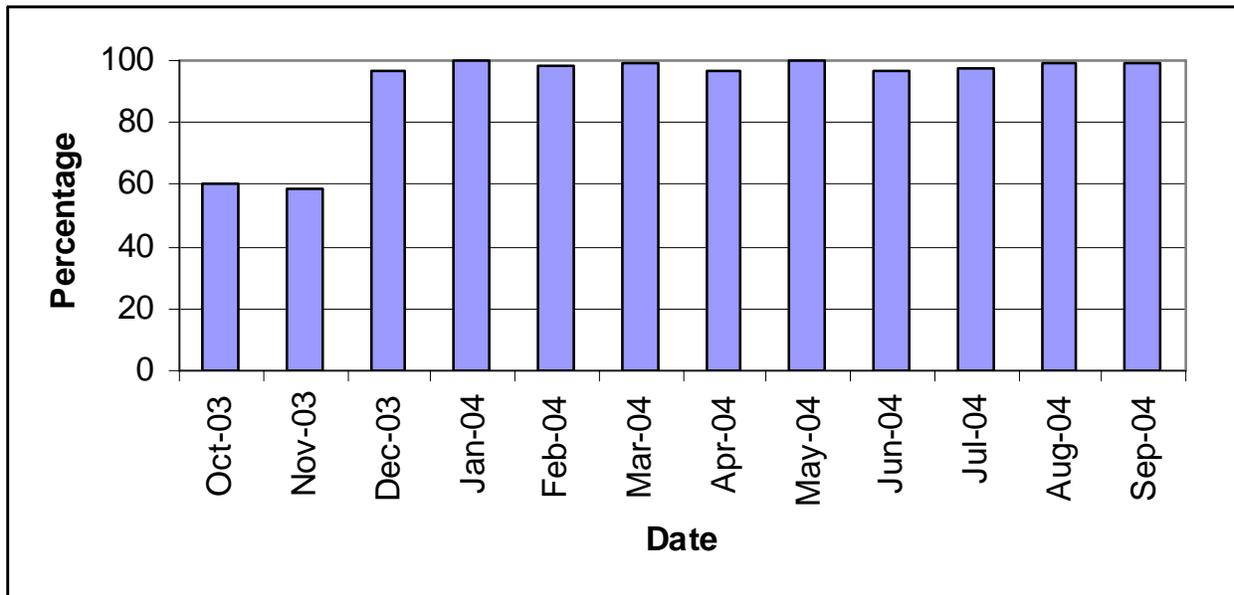


Figure 2-3. 200-UP-1 Operable Unit Pump-and-Treat System Availability.

**System availability:**

Total hours in FY04 = 8,784 hours

Total time available during FY04 (total hours minus scheduled outages) = 8,073.5 hours

Total time on-line during FY04 (total hours minus all outages) = 8,073.5 hours

System on-line availability ( $\{\text{total time on-line}/\text{total hours}\} \times 100$ ) = 91.9%

Total system availability ( $\{\text{total time available}/\text{total hours}\} \times 100$ ) = 91.9%

Total unscheduled down-time hours = 0 hours

**List of Scheduled System Outages**

Month	Scheduled Outages	Comments
October	32.00	Scheduled outage; ERDF leachate transfer.
	112.50	Scheduled outage; extraction well 299-W19-36 tie-in.
	168.00	Scheduled outage; ETF maintenance.
	<b>312.50</b>	<b>Total for October</b>
November	275.50	Scheduled outage; ETF maintenance.
December	22.00	Scheduled outage; ERDF leachate transfer.
February	11.50	Scheduled outage; ERDF leachate transfer.
March	8.00	Scheduled outage; ERDF leachate transfer.
April	24.50	Scheduled outage; ERDF leachate transfer.
June	24.00	Scheduled outage; ERDF leachate transfer.
July	18.00	Scheduled outage; ERDF leachate transfer.
August	7.50	Scheduled outage; ERDF leachate transfer.
September	7.00	Scheduled outage; ERDF leachate transfer.
<b>FY04 Total</b>	<b>710.5</b>	

ERDF = Environmental Restoration Disposal Facility

ETF = Effluent Treatment Facility

Figure 2-4. 200-UP-1 Operable Unit Trend of Influent/Effluent Contaminant Concentrations as Measured by the Effluent Treatment Facility. (2 sheets)

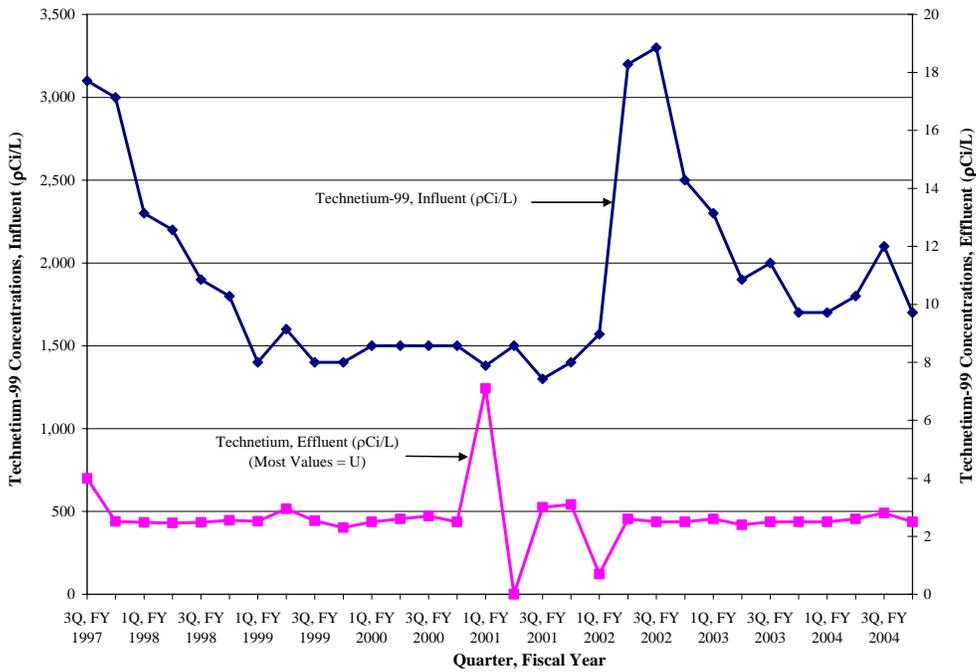
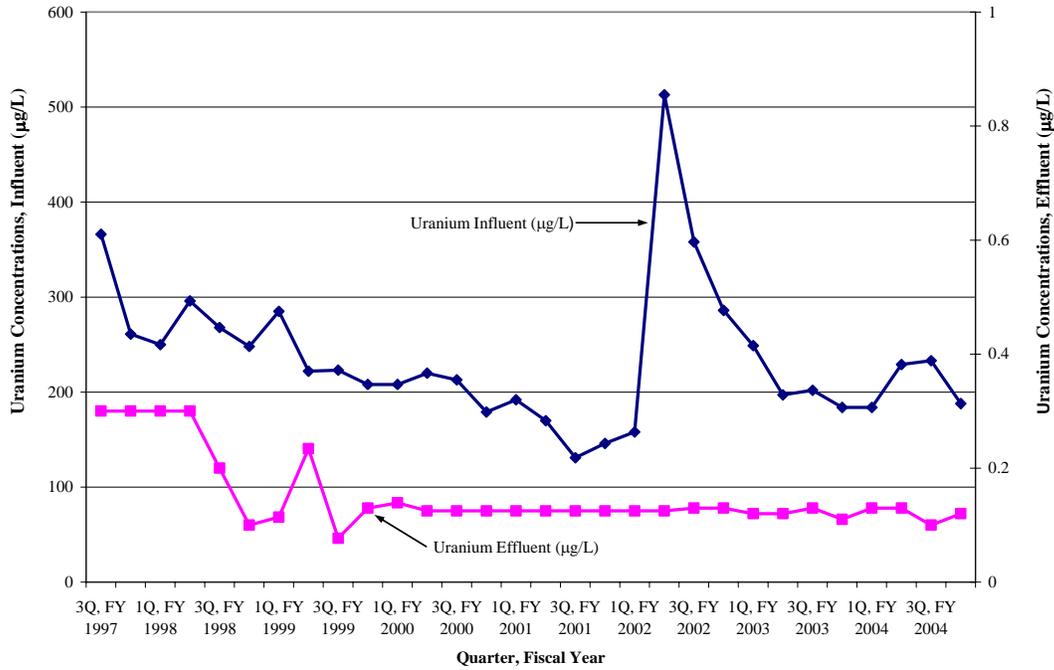


Figure 2-4. 200-UP-1 Operable Unit Trend of Influent/Effluent Contaminant Concentrations as Measured by the Effluent Treatment Facility. (2 sheets)

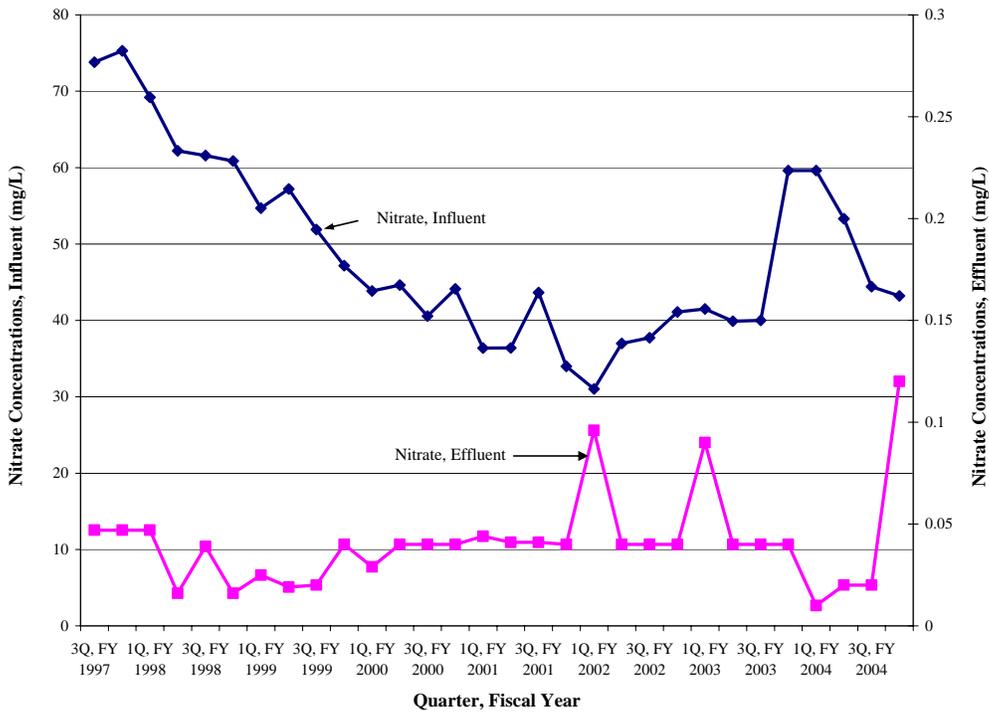
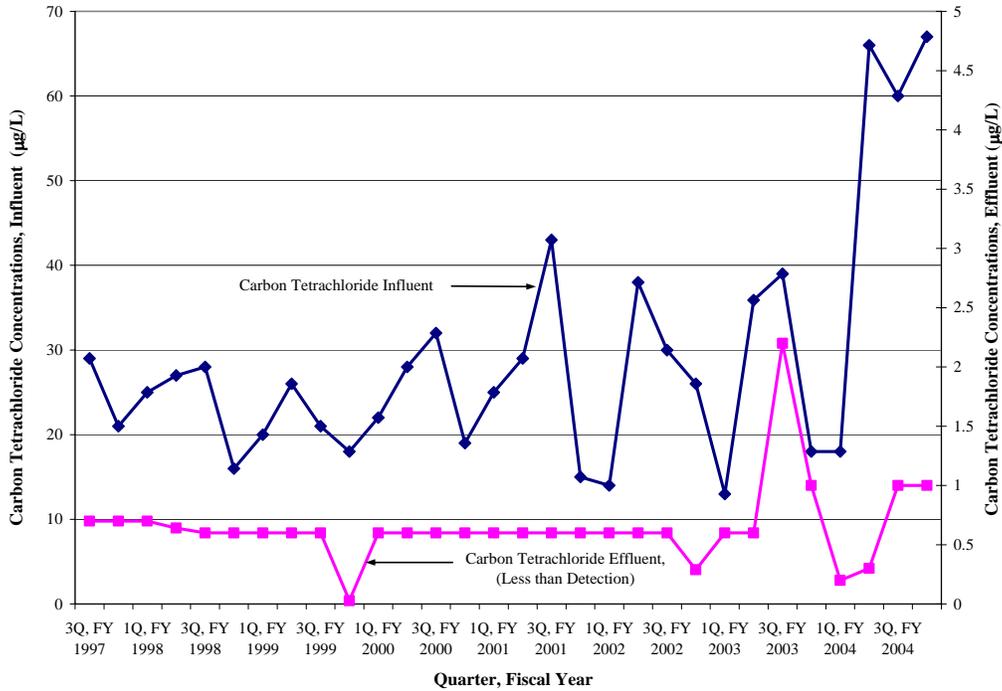
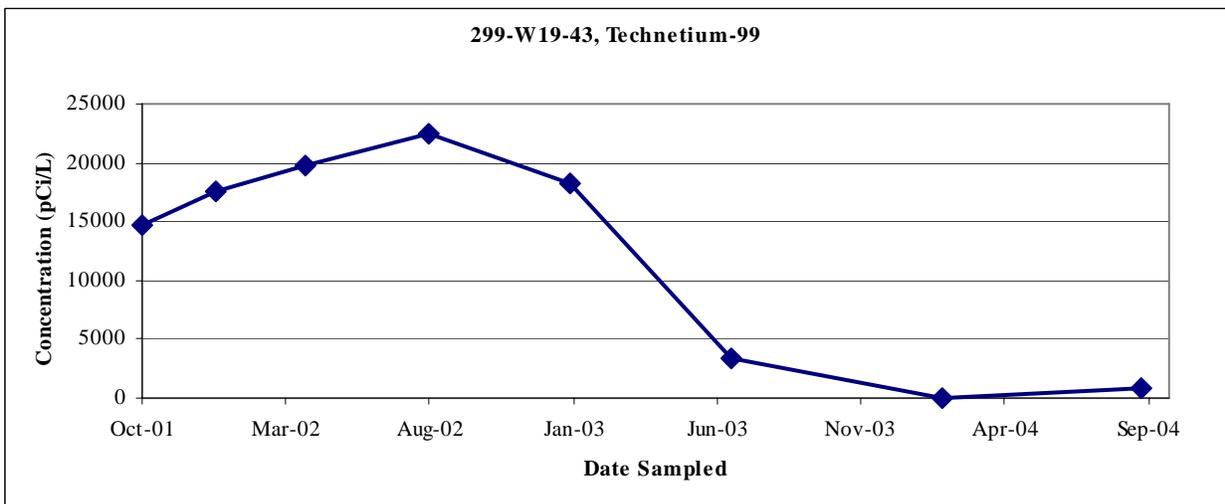
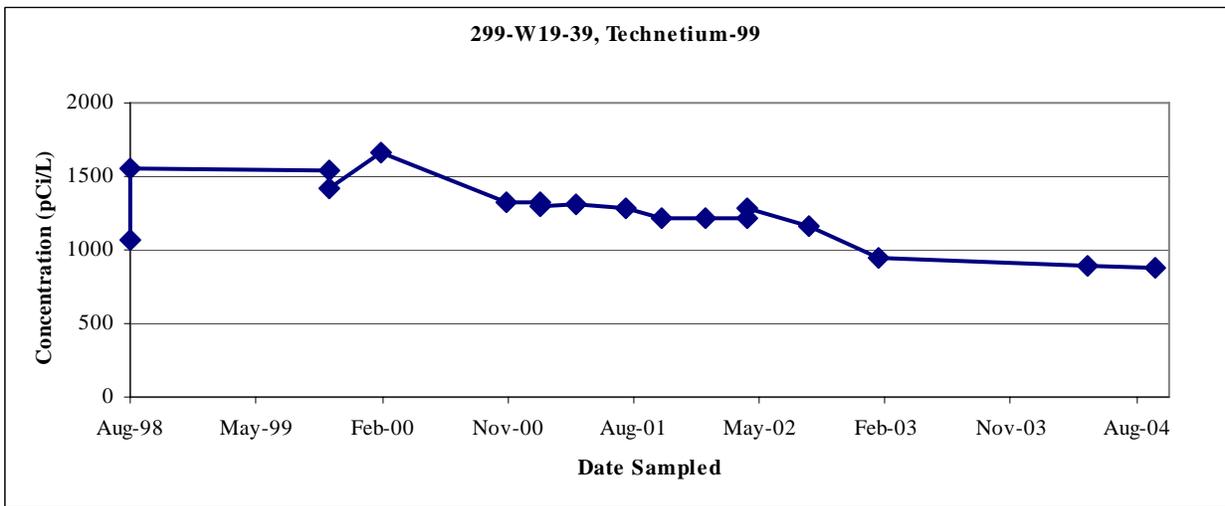
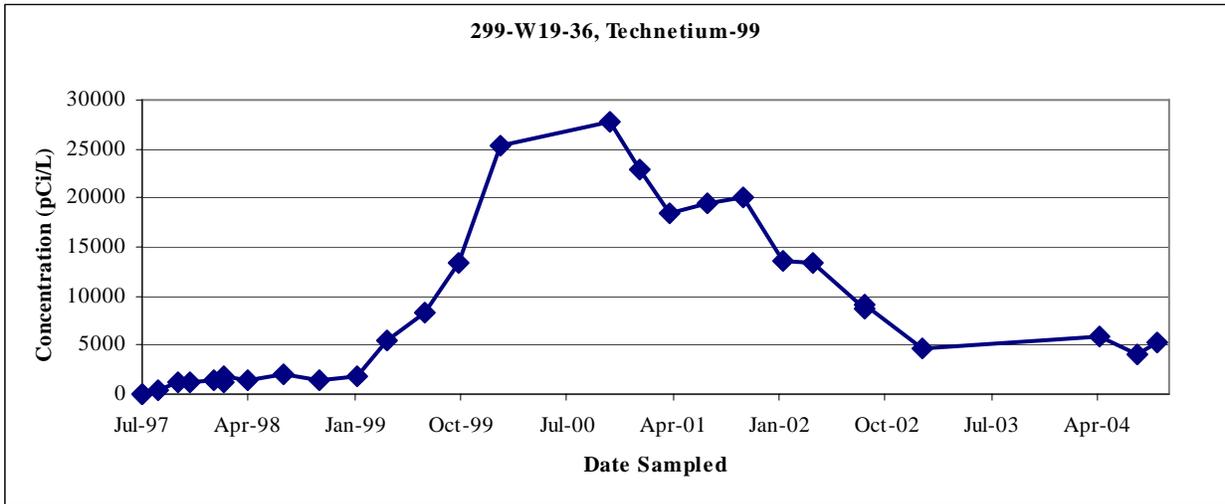




Figure 2-5. 200-UP-1 Operable Unit Contaminant Trend Plots for Influent as Measured at Extraction Wells 299-W19-36, 299-W19-39, and 299-W19-43. (3 sheets)





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Figure 2-6. 200-UP-1 Operable Unit Technetium-99 Contaminant Plume.

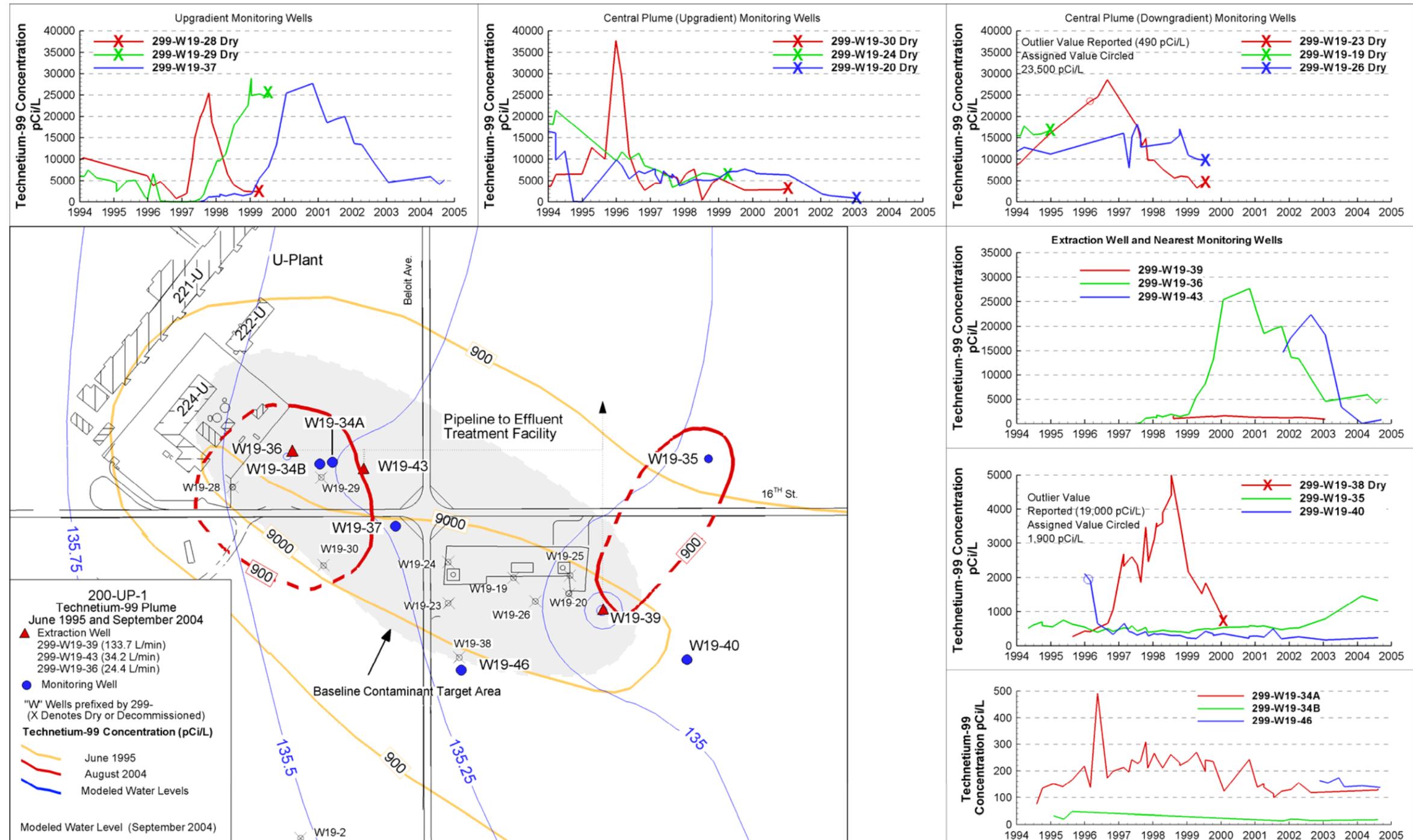


Figure 2-7. 200-UP-1 Operable Unit Uranium Contaminant Plume.

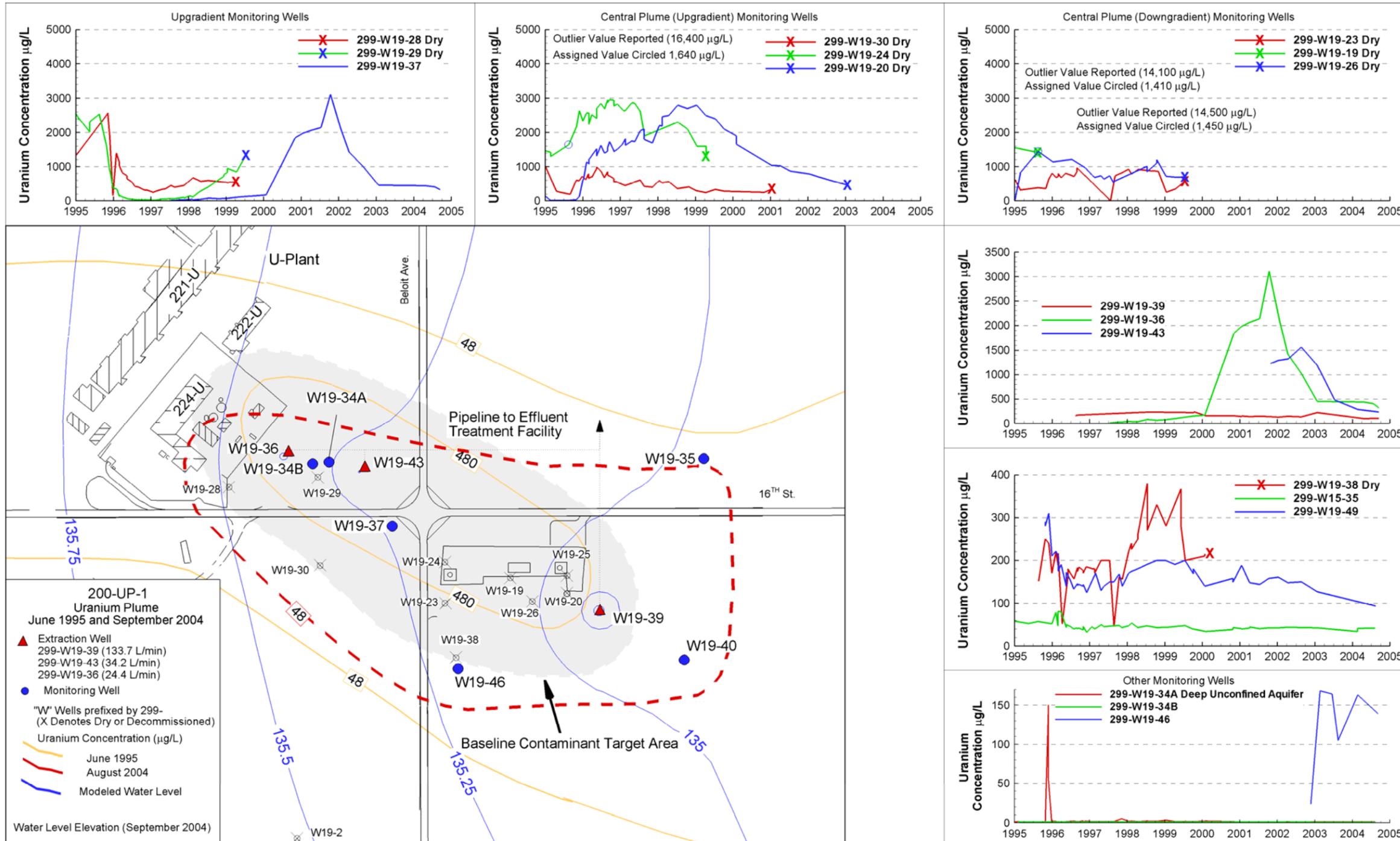


Figure 2-8. 200-UP-1 Operable Unit Water Table Map:  
 Baseline Water Table June 1995 Versus September 2004 Water Table.

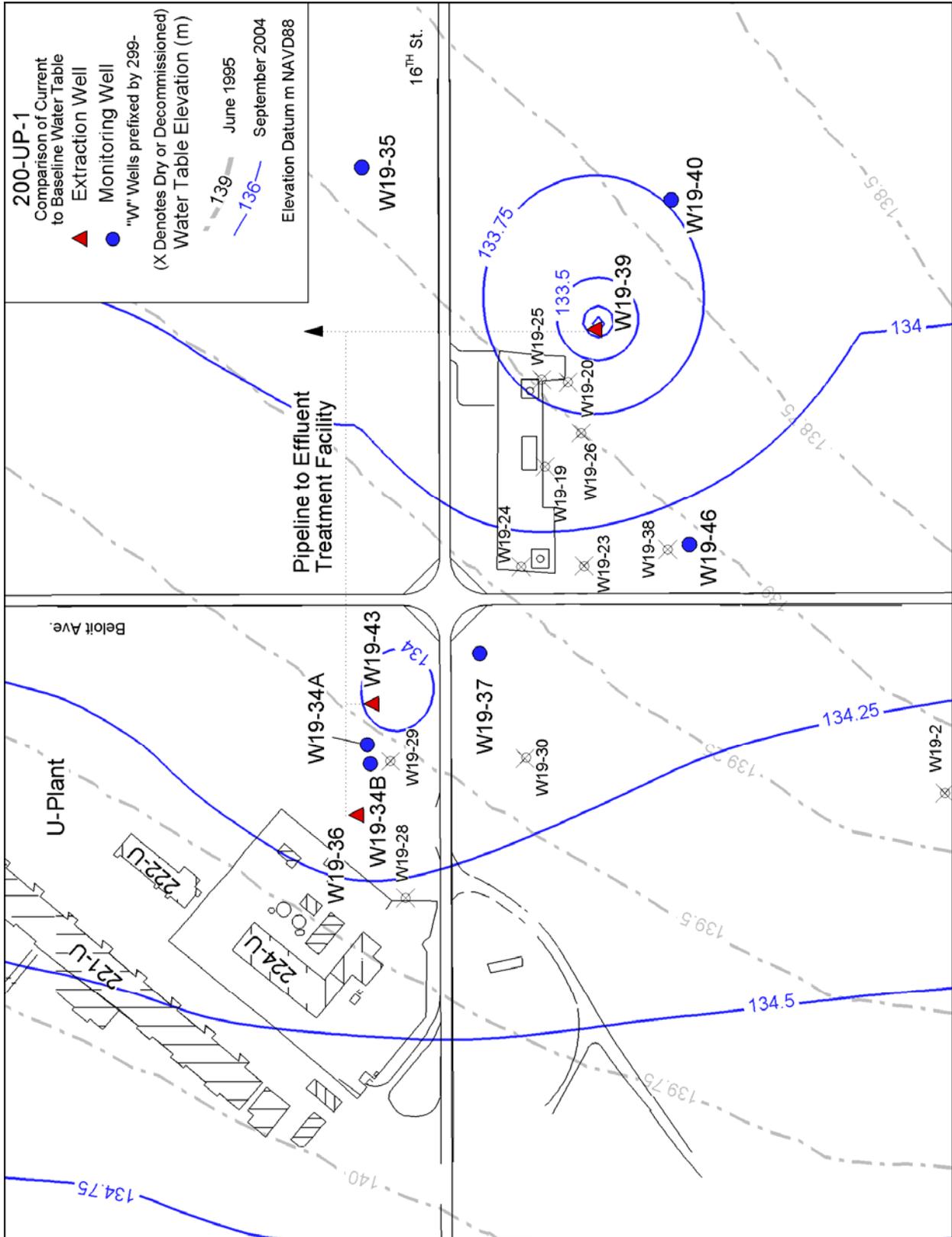




Figure 2-10. Technetium-99 Trend Plot at Well 299-W23-19.

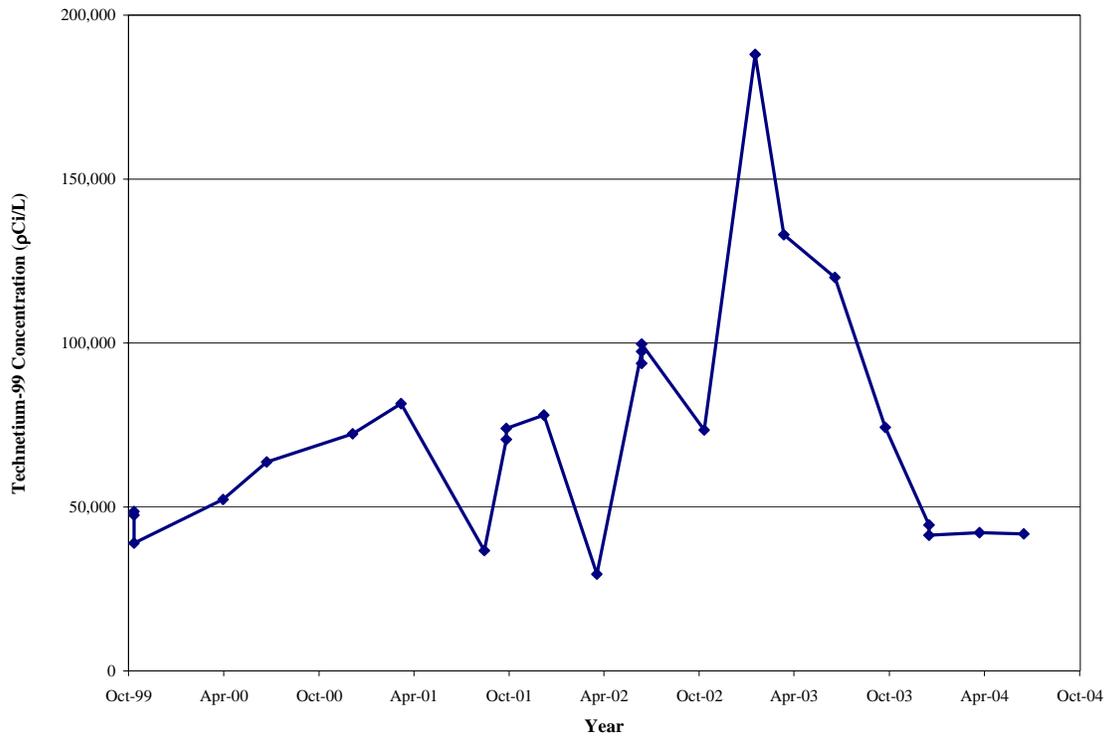


Table 2-1. Volume of Groundwater Treated and Mass of Contaminants Removed Since Initiation of Operations at the 200-UP-1 Operable Unit. (2 sheets)

Dates	Liters Treated	Mass Tc-99 Removed (g)	Mass Total Uranium Removed (g)	Mass Carbon Tetrachloride Removed (g)	Mass Nitrate Removed (kg)
March 1994 – November 1994 <sup>a</sup>	3,898,550	3.41	4,422	Not reported	N/A
December 1994 – August 1995	11,391,491	7.79	9,831	992	N/A
September 1995 – November 1995	17,198,571	3.95	3,895	630	N/A
December 1995 – March 1996	31,311,340	9.05	9,105	1,609	N/A
April 1996 – June 1996	22,459,108	5.4	6,845	1,569	N/A
July 1996 – September 1996	22,370,327	4.01	5,134	2,790	N/A
October 1996 – December 1996	20,300,000	3.33	5,607	2,980	N/A
January 1997 – February 1997 <sup>b</sup>	2,667,600	0.83	963	73	N/A
February – March 30, 1997	Shut down	N/A	N/A	N/A	N/A
March 31 – September 30, 1997	32,414,481	5.6	11,000	888	2,260
October 1 – December 31, 1997	20,390,054	3.31	6,300	572	1,530
January 1 – March 31, 1998	19,791,765	2.08	4,900	460	1,070
April 1 – June 30, 1998	33,538,750	3.58	8,680	907	2,150
July 1 – September 30, 1998	26,346,466	1.57	3,750	296	900
October 1 – December 31, 1998	22,174,396	1.49	4,910	341	979
January 1 – March 31, 1999	23,720,542	1.89	4,450	601	1,050
April 1 – June 30, 1999	24,369,400	2.29	5,400	600	1,400
July 1 – September 30, 1999	23,206,922	2.14	5,940	460	1,430
October 1 – December 31, 1999	14,858,190	1.25	3,080	286	681

Table 2-1. Volume of Groundwater Treated and Mass of Contaminants Removed Since Initiation of Operations at the 200-UP-1 Operable Unit. (2 sheets)

Dates	Liters Treated	Mass Tc-99 Removed (g)	Mass Total Uranium Removed (g)	Mass Carbon Tetrachloride Removed (g)	Mass Nitrate Removed (kg)
January 1 – March 31, 2000	14,636,480	1.29	3,100	352	645
April 1 – June 30, 2000	18,295,080	1.63	4,050	527	806
July 1 – September 30, 2000	15,439,630	1.45	3,410	494	675
October 1 – December 31, 2000	35,538,203	2.93	6,475	781	1,371
January 1 – March 31, 2001	17,352,328	1.41	3,332	434	631
April 1 – June 30, 2001	24,300,159	2.01	3,798	833	955
July 1 – September 30, 2001	25,284,628	2.02	3,523	696	967
October 1 – December 31, 2001	31,276,969	2.8	4,840	444	987
January 1 – March 31, 2001	6,102,084	2.54	4,350	854	850
April 1 – June 30, 2002	31,217,155	6.05	11,400	950	1,180
July 1 – September 30, 2002	17,290,247	3.11	5,830	499	669
October 1 - December 31, 2002	23,365,000	3.19	5,980	359	966
January 1 - March 31, 2003	24,550,000	2.90	5,210	699	991
April 1 - June 30, 2003	28,615,000	3.31	5,747	1,087	1,144
July 1 - September 30, 2003	21,813,000	2.39	4,238	654	1,056
October 1 - December 31, 2003	12,037,600	1.2	2,210	217	717
January 1 - March 31, 2004	26,497,900	4.94	9,840	1,670	2,010
April 1 - June 30, 2004	25,362,260	2.99	5,880	1,560	1,190
July 1 - September 30, 2004	29,866,899	2.97	5,610	2,000	1,290
<b>Totals</b>	<b>801,248,575</b>	<b>114.13</b>	<b>203,035</b>	<b>31,164</b>	<b>32,550</b>

<sup>a</sup> Data from the treatability test as reported in the *Treatability Report for the 200-UP-1 Operable Unit – Hanford Site* (DOE-RL 1995).

<sup>b</sup> Estimated values based on 189 L/min flow, running 24 hours/day, at 97.5% efficiency.

N/A = not applicable

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### 3.0 200-ZP-1 OPERABLE UNIT PUMP-AND-TREAT SYSTEM

The 200-ZP-1 OU pump-and-treat system is located near the middle of the 200 West Area (Figure 3-1) and is centered on a carbon tetrachloride plume formed by discharges to four waste sites located south and east of the 234-5Z Plutonium Finishing Plant (PFP). The broader 200-ZP-1 Groundwater OU includes groundwater plumes associated with the 234-5Z PFP, 221-T Plant, and waste sites located in the northern half of the 200 West Area. The pump-and-treat system is operated to capture and treat the primary contaminant of concern (carbon tetrachloride) and secondary contaminants (chloroform and TCE).

This section provides the annual performance report required by the *Declaration of the Interim Record of Decision for the 200-ZP-1 Operable Unit* (EPA et al. 1995). The system's process flow is shown in Figure 3-2. Appendix A presents the history of the pump-and-treat system and a synopsis of the waste site operations.

#### 3.1 FISCAL YEAR 2004 ACTIVITIES AND DEVELOPMENTS

During FY04, a variety of activities were undertaken at the 200-ZP-1 pump-and-treat system to improve system operation and understanding of contaminant behavior.

- A key achievement at the 200-ZP-1 OU involved addressing the issue of declining pumping rates at the extraction wells. Since 1996, pumping rates at wells 299-W15-33 and 299-W15-32 (Figure 3-1) have decreased by 60% and 70%, respectively. The primary cause of this is a decline in groundwater table elevation. Extraction wells 299-W15-32 and 299-W15-33 were replaced with new wells 299-W15-47 and 299-W15-45, respectively. Each was completed with longer screens spanning a greater thickness of the unconfined aquifer. Well 299-W15-45 was drilled in the third quarter of FY03, and 299-W15-47 was drilled in February 2004. Both wells were connected to the extraction system and began operating on April 26 and April 28, 2004, respectively. However, a leaking gasket shut down well 299-W15-47 between May 17 and August 2, 2004. Access to the repair was prevented until concern regarding asbestos in surface soils was resolved. In each case, the replacement well is located within 5 to 10 m (15 to 30 ft) of the original extraction well.
- The EPA and the DOE, Richland Operations Office (RL) agreed to expand the 200-ZP-1 extraction system. Monitoring wells 299-W15-40, 299-W15-43, 299-W15-44, and 299-W15-765 will be converted to extraction wells in FY05 to address a recently identified lobe of the >2,000 µg/L carbon tetrachloride RAO contour. This lobe extends north of the current extraction well system and lies west of the 241-TX and TY Tank Farm fence. The new wells will be connected to the existing pump-and-treat system via an over-ground, single-wall, high-density polyethylene pipeline. The addition is expected to be operating by July 31, 2005.
- In November 2003, upgradient monitoring well 299-W17-1 was drilled 800 m (2,625 ft) west of the 200 West Area's west fence line and approximately 1,000 m (3,280 ft) southwest of the 234-5Z Building (Figure 3-3). The boring was drilled to a depth of 92.5 m (303.4 ft) and groundwater was sampled at 10- to 15-m (33- to 49-ft) intervals below the water table. This well is intended to provide information on upgradient water levels and contaminants. Primary and secondary contaminants of concern (carbon

tetrachloride, technetium-99, and chloroform) were either not found at this well or were at slightly above detection concentrations.

- In December 2003, downgradient monitoring well 299-W13-1 was drilled approximately 1,600 m (5,250 ft) east-northeast of PFP (Figure 3-3). The well, located approximately 305 m (1,000 ft) east of the intersections of Beloit Avenue and 20<sup>th</sup> Street, was drilled to a depth of approximately 160.6 m (527 ft) and sampled at 6- to 12-m (20- to 40-ft) intervals below the water table. As discussed in Section 3.4, all of the carbon tetrachloride concentrations were above the MCL of 5 µg/L. Concentrations peaked at 1,238 µg/L at a depth of 42 m (138 ft) below the groundwater table, just above the Ringold Lower Mud Unit concentrations, and then decreased to 132 µg/L at the top of basalt.
- Well 299-W15-44, which is located between the southwest corner of the 241-TX Tank Farm fence line and extraction well 299-W15-34, was sampled twice in FY04 and yielded carbon tetrachloride concentrations of 1,600 and 3,000 µg/L. This well was added to the 200-ZP-1 monitoring well list for FY05. Well 299-W15-765, located near the northwest corner of the TY Tank Farm, was sampled once in FY04, yielding a carbon tetrachloride concentration of 3,400 µg/L. Well 299-W15-44 was added to the 200-ZP-1 monitoring well list for FY05. In addition, well 299-W15-763 has been added to the FY05 monitoring list.
- Well 299-W15-46 (Figure 3-1) is being drilled on the south side of the 216-Z-9 Trench to characterize the subsurface for the presence of dense, non-aqueous phase liquid (DNAPL) carbon tetrachloride, as required by the interim ROD for the 200-ZP-1 OU (EPA et al. 1997). The sampling and analysis activities support the RI/FS and remedial action decision-making processes for carbon tetrachloride present as a DNAPL in the vadose zone and groundwater. Drilling and sampling through the aquifer began in September 2004. Groundwater samples were analyzed using field screening techniques to characterize the vertical profile of carbon tetrachloride concentrations.

Based on the field screening results, the zone of higher groundwater concentrations of carbon tetrachloride was observed in the upper 21 m (70 ft) of the aquifer (Figure 3-4). The maximum carbon tetrachloride concentration was approximately 3,800 µg/L at a depth of 17 m (55 ft) below the water table. The groundwater samples were also field screened for chloroform and TCE (Figure 3-4). The maximum chloroform concentration was 1,100 µg/L at a depth of 27 m (89 ft) below the water table. A few zones of above-MCL TCE concentrations were also encountered. Groundwater samples and aquifer sediment samples were also submitted for laboratory analysis. The laboratory analytical results will be provided in a separate report.

- The second phase of the 200-PW-1 sampling design to investigate the potential presence of additional vadose zone sources of carbon tetrachloride contamination was approved in FY04 (DOE-RL 2004b, Appendix D). The investigation includes groundwater and soil vapor sampling in the areas of locally elevated carbon tetrachloride groundwater concentrations. Sampling is scheduled in FY05 as part of the 200-PW-1 OU dispersed carbon tetrachloride vadose zone plume remedial investigation.

- Well 299-W15-16 (Figure 3-1) went dry after the January 2004 sampling event and has been replaced in the monitoring network with nearby well 299-W15-30. Groundwater sampling resumed at well 299-W15-30 in FY04 and provided a brief opportunity to continue trends that began in FY96 at the two wells.
- Six monitoring wells (299-W15-10, 299-W15-18, 299-W15-19, 299-W15-24, 299-W18-4, and 299-W18-26), which were previously part of the 200-ZP-1 pump-and-treat monitoring system, were decommissioned in FY04.
- A DQO summary report and a work plan for the 200-ZP-1 OU have been prepared to support the RI/FS process. The *Data Quality Objectives Summary Report Supporting the 200-ZP-1 Operable Unit Remedial Investigation/Feasibility Study Process* (FH 2003) was released in July 2003. Work on the *Remedial Investigation/Feasibility Study Work Plan for the 200-ZP-1 Groundwater Operable Unit* (DOE-RL 2004c) was initiated late in FY03 and will be completed in FY05.
- In FY03, DOE initiated a project to determine whether carbon tetrachloride is present in DNAPL form in the 200 West Area. Three contractors prepared Phase I study reports and Phase II proposals, and one contractor, Vista Engineering Technologies, LLC, was selected to conduct a Phase II field investigation. The Phase II field investigation started in late FY04 and will be completed in FY06. In FY04, field investigations focused on characterization in the vadose zone. In FY05, field investigations will include vertical profile sampling of carbon tetrachloride in the aquifer and groundwater velocity measurements.

### 3.2 EXTRACTION SYSTEM PERFORMANCE

For FY04, the five original extraction wells produced an average of 484 L/min (128 gpm) with wells 299-W15-32 and 299-W15-33 on-line, and an average of 783 L/min (207 gpm) for the months of August and September with replacement wells 299-W15-45 and 299-W15-47 on-line. After the replacement wells went on-line, the average production rate jumped from 85% to 138% of the target extraction rate of 567.8 L/min (150 gpm). For FY04, the extraction wells produced 274.5 million L (72.5 million gal), bringing the total volume of groundwater pumped since 1994 to over 2.42 billion L (639 million gal) (Table 3-1). Even though wells 299-W15-33 and 299-W15-32 operated at low production rates for almost 7 months and well 299-W15-47 was off-line for 3 months, there was an 8.2% increase in the volume of water treated in FY04 compared to FY03. The FY04 average carbon tetrachloride concentrations were lower for two of the extraction wells and stable for the other three wells compared to the FY03 average concentrations.

For the individual wells, FY04 annual average pumping rates and average concentrations of carbon tetrachloride are presented in the following table. Contaminant trends for carbon tetrachloride, chloroform, and TCE are presented in Figures 3-5, 3-6, and 3-7, respectively. Additional information on the extraction well system is presented in Appendix B.

Well Name <sup>a</sup>	Carbon Tetrachloride Concentration				Mean Flow Rate (L/min)	Annual Comparison <sup>b</sup>
	FY04 Min. Value (µg/L)	FY04 Max. Value (µg/L)	FY03 <sup>d</sup>	FY04 <sup>d</sup>		
299-W15-33	1,500	3,100	3,308	2,630	46	Decreasing
299-W15-45 <sup>e</sup>	1,800	4,000	<sup>c</sup>	3,020	170	NA
299-W15-34	2,900	5,600	5,355	4,522	85	Stable
299-W15-35	1,800	3,600	3,233	2,650	246	Stable
299-W15-32	1,300	2,500	2,556	2,028	30	Decreasing
299-W15-47 <sup>f</sup>	1,800	3,100	<sup>c</sup>	2,425	205	NA
299-W15-36	560	1,800	1,097	908	77	Stable
Influent tank (T-01)	2,500	3,700	3,212	3,120	NA	Stable

<sup>a</sup> Wells are listed from north to south.

<sup>b</sup> Annual comparison is the percent difference between FY04 and FY03 and is calculated by the following equation:  $[(FY04 - FY03) / FY03] \times 100$ . Wells are considered stable if there is less than a 20% change in concentration from FY03 to FY04.

<sup>c</sup> Wells not operational in FY03.

<sup>d</sup> Values represent averages for the FY and include both laboratory and field results.

<sup>e</sup> Replaced well 299-W15-33 on April 26, 2004.

<sup>f</sup> Replaced well 299-W15-32 on April 28, 2004.

NA = comparison not applicable

Chloroform in groundwater has not exceeded the MCL concentration of 80 µg/L at any extraction well during FY04 or since the start of Phase II operations. Concentrations at the extraction wells ranged between 12 µg/L at well 299-W15-33 and 46 µg/L at well 299-W15-34. Average chloroform concentrations at the extraction wells were stable compared to FY03 annual averages.

Average annual TCE concentrations were stable or decreasing compared to FY03 values. The maximum concentration was 26 µg/L at well 299-W15-34. The TCE concentrations at wells 299-W15-34, 299-W15-35, and 299-W15-47 were routinely above the 5 µg/L MCL. At wells 299-W15-32, 299-W15-33, 299-W15-36, and 299-W15-45, the TCE concentrations either did not exceed 5 µg/L or exceeded that concentration for only one or two samples.

Contaminant concentrations at the treatment system's influent tank T-01 represent the composite average of all extraction well water entering the system. Carbon tetrachloride, chloroform, and TCE averages for FY04 were 3,120 µg/L, 18.5 µg/L, and 8.6 µg/L, respectively. The FY04 carbon tetrachloride concentration is down from the FY03 annual average by less than 3%, whereas the chloroform and TCE averages are nearly unchanged from FY03.

### 3.3 TREATMENT SYSTEM PERFORMANCE

The treatment system at the 200-ZP-1 OU uses an air-stripper column to remove carbon tetrachloride from the groundwater by bringing it into a vapor phase. It is then captured on granular activated carbon (GAC) in canisters that are sent offsite for regeneration. Treated groundwater is returned to the aquifer through three of five injection wells located south-southwest of the treatment facility. During FY04, all five injection wells were used, but wells

299-W15-29, 299-W18-36, and 299-W18-37 were used most frequently (Figure 3-1). The schematic for the 200-ZP-1 pump-and-treat system is shown in Figure 3-2.

The 8.2% increase in total volume of groundwater extracted in FY04 compared to FY03 contributed to a 2.5% increase in the amount of carbon tetrachloride removed (840.4 kg in FY04 versus 819.3 kg in FY03). The stable carbon tetrachloride concentrations at three of the five extraction wells and the replacement of wells 299-W15-33 and 299-W15-32 with wells 299-W15-45 and 299-W15-47, respectively, offset concentration declines at the extraction well and increased the total mass removed.

Treatment system availability is presented in the table below, and Figure 3-8 depicts monthly operational availability. The treatment system is set to shut off with low flow at 378.5 L/min (100 gpm) to protect the system in the event of an extraction pump failure.

Total possible hours run in a year (hours)	8,784
Total time on-line (hours)	8,396
Scheduled outages (e.g., maintenance, power outages, etc.) (hours)	31
Unscheduled outages (primarily shutdowns due to leak detection alarm shutdowns) (hours)	357.5
On-line availability $\{(\text{total hours} - \text{total outage hours}) / \text{total hours}\} \times 100$	95.6%
Total availability $\{(\text{total hours} - \text{total outage hours}) / \{(\text{total hours} - \text{scheduled outage hour})\} \times 100$	95.9%

A summary of key system performance measurements are presented in the following table:

<b>Total processed groundwater:</b>	
Total groundwater processed in FY04 (millions of L)	274.5
Total groundwater processed since startup (March 1994 - millions of L)	2,420
<b>Carbon tetrachloride mass removed:</b>	
Total mass of carbon tetrachloride removed in FY04 (kg)	840.4
Total mass of carbon tetrachloride removed since startup (March 1994 - kg)	8,508.5
<b>Summary of FY04 operational parameters:</b>	
Removal efficiency % by mass, average for year – $[(\text{influent} - \text{effluent}) / (\text{influent})] \times 100$	99.4
Removal efficiency % by mass, average for year – $[(\text{influent} - \text{adjusted effluent}^a) / (\text{influent})] \times 100$	99.99

<sup>a</sup> Adjusted effluent – effluent sample concentration is adjusted by subtracting field blank result from effluent sample results.

Figure 3-9 presents a graphical representation of the carbon tetrachloride removal efficiency calculated by influent and effluent concentrations at the process facility.

### 3.4 CONTAMINANT MONITORING

Data from groundwater monitoring and extraction wells around the 200-ZP-1 pump-and-treat system provide insight into the effectiveness of the groundwater remedial action. Carbon tetrachloride is the primary contaminant of concern, with chloroform and TCE as secondary contaminants. As discussed below, technetium-99 is also tracked at selected monitoring wells located between injection and extraction wells to gauge the rate of movement of treated water toward the extraction wells. Trend plots for the primary and secondary contaminants of concern for the 200-ZP-1 groundwater monitoring network are presented in Appendix H.

Contaminant monitoring highlights at the 200-ZP-1 pump-and-treat system for FY04 are as follows:

- For FY04, average annual carbon tetrachloride concentrations were stable at the extraction wells compared to the FY03 averages. From May to September 2004, replacement extraction wells 299-W15-45 and 299-W15-47 have shown increasing carbon tetrachloride concentrations with respect to values from wells that were replaced (299-W15-33 and 299-W15-32).
- The  $>4,000$   $\mu\text{g/L}$  carbon tetrachloride plume remained about the same size as in FY03 but also shifted slightly to the north, where, based on August 2004 data, it includes only two wells (299-W15-34 and 299-W15-45) (Figure 3-10). The  $>2,000$   $\mu\text{g/L}$  carbon tetrachloride plume (Figure 3-11) was extended to the north with recent data from wells on the west side of the TX-TY Tank Farm. At the time of baseline plume definition in FY96, a lack of wells and changing trends at the available wells did not support extending the plume to the north.
- Carbon tetrachloride concentrations at southernmost extraction well 299-W15-36 continue, at  $965$   $\mu\text{g/L}$ , to be below the  $>2,000$   $\mu\text{g/L}$  RAO limit. A  $>2,000$   $\mu\text{g/L}$  concentration was last reported in July 2000, and the annual carbon tetrachloride average for this well was  $1,097$   $\mu\text{g/L}$  in FY03.
- The average annual concentrations of chloroform were stable at the extraction wells, compared to the FY03 averages. The  $>20$   $\mu\text{g/L}$  chloroform plume contour has extended to the north to include monitoring well 299-W15-40 (Figure 3-12).
- The average annual TCE concentrations were also stable or decreasing at the extraction wells compared to the FY03 averages. The TCE plume has increased slightly in width over FY03 and has also extended south to extraction well 299-W15-47 and north toward wells on the west side of the TX-TY Tank Farm (Figure 3-13).
- New well 299-W13-1 was drilled in December 2003 at a location approximately 305 m (1,000 ft) east of the intersection of Beloit Avenue and 20<sup>th</sup> Street (Figure 3-3). Vertical profile sampling at 6- to 10-m (19.7- to 32.8-ft) intervals was conducted within the aquifer. Sampling revealed increasing concentrations of carbon tetrachloride, chloroform, and TCE from the top of groundwater to a depth of approximately 42 m (137.8 ft) below top of groundwater just above the Ringold Lower Mud Unit (Figure 3-14). At that depth, peak concentrations of the three contaminants were encountered:  $1,238$   $\mu\text{g/L}$  for carbon tetrachloride,  $82.3$   $\mu\text{g/L}$  for chloroform, and  $10.2$   $\mu\text{g/L}$  for TCE, all of which are above the respective MCLs. Carbon tetrachloride concentrations then declined with depth to the top of basalt but remained well above the

MCL. The location of this well coincides with a migration path for carbon tetrachloride from the 216-Z-9 Trench determined from a particle-tracking model (DOE-RL 2003a).

- Rapid increases in carbon tetrachloride were observed at all extraction wells during sampling on September 16, 2004. The previous sampling event for the wells on August 20, 2004, had yielded concentrations of carbon tetrachloride that were high but were within the range exhibited over the previous 5 to 12 months. The September 16, 2004, samples exhibited a 25% (well 299-W15-47) to 90% (well 299-W15-34) increase, reaching a peak at well 299-W15-34 of 9,700 µg/L. Analytical frequency was increased to weekly for the next several months, but concentrations returned to near-normal ranges by the end of September. Analysis of the data indicates that the samples were tested against degraded calibration standards. All sample results of carbon tetrachloride, chloroform, and TCE taken in September 2004 have been deleted from the Hanford Environmental Information System (HEIS) database and are not used in this report. Chloroform and TCE results showed similar spiking behavior (50% to 200% increases) at all extraction wells in October 2004 and have also been deleted from the HEIS database.

### 3.4.1 Carbon Tetrachloride Monitoring Results

Over 20 monitoring wells were sampled in FY04 to determine the carbon tetrachloride plume's configuration around the treatment system (Figure 3-10). This compares to the 30+ wells available in 1996 for plume monitoring. Several new wells have been drilled or added to the network, but more wells have been lost due to declining groundwater table elevations. The plume is depicted based on August 2004 data.

The table below compares FY04 with FY03 carbon tetrachloride annual averages. Well data were picked to be as close to a year apart as possible for all wells evaluated to eliminate seasonal variations. Changes to the number of wells that were sampled and analyzed between FY03 and FY04 have reduced the number of wells available for comparison.

Well Name	FY03 Avg. Concentration	FY04 Avg. Concentration	Annual Comparison <sup>a</sup>	First Quarter 2004	Second Quarter 2004	Third Quarter 2004	Fourth Quarter 2004
<i>Carbon Tetrachloride (µg/L)</i>							
299-W15-1	4,300	2,550	Decreasing	--	2,900	--	2,200
299-W15-7	2,900	2,850	Stable	3,100	--	--	2,600
299-W15-11	3,100	1,700	Decreasing	--	2,000	--	1,400
299-W15-16	2,129	610	Decreasing	--	610	--	--
299-W15-30	2,700 <sup>b</sup>	1,450	Decreasing	--	1,600	--	1,300
299-W15-31A	4,237	NA <sup>c</sup>	Decreasing	--	140 <sup>c</sup>	--	580 <sup>c</sup>
<b>299-W15-32</b>	<b>2,584</b>	2,288 <sup>b</sup>	NA	2,400	2,175	--	--
<b>299-W15-33</b>	<b>3,381</b>	<b>2,883</b>	Stable	<b>2,900</b>	<b>2,650</b>	--	<b>3,100</b>
<b>299-W15-34</b>	<b>5,300</b>	<b>4,888</b>	Stable	<b>4,950</b>	<b>4,550</b>	<b>5,200</b>	<b>4,850</b>
<b>299-W15-35</b>	<b>3,226</b>	<b>2,997</b>	Stable	<b>3,100</b>	<b>2,988</b>	<b>2,800</b>	<b>3,100</b>
<b>299-W15-36</b>	<b>1,100</b>	<b>972</b>	Stable	<b>943</b>	<b>995</b>	<b>926</b>	<b>1,025</b>

Well Name	FY03 Avg. Concentration	FY04 Avg. Concentration	Annual Comparison <sup>a</sup>	First Quarter 2004	Second Quarter 2004	Third Quarter 2004	Fourth Quarter 2004
299-W15-38	2,100	1,500	Decreasing	--	--	--	1,500
299-W15-40	2,400	2,650	Stable	2,800	--	--	2,500
299-W15-41	1,300	2,100	Increasing	--	2,100	--	--
299-W15-42	1,367	760	Decreasing	1,000	--	--	520
299-W15-43	2,075	1,800	Stable	2,200	--	--	1,400
299-W15-44	2,900	2,300	Decreasing	--	1,600	--	3,000
<b>299-W15-45</b>	NA	<b>3,775</b>	NA	--	--	<b>3,550</b>	<b>4,000</b>
<b>299-W15-47</b>	NA	<b>2,900</b>	NA	--	--	<b>2,700</b>	<b>3,100</b>
299-W15-765	3,200	3,400	NA	3,400	--	--	--
299-W17-1	NA	1	NA	2	--	0.15	0.35
299-W18-1	110	101	Stable	--	140	--	61

NOTE: Concentrations in **bold** are field analytical results only (average extraction well concentrations); all others are laboratory analytical results.

<sup>a</sup> Comparison is the percent difference between FY04 and FY03 and is calculated by the equation:  $[(FY04 - FY03) / FY03] \times 100$ . Wells are considered stable if there is less than a 20% change in concentration from FY03 to FY04.

<sup>b</sup> Results from August 20, 2002, average for this well.

<sup>c</sup> HEIS review qualifier "R." Do not use; results not valid.

NA = comparison is not applicable

-- = data not available

The majority of the monitoring and extraction wells have stable or decreasing average annual concentrations of carbon tetrachloride between FY03 and FY04. Only well 299-W15-41 has an increasing trend. The well's location, which is north of extraction wells 299-W15-34 and 299-W15-35, may show the efforts of continual pumping that may be pulling carbon tetrachloride from beneath the 241-TX Tank Farm.

Figure 3-11 shows the broader RAO plume ( $>2,000 \mu\text{g/L}$ ) for carbon tetrachloride depicted in the *Hanford Site Groundwater Annual Report for Fiscal Year 2004* (PNNL 2005), which has been superimposed on the 200-ZP-1 base map shown in Figure 3-1. Differences between the plume configurations in Figures 3-10 and 3-11 result from the respective data sets used in contouring. Figure 3-10 uses both field and laboratory data from August 2004 to construct contours of the carbon tetrachloride plume. Figure 3-11 used averaged field and laboratory values for the year to contour the plume.

The extraction well capture zone extends far enough to the north and west to capture the original 1996 baseline plume. The data suggest either that a second source of carbon tetrachloride is present north of the current extraction well layout or that well data were too sparse in 1996 to detect the plume. Plans are being developed to extend the extraction well system to the north. Four existing wells (299-W15-40, 299-W15-43, 299-W15-44, and 299-W15-765) will be reconfigured as extraction wells and will be connected to the 200-ZP-1 pump-and-treat system. The expansion is scheduled to be complete and operating by July 31, 2005.

### 3.4.2 Secondary Contaminants

Chloroform and TCE are the two secondary contaminants of concern at the 200-ZP-1 pump-and-treat system. Technetium-99 is also tracked at wells located between the injection and extraction wells as a means of monitoring movement of treated water through the aquifer. Chloroform is not present at concentrations above the MCL of 80 µg/L (Figure 3-12), whereas TCE is present in some wells above the MCL of 5 µg/L (Figure 3-13). A 10 µg/L TCE plume is depicted as extending from near extraction wells 299-W15-34 and 299-W15-35 to the north along the 241-TX/TY Tank Farm west fence line. The 20 µg/L chloroform contour includes all of the extraction wells.

The following table compares results of chloroform concentrations from FY03 to FY04 at monitoring and extraction wells around the plume using data obtained with similar analytical techniques:

Well Name	FY03 Avg. Concentration	FY04 Avg. Concentration	Annual Comparison <sup>a</sup>	First Quarter 2004	Second Quarter 2004	Third Quarter 2004	Fourth Quarter 2004
<i>Chloroform (µg/L)</i>							
299-W15-1	22	26	Stable	--	29	--	23
299-W15-7	18	22	Increasing	18	--	--	26
299-W15-11	14.5	18	Increasing	--	25	--	11
299-W15-15	0.23	0.2	Stable	0	0.23	--	0.17
299-W15-16	10.6	10	Stable	--	10	--	--
299-W15-30	12.5 <sup>b</sup>	12	Stable	--	12	--	12
299-W15-31A	24	19.5	Stable	--	24	--	15
<b>299-W15-32</b>	<b>20.5</b>	<b>22.0</b>	NA	21.7	22.3	--	--
<b>299-W15-33</b>	<b>15</b>	<b>13.5</b>	Stable	<b>13.5</b>	<b>12.5</b>	--	<b>14.5</b>
<b>299-W15-34</b>	<b>24</b>	<b>23.6</b>	Stable	<b>28.5</b>	<b>23.5</b>	<b>23.5</b>	<b>19</b>
<b>299-W15-35</b>	<b>17.3</b>	<b>17.7</b>	Stable	<b>20.5</b>	<b>17.8</b>	<b>17.3</b>	<b>15</b>
<b>299-W15-36</b>	<b>20.3</b>	<b>20</b>	Stable	<b>23.3</b>	<b>19.8</b>	<b>20</b>	<b>17</b>
299-W15-38	18	20	Stable	--	--	--	20
299-W15-40	10.6	18.5	Increasing	12		--	25
299-W15-41	7.4	12	Increasing	--	12	--	--
299-W15-42	16	11	Decreasing	13	--	--	10
299-W15-43	15	13.0	Stable	9.9	--	--	16
299-W15-44	17	21.5	Increasing	--	21	--	22
<b>299-W15-45</b>	NA	<b>13.8</b>	NA	--	--	<b>14.5</b>	<b>13</b>
<b>299-W15-47</b>	NA	<b>18.5</b>	NA	--	--	<b>19</b>	<b>18</b>

Well Name	FY03 Avg. Concentration	FY04 Avg. Concentration	Annual Comparison <sup>a</sup>	First Quarter 2004	Second Quarter 2004	Third Quarter 2004	Fourth Quarter 2004
299-W15-765	15	15	Stable	15	--	--	--
299-W17-1	NA	1.5	NA	4	--	0	0.22
299-W18-1	1	0.9	Stable	--	0.74	--	1

NOTE: Concentrations in bold are field analytical results only (average extraction well concentrations); all others are laboratory analytical results.

<sup>a</sup> Comparison is the percent difference between FY04 and FY03 and is calculated by the equation:  $[(FY04 - FY03) / FY03] \times 100$ . Wells are considered stable if there is less than a 20% change in concentration from FY03 to FY04.

<sup>b</sup> Results averaged from FY02 data for this well.

-- = data not available

For TCE, the table below presents comparable values for FY03 and FY04:

Well Name	FY03 Avg. Concentration	FY04 Avg. Concentration	Annual Comparison <sup>a</sup>	First Quarter 2004	Second Quarter 2004	Third Quarter 2004	Fourth Quarter 2004
<i>Trichloroethene (µg/L)</i>							
299-W15-1	5.6	4.8	Stable	--	4.9	--	4.6
299-W15-7	8	6.6	Stable	8.4	--	--	4.8
299-W15-11	3.2	2.9	Stable	--	3	--	2.7
299-W15-16	1.8	0.8	Decreasing	--	0.8	--	--
299-W15-30	2.0 <sup>b</sup>	1	Decreasing	--	1	--	1 (J)
299-W15-31A	3.3	2	Decreasing	--	2	--	2
<b>299-W15-32</b>	<b>4.4</b>	<b>4.9</b>	Stable	4.3	5.4	--	--
<b>299-W15-33</b>	<b>3.8</b>	<b>2.7</b>	Decreasing	<b>2.1</b>	<b>2.7</b>	--	<b>3.5</b>
<b>299-W15-34</b>	<b>11.5</b>	<b>12.7</b>	Stable	<b>20.3</b>	<b>11.5</b>	<b>8.9</b>	<b>9.9</b>
<b>299-W15-35</b>	<b>10</b>	<b>11.5</b>	Stable	<b>16.5</b>	<b>10.7</b>	<b>9.7</b>	<b>8.9</b>
<b>299-W15-36</b>	<b>2.5</b>	<b>2.7</b>	Stable	<b>2.1</b>	<b>3.1</b>	<b>2.6</b>	<b>2.8</b>
299-W15-38	4.2	3	Decreasing	--	--	--	3
299-W15-40	12.6	11	Stable	12.5		--	10
299-W15-41	7	10	Increasing	--	10	--	
299-W15-42	2.5	2	Stable	2.4 (J)	--	--	2
299-W15-43	3.8	4.5	Stable	5.4	--	--	3.5
299-W15-44	15	15	Stable	--	15	--	15
<b>299-W15-45</b>	NA	<b>2.5</b>	NA	--	--	<b>2.8</b>	<b>2.1</b>
<b>299-W15-47</b>	NA	<b>7</b>	NA	--	--	<b>7.4</b>	<b>6.6</b>
299-W15-765	14	14	Stable	14	--	--	--

Well Name	FY03 Avg. Concentration	FY04 Avg. Concentration	Annual Comparison <sup>a</sup>	First Quarter 2004	Second Quarter 2004	Third Quarter 2004	Fourth Quarter 2004
299-W17-1	NA	2.0 (U)	NA	2 (U)	--	--	0.1 (U)
299-W18-1	0.16 (U)	0.16 (U)	Stable	--	0.2 (U)	--	0.1 (U)

NOTE: Concentrations in bold are field analytical results only (average extraction well concentrations); all others are laboratory analytical results.

<sup>a</sup> Comparison is the percent difference between FY04 and FY03 and is calculated by the equation:  $[(FY04 - FY03) / FY03] \times 100$ . Wells are considered stable if there is less than a 20% change in concentration from FY03 to FY04.

<sup>b</sup> Results averaged from FY02 data for this well.

-- = data not available

The annual average chloroform concentrations were stable or decreased in 12 wells and increased in 5 wells. The annual average TCE concentrations were stable or decreasing in all wells.

Technetium-99 has been detected at elevated but below MCL concentrations in several extraction wells near the 216-T-19 Crib. The technetium-99 passes through the treatment system and returns to the water table at upgradient injection wells. The technetium serves as a tracer at downgradient monitoring wells, indicating movement of cleaner treatment water toward the baseline plume and extraction wells. Nitrate is also transported through the treatment system and exhibits similar trends. Concentrations of nitrate in extraction wells 299-W15-35 and 299-W15-47 have ranged between 280 and 360 mg/L, and 221 and 242 mg/L, respectively. Monitoring well 299-W15-41, adjacent to the 216-T-19 Crib, averaged 377 pCi/L technetium-99 and 80.9 mg/L nitrate. Conversely, monitoring wells 299-W15-15, 299-W18-21, and 299-W18-23 have all recorded significant increases in technetium-99 concentration, to between 150 and 170 pCi/L.

### 3.5 AQUIFER RESPONSE

Aquifer response is important in assessing the effectiveness of the pump-and-treat system. Water-level measurements provide the basis for assessing the control pumping exerts over the flow around the plumes. Coupled with the knowledge of aquifer properties, the pumping system's capture zone and groundwater velocities can be predicted.

#### 3.5.1 Hydraulic Monitoring

Groundwater flow in the 200-ZP-1 OU is generally from the southwest to the northeast, with a hydraulic gradient of 0.0018 m/m (Figure 3-15). The regional flow is generally more west-southwest to east-northeast (70 degrees azimuth) across this portion of the 200 West Area, but the effects of injection and extraction are locally creating a more northeasterly closed cell flow. The impacts of pumping on the monitoring well water levels are observed at several locations.

Groundwater elevation data collected during FY04 at locations away from the extraction wells but near the 200-ZP-1 pump-and-treat system indicate that the groundwater surface declined an average of 0.37 m/year (1.21 ft/year). This is essentially the same rate of decline as the previous 2 years of 0.36 m/year (1.18 ft/year), but is significantly less than the 0.46 m/year (1.51 ft/year) reported for FY98. As at the 200-UP-1 OU, the decline at 200-ZP-1 is related primarily to

cessation of discharges in 1985 to the 216-U-10 Pond and a Sitewide halt to disposal of low-level liquid waste streams to the soil column in 1995. The 2607-Z sanitary tile field received an estimated 23,000 L/day (6,000 gal/day) (DOE-RL 1992) and was active until 1999. Additional information regarding hydraulic monitoring is presented in Appendix C.

### **3.5.2 Numerical Modeling**

Numerical modeling has been used to calculate FY04 capture zones around the extraction wells and recharge zones at the injection wells, as shown in Figure 3-16. Modeling results indicate that the extraction wells are capturing contaminants in the baseline plume area. Capture zones are a qualitative measure of the effectiveness of the pump-and-treat system. When supplemented with groundwater head impacts from extraction wells at monitoring wells and with the revised calculations of allowable shut-off times at extraction wells, it can be seen that contaminants are not escaping the extraction system. Appendix E provides additional information about groundwater modeling.

The streamlines for the capture zones around the five extraction wells and the area of influence around the three main injection wells represent the approximate successive locations of a water particle being drawn to or moving from a well for FY04 operations. This capture zone/area of influence depiction is in addition to that presented in Figure 3-13 (DOE-RL 2004b). Changes to the extraction system and modeling techniques did not support multiple-year capture zone depictions. The extraction wells were all operating at constant pumping rates for the last 2 months of FY04. For ease of calculation, the velocities from the last 2 months were used for the one-year streamlines. The streamlines are more qualitative than absolute and show the width of the capture zone for each of the five extraction wells. Wells 299-W15-47 and 299-W15-45 replaced wells 299-W15-32 and 299-W15-33, respectively, and were located very close to the old wells. The new wells have a much higher extraction rate than the older wells. The new extraction rates are about 151 to 170 L/min (40 to 45 gpm) for well 299-W15-45 and 208 to 227 L/min (55 to 60 gpm) for well 299-W15-47, compared to less than one-fourth that for the older wells.

The FY98 annual report (DOE-RL 1999) contained a calculation of the time period that the extraction well pump at 200-ZP-1 could be shut down before high-concentration contaminants would move from the well to beyond the downgradient capture zone. This calculation has been adjusted for current hydrologic conditions (Appendix E) and concludes that pumps could be shut down for between 227 to 500 days before carbon tetrachloride concentration at an extraction well would exit the capture zone. All of the monitoring wells show a decrease in carbon tetrachloride concentrations over the last 2 years.

## **3.6 QUALITY ASSURANCE/QUALITY CONTROL**

A quality control check for the 200-ZP-1 OU was performed using field and offsite replicate and field/offsite laboratory splits analysis for carbon tetrachloride, chloroform, and TCE. All of the results are from wells associated with the pump-and-treat system. Highlights of the quality control data are presented in the following table, and more detailed information and data sets are presented in Appendix G. Monitoring wells close to the RAO plume were sampled semi-annually, and wells near the plume periphery were sampled annually.

Type of Control Sample	Number of Pairs	Number of Calculated RPD Values	Number of Pairs <20% RPD	Calculate Sample Pairs with RPD <20%
Laboratory replicates, carbon tetrachloride	6	0	0	N/A
Laboratory replicates, TCE	7	6	6	100%
Laboratory replicates, chloroform	7	5	5	100%
Field replicates, carbon tetrachloride	6	6	5	83%
Field replicates, TCE	7	5	5	100%
Field replicates, chloroform	7	7	6	86%
Field laboratory splits, carbon tetrachloride	17	14	2	14%
Field laboratory splits, TCE	20	8	0	0%
Field laboratory splits, chloroform	20	15	4	27%

The EPA functional guideline for field replicates is  $\pm 20\%$  (EPA 1988); there are no functional guidelines for splits results. For replicates, 27 of the 29 samples for which an RPD was calculated, were within the  $\pm 20\%$  standard.

Two of 14 carbon tetrachloride field/offsite laboratory splits were within the 20% RPD precision guideline. For 10 of the other 12 sample pairs, the results appear similar to a pattern observed in FY03. For these 10 sample pairs, RPDs of 20.8% to 57.1% were reported with the offsite laboratory results significantly lower than the field results. This is attributed to the longer holding times before the samples were analyzed (i.e., 8 to 14 days for the 14 samples in FY04) (Appendix G). In no case was the holding-time limit exceeded. A general correlation between longer holding times and lower carbon tetrachloride results is suspected, but the difference may also correlate with different testing methods.

Several attempts were made to obtain quick turnaround results on field-laboratory splits. In one case, equipment failure at the Waste Sampling and Characterization Facility (WSCF) laboratory prevented testing. A second attempt was made at several extraction wells sampled on July 28, 2004. Samples were analyzed at WSCF on August 2, 2004. The results are presented in the table below:

Well	Field Results	Laboratory Results	RPD
299-W15-33	3,100; 3,100	2,900; 2,900	6.7%
299-W15-34	4,500	3,600	22.2%
299-W15-35	2,600	2,200	15.4%
299-W15-36	850	690	20.8%

### 3.7 CONCLUSIONS

Measurable progress was made this year toward meeting the specific interim remedial measures. The results for each RAO are discussed below:

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

**Results:** The pump-and-treat system continues to capture the high-concentration levels of carbon tetrachloride (>2,000 to 3,000 µg/L) at the extraction wells. The modeling analysis shows that even with mildly reduced extraction rates for March in FY04, the baseline groundwater plume is still being captured by the extraction wells. The phenomenon of treated water pushing contaminated water toward the extraction wells is illustrated at several wells where technetium-99 and nitrate concentrations are increasing, indicating the arrival of treated injected water. Downgradient well 299-W15-39, which is located outside the zone of influence of adjacent extraction wells, has consistently been below the >2,000 µg/L RAO since the start of monitoring in July 1996, at the beginning of Phase II operations. Only one value, 2,500 µg/L in January 2000, exceeded the RAO, and concentrations have since declined to <1,500 µg/L.

Based on current extraction and monitoring well data, the 4,000 µg/L carbon tetrachloride contour has decreased significantly in size. Only well 299-W15-34 currently averages >4,000 µg/L per annum. Continued monitoring will allow tracking of the decline in carbon tetrachloride concentrations.

At well 299-W15-36, concentrations of carbon tetrachloride are less than 50% of the >2,000 µg/L RAO. The FY03 annual report (DOE-RL 2004a) recommended that the well should be shut down if the production wells can pump enough water to reach an extraction rate of 567.8 L/min (150 gpm). Well 299-W15-37 was shut down in January 2001, and carbon tetrachloride concentrations have declined from around 500 to 85 µg/L in August 2004. However, with expansions at the extraction well system, this well should be kept running in the event that increased injection rates mobilize more contaminant mass.

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

**Results:** The treatment system removed 840.4 kg of carbon tetrachloride in FY04 from 274,500,000 L (72,500,000 gal) of groundwater. Since the startup of operations, over 2,420,000,000 L (639,400,000 gal) of water have been extracted and 8,508.52 kg of carbon tetrachloride have been removed.

Concentrations of carbon tetrachloride continue to decrease. The average concentration for FY04 was 3,120 µg/L, as measured at the T-01 influent holding tank, compared to the FY03 value of 3,212 µg/L. Carbon tetrachloride concentrations at each extraction well showed small to moderate decreases over the FY03 averages.

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

**Results:** Where possible, data that help to refine the conceptual model for the carbon tetrachloride plume are collected during characterization and remediation activities. In FY04, this included collecting vertical profile samples and geologic data during installation of new extraction well 299-W15-47, a new downgradient monitoring well (299-W13-1), and a new upgradient monitoring well (299-W17-1). In addition, two *Resource Conservation and Recovery Act of 1976* wells (299-W15-44 and 299-W15-765) were sampled for carbon tetrachloride. Based on significant contaminant concentrations, well 299-W15-44 was added to the FY04 monitoring well list, and wells 299-W15-765 and 299-W15-763 have been added to the FY05 monitoring well list. Well 299-W15-46 was drilled at the south side of the 216-Z-9 Trench and reached groundwater in September 2004. Field analyses indicated above-MCL carbon tetrachloride and chloroform concentrations over most of the interval between the water table and the top of basalt. The maximum carbon tetrachloride concentration, 3,800 µg/L, was encountered 17 m (56 ft) below the water table. The maximum chloroform concentration, 1,100 g/L was encountered 27 m (89 ft) below the water table. Zones with above-MCL concentrations of TCE were also found in a few parts of the aquifer. This borehole will be completed as a monitoring well.

### 3.8 RECOMMENDATIONS

The following recommendation is made to improve performance at the 200-ZP-1 pump-and-treat system:

- **Reassess groundwater monitoring program in 200-ZP-1 OU.**

Analytical results from well 299-W13-1, which is located 300 m east of the 2724-W laundry site, have raised questions about the distribution of carbon tetrachloride in the groundwater beneath the 200 West Area. The results indicated near-RAO concentrations of carbon tetrachloride in a location supported by FY02 particle-tracking model results. The model predicted a general flow to the east-northeast from the 216-Z-9, 216-Z-1A, and 216-Z-18 Cribs into the area at and north of well 299-W13-1.

Data from this well raise questions about the carbon tetrachloride conceptual model. The unanticipated part of the results was that contamination appears to be deeper in the aquifer than observed elsewhere. The area bounded by Beloit and Camden Avenues and 16<sup>th</sup> and 23<sup>rd</sup> Streets is populated with few, if any, groundwater monitoring wells.

The DQO process for 200 West Area groundwater monitoring (BHI 2002) should be reopened to examine the impact of the new data and to assess what additional work is needed to update the carbon tetrachloride conceptual model. This effort is recommended to occur simultaneously with a similar re-examination of groundwater monitoring at the 200-UP-1 OU.

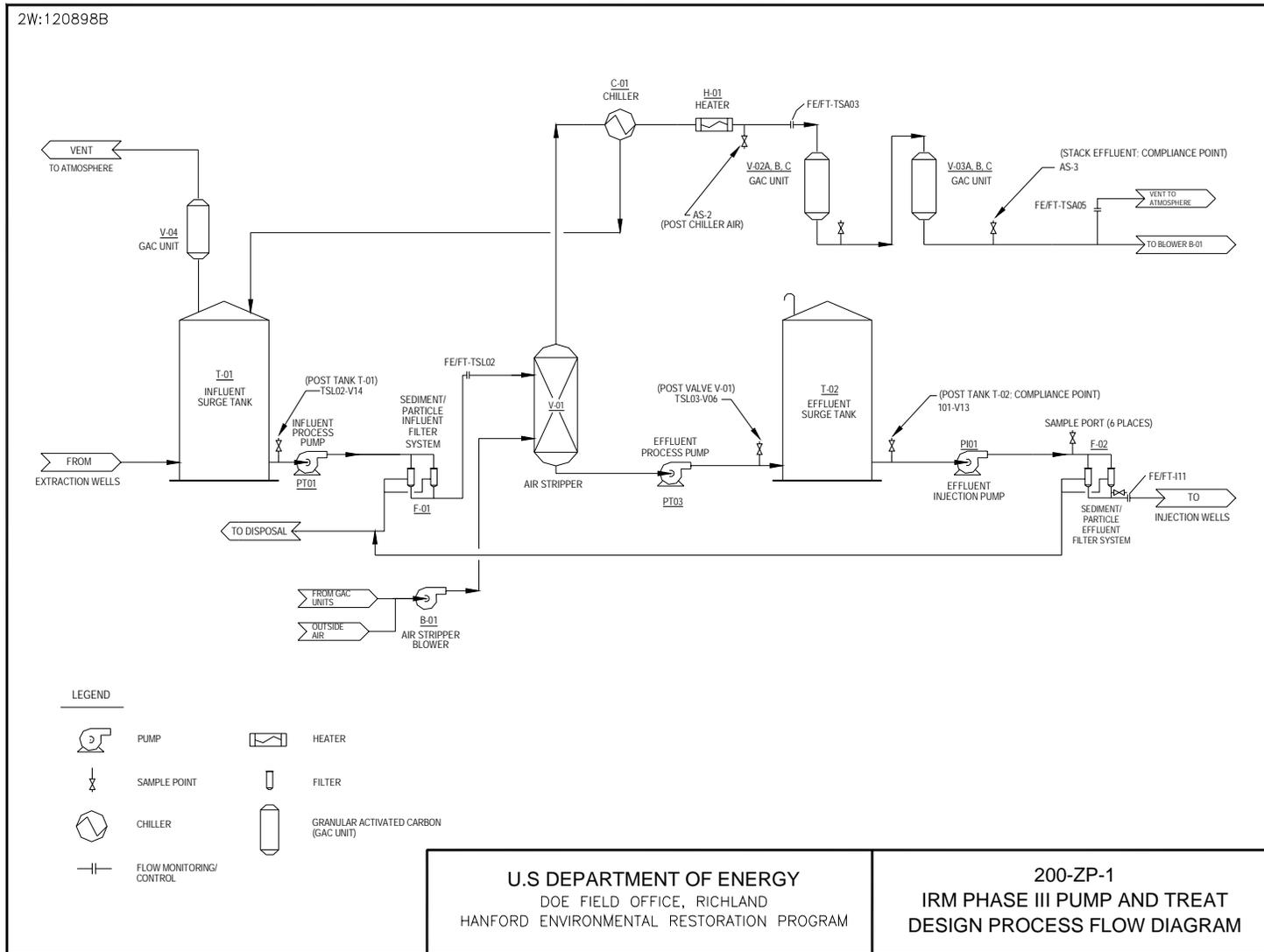
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Figure 3-1. 200-ZP-1 Operable Unit Groundwater Well Network and Other Monitoring Wells.



Figure 3-2. 200-ZP-1 Operable Unit Interim Remedial Operation Phase III Pump-and-Treat Design Process Flow Diagram.

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Figure 3-3. Fiscal Year 2004 New Groundwater Wells.

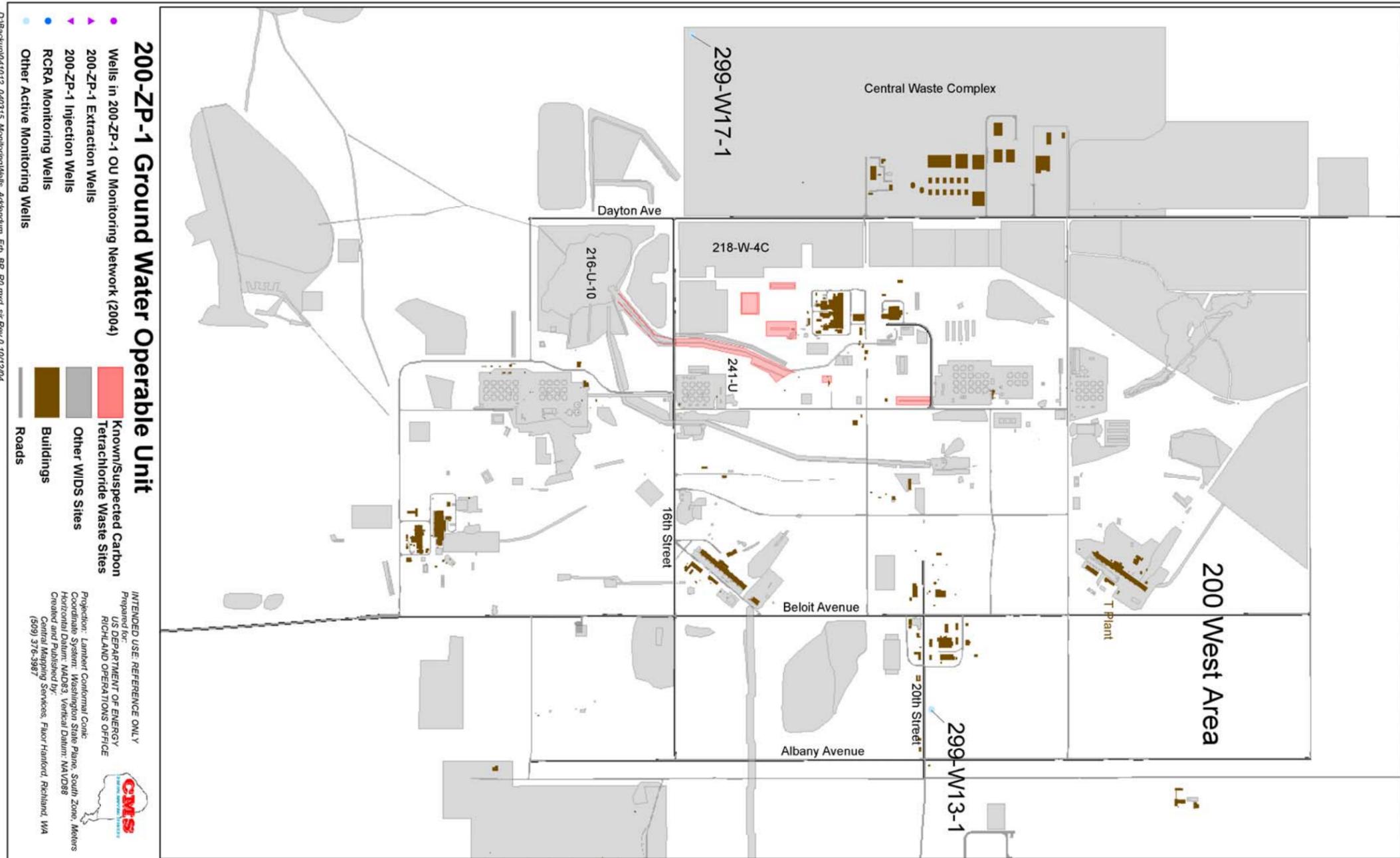


Figure 3-4. Field Screening Results for Groundwater Samples Collected During Drilling of Well 299-W15-46 (C3426).

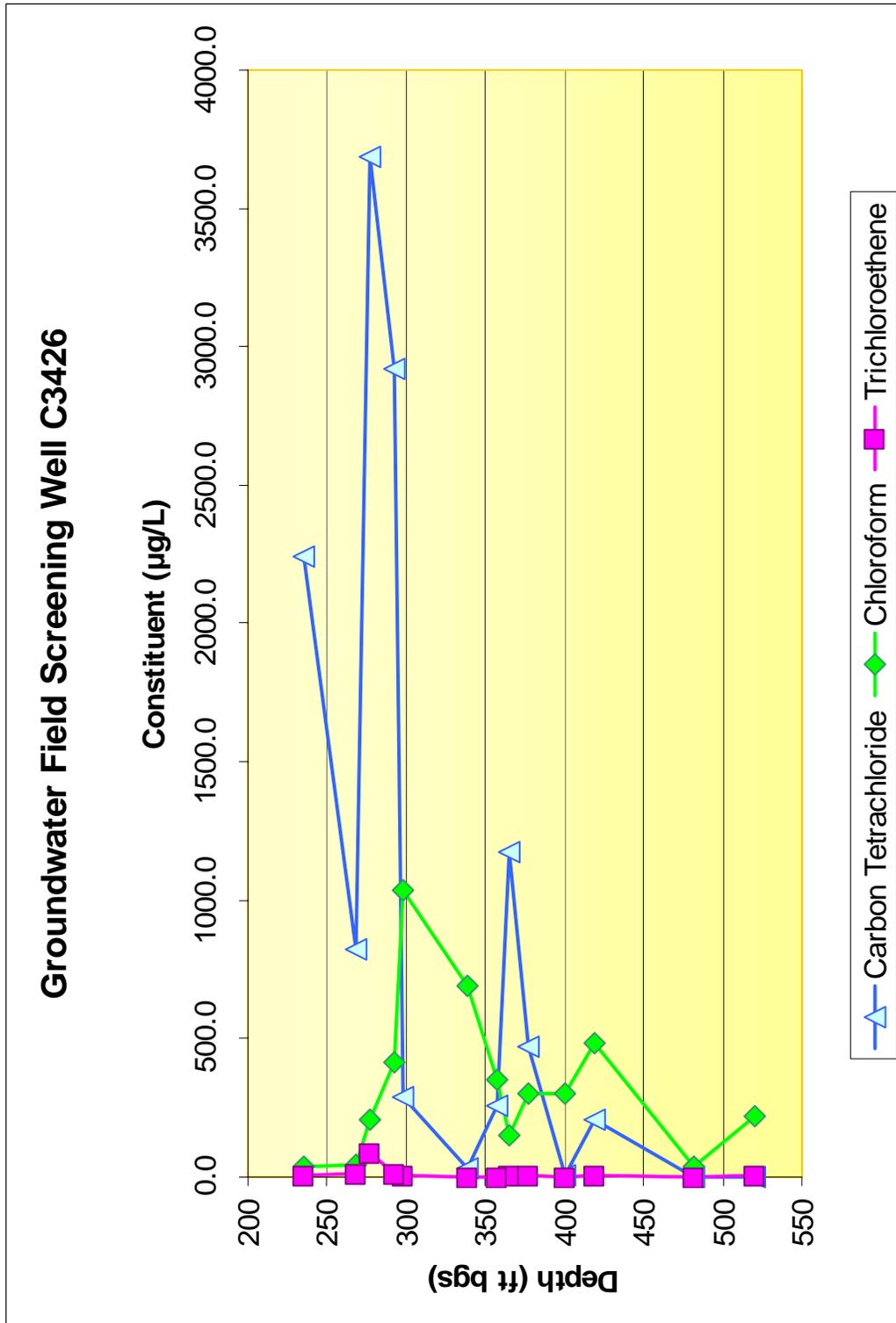


Figure 3-5. Carbon Tetrachloride Extraction Well Trend Plots. (3 sheets)

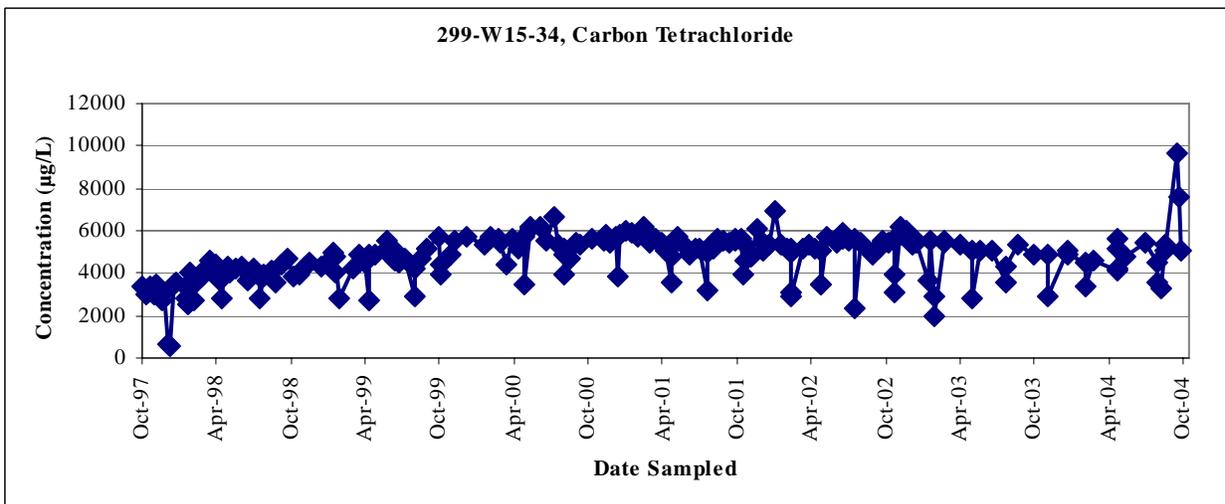
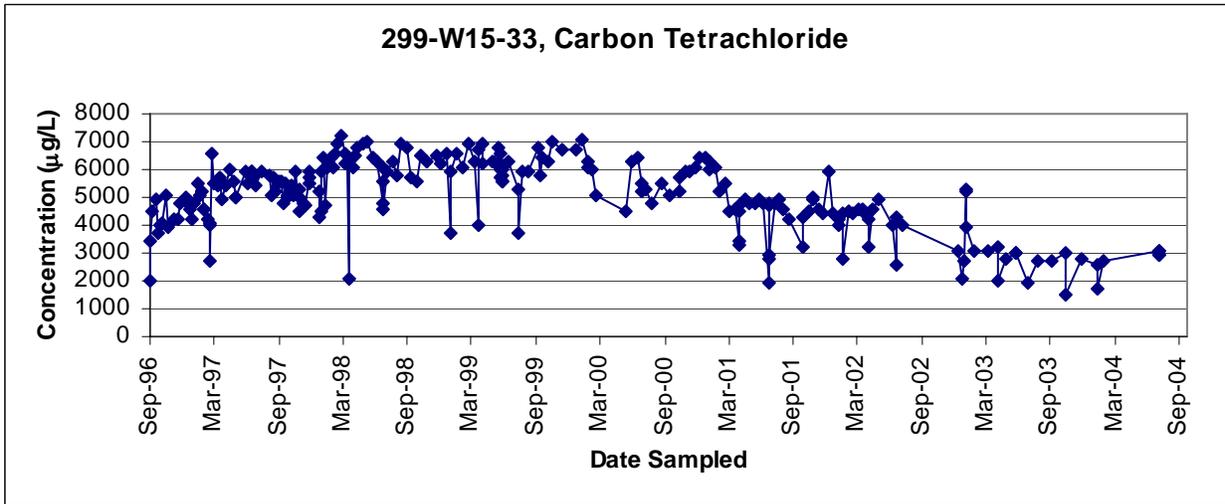
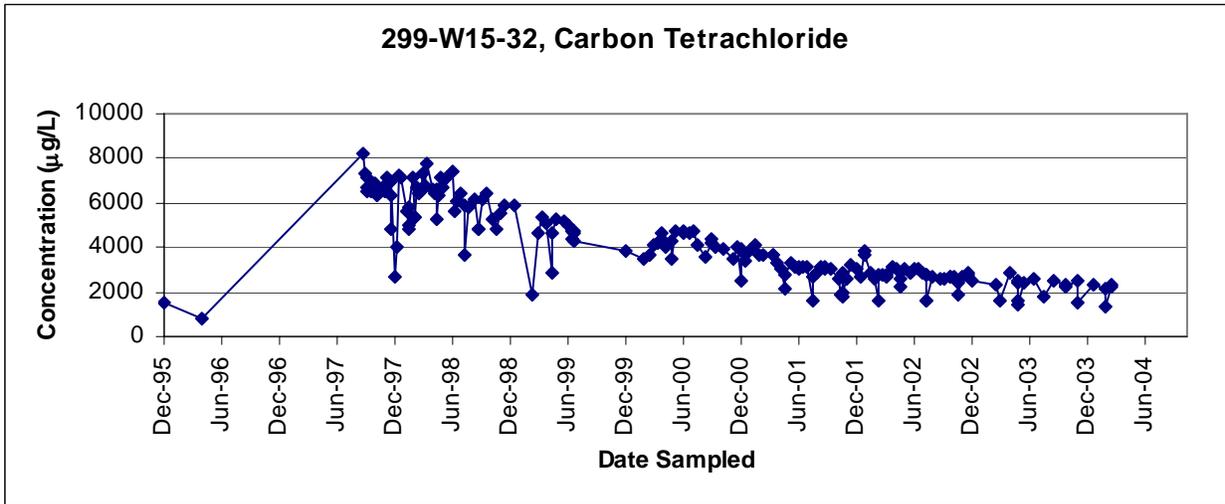


Figure 3-5. Carbon Tetrachloride Extraction Well Trend Plots. (3 sheets)

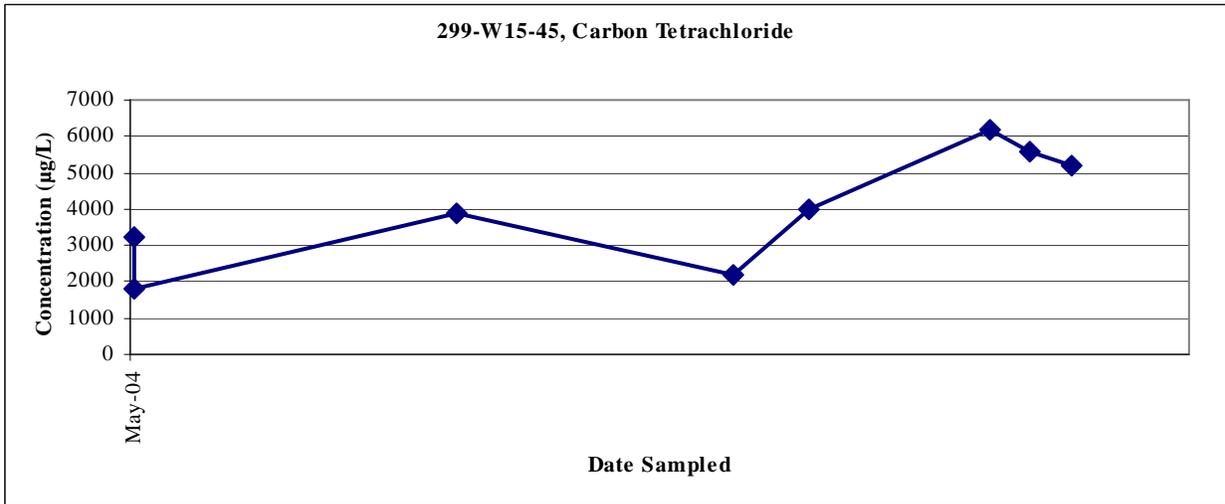
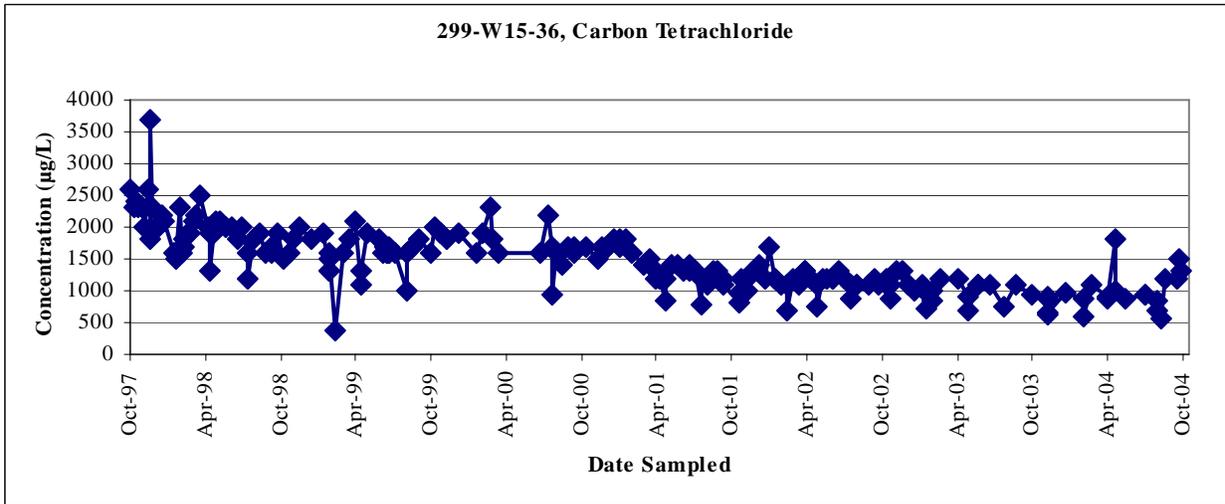
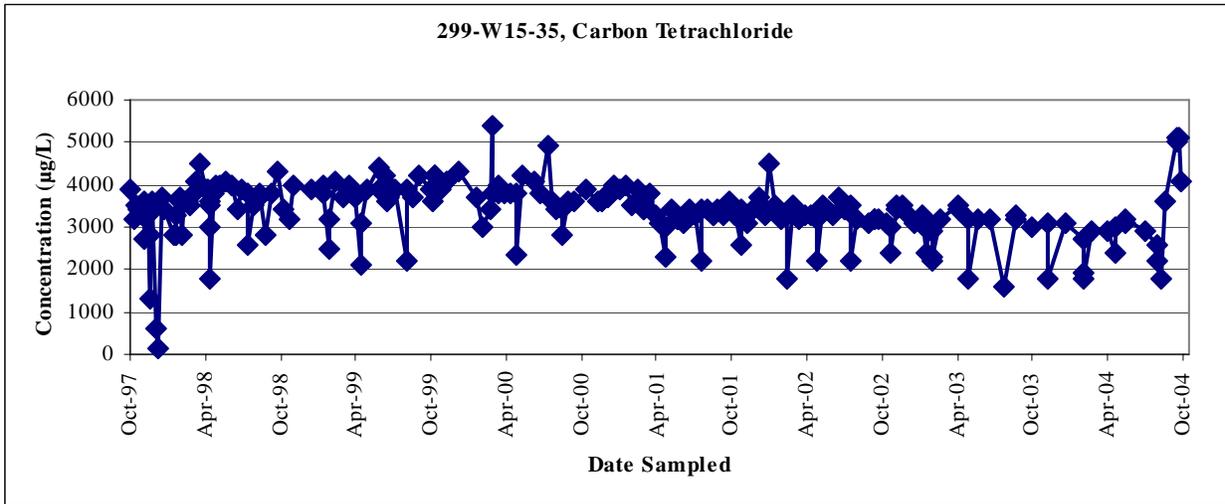


Figure 3-5. Carbon Tetrachloride Extraction Well Trend Plots. (3 sheets)

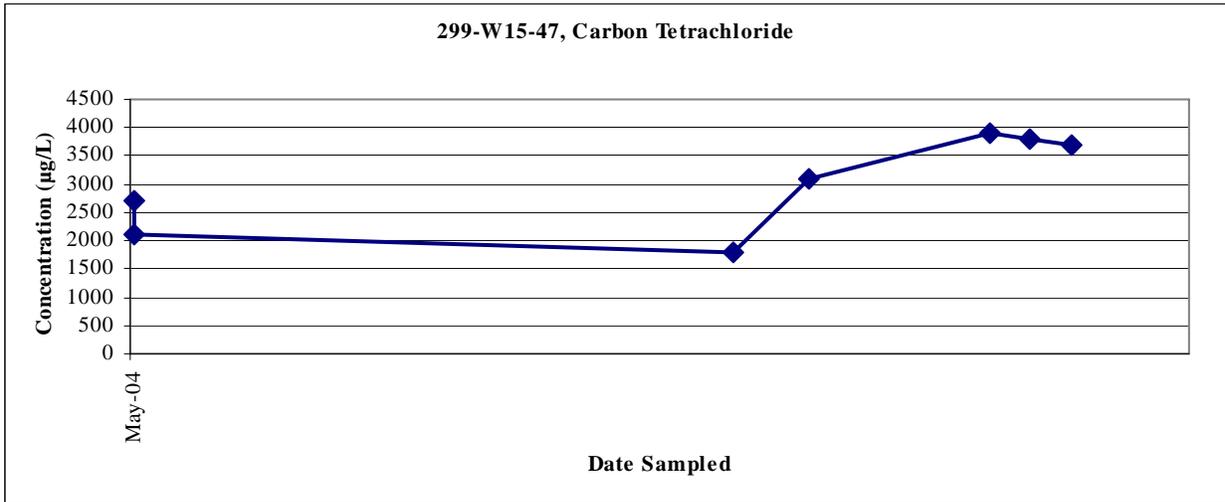


Figure 3-6. Chloroform Extraction Well Trend Plots. (3 sheets)

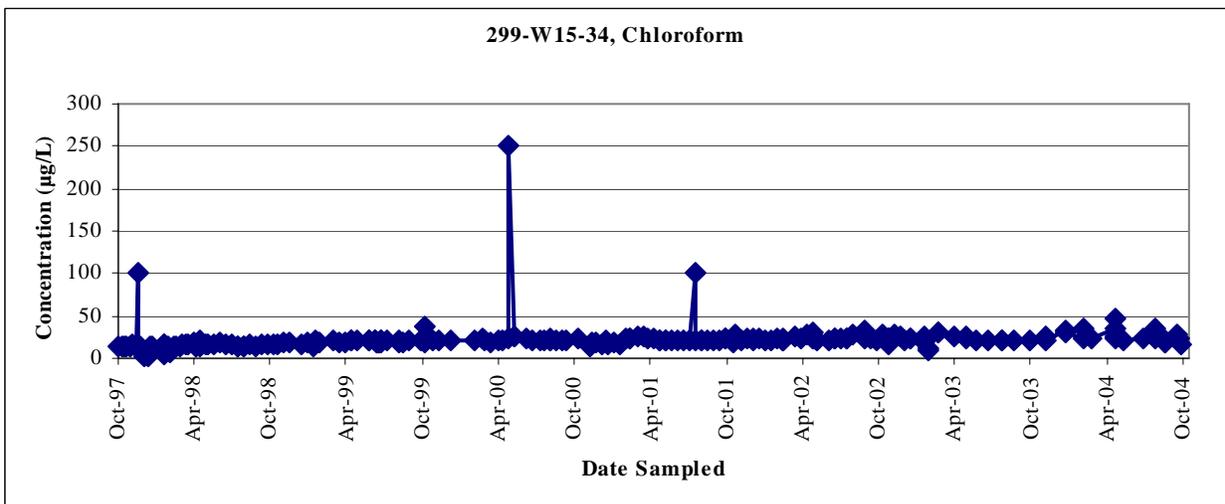
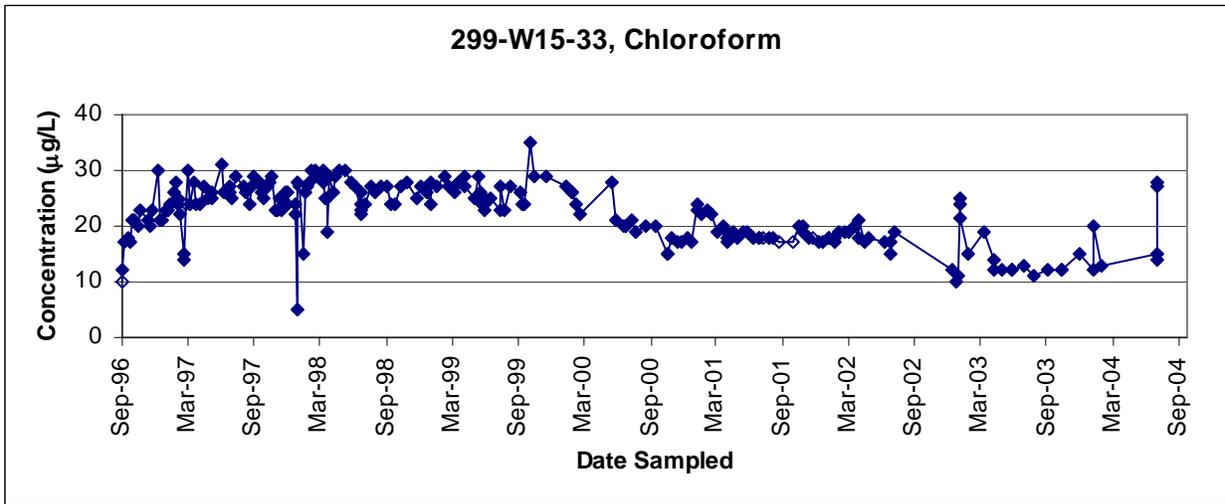
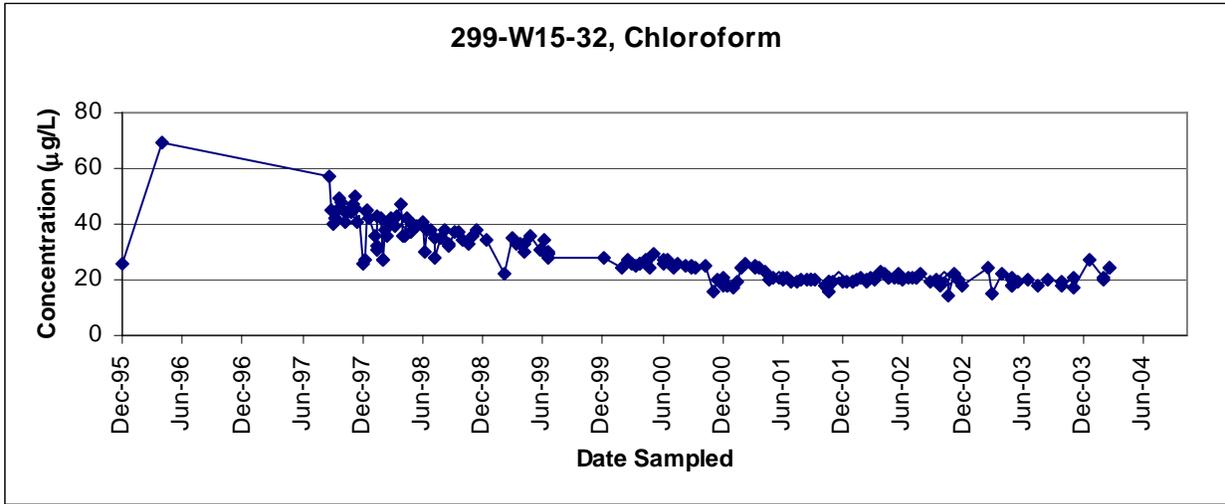


Figure 3-6. Chloroform Extraction Well Trend Plots. (3 sheets)

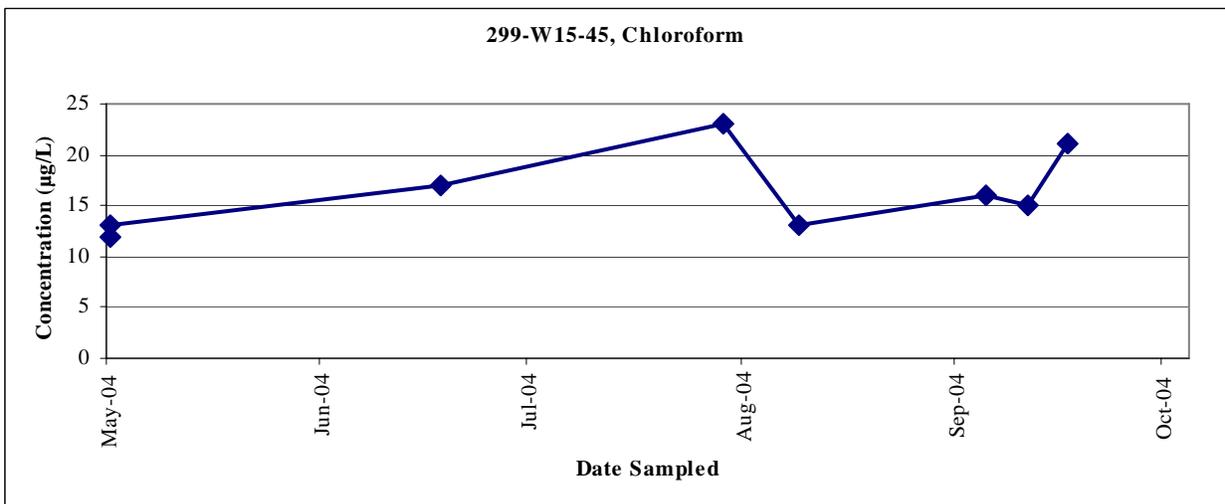
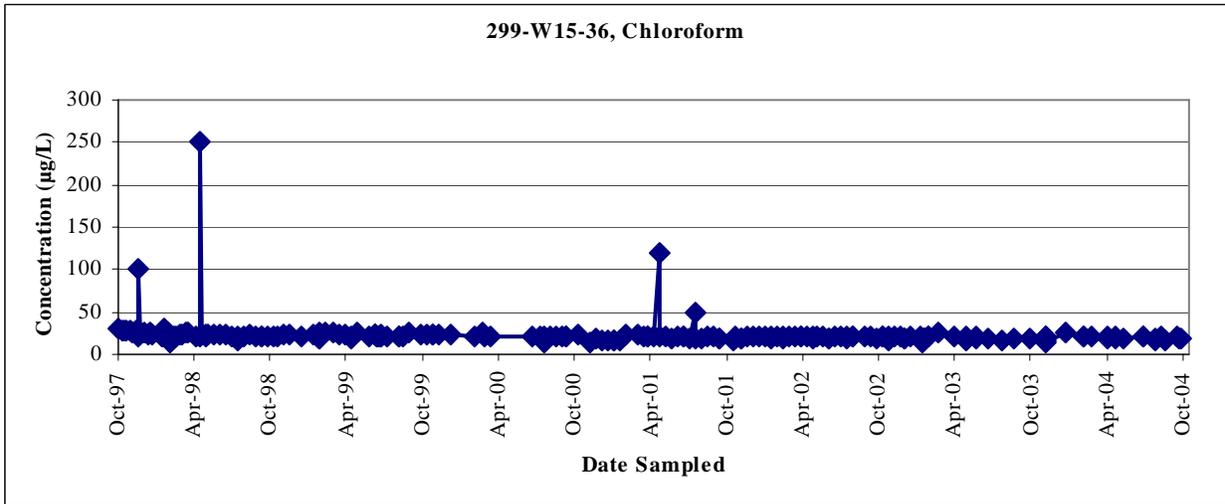
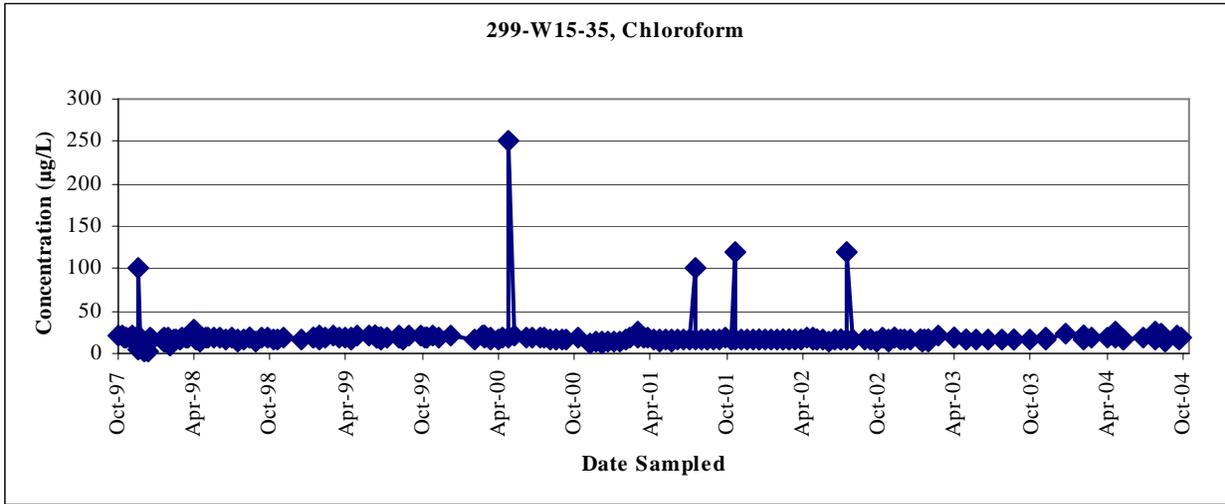


Figure 3-6. Chloroform Extraction Well Trend Plots. (3 sheets)

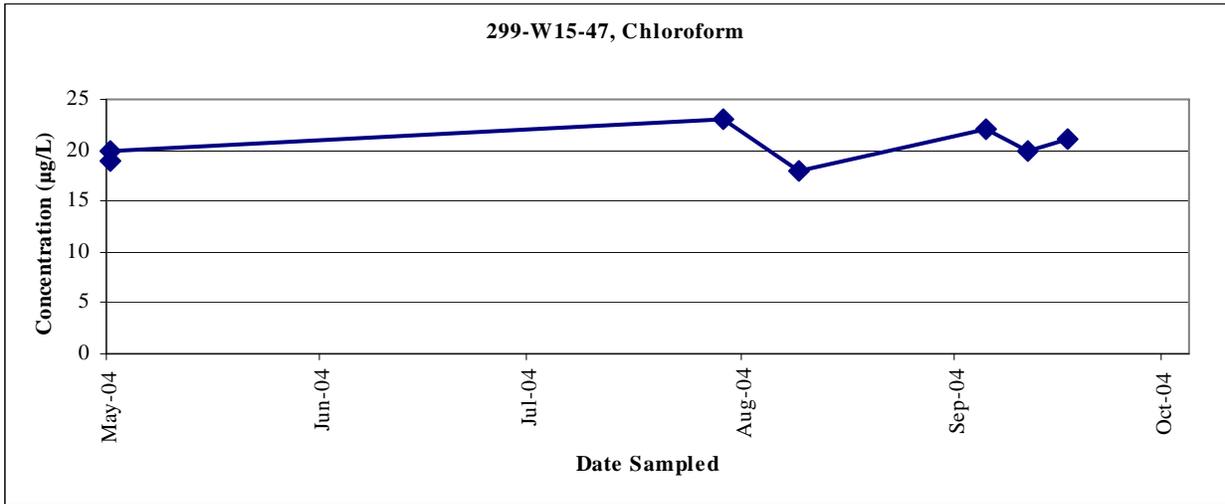


Figure 3-7. Trichloroethene Extraction Well Trend Plots. (3 sheets)

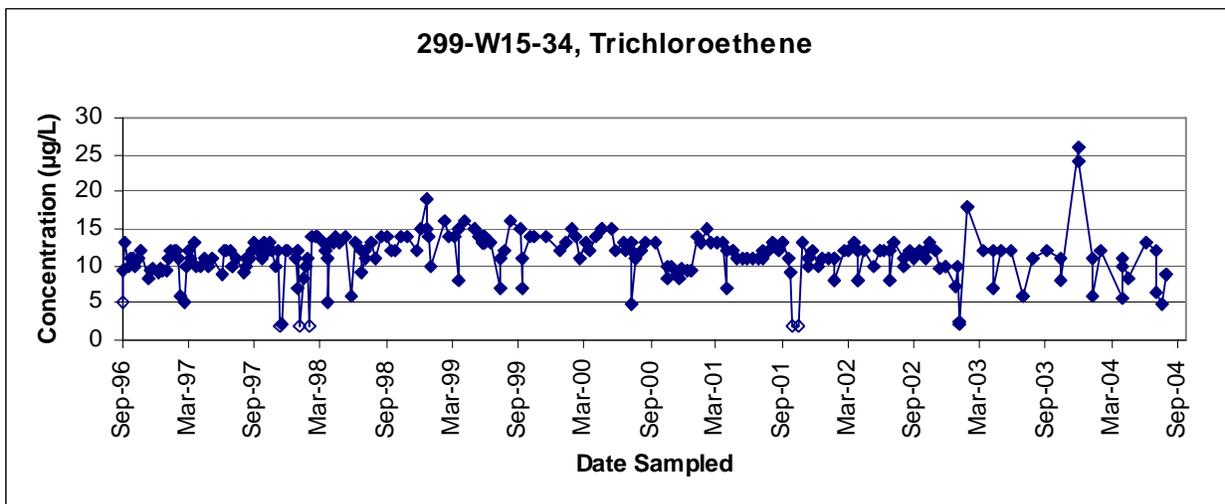
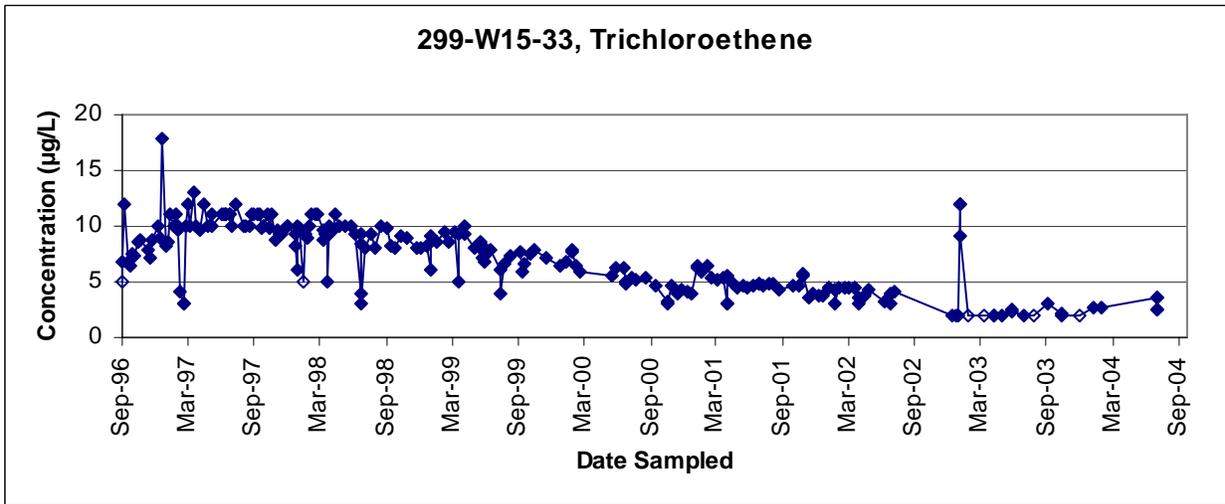
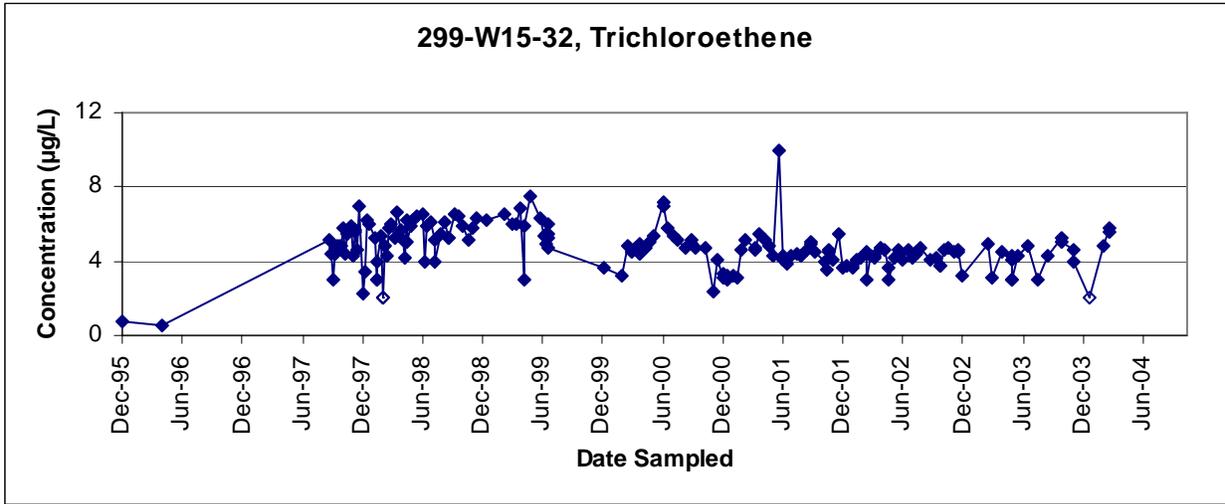


Figure 3-7. Trichloroethene Extraction Well Trend Plots. (3 sheets)

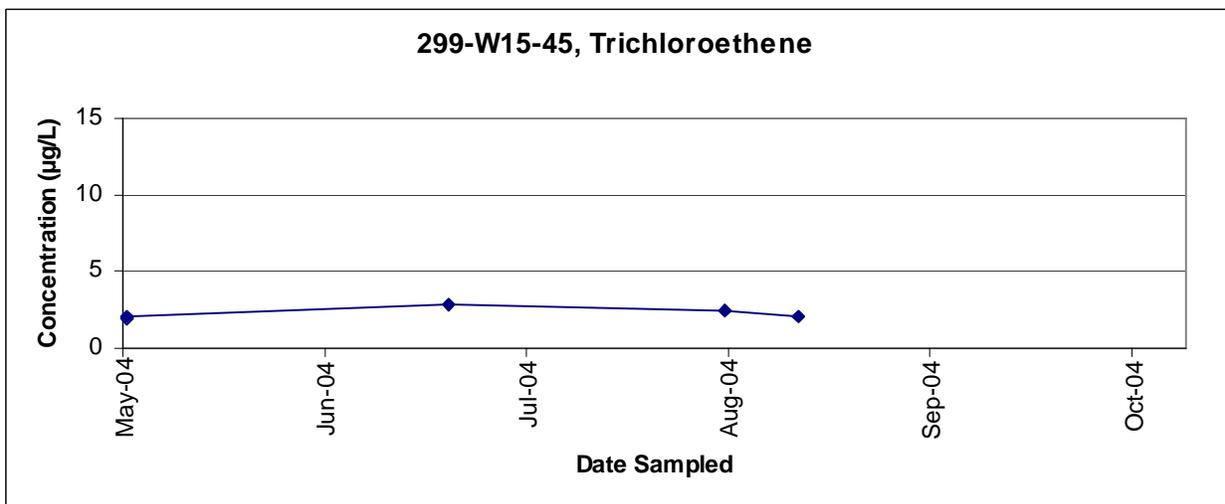
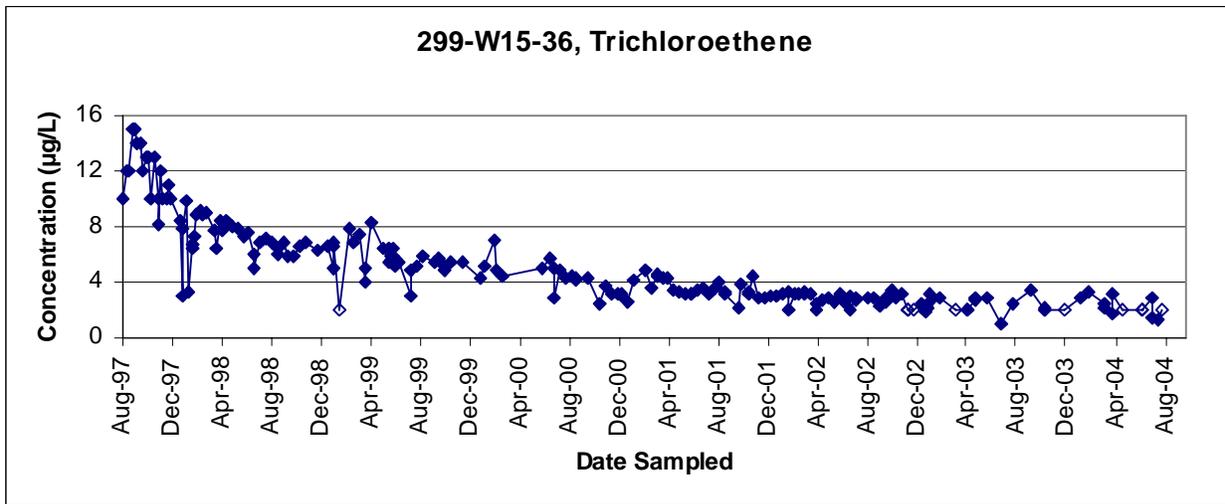
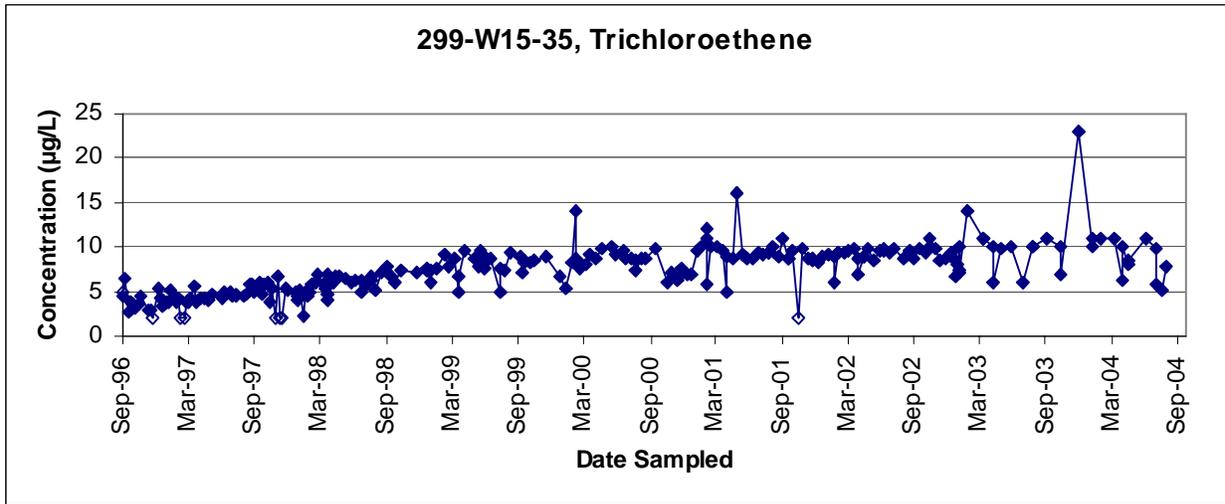


Figure 3-7. Trichloroethene Extraction Well Trend Plots. (3 sheets).

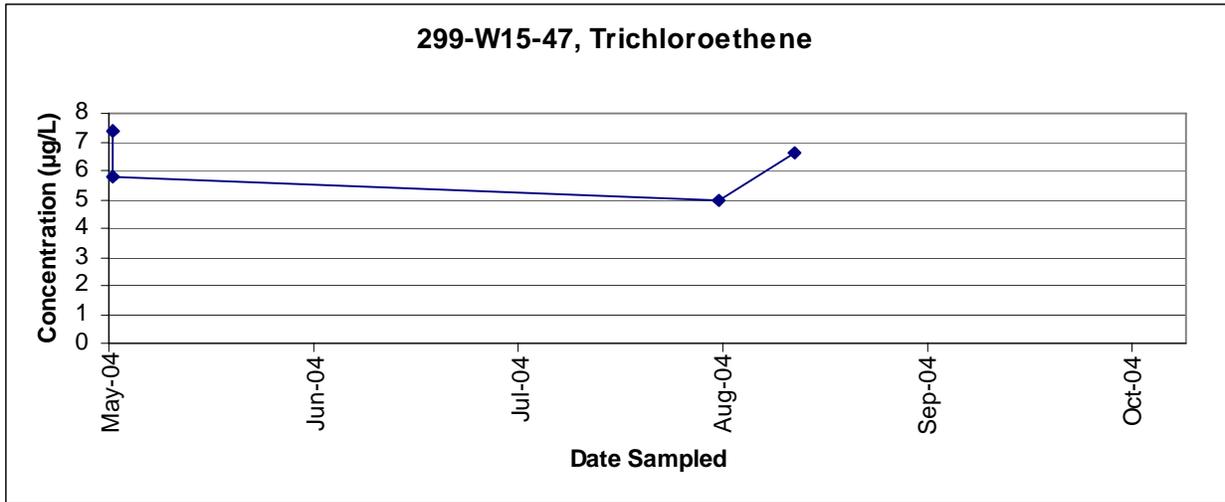
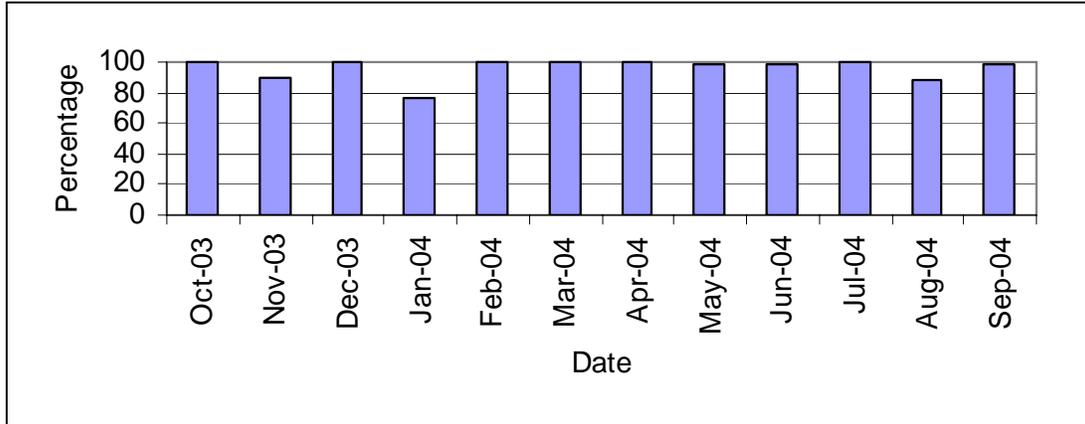


Figure 3-8. 200-ZP-1 Operable Unit Pump-and-Treat System Availability.

**System availability:**

Total hours in FY04 = 8,784 hours

Total time available during FY04 (total minus scheduled outages) = 8,753 hours

Total time on-line during FY04 (total hours minus all outages) = 8,395.5 hours

System on-line availability ( $\{\text{total time on-line}/\text{total hours}\} \times 100$ ) = 95.6%

Total system availability ( $\{\text{total time available}/\text{total hours}\} \times 100$ ) = 95.9%

**List of Unscheduled Outages**

Month	Unscheduled Outage	Comments
October	2.00	Unscheduled outage; system shut down for an unknown reason on October 29, 2003.
November	64.50	Unscheduled outage; system shut down due to leak detection on November 5, 2003, in injection line. System shut down on November 7, 2003, due to condensation buildup in injection line causing leak detection.
	6.00	Unscheduled outage; system shut down due to leak detection (as above).
	<b>70.50</b>	<b>Total for November</b>
December	2.50	Unscheduled outage; system shut down on December 11, 2003, due to condensation built up in extraction line between Buildings 1 and 2 tripping the leak detection alarm off.
January	7.50	Unscheduled outage; system shut down on January 4, 2004, due to a frozen level transmitter on the air stripper.
	168.00	Unscheduled outage; system shut down due to frozen pipes.
	23.00	Unscheduled outages; system shut down on January 13 and 14, 2004, due to a flow transmitter not showing any indication of flow.
	<b>198.50</b>	<b>Total for January</b>
August	5.50	Unplanned outage; system shut down on May 10, 2004, due to high filter pressure.
	11.00	Unplanned outage; system shut down on August 11, 2004, due to broken instrumentation (gas analyzer).
	51.00	Unplanned outage; system shut down on August 27, 2004, due to broken instrumentation (gas analyzer).
	<b>62.00</b>	<b>Total for August</b>
September	13.50	Unplanned outage; system shut down (continued) due to broken instrumentation (gas analyzer).
<b>FY04 Total</b>	<b>357.5</b>	

Figure 3-9. 200-ZP-1 Operable Unit Carbon Tetrachloride Concentrations at Influent Tank T-01 and Effluent Tank T-02 (with Removal Efficiencies), Fiscal Year 2004.

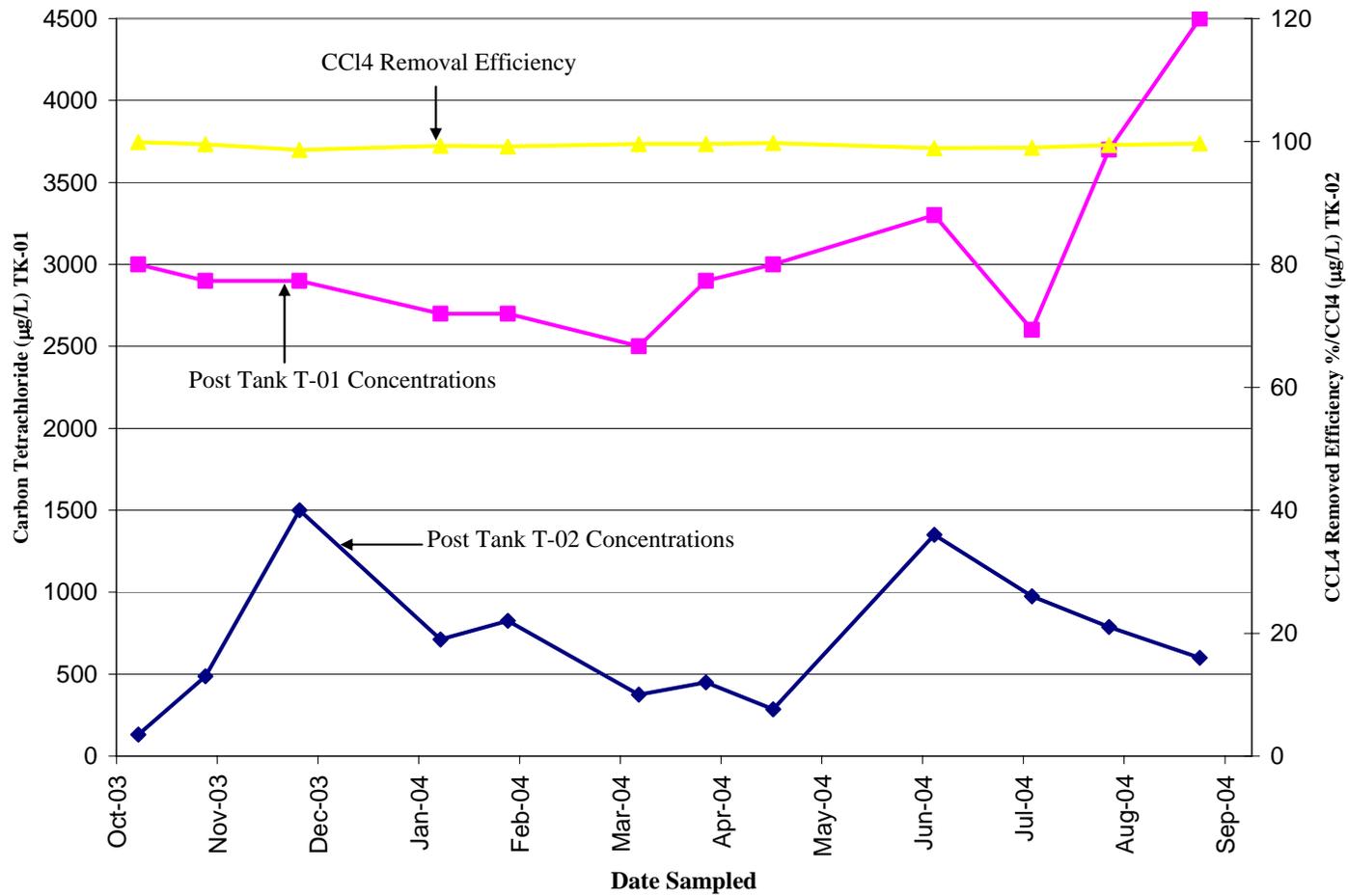


Figure 3-10. 200-ZP-1 Operable Unit Carbon Tetrachloride Contaminant Plume: Baseline June 1996 Versus August 2004.

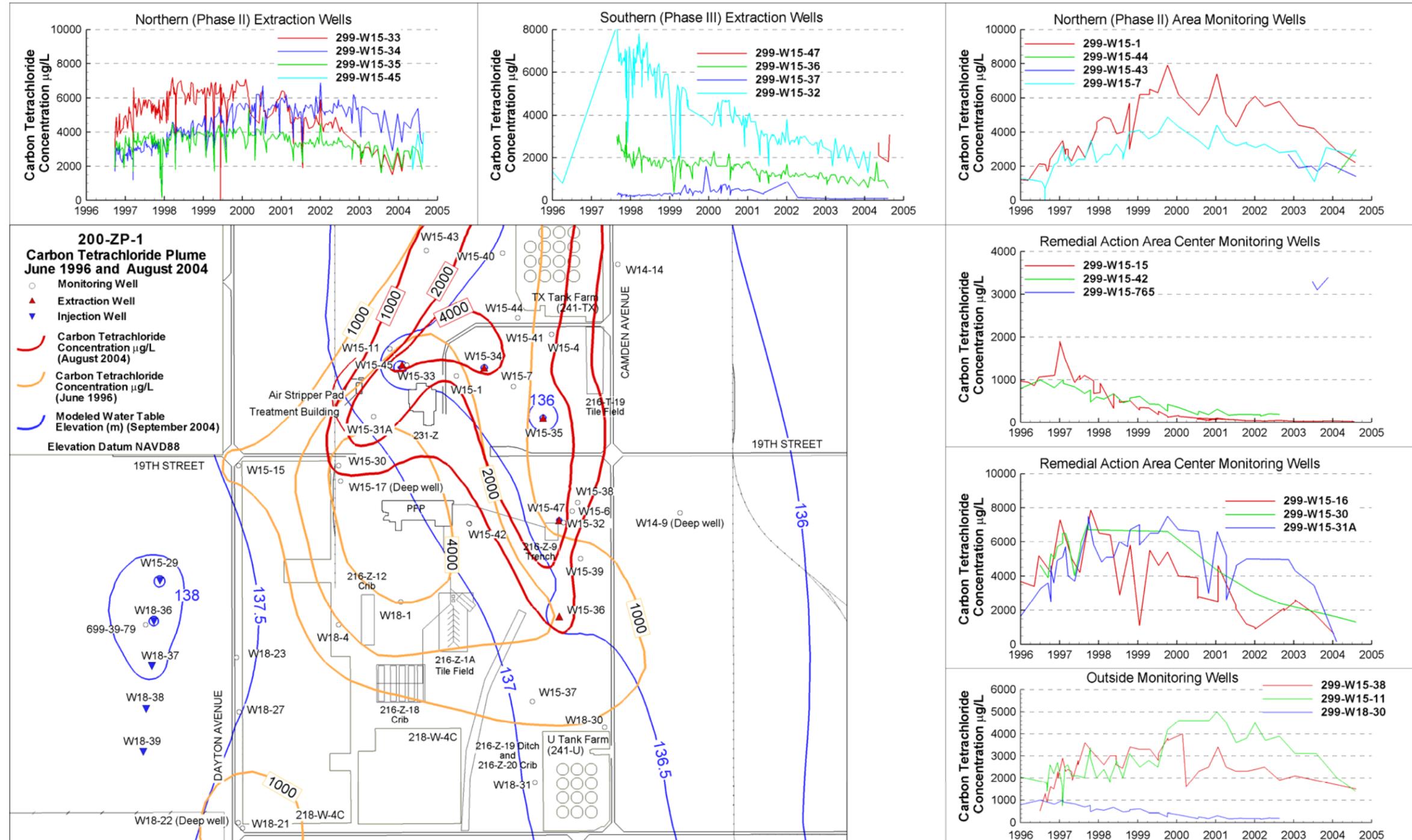


Figure 3-11. 200-ZP-1 Monitoring Wells, Z Plant with Plume.

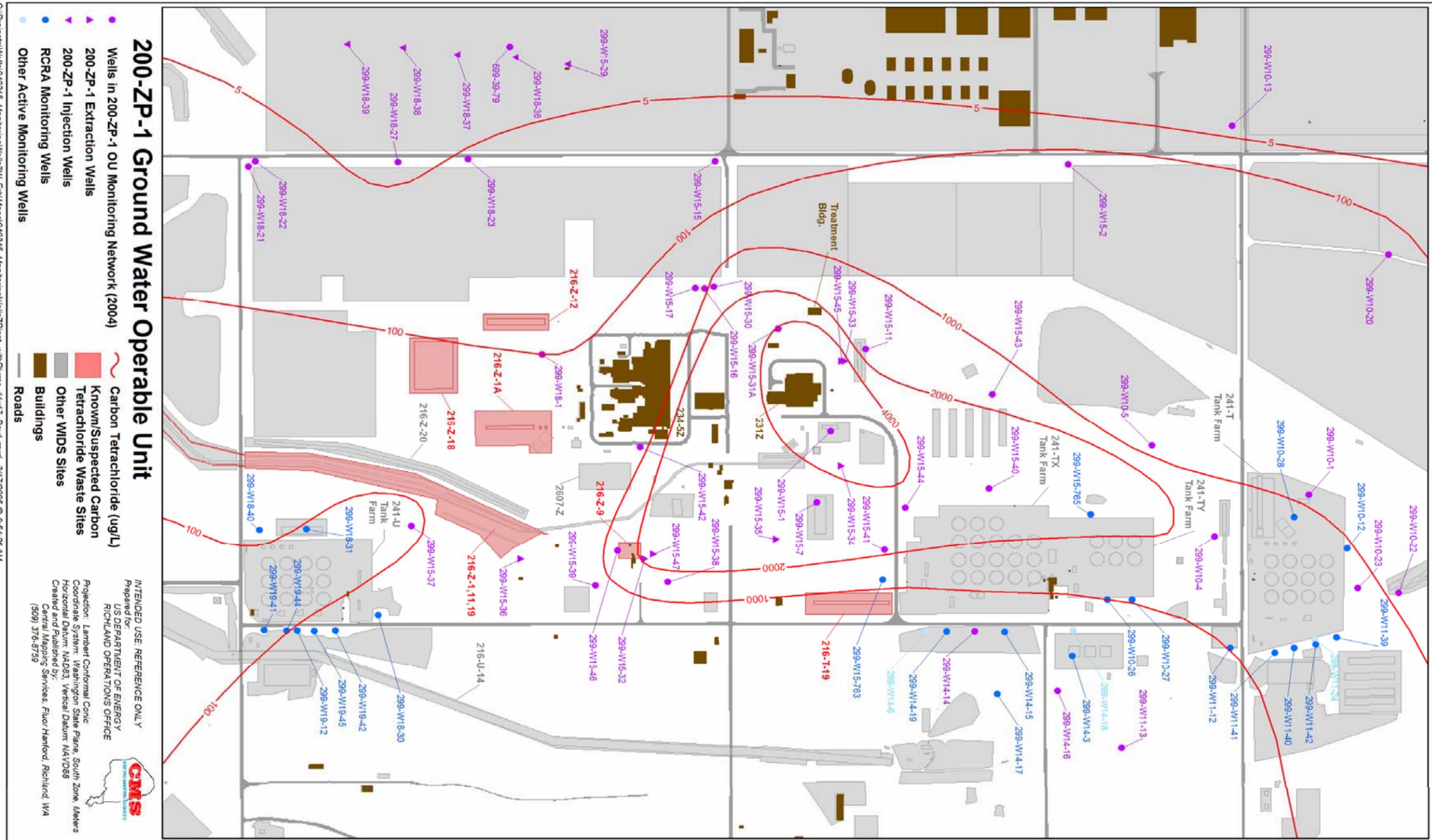


Figure 3-12. 200-ZP-1 Operable Unit Chloroform Contaminant Plume, August 2004.

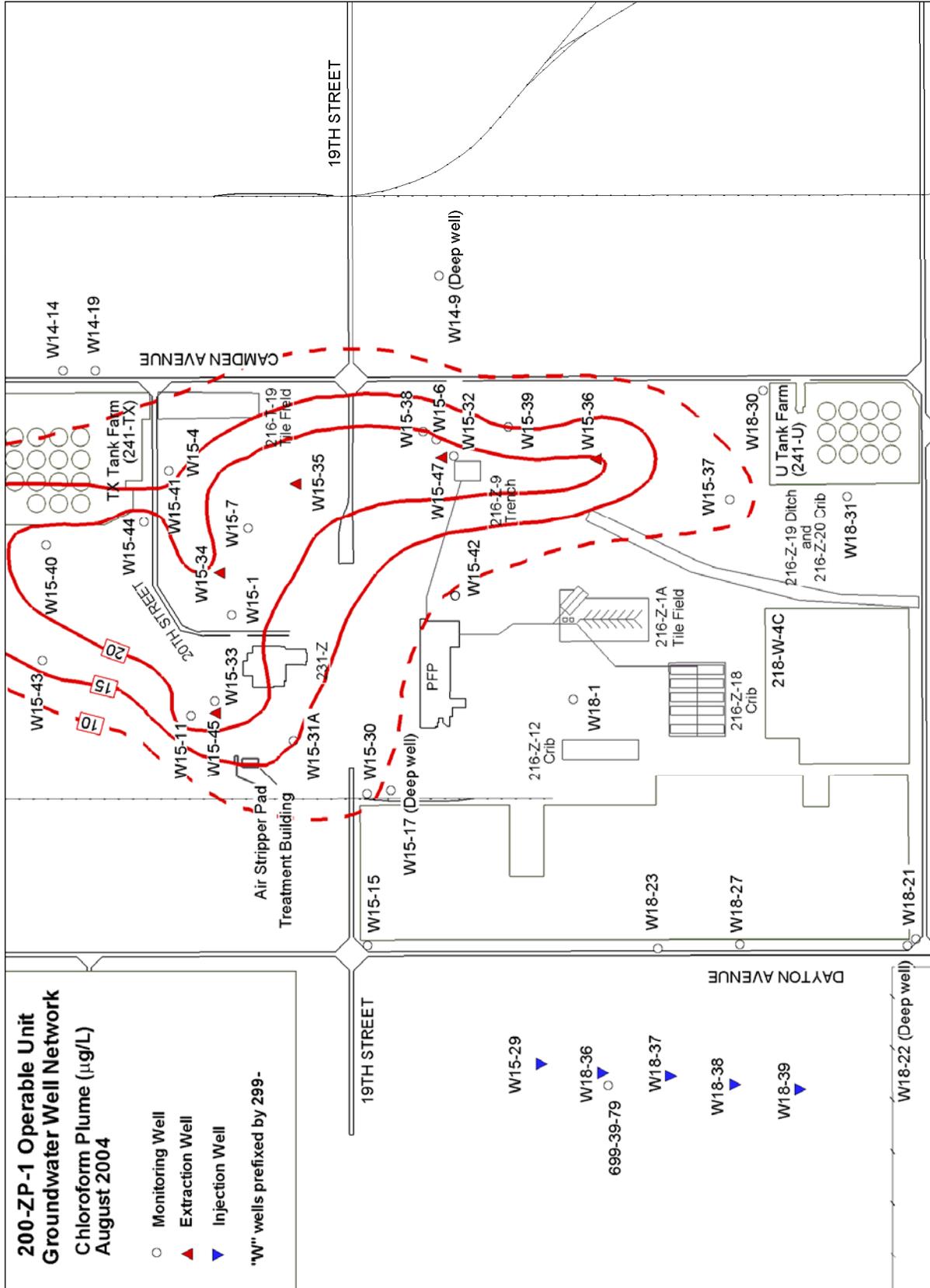


Figure 3-13. 200-ZP-1 Operable Unit Trichloroethene Contaminant Plume, August 2004.

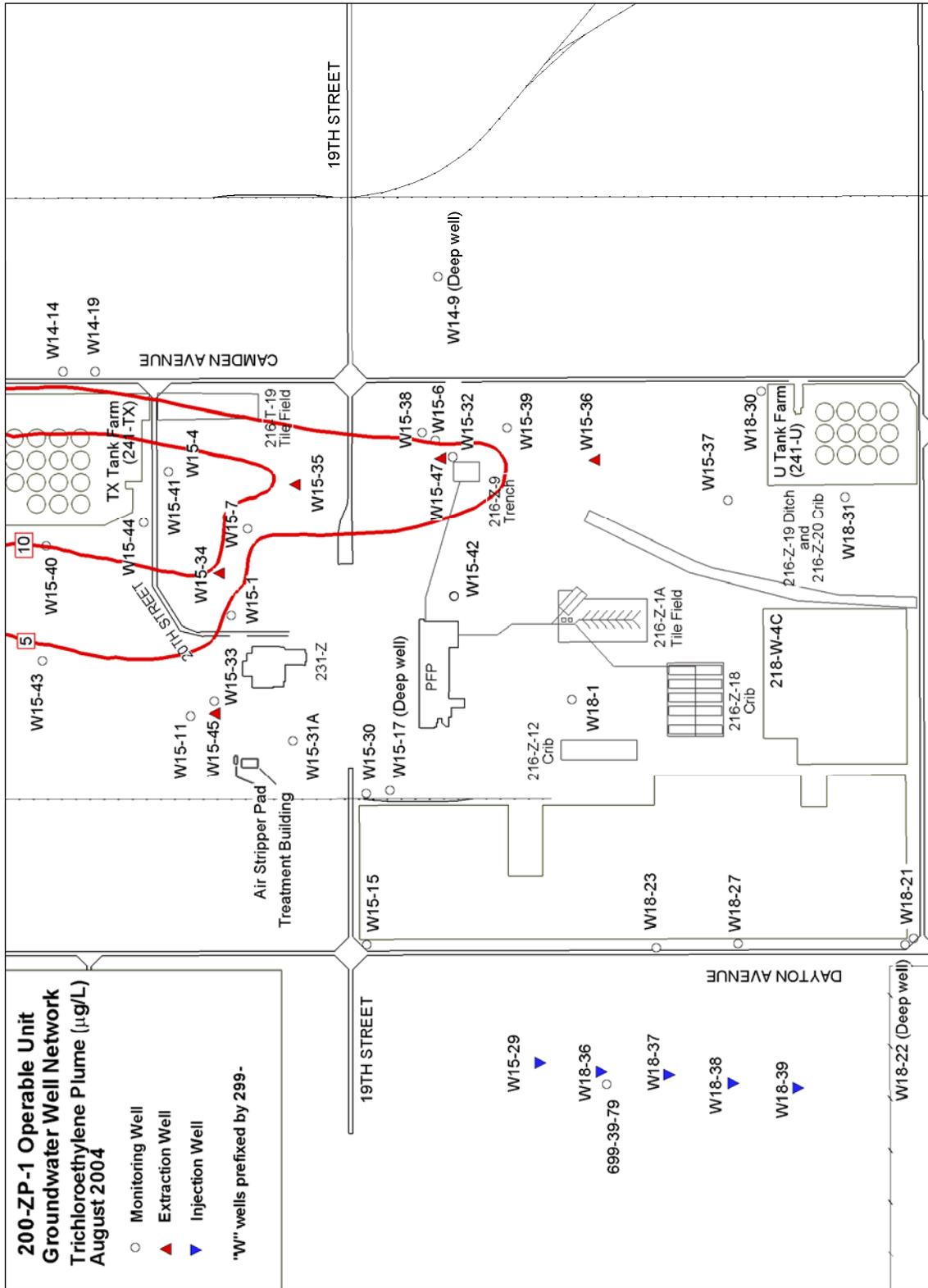
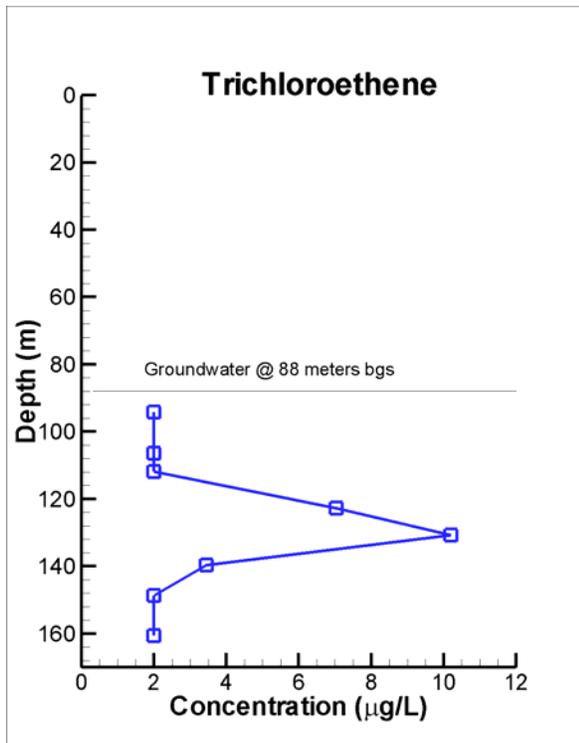
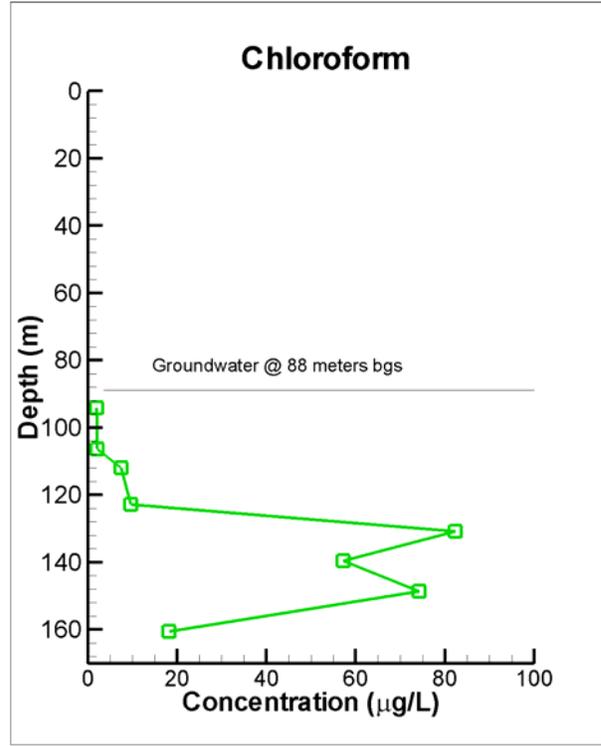
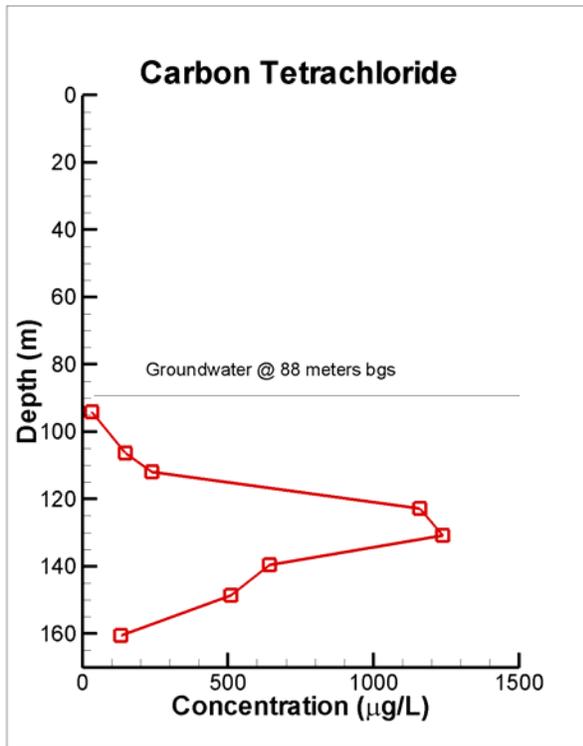


Figure 3-14. Vertical Profile of Contaminants at Well 299-W13-1.



**299-W13-1 Vertical Profile  
Carbon Tetrachloride Sampling  
Results**

**Sample results obtained  
12/3/2003 to 12/22/2003**

Figure 3-15. 200-ZP-1 Operable Unit Water Table Map:  
Baseline June 1996 Water Table Versus September 2004 Water Table.

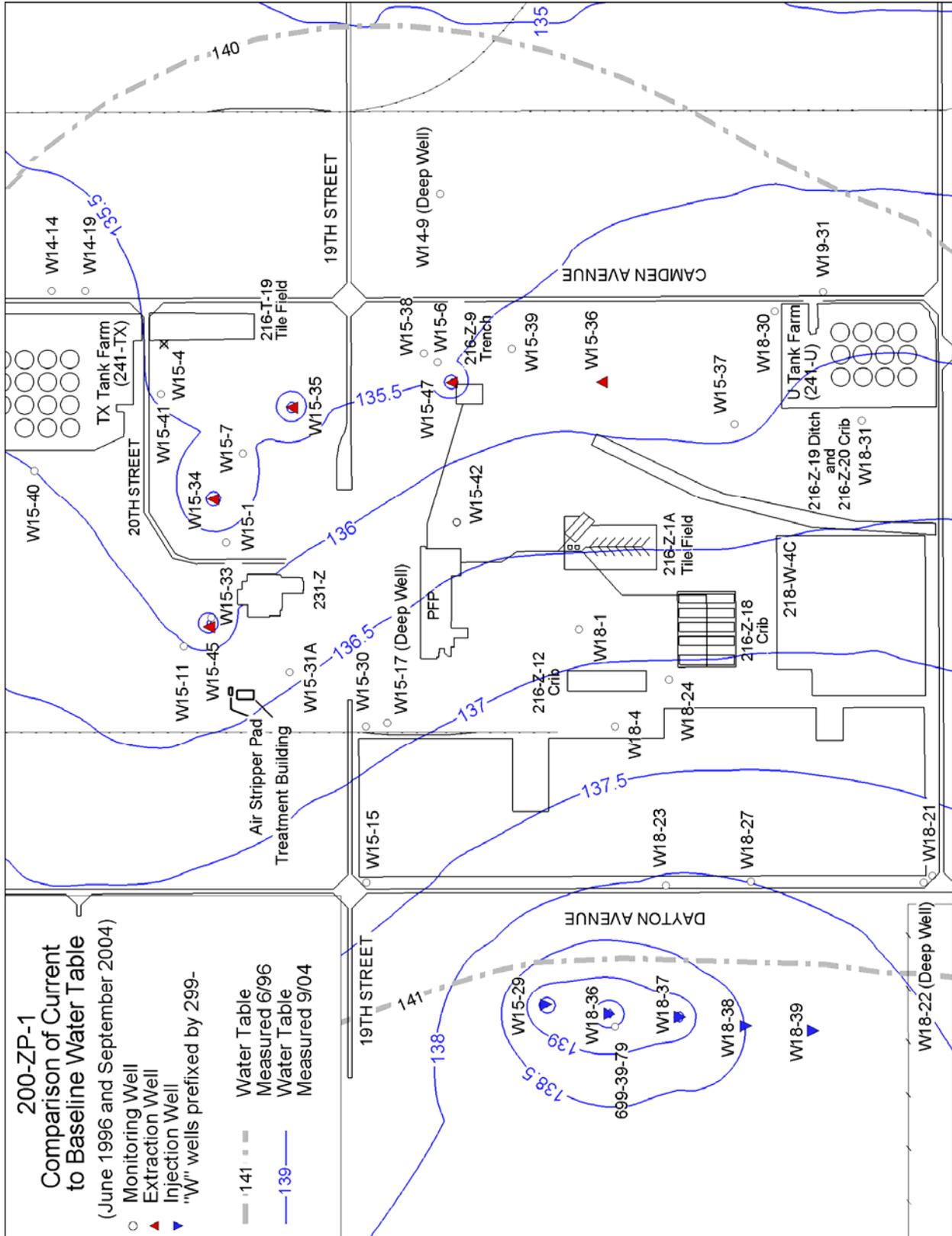




Table 3-1. Volume of Groundwater Treated and Carbon Tetrachloride Mass Removed Since Initiation of 200-ZP-1 Operable Unit Pump-and-Treat Operations. (2 sheets)

<b>Reporting Period</b>	<b>Liters Treated</b>	<b>Mass of Carbon Tetrachloride Removed (kg)</b>
August 1994 – July 1996	26,676,000	75.9
August 1996 – September 1996	33,232,327	61
October 1996 – December 1996	44,583,715	143.5
January 1997 – March 1997	69,869,903	237.2
April 1997 – June 1997	41,877,094	140.8
July 1997 – September 1997	62,469,305	228.8
October 1997 – December 1997	81,629,000	245.7
January 1998 – March 1998	72,791,000	279.5
April 1998 – June 1998	90,842,900	348.9
July 1998 – September 1998	90,899,200	338.1
October 1998 – December 1998	84,386,385	315.6
January 1999 – March 1999	77,079,401	310.2
April 1999 – June 1999	90,657,483	337.8
July 1999 – September 1999	88,657,767	323.7
October 1999 – December 1999	53,073,892	201.8
January 2000 – March 2000	90,920,220	370
April 2000 – June 2000	74,312,943	307.8
July 2000 – September 2000	82,096,586	303.7
October 2000 – December 2000	94,110,990	336.8
January 2001 – March 2001	85,367,099	330.5
April 2001 – June 2001	84,283,176	297.1
July 2001 – September 2001	75,085,163	261.9
October 2001 – December 2001	81,274,965	287.3
January 2002 – March 2002	80,386,480	289.9
April 2002 – June 2002	73,058,873	258.9

Table 3-1. Volume of Groundwater Treated and Carbon Tetrachloride Mass Removed Since Initiation of 200-ZP-1 Operable Unit Pump-and-Treat Operations. (2 sheets)

<b>Reporting Period</b>	<b>Liters Treated</b>	<b>Mass of Carbon Tetrachloride Removed (kg)</b>
July 2002 – September 2002	66,562,164	216.6
October 2002 – December 2002	61,253,813	200.4
January 2003 – March 2003	66,707,490	204.2
April 2003 – June 2003	66,077,797	223.2
July 2003 – September 2003	59,562,556	191.5
October 2003 – December 2003	62,687,970	180.1
January 2004 – March 2004	53,962,259	147.1
April 2004 – June 2004	68,812,409	200.3
July 2004 – September 2004	89,041,628	312.9
<b>Totals</b>	<b>2,424,289,953</b>	<b>8,508.52</b>

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#### 4.0 PUMP-AND-TREAT SYSTEMS COST DATA

Actual costs for the 200-UP-1 and 200-ZP-1 OU pump-and-treat systems, recorded by the Environmental Restoration Contractor and FH since project startup, can be used to determine the actual capital and labor costs associated with a specific activity over a given period of time. Tables 4-1 and 4-2 provide comparisons of the costs for the 200-UP-1 OU and 200-ZP-1 pump-and-treat systems, respectively, from FY95 through FY04. These data have been used to estimate actual project costs (burdened) and project future costs (based on actual costs to date). Specific activities are described below:

- **Initial design:** Includes initial design activities to support pump-and-treat 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 pump-and-treat system. Includes all Environmental Restoration Contractor and FH labor required for oversight and support of initial well installation.
- **Project support:** Includes project coordination-related activities and technical consultation as required during the course of the facility design, construction, acceptance testing, and operation.
- **Operations and maintenance:** This cost represents 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 pump-and-treat operations and periodic maintenance.
- **Performance monitoring:** Includes system and groundwater sampling and sample analysis as required in accordance with the interim action work plans (DOE-RL 1996, 1997). It also includes development of this 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 GAC at the 200-ZP-1 OU in accordance with the applicable laws for suspect hazardous, toxic, and regulated wastes. It includes waste designation sampling and analysis. There are currently no charges to the 200-UP-1 OU project from the ETF for groundwater treatment costs.
- **Regeneration subcontract:** This includes cost for the regeneration of GAC used by the 200-ZP-1 OU treatment system.
- **Construction capital:** This includes the cost for reconfiguring existing monitoring wells as extraction wells and the cost of the design for tying these new extraction wells into the transfer pipeline that conveys groundwater to the ETF for treatment.

- **Well installation:** This includes costs for installation of new monitoring and extraction wells at the 200-UP-1 and 200-ZP-1 OUs. Although new monitoring wells 699-38-70B, 699-38-70C, and 699-40-65, plus well 699-36-70B and well “R” (699-30-66), were drilled in FY04, none of these wells directly supported 200-UP-1 monitoring. New 200-ZP-1 extraction well 299-W15-47 was drilled and counted toward the cost of operation for the pump-and-treat system.

#### 4.1 200-UP-1 OPERABLE UNIT PUMP-AND-TREAT COSTS

The costs for operation of the 200-UP-1 OU pump-and-treat system are summarized in Figure 4-1 and Table 4-1. The FY04 costs are displayed by percent of the total costs in the pie chart in Figure 4-1. Costs per gram of constituent removed have increased from FY03 for all constituents except carbon tetrachloride because of installation and sampling of new monitoring wells at the 200-UP-1 OU. Groundwater production costs are \$0.007/L. Based on the FY04 costs and the yearly groundwater production rate (93.7 million L [approximately 24.8 million gal]), the treatment costs can be summarized as follows (see Table 4-1 for further information):

- Uranium (23.54 kg of uranium removed) = \$27.39/g of uranium removed
- Technetium-99 (12.1 g of technetium-99 removed) = \$53,110/g of technetium-99 removed
- Carbon tetrachloride (5.45 kg of carbon tetrachloride removed) = \$118/g of carbon tetrachloride removed
- Nitrate (5,207 kg of nitrate removed) = \$0.21/g of nitrate removed.

Figure 4-1 shows that 45% of the FY04 costs for the 200-UP-1 OU pump-and-treat project are associated with operations and maintenance. New wells were drilled at the 200-UP-1 OU in FY04 but none were determined to be close enough to directly support the pump-and-treat operations or improve on baseline plume configurations. The ETF’s operating expenses are not factored into overall project costs.

The declining groundwater table continues to impact the cost of system operation, due in part to the operations and maintenance costs resulting from increased pump maintenance. The RAO requirement to pump 189.3 L/min (50 gpm) and the need to provide satisfactory monitoring capability for the plume also requires drilling new wells as existing wells go dry. To date, 11 wells that were previously active in earlier stages of pump-and-treat operations have gone dry. New wells have been drilled as partial replacements, and additional well “K” (299-W19-48) is scheduled to be drilled around the baseline plume area in FY05.

#### 4.2 200-ZP-1 OPERABLE UNIT PUMP-AND-TREAT COSTS

The costs for operation of the 200-ZP-1 OU pump-and-treat system are summarized in Figure 4-2 and Table 4-2. The FY04 costs are displayed by percent of total costs in the pie chart in Figure 4-2. Based on the FY04 costs and yearly production rate (274.5 million L [approximately 72.5 million gal] of water and 840.4 kg of carbon tetrachloride removed), the FY04 treatment costs equate to \$0.006/L of water and \$1,933/kg of carbon tetrachloride removed.

Figure 4-2 shows that 43% of FY04 costs for the 200-ZP-1 pump-and-treat project were associated with operations and maintenance. New 200-ZP-1 OU monitoring well 299-W15-47, which was drilled and completed in FY04, represented 15% of the total operating cost.

Overall, the trends over the last several years indicate that some of the increased operating costs are resulting from declines in groundwater table elevations. New extraction wells are being drilled to replace old wells where declining water levels are causing decreases in overall extraction rates. The new wells are required to ensure adequate plume monitoring coverage. The new monitoring and extraction wells are more expensive because they are being drilled deeper, they are constructed to larger diameters than monitoring wells, and they have greater lengths of expensive well screen installed to provide longer well life.

Figure 4-1. Cost Breakdown for 200-UP-1 Operable Unit Pump-and-Treat Operations. (3 sheets)

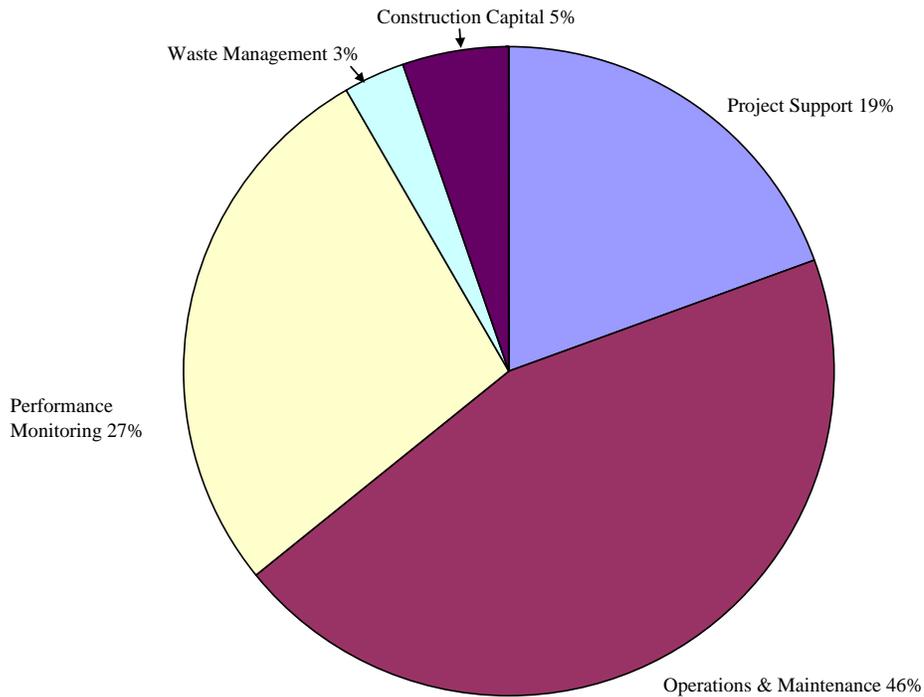


Figure 4-1. Cost Breakdown for 200-UP-1 Operable Unit Pump-and-Treat Operations. (3 sheets)

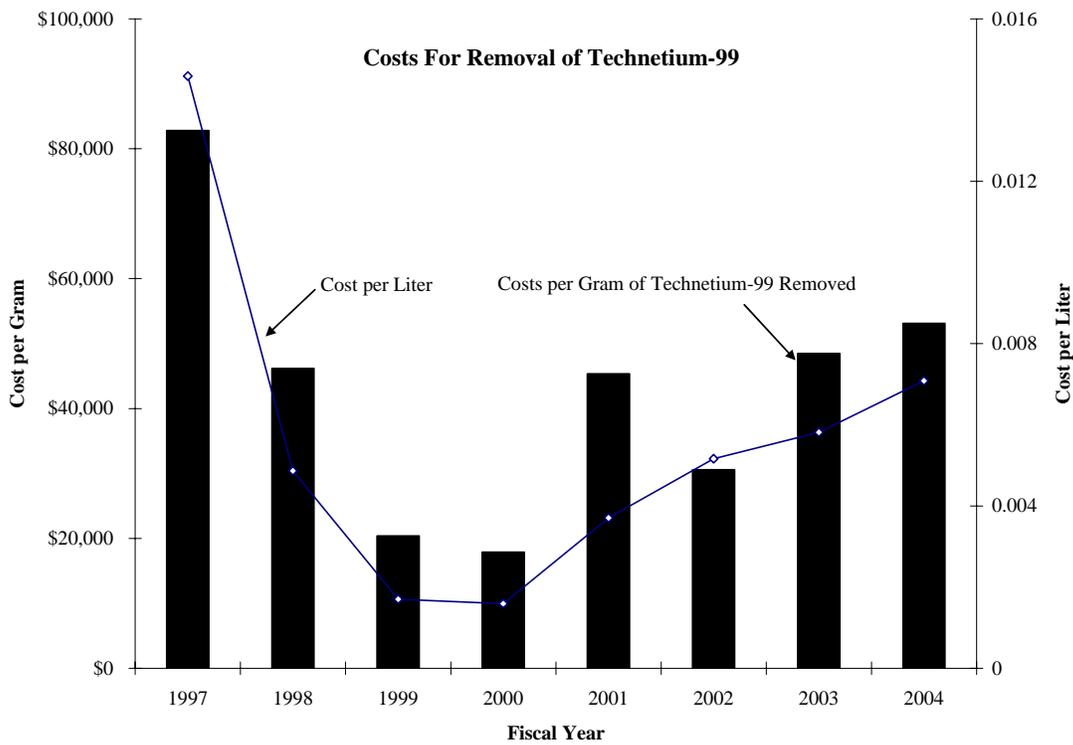
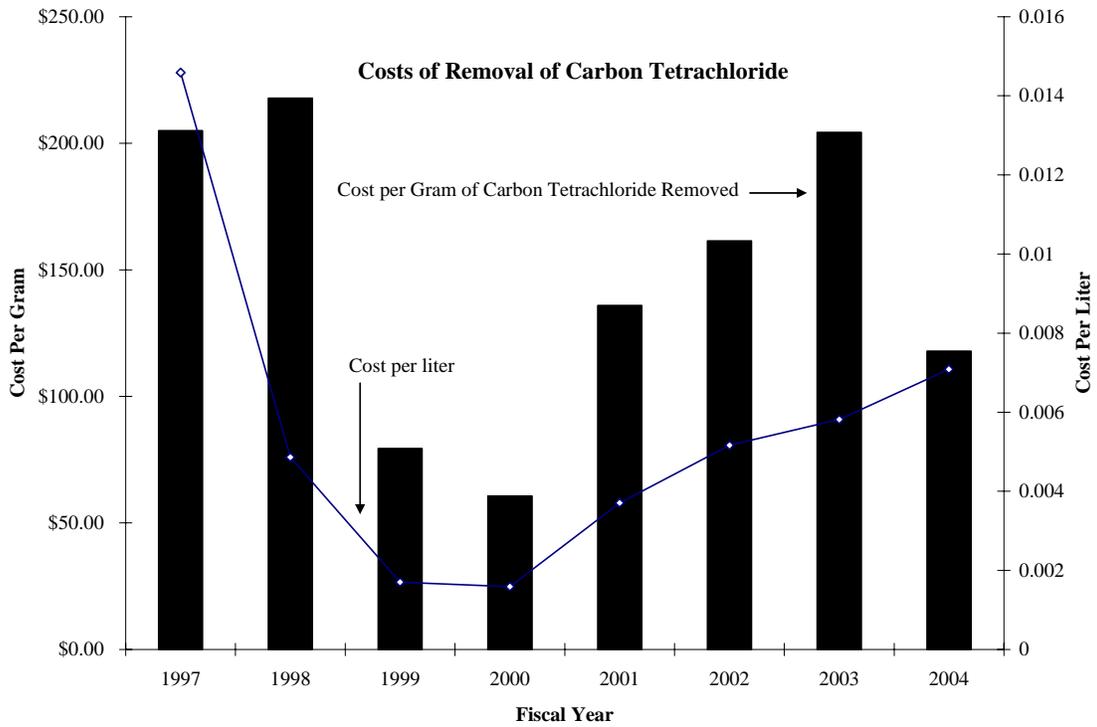


Figure 4-1. Cost Breakdown for 200-UP-1 Operable Unit Pump-and-Treat Operations. (3 sheets)

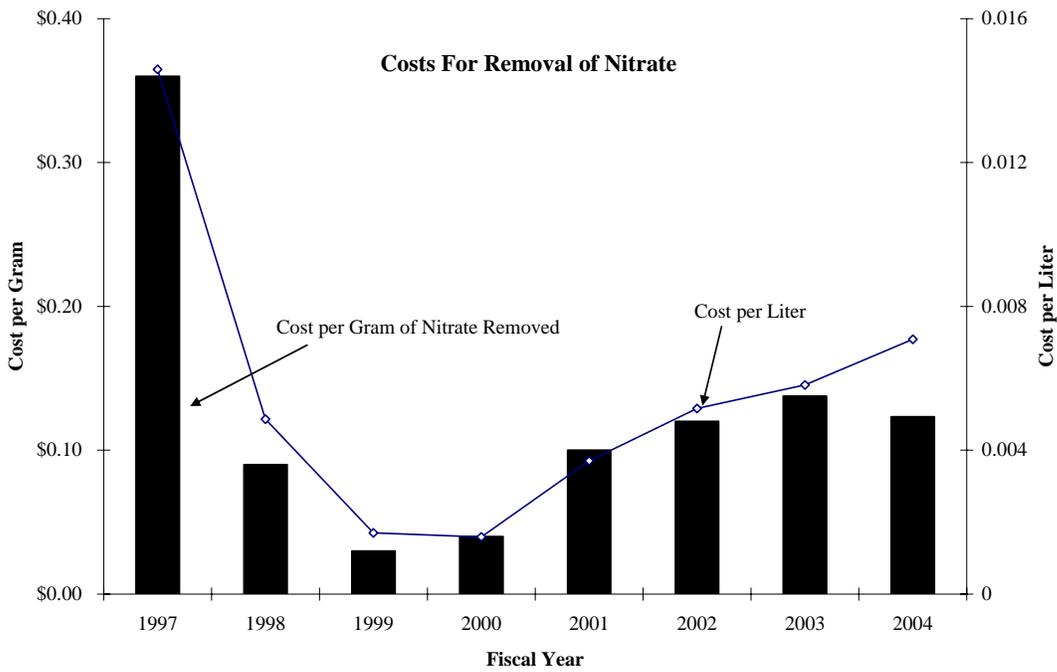
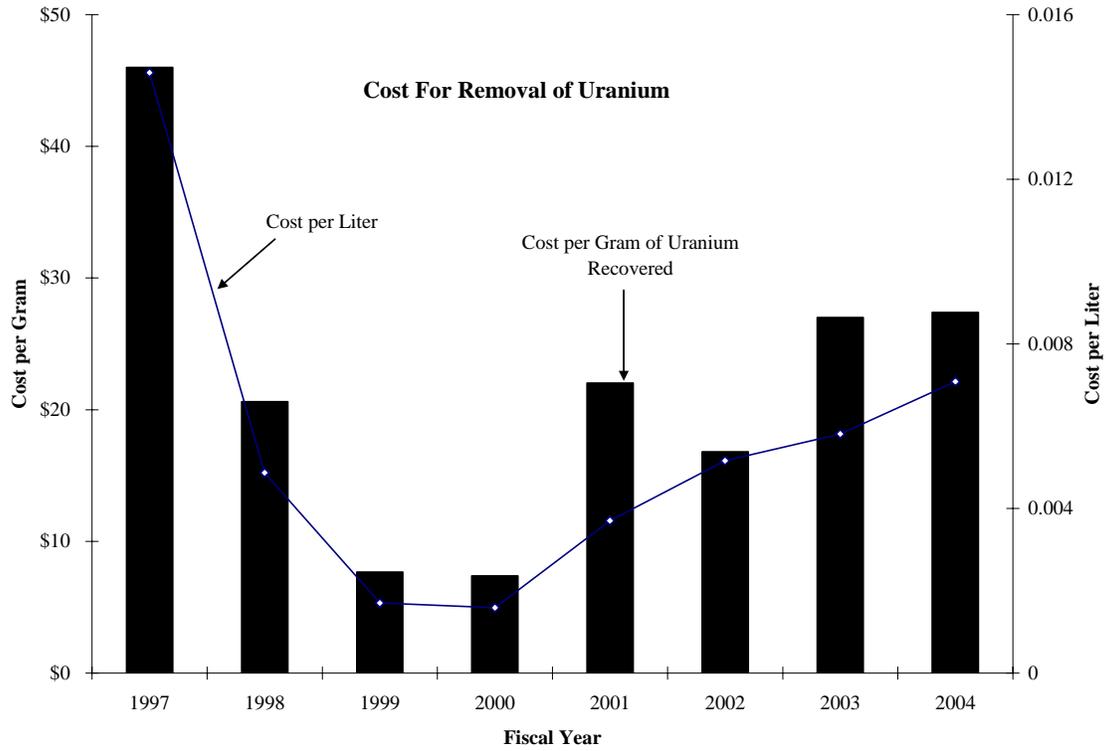


Figure 4-2. Cost Breakdown for 200-ZP-1 Operable Unit Pump-and-Treat Operations.

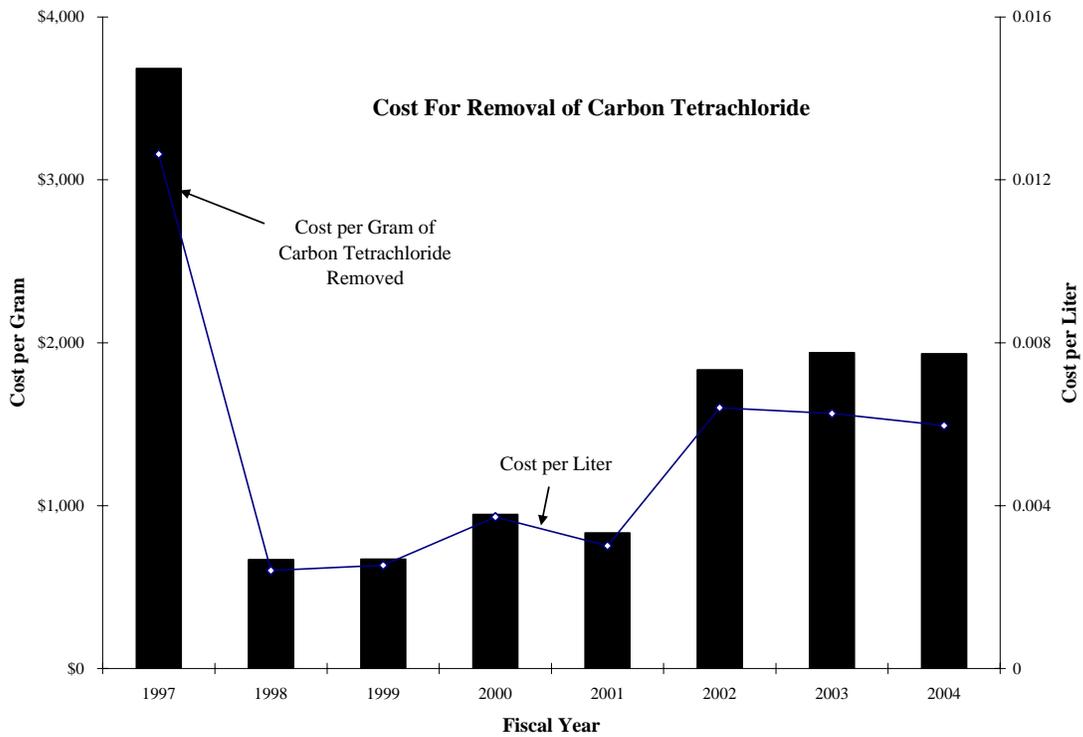
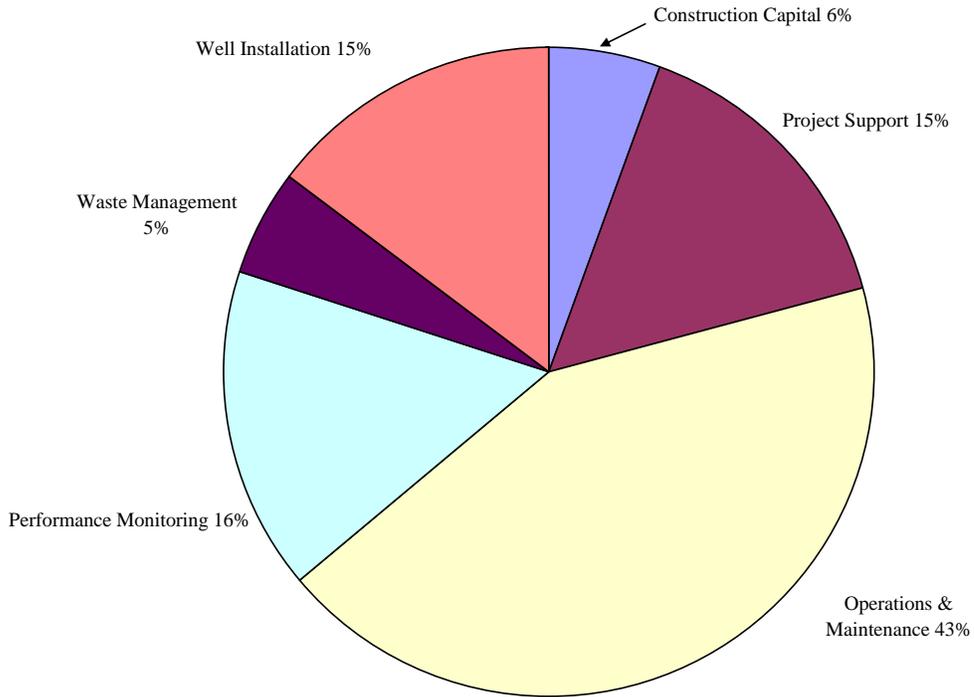


Table 4-1. Comparison of Yearly Costs for Operation of 200-UP-1 Pump-and-Treat System – Fiscal Year 1995 Through Fiscal Year 2004.

Description	Actual Costs (in \$1,000's)									
	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Initial design	1,503.1	511								
Project support			101	86	31.3	39.6	0.3	140.1	89.1	124.9
Operations and maintenance	2,821	2,135	707	400.8	127.8	18.8	52	78.4	171	287.7
Performance monitoring						32.2	35.9	33.1	84.3	175.4
Waste management						10	21.3	8.2	33.3	19.6
Construction capital							71.7	149.5	48.1	34.5
Well installation							198.5	34.1	145.9	0
<b>Totals</b>	<b>\$4,324.1</b>	<b>\$2,646</b>	<b>\$808</b>	<b>\$486.8</b>	<b>\$159.1</b>	<b>\$100.6</b>	<b>\$379.7</b>	<b>\$443.4</b>	<b>\$571.7</b>	<b>\$642.1</b>

NOTE: The well installation total for FY04 includes costs for five wells installed across the greater 200-UP-1 Operable Unit. Some of these wells may have directly supported 200-UP-1 pump-and-treat operations and monitoring.

Table 4-2. Comparison of Yearly Costs for Operation of 200-ZP-1 Pump-and-Treat System – Fiscal Year 1995 Through Fiscal Year 2004.

Description	Actual Costs (in \$1,000's)									
	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Initial design	2,854.4	271								
Treatment system capital		3,992.0								92.3
Project support			444	183.8	158.9	115.1	30.9	141.6	171.1	249.9
Operations and maintenance	1,139.0	6,010.0	2,320	626.2	704.5	701.3	550.8	478.4	724.8	703.4
Performance monitoring						256.9	177	146.1	127.6	265.3
Waste management						45.3	52.6	92.2	167.2	85.1
Regeneration subcontract							142.6			
Well installation							68	1,071.5	397.9	241.8
<b>Totals</b>	<b>\$3,993.4</b>	<b>\$10,273</b>	<b>\$2,764</b>	<b>\$810</b>	<b>\$863.4</b>	<b>\$1,118.6</b>	<b>\$1,021.9</b>	<b>\$1,929.8</b>	<b>\$1,588.6</b>	<b>\$1,637.8</b>

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- A WASTE SITE, OPERABLE UNIT, AND PUMP-AND-TREAT OPERATIONAL HISTORY
- B TREATMENT SYSTEM PERFORMANCE
- C HYDROGRAPHS AND AQUIFER RESPONSE
- D TREND PLOTS FOR WELLS AT THE 200-UP-1 OPERABLE UNIT
- E NUMERICAL MODELING FOR HYDRAULIC CAPTURE ANALYSIS
- F TECHNETIUM-99 AT WELL 299-W23-19
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**APPENDIX A**

**WASTE SITE, OPERABLE UNIT,  
AND PUMP-AND-TREAT HISTORY**

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## APPENDIX A

### WASTE SITE, OPERABLE UNIT, AND PUMP-AND-TREAT HISTORY

#### A1.0 INTRODUCTION

This appendix describes the waste disposal operations and regulatory history for the 200-UP-1 and 200-ZP-1 Operable Unit (OU) pump-and-treat systems. The data are provided to better understand the evolution of the current treatment approaches.

#### A2.0 200-UP-1 OPERATIONAL HISTORY

##### A2.1 WASTE DISPOSAL

The 216-U-1 and 216-U-2 Cribs, as well as the 241-U-361 tank, comprised a waste disposal system that received significant volumes of liquid from a series of uranium recovery processes. A reverse or injection well (299-W19-9) 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)-high, open structures, resting at the bottom of 6.1-m (20-ft)-deep excavations. The two cribs were connected in series, requiring wastewater to overflow into the 216-U-2 Crib after backing up in the 216-U-1 Crib pipeline.

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, retrieving uranium from bismuth-phosphate process metal wastes stored in the B, C, T, and U Tank Farms. The chemical separations process recovered the 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 Facility converted batches of dilute uranyl nitrate hexahydrate (UNH) first into concentrated uranyl nitrate hexahydrate, and then into uranium trioxide ( $\text{UO}_3$ ) by calcining (i.e., heating) in furnaces. Concentrated UNH from the 202-S Reduction-Oxidation (REDOX) Plant was also calcined into  $\text{UO}_3$ , as was UNH trucked from the 202-A Plutonium-Uranium (PUREX) Facility. Additions and modifications to the  $\text{UO}_3$  process were made with the addition of the 224-UA and other supporting facilities, all of which permitted continuous calcining operations. The  $\text{UO}_3$  process was active until 1989 and then again for a final cleanout run in 1992 following a cleanout run at the PUREX Facility.

The nature of waste-generating activities at these facilities is not well documented. Piping in the 221-U Facility was decontaminated in 1966-1967 with acid washes, which were then discharged to the 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/U-2 Cribs received  $4.62 \times 10^7$  L ( $1.22 \times 10^7$  gal) of process wastes from the URP and multiple  $\text{UO}_3$  processes through 1967. The liquid wastes included trace to minor concentrations of uranium, which accumulated to 4,040 kg of uranium (Baker et al. 1988) at the waste site. Diediker (1999) lists an inventory of 0.701 Ci (2,096 kg) of total uranium,  $6.82 \times 10^{-4}$  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). Schmittroth (1995) used data from an ORIGEN2 model to estimate the amount of fission products generated at the Hanford reactors. From that, Schmittroth estimated that up to 11 Ci of technetium-99 had been disposed at the 216-U-1, 216-U-2, and 216-U-8 Cribs. With the end of discharges to the 216-U-1/U-2 Cribs in 1967, other waste sites were either on-line or were brought into use for the waste streams, primarily the following cribs: 216-U-8 (1952 through 1960), 216-U-12 (1960 through 1988), and 216-U-17 (1988 through 1994).

Groundwater contamination was discovered at the 216-U-1/U-2 Cribs in January 1985, when samples from two nearby wells, 299-W19-3 and 299-W19-11, revealed unusually high (up to 85,000 pCi/L) concentrations of uranium (Baker et al 1988, Delegard et al. 1985) compared with 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 Crib. This crib received large volumes of cooling water from 224-U between July 1984 and 1987. Boreholes were drilled to characterize the site, and an ion-exchange (IX) system based at the 242-S evaporator was set up. The IX system treated approximately  $3.0 \times 10^7$  L (8 million gal) of groundwater and recovered 687 kg of uranium between June and November 1985. The WIDS database notes that an additional 830 kg of uranium were thought to remain in the groundwater after this pump-and-treat operation.

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 (Delegard et al. 1985). The 1983 data 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), but the uranium was spread across the upper 8 m (26.2 ft) of the soil column directly below the 6-m (19.7-ft)-deep crib. Uranium concentrations then generally decreased with depth before rising to 100 ppm at 50 m (164.1 ft) bgs near the Plio-Pleistocene caliche unit. Uranium concentration 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 those in surrounding sediments. The geophysical logging also indicated that activity levels at the water table were higher than those from the sediment layers above.

More detailed chemical analyses were performed on the 1983 soil samples (Delegard et al. 1985). For the samples at 10.8 m (35.4 ft), the sediment was found to be acidic from the wastes previously discharged and contained 0.3% 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.

Characterization activities after startup of the 216-U-16 Crib and the resulting uranium plume at the 216-U-1/U-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 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. Delegard et al. (1985) assumed that access to

the aquifer was by holes in the caliche layer or by migration along well casings penetrating the caliche.

## A2.2 CURRENT REMEDIATION ACTIVITIES

The current pump-and-treat program emerged in 1994 following a recommendation made in the *200 West Groundwater Aggregate Area Management Study Report* (DOE-RL 1993) that the 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), the U.S. Environmental Protection Agency, and the Washington State Department of Ecology as *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al. 2003) Milestone 13-93-03. The agreement specified an IX pump-and-treat system as a pilot-scale treatability test and identified uranium and technetium-99 as the primary contaminants of concern. The *Remedial Investigation/Feasibility Study Work Plan for the 200-UP-1 Groundwater Operable Unit* (DOE/RL-92-76, currently being revised [DOE-RL 2004b]) and the *Pilot-Scale Treatability Test Plan for the 200-UP-1 Groundwater Operable Unit* (DOE-RL 1994a) were prepared to guide development of the IX system. Carbon tetrachloride was added as a secondary contaminant of concern, but nitrate was dropped as a target constituent for the treatability test.

The pilot-scale treatability test was constructed and operated between March 1994 and September 1995 (*Treatability Report for the 200-UP-1 Operable Unit – Hanford Site* [DOE-RL 1995c]). The treatability test consisted of an onsite pump-and-treat 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 on-line 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 (which were originally installed between 1986 and 1990 to monitor 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 in removing uranium/technetium-99 and carbon tetrachloride, respectively, from groundwater.

Following completion of the pilot test, pump-and-treat operations continued. A 1994-1995 drilling program 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 pump-and-treat 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 extracted at a rate of 189.3 L/min (50 gpm). During this period, operations continued in anticipation of release of the *Interim Remedial Measure Proposed Plan for the 200-UP-1 Operable Unit, Hanford, Washington* (DOE-RL 1995b) and issuance of an interim action Record of Decision (ROD).

On February 25, 1997, the *Record of Decision for the 200-UP-1 Interim Remedial Measure* (EPA et al. 1997) was issued for 200-UP-1 OU pump-and-treat operations. The *200-UP-1 Groundwater Remedial Design/Remedial Action Work Plan* (DOE-RL 1997a) 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 the pipeline conveying groundwater to the ETF.

The selected remedy section of the 200-UP-1 interim action ROD (EPA et al. 1997) 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 maximum contaminant level (MCL). For uranium, the selected remedy's high-concentration zone was a contour set at 480 µg/L, or 10 times the 1997 *Model Toxics Control Act* (MTCA) (*Washington Administrative Code* [WAC] 173-340) standard of 48 µg/L. Since then, the MTCA standard has been lowered twice: first to 40 µg/L, and in fiscal year 2004 (FY04) to 30 µg/L. The pump-and-treat system continues to be evaluated against the ROD's selected remedy value of 10 times the 48 µg/L MTCA standard, or 480 µg/L.

Phase II operations were initiated on March 31, 1997, and continue to the present. During Phase II, contaminated groundwater has been transported 11.3 km (7 mi) through a pipeline from the extraction wells in the 200 West Area to the ETF for treatment. After treatment, groundwater is discharged to the State-Approved Land Disposal Site, located north of the 200 West Area.

Over time, declines in water table elevation at 200-UP-1 have reduced the volume of water pumped at extraction well 299-W19-39. As a result, well 299-W19-36 has been used as an extraction well between December 27, 2001, and May 15, 2003, and again from November 21, 2003, to the present. Well 299-W19-43 commenced operations as an extraction well on May 22, 2003, and has continued pumping to the present.

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

- *Remedial Investigation/Feasibility Study Work Plan for the 200-UP-1 Groundwater Operable Unit* (DOE-RL 2004b)
- *200-UP-1 Groundwater Remedial Design/Remedial Action Work Plan* (DOE-RL 1997a)
- *Engineering Evaluation/Conceptual Plan for the 200-UP-1 Groundwater Operable Unit Interim Remedial Measure* (BHI 1996b).

Information regarding the progress of the 200-UP-1 OU pump-and-treat operations is provided in the following documents:

- *200-UP-1 Groundwater Pump-and-Treat Phase I Annual Report, FY 1996* (BHI 1996a)
- *Fiscal Year 1997 Annual Report for the 100-NR-2, 200-UP-1, and 200-ZP-1 Pump-and-Treat Operations and Operable Units* (BHI 1998)
- *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 1999)
- *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)
- *Fiscal Year 2000 Annual Summary Report for the 200-UP-1 and 200-ZP-1 Pump-and-Treat Operations* (DOE-RL 2001)
- *Fiscal Year 2001 Annual Summary Report for the 200-UP-1 and 200-ZP-1 Pump-and-Treat Operations*(DOE-RL 2002)

- *Fiscal Year 2002 Annual Summary Report for the 200-UP-1 and 200-ZP-1 Pump-and-Treat Operations* (DOE-RL 2003)
- *Fiscal Year 2003 Annual Summary Report for the 200-UP-1 and 200-ZP-1 Pump-and-Treat Operations* (DOE-RL 2004a).

Minor volumes of effluents are being discharged to the 2607-W5 septic tank tile field, which lies just north of the 216-U-1/U-2 Cribs. The discharges are scheduled to be halted on March 2005. In addition, aging and potentially leaking water, steam, and high-activity transfer lines criss-cross the area around the 216-U-1/U-2 Cribs and the 221-U Canyon Building and its connecting pipelines. A water line failure just south and west of the two cribs discharged 6.4 million L (1.7 million gal) of water to the soil column between July 23 and November 22, 2002. Another leak of unknown but low volume occurred in June 2003 at a location further west of the 216-U-1/U-2 Cribs. Incidents such as these have raised concerns that leaks provide a full- or part-time driving force for contaminant movement.

At the end of FY04, the current pump-and-treat system has removed 203.0 kg of uranium and 114.1 g of technetium-99. Including the 1985 pump-and-treat action, more than 886 kg of uranium have been removed from parts of the uranium plume.

### **A3.0 200-ZP-1 OPERABLE UNIT**

#### **A3.1 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. RECUPLEX was a solvent extraction process used to recover plutonium from plutonium metal and compound scraps. Tributyl phosphate mixed 15% to 20% by volume with carbon tetrachloride removed plutonium in the exchange process from the inorganic acid feed (FDH 1997). 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 plutonium-refining process at the 234-5Z 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 (PRF) between 1964 and 1987 (FDH 1997). 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 (in service between 1963 and 1976) was involved with the recovery of americium-241 and plutonium in an IX batch process using 30% dibutyl butyl phosphonate and 70% carbon tetrachloride between 1964 and 1970. Wastes from this process were also discharged to the disposal sites receiving the PRF waste.

From the above sources, carbon tetrachloride was discharged to the ground during operations at the 234-5Z 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 (*Waste Site Grouping for 200 Areas Soil Investigations* [DOE-RL 1997b]). Three other sites (216-T-19 and 216-Z-12 Cribs and 216-Z-19 Ditch) also are known or suspected to have received 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, and a plume has formed roughly coincident with the part of the carbon tetrachloride plume north of the waste sites.

Chloroform, which is a secondary contaminant of concern for the interim remedial measure, is a degradation product of carbon tetrachloride (Truex et al. 2001). Chloroform (drinking water standard [DWS] = 80 µg/L) is also associated with septic waste disposal. The 2607-Z septic system and drain field (active from 1949 to 1999) is 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. The current chloroform plume is depicted around all of the extraction wells.

The origin of trichloroethene (TCE) in the waste streams is unknown, but it is thought to have been used as a degreaser. A baseline TCE (DWS = 5 µg/L) plume was not prepared in 1996 because of low TCE concentrations at carbon tetrachloride monitoring wells. The TCE plume is currently centered around wells 299-W15-34 and 299-W15-35 and extends north toward the 241-TY Tank Farm.

### **A3.2 REMEDIATION TREATMENT ACTIVITIES**

Carbon tetrachloride was first detected in groundwater samples from several wells in 1986 (*Environmental Monitoring at Hanford for 1986* [PNL 1987]) and was recognized as a broad plume beneath the 200 West Area in 1987. The *200 West Area Groundwater Aggregate Area Management Study Report* (DOE-RL 1993) discussed the groundwater carbon tetrachloride plume and recommended it for expedited response action. It became the target of an expedited response action when the regulators requested that DOE assess groundwater contamination and evaluate alternatives for carbon tetrachloride contamination in the 200 West Area. A treatability test plan (DOE-RL 1994b) proposed and implemented a treatment system, which later became Phase I of the 200-ZP-1 pump-and-treat system.

In a separate and preceding action, the regulators requested that DOE assess carbon tetrachloride in the vadose zone (200-ZP-2, currently 200-PW-1) and evaluate alternatives to treat the contaminant. This led to preparation of the *Expedited Response Action Proposal (EE/CA & EA) for 200 West Carbon Tetrachloride Plume* (DOE-RL 1991). Soil vapor extraction (SVE) was recommended and 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. Operations are currently conducted between April 1 and September 30 each year. Passive SVE systems have also 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 2002* (FH 2003) reports on SVE site operations and vadose zone conditions.

The 200-ZP-1 OU pump-and-treat system was implemented in a three-phased approach. Phase I operations consisted of the 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 1995a).

Concurrent with Phase I operations, the *Declaration of the Interim Record of Decision for the 200-ZP-1 Operable Unit* (EPA et al. 1995) was issued in June 1995. The selected remedy was to use groundwater pump-and-treat 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 et al. 1995) 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 567.8 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 Phase Interim Remedial Measure Quarterly Report, October – December 1996* (BHI 1997). Phase II operations were terminated on August 8, 1997, to transition to 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 wells 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 1,893 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 et al. 1995). 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 2002).

Two new extraction wells were drilled and brought on-line in FY04. Well 299-W15-45 replaced 299-W15-33, and well 299-W15-47 replaced 299-W15-32. Both new wells have been drilled deeper into the aquifer and were constructed with 15.2-m (50-ft) screens, starting 1.5 m (5 ft) below the water table in the upper, unconfined aquifer. The old wells have been reconfigured to monitor water levels.

For additional site characterization and background information on the 200-ZP-1 OU and the pump-and-treat activity, refer to the following documents:

- *Engineering Evaluation/Conceptual Plan for the 200-ZP-1 Operable Unit Interim Remedial Measure* (BHI 1994)
- *200-ZP-1 IRM Phase II and III Remedial Design Report* (DOE-RL 1996)

- *Hydrogeologic Conceptual Model for the Carbon Tetrachloride and Uranium/ Technetium Plumes in the 200 West Area: 1994 Through 1999 Update* (BHI 1999).

Information regarding the progress of the 200-ZP-1 OU pump-and-treat operations is provided in the following documents:

- *200-ZP-1 Operable Unit Treatability Test Report* (DOE-RL 1995a)
- *Fiscal Year 1997 Annual Report for the 100-NR-2, 200-UP-1, and 200-ZP-1 Pump-and-Treat Operations and Operable Units* (BHI 1998)
- *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 1999)
- *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)
- *Fiscal Year 2000 Annual Summary Report for the 200-UP-1 and 200-ZP-1 Pump-and-Treat Operations* (DOE-RL 2001)
- *Fiscal Year 2001 Annual Summary Report for the 200-UP-1 and 200-ZP-1 Operable Unit Pump-and-Treat Operations* (DOE-RL 2002)
- *Fiscal Year 2002 Annual Summary Report for the 200-UP-1 and 200-ZP-1 Operable Unit Pump-and-Treat Operations* (DOE-RL 2003)
- *Fiscal Year 2003 Annual Summary Report for the 200-UP-1 and 200-ZP-1 Operable Unit Pump-and-Treat Operations* (DOE-RL 2004a).

By 1995, all of the liquid waste discharges around the PFP and baseline plume had been terminated. The 2607-Z tile field was taken out of service in 1999. A variety of water, steam, and process lines cross the area and may provide an opportunity for leaks, but none have been reported. By the end of FY04, the 200-ZP-1 pump-and-treat system has removed 8,508 kg of carbon tetrachloride. Combined with the more than 78,348 kg removed by the SVE systems, more than 86,850 kg of carbon tetrachloride have been recovered.

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**APPENDIX B**  
**TREATMENT SYSTEM PERFORMANCE**

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## APPENDIX B

### TREATMENT SYSTEM PERFORMANCE

This appendix presents supplementary data to support the discussion in Sections 2.0 and 3.0 of this fiscal year 2004 (FY04) annual report. The figures and tables compare and summarize trends in the 200-UP-1 and 200-ZP-1 Operable Unit (OU) pump-and-treat systems for FY04 versus previous FYs.

#### B1.0 200-UP-1 OPERABLE UNIT PUMP-AND-TREAT SYSTEM PERFORMANCE

Figures B-1 through B-3 present graphs showing quarterly cumulative increases in uranium, technetium-99, carbon tetrachloride, and nitrate, as well as the groundwater treated.

Table B-1 summarizes the availability of the treatment system, as affected by scheduled and unscheduled outages. The contaminant concentrations in the extracted water, the mass removed, and the amount of waste generated at the Effluent Treatment Facility (ETF) are summarized in Table B-2. Table B-3 presents an annual breakdown of the volume of groundwater treated and the mass of the primary and secondary contaminants removed by the ETF. Table B-4 presents the analytical results for technetium-99, uranium, and carbon tetrachloride from extraction and baseline monitoring wells at the 200-UP-1 pump-and-treat system.

#### B1.1 PIPELINE LEAK DETECTION

Based on individual well totalizers, the 200-UP-1 system extracted more than 90,515,286 L (23,911,609 gal) of water. By comparison, the flow totalizer at the receiving Liquid Effluent Retention Facility (LERF) reported 92,617,670 L (24,467,000 gal) for the year. The ETF's treated groundwater data, the record basis for quantities of groundwater treated, and the mass of contaminants removed reported processing 93,764,659 L (24,772,623 gal). The differences in totalizer and flow rate values are attributable mainly to system flow meter variability. There was also some carryover of groundwater pumped in FY02 and processed at the ETF at the beginning of FY03.

Persistent, elevated differences in flow rates (greater than routine differences between the well head flow versus the LERF) are used to determine if the system is leaking (Procedure POP-30-001, *Effluent Treatment Facility Control Room Rounds* [<http://apweb02/wmpdol>]). Most flow rate differences throughout the course of FY04 were less than 1% (under 2 L/min [0.5 gallons per minute {gpm}]). The ETF did not report any pipeline system leaks.

#### B2.0 200-ZP-1 OPERABLE UNIT PUMP-AND-TREAT SYSTEM PERFORMANCE

Figure B-4 presents cumulative volumes in extracted groundwater versus the cumulative mass recovered of carbon tetrachloride.

Table B-5 presents the pumping rates at the extraction wells for the past 8 years, which reveal a general downward trend in the individual wells' overall pumping capacities. In general, the decreasing rates correlate with the wells extracting from a smaller, less productive thickness of aquifer. Table B-6 presents a comparison of treatment volumes and carbon tetrachloride mass

removed through FY04. The last 5 years of extraction system operation are summarized in Table B-7. Tables B-8 through B-10 summarize contaminant concentration changes for carbon tetrachloride, chloroform, and trichloroethene per extraction well for the past 8 years. Table B-11 presents contaminant trends at selected monitoring well trends and shows both FY04 and long-term changes.

### **B3.0 REFERENCES**

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Figure B-1. Cumulative Groundwater Treated Versus Technetium-99 Extracted, 200-UP-1 Operable Unit Pump-and-Treat System, Fiscal Year 2004.

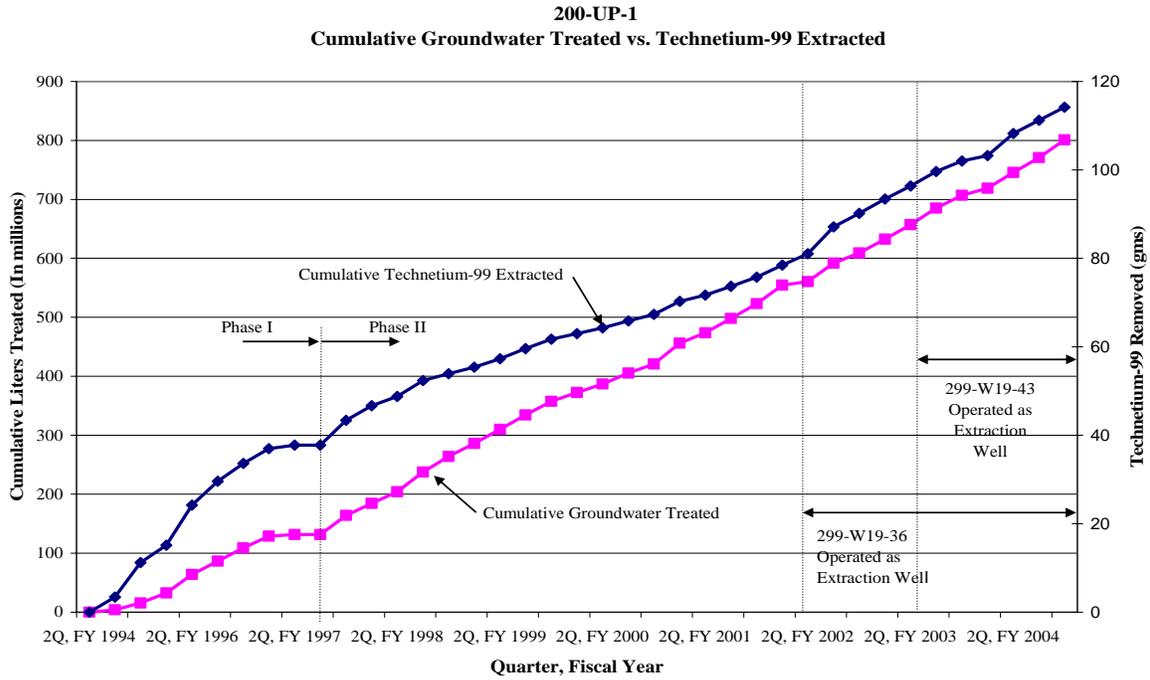


Figure B-2. Cumulative Groundwater Treated Versus Uranium Extracted, 200-UP-1 Operable Unit Pump-and-Treat System, Fiscal Year 2004.

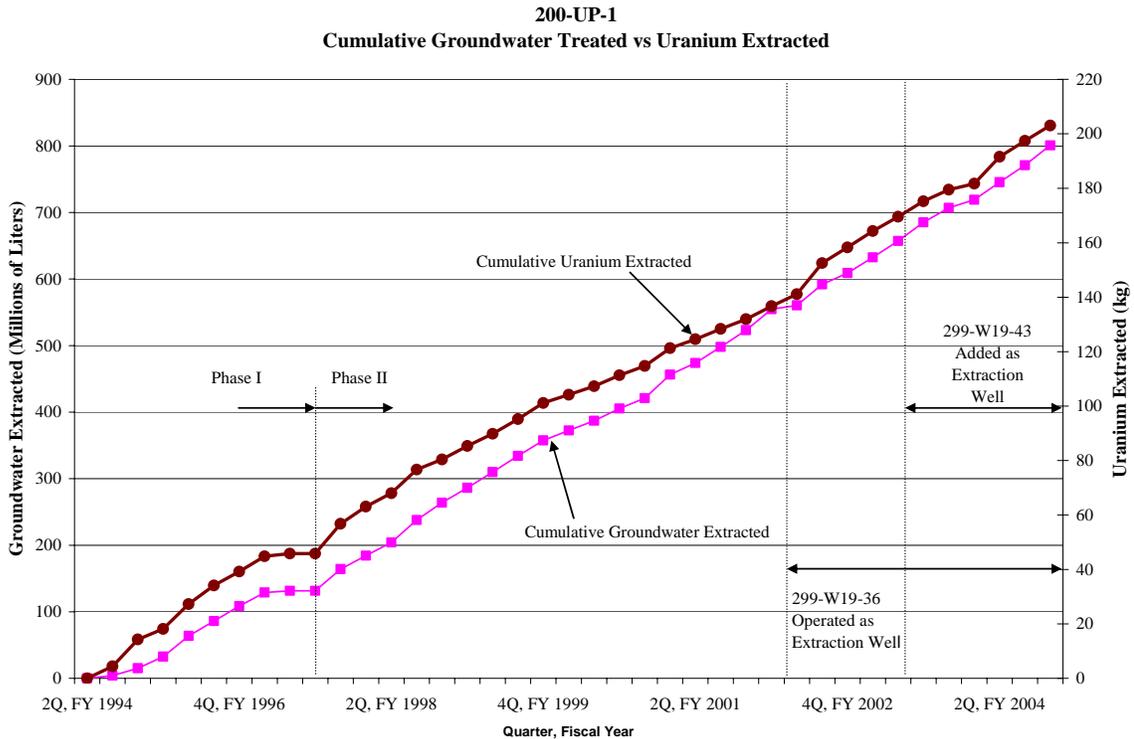


Figure B-3. Cumulative Groundwater Treated Versus Carbon Tetrachloride and Nitrate Extracted, 200-UP-1 Operable Unit Pump-and-Treat System, Fiscal Year 2004.

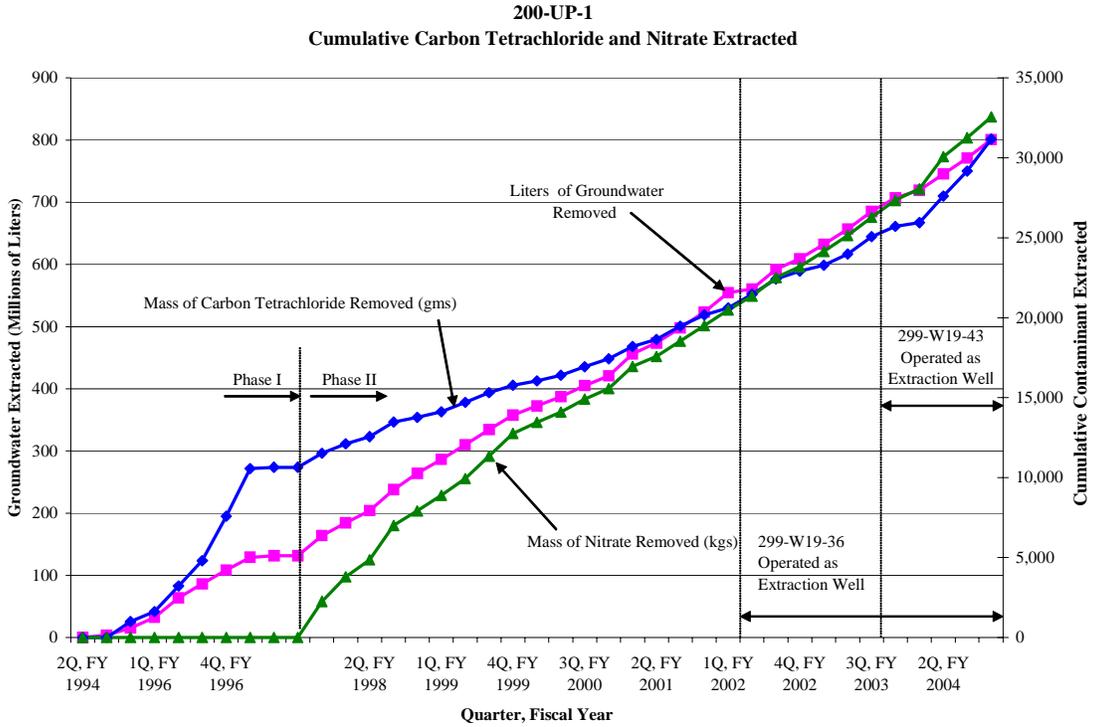


Figure B-4. Cumulative Groundwater Treated Versus Carbon Tetrachloride Extracted, 200-ZP-1 Operable Unit Pump-and-Treat System, Fiscal Year 2004.

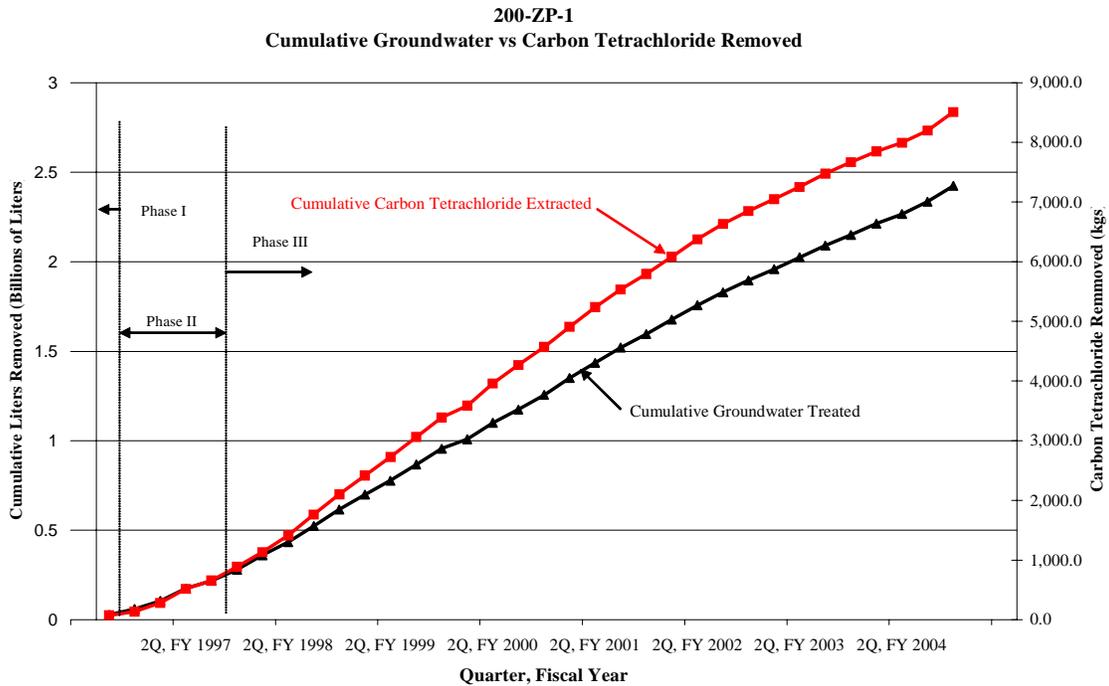


Table B-1. Treatment System Availability of 200-UP-1 Operable Unit  
Pump-and-Treat System, Fiscal Years 2000 to 2004.

<b>Parameter</b>	<b>FY00</b>	<b>FY01</b>	<b>FY02</b>	<b>FY03</b>	<b>FY 04</b>
Total hours in FY	8,784	8,760	8,760	8,760	8784
Scheduled outage hours	1,270 <sup>a</sup>	246	501	231	710.5
Unscheduled outage hours	0	187	446.5	45	0
Total time available (total hours - scheduled outages)	7,527	8,514	8,259	8,529	8073.5
Total time on-line (total hours – [scheduled + unscheduled outages])	7,527	8,327	7,812.5	8,484	8073.5
System on-line availability (total time on-line/total hours)	85.7%	95.1%	89.2%	96.8%	91.9%
Total system availability (total time available/total time on-line)	100%	97.8%	94.6%	99.5%	100%

<sup>a</sup> System shut down for approximately 31 days (December 27, 1999, through January 26, 2000) in anticipation of year 2000 rollover problems and resolution of Federal funding issues.

FY = fiscal year

Table B-2. 200-UP-1 Groundwater Pump-and-Treat Summary of Operations,  
Fiscal Year 1998 to Fiscal Year 2004.

Activity	FY98	FY99	FY00	FY01	FY02	FY03	FY 04
System on-line availability	85.2%	97.5%	85.7%	95.1%	89.2%	96.8%	91.9%
System availability	--	--	100.0%	97.8%	94.3%	99.4%	100%
Annual average pumping rate, L	190	182	180	183	197	178.3	170.9
Average well head technetium-99 concentration, pCi/L	2,050	1,400	1,475	1,395	2,502	1,980	1,433
Average well head uranium concentration, µg/L	265.5	208	214	160	282	200	166
Average well head carbon tetrachloride concentration, µg/L	24	18	25	28	24	27.4	113.1
Average well head nitrate concentration, mg/L	63.4	47.2	44	38	36	44.7	207.6
Total volume treated at ETF, L	100,700,000	93,500,000	63,229,380	102,475,318	85,886,455	98,343,000	93,764,659
Technetium-99 removed, g (Ci)	10.54 (0.18)	7.8 (0.13)	5.6 (0.10)	8.4 (0.14)	14.5 (0.25)	11.8 (0.2)	12.1 (0.21)
Uranium removed, kg	23.6	20.7	13.6	17.1	26.4	21.2	23.5
Carbon tetrachloride removed, kg	2.2	2.0	1.7	2.7	2.7	2.8	5.4
Carbon tetrachloride lost in transit, kg	8.9	9.3	5.7	6.6	7.6	5.8	9.1
Nitrate removed, kg	5,650	4,859	2,807	3,924	3,686	4,158	5,207
Powder waste produced, number of 208-L (55-gal) drums	425	474	313	343	426	461	471
Sludge/other waste produced, number of 208-L (55-gal) drums	353	236	13	44	9	9	9
Contact waste produced, boxed, m <sup>3</sup>	14.5	7.2	10.9	30.6	27.6	18	18.2

ETF = Effluent Treatment Facility  
FY = fiscal year

Table B-3. Quantity of Treated Groundwater and Contaminant Mass Removed Since Initiation of 200-UP-1 Pump-and-Treat Operations.

Reporting Period	Liters Treated	Mass Tc-99 Removed (g)	Mass Total U Removed (g)	Mass Carbon Tet. Removed (g)	Mass Nitrate Removed (kg)
March 1994 to September 1996	108,629,387	33.6	39,232	7,590	NA
FY97	55,382,081	9.8	17,570	3,941	2,260
FY98	100,067,035	10.5	23,630	2,235	5,650
FY99	93,471,260	7.8	20,700	2,002	4,859
FY00	63,229,380	5.6	13,640	1,659	2,807
FY01	102,475,318	8.4	17,128	2,744	3,924
FY02	85,886,455	14.5	26,420	2,747	3,686
FY03	98,343,000	11.8	21,174	2,799	4,158
FY 04	93,764,659	12.1	23,450	5,447	4,207
<b>Totals</b>	<b>801,248,575</b>	<b>114.1</b>	<b>203,034</b>	<b>31,164</b>	<b>32,550</b>

FY = fiscal year

Table B-4. Summary by Fiscal Year and Fiscal Year 2004 Quarters of Technetium-99, Uranium, and Carbon Tetrachloride Concentrations Measured at Active 200-UP-1 Wells. (2 sheets)

Well ID	Well Name	FY99 Avg.	FY00 <sup>a</sup> Avg.	FY01 Avg.	FY02 Avg.	FY03 Avg.	FY04 Concentration	Annual Comparison <sup>b</sup>	1 <sup>st</sup> Qtr. 2004	2 <sup>nd</sup> Qtr. 2004	3 <sup>rd</sup> Qtr. 2004	4 <sup>th</sup> Qtr. 2004	Quarterly Comparison <sup>c</sup>
<b>Technetium-99 (pCi/L)</b>													
A4949	299-W19-20	6,218	7,330	5,320	1,480	838	--	Decreasing	--	--	--	--	
A9517	299-W19-34A	232	179	158	131	NA	130	NA	--	--	--	130	
A9515	299-W19-35	460	515	563	518	795	1,395	Increasing	--	1,460	--	1,330	
A2461	299-W19-36	4,280	19,350 <sup>d</sup>	22,125 <sup>d</sup>	13,015 <sup>d</sup>	4,600	5,087	Decreasing	--	5,910	--	4,140 5,210	
B2465	299-W19-37	2,643	1,068	600	586	622 <sup>e</sup>	402	Stable	--	340	--	464	
B2460	299-W19-39		1,540	1,310	1,216	952	884	Decreasing	--	--	886	880	
B2464	299-W19-40	291	356	324	224	170	234	Decreasing	--	--	--	234	
C3381	299-W19-43	--	--	--	18,575 <sup>d</sup>	10,795 <sup>e</sup>	836	Decreasing	--	22.4 <sup>f</sup>	--	836	
C3598	299-W19-46	--	--	--	--	157 <sup>e</sup>	140	NA	--	143	--	137	
<b>Uranium (µg/L)</b>													
A4949	299-W19-20	2,600 <sup>d</sup>	2,000 <sup>d</sup>	979 <sup>d</sup>	687 <sup>d</sup>	459	--	Decreasing	--	--	--	--	
A9517	299-W19-34A	2.1	2	1	1.2	NA	0.97	Stable	--	--	--	0.97	
A9515	299-W19-35	45	37	41	42	42.7	39.7	Stable	--	37.5	--	42.1	
A2461	299-W19-36	92	160	2,005 <sup>d</sup>	1,724 <sup>d</sup>	453	388	Stable	--	438	--	407, 319	
B2465	299-W19-37	307	195	272	262	266 <sup>e</sup>	205	Decreasing		208	-	201	
B2460	299-W19-39		240	149	137	223	103	Decreasing	--	102	--	103	
B2464	299-W19-40	198	160	159	153	127	93.7	Decreasing	--	--	--	93.7	
C3394	299-W19-43	--	--	--	1,560 <sup>d</sup>	835	259	Decreasing	--	285	--	232	
C3958	299-W19-96	--	--	--	--	142 <sup>e</sup>	151	Stable	--	163	--	139	

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Table B-4. Summary by Fiscal Year and Fiscal Year 2004 Quarters of Technetium-99, Uranium, and Carbon Tetrachloride Concentrations Measured at Active 200-UP-1 Wells. (2 sheets)

Well ID	Well Name	FY99 Avg.	FY00 <sup>a</sup> Avg.	FY01 Avg.	FY02 Avg.	FY03 Avg.	FY04 Concentration	Annual Comparison <sup>b</sup>	1 <sup>st</sup> Qtr. 2004	2 <sup>nd</sup> Qtr. 2004	3 <sup>rd</sup> Qtr. 2004	4 <sup>th</sup> Qtr. 2004	Quarterly Comparison <sup>c</sup>
<i>Carbon Tetrachloride (µg/L)</i>													
A4949	299-W19-20	48	48	47	34	34	--	--	--	--	--	--	
A9517	299-W19-34A	177	185	131	139	NA	125	Stable	--	--	--	125	
A9515	299-W19-35	209	205	127	138	94	84	Stable	--	94	--	74	
A2461	299-W19-36	87	210	293	214	270	463	Increasing	--	490 <sup>g</sup>	--	650, 250	
B2465	299-W19-37	97	98	77	78	73 <sup>e</sup>	140	Increasing	160	--	--	120	
B2460	299-W19-39	150	100	82	91	72	50	Decreasing	--	48	--	52	
B2464	299-W19-40	86	71	46	40	24	12	Decreasing	--	--	--	12	
C3381	299-W19-43	--	--	--	109	80 <sup>e</sup>	114	Increasing	--	190	--	37	
C3958	299-W19-46	--	--	--	--	81 <sup>e</sup>	46	Decreasing		32		59	

<sup>a</sup> Third and fourth quarter data from FY00 were not included because waste control issues precluded sampling of all 200-UP-1 wells.

<sup>b</sup> Percent difference between FY04 and FY03 and is calculated as follows:  $[(FY04 - FY03) / FY03] \times 100$ . Wells are considered stable if there is less than a 20% change in concentration between FY03 and FY04.

<sup>c</sup> Quarterly comparisons are based on a visual inspection of the data.

<sup>d</sup> Concentrations or activities above the remedial action objective of 9,000 pCi/L or the remedial action objective of 480 µg/L for uranium.

<sup>e</sup> Concentration averaged for the year.

<sup>f</sup> Value considered suspect during data review, not considered in calculations.

<sup>g</sup> Value rejected during data review

FY = fiscal year

ID = identification

NA = not applicable

Table B-5. Average Annual Pumping Rates (L/min) at Individual 200-ZP-1 Extraction Wells By Fiscal Year.

Well ID	FY97	FY98	FY99	FY00	FY01	FY02	FY03	FY04
299-W15-33	111	66	64	36	55	42	43	46
299-W15-34	160	101	88	82	93	85	77	85
299-W15-35	303	301	325	245	307	301	282	246
299-W15-32	97	81	67	114	40	34	34	30
299-W15-36	62	112	67	92	131	106	77	79
299-W15-37	62	63	60	56	63	--	--	--
299-W15-45	--	--	--	--	--	--	--	170 <sup>a</sup>
299-W15-47	--	--	--	--	--	--	--	205 <sup>a</sup>
<b>Annual sum</b>	<b>795</b>	<b>724</b>	<b>671</b>	<b>625</b>	<b>689</b>	<b>568</b>	<b>513</b>	<b>484/ 783<sup>b</sup></b>

<sup>a</sup> Estimated extraction values, starting April 26, 2004, and April 28, 2004, respectively. Well 299-W15-45 replaced 299-W15-33, and well 299-W15-47 replaced 299-W15-32.

<sup>b</sup> Average with wells 299-W15-32 and 299-W15-33 included versus wells 299-W15-45 and 299-W15-47.  
FY = fiscal year

Table B-6. Quantity of Treated Groundwater and Contaminant Mass Removed Since Initiation of 200-UP-1 Pump-and-Treat Operations.

Reporting Period	Liters Treated	Mass Carbon Tet. Removed (g)
August 1994 to July 1996	26,676,000	75.9
August to September 1996	33,232,327	61.0
FY97	218,800,017	750.3
FY98	336,162,100	1,212.2
FY99	340,781,036	1,287.3
FY00	300,403,641	1,183.3
FY01	338,846,428	1,226.3
FY02	301,282,482	1,052.7
FY03	253,601,656	819.3
FY04	274,504,266	840.4
<b>Totals</b>	<b>2,420,136,1407</b>	<b>8,508.5</b>

FY = fiscal year

Table B-7. Treatment System Availability of 200-ZP-1 Operable Unit  
Pump-and-Treat System, Fiscal Years 2000 to 2004.

<b>Parameter</b>	<b>FY00</b>	<b>FY01</b>	<b>FY02</b>	<b>FY03</b>	<b>FY04</b>
Total hours in FY	8,784	8,760	8,760	8,760	8,784
Scheduled outage hours	1,218 <sup>a</sup>	76	236	250	21
Unscheduled outage hours	477	176	352.5	168	357.5
Total time available (total hours - scheduled outages)	7,566	8,684	8,524	8,510	8,753
Total time on-line (total hours - [scheduled + unscheduled outages])	7,089	8,508	8,171.5	8,342	8395.5
System on-line availability, % (total time on-line/total hours) x 100	80.7	97.1	93.3	95.2	95.6
Total system availability, % (total time on-line/total time available) x100	93.7	97.8	95.9	98.0	95.9

<sup>a</sup> Includes downtime due to year 2000 rollover (December 6, 1999, through January 3, 2000) and Federal budget resolution.

FY = fiscal year

Table B-8. Average Carbon Tetrachloride Concentration for Each of the Extraction Well and Influent Tank at 200-ZP-1 Operable Unit During Fiscal Years 1997 to 2004.

Well Name <sup>a</sup>	FY04 Min. Value (µg/L)	FY04 Max. Value (µg/L)	Mean Concentration Carbon Tetrachloride (µg/L)								Mean Flow Rate (L/min)	Annual Comparison <sup>b</sup>
			FY97	FY98	FY99	FY00	FY01	FY02	FY03	FY04		
299-W15-33	1,500	3,100	5,058	6,000	6,218	5,956	4,865	4,413	3,308	2,630	46	Decreasing
299-W15-34	2,900	9,700 <sup>c</sup>	2,900	3,770	4,700	5,517	5,355	5,333	5,355	4,922	85	Stable
299-W15-35	1,800	5,100 <sup>c</sup>	3,351	3,660	3,858	3,842	3,413	3,344	3,233	3,045	246	Stable
299-W15-32	1,300	2,500	7,120	6,560	5,023	4,224	3,255	2,778	2,556	2,028	30	Stable
299-W15-36	560	1,800	2,820	2,040	1,697	1,779	1,377	1,195	1,097	965	79	Stable
299-W15-45	1,800	6,200 <sup>c</sup>	--	--	--	--	--	--	--	3,014	170	NA
299-W15-47	1,800	3,900	--	--	--	--	--	--	--	3,102	205	NA
Influent tank (T-01)	2,800	4,300	3,270	3,530	3,788	4,041	3,600	3,356	3,212	3,120	--	Stable

<sup>a</sup> Wells are listed from north to south.

<sup>b</sup> Annual comparison is the percent difference between FY01 and FY00 (or two most recent years) and is calculated by the following equation:  $[(FY04 - FY03) / FY03] \times 100$ . Wells are considered stable if there is less than a 20% change in concentration from FY03 to FY04.

<sup>c</sup> Review qualifier "G." Record was reviewed and determined to be accurate; equipment malfunction suspected.

FY = fiscal year

N/A = not available

Table B-9. Average Chloroform Concentrations for Each of the Extraction Wells and the Influent Tank at 200-ZP-1 Operable Unit During Fiscal Years 1998 to 2004.

Well Name <sup>a</sup>	FY04 Min. Value (µg/L)	FY04 Max. Value (µg/L)	Mean Concentration Chloroform (µg/L)							Annual Comparison <sup>b</sup>
			FY98	FY99	FY00	FY01	FY02	FY03	FY04	
299-W15-33	12	15	26.6	25.7	24.1	25.9	18.2	14.7	13	Stable
299-W15-34	19	46	14.9	18.9	21.7	23.4	23.4	23.8	27	Stable
299-W15-35	14	26	16.7	18.7	18.2	18.6	16.6	17.2	18.8	Stable
299-W15-32	17	27	39.9	32.4	26.7	26.8	20.2	20.3	22.8	Stable
299-W15-36	15	26	24	22.5	21.9	23.9	20.1	20.2	19.3	Stable
299-W15-45 <sup>c</sup>	12	23	--	--	--	--	--	--	15.6	NA
299-W15-47 <sup>c</sup>	18	23	--	--	--	--	--	--	20.0	NA
Influent tank (T-01)	16	24	20.5	20	21.1	18.3	18.6	18.8	18.5	Stable

<sup>a</sup> Wells are listed from north to south.

<sup>b</sup> Annual comparison is the percent difference between FY02 and FY01 (or two most recent years) and is calculated by the following equation:  $[(FY04 - FY03) / FY03] \times 100$ . Wells are considered stable if there is less than a 20% change in concentration from FY03 to FY04.

<sup>c</sup> Wells 299-W15-45 and 299-W15-47 replaced wells 299-W15-33 and 299-W15-32, respectively, on April 26, 2004.

FY = fiscal year

N/A = not available

Table B-10. Average Trichloroethene Concentrations for Each of the Extraction Wells and the Influent Tank at 200-ZP-1 Operable Unit During Fiscal Years 1998 to 2004.

Well Name <sup>a</sup>	FY04 Min. Value (µg/L)	FY04 Max. Value (µg/L)	Mean Concentration Trichloroethene (µg/L)							Annual Comparison <sup>b</sup>
			FY98	FY99	FY00	FY01	FY02	FY03	FY04	
299-W15-33	2	12	9.7	8.1	6.3	4.6	4.1	3.7	2.4	Stable
299-W15-34	2.2	18	11.3	13.5	13.2	11.4	11.2	11.7	10.7	Stable
299-W15-35	8.5	14	5.4	8.3	8.5	9	9.1	10.1	9.7	Stable
299-W15-32	3.2	5.6	5.4	5.8	4.9	4.5	4.2	4.6	5.1	Stable
299-W15-36	2	3.5	9	6.1	5	3.5	2.9	2.6	2.3	Stable
299-W15-45	2.1	12	--	--	--	--	--	--	2.4	NA
299-W15-47	5	12	--	--	--	--	--	--	1.6	NA
Influent tank (T-01)	6.2	16	6.6	7.8	8.5	7.4	7.9	8.7	8.6	Stable

<sup>a</sup> Wells are listed from north to south.

<sup>b</sup> Annual comparison is the percent difference between FY02 and FY01 (or two most recent years) and is calculated by the following equation:  $[(FY04 - FY03) / FY03] \times 100$ . Wells are considered stable if there is less than a 20% change in concentration from FY03 to FY04.

FY = fiscal year

N/A = not available

Table B-11. Summary of Constituent Concentrations Measured at 200-ZP-1 Operable Unit Monitoring Wells. (4 sheets)

Well ID	Well Name	FY99 Avg.	FY00 <sup>a</sup> Avg.	FY01 Avg.	FY02 Avg.	FY03 Avg.	FY04 Concentration	Annual Comparison <sup>b</sup>	1 <sup>st</sup> Qtr. 2004	2 <sup>nd</sup> Qtr. 2004	3 <sup>rd</sup> Qtr. 2004	4 <sup>th</sup> Qtr. 2004	Quarterly Comparison <sup>c</sup>
<i>Carbon Tetrachloride (µg/L)</i>													
C4238	299-W13-1	--	--	--	--	--	1,679	--	1,238	--	1,900	1,900	
A4915	299-W14-9	43	24	38	51	--	--	NA	--	--	--	--	
A7348	299-W15-1	6,100	6,367	5,675	5,800	4,300	2,850	Decreasing	--	2,900	--	2,200	
A5476	299-W15-7	3,900	4,233	3,525	3,138	2,000	2,850	Increasing	3,100	--	--	2,600	
A5474	299-W15-11	2,725	4,400	4,425	3,975	3,100	1,700	Decreasing	--	2,000	--	1,400	
A4919	299-W15-15	364	126	67	37	24.5	26	Stable	--	30	--	21	
A4920	299-W15-16	5,650	4,033	2,875	1,075	2,129	610	Decreasing	--	610	--	--	
A5476	299-W15-17	--	--	--	--	13.5	23	Increasing	--	28	--	17	
A4922	299-W15-18	1,500	825	--	--	--	--	NA	--	--	--	--	
B2410	299-W15-30	--	6,600	4,300	2,700	--	1,450	NA	--	1,600	--	1,300	
B2471	299-W15-31A	6,525	6,933	4,838	5,000	4,237	--	NA	--	140 <sup>d</sup>	--	580 <sup>d</sup>	
B2754	299-W15-38	3,238	3,333	2,675	2,275	2,100	1,500	Decreasing	--	--	--	1,500	
B2477	299-W15-39	1,200	1,577	743	483	650	465	Decreasing	--	460	--	470	
C3803	299-W15-42	--	--	--	1,480	1,367	760	Decreasing	1,000	--	--	520	
C3955	299-W15-43	--	--	--	--	2,075	1,800	Stable	2,200	--	--	1,400	
C3956	299-W15-44	--	--	--	--	2,900	2,300	Decreasing	--	1,600	--	3,000	
C3397	299-W15-765	--	--	--	--	3,100	3,400	Stable	3,400	--	--	--	
A5481	299-W18-1	1,375	923	398	183	110	100	Decreasing	--	140	--	61	
A4933	299-W18-21	185	87	27	16	13.5	9	Decreasing	--	11	--	7	
A4936	299-W18-24	1,250	843	555	32	--	--	NA	--	--	--	--	
A4939	299-W18-27	374	263	104	143	4.6	4.6	Decreasing	--	4.6	--	--	
A4942	299-W18-30	499	317	210	185	120	125	Decreasing	--	120	--	130	

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Table B-11. Summary of Constituent Concentrations Measured at 200-ZP-1 Operable Unit Monitoring Wells. (4 sheets)

Well ID	Well Name	FY99 Avg.	FY00 <sup>a</sup> Avg.	FY01 Avg.	FY02 Avg.	FY03 Avg.	FY04 Concentration	Annual Comparison <sup>b</sup>	1 <sup>st</sup> Qtr. 2004	2 <sup>nd</sup> Qtr. 2004	3 <sup>rd</sup> Qtr. 2004	4 <sup>th</sup> Qtr. 2004	Quarterly Comparison <sup>c</sup>
A7522	299-W18-4	265	113	36	17	--	--	NA	--	--	--	--	
A5151	699-39-79	2(U)	2(U)	--	2(U)	0.15	--	Increasing	--	--	--	--	
A5202	699-47-60	2(U)	2(U)	--	1.4(U)	0.15	--	Increasing	--	--	--	--	
A8868	699-55-60A	--	0.23(U)	--	2(U)	0.15	--	Increasing	--	--	--	--	
<b>Chloroform (µg/L)</b>													
C4238	299-W13-1	--	--	--	--	--	--	--	82.3		15	22	
A4915	299-W14-9	127	110	115	61	NA	--	NA	--	--	--	--	
A7348	299-W15-1	28	32	28	28	22	26	Decreasing	--	29	--	23	
A5476	299-W15-7	32	29	20	22	18	22	Stable	18	--	--	26	
A5474	299-W15-11	18	26	21	19	14.5	25	Decreasing	--	25	--	11(U)	
A4919	299-W15-15	2(U)	1.5	1	0.27	0.22	0.2	Stable	--	0.23	--	0.17	
A4920	299-W15-16	31	23	16	15	10.6	10	Decreasing	--	10	--	--	
A5476	299-W15-17	--	--	--	--	2	2.4	NA	--	2.9	--	1.9	
A4922	299-W15-18	7.3	4	--	--	NA	--	NA	--	--	--	--	
B2410	299-W15-30	--	34	21	13	NA	12	NA	--	12	--	12	
B2471	299-W15-31A	38	37	34	49	24	20	Decreasing	--	24	--	15	
B2754	299-W15-38	26	23	20	19	18	20	Stable	--	--	--	20	
B2477	299-W15-39	15	18	14	14	12	14	Stable	--	14	--	14	
C3803	299-W15-42	--	--	--	28	16	11.3	Decreasing	13	--	--	9.6	
C3955	299-W15-43	--	--	--	--	15	13	NA	9.9	--	--	16	
C3956	299-W15-44	--	--	--	--	17	22	NA	--	21	--	22	
C3397	299-W15-765	--	--	--	--	15	15	Stable	15	--	--	--	
A5481	299-W18-1	11	5	2(U)	1.2	1	0.71	Stable	--	0.74	--	0.68	
A4933	299-W18-21	2(U)	1.1	--	0.22	0.12	--	Increasing	--	0.16(U)	--	0.11(U)	

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Table B-11. Summary of Constituent Concentrations Measured at 200-ZP-1 Operable Unit Monitoring Wells. (4 sheets)

Well ID	Well Name	FY99 Avg.	FY00 <sup>a</sup> Avg.	FY01 Avg.	FY02 Avg.	FY03 Avg.	FY04 Concentration	Annual Comparison <sup>b</sup>	1 <sup>st</sup> Qtr. 2004	2 <sup>nd</sup> Qtr. 2004	3 <sup>rd</sup> Qtr. 2004	4 <sup>th</sup> Qtr. 2004	Quarterly Comparison <sup>c</sup>
A4936	299-W18-24	11	8	3	2(U)	NA	--	NA	--	--	--	--	
A4939	299-W18-27	--	--	2(U)	1.2	0.8	--	Decreasing	--	--	--	--	
A4942	299-W18-30	13	11	10	12	11	11	Stable	--	--	--	11	
A7522	299-W18-4	93	17	18	12	NA	--	NA	--	--	--	--	
A5151	699-39-79	2(U)	2(U)	--	2(U)	0.07(U)	--	Stable	--	--	--	--	
A5202	699-47-60	2(U)	2(U)	--	2(U)	0.07(U)	--	Stable	--	--	--	--	
A8868	699-55-60A	--	0.23(U)	--	2(U)	0.07(U)	--	Stable	--	--	--	--	
<b>Trichloroethene (µg/L)</b>													
C4238	299-W13-1	--	--	--	--	--	9.1	NA	10.2	--	9.6	7.6	
A4915	299-W14-9	5.4	4	4	4.3	NA	--	NA	--	--	--	--	
A7348	299-W15-1	16	14	10	2.8	5.5	--	Increasing	--	4.9	--	4.6	
A5476	299-W15-7	29	28	16	12.3	8	--	Decreasing	--	8.4	--	4.8	
A5474	299-W15-11	4	5	5	4	3.2	--	Stable	--	3	--	2.7	
A4919	299-W15-15	2(U)	3	2(U)	1.7(U)	0.16(U)	--	Stable	--	0.16(U)	--	0.09(U)	
A4920	299-W15-16	6	3	3	2.2	1.8	--	Stable	--	0.83	--	--	
A5476	299-W15-17	--	--	--	--	1.1	--	NA	--	0.99	--	0.98	
A4922	299-W15-18	2(U)	3	--	--	NA	--	NA	--	--	--	--	
B2410	299-W15-30	--	5	3	2(U)	NA	--	NA	--	1.1	--	0.94	
B2471	299-W15-31A	7	6	5	4.6	3.3	--	Decreasing	--	2	--	1.9	
B2754	299-W15-38	4	5	5	4.6	4.2	--	Stable	--	--	--	3.4	
B2477	299-W15-39	2.1	3	2(U)	2(U)	2	--	Increasing	--	1.3	--	1.5	
C3803	299-W15-42	--	--	--	2.4	2.5	--	Stable	2.4	--	--	1.7	
C3955	299-W15-43	--	--	--	--	3.8	--	NA	5.4	--	--	3.5	
C3956	299-W15-44	--	--	--	--	15	--	NA	--	15	--	15	

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Table B-11. Summary of Constituent Concentrations Measured at 200-ZP-1 Operable Unit Monitoring Wells. (4 sheets)

Well ID	Well Name	FY99 Avg.	FY00 <sup>a</sup> Avg.	FY01 Avg.	FY02 Avg.	FY03 Avg.	FY04 Concentration	Annual Comparison <sup>b</sup>	1 <sup>st</sup> Qtr. 2004	2 <sup>nd</sup> Qtr. 2004	3 <sup>rd</sup> Qtr. 2004	4 <sup>th</sup> Qtr. 2004	Quarterly Comparison <sup>c</sup>
C3397	299-W15-765	--	--	--	--	14	--		14	--	--	--	
A5481	299-W18-1	2(U)	1.5	2(U)	2(U)	0.16(U)	--	Stable	--	0.16(U)	--	0.09(U)	
A4933	299-W18-21	2(U)	0.8	1.1(U)	1.2(U)	0.16(U)	--	Stable	--	0.16(U)	--	0.09(U)	
A4936	299-W18-24	2(U)	4	1	1.2(U)	NA	--	NA	--	--	--	--	
A4939	299-W18-27	2(U)	2(U)	2(U)	1.1(U)	0.16(U)	--	Stable	--	--	--	--	
A4942	299-W18-30	2(U)	1.7	1	2(U)	0.7	--	Increasing	--	--	--	0.57	
A7522	299-W18-4	2(U)	2(U)	2(U)	2(U)	NA	--	NA	--	--	--	--	
A5151	699-39-79	2(U)	2(U)	--	2(U)	0.16(U)	--	Stable	--	--	--	--	
A5202	699-47-60	2(U)	2(U)	--	--	0.16(U)	--	Stable	--	--	--	--	
A8868	699-55-60A	--	0.23(U)	--	--	0.16(U)	--	Stable	--	--	--	--	

<sup>a</sup> Annual comparison is the percent difference between FY02 and FY01 (or two most recent years) and is calculated by the following equation:  $[(FY04 - FY03) / FY03] \times 100$ .

Wells are considered stable if there is less than a 20% change in concentration from FY03 to FY04.

<sup>b</sup> Quarterly comparisons are based on a visual inspection of the data.

<sup>c</sup> No comparison possible.

<sup>d</sup> Data review did not validate laboratory results; deleted from calculations.

-- = Data not available.

FY = fiscal year

ID = identification

NA = not available

**APPENDIX C**  
**HYDROGRAPHS AND AQUIFER RESPONSE**

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## APPENDIX C

### HYDROGRAPHS AND AQUIFER RESPONSE

The hydraulic responses of the aquifer at both 200-UP-1 and 200-ZP-1 Operable Units (OUs) are measured through the use of water-level data, which are collected by both direct tape measurement and automated data logger recording of in-well pressure transducers. The water-level data are used to assess the effects of the extraction wells on the aquifer through the following methods:

- Generation of water table maps to compare changes in the water table surface over time
- Calculation of drawdown at monitoring wells, which establishes the radius of influence and zone of capture of contaminants
- Numerical modeling, which when combined with contaminant data yields contaminant movement and behavior data.

Changes in groundwater levels result from the cessation of discharges to waste sites at the 200 West Area and a slow return to pre-Hanford Operations conditions. The 216-U-10 Pond and its contributing ditches received an estimated 165 billion L (43.6 billion gal) of wastewater between 1944 and 1965. Beginning in 1984 with the shutdown of the 216-U-10 Pond and continuing through activation of the Treated Effluent Disposal Facility in 1995, other waste streams ceased discharging to the soil column. Past that date, one sanitary tile field remained active near each pump-and-treat site. The 2607-Z tile field received an estimated 23,000 L/day (6,000 gal/day) (according to the Waste Information Data System database) and was shut down in 1999. The 2607-W-5 tile field remains active to the present. The waste site receives minor amounts of wastewater from the 271-U Building, and this source is scheduled to be terminated by March 2005.

Drawdown data are presented here but are used primarily with numerical modeling, as discussed in Appendix E. The data are gathered when extraction well pumps are shut down or restarted. The water-level changes from the rebound after shutdown or declines at restart of the pump are captured at both extraction and nearby monitoring wells.

#### **C1.0 200-UP-1 OPERABLE UNIT AQUIFER RESPONSE**

The following subsections discuss the response of the aquifer to the operation of the 200-UP-1 OU pump-and-treat activity during fiscal year 2004 (FY04) with data gathered from the existing well network. This response is discussed in terms of the hydraulic and contaminant changes observed during FY04. The hydraulic monitoring data are used with groundwater modeling, which is reported in Appendix E.

#### **C1.1 HYDRAULIC MONITORING**

The water-level monitoring network, first installed in August 1995 at the 200-UP-1 OU, has undergone several revisions. The elevation and contours of the groundwater table across the 200-UP-1 OU are presented in Figure C-1. The continued decline in the regional water table has

resulted in certain monitoring wells becoming unserviceable (denoted by an “X” in Figure 2-8 [see the main text of this annual report]). During FY04, the pump-and-treat configuration continued to undergo changes. Well 299-W19-20 became unusable for monitoring purposes on December 10, 2003. As monitoring well 299-W19-20 was going dry, new monitoring well 299-W19-46 was brought on-line in the automated water-level network (AWLN) on December 16, 2003. By the end of FY04, the AWLN consisted of three extraction wells (299-W19-39, 299-W19-36, and 299-W19-43) and five monitoring wells (299-W19-34A, 299-W19-35, 299-W19-37, 299-W19-40, and 299-W19-46) that recorded water levels on an hourly basis. As FY05 began, an expansion of the monitoring well network was in progress, with the planned addition of four wells in the 200-UP-1 OU. One of these new wells is within the baseline 200-UP-1 plume boundaries and is scheduled to go on-line in the AWLN during January 2005. The hydrographs of the three extraction wells and several monitoring wells are presented in Figure C-2. The hydrograph for well 299-W19-39 suggests a continued malfunction of the transducer, which was not changed out due to the interference with operations.

Based on the water-level data collected during FY04, it appears that the unconfined aquifer underlying the 200-UP-1 OU declined at a rate of 0.36 m/year (1.18 ft/year) (Figure C-3). This is essentially the same rate of decline as noted in FY03 and FY02 (0.38 and 0.36 m/year, respectively) but is significantly less than 0.66 m/year (2.16 ft/year) reported for FY98. The rate of decline is based on data from wells 299-W19-35 and 299-W19-37, which are least affected by the extraction well activities (though well 299-W19-35 appears to be showing greater impact from extraction than 299-W19-37).

The decline in the water table continues to affect the 200-UP-1 OU monitoring well network through the loss of water-level monitoring wells. During the last 3 years, wells 299-W19-20, 299-W19-38, and 299-W19-40 were lost for water-level monitoring because the water levels in these wells dropped below levels that would allow transducer usage. Well 299-W19-20 is impacted by pumping at extraction well 299-W19-39 and might otherwise intersect the water table. Well 299-W19-40 is no longer sampled by dedicated sampling pump and the pump has been removed, which has allowed the well to be brought back into the AWLN. It should be noted that at the present rate of decline, well 299-W19-40 will become completely unusable by the end of FY05/beginning of FY06.

Figure 2-8 in the main text of this annual report shows the change in the water table from 1995 to 2004. The direction of the regional groundwater flow has changed at 200-UP-1 from west/northwest to east/southeast in FY95, to nearly west to east in FY03, and has continued in that direction for FY04. Water levels have declined 4 m (13.1 ft) or more at most points in the baseline plume.

## **C1.2 DRAWDOWN**

As explained above, three different wells were employed to extract groundwater for treatment during FY04. Drawdown at each well was calculated from water-level recovery data collected after shutdown or restart of the extraction well pump. A separate period was selected for each well in which the other two wells were either not pumping or were in a stable pumping state. Drawdown for well 299-W19-39 was calculated from May 23 through 24, 2004; for well 299-W19-36, drawdown was calculated from the initial restart on November 13, 2003; and for well 299-W19-43, drawdown was calculated from October 21 through November 13, 2003.

To calculate the drawdown caused by an extraction well, water-level data were adjusted to account for barometric effects and the regional water-level decline. The technique used to account for the barometric effects and water-level decline is described in *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 1999).

Extraction well 299-W19-39 pumped at 36.8 gallons per minute (gpm) (37 gpm FY03), with a drawdown of 7.8 m (7.2 m FY03). Well 299-W19-36 pumped at 9.9 gpm (8.2 gpm FY03), with a drawdown of 5.66 m (4.76 m FY03). Well 299-W19-43 pumped at 12.2 gpm (13.5 gpm FY03), with a drawdown of 6.4 m (1.78 m FY03).

The maximum observed drawdown at adjacent monitoring wells was 0.26 m (0.85 ft) at well 299-W19-20, which is the closest well to 299-W19-39. This is a decrease in the drawdown calculated in both FY03 (0.32 m [1 ft]) and FY02 (0.42 m [1.39 ft]). The decrease can be partially contributed to the lack of available water in the well. Well 299-W19-20 went dry in early December 2003, shortly after the period used to calculate drawdown. Drawdown for well 299-W19-35 appeared to be only affected by extraction well 299-W19-39 and was calculated to 0.024 m. Drawdown of about 0.05 m was detected at well 299-W19-35, which was equal to that of FY03 but was a significant decrease from FY02 (0.18 m). Drawdown of 0.08 m was detected at well 299-W19-37, which was a significant increase from FY03 (0.01 m) but similar to FY02 (0.09 m).

When well 299-W19-43 was pumping water, drawdown at monitoring well 299-W19-36 during the June shutdown and restart of well 299-W19-43 was 0.02 m (0.787 in.). At well 299-W19-37, drawdown was 0.05 m (1.96 in.) and was negligible at well 299-W19-35, with respect to the drawdown caused by the pumping of well 299-W19-39. Given the differences in pumping rates, the results indicating the effects of well 299-W19-39 being more widely evident well than either 299-W19-36 or 299-W19-43 are not surprising. Furthermore, well 299-W19-43 has a greater impact than well 299-W19-36.

The drawdown also determines the radius of influence of the pumping well. The radius of influence represents the farthest extent that drawdown may be observed with steady-state pumping at an extraction well. The radius of influence can be used as a check on the modeled plume capture area. It should be noted that the radius of influence is about twice that of the capture zone. The drawdown observed laterally and downgradient from the extraction well may not be great enough to overcome the prevailing gradient in the aquifer. The radius of influence of the extraction wells was not calculated due to lack of well coverage.

Some additions to the water-level monitoring network are necessary to continue monitoring the effectiveness of the pump-and-treat operation. As previously mentioned, the declining water table has eliminated many wells from the current monitoring network (see Table C-1). As noted earlier, water-level declines at well 299-W19-20 have rendered the well non-operational, and it will be replaced with new well 299-W19-48 early in calendar year 2005. Although well 299-W19-40 was brought back on-line after the sampling pump was removed from the well, it will no longer function as a water-level monitoring well starting sometime in late FY05 or early FY06. Well 299-W19-46 added monitoring coverage to the south in FY04, but there will be limited hydraulic data coverage downgradient and to the southeast of the plume until an additional well is installed near 299-W19-40. With the reconfiguration of the extraction system

and the conversion of well 299-W19-43 to an extraction well, there is no longer hydraulic coverage upgradient in the northwest portion of the plume.

## **C2.0 200-ZP-1 OPERABLE UNIT AQUIFER RESPONSE**

The following subsections discuss the response of the aquifer to the operation of 200-ZP-1 OU pump-and-treat operations during FY04. This response is discussed in terms of the hydraulic and contaminant changes observed and the numerical modeling results from data collected during FY04. These observations and analyses are based on data gathered from the existing network of wells in the 200-ZP-1 OU.

### **C2.1 HYDRAULIC MONITORING**

The AWLN, installed in June 1996, measured groundwater elevation data from as many as 18 wells on an hourly basis during FY04. Water levels in the five extraction wells and five injection wells (Figures C-4 and C-5, respectively) are monitored and recorded by the 200-ZP-1 treatment system's operator interface computer. Figures C-6 through C-10 provide hydrographs of representative monitoring wells. Depth-to-water tape measurements provide references for determining water-level elevation. The elevation and contours of the groundwater table across the 200-ZP-1 OU are presented in Figure C-11. The water level across the baseline plume area has declined by 4.75 m (15.6 ft) since June 1996.

The unconfined aquifer at the 200-ZP-1 OU continues to decline. The decline rate is calculated based on the data from wells 299-W18-1 and 299-W18-30, which are both assumed to be located outside the area of influence of the extraction and injection wells. Based on data collected from this well (Figure C-10), the water-level rate of decline has increased to 0.37 m/year (1 ft/year) versus 0.32 m/year in FY03, but decreased versus 0.40 m/year in FY01, and is very similar to the 0.36 m/year rate in FY02. This rate of decline is very similar to that calculated for FY04 at the 200-UP-1 OU (0.36 m/year).

The overall water table decline is impacting the pump-and-treat operations through the loss of available head in the extraction wells. At least one well (299-W15-16) went dry in FY04. Well 299-W15-30, located 15 m (49.2 ft) north of well 299-W15-16, is screened at similar elevations of the groundwater and will provide a suitable alternate for both water quality and water-level measurements. Well 299-W15-30 has been equipped with an automatic water-level recording system since July 1996. Regular sampling and analysis of groundwater was restarted at well 299-W15-30 in FY04. Wells 299-W15-10 and 299-W15-25 were decommissioned during FY04. Well 299-W15-33, which was pulled from service as an extraction well (replaced by 299-W15-45), is scheduled to be added to the AWLN in early FY05 and should fill in the gap created by the loss of wells 299-W15-10 and 299-W15-25. Well 299-W15-32 was replaced as an extraction well by 299-W15-47. Well 299-W15-32 is also scheduled to be added to the AWLN in early FY05.

### **C2.2 DRAWDOWN**

Drawdown analyses are performed to evaluate the extent of the impact of the pump-and-treat system and to determine whether the aquifer response to the pump-and-treat system has remained consistent or has changed during the year. This evaluation has been performed and reported in previous annual reports (DOE-RL 1998, 1999, 2000, 2001, 2002, 2003, and 2004).

The drawdown and buildup calculations for this report were performed using the same methodology described in these previous annual reports, using the data collected during FY04. Table C-2 summarizes available data regarding drawdown and buildup in the extraction, injection, and monitoring wells for FY04 and compares it to FY03 and FY02 data.

### **C2.2.1 Extraction and Injection Well Hydraulic Responses**

In general, drawdown and specific capacity calculated in the extraction wells has remained relatively consistent, except when changes in pumping rates resulted in changes in the drawdown. The exceptions to this were wells 299-W15-32 and 299-W15-33, which were showing a declining trend to the point of needing replacement. These two wells were replaced during FY04 by wells 299-W15-47 and 299-W15-45, respectively. Overall, the pumping rates have been declining from FY98 through FY02 and seem to be leveling off for the last 3 years (FY02 through FY04). This decline in pumping rates can be attributed to the combination of the declining water table, which causes loss of available head in the extraction wells and the loss of well efficiency that can be expected in a constantly pumped well. An additional cause, and one that was a likely factor with well 299-W15-32, is the loss of aquifer in the more productive formation. This loss of the upper water table effects wells differently depending on the lithology in the immediate area of the well.

During FY04, drawdown ranged from 1.2 m to 10.1 m. For the most part, drawdowns were consistent with the FY03 data, except where there was a change in the pumping scheme. Using drawdown and pumping information, the specific capacities were calculated for the extraction wells. The FY04, FY03, and FY02 specific capacities are listed for comparison in Table C-2.

During FY04, buildup (or mounding) at the injection wells ranged from 13.3 to 25.9 m. Overall, this is a slight decrease compared to FY03. All injection wells were used during FY04, but the northern three (299-W15-29, 299-W18-36, and 299-W18-37) were routinely used, and the southern two were used very sparingly. Using injecting rates and buildup information, the specific capacities have been calculated for the injection wells. The FY04, FY03, and FY02 specific capacities are listed for comparison in Table C-2.

### **C2.2.2 Monitoring Well Hydraulic Responses**

Drawdown and buildup at the observation wells are used to evaluate the effectiveness of pumping and injecting in the aquifer, away from the extraction and injection wells. Table C-2 summarizes the results of FY04 analysis and compares these results to drawdown and buildup measured in FY03 and FY02.

The drawdown and buildup at all of the monitoring wells has increased compared to FY03. The drawdown and buildup results can be jointly attributed to the declining water table and change in pumping schemes. The hydraulic flow field is still being modified in the area of the pump-and-treat system by the local and regional declines in the water table. The uniform increase in drawdown at the monitoring wells indicates that the radius of influence, in general, is also increasing. The hydraulic gradient and groundwater flow continue to move from the injection well field, toward the extraction wells, and the extraction well network continues to contain the high-concentration area of the plume, all of which continues to support remedial action objective performance criteria. The complete extent of the radius of influence of the extraction wells projects beyond the current monitoring well network cannot accurately be determined to the

north or east of the pump-and-treat area. The overall impact to the aquifer downgradient of the extraction wells, particularly around the TX and U Tank Farms, and to the east of the pump-and-treat system is unclear, and additional boreholes are needed to determine the impact.

### **C3.0 REFERENCES**

DOE-RL, 1998, *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-98-38, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1999, *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-99-02, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 2000, *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-99-79, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 2001, *Fiscal Year 2000 Annual Summary Report for the 200-UP-1 and 200-ZP-1 Pump-and-Treat Operations*, DOE/RL-2000-71, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 2002, *Fiscal Year 2001 Annual Summary Report for the 200-UP-1 and 200-ZP-1 Groundwater Operable Units Pump-and-Treat Operations*, DOE/RL-2001-53, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 2003, *Fiscal Year 2002 Annual Summary Report for the 200-UP-1 and 200-ZP-1 Groundwater Pump-and-Treat Operations*, DOE/RL-2002-67, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 2004, *Fiscal Year 2003 Annual Summary Report for the 200-UP-1 and 200-ZP-1 Groundwater Pump-and-Treat Operations*, DOE/RL-2003-58, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

Figure C-1. 200-UP-1 Water Table Map: Baseline Water Table, June 1995 Versus September 2003 Water Table.

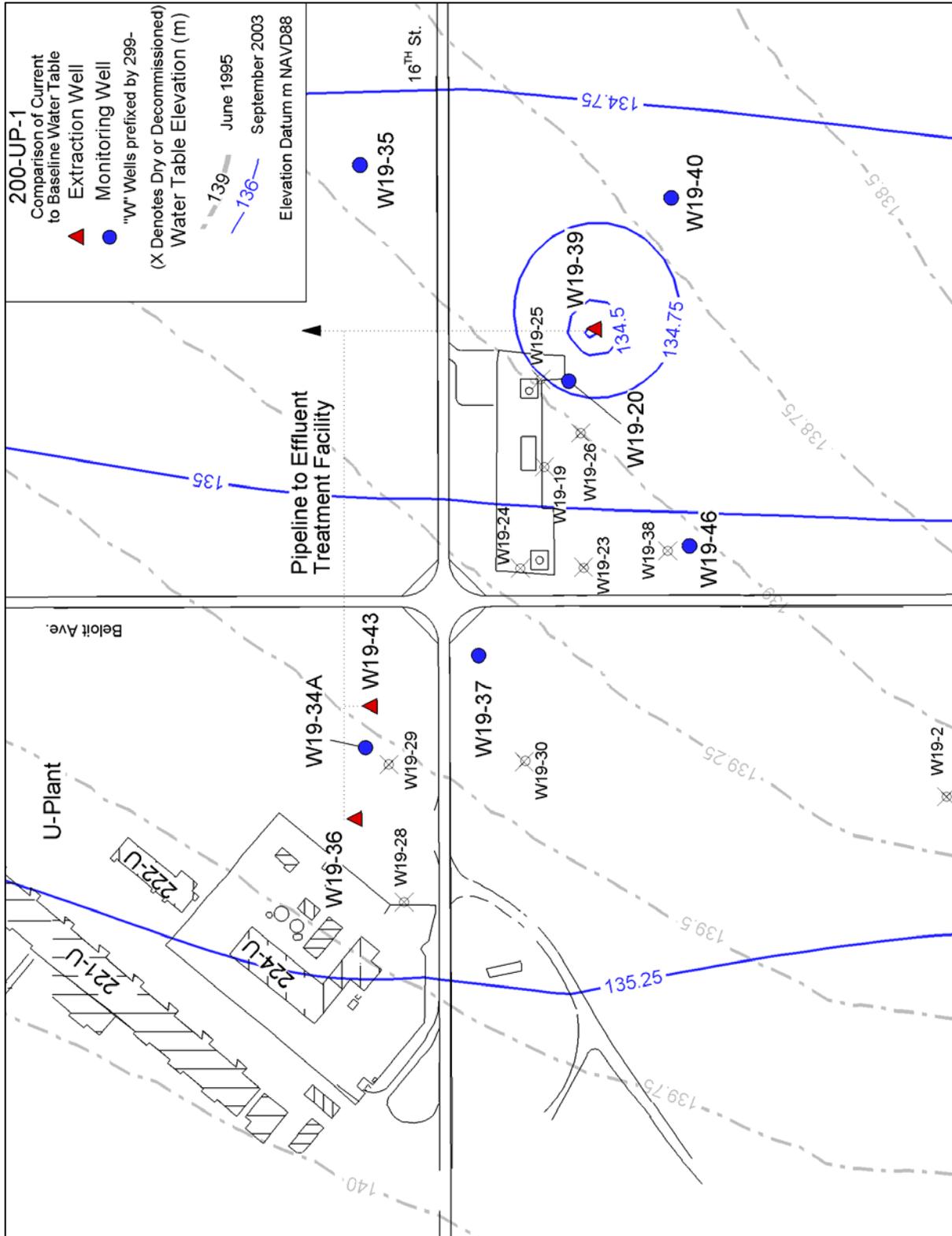


Figure C-2. Hydrographs of Extraction Wells 299-W19-39, 299-W19-36, and 299-W19-43, Plus Monitoring Wells 299- W19-20 and 299-W19-34A.

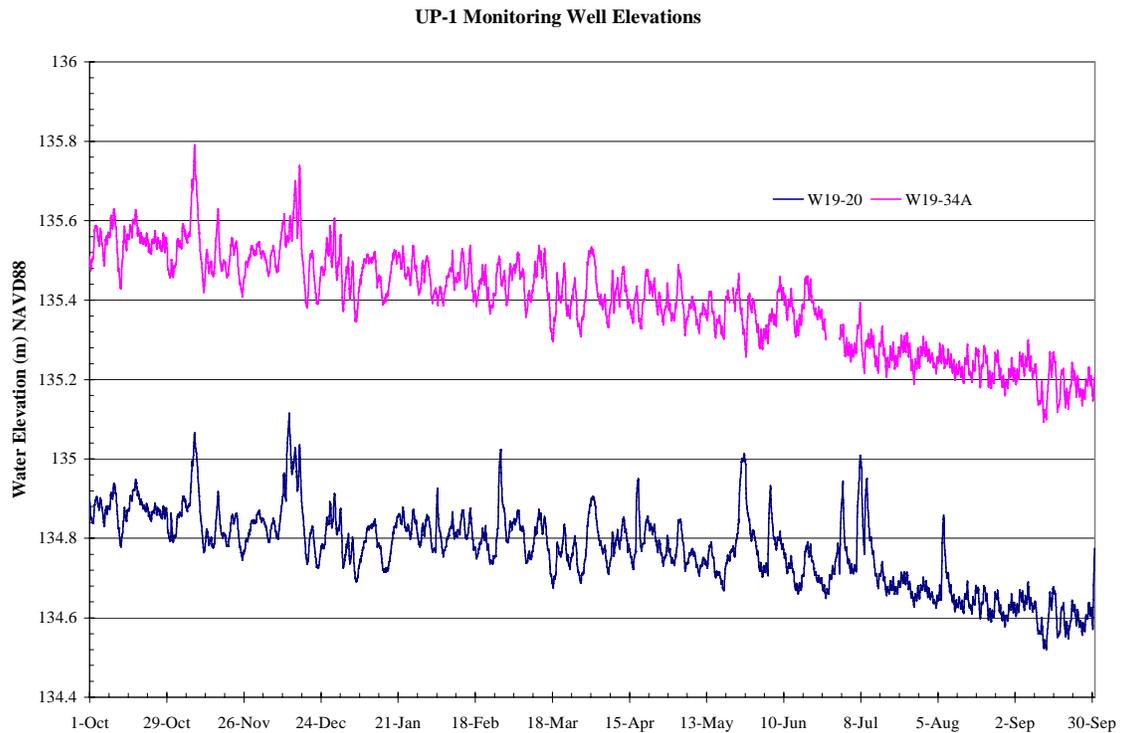
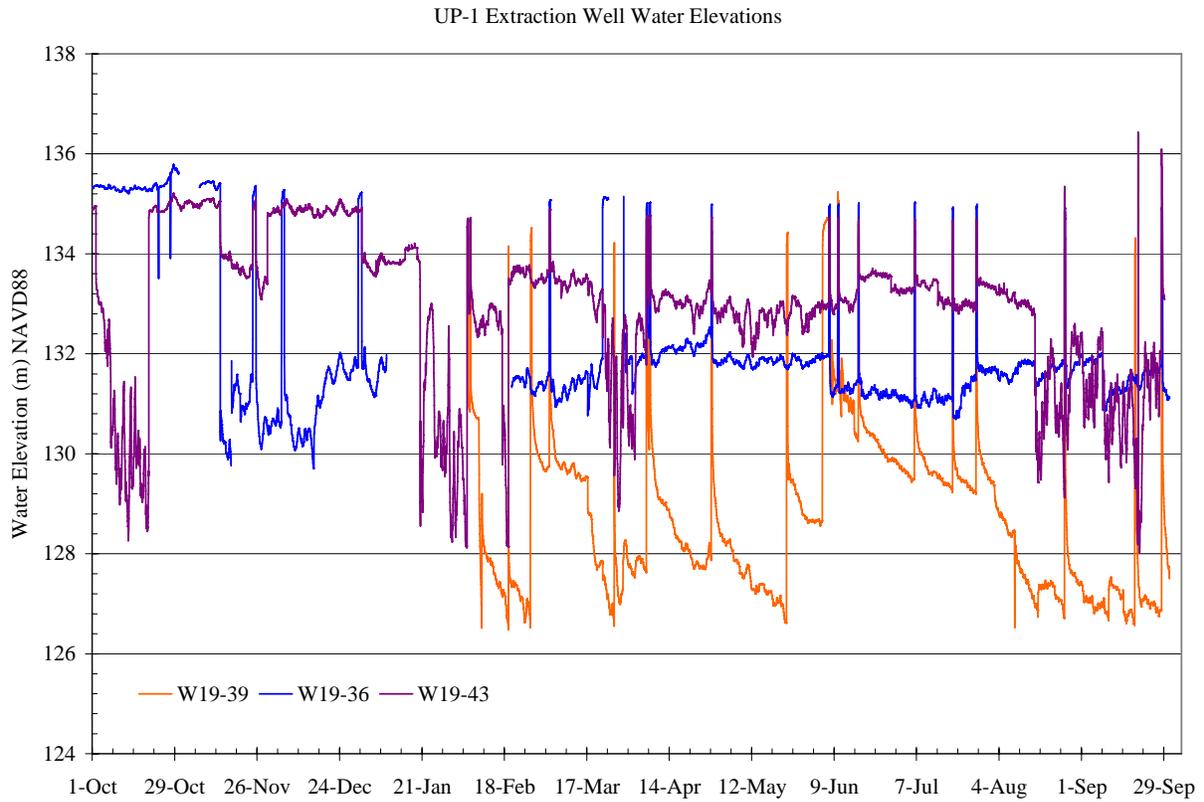


Figure C-3. Hydrographs of Monitoring Wells 299-W19-35 and 299-W19-37, Plus Calculation of Groundwater Level Decline Rate.

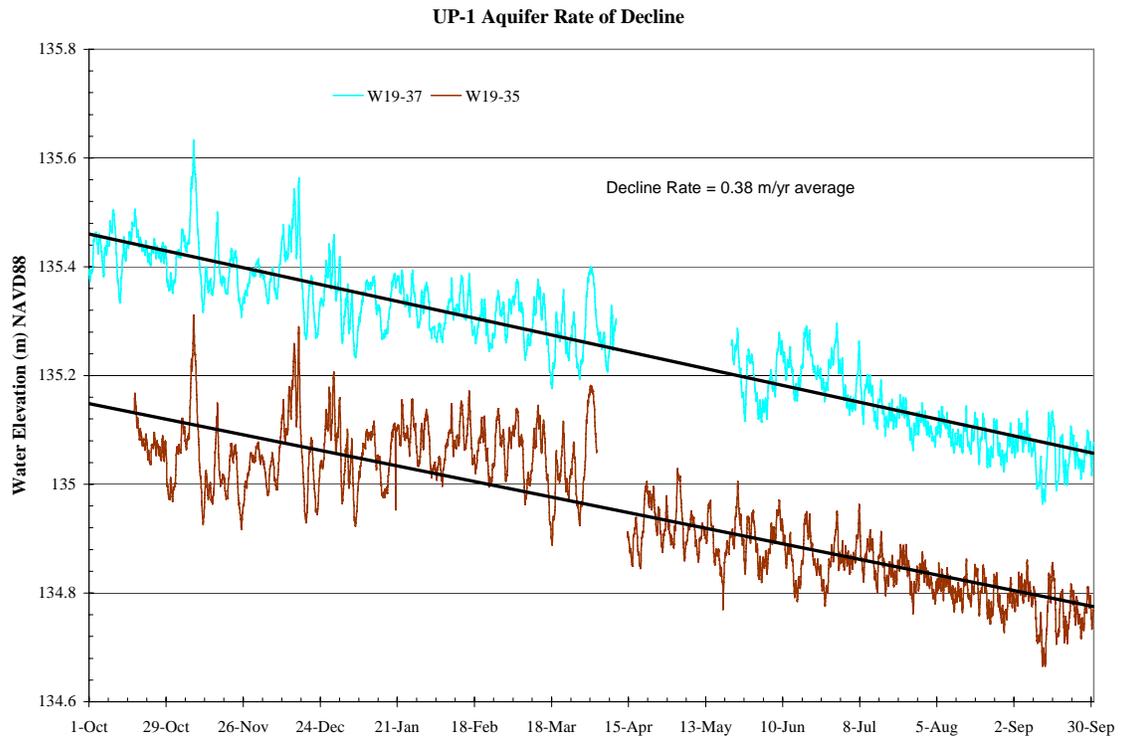
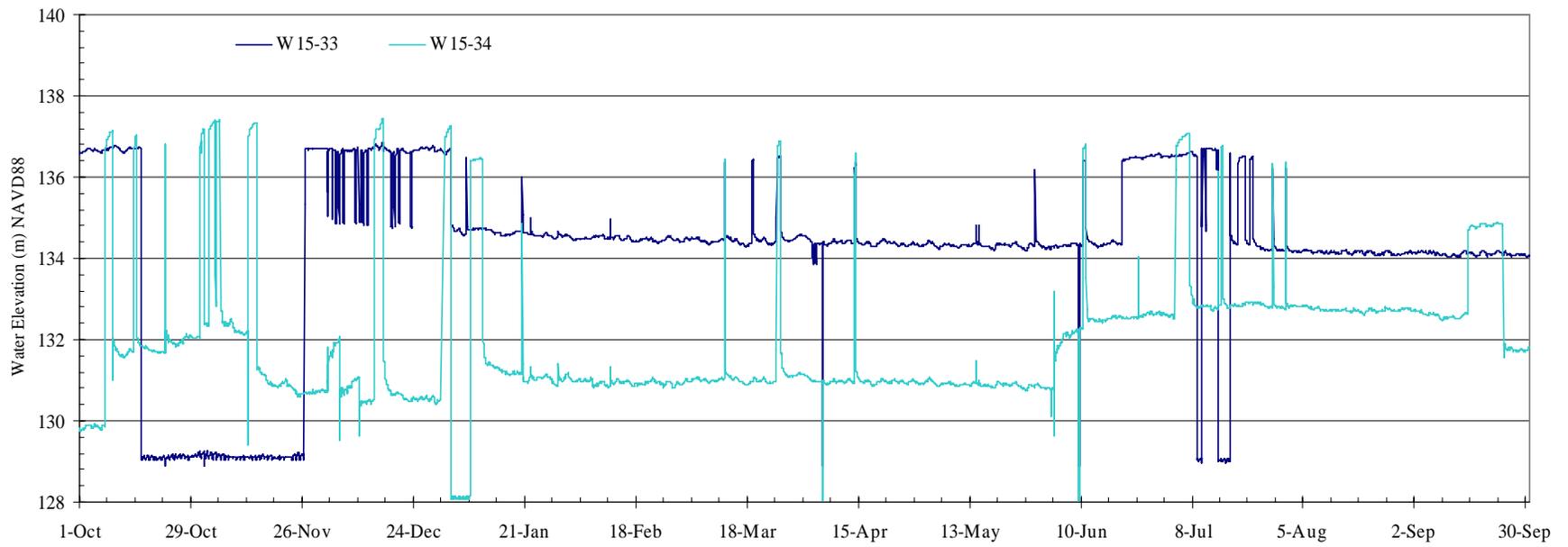


Figure C-4. Hydrographs of Extraction Wells 299-W15-33 and 299-W15-34, 299-W15-35 and 299-W15-32, and 299-W15-36. (3 sheets)



C-10

Figure C-4. Hydrographs of Extraction Wells 299-W15-33 and 299-W15-34, 299-W15-35 and 299-W15-32, and 299-W15-36. (3 sheets)

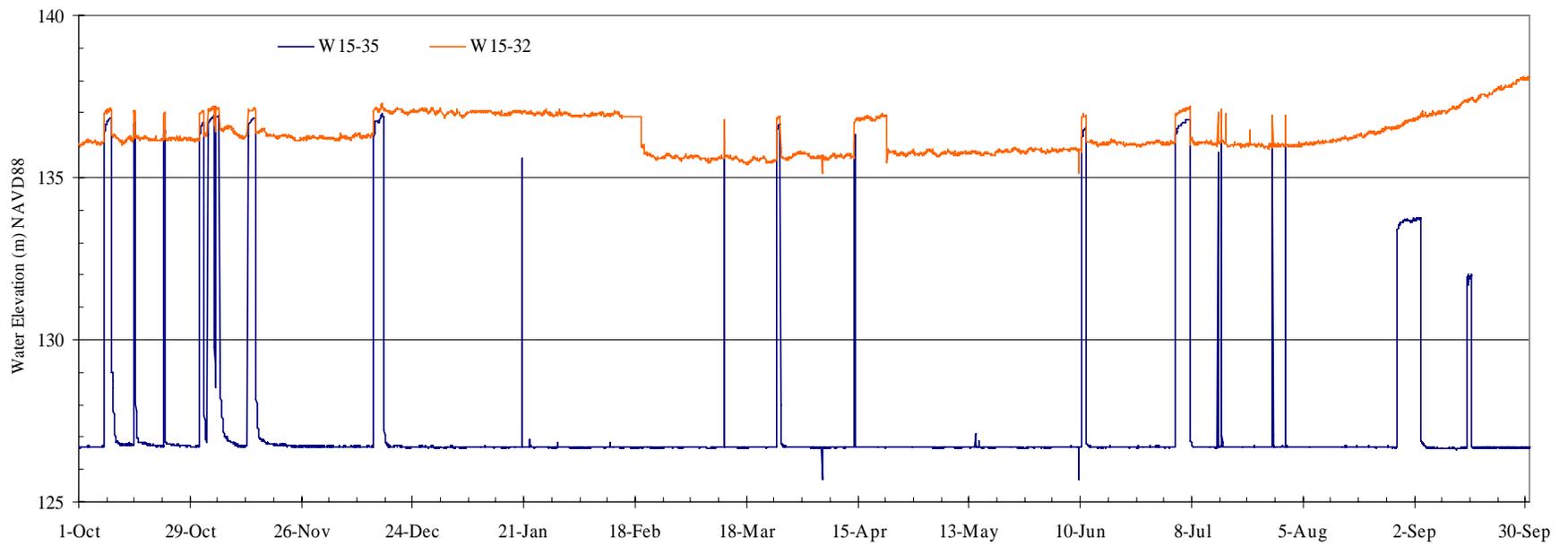


Figure C-4. Hydrographs of Extraction Wells 299-W15-33 and 299-W15-34, 299-W15-35 and 299-W15-32, and 299-W15-36. (3 sheets)

C-12

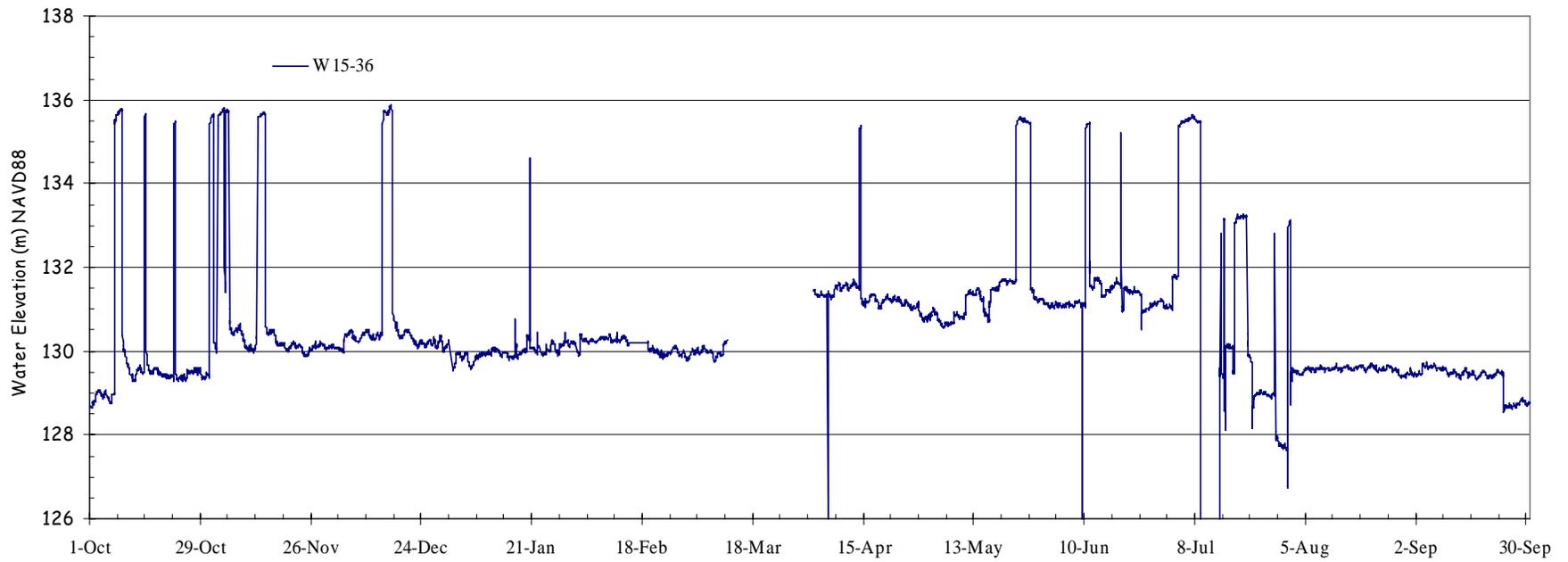


Figure C-5. Hydrographs of Injection Wells 299-W15-29 and 299-W18-36, 299-W18-37 and 299-W18-38, and 299-W18-38 and 299-W18-39. (3 sheets)

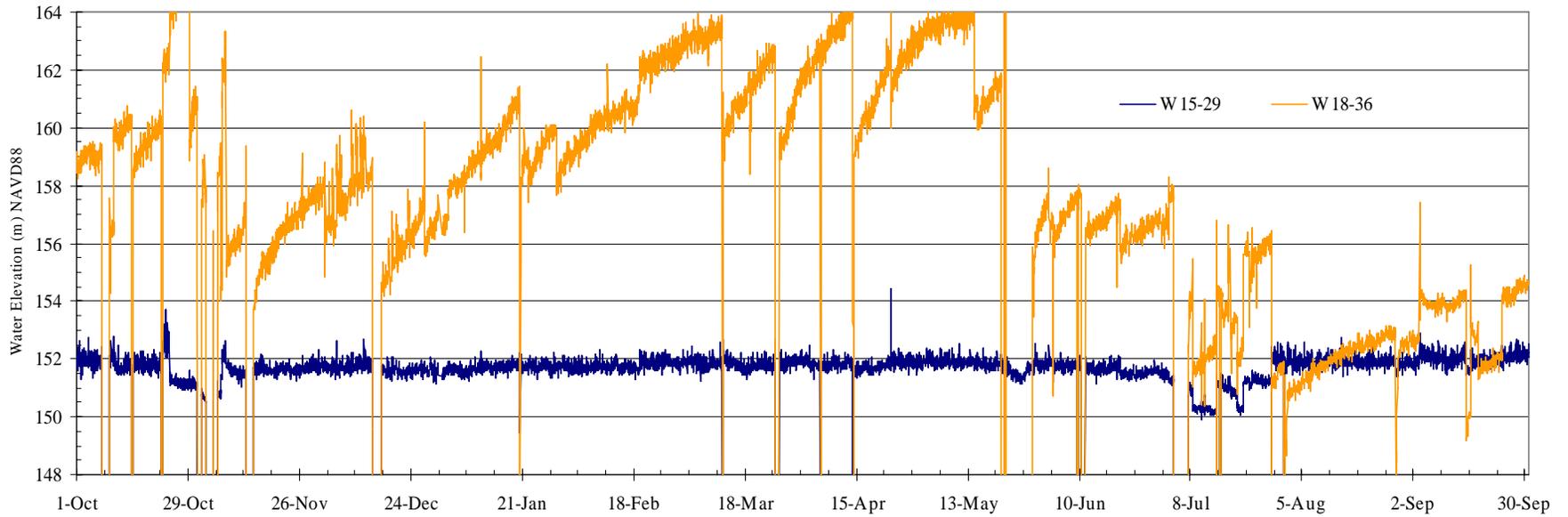


Figure C-5. Hydrographs of Injection Wells 299-W15-29 and 299-W18-36, 299-W18-37 and 299-W18-38, and 299-W18-38 and 299-W18-39. (3 sheets)

C-14

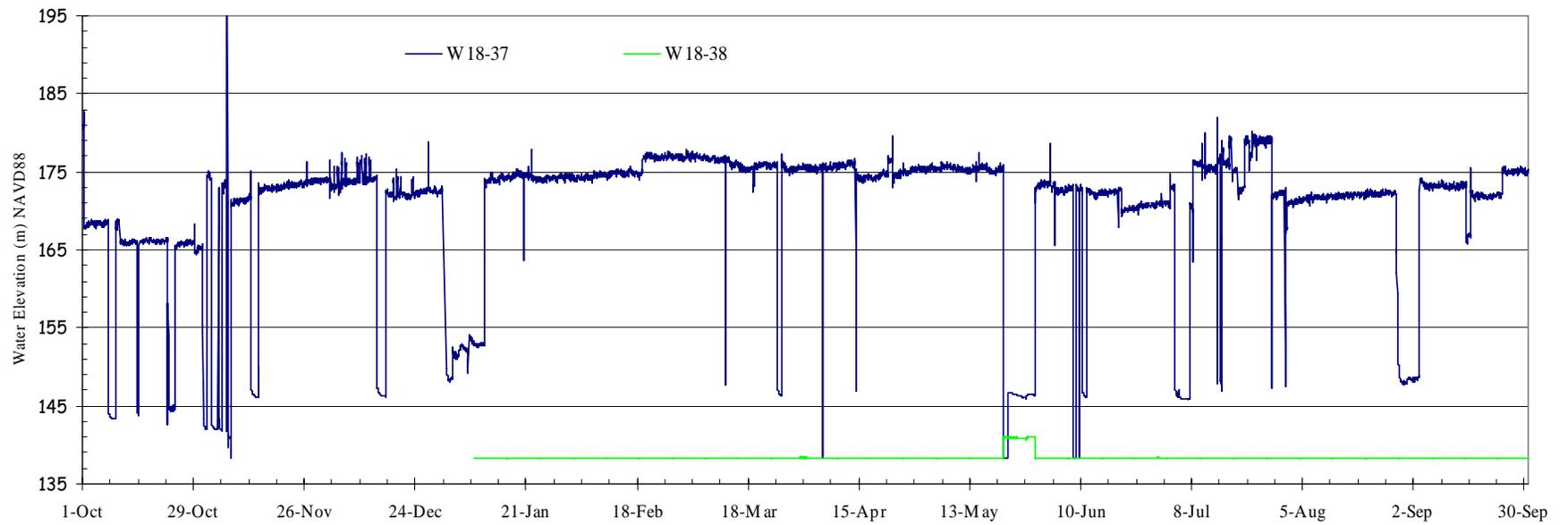


Figure C-5. Hydrographs of Injection Wells 299-W15-29 and 299-W18-36, 299-W18-37 and 299-W18-38, and 299-W18-38 and 299-W18-39. (3 sheets)

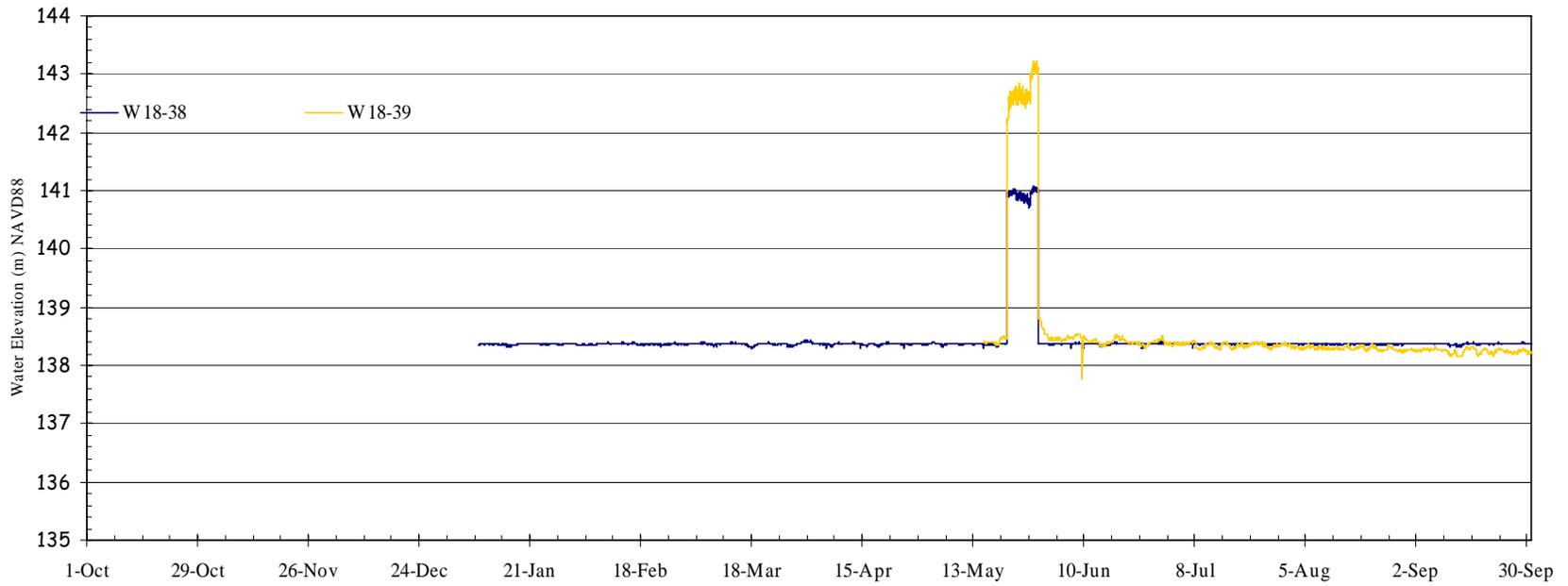


Figure C-6. Hydrographs of Monitoring Wells 299-W15-1, 299-W15-7, 299-W15-11, and 299-W15-41.

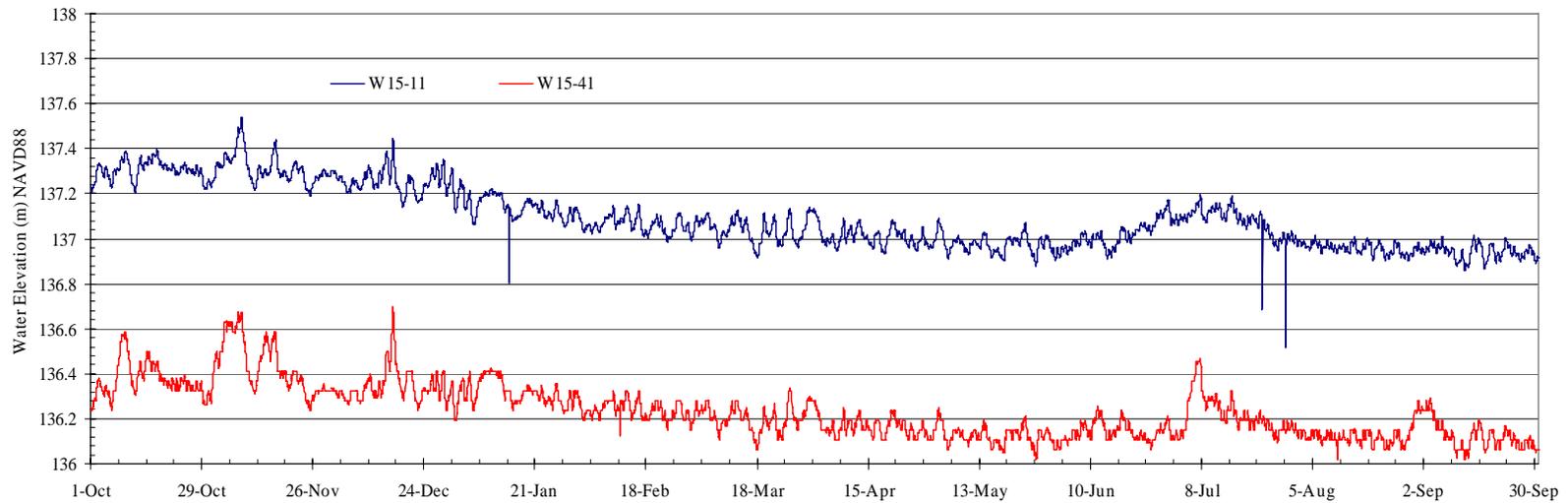
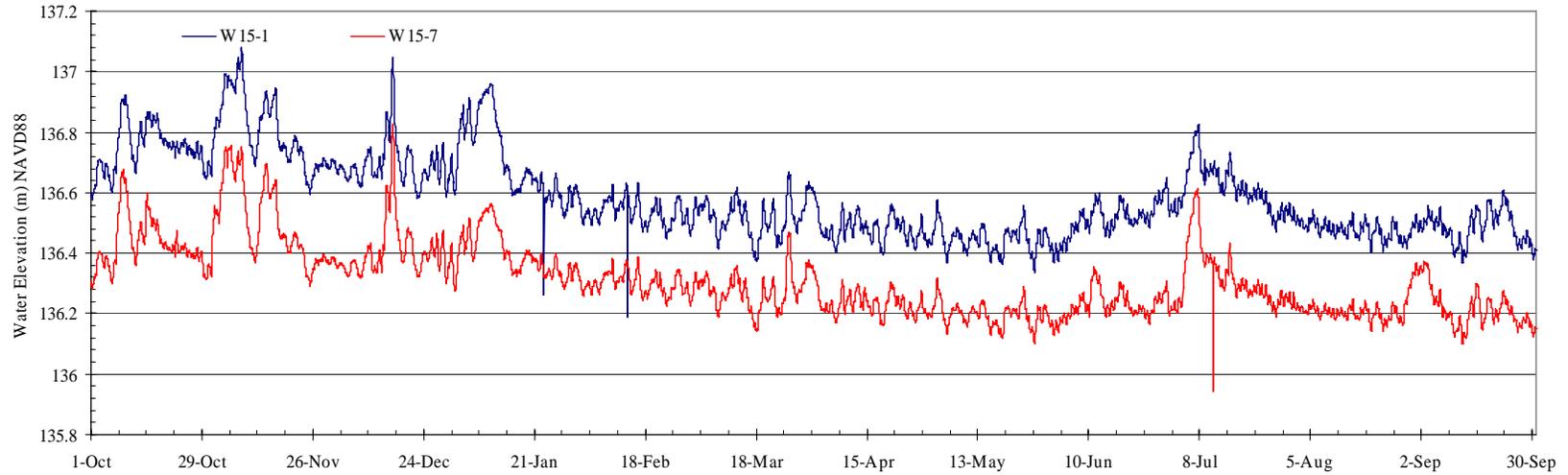


Figure C-7. Hydrographs of Monitoring Wells 299-W15-10, 299-W15-16, 299-W15-17, 299-W15-30, and 299-W15-31A.

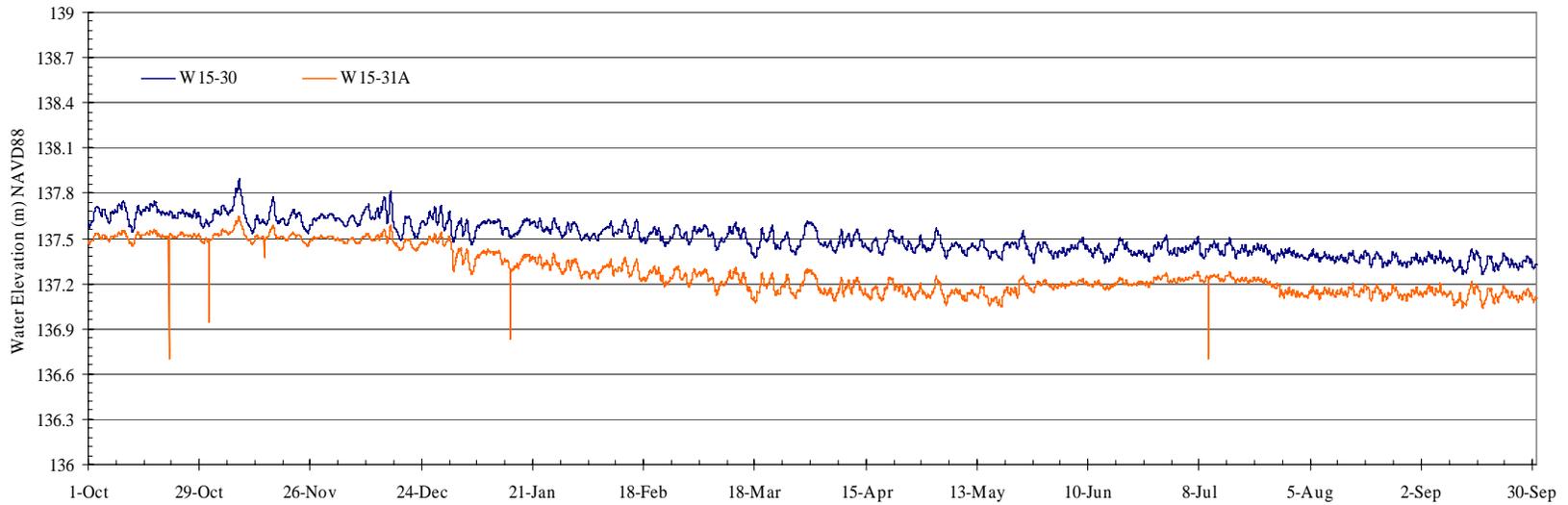
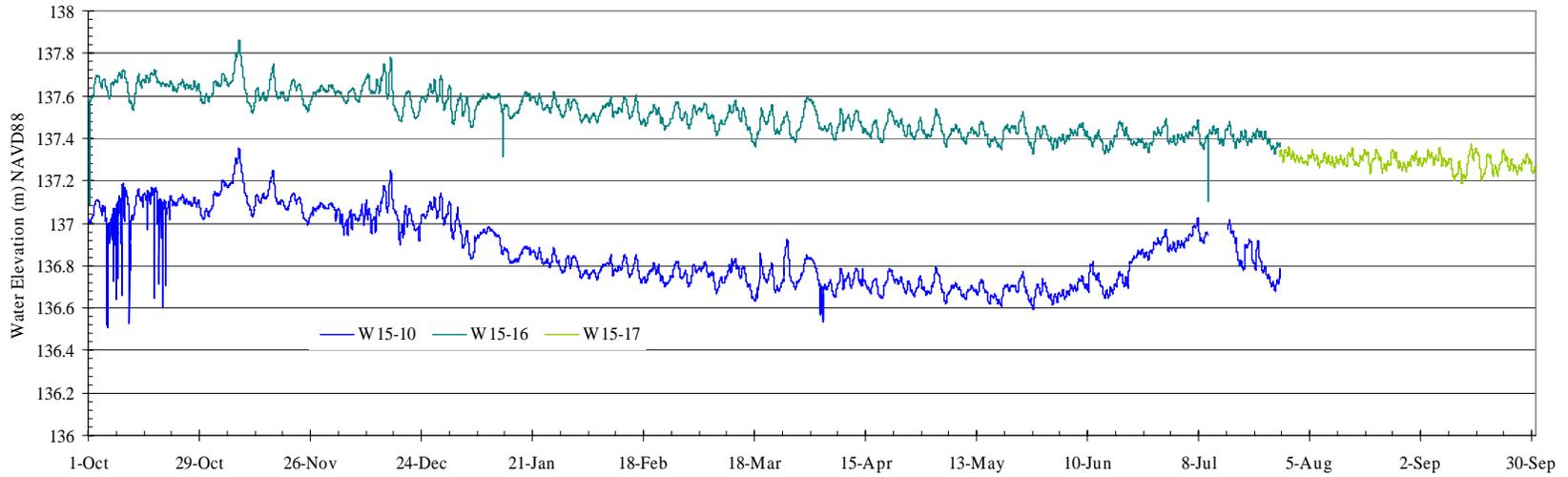


Figure C-8. Hydrographs of Monitoring Wells 299-W15-38, 299-W15-39, 299-W14-09, and 299-W8-22.

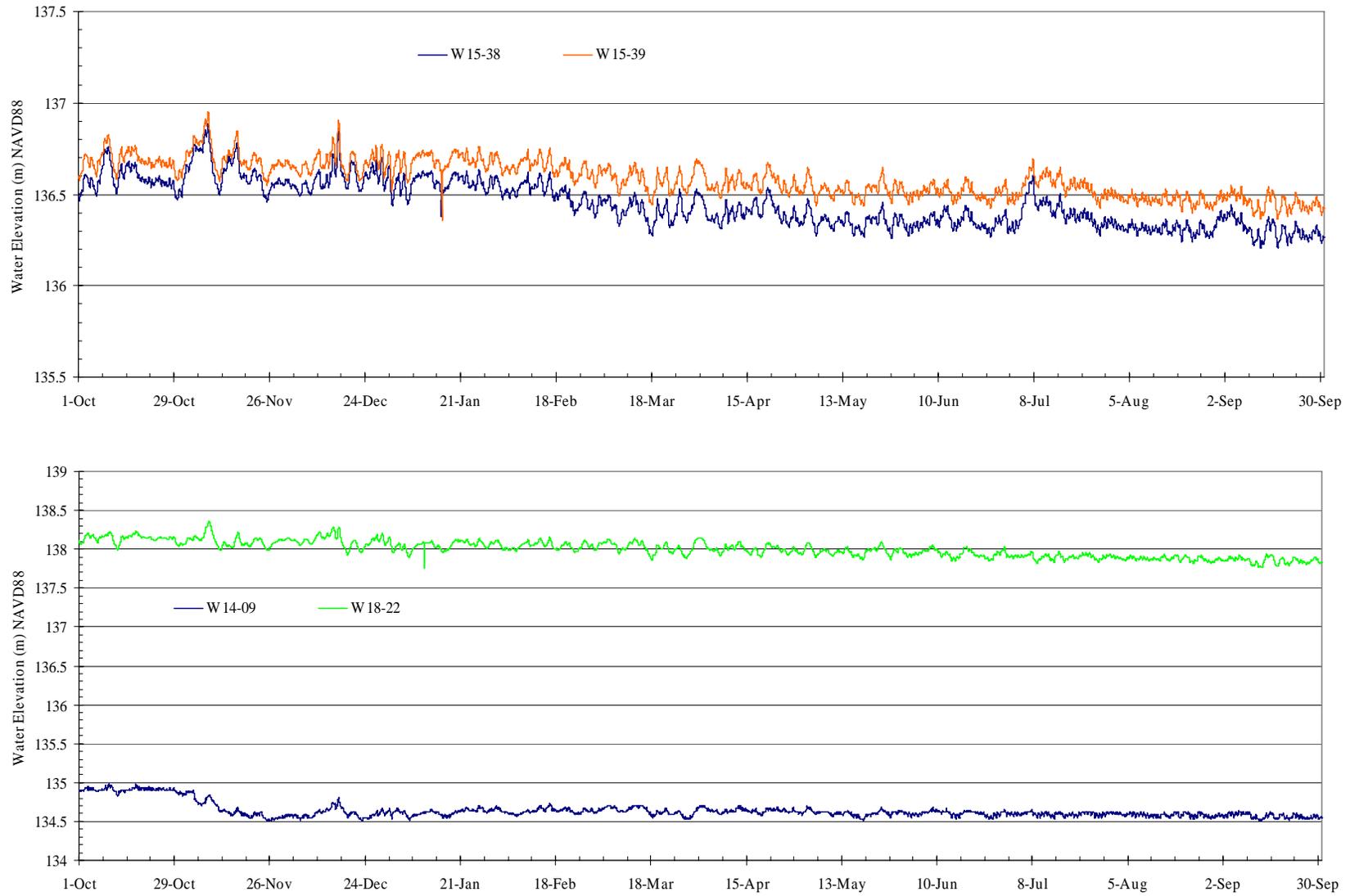


Figure C-9. Hydrographs of Monitoring Wells 699-39-79, 299-W18-23, 299-W18-21, and 299-W18-30.

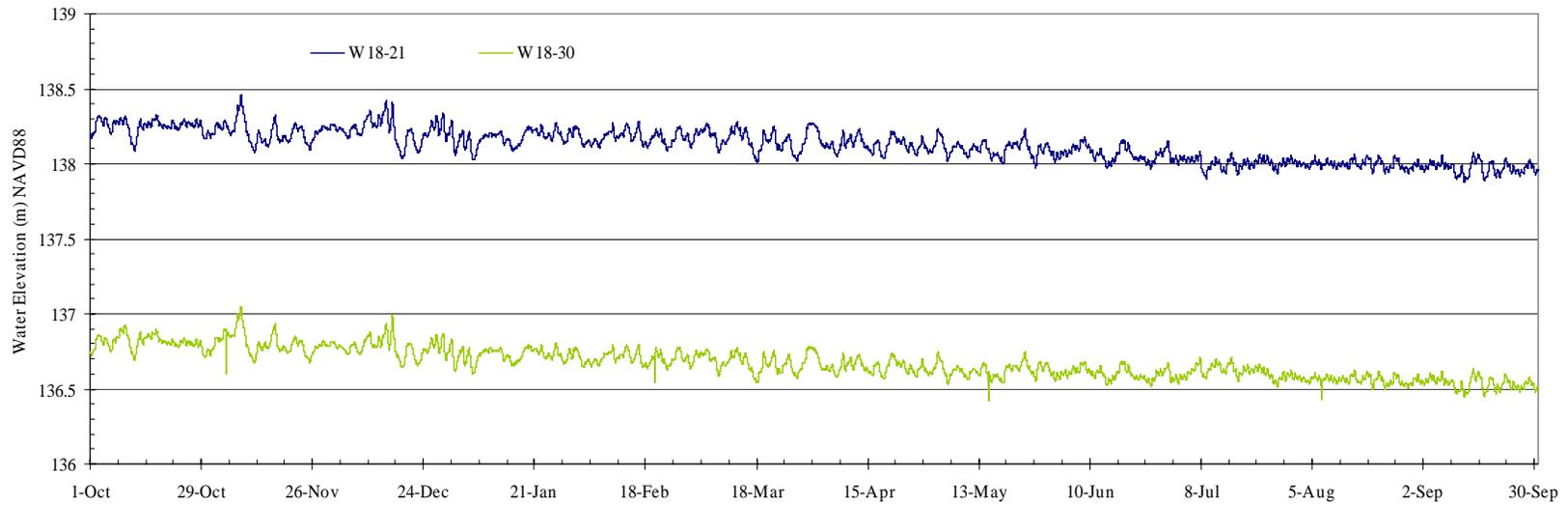
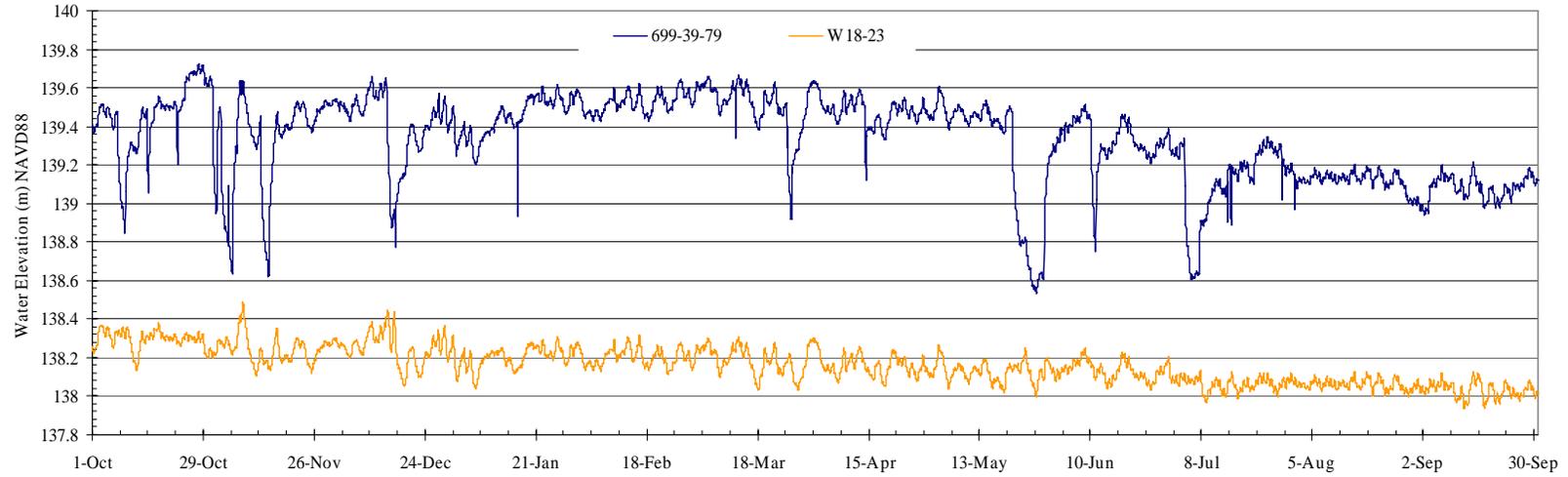
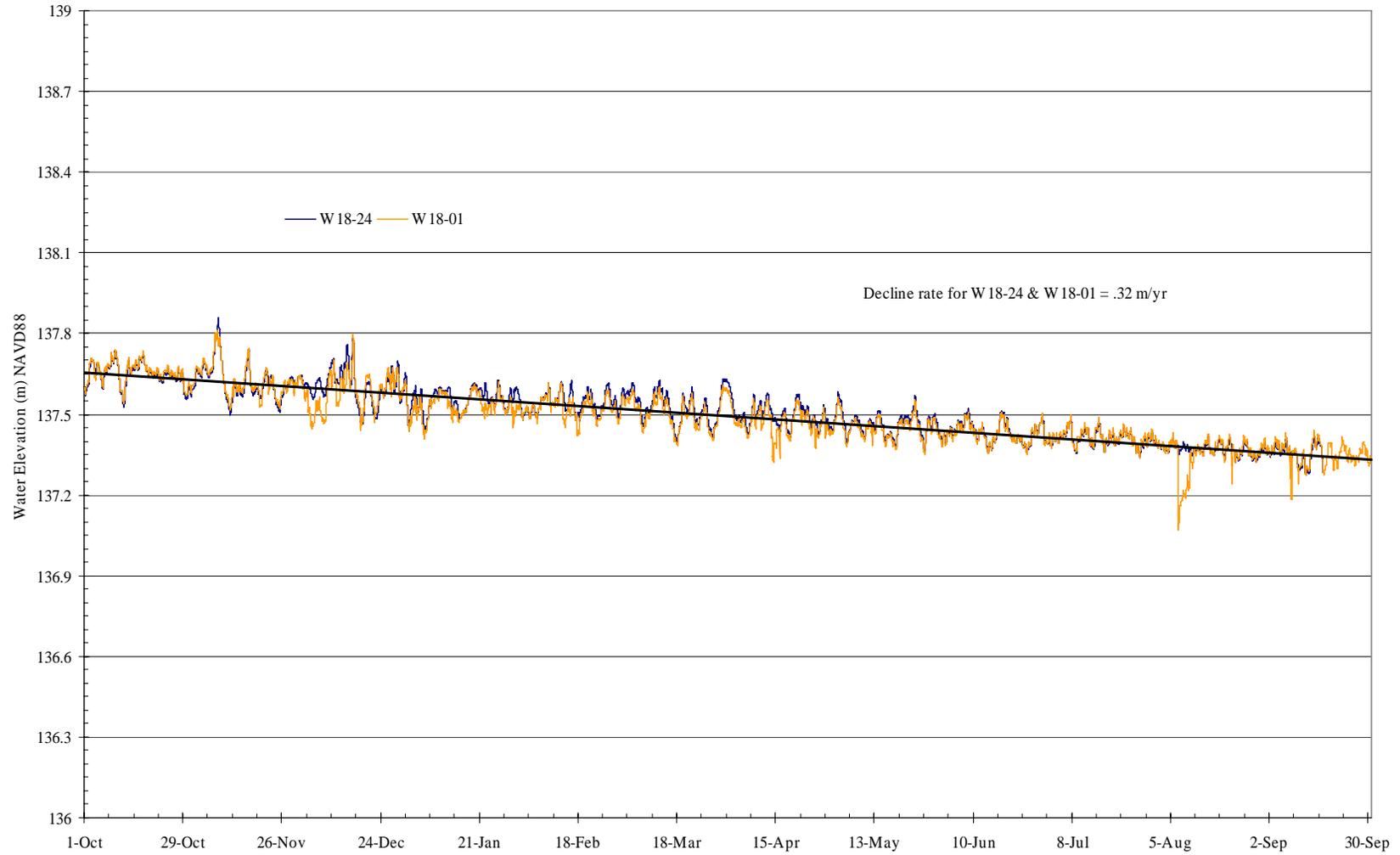


Figure C-10. Hydrographs of Monitoring Wells 299-W18-24 and 299-W18-1, Plus Calculation for Regional Groundwater Decline.



C-20

Figure C-11. 200-ZP-1 Water Table Map: Baseline June 1996 Water Table Versus September 2003 Water Table.

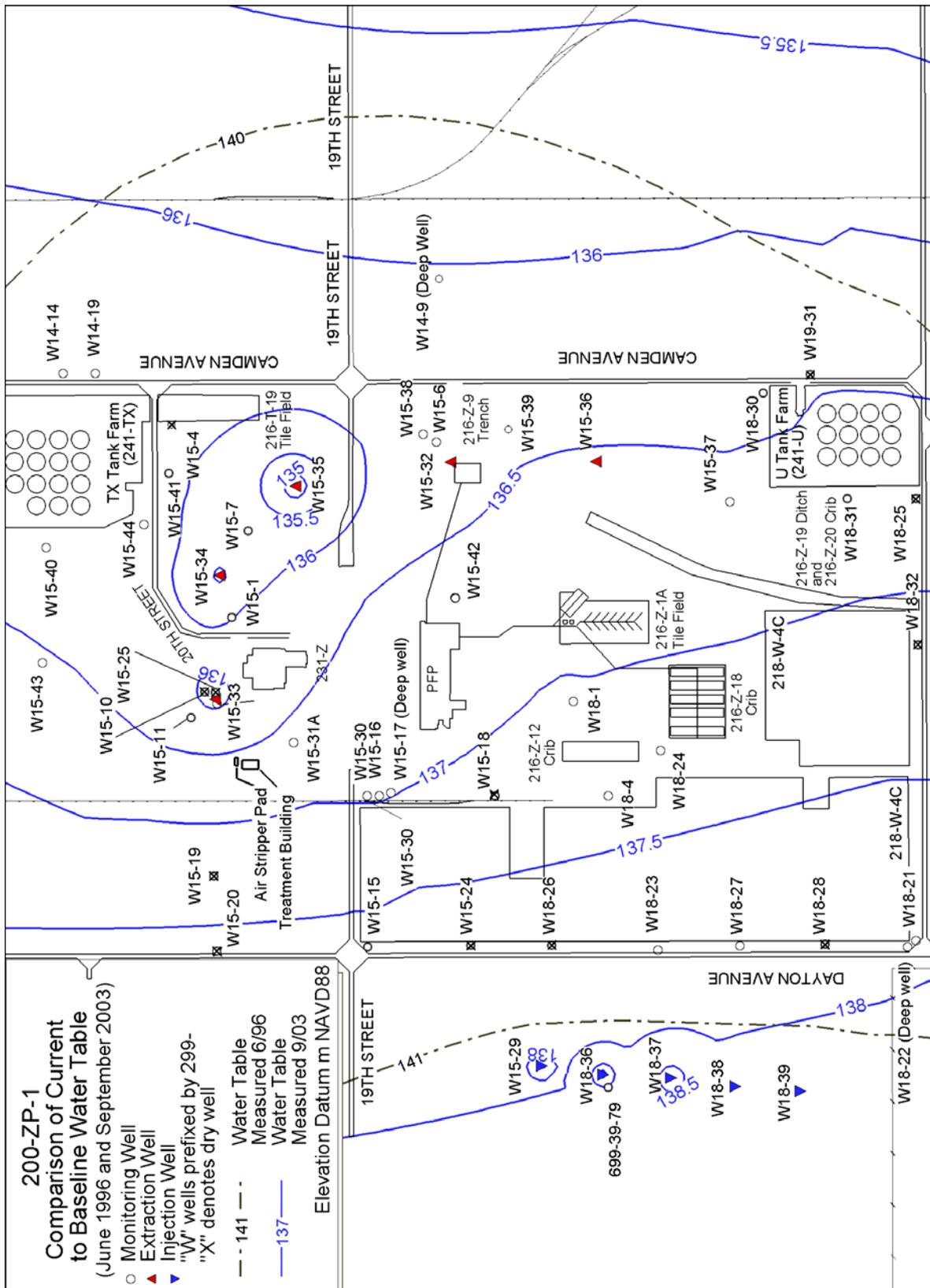


Table C-1. Effects of Declining Water Table on the 200-UP-1 Operable Unit Water-Level Monitoring Network.

<b>Well Name</b>	<b>Direction from Extraction Pump</b>	<b>Well Type</b>	<b>Actual or Forecasted Date Dry</b>
<b>299-W19-19</b>	<b>Northwest</b>	<b>Near-field, upgradient</b>	<b>May 1999</b>
<b>299-W19-20<sup>a</sup></b>	<b>Northwest</b>	<b>Near-field, upgradient</b>	<b>March 2004</b>
<b>299-W19-23</b>	<b>West/southwest</b>	<b>Mid-field, upgradient</b>	<b>July 2000</b>
<b>299-W19-24</b>	<b>West</b>	<b>Mid-field, upgradient</b>	<b>June 2000</b>
<b>299-W19-25</b>	<b>Northwest</b>	<b>Near-field, upgradient</b>	<b>February 1998</b>
<b>299-W19-26</b>	<b>West</b>	<b>Near-field, upgradient</b>	<b>August 2000</b>
<b>299-W19-28<sup>b</sup></b>	<b>Northwest/southwest</b>	<b>Near-field, downgradient</b>	<b>November 1999</b>
<b>299-W19-29<sup>b</sup></b>	<b>Northwest/southeast</b>	<b>Near-field, downgradient</b>	<b>December 2000</b>
<b>299-W19-30</b>	<b>West</b>	<b>Mid-field, upgradient</b>	<b>March 2001</b>
299-W19-34A	West (39)/east (36)	Deep near-field	Beyond 2010
299-W19-35	Northeast	Boundary well, northeast downgradient	Beyond 2010
299-W19-36	Northwest	Extraction well	Beyond 2010
299-W19-37	Northwest	Mid-field, upgradient	FY09
<b>299-W19-38</b>	<b>South/southwest</b>	<b>Southern boundary well</b>	<b>June 2001</b>
299-W19-39	Center	Extraction well	Beyond 2010
299-W19-40 <sup>d</sup>	Southeast	Downgradient	June 2005
299-W19-43 <sup>c</sup>	Northwest/southeast <sup>c</sup>	Extraction well	Beyond 2010
299-W19-46	South-southwest	Southern boundary well	Beyond 2010

NOTE: Bolded text in this table indicates dry monitoring wells in FY03.

<sup>a</sup> Mud on E-tape probe February 2004.

<sup>b</sup> Originally monitored the former injection well.

<sup>c</sup> Started in FY03 as a monitoring well; converted to an extraction well in mid-FY03.

<sup>d</sup> Sampling pump pull, which has allow further water level monitoring.

FY = fiscal year

Table C-2. Drawdown and Buildup at 200-ZP-1  
Pump-and-Treat and Monitoring Wells.

Well Name	Buildup /Drawdown (-/+) (m)			Flow Rate (L/min)			Specific Capacity (L/min/m)		
	FY02	FY03	FY04	FY02	FY03	FY04	FY02	FY03	FY04
299-W15-32	1.33	1.04	1.2	34	34	25	25.9	32.7	21.6
299-W15-47	---	---	7.6	---	---	208.2	---	---	27.3
299-W15-33	7.52	2.22	2.7	26	44	46.2	3.5	19.8	16.8
299-W15-45	---	---	5.2	---	---	170.3	---	---	32.5
299-W15-34	6.59	4.54	3.6	74	73	72.3	11.2	16.1	20.3
299-W15-35	10.51	10.07	10.1	293	272	246.8	27.9	27.1	24.3
299-W15-36	6.99	4.18	8.4	92	77	83.3	13.2	18.4	9.9
299-W15-29	-13.7	-12.8	-13.7	271	151	223.3	19.8	11.8	16.4
299-W18-36	20.37	17.4	-13.3	205	194	152.9	10.1	11.1	11.5
299-W18-37	ND	26.5	-25.9	130	120	111.3	-	4.5	4.3
299-W18-38	-0.18	ND	2.5	-	-	174.1	-	-	69.7
299-W18-39	ND	ND	ND	-	-	140.1	-	-	ND
Well Name	Buildup /Drawdown (-/+) (m)			Drawdown Trend					
	FY02	FY03	FY04	FY02/03	FY03/FY04				
299-W15-01	0.62	0.25	0.4	Decrease	Increase				
299-W15-07	0.65	0.31	0.4	Decrease	Increase				
299-W15-11	0.39	0.14	0.3	Decrease	Decrease				
299-W15-30	0.07	0.03	0.14	Decrease	Increase				
299-W15-31A	0.12	0.01	.21	Decrease	Increase				
299-W15-37	---	---	0.21	N/A	N/A				
299-W15-38	0.37	0.17	0.63	Decrease	Increase				
299-W15-39	0.23	0.09	0.28	Decrease	Increase				
299-W15-41	0.54	0.25	0.27	Decrease	Increase				
299-W15-42	---	---	0.12	N/A	N/A				
299-W18-21	-0.16	-0.03	-0.07	Decrease	Increase				
299-W18-23	-0.19	-0.05	-0.10	Decrease	Increase				
299-W18-30	0.10	0.04	0.06	Decrease	Increase				
699-39-79	-1.18	-0.66	-1.08	Decrease	Increase				

<sup>a</sup> The transducers in wells 299-W18-38 and 299-W18-39 do not have the accuracy to make any meaningful calculation.

ND = no data for that year

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**APPENDIX D**  
**TREND PLOTS FOR WELLS**  
**AT THE 200-UP-1 OPERABLE UNIT**

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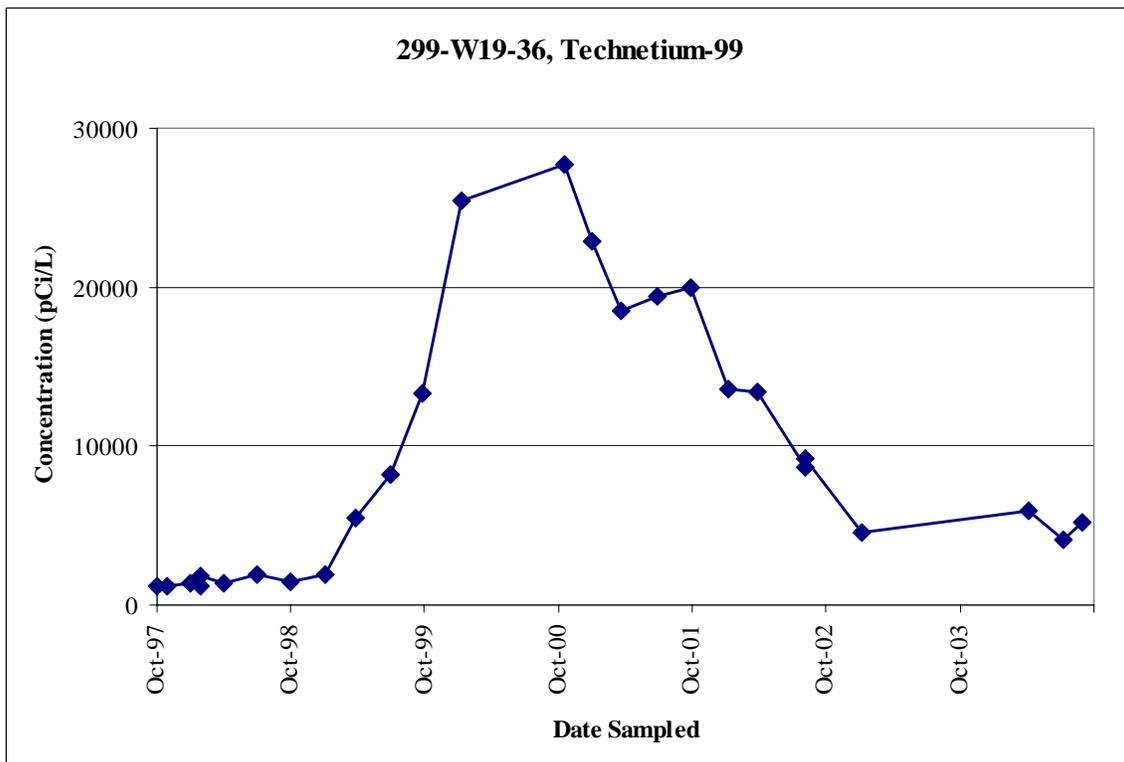
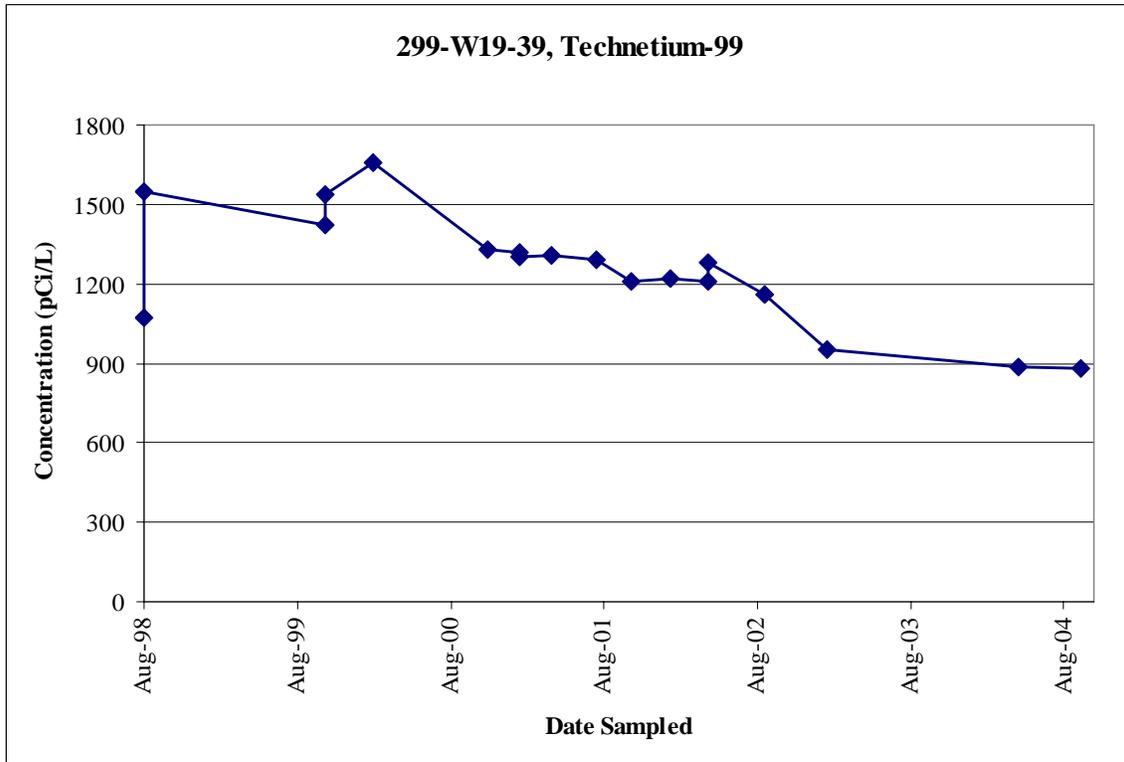


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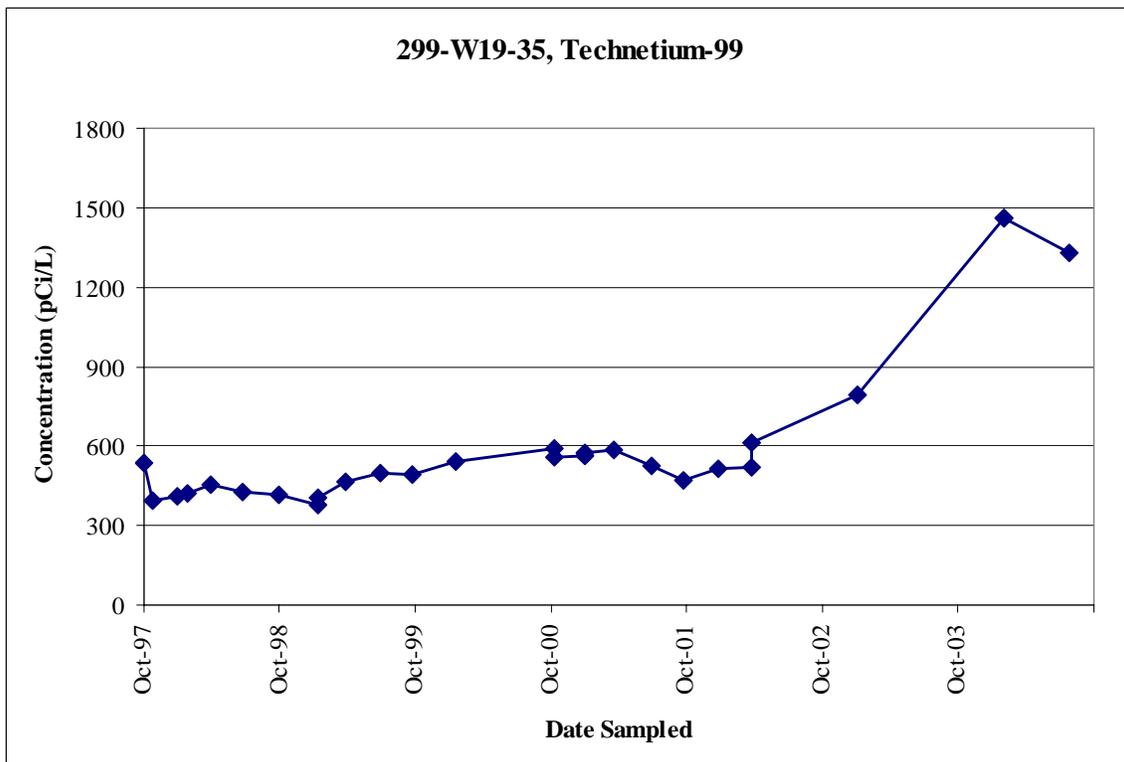
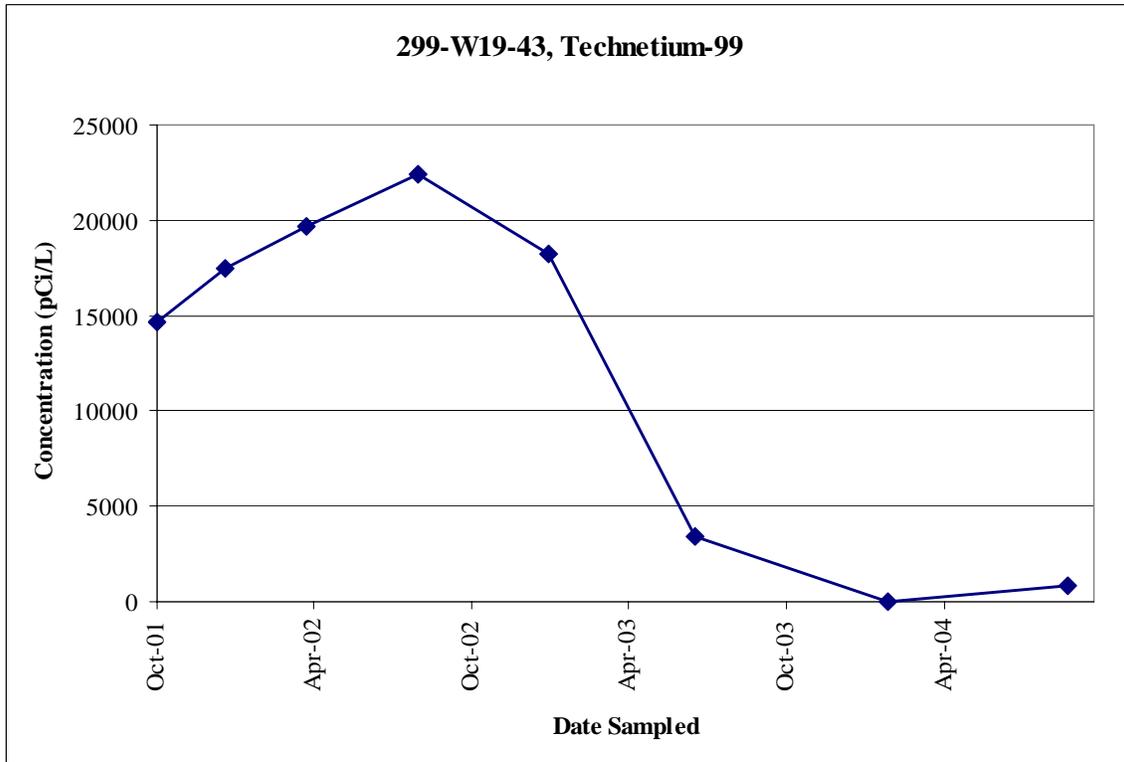


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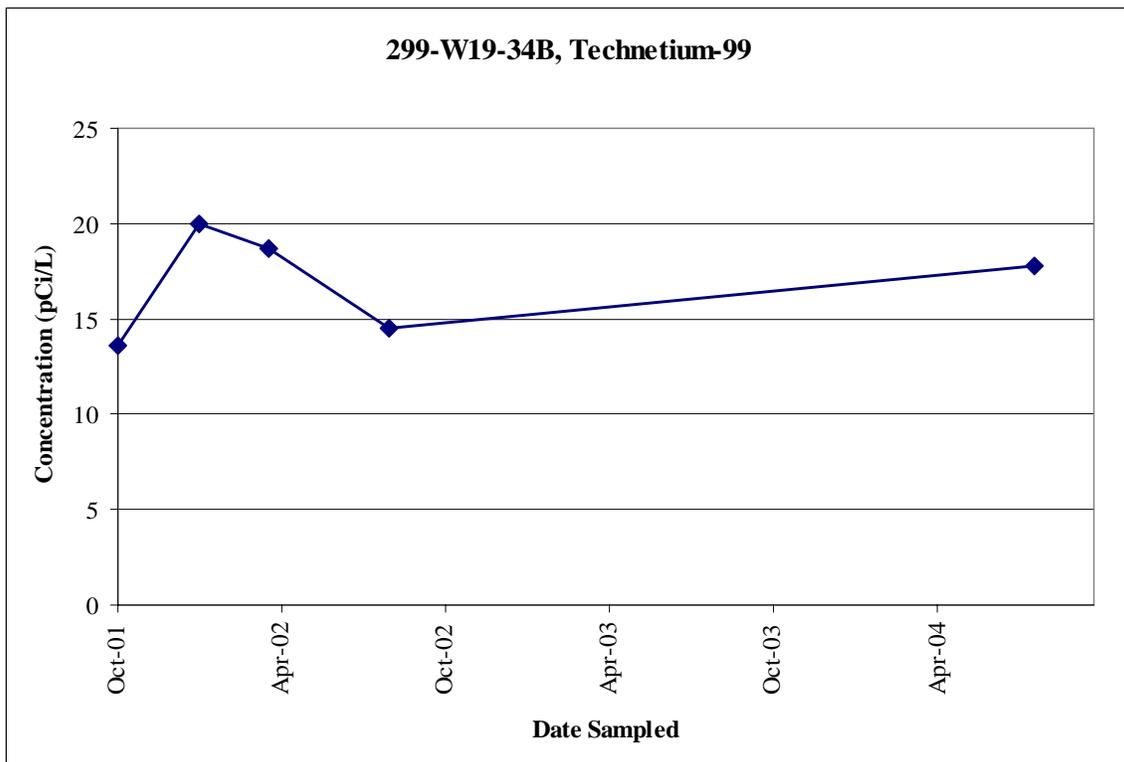
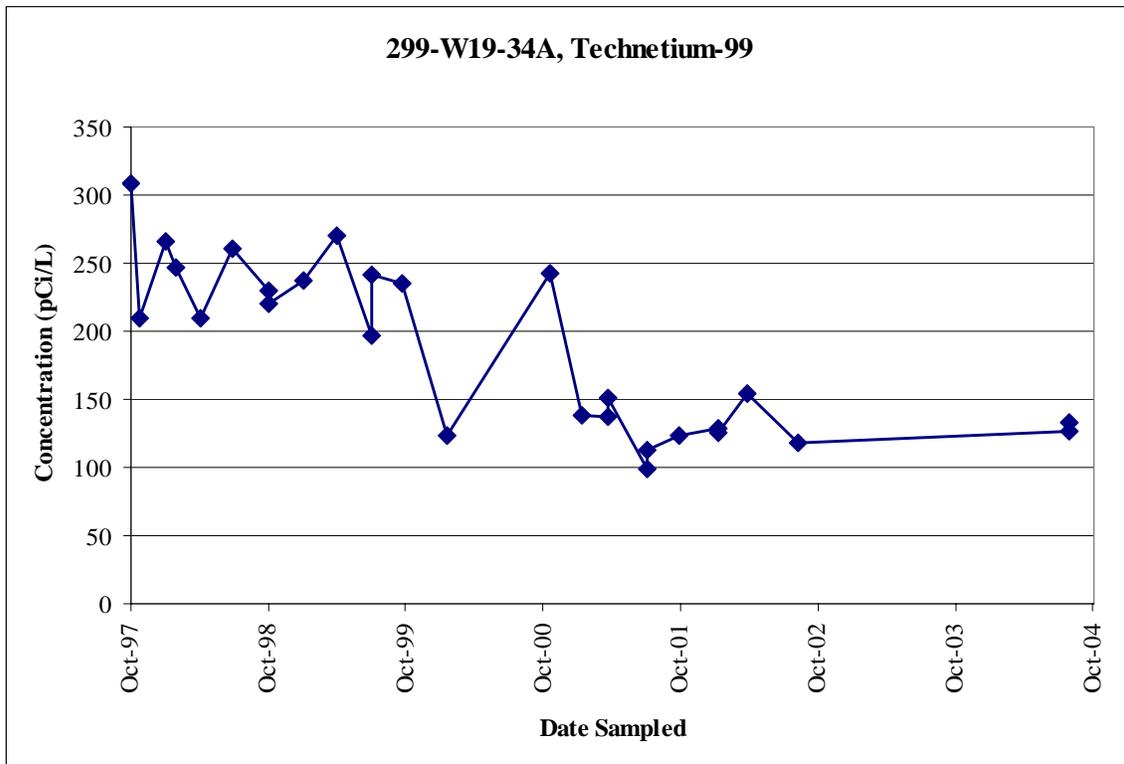


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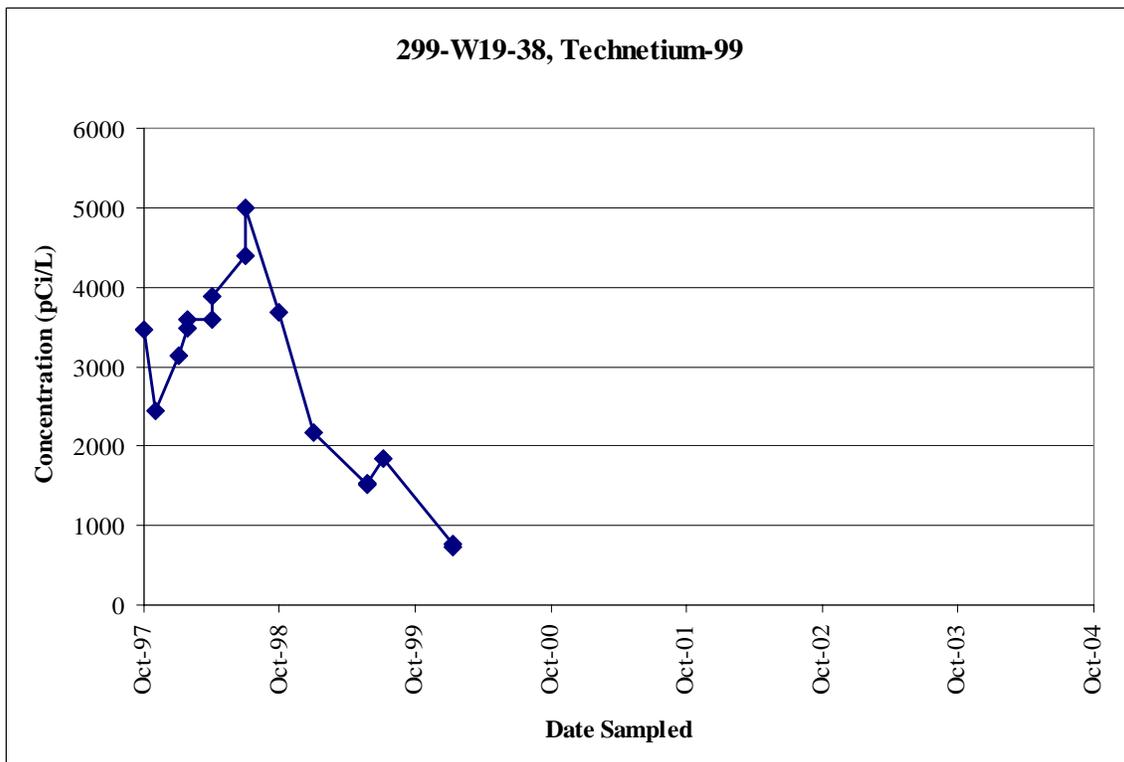
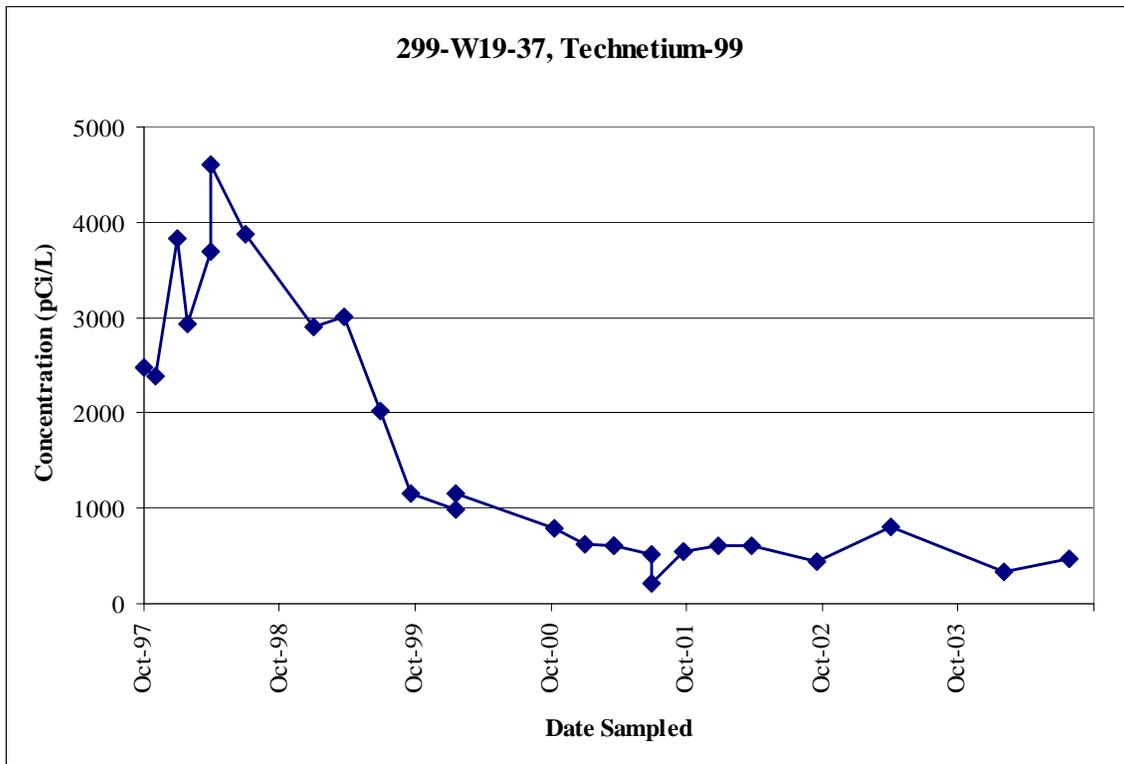


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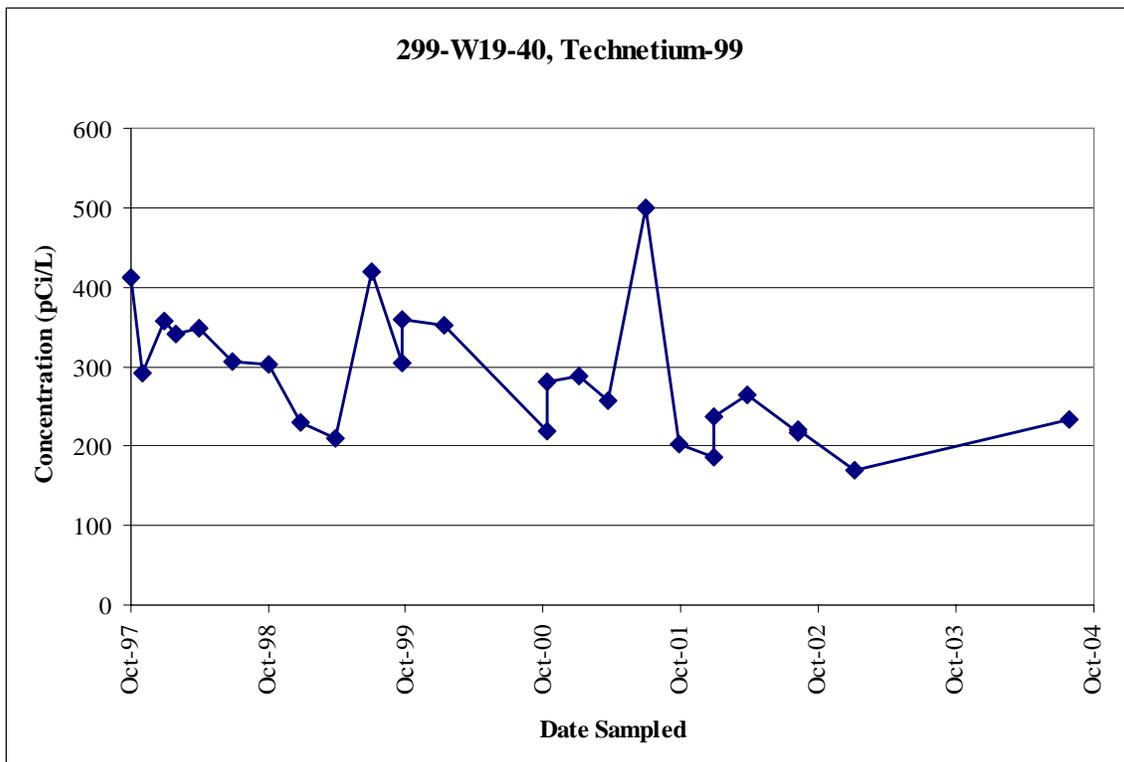
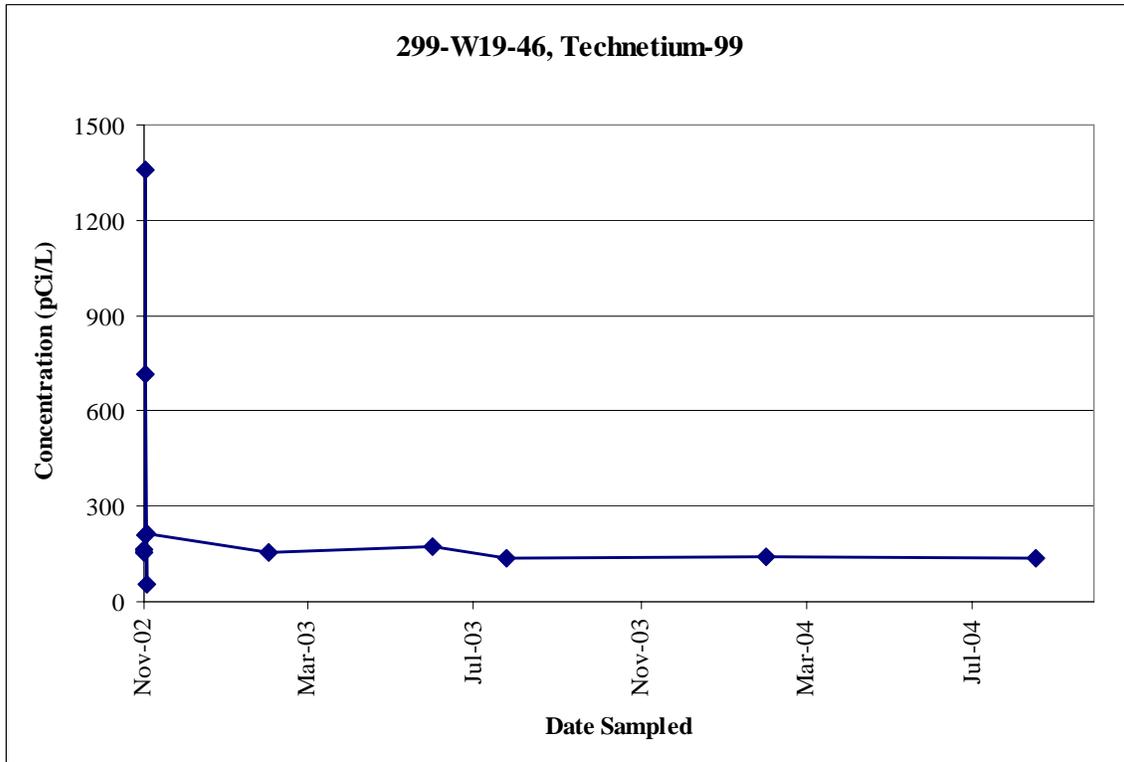


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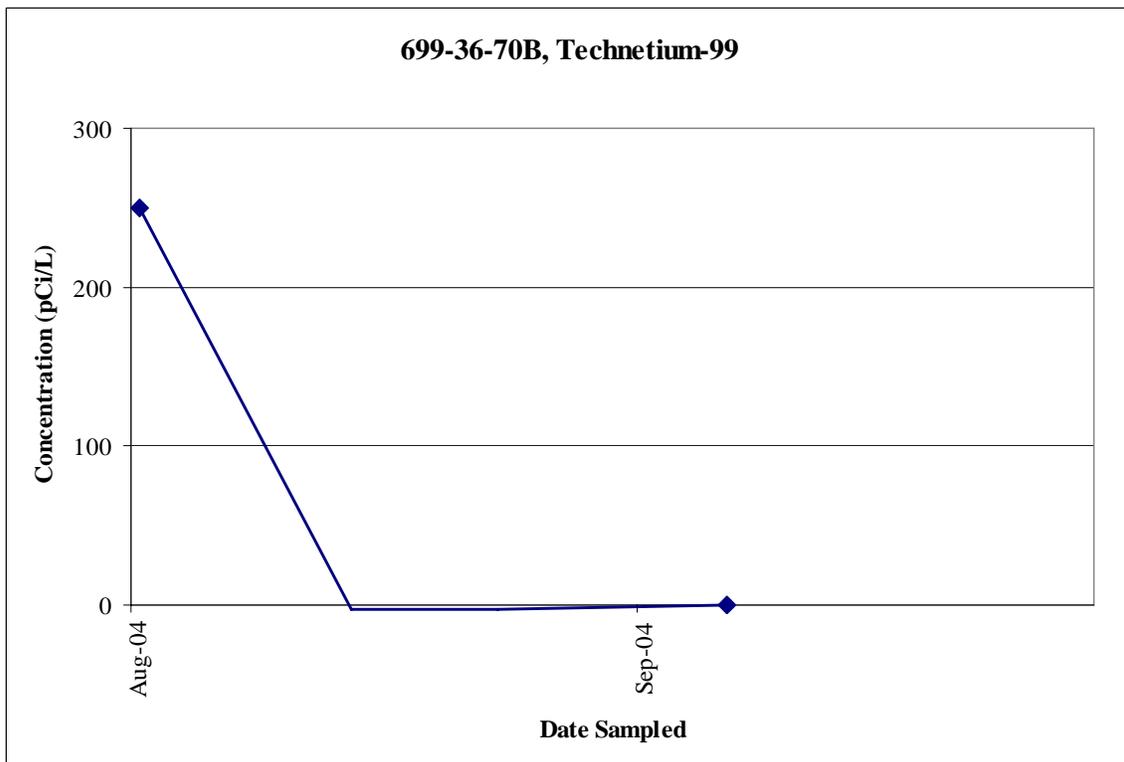
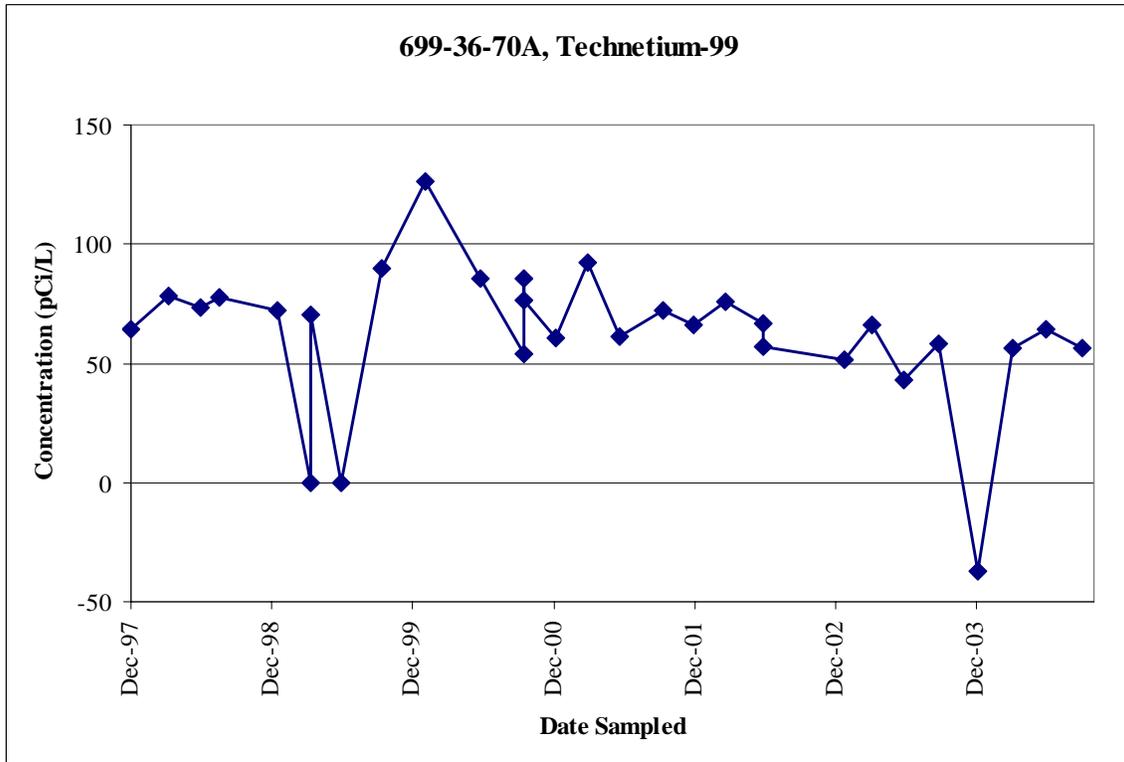


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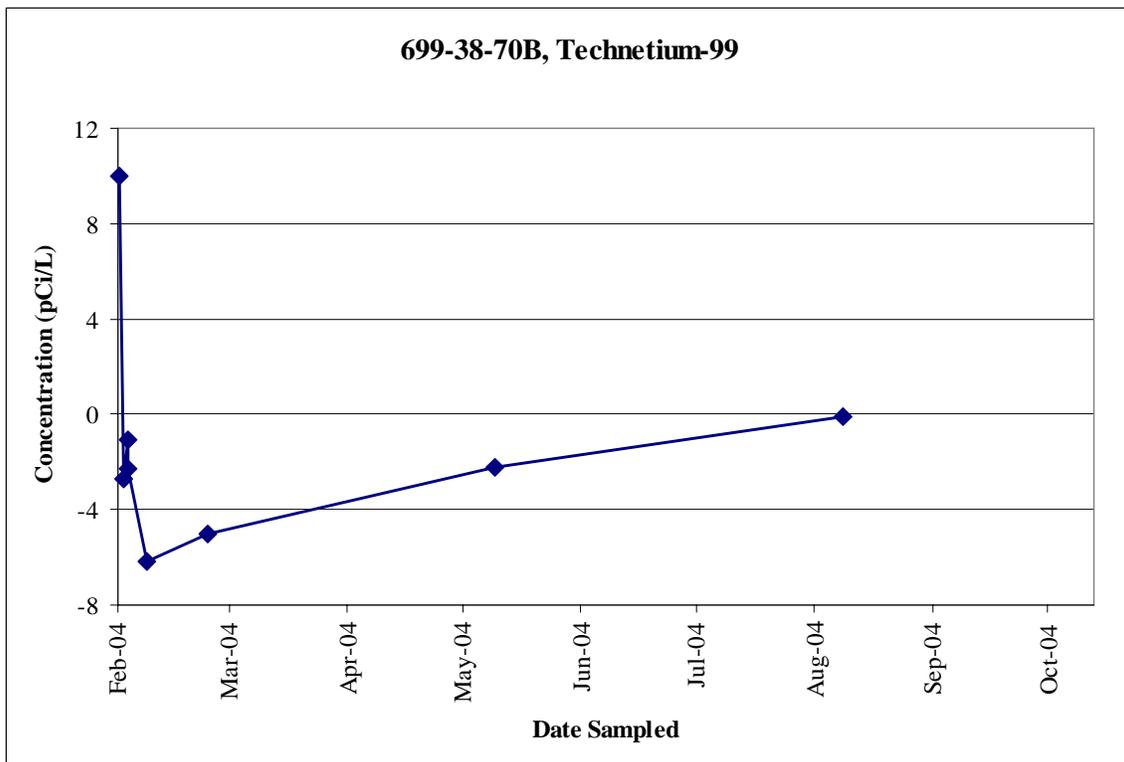
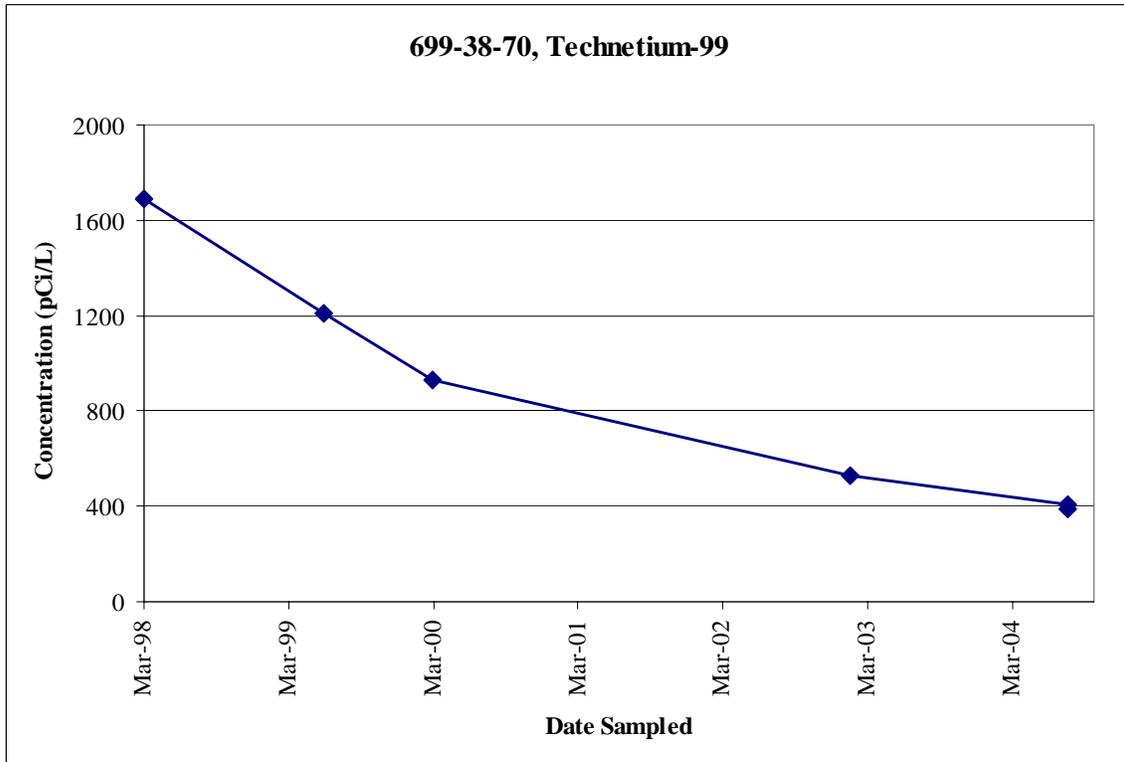


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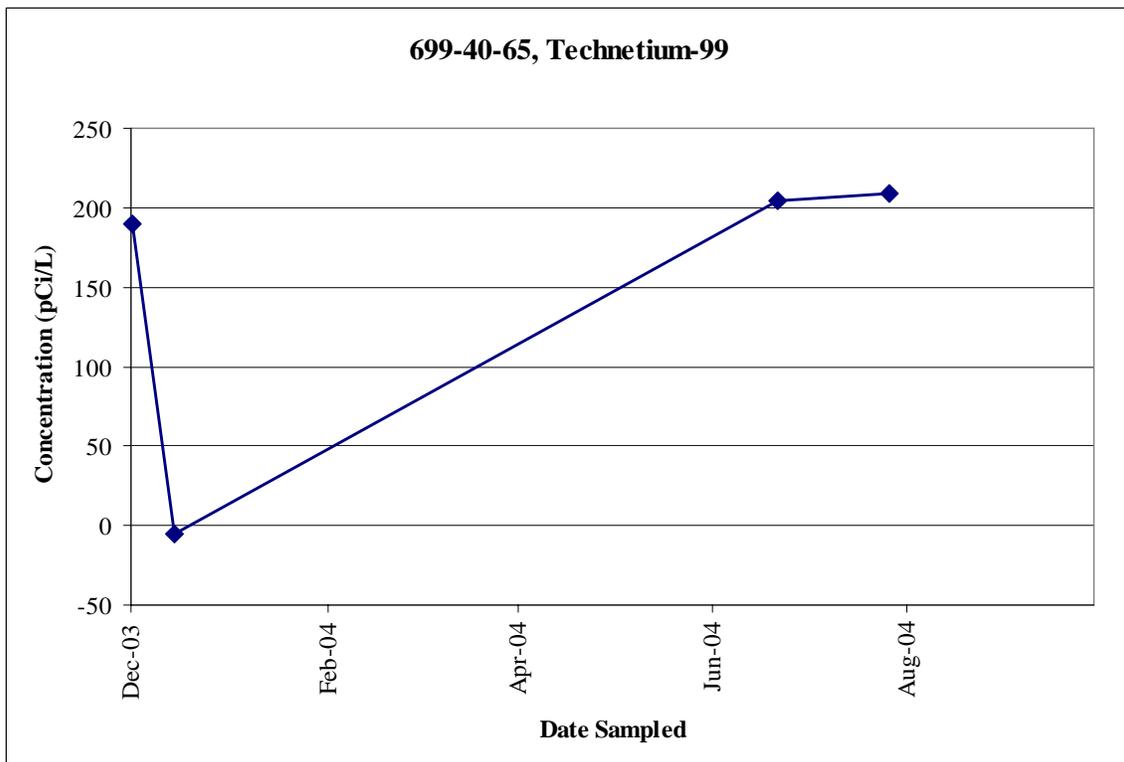
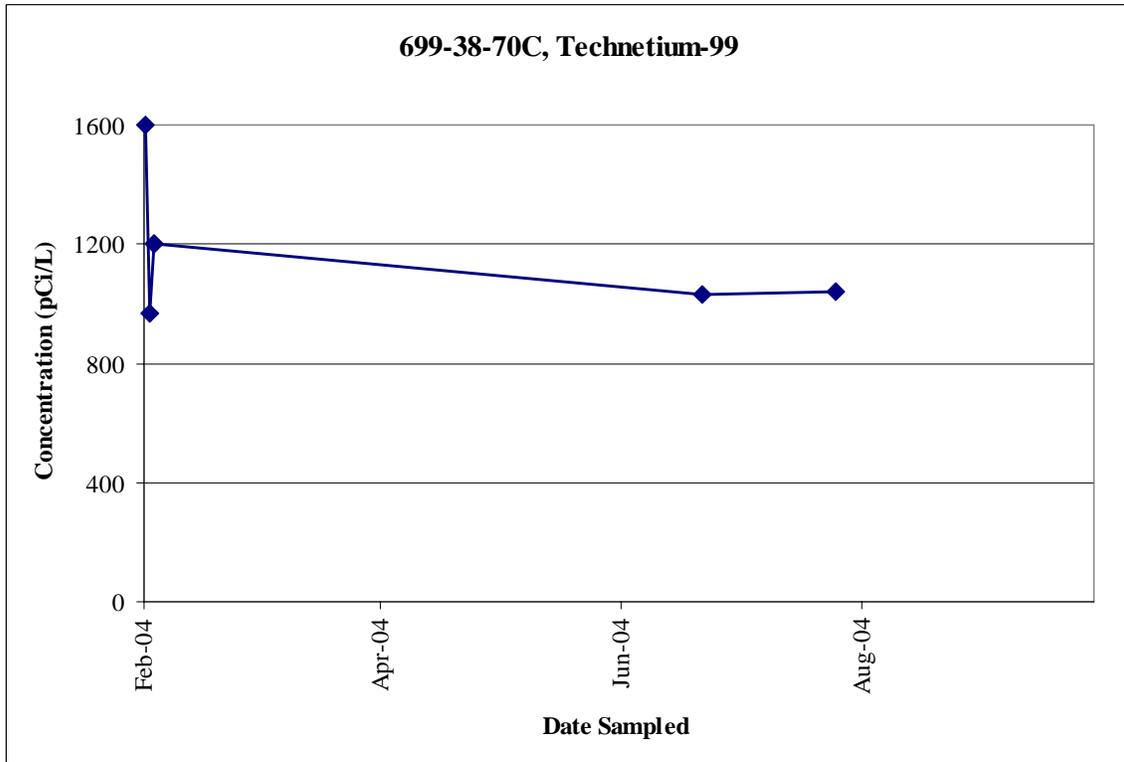


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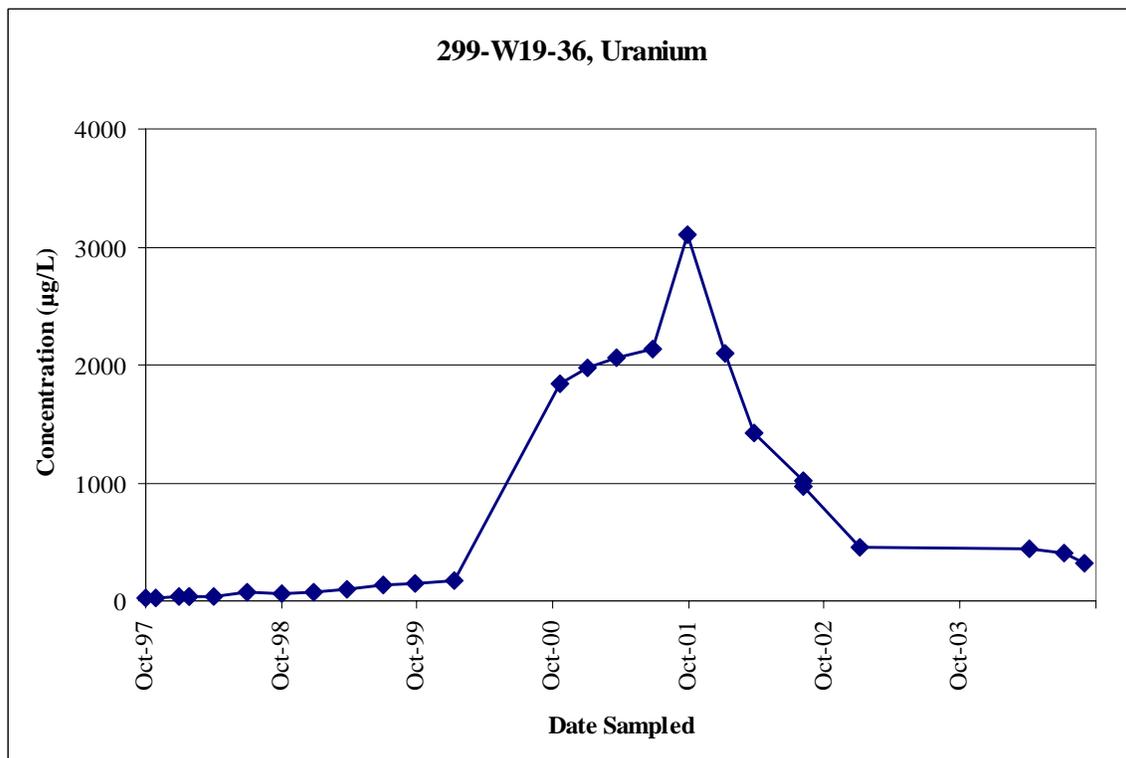
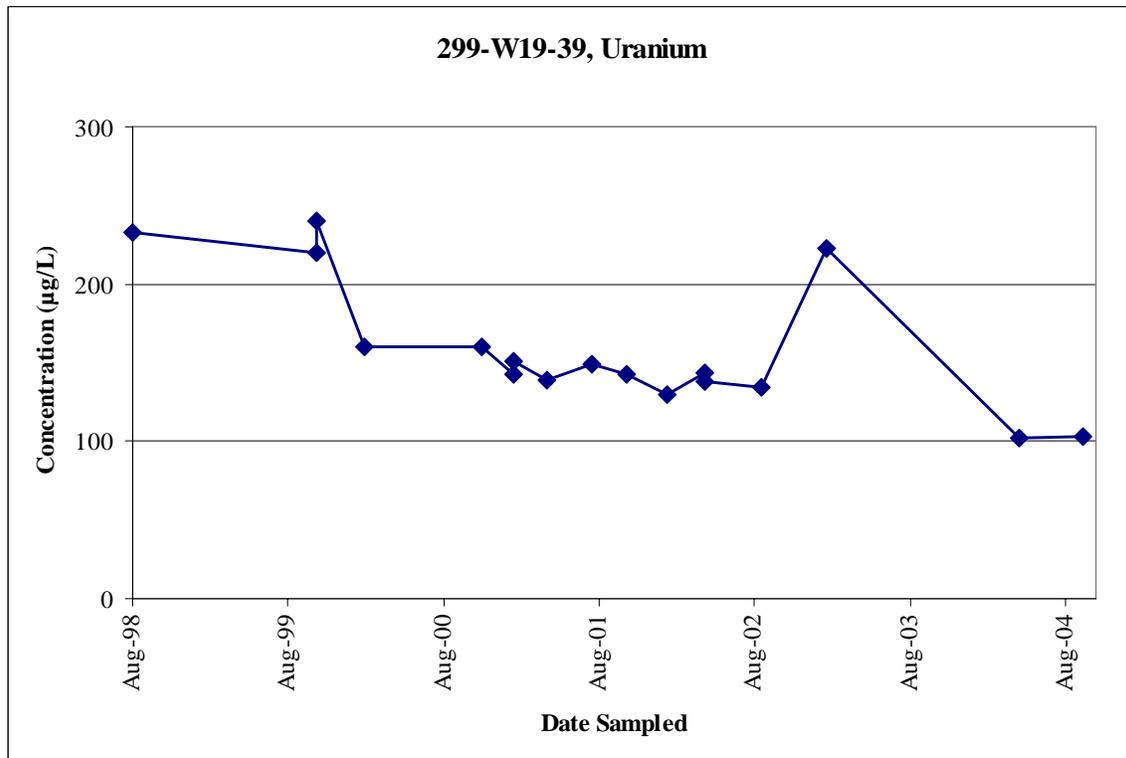


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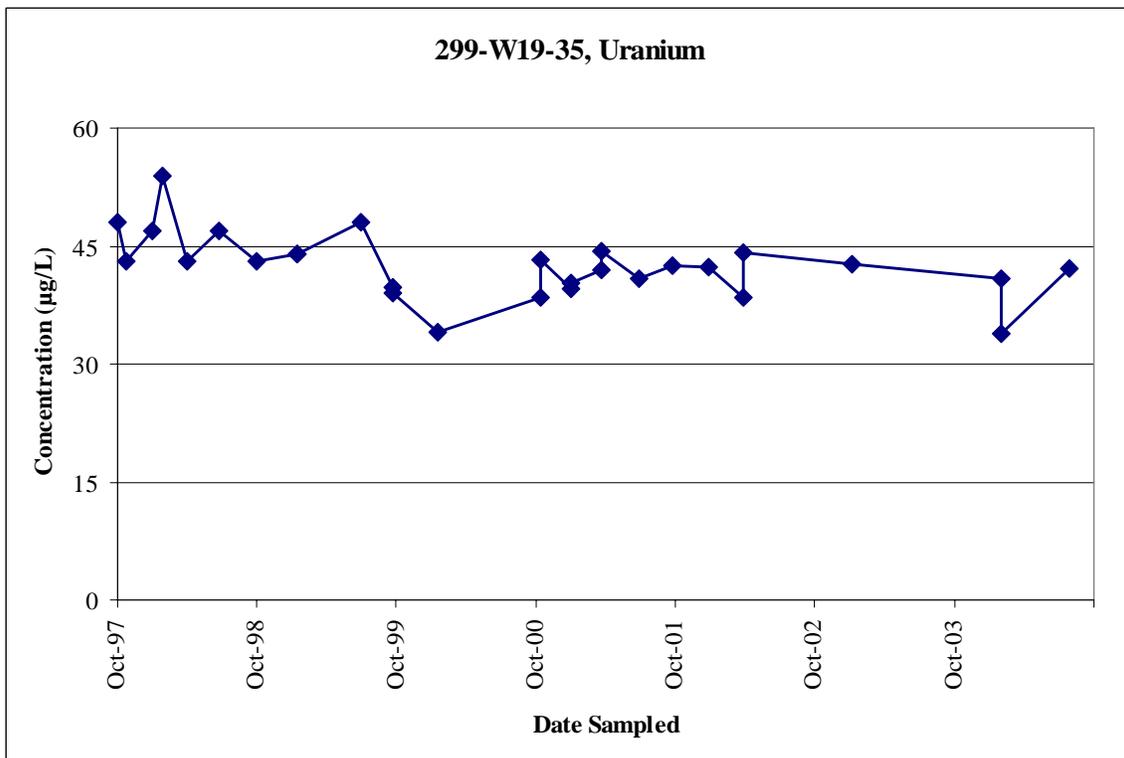
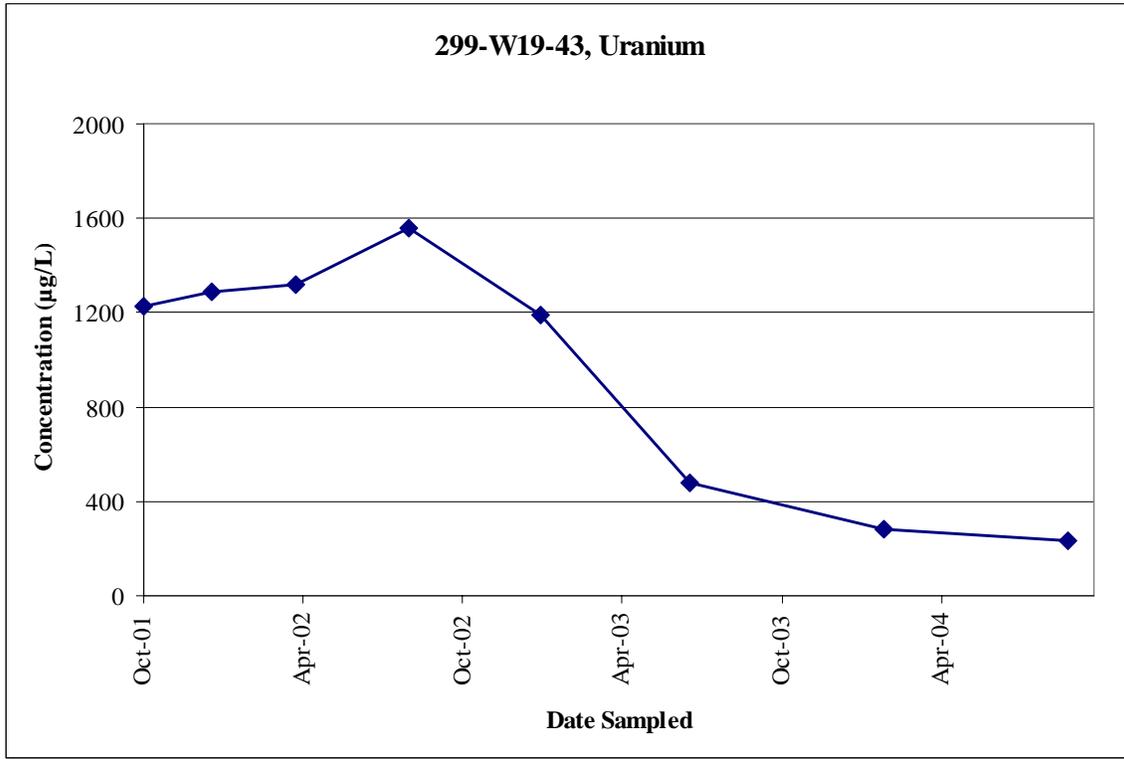


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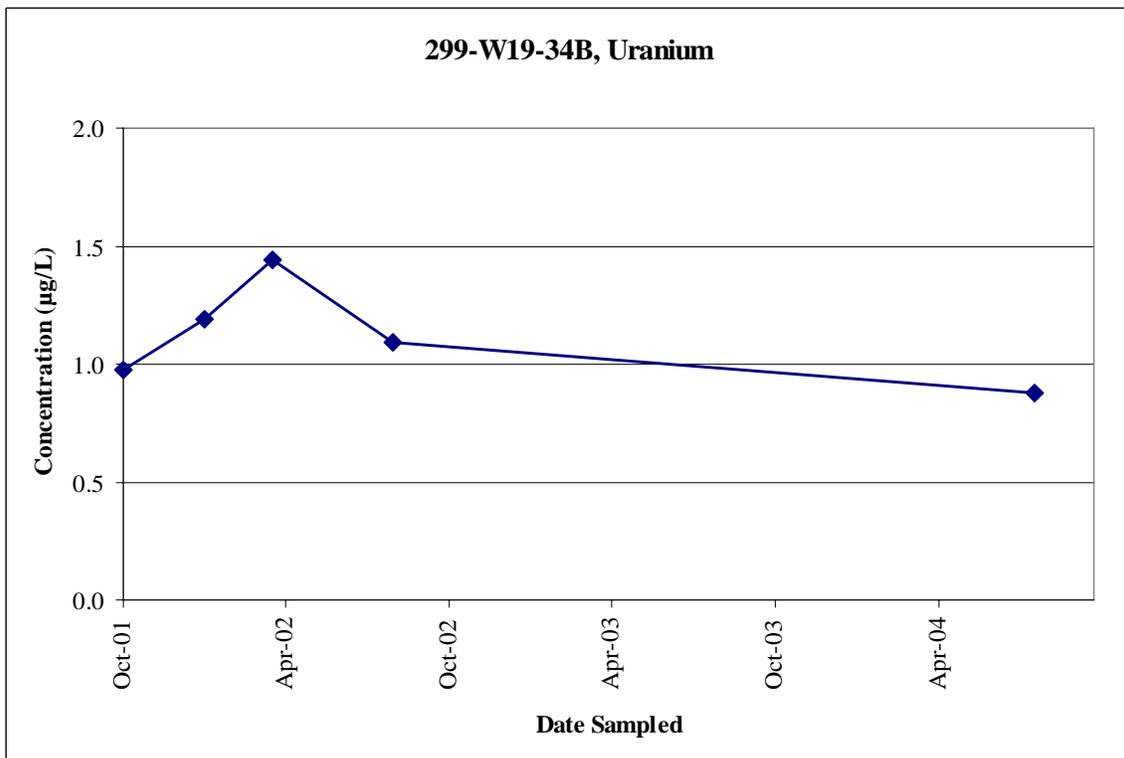
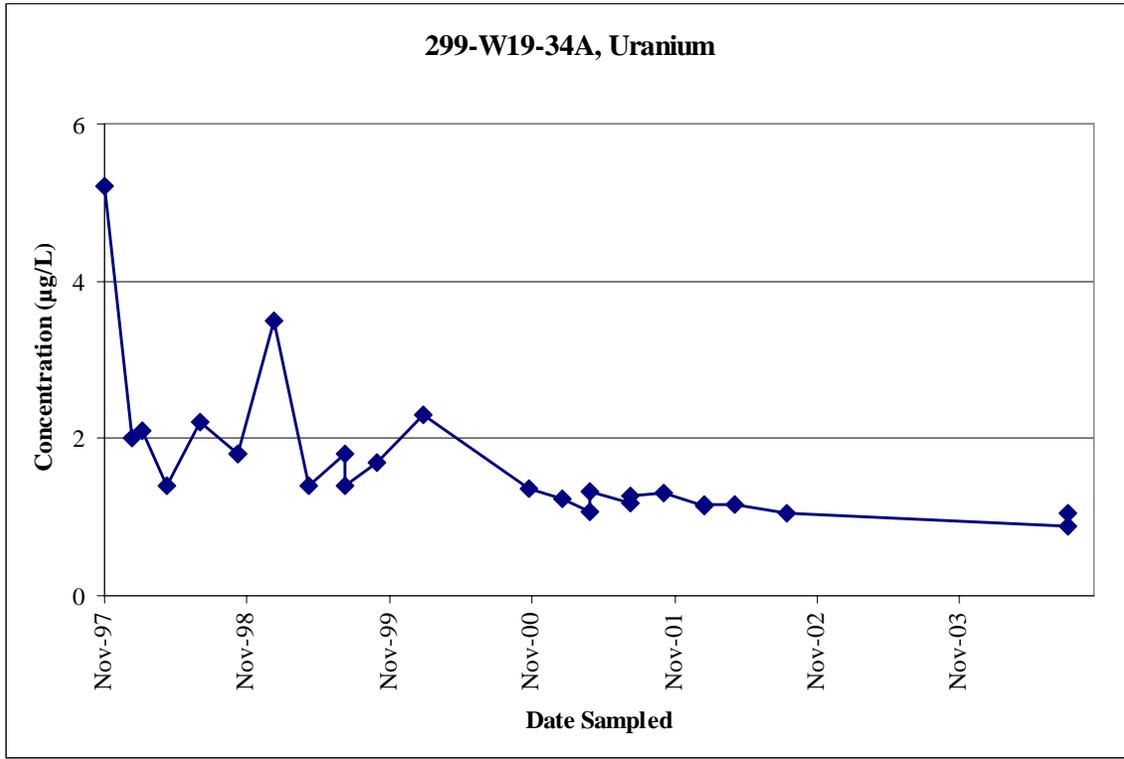


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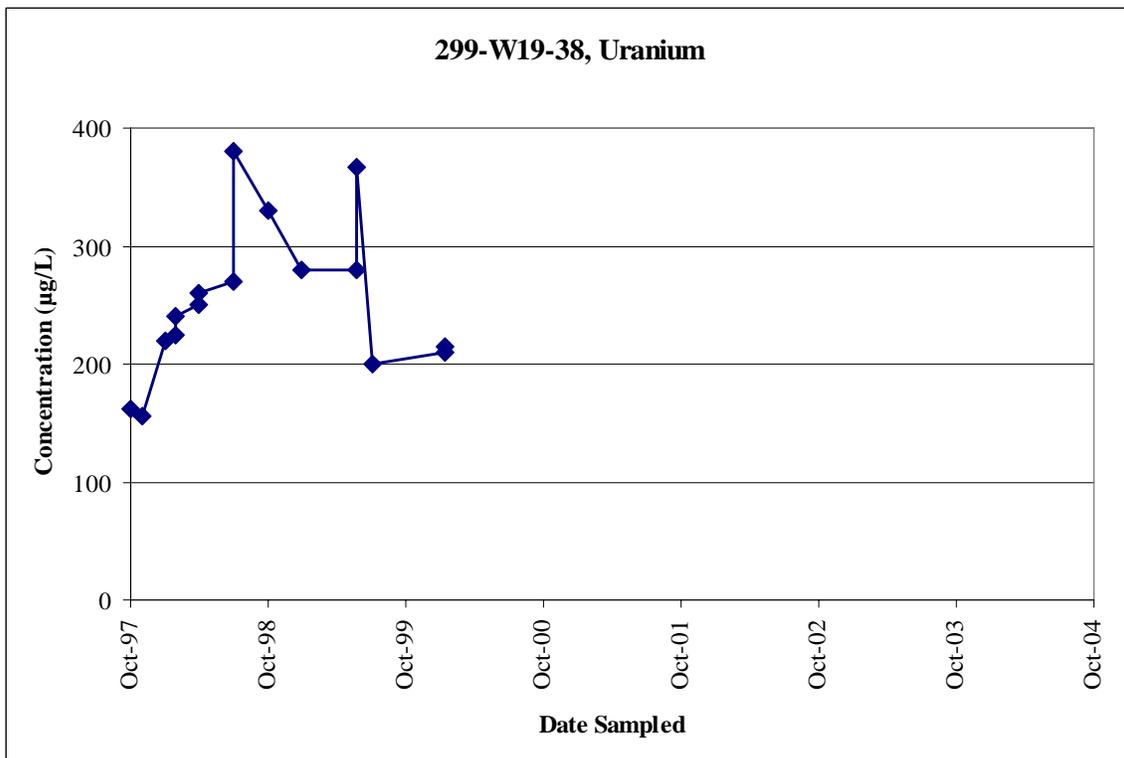
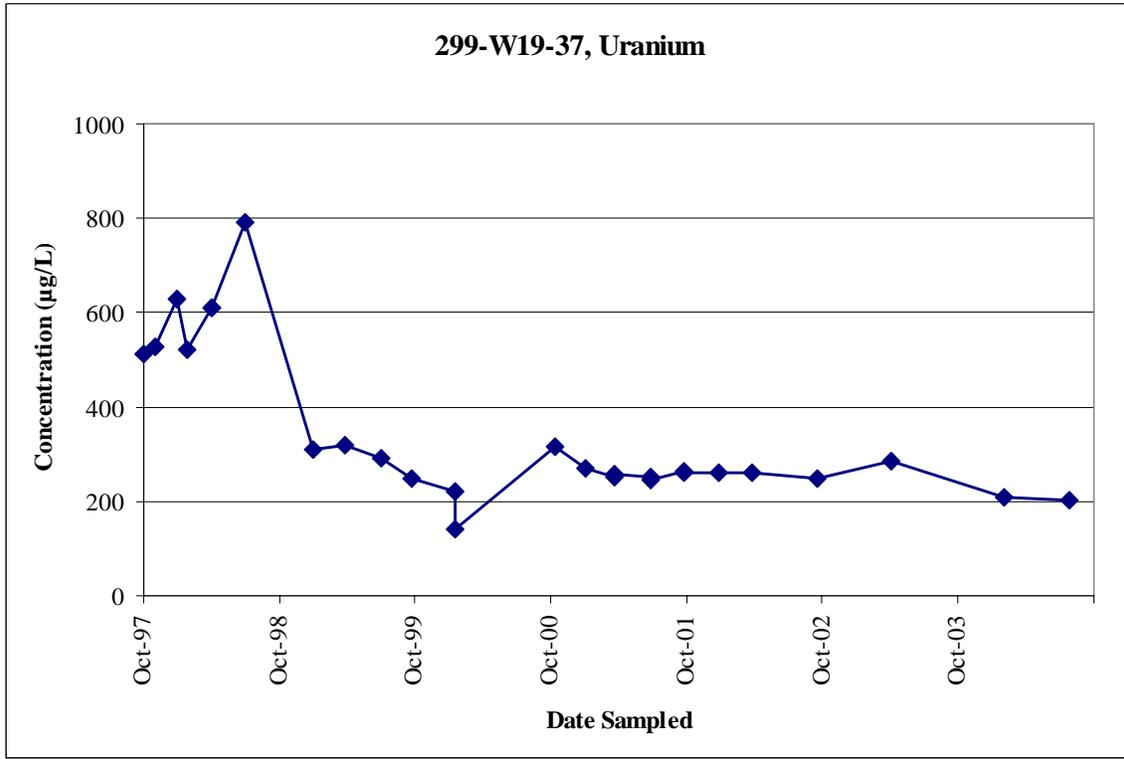


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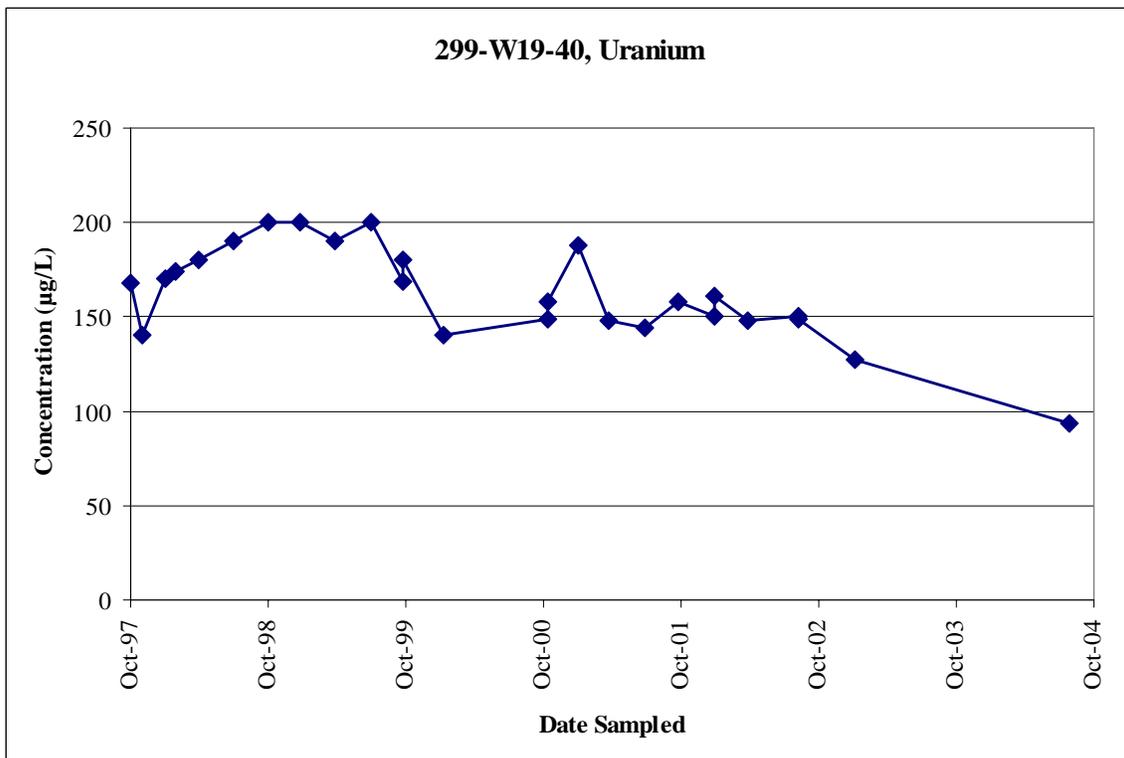
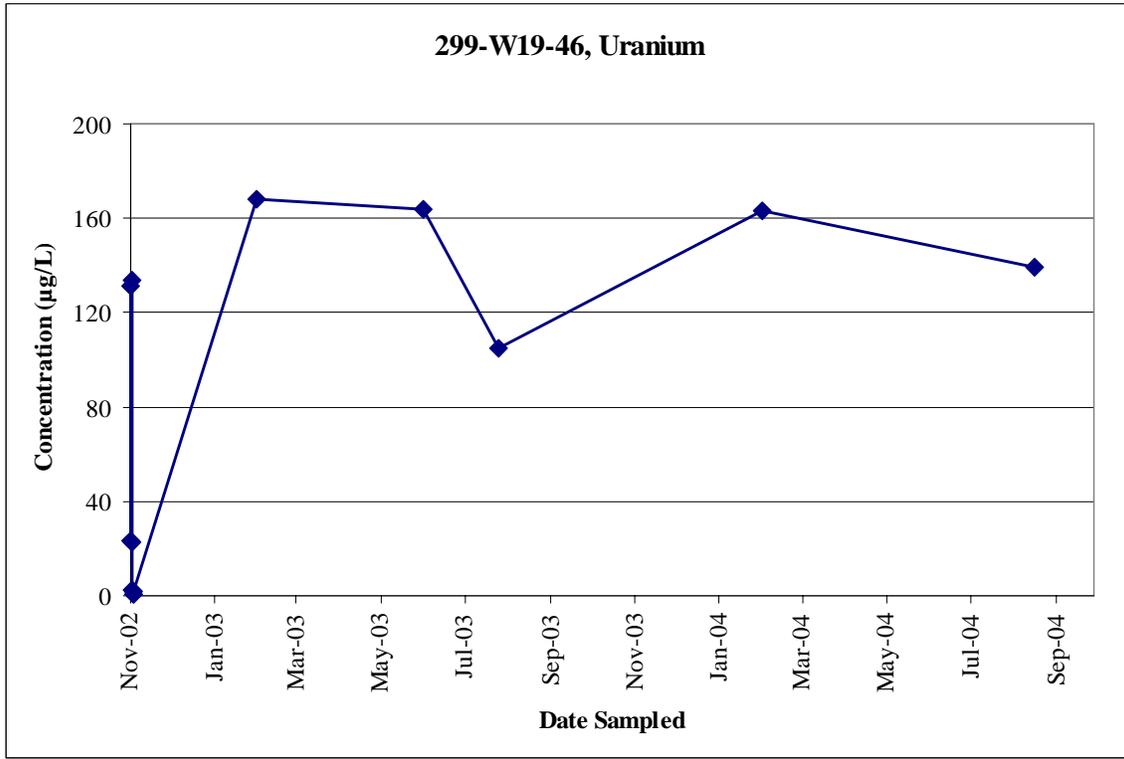


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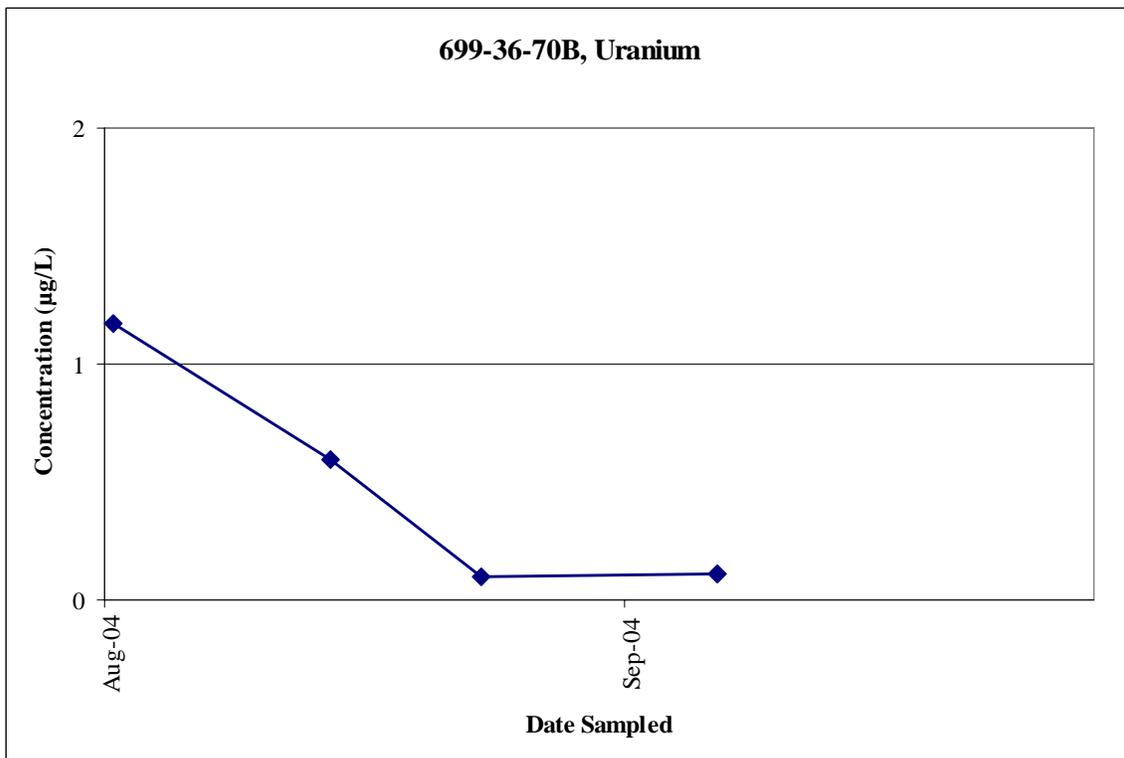
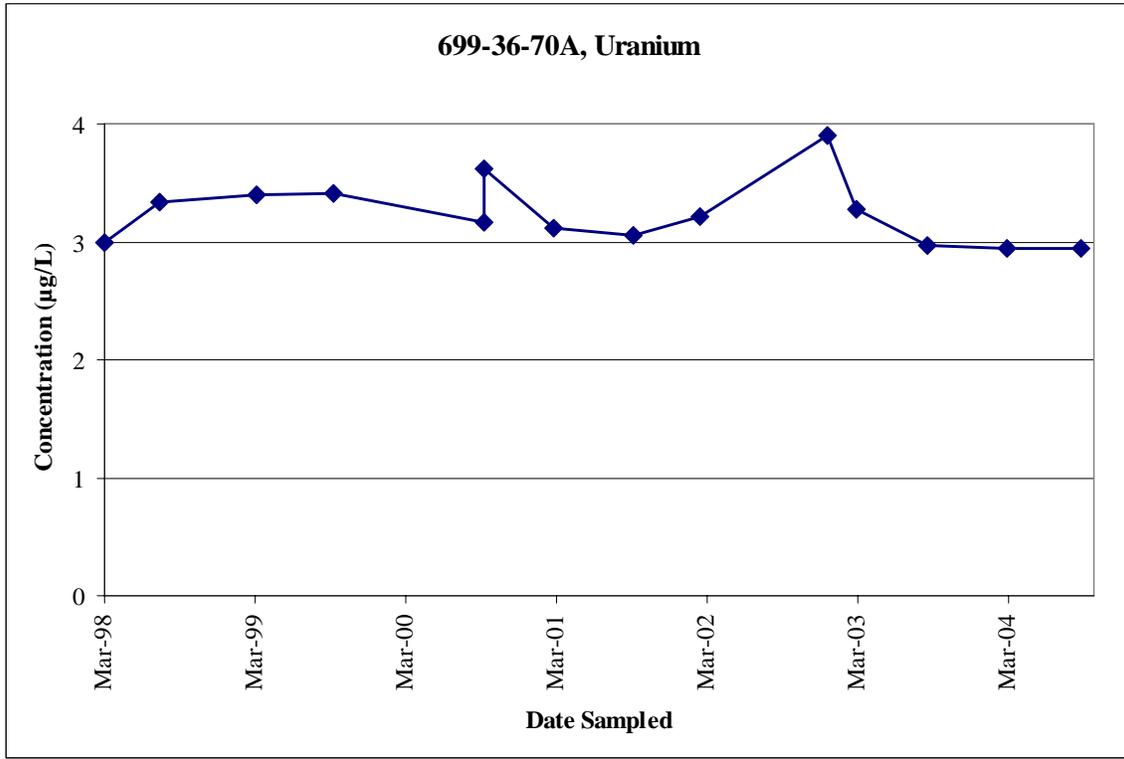


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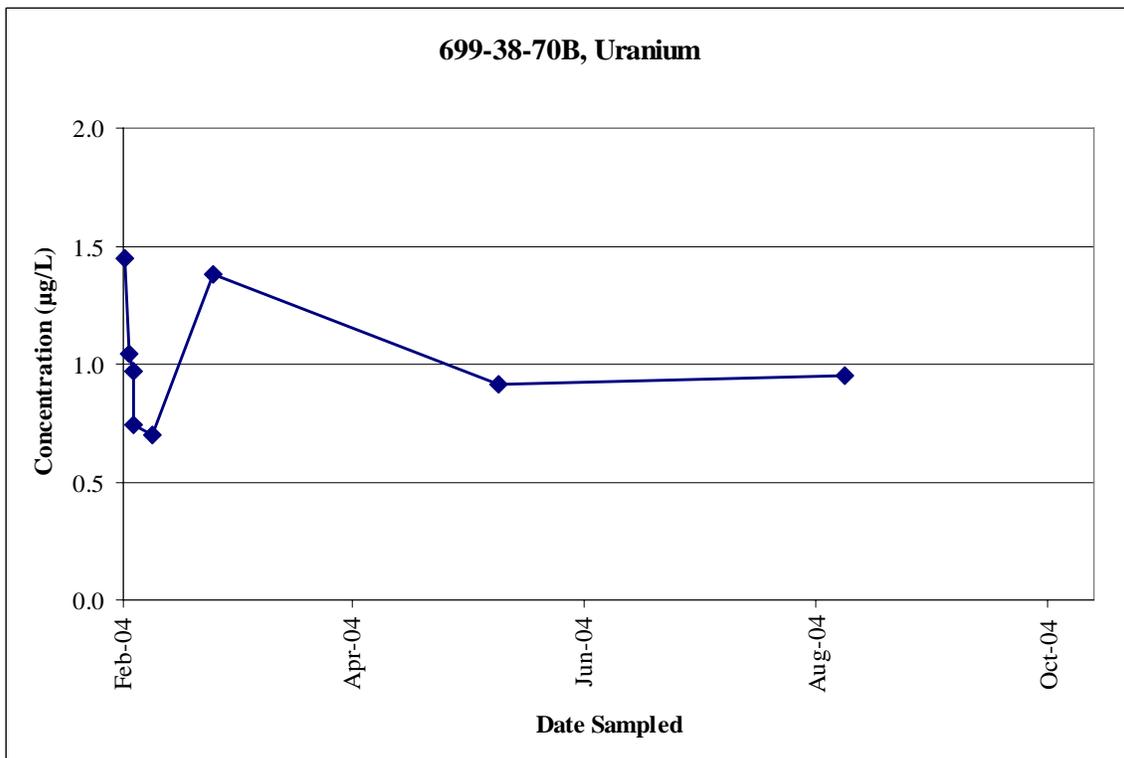
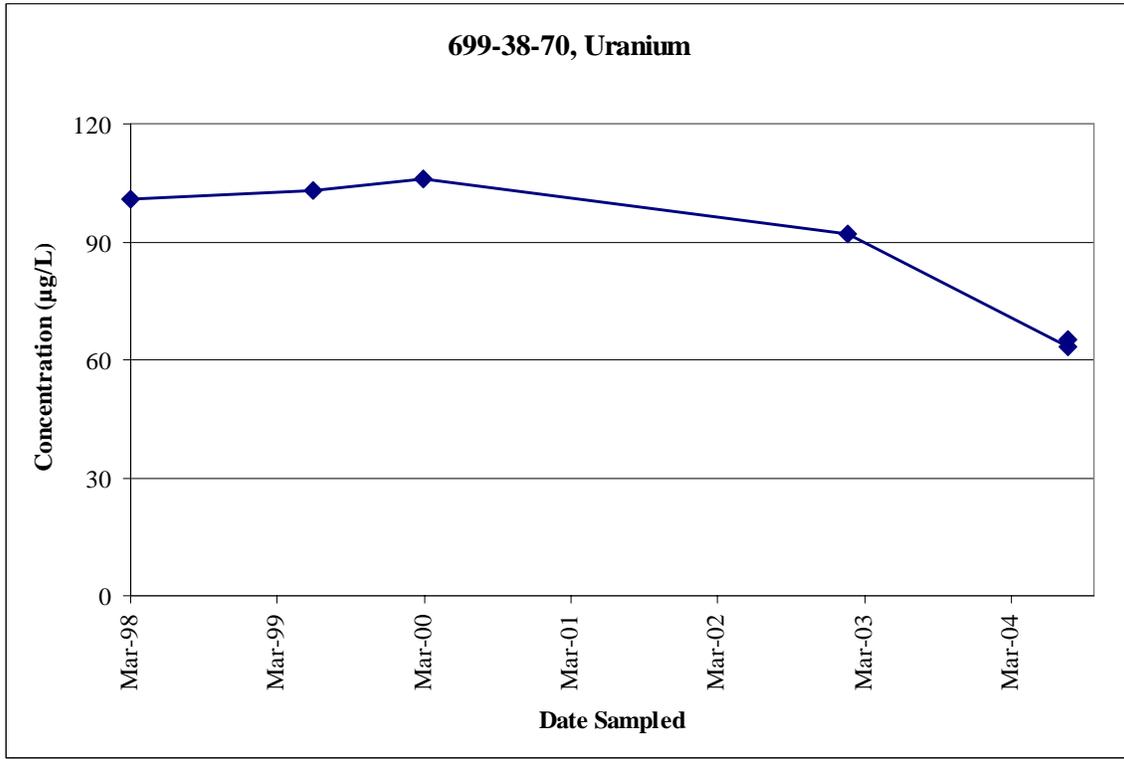


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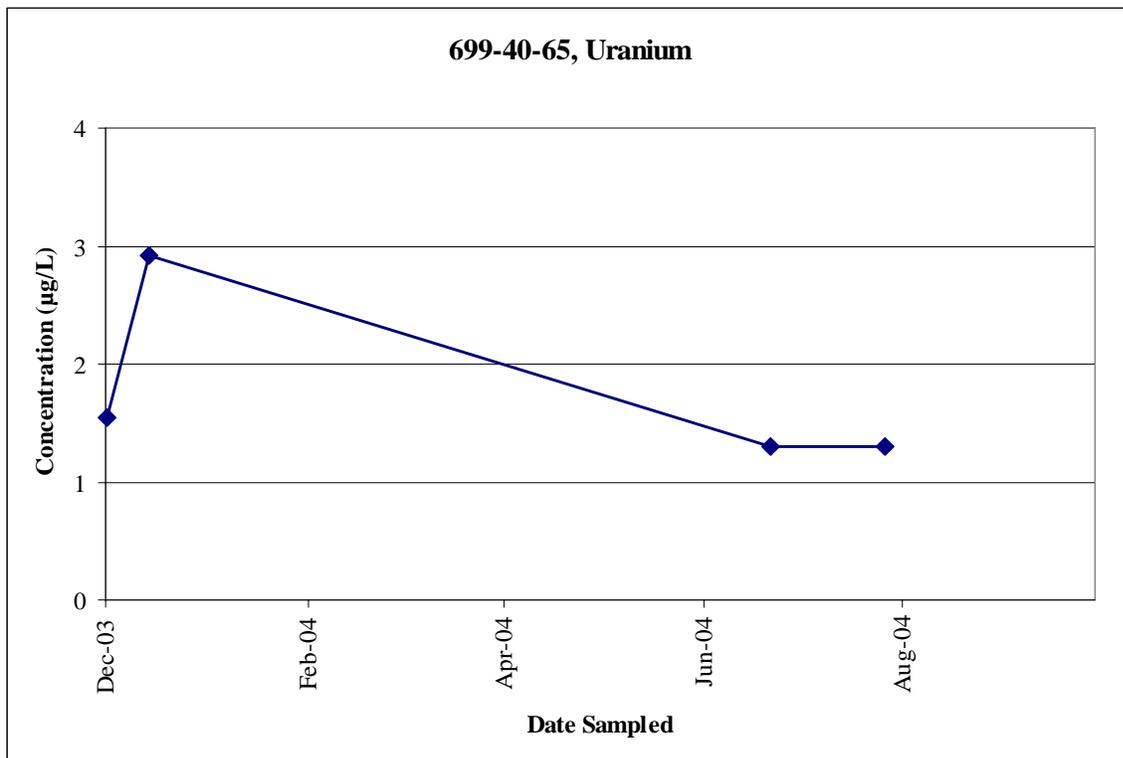
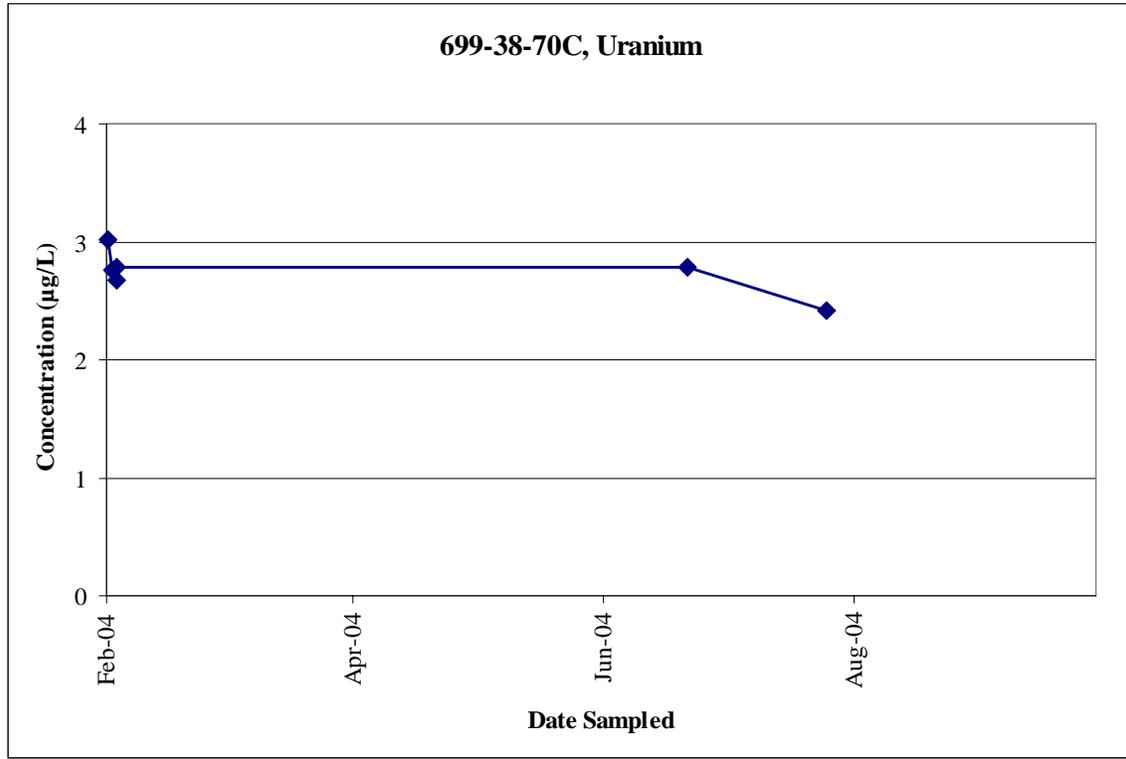




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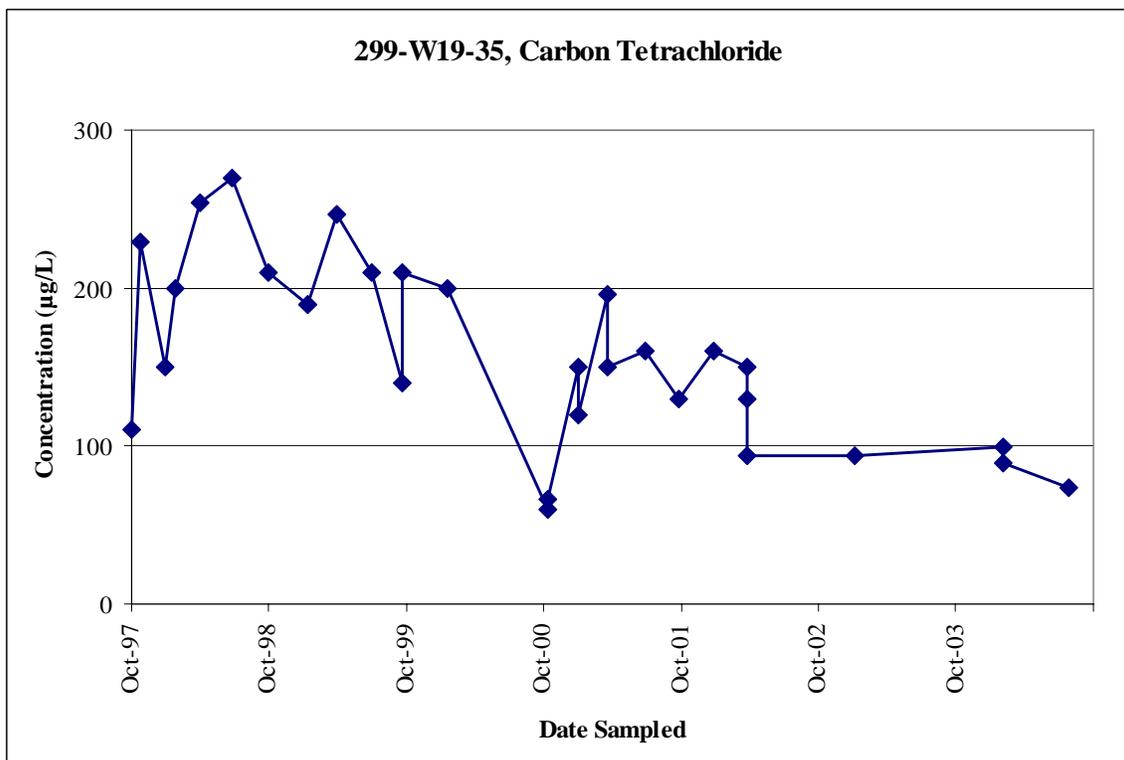
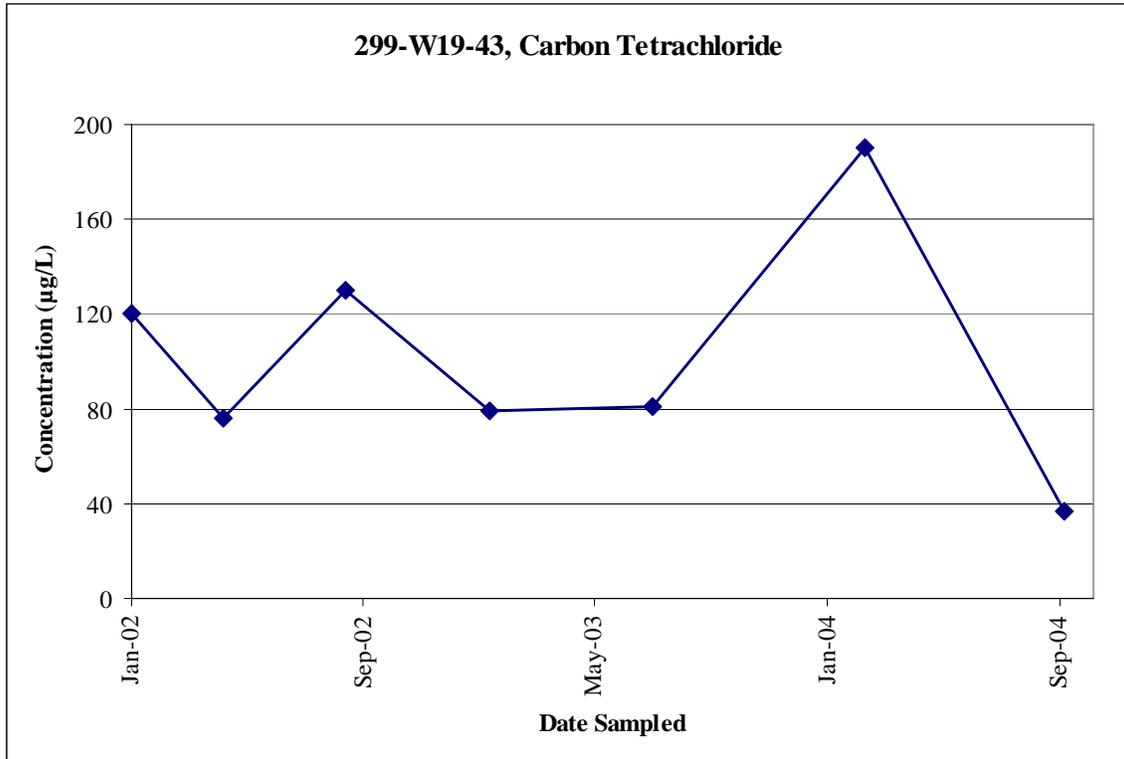


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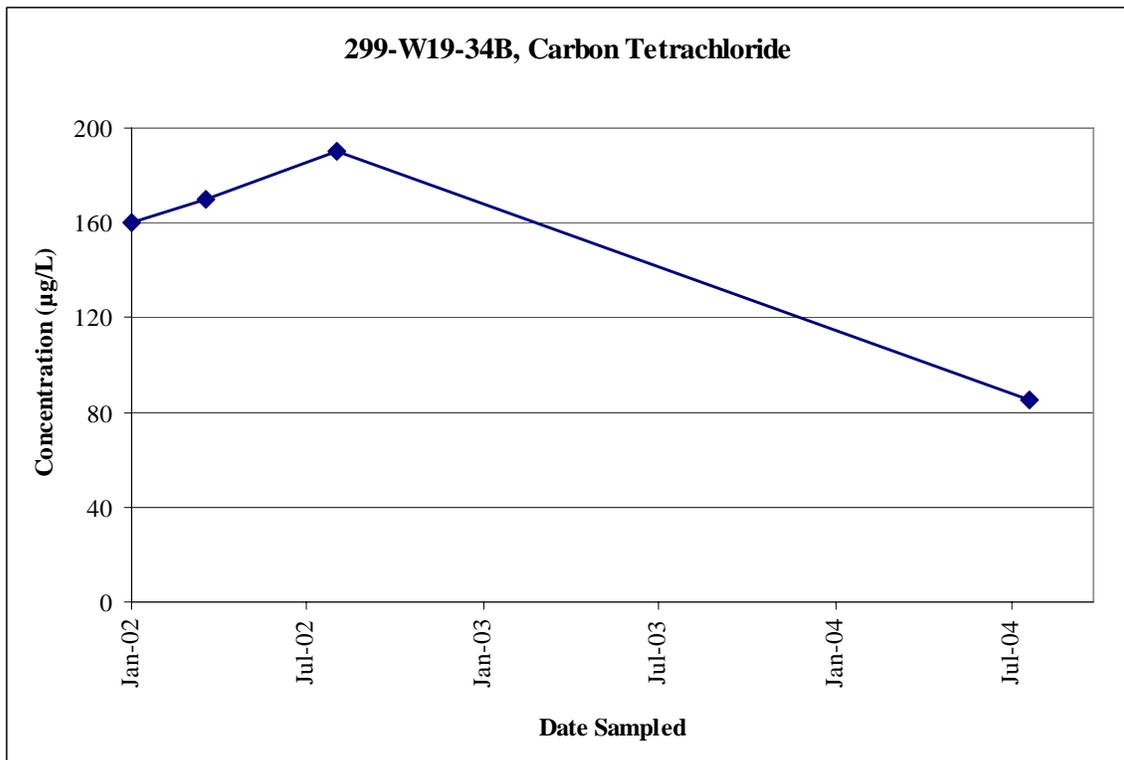
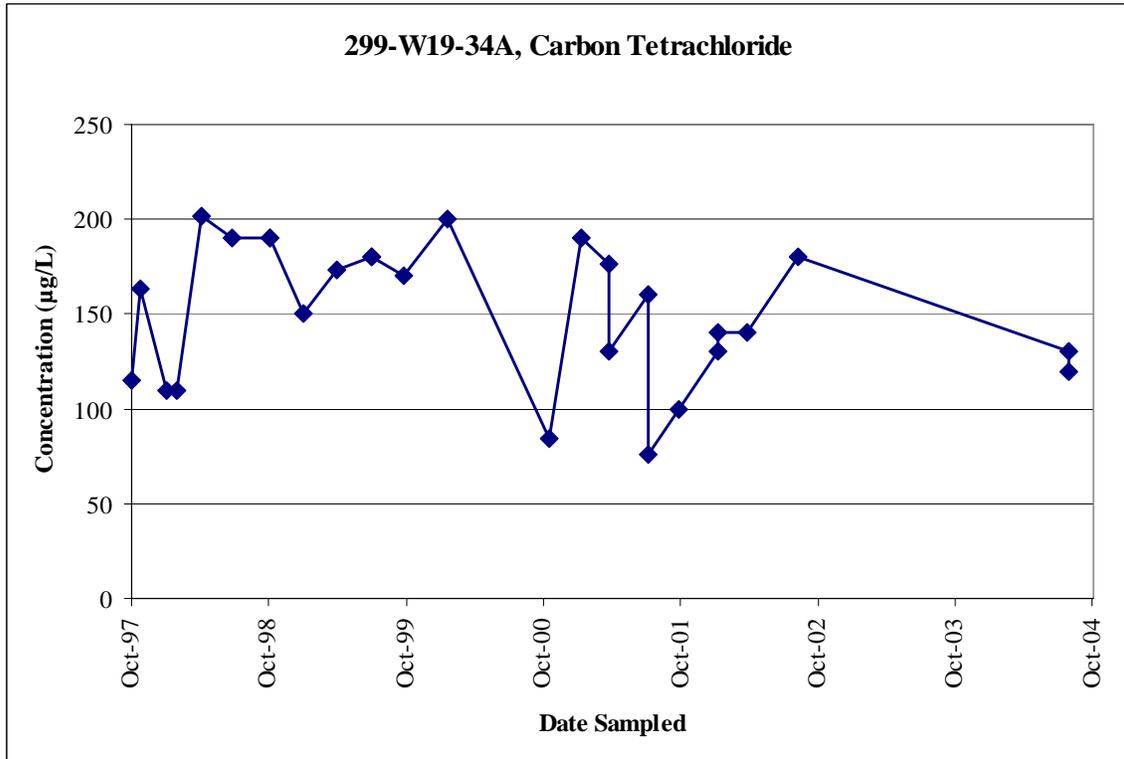


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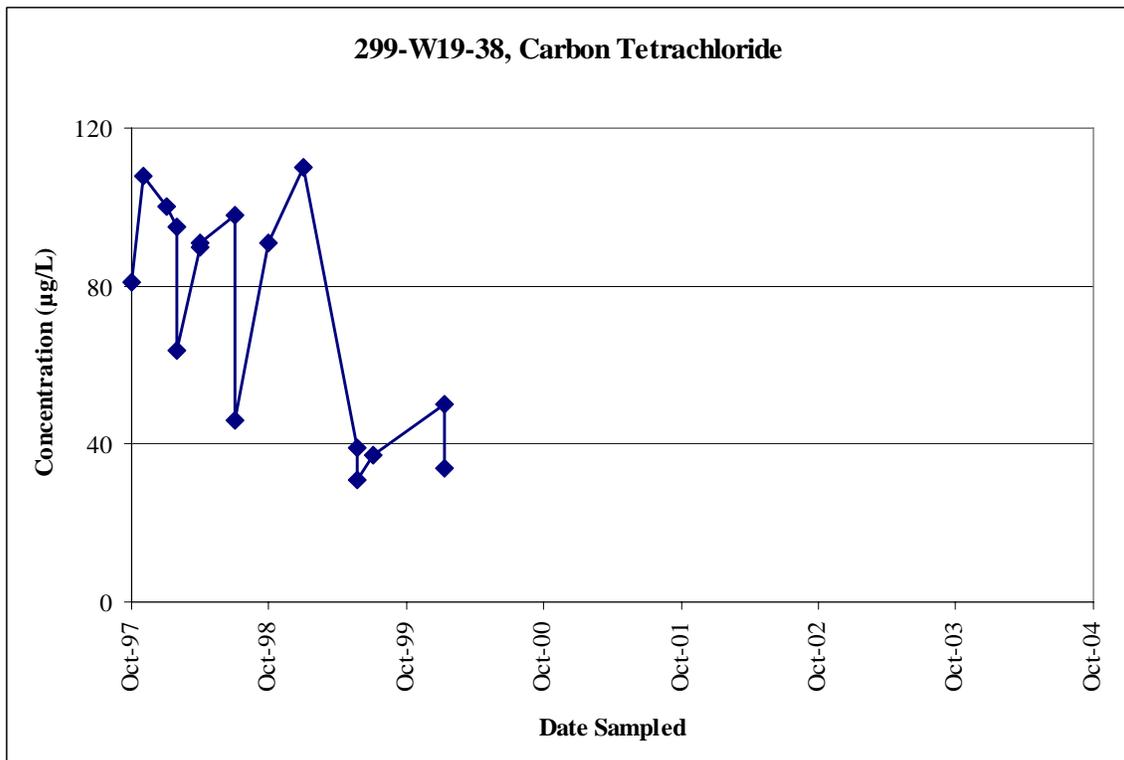
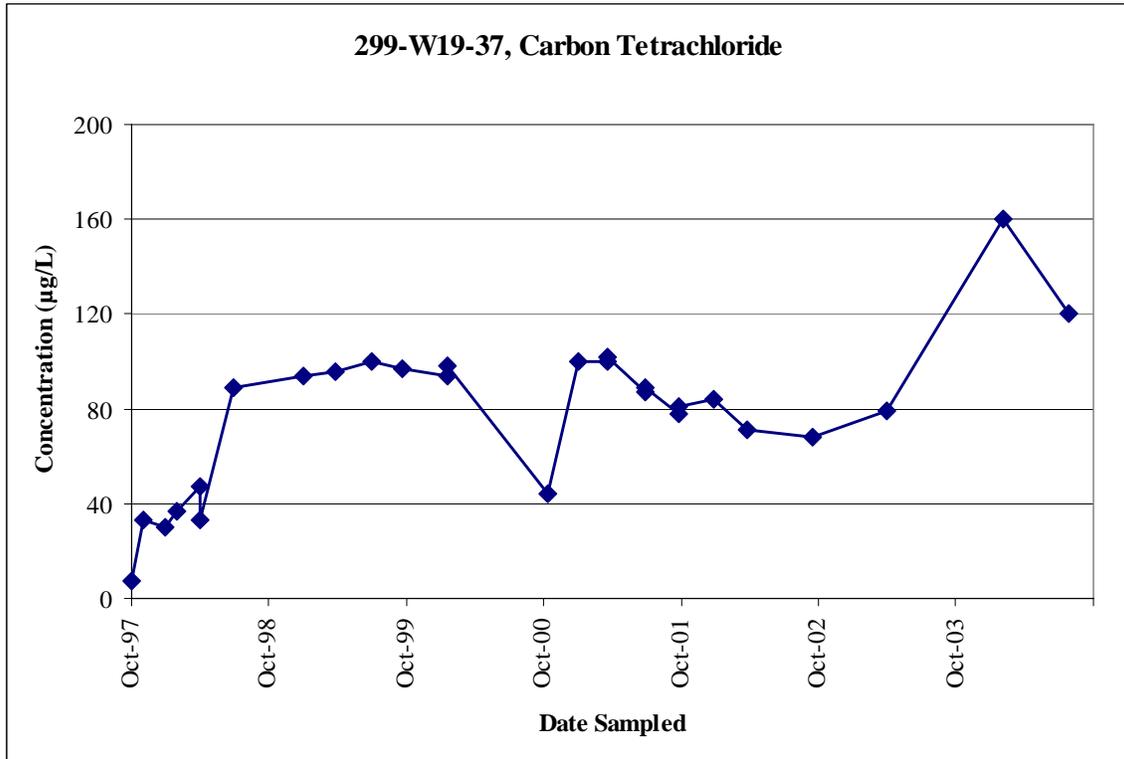


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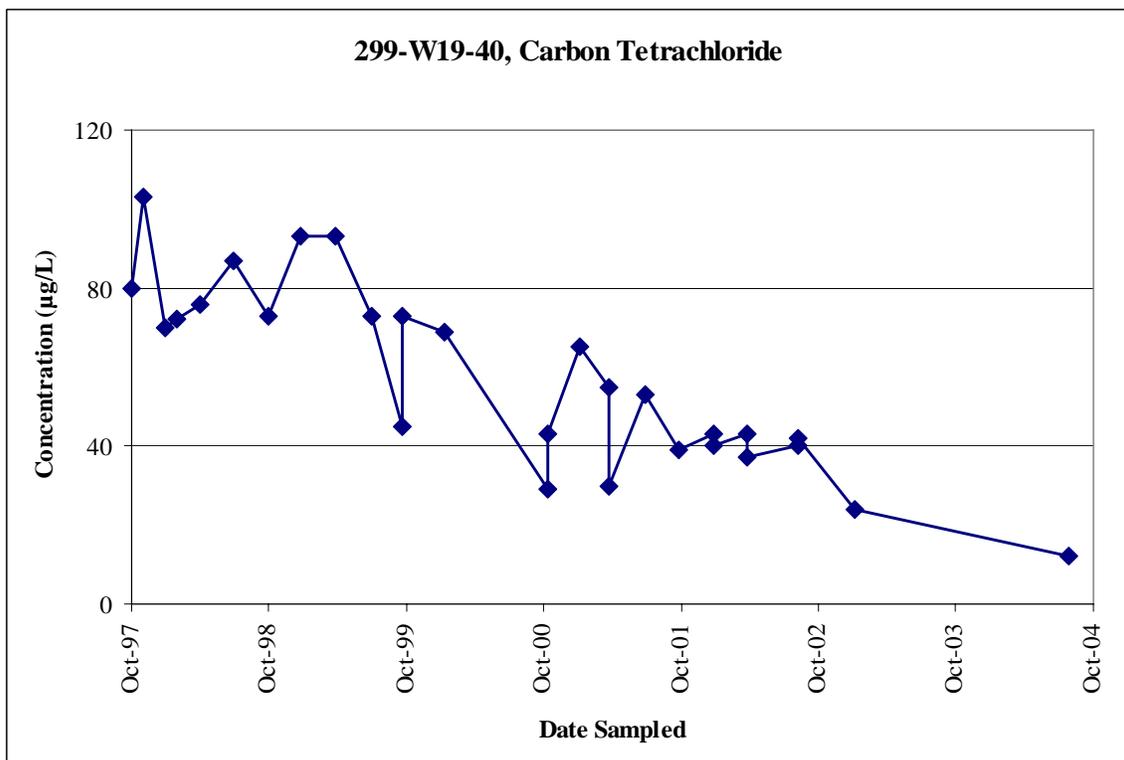
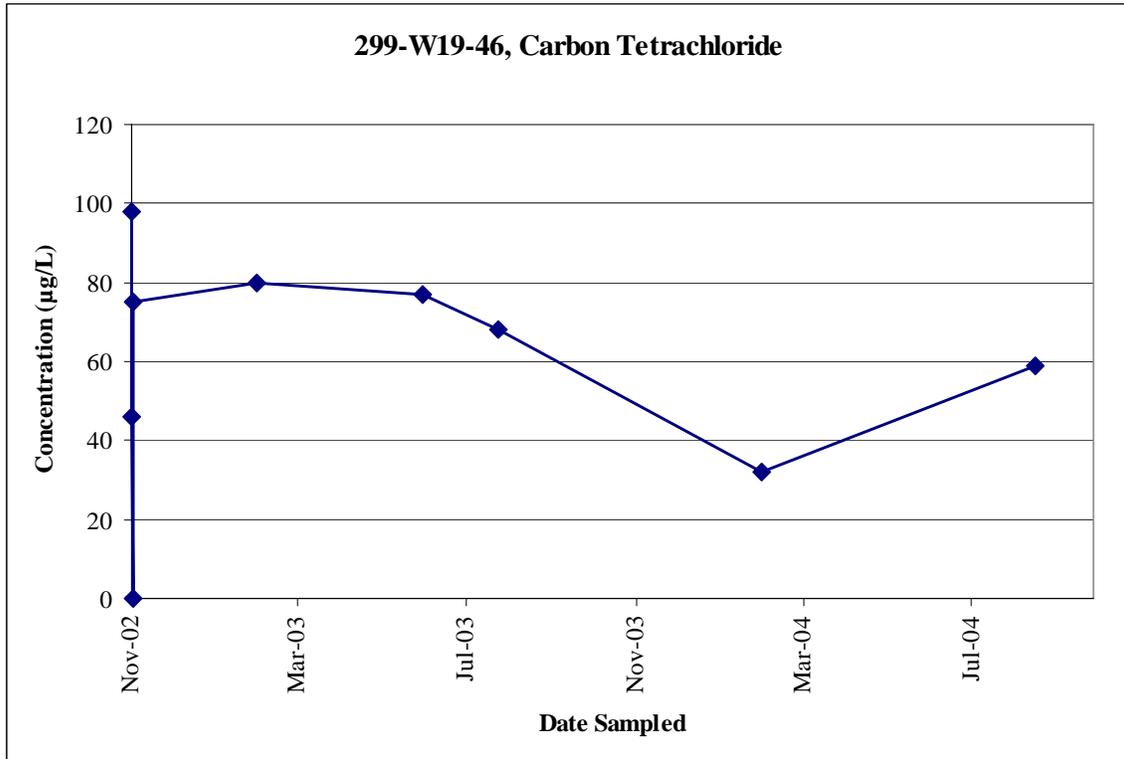


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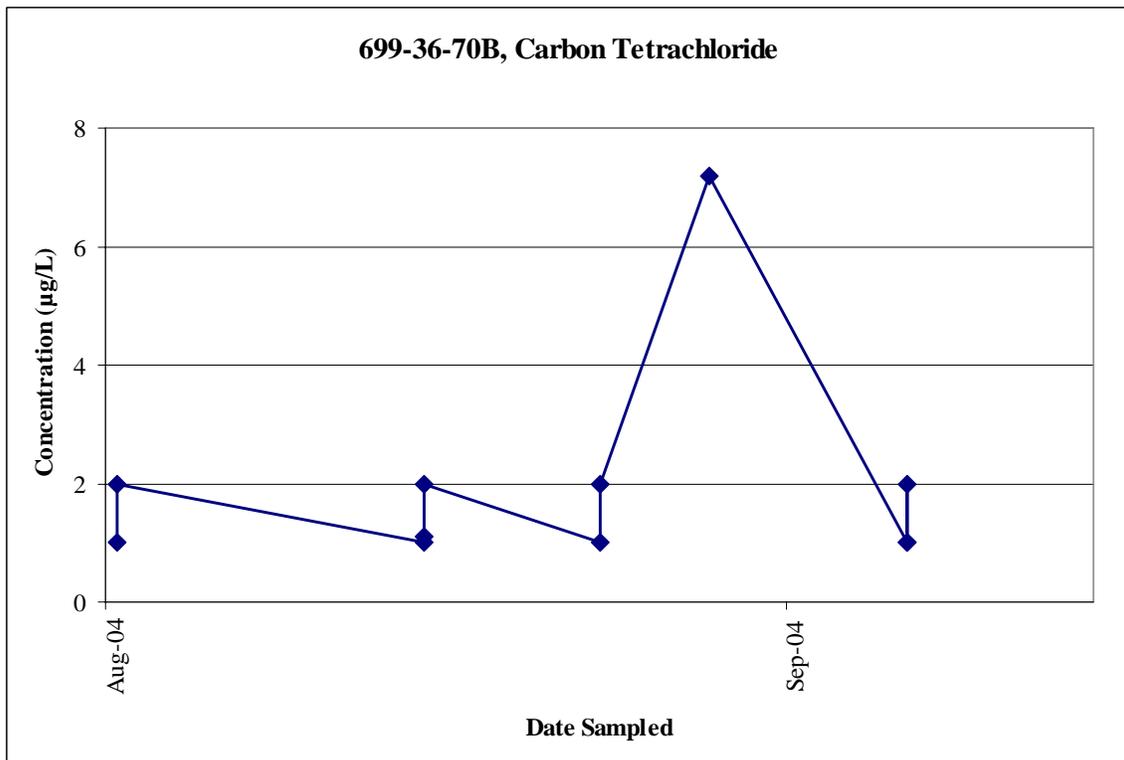
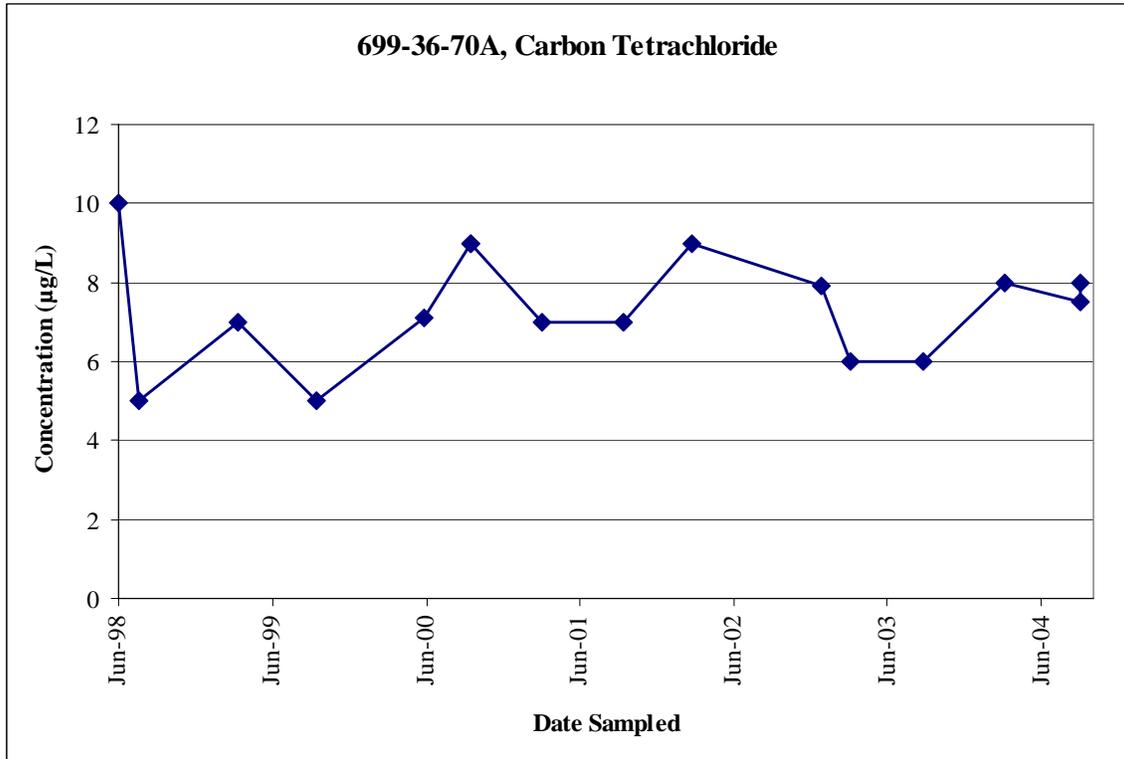


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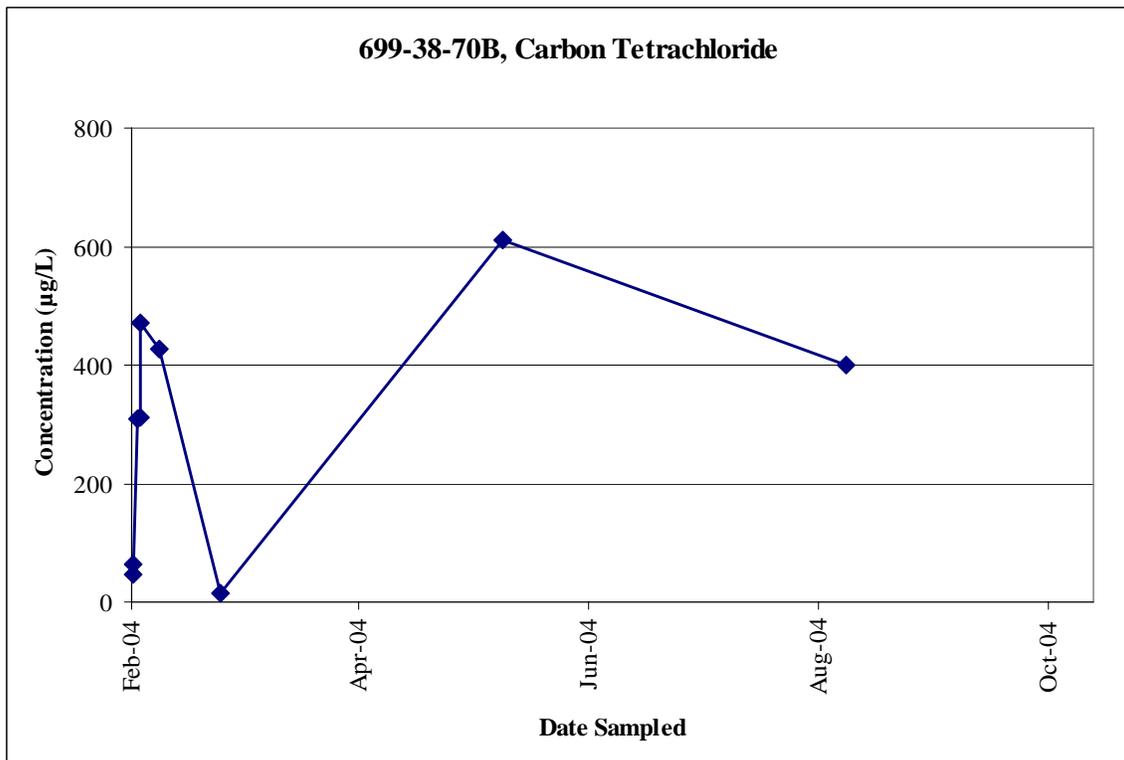
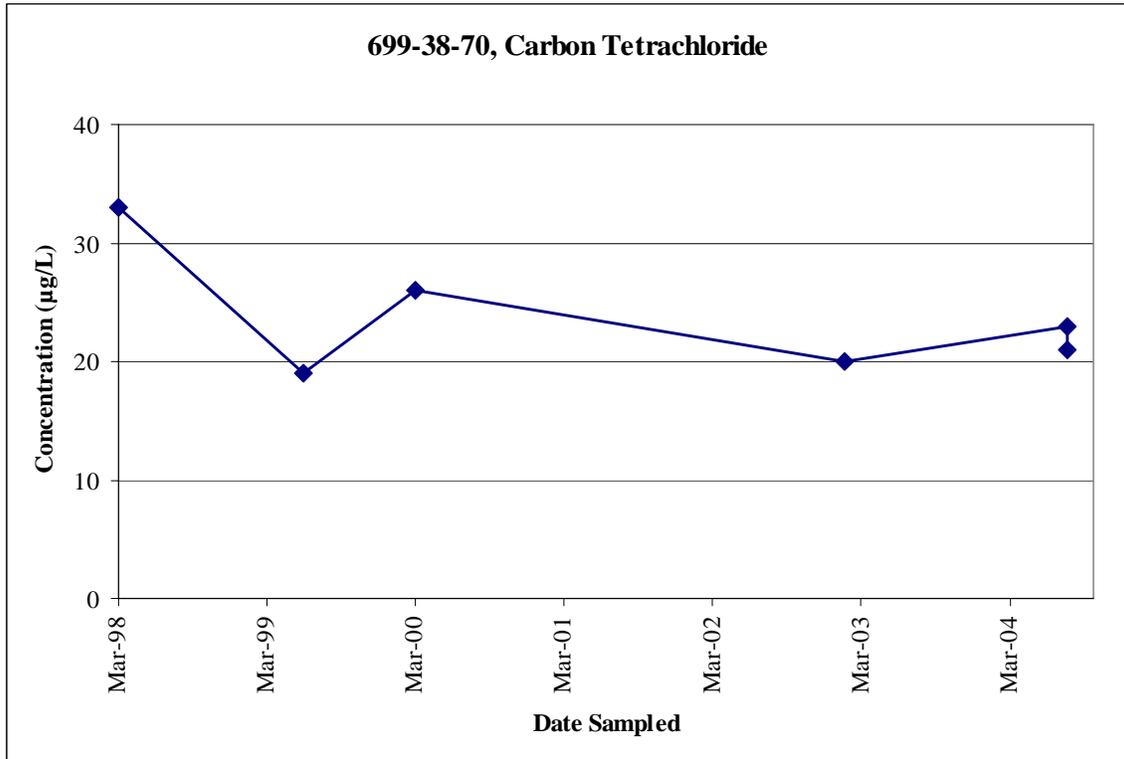


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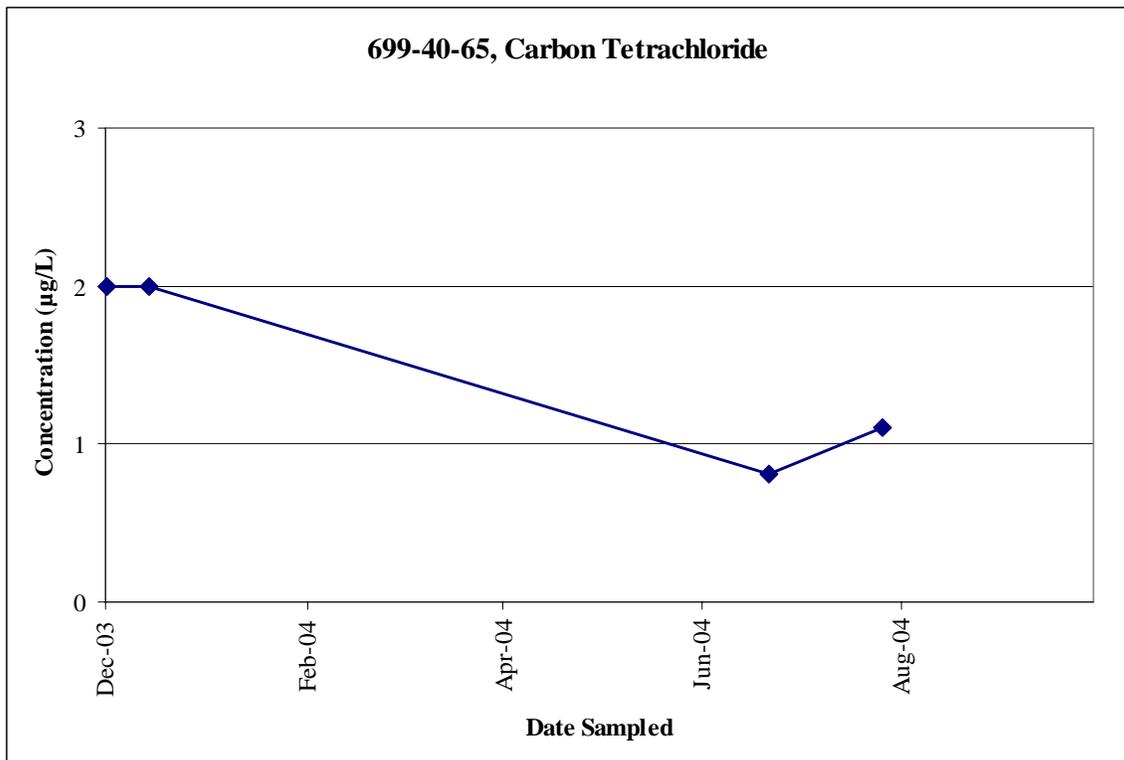
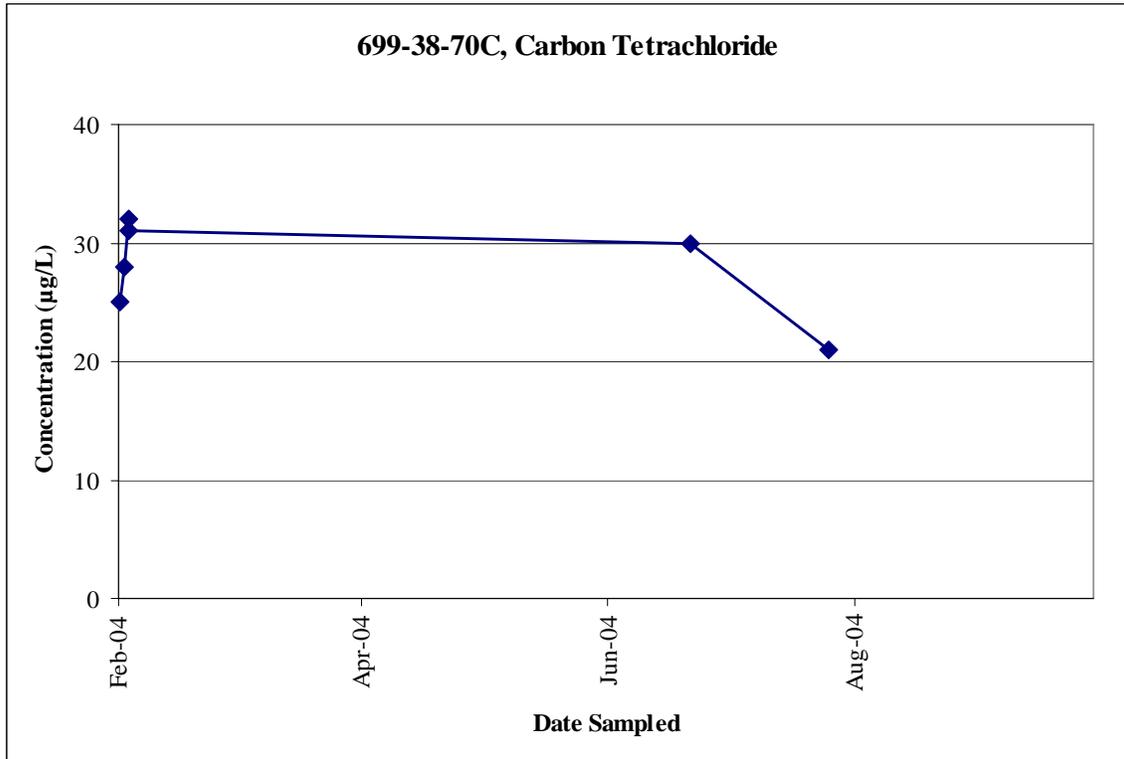




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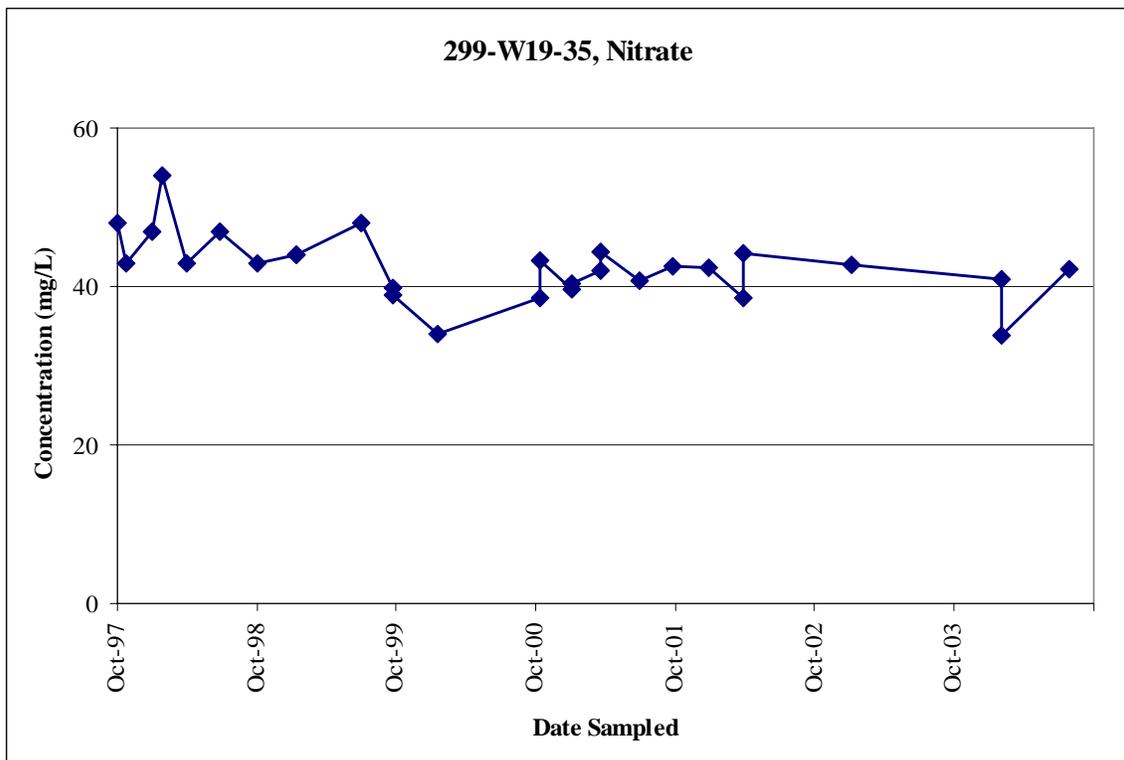
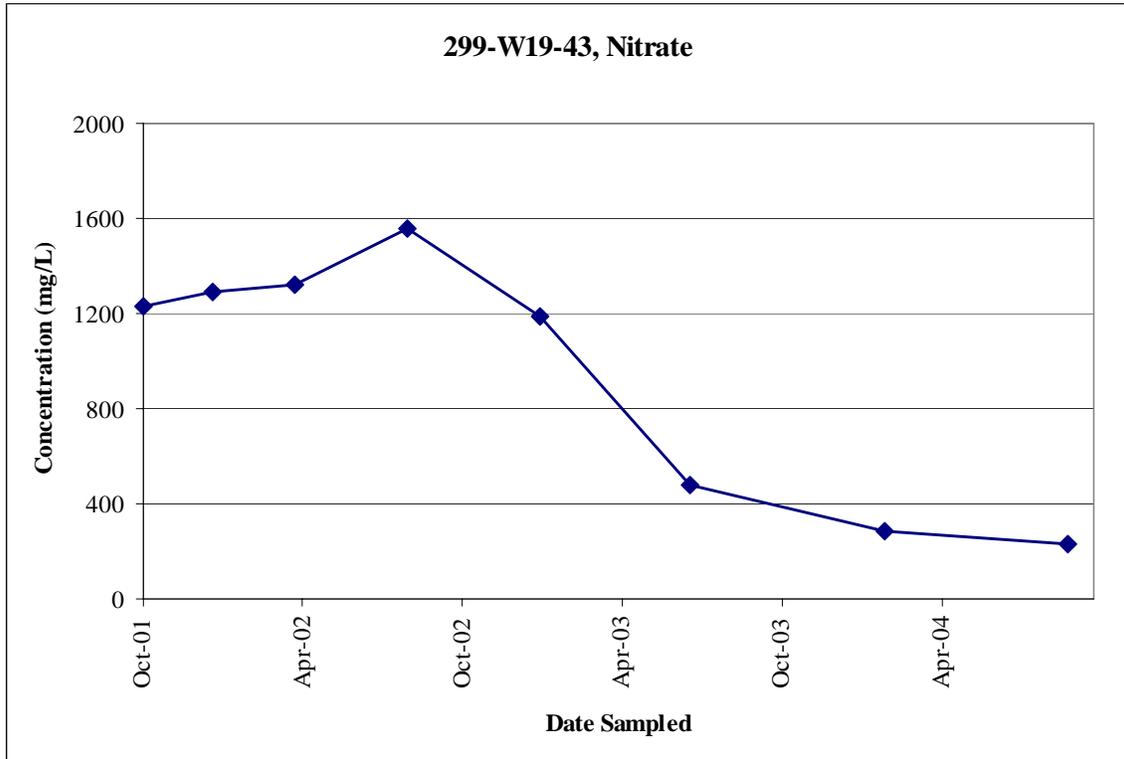


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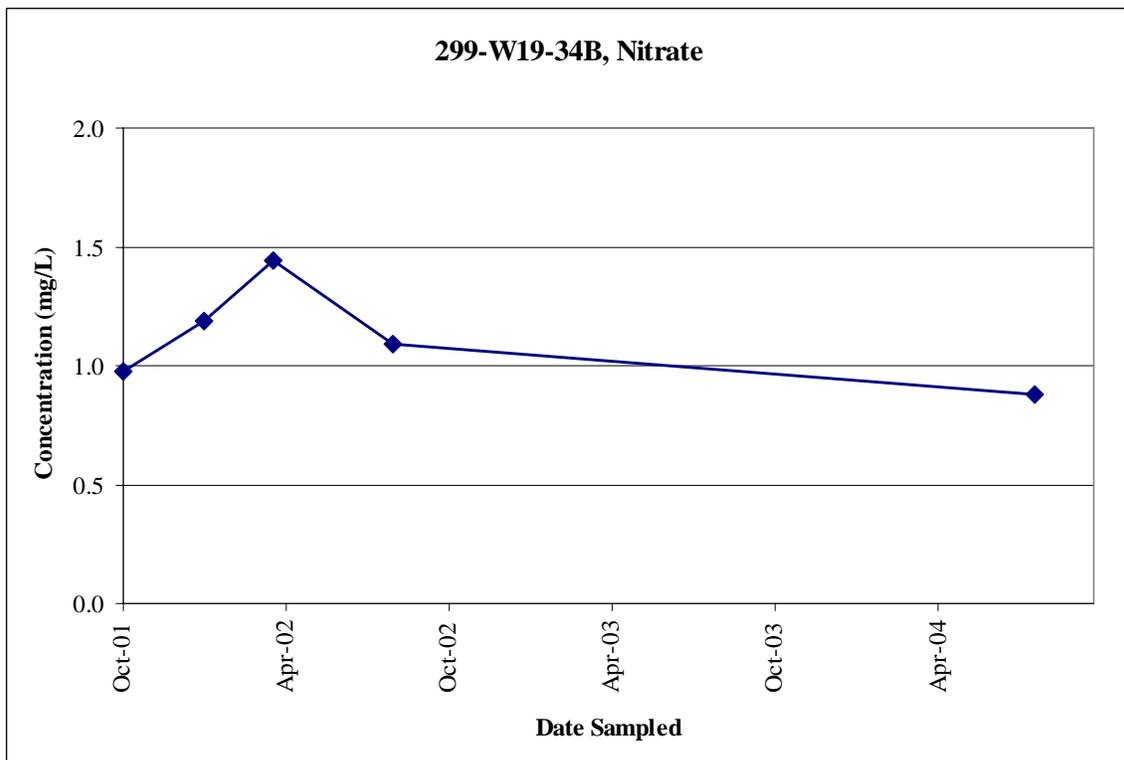
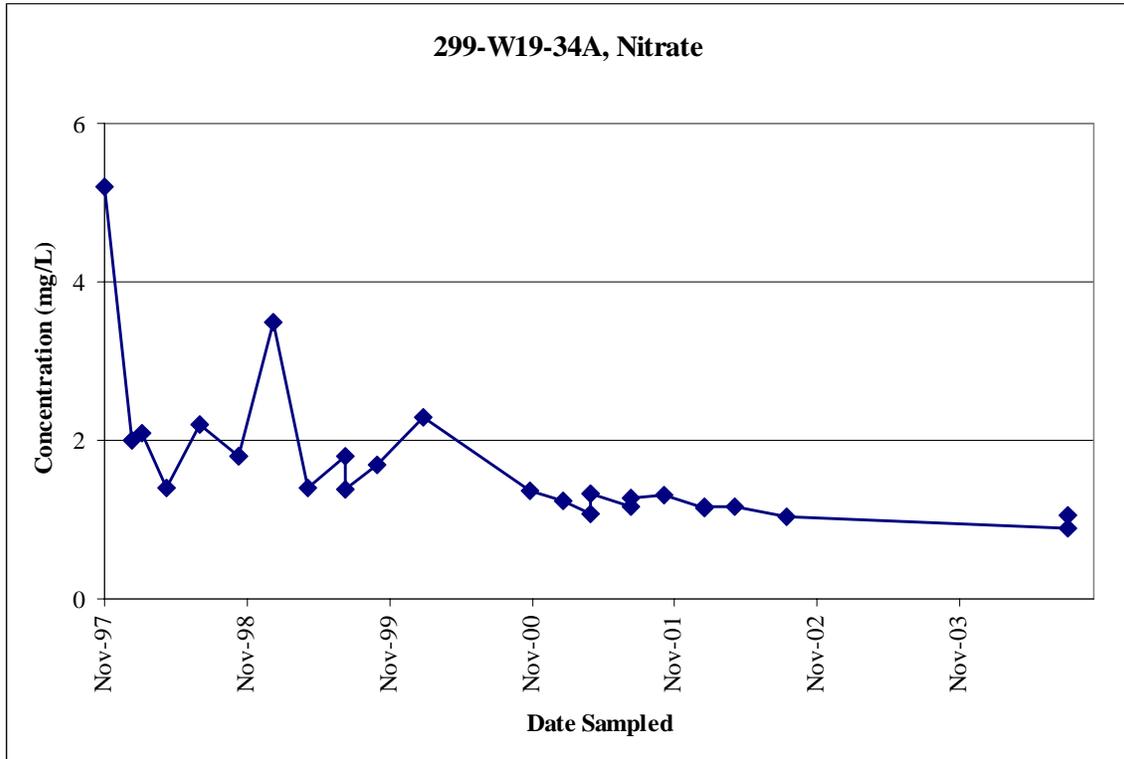


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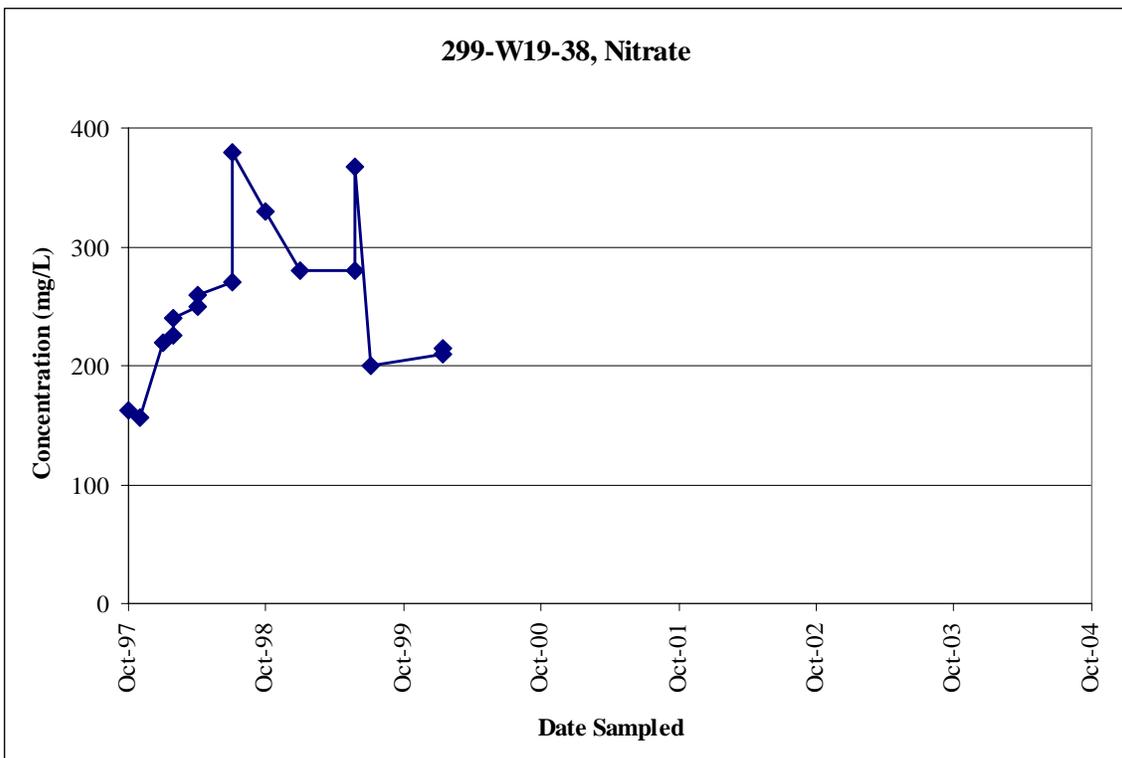
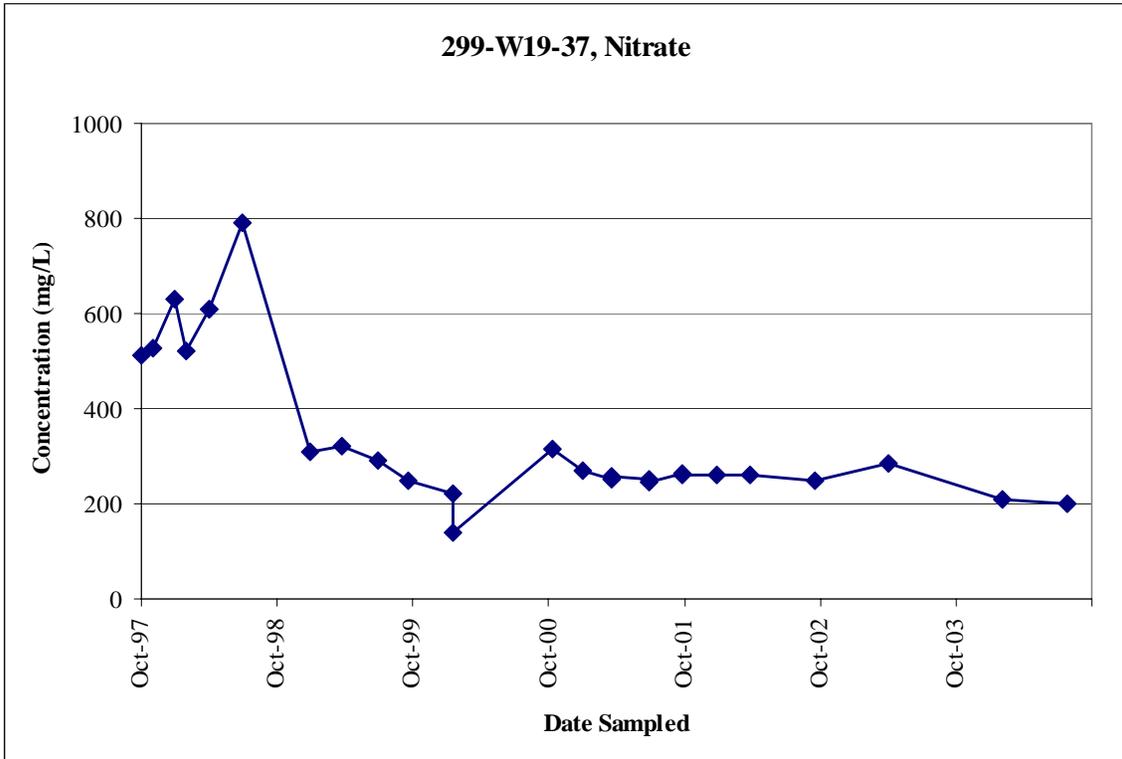


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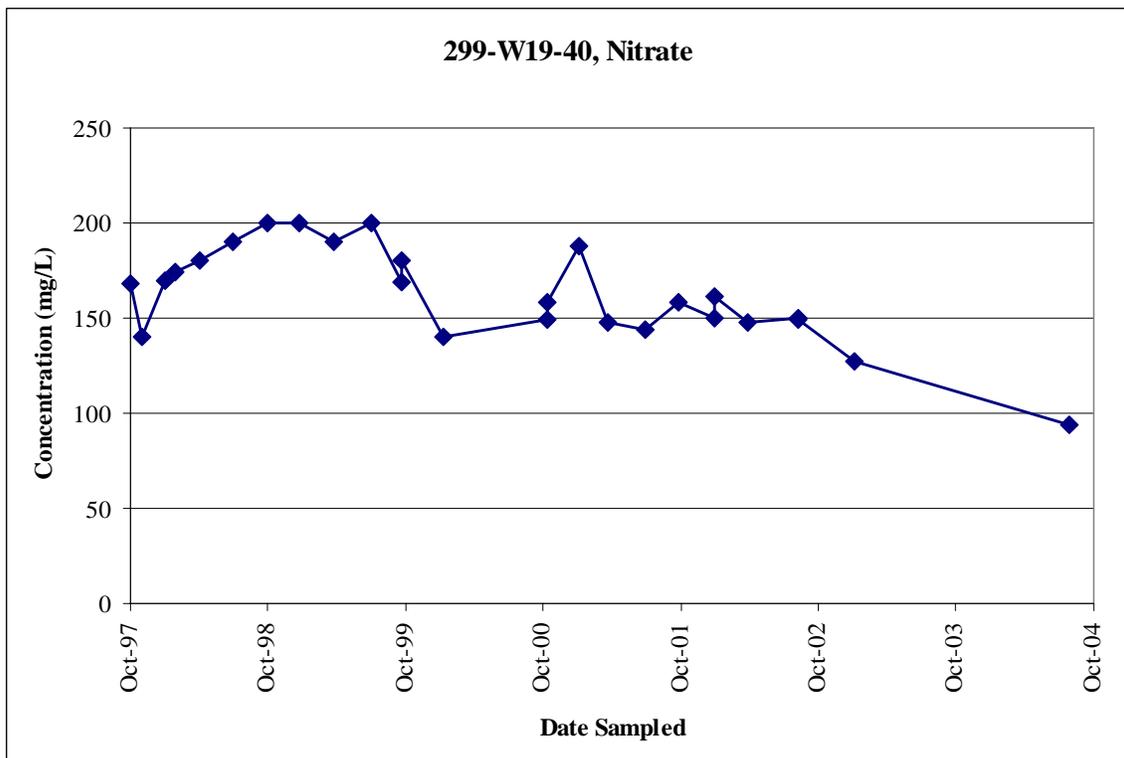
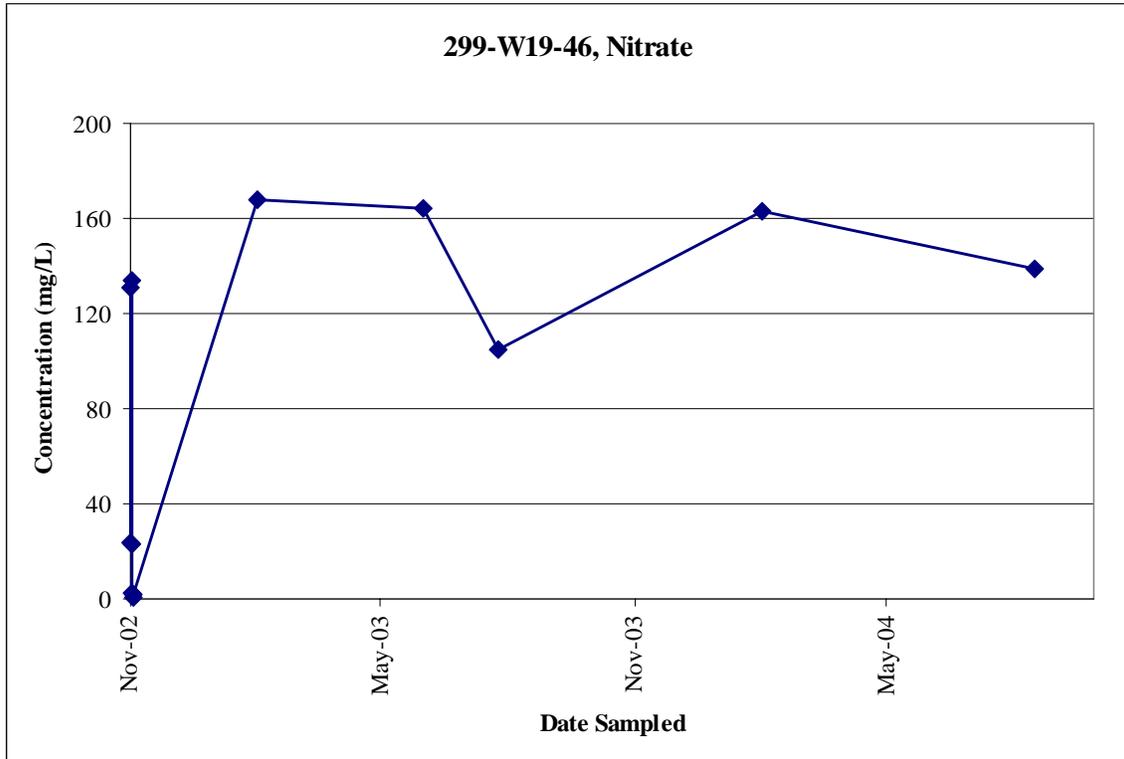


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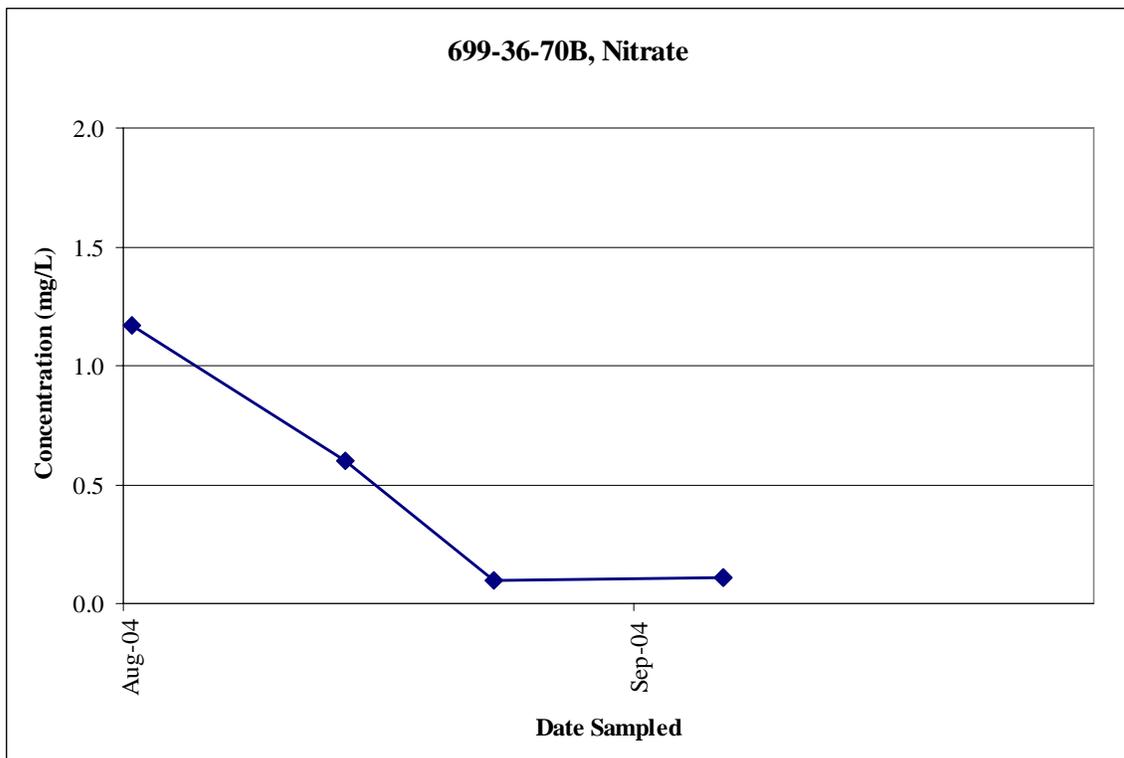
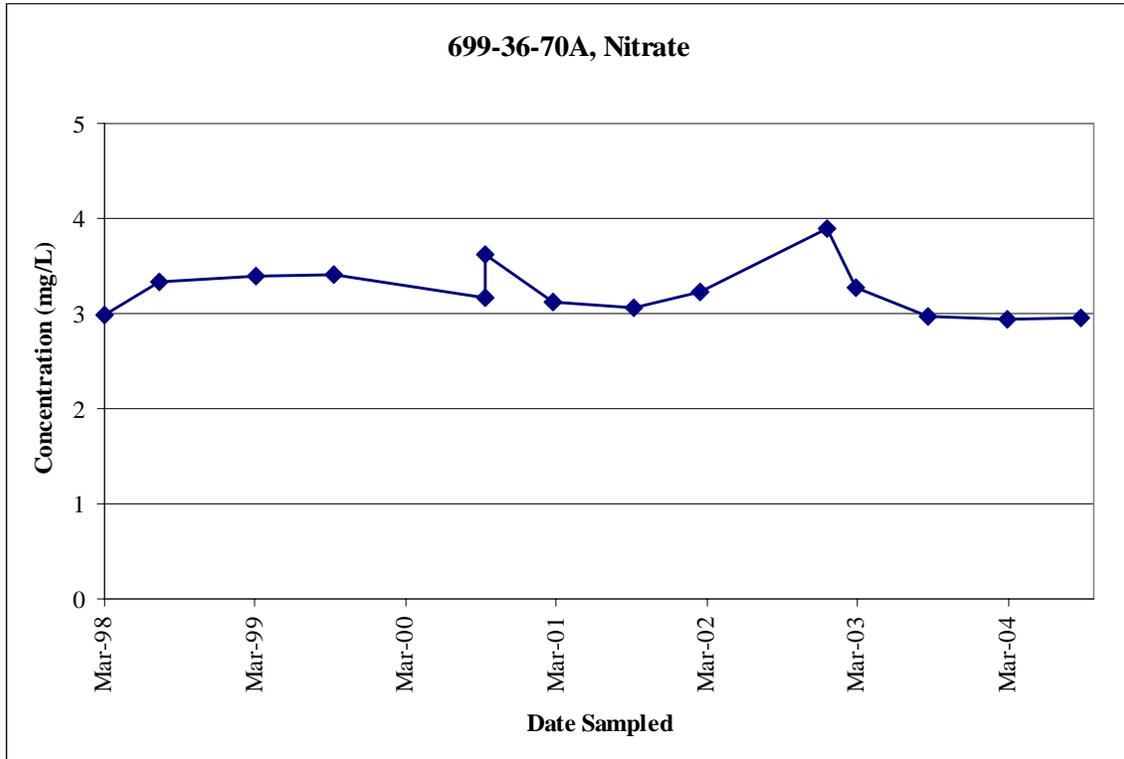


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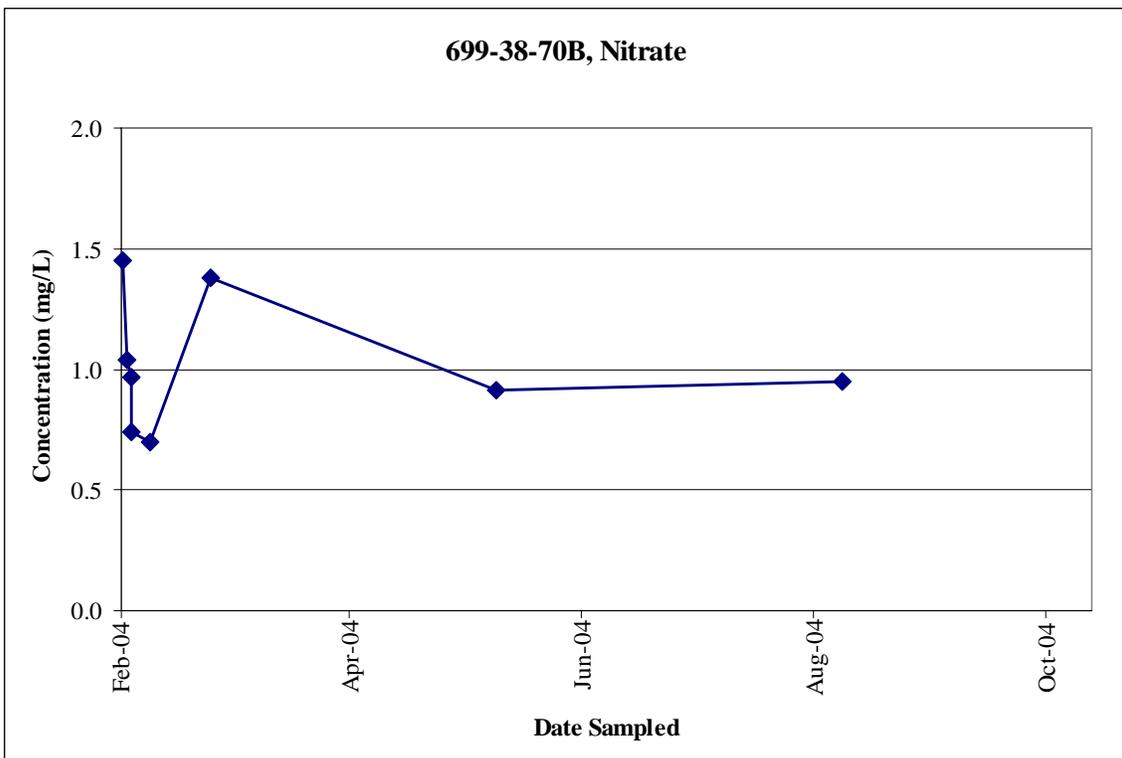
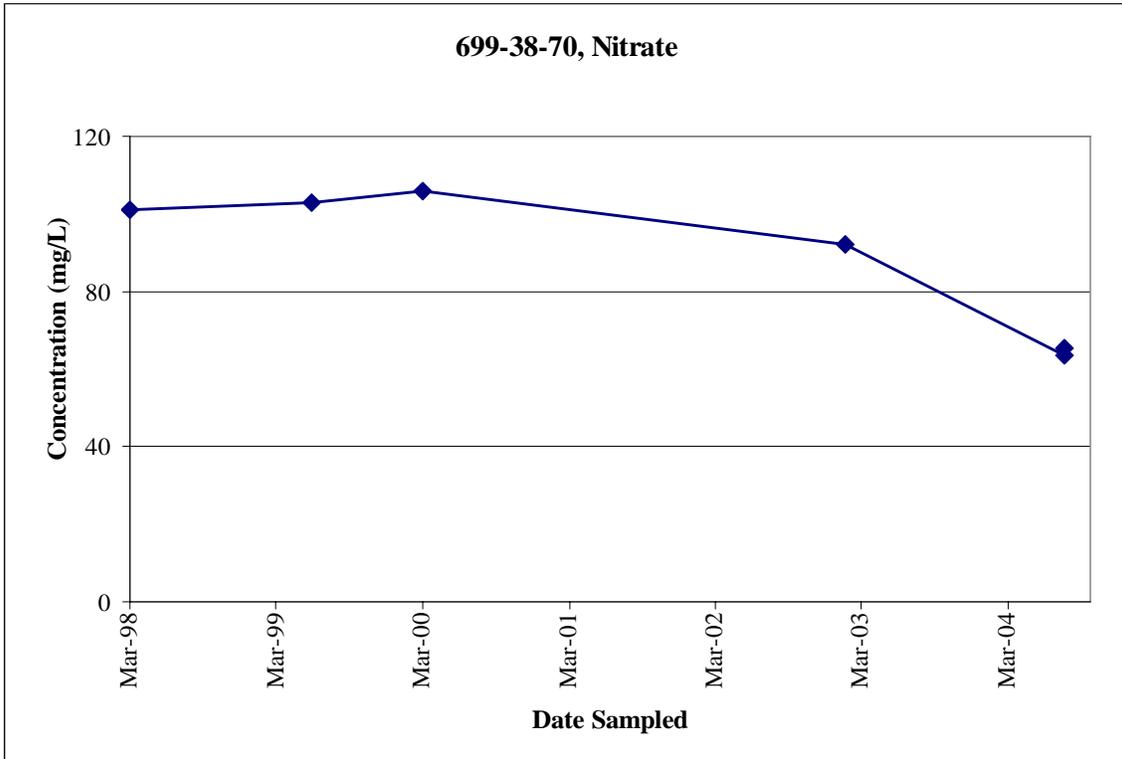
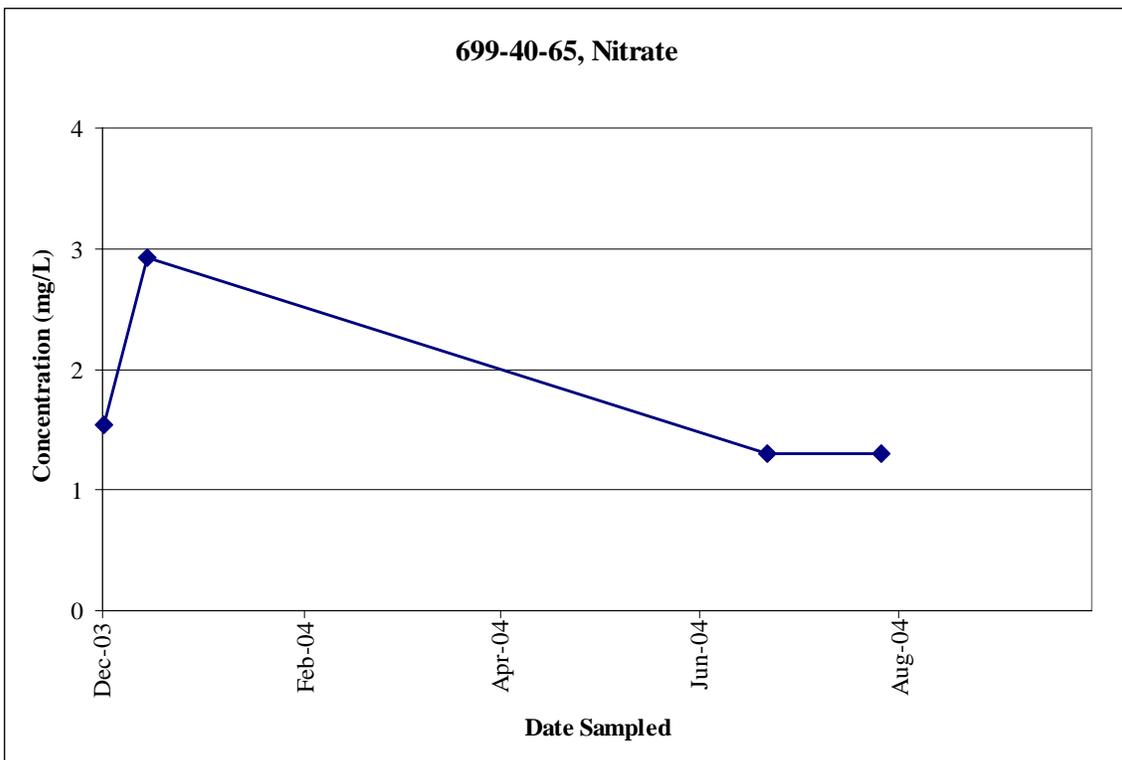
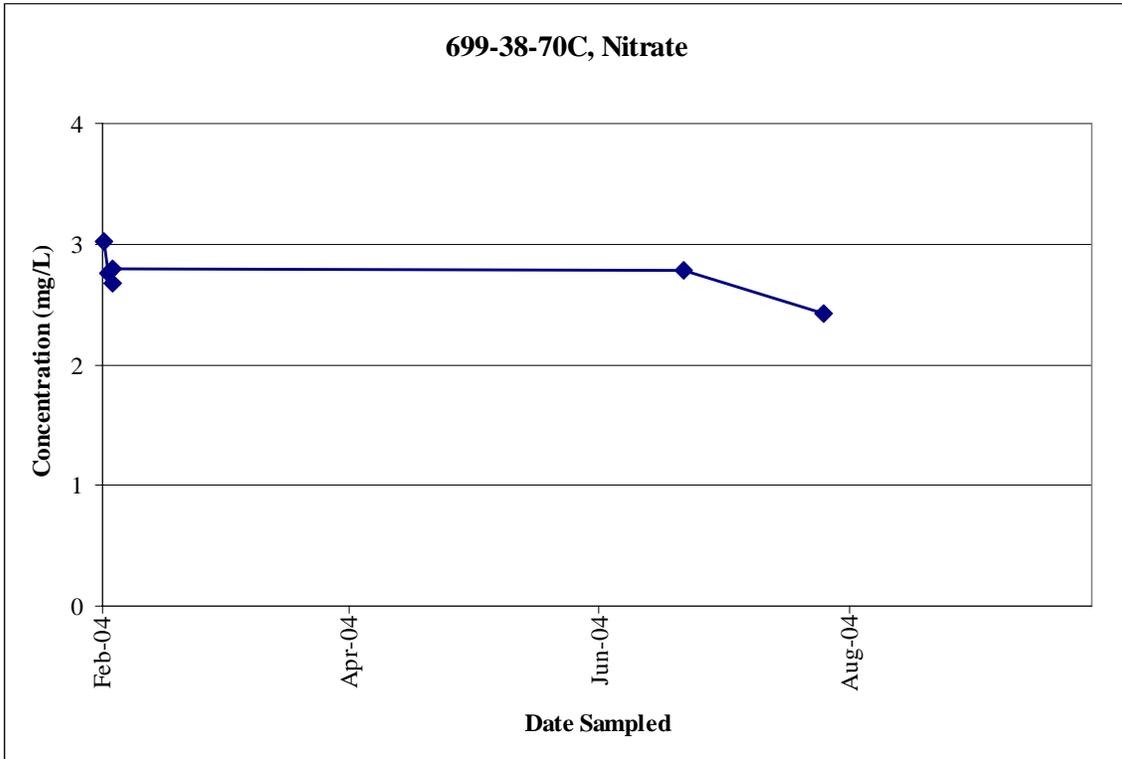


Figure D-4. 200-UP-1 Groundwater Operable Unit, Nitrate Concentration Trends at Selected Monitoring Wells. (8 sheets)



**APPENDIX E**

**NUMERICAL MODELING  
FOR HYDRAULIC CAPTURE ANALYSIS**

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## APPENDIX E

### NUMERICAL MODELING FOR HYDRAULIC CAPTURE ANALYSIS

Numerical modeling is used to evaluate and predict responses of an aquifer to natural and engineered flow conditions. A capture zone analysis is an application that determines which part of an aquifer is brought into a pumping extraction well system over time. This application is particularly useful for groundwater remediation where extraction and injection wells are used to control movement of a contaminant. Physically, a capture zone is the width of that part of the steady-state cone of depression that is drawn into the pumping well. The zone of influence is the broader area over which flow direction is changed by pumping but does not reach the pumping well.

The time that the system operates and the velocity and direction of regional groundwater flow determine the upgradient extent, or “reach,” of pumping at the well. The groundwater model may be applied to design an extraction well system or may be used (as here) to show the area of aquifer swept by the treatment system during a period of operation. A capture zone is depicted as a series of streamlines approaching an extraction well or emanating from an injection well, each streamline depicting the theoretical path of a representative particle of water drawn to, or pushed from, a well.

Model development for the 200 West Area pump-and-treat systems has been discussed in the *200-UP-1 Groundwater Pump-and-Treat Phase I Annual Report* (BHI 1996); *Fiscal Year 1997 Annual Report for the 100-NR-1, 200-UP-1, and 200-ZP-1 Pump-and-Treat Systems and Operable Units* (DOE-RL 1998); and *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 1999). To improve the performance of the model and the consistency of modeling results for the Hanford Site, hydraulic conductivity and geologic layering data from the Sitewide model developed by Pacific Northwest National Laboratory (PNNL) were incorporated in the areas surrounding the pump-and-treat systems. The PNNL Sitewide model has undergone extensive calibration and review and represents the best available evaluation of Sitewide groundwater flow. While the PNNL Sitewide model is fully three-dimensional and contains hydraulic data for multiple hydrogeologic layers, for the purpose of capture analysis, using three model aquifer layers appears to be adequate to represent the flow around the extraction well. Grid spacing for the Sitewide model is large at 120 m (393.7 ft); thus, near the pump-and-treat systems, the results of the aquifer testing and drawdown analyses were used to refine the model properties.

In summary, the pump-and-treat numerical model uses a two-dimensional, finite element grid for the horizontal dimensions and has three large, finite difference layers in the vertical dimension. In other words, the model contains three, two-dimensional aquifer layers of variable thickness. Water is extracted from only the top aquifer layer, although water may enter this layer from the deeper layers. The top aquifer layer varies in thickness from about 17.5 to 19 m (57.4 to 62.3 ft) in the 200-UP-1 Operable Unit (OU), and from 19 to 21 m (62.3 to 68.9 ft) in the 200-ZP-1 OU. In reality, the extraction wells are partially penetrating into the top aquifer layer, with well screens typically around 50 ft. The capture zone plots shown in Figures E-1 and E-2 represent flow occurring only in the uppermost aquifer layer. Only water movement is modeled, with no details of contaminant transport included. Heavy mobile contaminants (e.g., carbon

tetrachloride) are expected to be more concentrated at the lower elevations of the aquifer and be pulled upward into the extraction wells, resulting in capture by the wells. Dividing the aquifer into three layers provided a simple approach to address the fact that the extraction wells only partially penetrate the unconfined aquifer, as well as to account for the anisotropy known to occur in the aquifer.

### **E1.0 200-UP-1 OPERABLE UNIT NUMERICAL MODELING**

Numerical modeling was used to evaluate the effects of interim remedial action on the 200-UP-1 OU aquifer during fiscal year 2003 (FY03). Three extraction wells were used during the course of the year. Well 299-W19-39 operated nearly continuously (for 350 days) throughout FY04, as it has since March 1996. Monitoring well 299-W19-43, installed at the end of FY01, was converted to an extraction well in May 2003 and began continuous operation in July 2003. Well 299-W19-36 was converted to an extraction well in December 2001 and was later changed back to a monitoring well in May 2003 due to low extraction rates. The well was re-equipped for extraction in late FY03 and was used in FY04.

The areas of capture around wells 299-W19-39, 299-W19-36, and 299-W19-43 during the current FY (Figure E-1) are approximately circular, with an area of approximately 38,200 m<sup>2</sup> (411,181 ft<sup>2</sup>), 7,950 m<sup>2</sup> (85,573 ft<sup>2</sup>), and 2,500 m<sup>2</sup> (26,910 ft<sup>2</sup>) (radii of about 110 m [360.9 ft], 50 m [164 ft], and 28 m [91.9 ft]) around the wells, respectively. The capture zone around well 299-W19-36 is not expected to extend downgradient to well 299-W19-43, where concentrations of both technetium-99 and uranium exceeded the remedial action objective levels during FY02 and the first half of FY03. However, extraction at well 299-W19-43 may extend the capture zone upgradient to well 299-W19-36.

The capture areas shown in Figure E-1 are limited to the approximate capture occurring during the current FY. Prior to FY02, previous reports portrayed the entire area of capture since the beginning of the pump-and-treat operations in 1995. As of September 1999, extraction well 299-W19-39 was depicted as having removed at least one pore volume of groundwater to a depth of about 15 m (49 ft) from the baseline plume area (DOE-RL 2000). Most water extracted after that time likely originated from the area upgradient of the original plume area. Only very limited data are available to evaluate the aquifer conditions upgradient of the original targeted area. There are no wells between the 216-U-1 and 216-U-2 waste disposal cribs and original baseline plume wells (e.g., 299-W19-28 and 299-W19-29). Further complicating the analysis is the injection that occurred in well 299-W19-36 between October 1996 and February 1997 during Phase I pump-and-treat operations. Because of the changes in the pumping (both extraction and injection) and the changes in the plume geometry, the extent of the capture areas shown in Figure E-1 are limited to the approximate capture occurring since FY01. This depiction appears to be more consistent with the current focus of the pump-and-treat operation.

The source of the technetium-99 currently observed in wells 299-W19-36 and 299-W19-43 starting in September 2001 has been attributed to the movement of treated injected water through that part of the soil column once occupied by the elevated groundwater table (DOE-RL 2003). The impact of injecting treated water was observed with peaking technetium-99 concentrations at wells 299-W19-28 and 299-W19-29 before they went dry. This same effect is thought to have occurred at well 299-W19-43. Peaking technetium-99 at well 299-W19-36 is thought to have resulted from draining of groundwater mound around the injection well carrying some residual contamination to samples. A driving mechanism for technetium-99 mobilization and transport

may still be available from leaking water lines and the operation of a sanitary tile field (2607-W5) located near the 216-U-1 and 216-U-2 Cribs.

Uranium is thought to have behaved similarly, as it was likely present in the aquifer near well 299-W19-43 at the start of pump-and-treat operations. While continued pumping in well 299-W19-39 may eventually capture the groundwater around well 299-W19-43, transport of both contaminants to that well (and the consequent reduction in contaminant concentration) may require several years to accomplish. The conversion of monitoring well 299-W19-43 to extraction well in July 2003 with a flow rate of 51 L/min (13.5 gallons per minute [gpm]) has accelerated the process of contaminant removal. For 3 months of operation, the capture zone around this well extended to an area of approximately 2,500 m<sup>2</sup> (26,910 ft<sup>2</sup>).

The technetium-99 concentration trends appear to substantiate the earlier modeling evaluation that extraction well 299-W19-39 removed a pore volume from the original targeted plume area. However, removal of a pore volume of groundwater does not assure complete removal of all contaminants. During FY02, increasing or peaking concentrations at wells 299-W19-36 and 299-W19-43 were increasing or had peaked and were declining. Although the decline at both wells appears to be encouraged by extraction, the response, although quicker, is very similar to that observed at a number of other wells within the baseline plume boundary. The concentration of technetium-99 in wells 299-W19-30, 299-W19-20, and 299-W19-37 (all located upgradient of well 299-W19-39) followed similar peak and decline patterns. The measured technetium-99 concentration in well 299-W19-43 decreased from a high of 22,400 pCi/L in FY02 to less than 4,000 pCi/L in FY03. At well 299-W19-36, technetium-99 concentrations declined from 27,700 pCi/L in November 2000 to an average of 8,915 pCi/L in August 2002, before declining in January 2003 to 4,600 pCi/L.

### **E1.1 CONTAMINANT ESCAPE TIMES FROM 200-UP-1 EXTRACTION WELLS**

If an extraction well is shut down for some time period, it is of interest to know how long it can be inactive before the contaminants start to escape the well's capture zone under normal operations. After an extraction well is shut down, there will be some time before the local water table reaches a natural level, and after a well is turned on, there will be some time before the aquifer level is pulled down in a cone of depression around the well. These restoration times are assumed to be equal, so that only a travel time under natural flow conditions needs to be calculated, using Darcy's law:

$$V = (K dh/dx) / \eta \quad (\text{Equation 1})$$

where:  $V$  = the water's pore velocity = distance/time =  $x/t$   
 $K$  = hydraulic conductivity = transmissivity/aquifer thickness  
 $dh/dx$  = hydraulic gradient; actually negative, but absolute value for Equation 1  
 $\eta$  = effective porosity.

The modeled capture zones for each extraction well are shown in Figure E-1. The largest extraction well, 299-W19-39, has a capture zone that extends beyond the 1-year travel line. The 1-year travel line has a downgradient distance of approximately 75 m (Figure E-1) and is beyond monitoring well 299-W19-40. This capture zone extends beyond 75 m, but only 75 m will be used in the travel-time calculation to be conservative and predict a smaller escape time. The local capture zones of wells 299-W19-36 and 299-W19-43 overlap, so only the more

downgradient well's capture zone around 299-W19-43, which has a distance of about 30 m, is used for the escape-time calculation.

The hydraulic conductivity, "K," is assumed to be about 15 m/day, which is considered a high conservative value. The natural hydraulic gradient, "dh/dx," has a value of 0.00147 in the natural 200-UP-1 area based on current head measurements and head contours for the aquifer with the extraction well effects excluded. The effective porosity, or storativity, "η," has values ranging from 0.10 to 0.12, so the most conservative value of 0.10 is used, which reduces the escape time compared to higher values of effective porosity. The escape time can be expressed by re-arranging terms in Equation 1 as the following:

$$t = (x \eta) / (K \text{ dh/dx}) \quad (\text{Equation 2})$$

where:  $x$  = escape distance = 75 m for well 299-W19-39, and 30 m for well 299-W19-43.

Using Equation 2, the following escape times are calculated:

$$\begin{aligned} t &= 75 \text{ m (0.10)} / [15 \text{ m/day (0.00147)}] \\ &= 340 \text{ days for well 299-W19-39, with an average velocity of 0.22 m/day} \end{aligned}$$

$$\begin{aligned} t &= 30 \text{ m (0.10)} / [15 \text{ m/day (0.00147)}] \\ &= 136 \text{ days for well 299-W19-43, with an average velocity of 0.22 m/day.} \end{aligned}$$

## **E2.0 200-ZP-1 OPERABLE UNIT NUMERICAL MODELING**

The capture zone analysis evaluates and tracks the effects of the interim remedial action on the aquifer. The extraction well-flow lines show that the 200-ZP-1 OU pump-and-treat system is capturing the baseline high-concentration portion of the plume. The flow lines also show that the extraction wells provide a continuous line of hydraulic containment. The flow lines (Figure E-2) represent the travel paths of water particles drawn to extraction wells or driven away from injection wells in the pump-and-treat system by the end of September 2003. The composite of the flow lines around the extraction wells represents the capture area or where the extraction wells have removed a pore volume of groundwater through the upper portion of the aquifer.

Most capture areas around the extraction wells extend into the high-concentration area (greater than 2,000 µg/L) of the baseline June 1996 carbon tetrachloride plume. The capture flow lines (Figure E-2) represent a steady-state approximation of the hydraulic capture of the extraction wells relative to the aquifer conditions existing at the beginning of pumping. Groundwater entering the 1996 Phase II extraction wells during this FY was located near to, or at the end of, the capture flow lines in August 1996, and groundwater entering the Phase III extraction wells was now located at the end of the capture flow lines in August 1997. The capture area around well 299-W15-37 (shown in Figure E-2) represents the area captured before pumping was stopped on January 17, 2001. The capture areas are approximate because of the changing aquifer conditions (the regional decline in the water table coupled with the changing water levels caused by the pumping), changing pumping rates, and the periods of inactivity during shutdowns.

The Phase II extraction wells have operated since August 1996 and exhibit the greatest capture area. Around well 299-W15-33 (W15-45), one pore volume has been removed as far as 220 m (721.8 ft) upgradient and approximately 100 m (328.1 ft) laterally. Pumping in wells 299-W15-34 and 299-W15-35 creates overlaps in capture zones with that formed at well

299-W15-33 (W15-45). As a result, the capture zones around wells 299-W15-34 and 299-W15-35 extend more to the northwest than they otherwise might. Similarly, the capture zone for well 299-W15-35 also overlaps that of 299-W15-47 (which replaced well 299-W15-32). This effect is demonstrated by the elevated carbon tetrachloride results at well 299-W15-38. Carbon concentrations have exceeded 2,000 µg/L for most sampling events since December 1996. For well 299-W15-35, one pore volume has been removed as far as 470 m (1,542 ft) upgradient of the well, about 280 m (918.6 ft) laterally, and about 300 m (984 ft) downgradient. The Phase III extraction wells have operated since August 1997.

Pumping at well 299-W15-37 was discontinued because the concentration of carbon tetrachloride in that well was substantially below the remedial action objective level of 2,000 µg/L. Continued operation of that well might have resulted in spreading the high-concentration area of the plume. The shape and dimensions of the capture zones around wells 299-W15-47 and 299-W15-36 are similar to one another, except that latter is smaller, as is shown in Figure E-2.

A recommendation to shut down well 299-W15-36 for similar reasons is under consideration, if replacement wells for 299-W15-32 (W15-47) and 299-W15-33 (W15-45) can produce enough water to equal the extraction system's goal of 567.8 L/min (150 gpm).

Water injected into well 299-W15-29 has displaced one pore volume as far as 440 m (1,443.6 ft) from the well. Water injected into the other two injection wells currently operating (wells 299-W18-36 and 299-W18-37) has displaced one pore volume of groundwater within approximately 145 m (475.7 ft) of those wells.

## E2.1 CONTAMINANT ESCAPE TIMES FROM 200-ZP-1 EXTRACTION WELLS

Figure E-2 shows the capture zone for the 200-ZP-1 wells out to one year. The capture distance is estimated conservatively to be 50 m for well 299-W15-36 and 75 m for other four extraction wells, with well 299-W15-35 having the largest capture distance, which is greater than 75 m (but 75 m will be used in the escape-time calculation). The natural hydraulic gradient is estimated at 0.001 for the northern three wells and 0.00147 for the 299-W15-47 and 299-W15-36 wells.

Using Equation 2, the following escape times are calculated:

$$\begin{aligned}
 t &= 75 \text{ m (0.10)} / [15 \text{ m/day (0.0010)}] \\
 &= 500 \text{ days for wells 299-W15-35, 299-W15-34, and 299-W15-45, with} \\
 &\quad \text{an average velocity of 0.15 m/day,} \\
 \\
 t &= 75 \text{ m (0.10)} / [15 \text{ m/day (0.00147)}] \\
 &= 340 \text{ days for well 299-W15-47, with an average velocity of 0.22 m/day,} \\
 \\
 t &= 50 \text{ m (0.10)} / [15 \text{ m/day (0.00147)}] \\
 &= 227 \text{ days for well 299-W15-36, with an average velocity of 0.22 m/day.}
 \end{aligned}$$

### E3.0 CONCLUSIONS

From the standpoint of designing a pump-and-treat system, capture zone modeling is essential to help establish and evaluate a well field that is capable of containing or removing a known contaminant plume. Injection wells may be added to hasten the flow to the extraction wells. As a check on system performance, the model is run according to known operating parameters (i.e., extraction and injection rates at wells) to depict how the two are functioning at containing plume movement. Plume location, as determined by regular sampling at monitoring wells and contouring of the results, establishes plume location, size, and mass. A comparison between plume boundaries and the well field capture zone leads to an assessment of how efficiently the treatment system is containing the plume, or where contaminants may be beyond the influence of the well field. Thus, the model provides a check on the effectiveness of the remedial action and indicates how well the system is meeting the Records of Decision (EPA et al. 1995, 1997) for containing the plumes.

### E4.0 REFERENCES

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Figure E-1. 200-UP-1 Operable Unit Area of Hydraulic Capture Through September 2003.

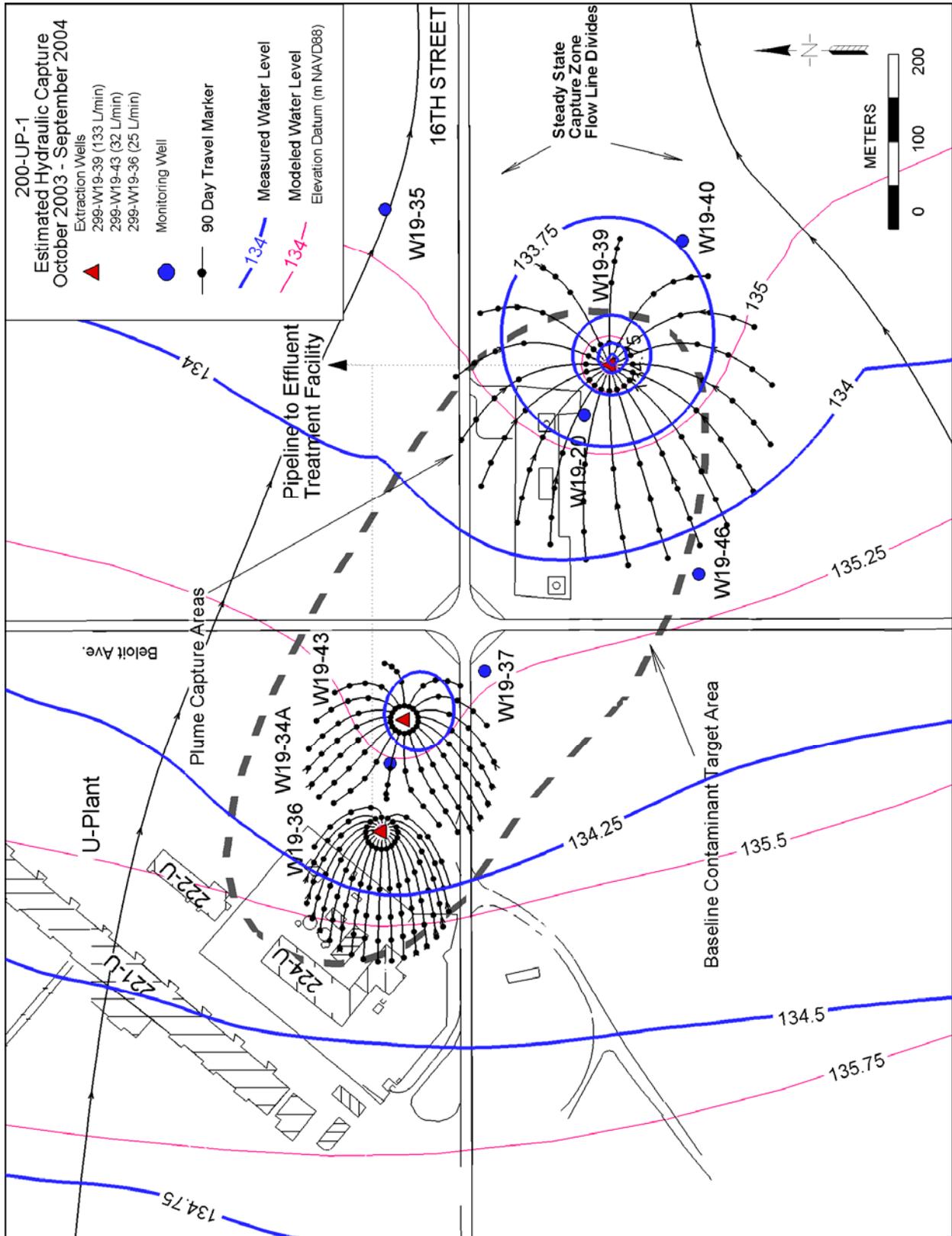
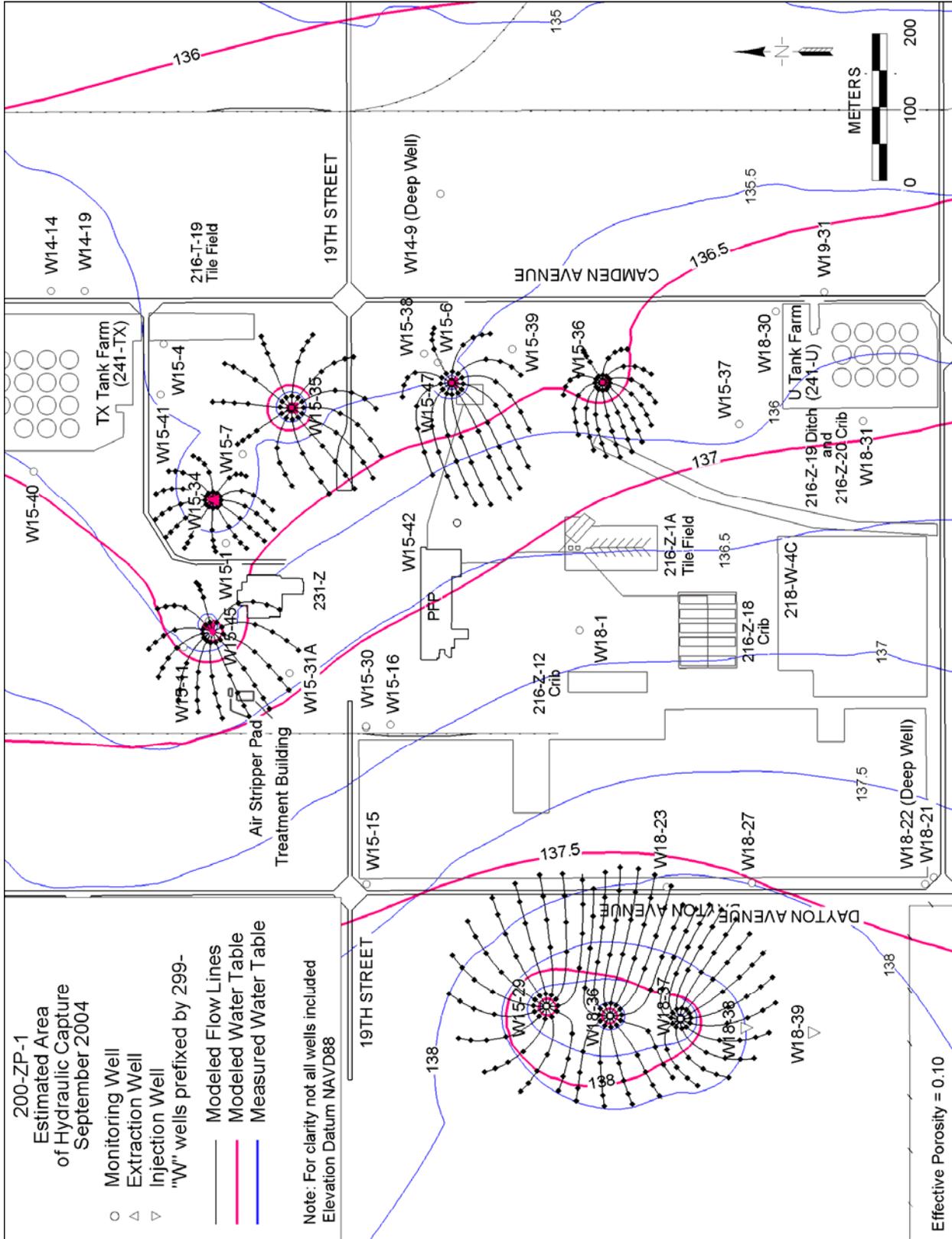


Figure E-2. 200-ZP-1 Operable Unit Area of Hydraulic Capture Through September 2003.



**APPENDIX F**  
**TECHNETIUM AT WELL 299-W23-19**

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## **TERMS**

DOE	U.S. Department of Energy
ETF	Effluent Treatment Facility
FY	fiscal year
gpm	gallons per minute
OU	operable unit

## APPENDIX F

### TECHNETIUM-99 AT 299-W23-19

#### F1.0 HISTORICAL DEVELOPMENT

Groundwater monitoring well 299-W23-19 was drilled near the southwest corner of the SX Tank Farm between August and September 1999, sampled initially in October, and completed in November 1999. The boring was intended only for characterization of the vadose zone, but high concentrations of technetium-99 were found in groundwater grab samples. A decision was made to install a well for groundwater monitoring. The first analytical results for technetium-99 averaged 45,000 pCi/L. Following that, concentrations ranged between 29,500 and 99,700 pCi/L, both since inception of sampling and through fiscal year 2002 (FY02). In FY03, technetium-99 concentrations peaked at 188,000 pCi/L, then began declining (Figure F-1). At the end of FY 2004, concentrations have leveled out in the 40,000-45,000 pCi/L range. This plume and the well are located in the 200-UP-1 Groundwater Operable Unit (OU).

The elevated concentrations were noted by the Washington State Department of Ecology in a May 31, 2001, letter to the U.S. Department of Energy (DOE) (Ecology 2001), which requested an evaluation of interim measures for the groundwater. The DOE authorized an evaluation by CH2M HILL Hanford Group, Inc., which examined three options for groundwater treatment: (1) using a skid-mounted pump-and-treat system with reinjection of treated water; (2) hauling pumped groundwater in tanker trucks to the Effluent Treatment Facility (ETF) for treatment; and (3) constructing a pipeline to the 200-UP-1 pump-and-treat site, where the pipe could be tied in to the existing pipeline for conveyance to the ETF.

The study calculated the cost of construction and operation, and also identified regulatory issues that potentially hampered each of the three options. The technical feasibility of the three was predicated upon an unknown but low, sustainable groundwater extraction rate from well 299-W23-19. Administrative feasibility issues varied with individual options and included: 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; and determining whether the ETF could handle a sustained flow of 208 to 227 L/min (55 to 60 gallons per minute [gpm]).

A geohydrologic analysis of the technetium-99 plume at well 299-W23-19 was conducted and included a pumping test plus numerical modeling of plume configuration and response to pumping. The pumping test was conducted between December 13 and 20, 2001. The results and analysis are reported in *Technetium-99 in Groundwater at Hanford Well 299-W23-19: Options Analysis and Recommended Action Report* (CHG 2002). 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 a 72-hour pump test, coupled with specific conductance meter readings, indicated a fairly uniform distribution of technetium-99 concentrations around the well.

Numerical modeling was conducted (CHG 2002) to quantify the effects of extraction on the aquifer and contaminant plume and to evaluate the effects of an interim remedial measure. Many of the aquifer properties were calculated with pumping test-based data, while other properties were gathered from previous testing at nearby wells. Numerical modeling based on data from the 72-hour pump test, indicated a capture zone extending approximately 30 m (100 ft) around the well (Figure F-2). Groundwater flow velocities under constant pumping indicated that the area beneath tank farms would be treated within 2 years. The 9,000  $\mu\text{g/L}$  contour of the technetium-99 plume was compared with the downgradient reach of the capture zone and was found to be mostly contained within the capture zone and beneath the boundary of the SX Tank Farms. Less concentrated portions of the plume exceeded the boundary of both the capture zone and the tank farms and were beyond the range of interim remediation options at well 299-W23-19. Note that the capture zone shown in Figure F-2 does not represent the capture zone of a quarterly, extended purge when sampling at the well.

## **F2.0 STATUS FOR FISCAL YEAR 2004**

The quantities of water pumped and waste treated is presented in this appendix and in Section 2.8 of the main text of this document. For FY04, the well was sampled four times, all of which were accompanied by purgewater collection and treatment. The collected groundwater was taken by tanker to the Liquid Effluent Retention Facility where it is unloaded and combined with groundwater received from the 200-UP-1 extraction wells. The combined waters were then treated at the ETF. The trend plot for technetium-99 since the start of monitoring is presented in Figure F-1. The figure shows a peak concentration in January 2003 of 188,000  $\rho\text{Ci/L}$ , followed by a substantial decline to 41,400  $\rho\text{Ci/L}$  in December 2003. Since then, concentrations have varied from 41,800 to 46,100  $\rho\text{Ci/L}$  in September 2004, values which are up to 5 times greater than the RAO of 9,000  $\rho\text{Ci/L}$ .

The analytical results from the individual sampling events are assumed to be representative over the duration of pumping. The ETF reported 100% removal of technetium-99 throughout FY04. From this information, the technetium-99 curie content was calculated and converted to a mass value using the specific activity value of 0.017 Ci/g. Table F-1 presents data on the accumulated volume of waste and the concentration of the initial sample. As shown in Table F-1, a total of approximately 0.00187Ci of technetium-99 have been recovered, or 0.108 g, in 27,649 L (7,304 gal) of treated water.

In general, the more linear concentrations of technetium-99 observed at 299-W23-19 may indicate that a concentrated part of the plume has moved beyond the range of quarterly extraction activities. Downgradient wells 299-W22-46 and 299-W22-50 averaged 9,495  $\rho\text{Ci/L}$  and 11,058  $\rho\text{Ci/L}$ , respectively, for FY04 (Figure F-1). These values continue to increase for the respective wells, from 7,333  $\rho\text{Ci/L}$  and 9,075  $\rho\text{Ci/L}$  in FY03 and 5,655 and 5,588  $\rho\text{Ci/L}$  in FY02.

The *Hanford Site Groundwater Annual Report for Fiscal Year 2004* (PNNL 2005) presents a more detailed discussion of technetium-99 at this well.

### **F3.0 REFERENCES**

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PNNL, 2005, *Hanford Groundwater Annual Report for Fiscal Year 2004*, PNNL-15070, Pacific Northwest National Laboratory, Richland, Washington.

*Resource Conservation and Recovery Act of 1976*, 42 U.S.C. 6901, et seq.

Figure F-1. Plot of Fiscal Year 2004 Technetium Concentrations at Well 299-W23-19.

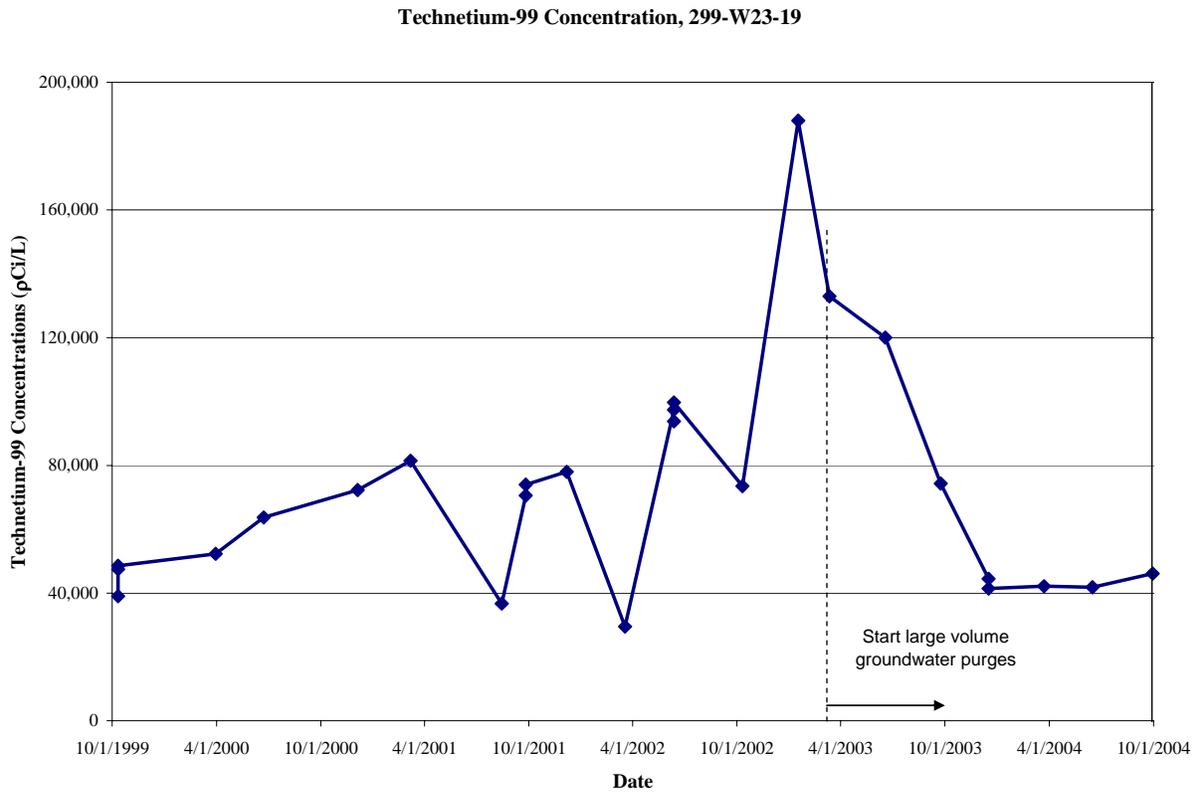


Figure F-2. Technetium-99 Groundwater Plume and Capture Zone at Well 299-W23-19 (CHG, 2002)

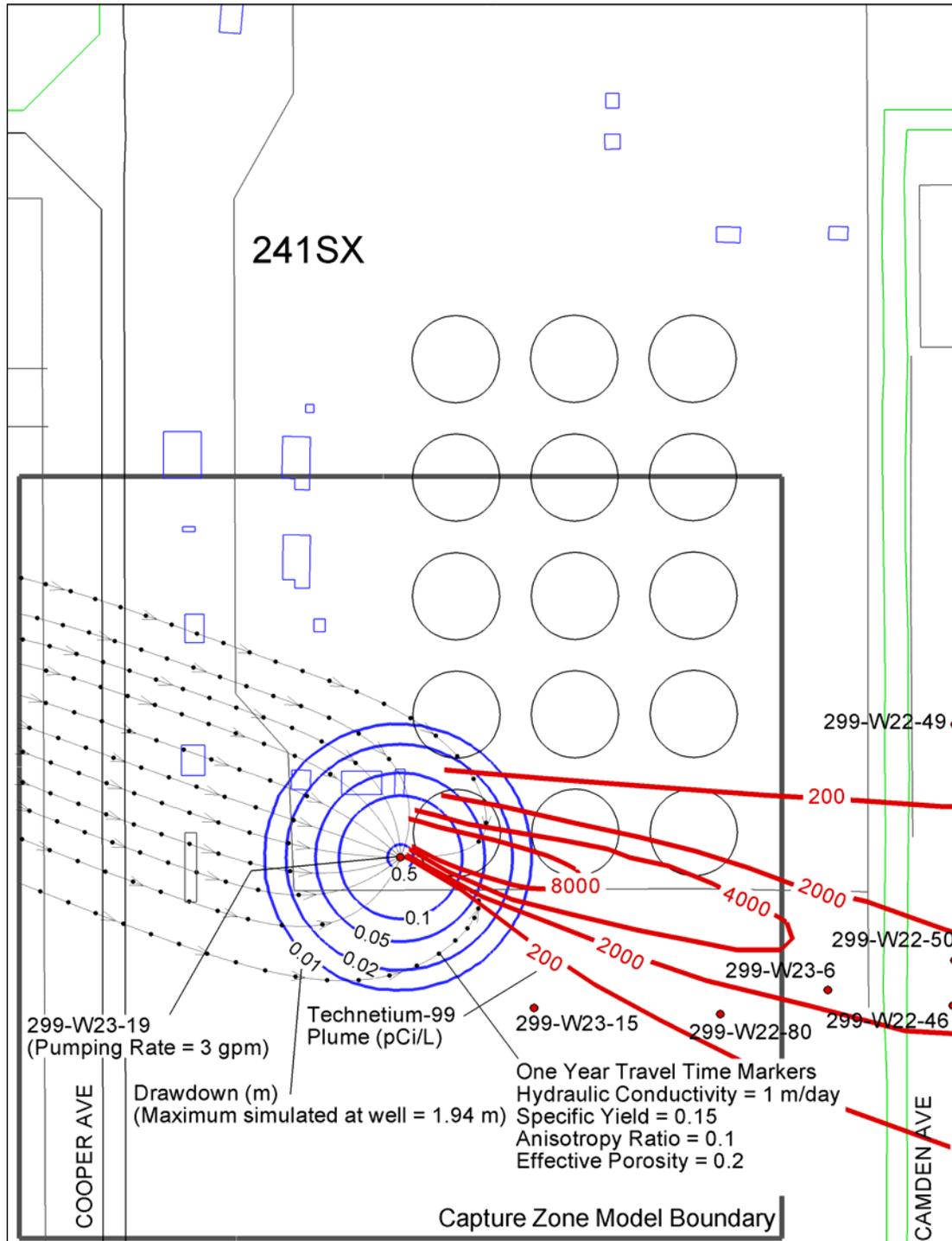


Table F-1. Accumulated Volume of Waste and Concentration of Initial Technetium-99 Samples.

<b>Date of Sampling</b>	<b>Groundwater Pumped, L (gal)</b>	<b>Technetium-99 Concentration (<math>\mu</math>Ci/L)</b>	<b>Curies of Technetium-99</b>	<b>Mass of Technetium-99 (g)<sup>a</sup></b>
March 12, 2003	2,722 (719)	133,000	0.00036	0.021
June 18, 2003	4,028 (1,064)	120,000	0.00048	0.028
September 23, 2003	4,013 (1,060)	74,300	0.00030	0.018
December 16, 2003	3,944 (1,042)	44,500 & 41,400 (Avg = 42,950)	0.00017	0.010
March 22, 2004	4,845 (1,280)	42,200	0.00020	0.012
June 16, 2004	3,986 (1,053)	41,800	0.00017	0.010
September 29, 2004	4,111 (1,086)	46,100	0.00019	0.011
Total to Date	27,649 (7,304)	--	0.00187	0.108

<sup>a</sup> Specific activity of technetium-99 is 0.017 Ci/g, or 58.7 g/Ci.

**APPENDIX G**  
**QUALITY ASSURANCE/QUALITY CONTROL**

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## APPENDIX G

### QUALITY ASSURANCE/QUALITY CONTROL

Field replicates, offsite laboratory replicates, field/offsite laboratory splits, and offsite laboratory splits are quality control (QC) samples used to assess the precision of chemical analyses.

Establishing precision of samples analyzed by field screening consisted of comparing analyses of replicates and calculating the relative percent difference (RPD) as follows:

$$RPD = \frac{(C_1 - C_2) \times 100\%}{(C_1 + C_2) / 2}$$

where  $C_1$  is the larger of the two observed concentrations or activities and  $C_2$  is the smaller of the two observed concentrations or activities. The U.S. Environmental Protection Agency (EPA) issued guidelines (EPA 1988) applicable to field analytical techniques in which a 20% RPD was regarded as indicating good precision. These guidelines are not applicable to other comparisons between field and laboratory results but are used here for comparison. The RPDs were not calculated for nondetects or sample pairs with different laboratory qualifiers.

A second statistical method to evaluate precision is with the relative error ratio (RER) test, which is calculated by the following equation:

$$RER = \frac{|\text{Result1} - \text{Result2}|}{\sqrt{(\text{Error1})^2 + (\text{Error2})^2}}$$

where the error is total analytical error (propagated error or counting error) reported by the laboratory for each of the data pair. This test is useful for analytical values within five times the minimum detection limit. A value from this calculation falling within an RER of 1 to 1.5 is regarded as indicating satisfactory precision.

#### G1.0 200-UP-1 OPERABLE UNIT QUALITY ASSURANCE/QUALITY CONTROL

The 200-UP-1 offsite laboratory replicate results for uranium, technetium-99, carbon tetrachloride, trichloroethene (TCE), and chloroform QC sample analyses are presented in Table G-1 by sample number and result. The replicate samples were taken at wells identified in the *Sampling and Analysis Plan for the 200-UP-1 Groundwater Monitoring Well Network* (DOE-RL 2002) but did not include monitoring wells around the baseline plume boundary.

#### G1.1 OFFSITE LABORATORY REPLICATES

- Uranium:** Uranium replicates were analyzed by offsite laboratories using laser phosphorimetry. The RPDs ranged from 3.4% to 54.1%. The RPD exceedence may be explained by the fact that the replicate pair value concentrations were within five times the detection level. Concentrations within five times of the detection level are prone to greater variability due to unavoidable analytical errors. Calculating the RER of the data pair resulted in a value of 3.28; thus, the two results are different.

- **Technetium-99:** Technetium-99 replicates were analyzed by offsite laboratories using a liquid scintillation counter. The RPDs ranged from 8.9% to 25%. Two of three technetium-99 sample replicate pairs exceeded 20% RPD. The 66% rate of RPD guideline exceedences is difficult to evaluate. For the two exceedence samples, concentrations were greater than five times the reported minimum detection limit value of 11.7 pCi/L (MDL), so RER values were not calculated.
- **Carbon tetrachloride, chloroform, and TCE:** These replicates were analyzed using a gas chromatograph. Six of nine replicate sample pairs were suitable for RPD calculations, and all RPDs ranged between 0 to 16.7%. Using this criterion, the RPD range for volatile organic analytes appears reasonable.

## **G2.0 200-ZP-1 OPERABLE UNIT QUALITY ASSURANCE/QUALITY CONTROL**

The 200-ZP-1 field replicate, offsite laboratory replicate, and field-laboratory split results for carbon tetrachloride, TCE, and chloroform QC sample analyses are presented in Table G-2 by sample number and result. All samples were analyzed in the field using a gas chromatograph and offsite using EPA Method 8260 (SW-846 [EPA 1997]).

### **G2.1 FIELD REPLICATES**

- **Carbon tetrachloride, chloroform, and TCE:** These replicates were analyzed in the field using a gas chromatograph. The RPDs ranged from 0 to 9.5%. The EPA's functional guidelines for field replicates is  $\pm 20\%$  (EPA 1988), and all 42 replicate pairs met the guideline.

### **G2.2 OFFSITE LABORATORY REPLICATES**

- **Carbon tetrachloride, chloroform, and TCE:** Twenty-seven offsite laboratory replicate sample pairs were analyzed, of which 14 were not tested for RPD because they contained some form of laboratory qualifier. Of the remaining 13 samples, only one exceeded an RPD of 20%. Calculation of the RER was not performed because the sample data did not possess a total analytical error value.

### **G2.3 SPLITS**

- **Carbon tetrachloride, chloroform, and TCE:** These samples were analyzed in the field using a gas chromatograph and offsite using EPA Method 8260 (SW-846 [EPA 1997]). The range of RPDs was 0 to 173.8% for the 28 splits analyzed. Although there is no EPA functional guideline for split samples, the RPD calculation was performed. Six of seven carbon tetrachloride data pairs and five of six TCE data pairs exceeded the RPD guideline value of 20%. The RER values were not calculated because total error data was not reported.
- **Carbon tetrachloride and TCE:** An interesting phenomenon has been observed in variations between offsite laboratories and field testing results. Although not evident from the data in Table G-2, a general correlation between greater holding time for samples at offsite laboratories and lower carbon tetrachloride concentrations is known from fiscal year 2002 (FY02) data (DOE-RL 2003). Although most of the holding times

were met, samples taken on August 9, 2004, exceeded the 14-day contract laboratory requirement for volatile organic analysis by 2 days. Those samples with distinctly longer holding times showed a greater difference between field and laboratory analyses than the samples with shorter holding times. Available holding-time data received for FY04 carbon tetrachloride offsite laboratory samples are presented in Table G-3. See Table G-2, sheet 3 of 3, for a comparison of field versus laboratory analytical values.

An effort was made to have laboratory and field sample analyses performed closer together in time. Samples taken at well 299-W15-33 on July 28, 2004 (after the extraction well had been replaced by 299-W15-45), were analyzed on August 2, 2004, by the Waste Sampling and Characterization Facility (WSCF). Field analyses indicate carbon tetrachloride concentrations at 3,100 µg/L, while WSCF analyses reported 2,900 µg/L. Additional efforts are planned for FY05 to compare analytical techniques by field and laboratory personnel.

### **G3.0 REFERENCES**

DOE-RL, 2002, *Sampling and Analysis Plan for the 200-UP-1 Groundwater Monitoring Well Network*, DOE/RL-2002-10, Rev. 0, U. S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 2003, *Fiscal Year 2002 Annual Summary Report for the 200-UP-1 and 200-ZP-1 Pump-and-Treat Operations*, DOE/RL-2002-67, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

EPA, 1988, *Laboratory Data Validation Functional Guidelines for Evaluating Inorganics Analysis*, EPA/540/R-9/4083, Hazardous Site Evaluation Division, U.S. Environmental Protection Agency, Washington, D.C.

EPA, 1997, *Test Methods for Evaluation Solid Waste: Physical/Chemical Methods*, SW-846, 3<sup>rd</sup> edition (as amended by Update I [July 1992], Update IIA [August 1993], Update IIB [January 1995], and Update III), U.S. Environmental Protection Agency, Washington, D.C.

Table G-1. Quality Control Results for 200-UP-1 Operable Unit Sampling.

Sample Number	Value	Sample Number	Value	RPD%	CRDL Detection, Soil	Well
<b>Offsite Laboratory Replicates</b>						
<b><i>Carbon Tetrachloride (µg/L)</i></b>					5	
B17457	110(D)	B17453	110(D)	0.0		
B16B95	1	B16B94	1.1	9.5		
B16JX2	11	B16JX1	13	16.7		
<b><i>Trichloroethene (µg/L)</i></b>						
B17453	0.23(J)	B17457	0.2(J)	N/A	5	
B16B94	11	B16B95	11	0.0		
B16JX1	0.16(U)	B16JX2	0.16(U)	N/A		
<b><i>Chloroform (µg/L)</i></b>						
B17453	3.8	B17457	3.8	0.0	5	
B16B95	5.4	B16B94	5.3	1.9		
B16JX2	1.7(J)	B16JX1	2(J)	N/A		
<b><i>Uranium (µg/L)</i></b>					1	
B17455	21.3(B)	B17454	20.8(B)	N/A		
B16B93	10.3	B16B92	9.62	6.8		
B16JW9	3.44	B16JX0	5.99	54.1		299-W22-46
B16YT0	6.81	B16YR9	6.58	3.4		
<b><i>Technetium-99 (pCi/L)</i></b>					15	
B16B93	116	B16B92	90.2	25.0		299-W22-20
B16JX0	7,500	B16JW9	6,860	8.9		
B16YT0	5,770	B16YR9	7,060	20.1		299-W22-46

(D) = diluted  
(J) = estimated  
(U) = undetected  
(B) = result  $\geq$  two times the minimum detectable activity  
CRDL = contract-required detection limit  
N/A = not applicable  
RPD = relative percent difference

Table G-2. Quality Control Results for 200-ZP-1  
Operable Unit Sampling. (3 sheets)

Sample Number	Value	Sample Number	Value	RPD (%)
<b>Field Replicates</b>				
<i>Carbon Tetrachloride (µg/L)</i>				
B15RJ1	2,900	B13NK2	2,800	3.5
B15RN2	2,500	B15RN1	2,400	4.1
B15RL1	5,300	B15RL2	5,200	1.9
B15RP0	3,000	B15RP1	3,000	0.0
B13NJ0	5,500	B13NJ1	5,600	1.8
B15RJ8	5,500	B15RJ9	5,400	1.8
B15RL8	5,500	B15RL7	5,400	1.8
B13NJ6	3,400	B13NJ7	3,500	2.9
B15RK4	3,300	B15RK3	3,100	6.3
B15RM4	3,500	B15RM5	3,400	2.9
B15RR4	3,200	B15RR5	3,300	3.1
B15RJ7	1,100	B15RJ6	1,100	0.0
B15RL0	940	B15RK9	960	2.1
B15RN9	1,100	B15RN8	1,100	0.0
<i>Trichloroethene (µg/L)</i>				
B13NK2	4.5	B15RJ1	4.6	2.2
B15RN1	4.1	B15RN2	4.3	4.8
B15RL1	12	B15RL2	12	0.0
B15RP0	2.5	B15RP1	2.3	8.3
B13NJ0	11	B13NJ1	12	8.7
B15RJ8	10	B15RJ9	10	0.0
B15RL8	18	B15RL7	18	0.0
B13NJ7	11	B13NJ6	10	9.5
B15RK4	9.3	B15RK3	8.9	4.4
B15RM4	11	B15RM5	11	0.0
B15RR5	10	B15RR4	10	0.0
B15RJ6	2(U)	B15RJ7	2(U)	N/A
B15RK9	2.2	B15RL0	2.1	4.7
B15RN9	2.8	B15RN8	2.7	3.6
<i>Chloroform (µg/L)</i>				
B15RJ1	20	B13NK2	20	0.0
B15RN1	20	B15RN2	21	4.9
B15RL1	25	B15RL2	24	4.1
B15RP0	12	B15RP1	12	0.0
B13NJ1	23	B13NJ0	23	0.0
B15RJ8	24	B15RJ9	23	4.3
B15RL7	31	B15RL8	30	3.3
B13NJ7	19	B13NJ6	18	5.4
B15RK3	17	B15RK4	17	0.0

Table G-2. Quality Control Results for 200-ZP-1  
Operable Unit Sampling. (3 sheets)

Sample Number	Value	Sample Number	Value	RPD (%)
B15RM4	18	B15RM5	18	0.0
B15RR5	16	B15RR4	16	0.0
B15RJ7	19	B15RJ6	19	0.0
B15RL0	18	B15RK9	19	5.4
B15RN8	19	B15RN9	20	5.1
Offsite Laboratory Replicates				
<i>Carbon Tetrachloride (µg/L)</i>				
B169T3	2,600(D)	B169T1	2,500(D)	N/A
B173F8	12	B173F4	12	0.0
B17470	3,400(D)	B17469	3,500(D)	N/A
B16W50	1,400(D)	B16VY7	1,400(D)	N/A
B16771	0.15(UN)	B16767	0.15(UN)	N/A
B16JX1	13	B16JX2	11	16.7
B16X03	1,600(D)	B16X02	1,400(D)	N/A
B15T18	3,100	B15T17	3,941	23.9
B167P1	2,218	B167P2	2,276.6	2.6
<i>Chloroform (µg/L)</i>				
B169T3	11	B169T1	12	8.7
B173F8	2	B173F4	1.9	5.1
B17469	17	B17470	18	5.7
B16W50	14	B16VY7	15	6.9
B16767	0.3(J)	B16771	0.3(J)	N/A
B16JX1	2(J)	B16JX2	1.7(J)	N/A
B16X03	18	B16X02	18	0.0
B15T18	16(J)	B15T17	20(J)	N/A
B167P1	16.1	B167P2	15.1	6.4
<i>Trichloroethene (µg/L)</i>				
B169T3	2.1	B169T1	2	4.9
B173F4	0.97(J)	B173F8	1.1	N/A
B17469	2.6	B17470	2.7	3.8
B16W50	2.4(J)	B16VY7	2.6(J)	N/A
B16771	0.16(U)	B16767	0.16(U)	N/A
B16JX2	0.16(U)	B16JX1	0.16(U)	N/A
B16X02	3(J)	B16X03	3(J)	N/A
B15T18	50(U)	B15T17	50(U)	N/A
B167P1	7.2	B167P2	7.4	2.7

Table G-2. Quality Control Results for 200-ZP-1  
Operable Unit Sampling. (3 sheets)

Sample Number	Value	Sample Number	Value	RPD (%)
<b>Field Offsite Laboratory Splits</b>				
<b>Field</b>		<b>Laboratory</b>		
<i><b>Carbon Tetrachloride (µg/L)</b></i>				
B150C4	2,100(D)	B15M23	1,973	N/A
B13NJ3	2,400	B15T20	1,900	23.3
B15RL3	2,900	B167P0	1,974	38.0
B15RM9	5,100	B16X01	2,800	58.2
B15RN0	3,200	B16X08	1,800	56.0
B15T21	860	B13NJ4	1,100	24.5
B15RL5	1,000	B167P3	854	15.7
B15RN3	900	B16X04	690	26.4
<i><b>Chloroform (µg/L)</b></i>				
B150C4	12	B15M23	12	0.0
B13NJ3	20	B15T20	14(J)	N/A
B15RM8	14	B16X00	12	15.4
B15RL3	12	B167P0	9.9	19.2
B16X01	26	B15RM9	24	8.0
B13NJ2	16	B15T19	13(J)	N/A
B15RN0	17	B16X08	16	6.1
B13NJ4	20	B15T21	17	16.2
B15RL5	21	B167P3	20.2(J)	N/A
B16X04	17	B15RN3	20	16.2
<i><b>Trichlorethene (µg/L)</b></i>				
B15M23	2	B150C4	2	0.0
B13NJ3	4.7	B15T20	50	165.6
B16X00	2(J)	B15RM8	2	N/A
B167P0	2.4(J)	B15RL3	2.2	N/A
B16X01	7	B15RM9	12	52.6
B15RN0	10	B16X08	6	50.0
B13NJ4	3.5	B15T21	50	173.8
B15RL5	3.1	B167P3	2.5	21.4
B16X04	2(J)	B15RN3	2	N/A
B13NJ2	9.4	B15T19	50(U)	N/A

(D) = diluted  
(J) = estimated  
(U) = undetected  
N/A = not applicable  
RPD = relative percent difference

Table G-3. Available Holding Time Data Received for Fiscal Year 2003  
Carbon Tetrachloride Offsite Laboratory Samples.

Sample Identification	Calculated RPD	Laboratory Received Date	Laboratory Analysis Date	Holding Time
B15T20	23.3	10/25/02	10/31/02	6
B15T21	24.1 <sup>a</sup>	10/25/02	10/31/02	6
B16X04	26.4	05/02/03	05/12/03	10
B16X08	56.0	05/02/03	05/12/03	10
B16X01	58.2	05/02/03	05/12/03	10
B167P0	38.0	01/31/03	02/11/03	11

<sup>a</sup> Laboratory results are higher than field results.

**APPENDIX H**  
**TREND PLOTS FOR WELLS**  
**AT THE 200-ZP-1 OPERABLE UNIT**

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Figure H-1. 200-ZP-1 Groundwater Operable Unit, Carbon Tetrachloride Concentration Trends at Selected Monitoring Wells. (17 sheets)

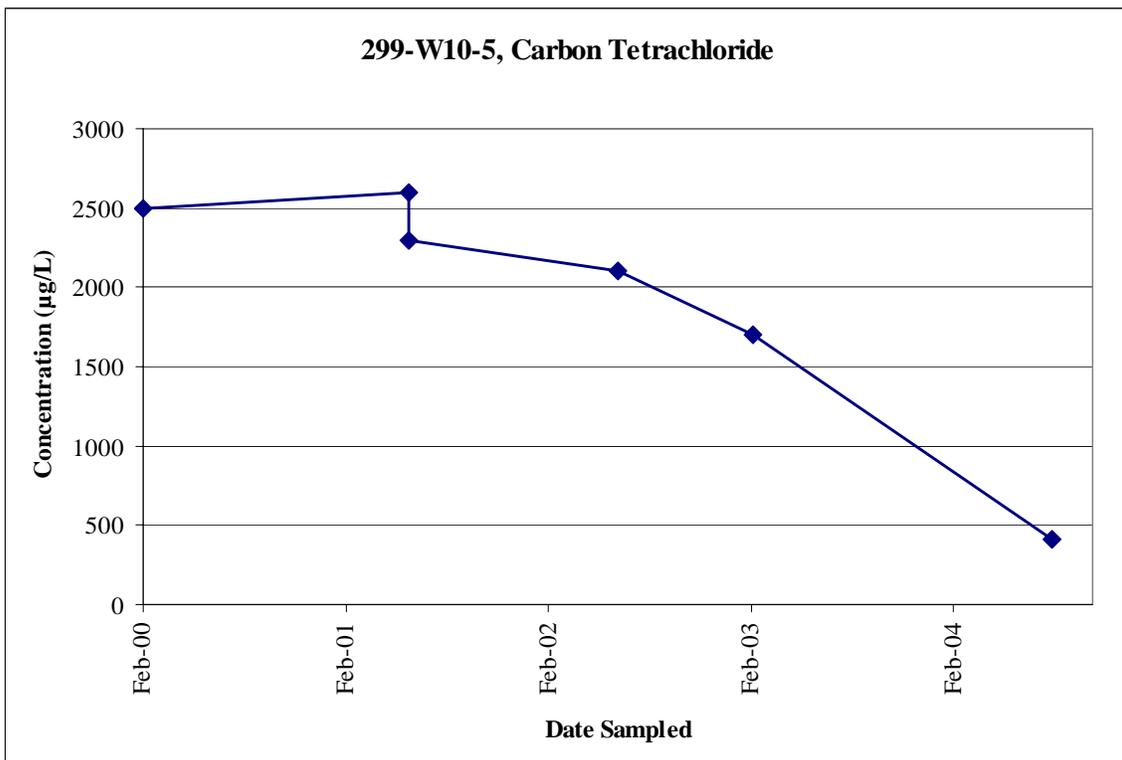
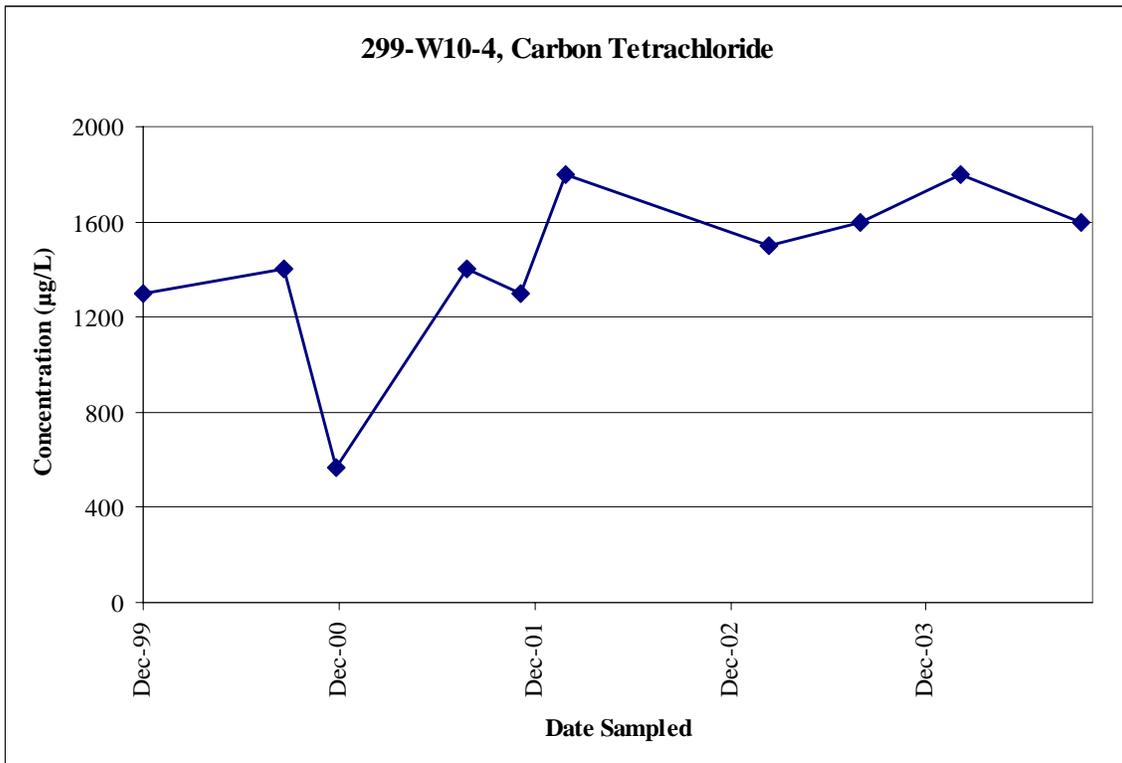


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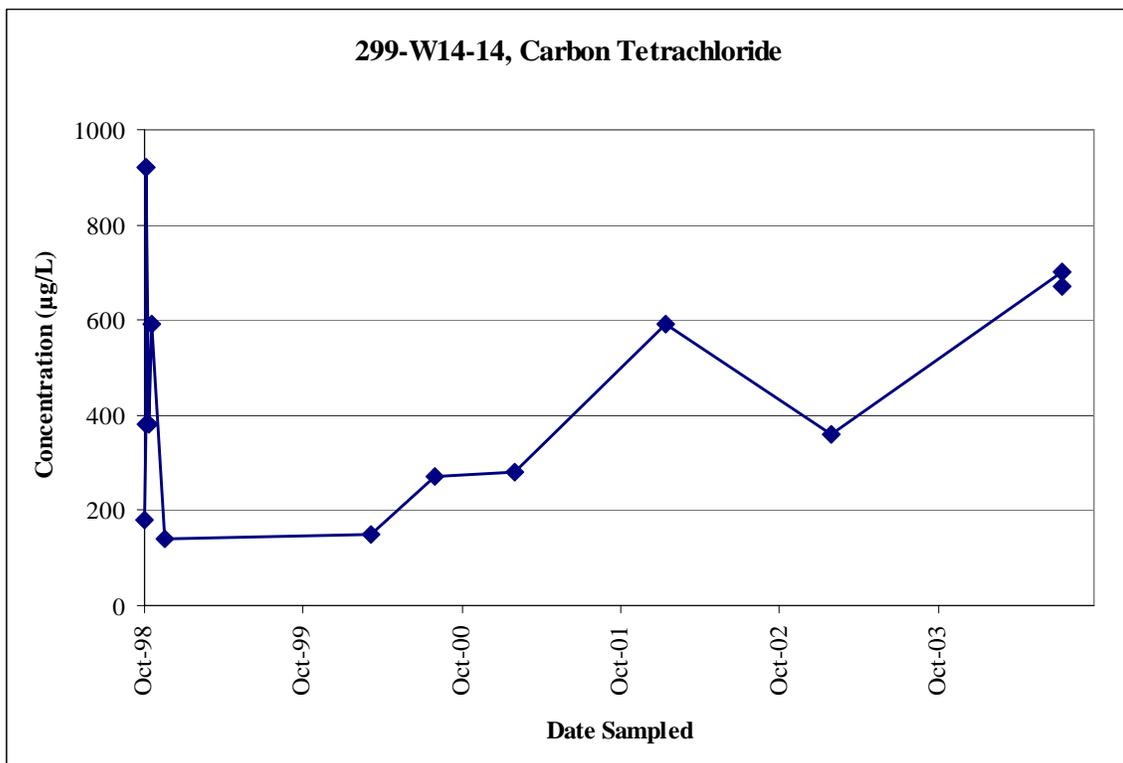
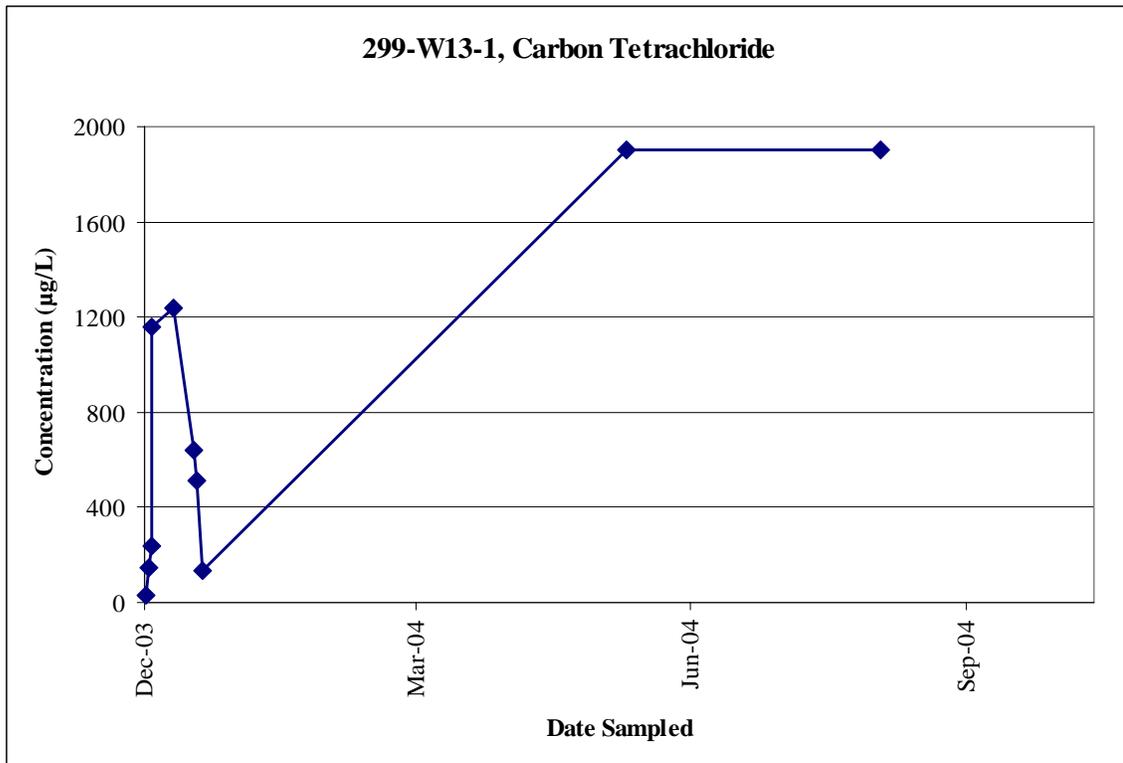


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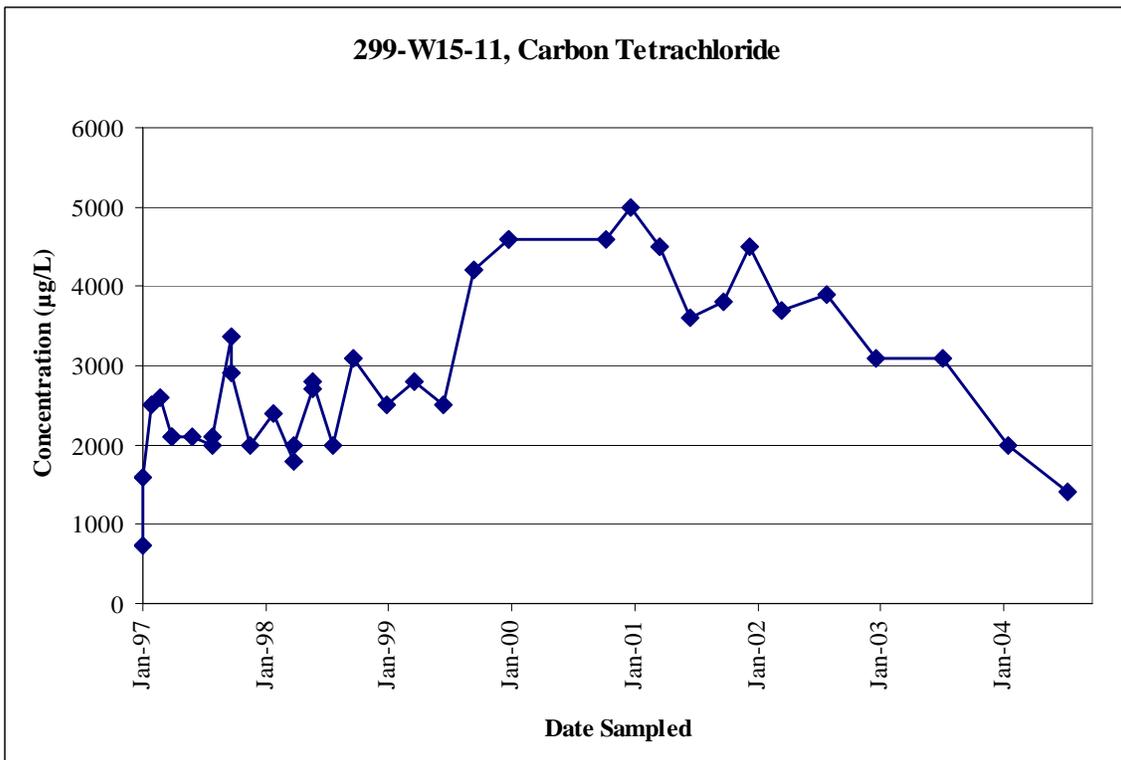
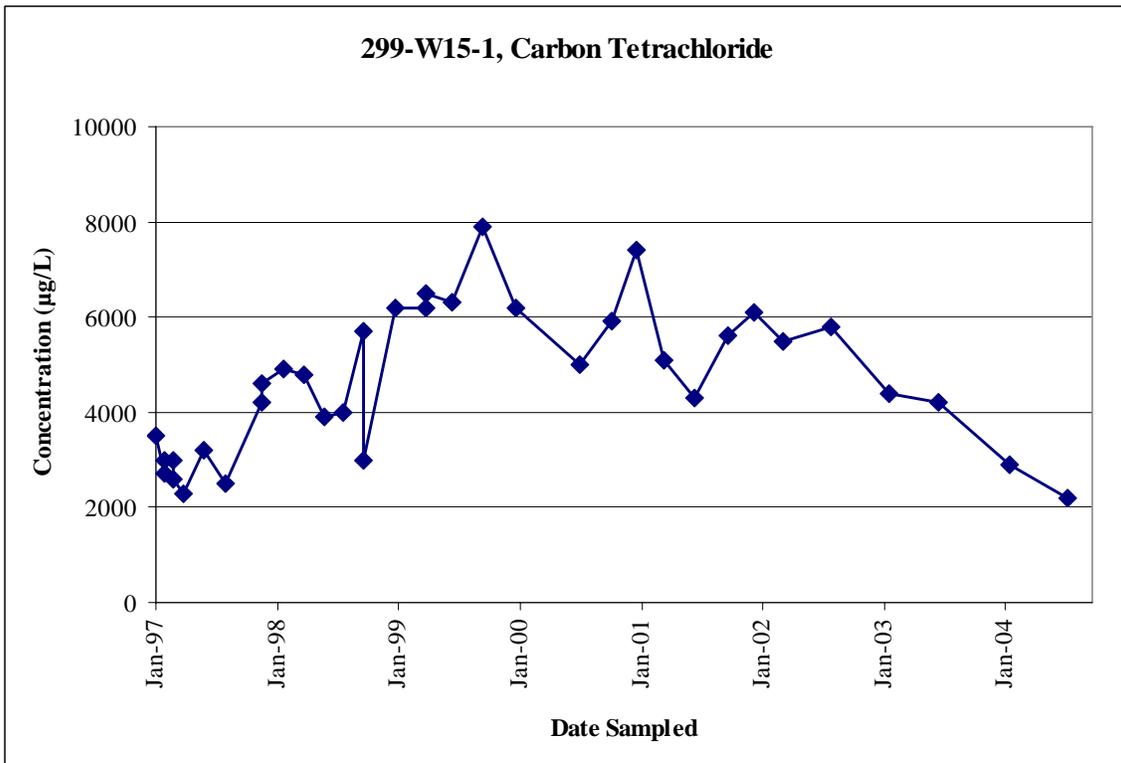




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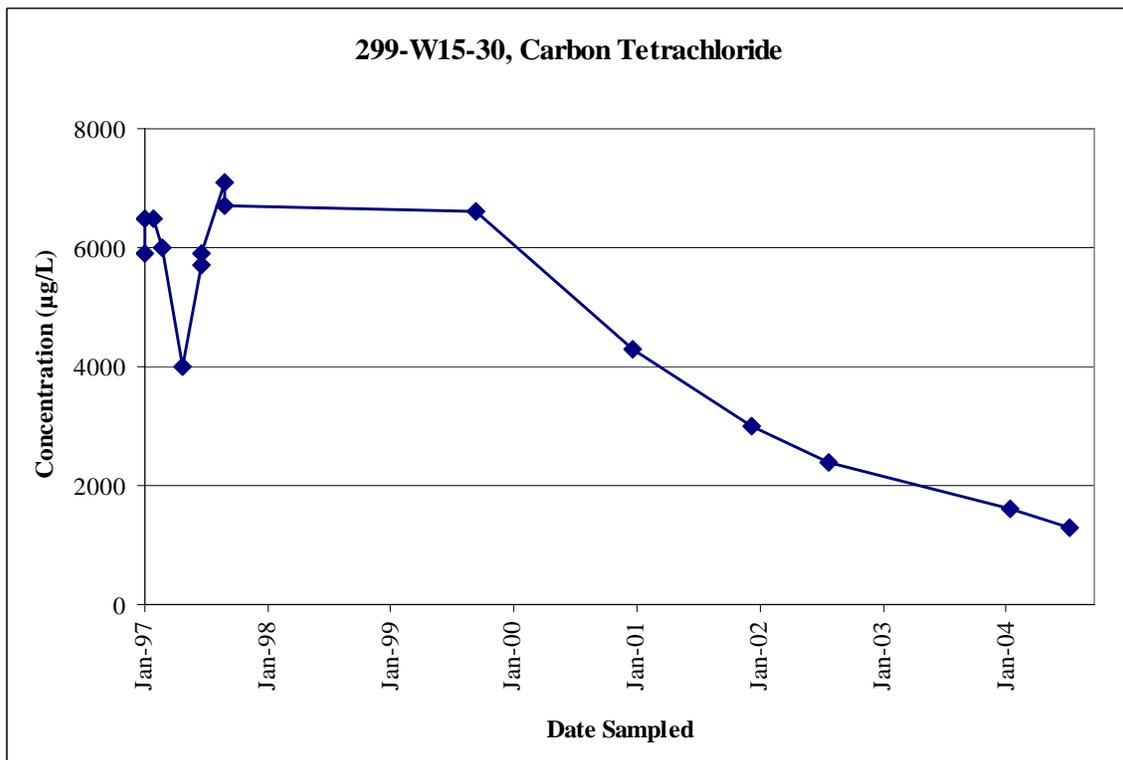
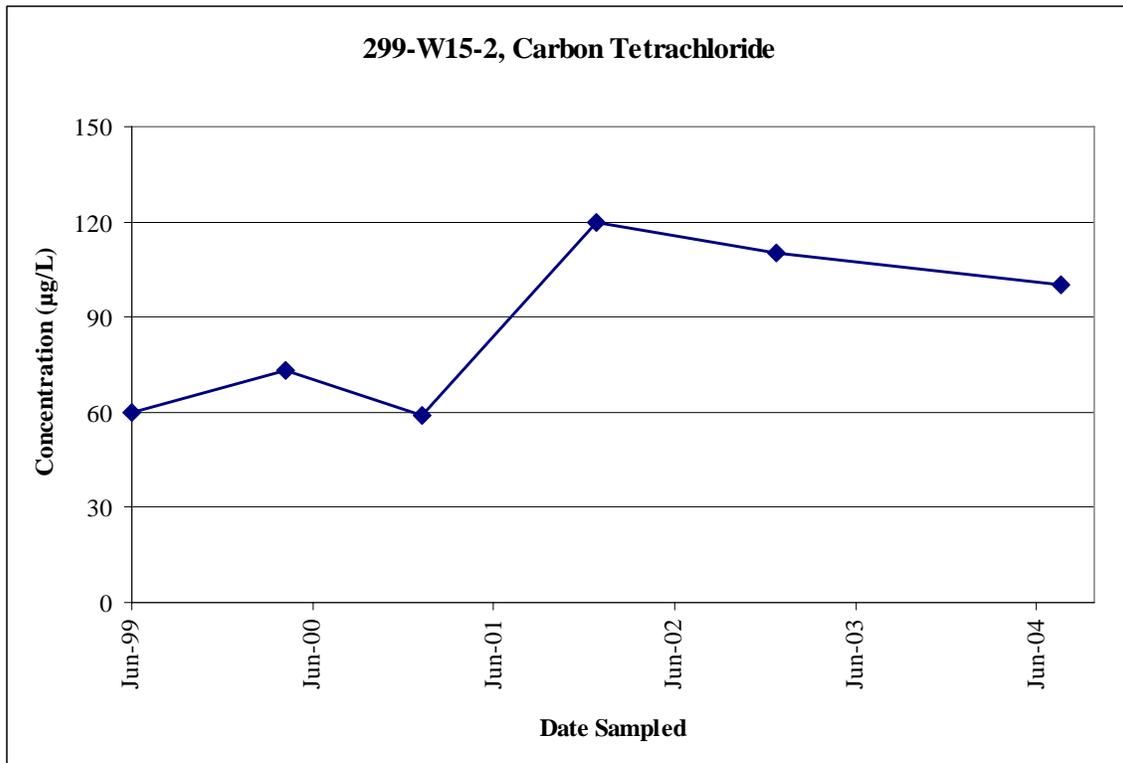


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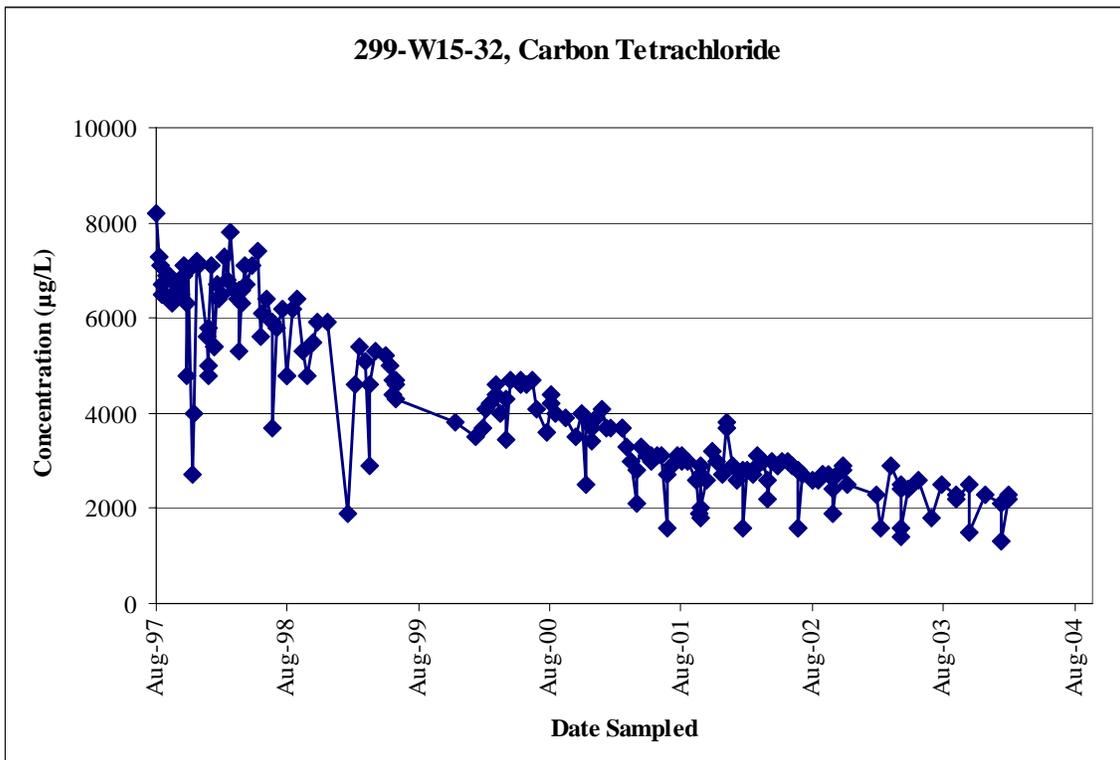
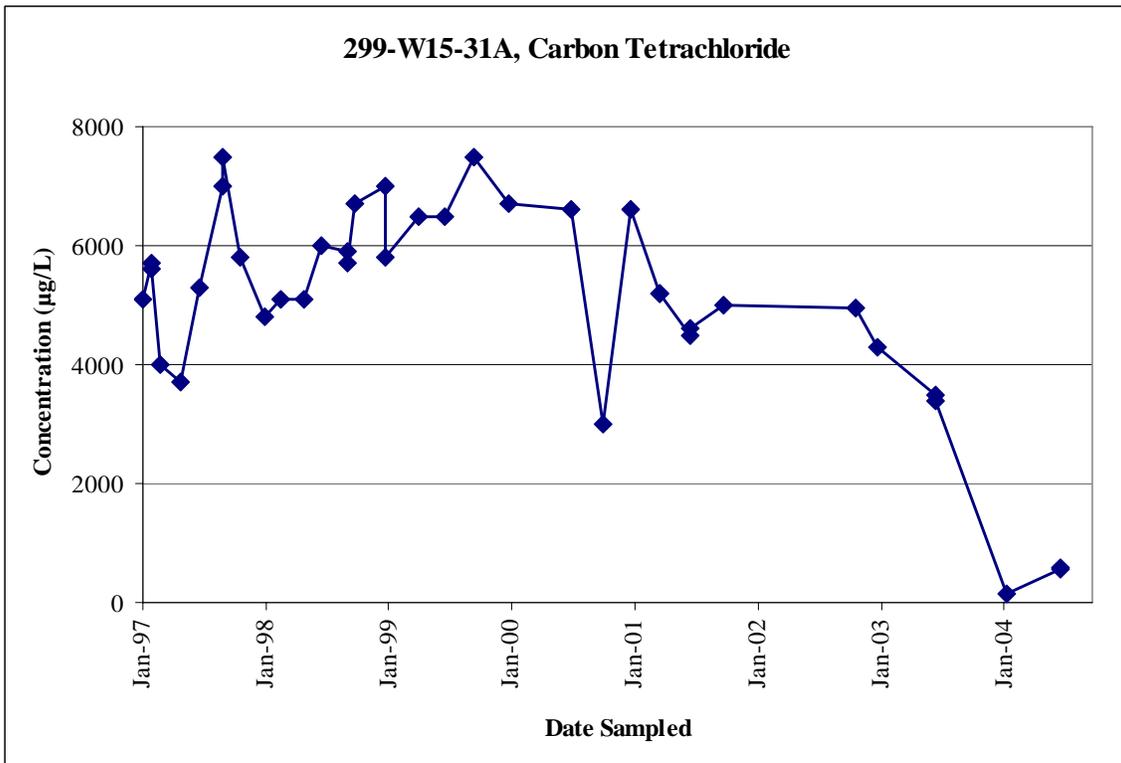


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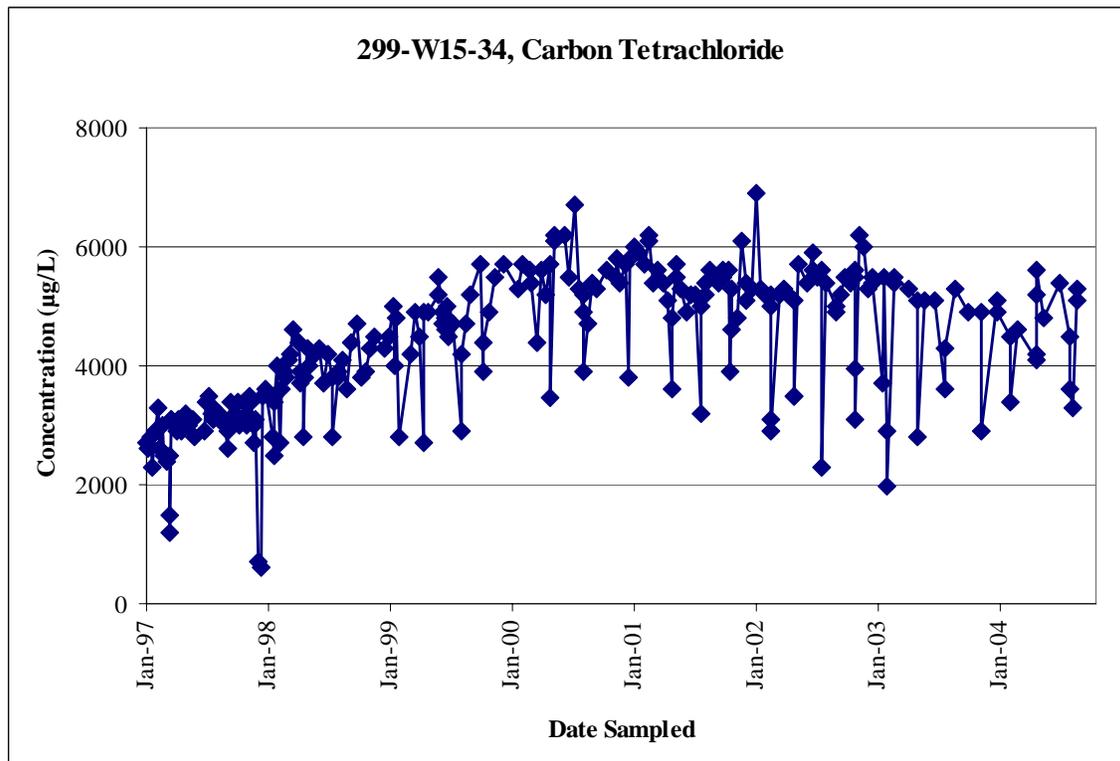
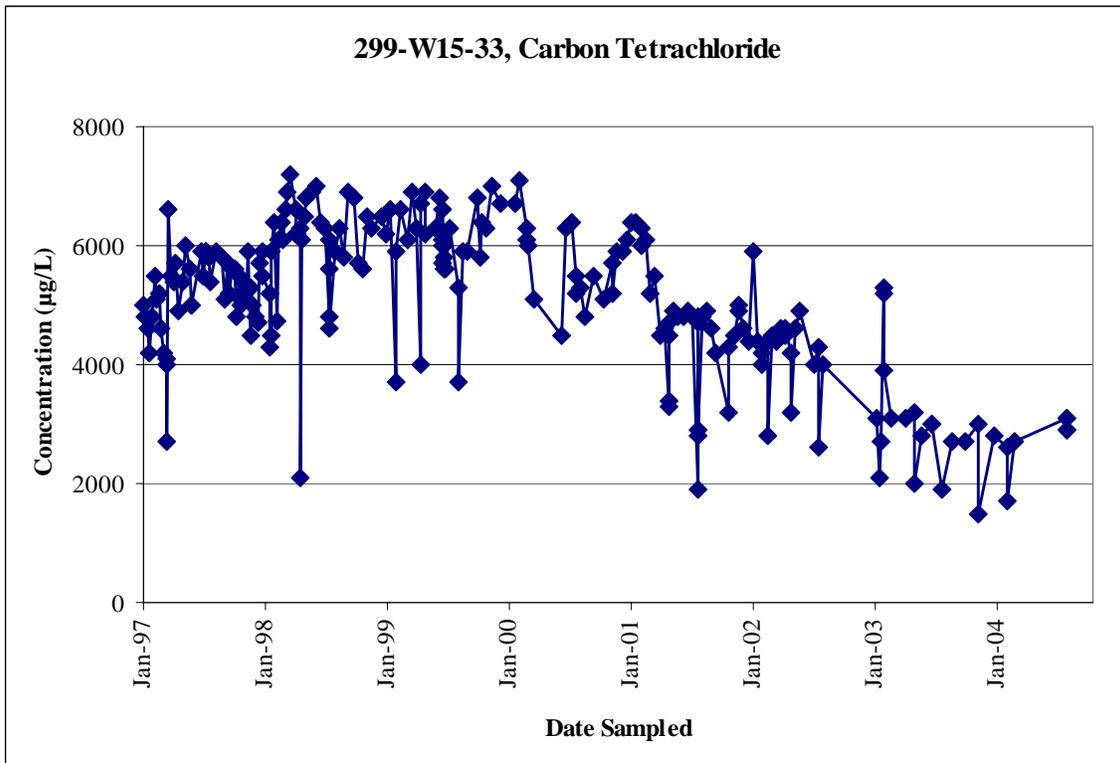






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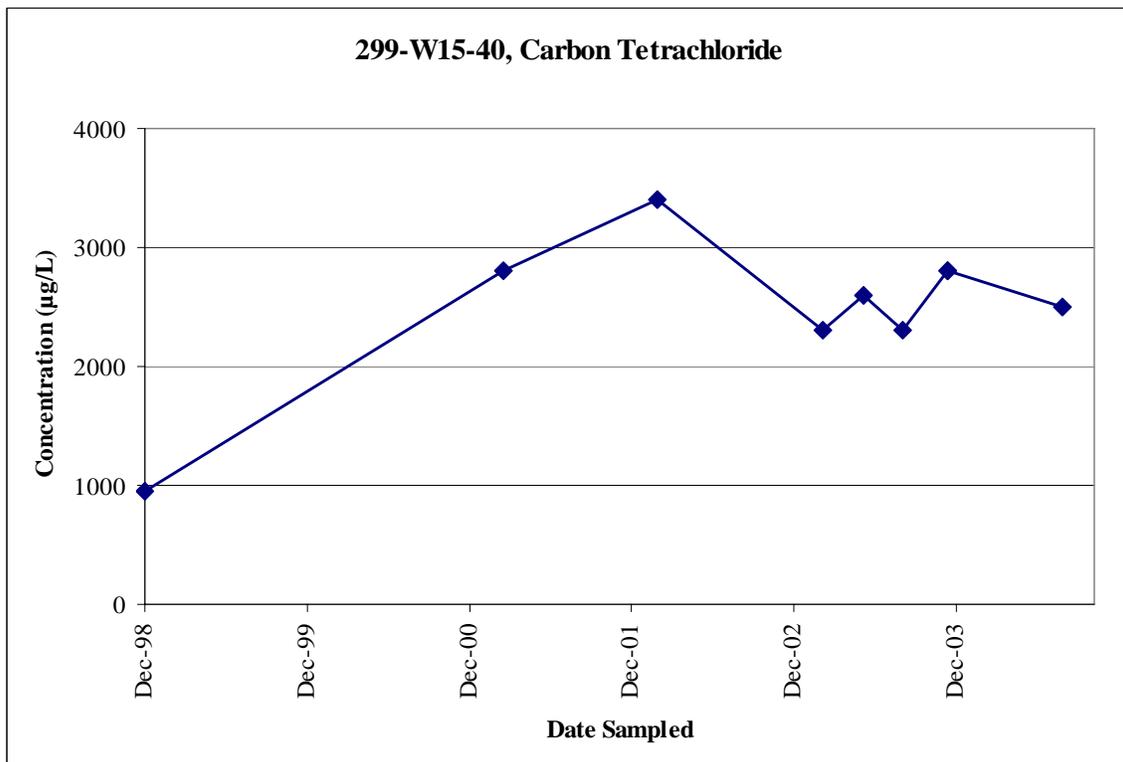
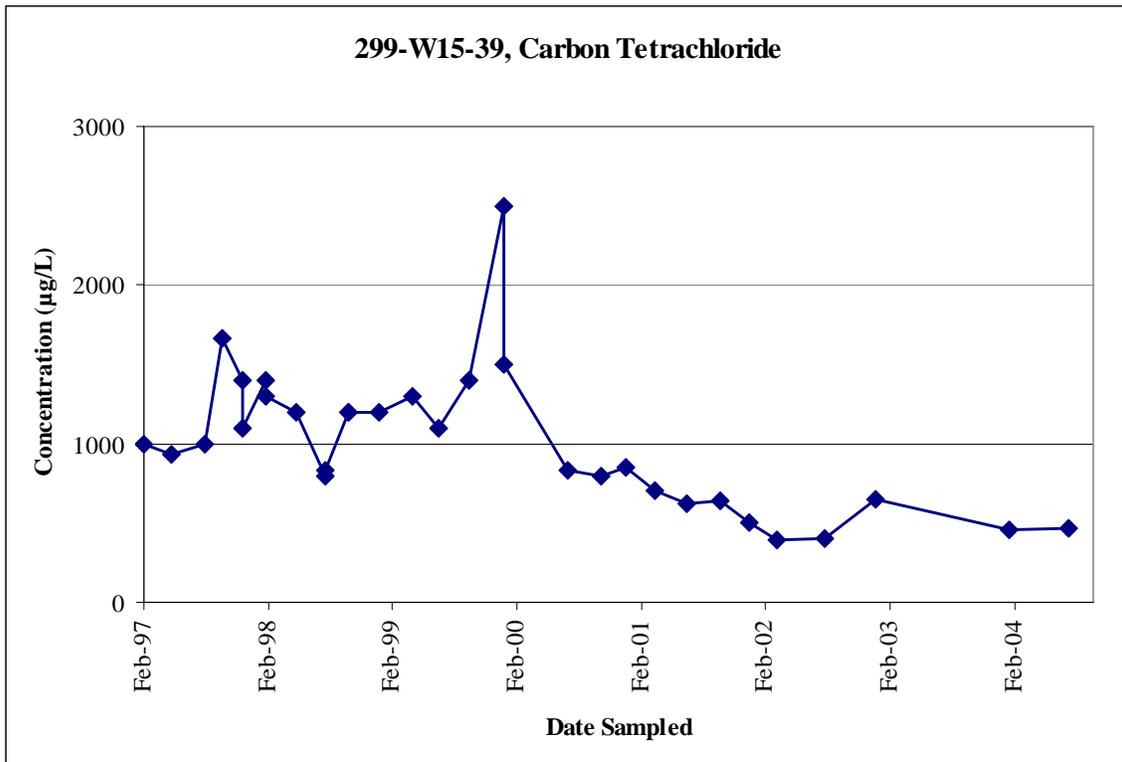


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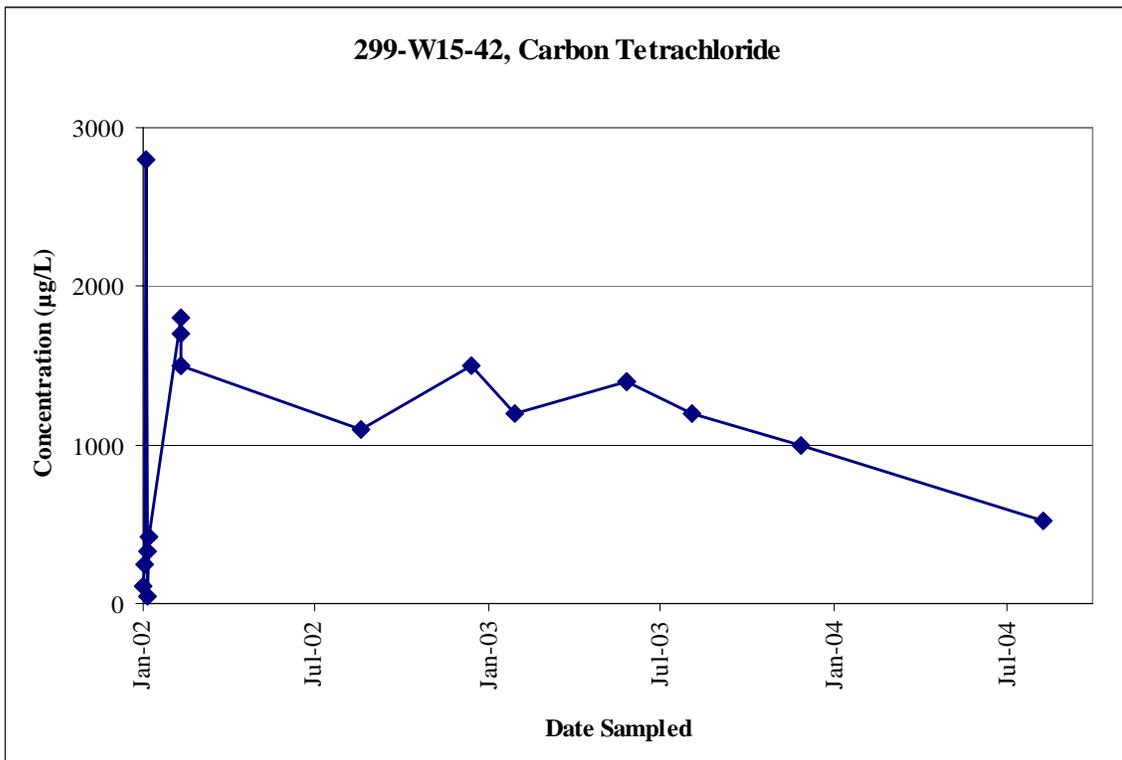
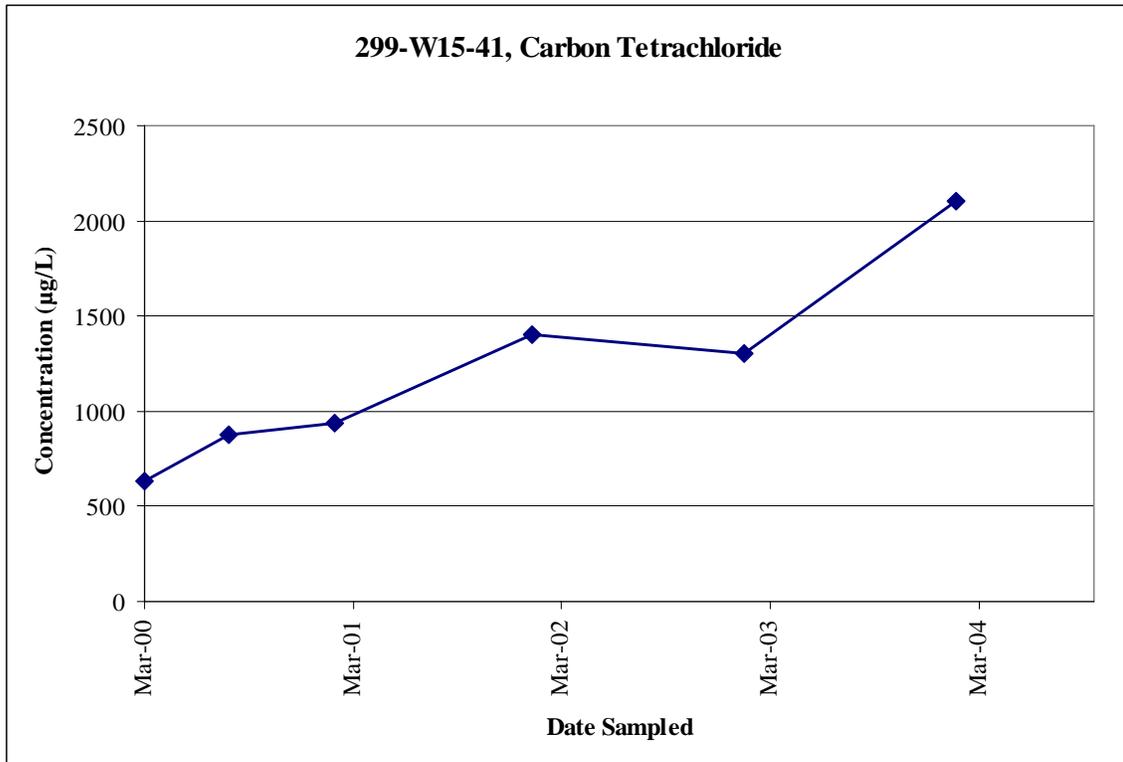


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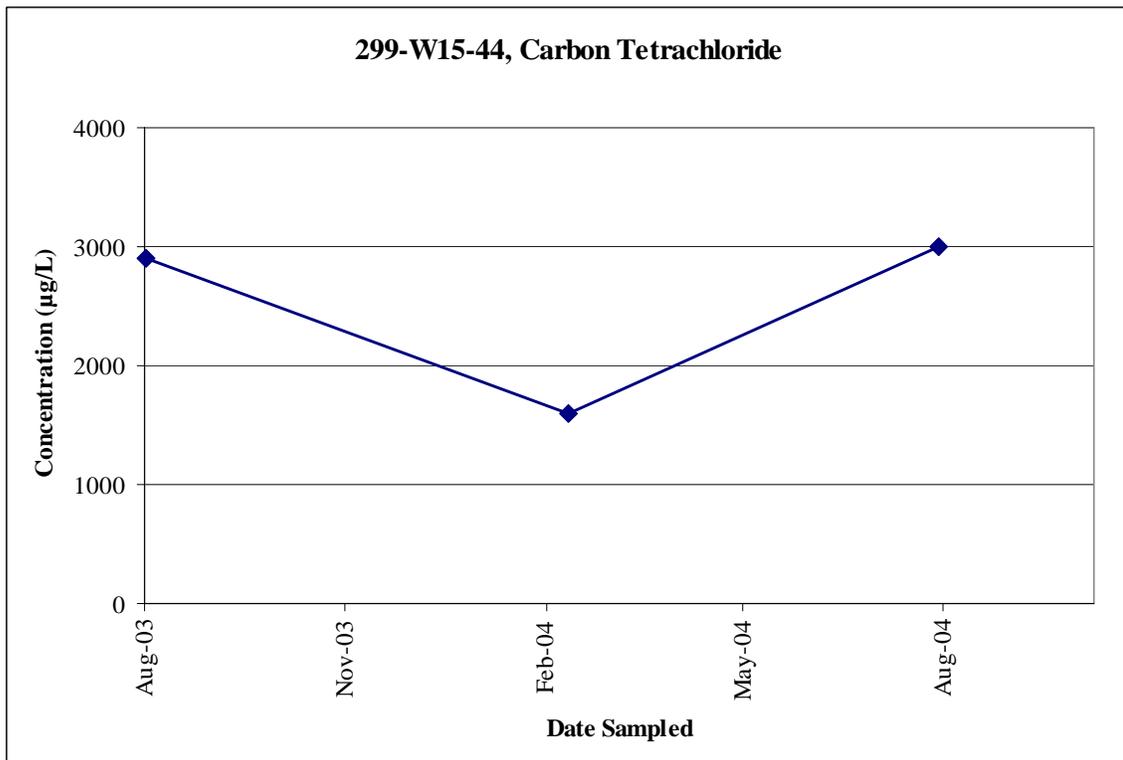
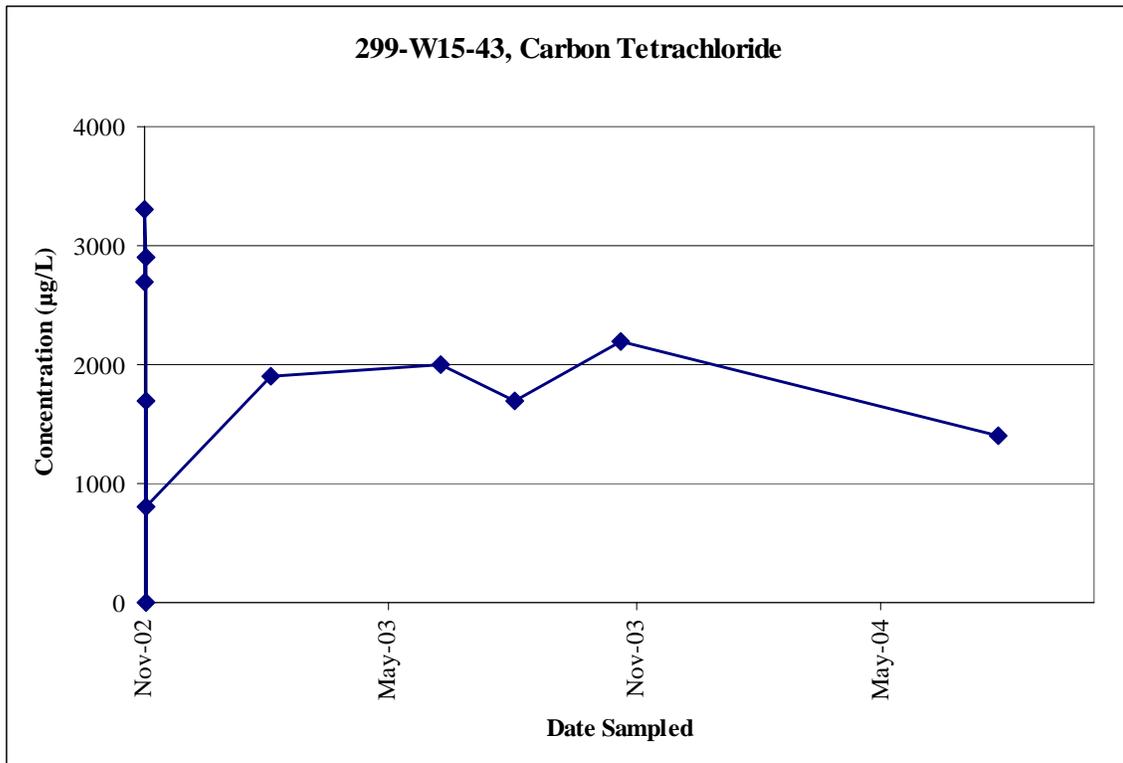


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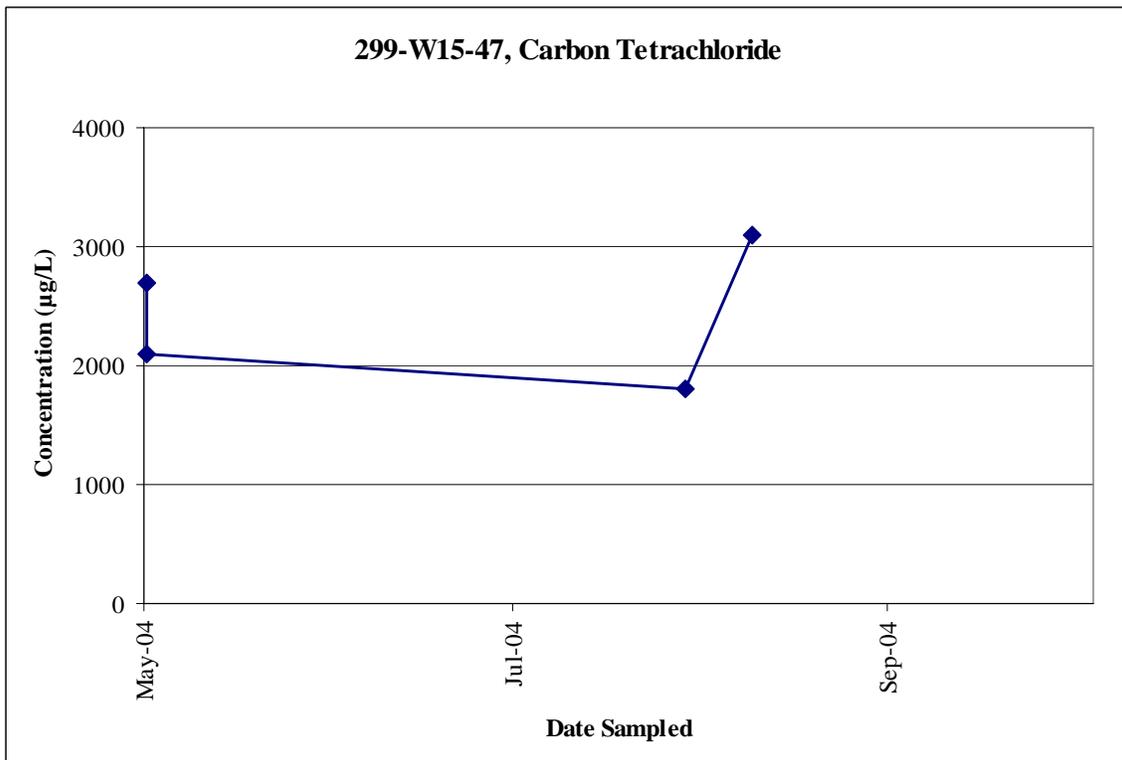
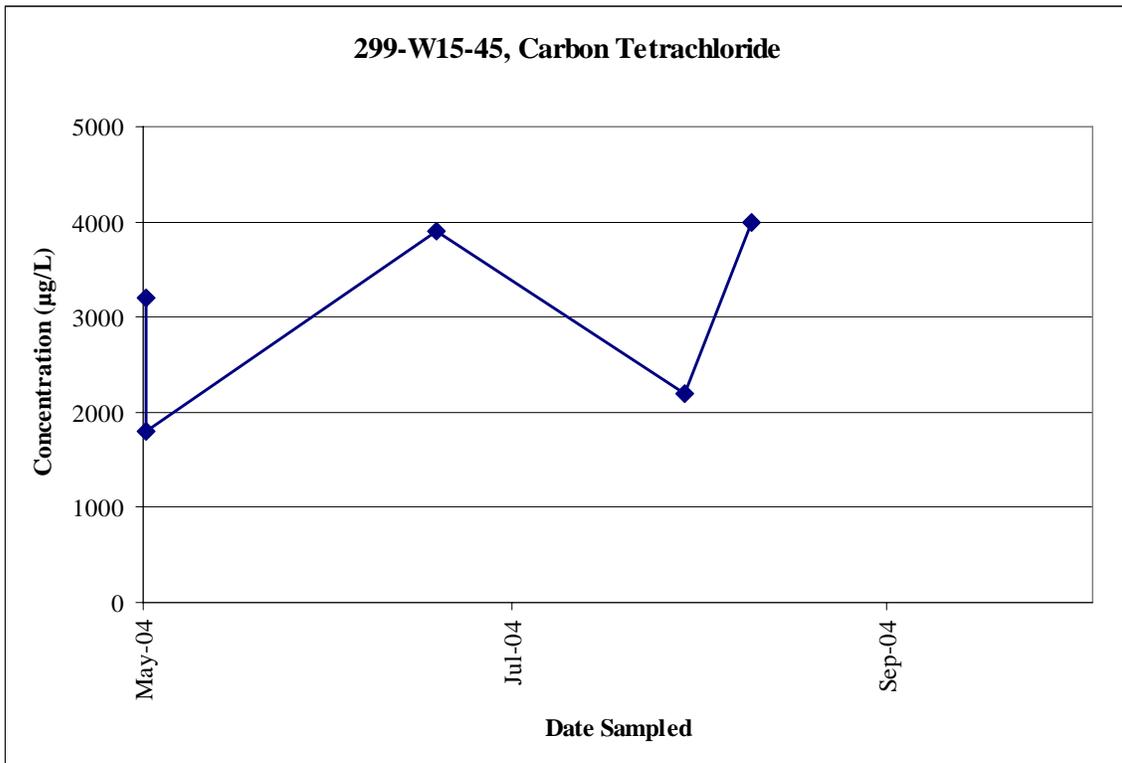


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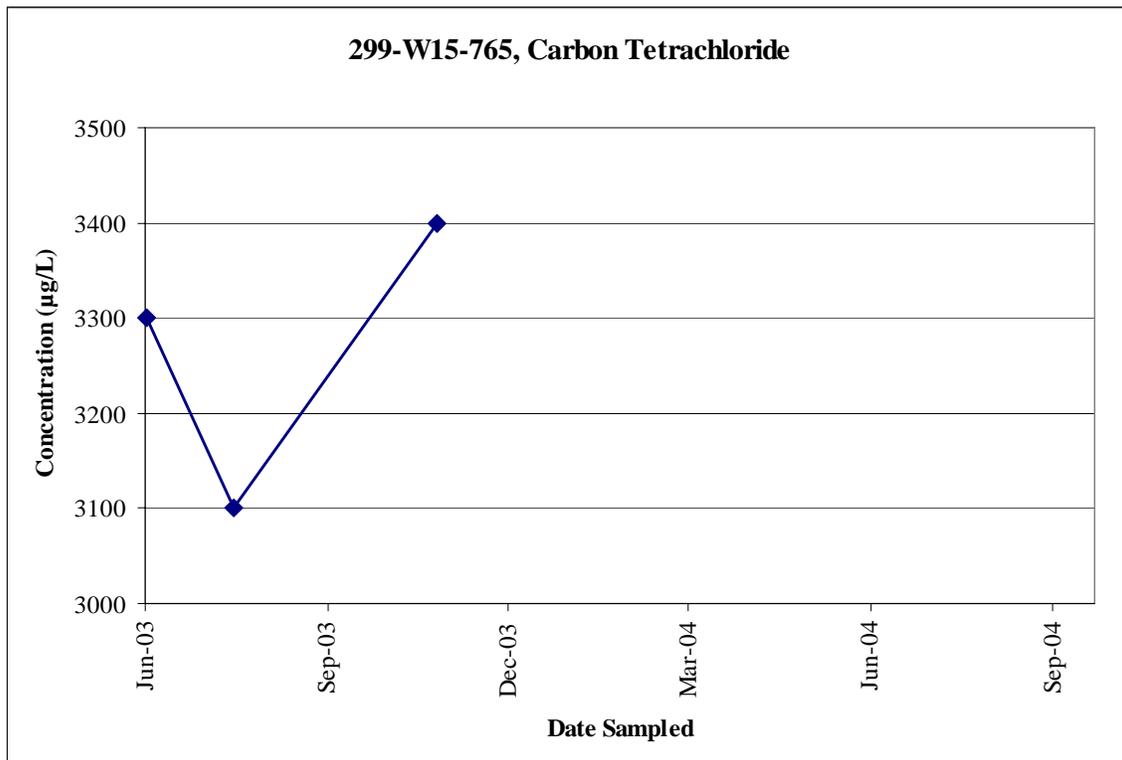
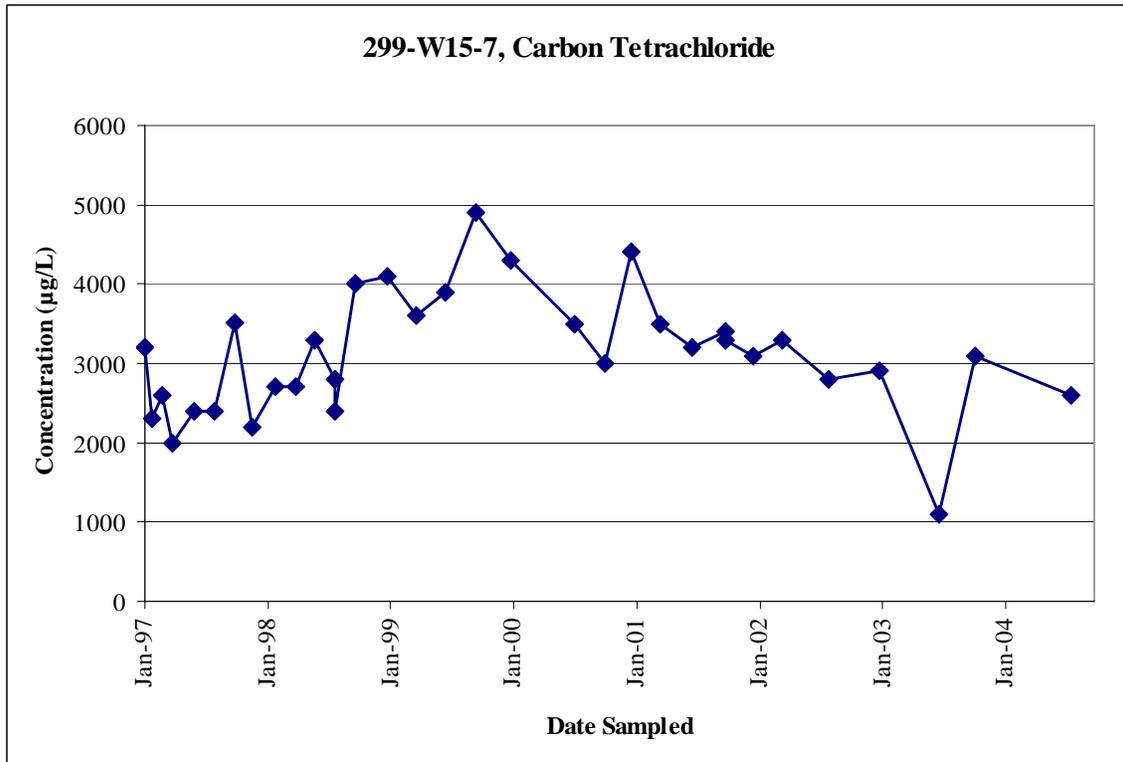


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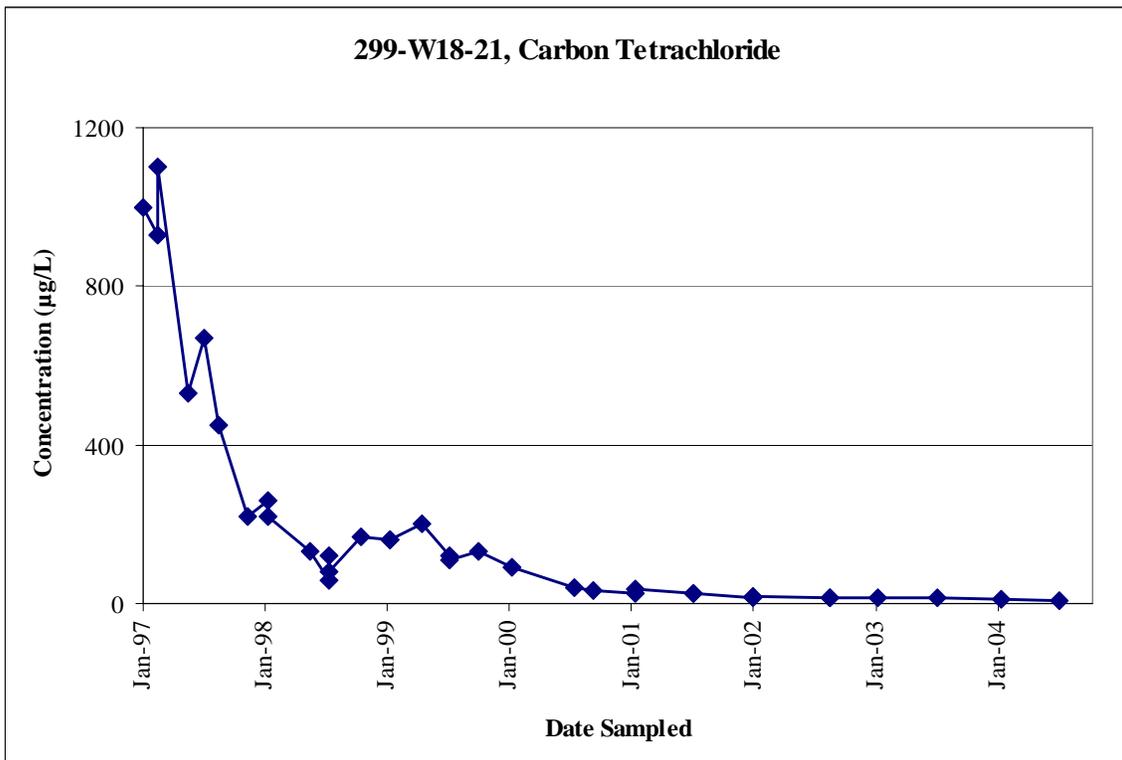
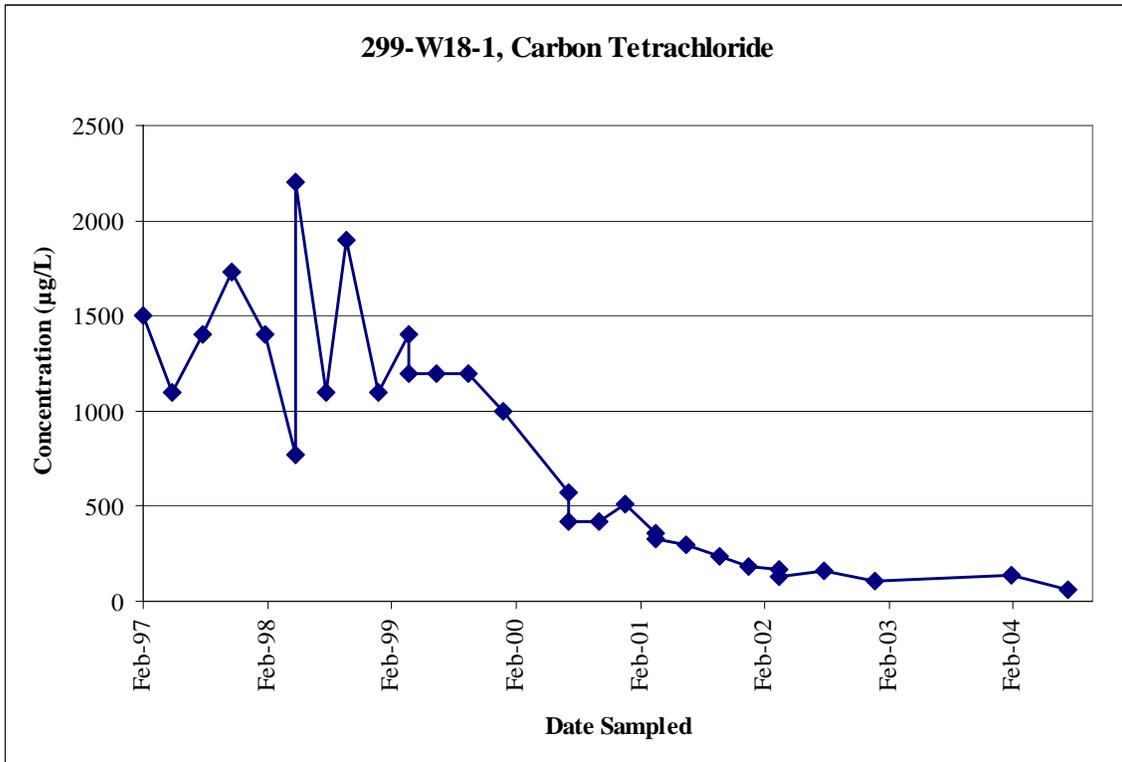


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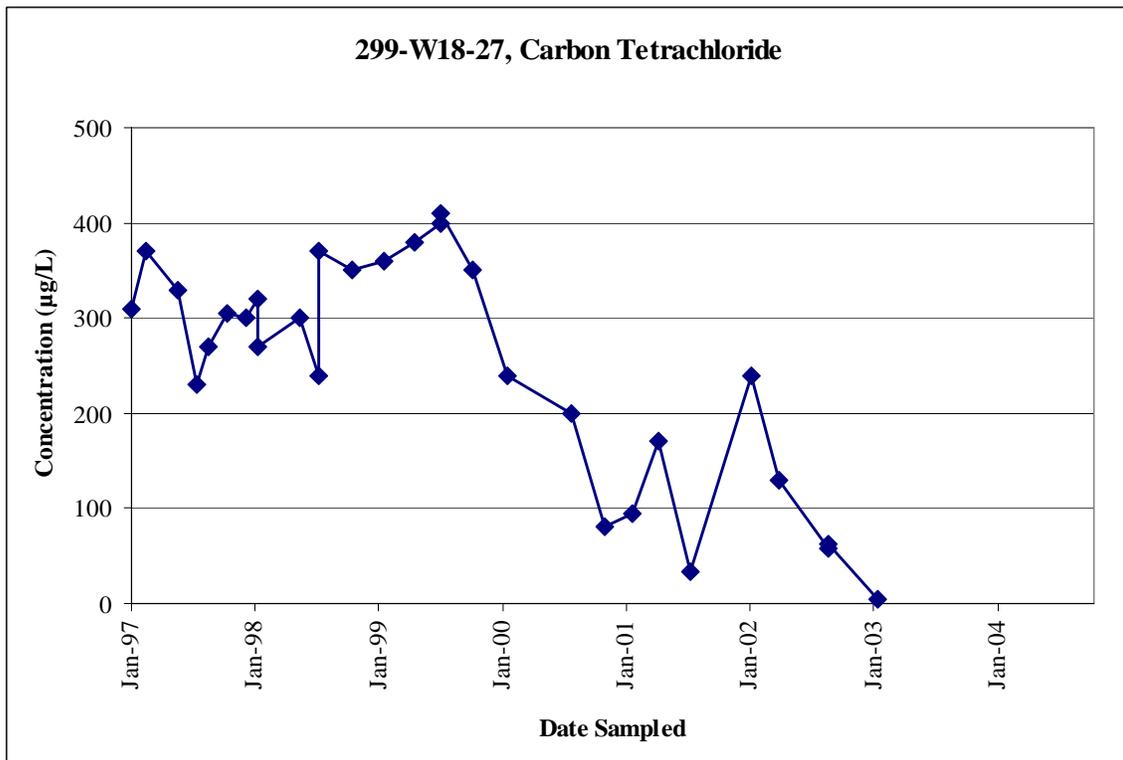
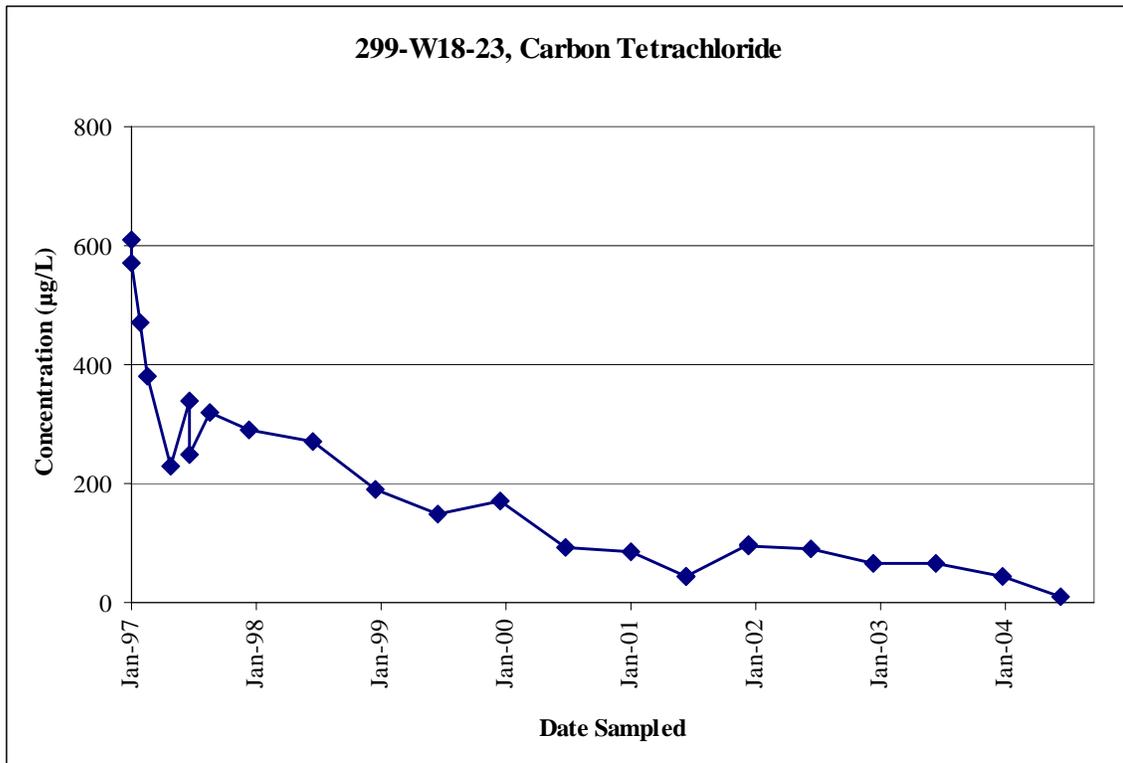


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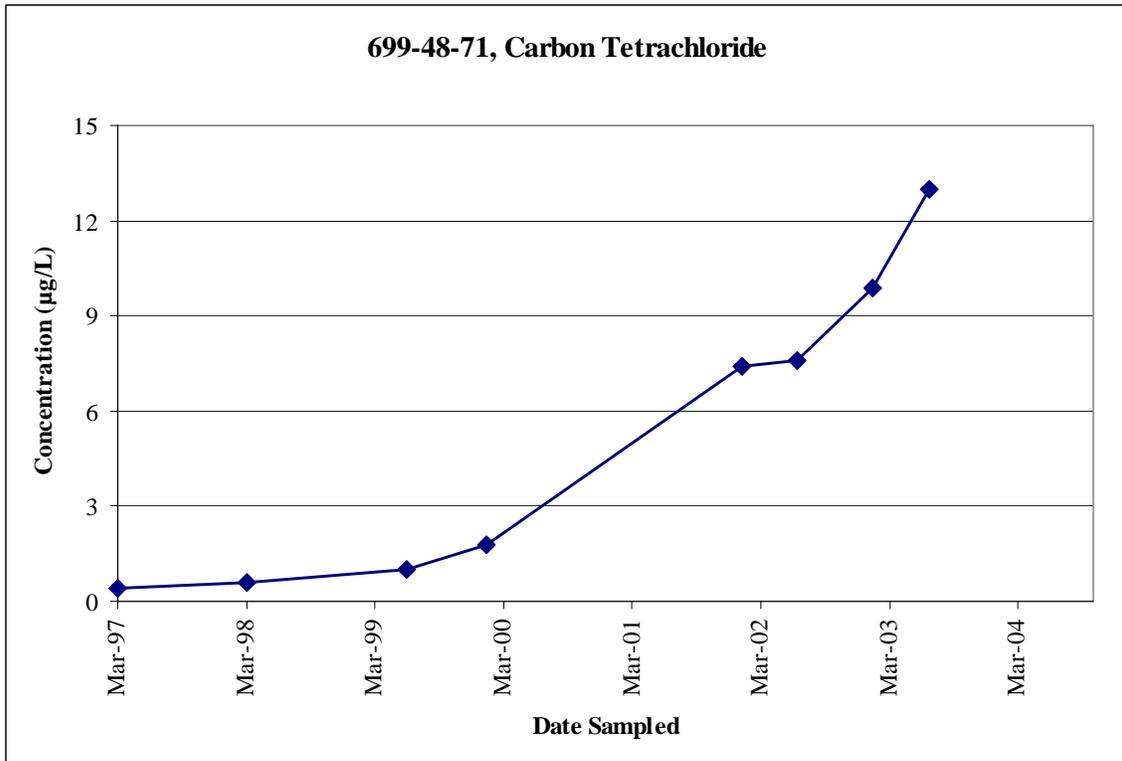


Figure H-2. 200-ZP-1 Groundwater Operable Unit, Chloroform Concentration Trends at Selected Monitoring Wells. (17 sheets)

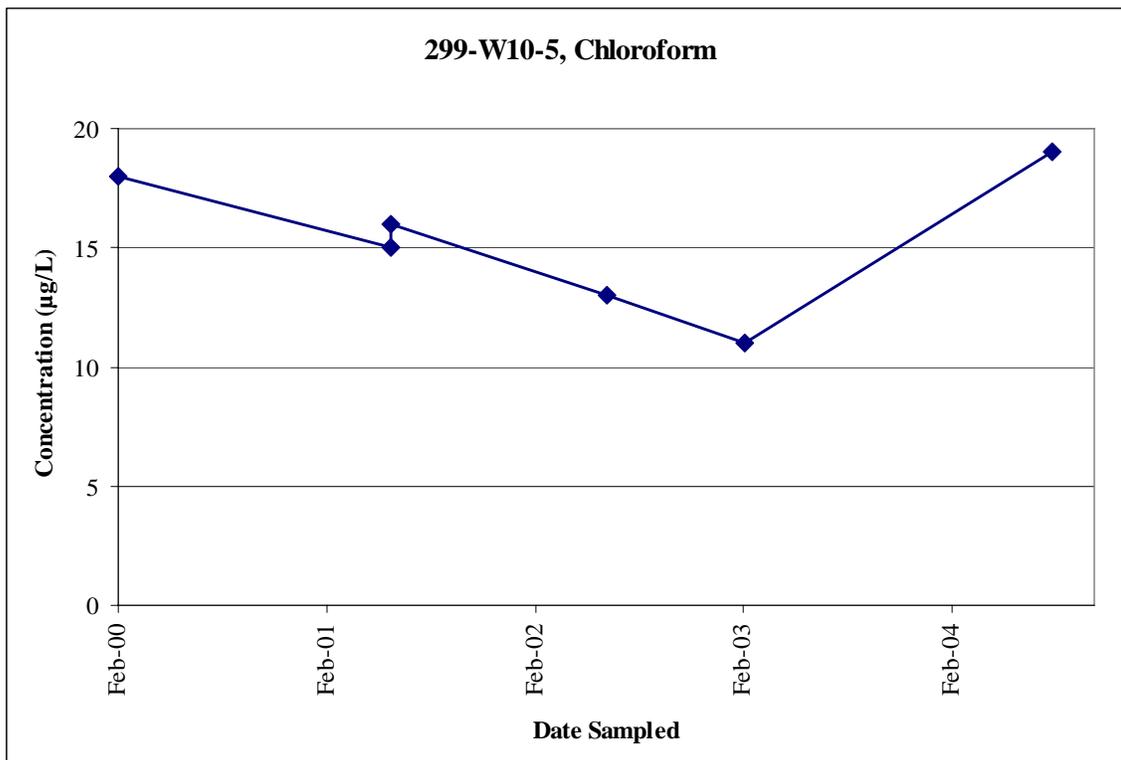
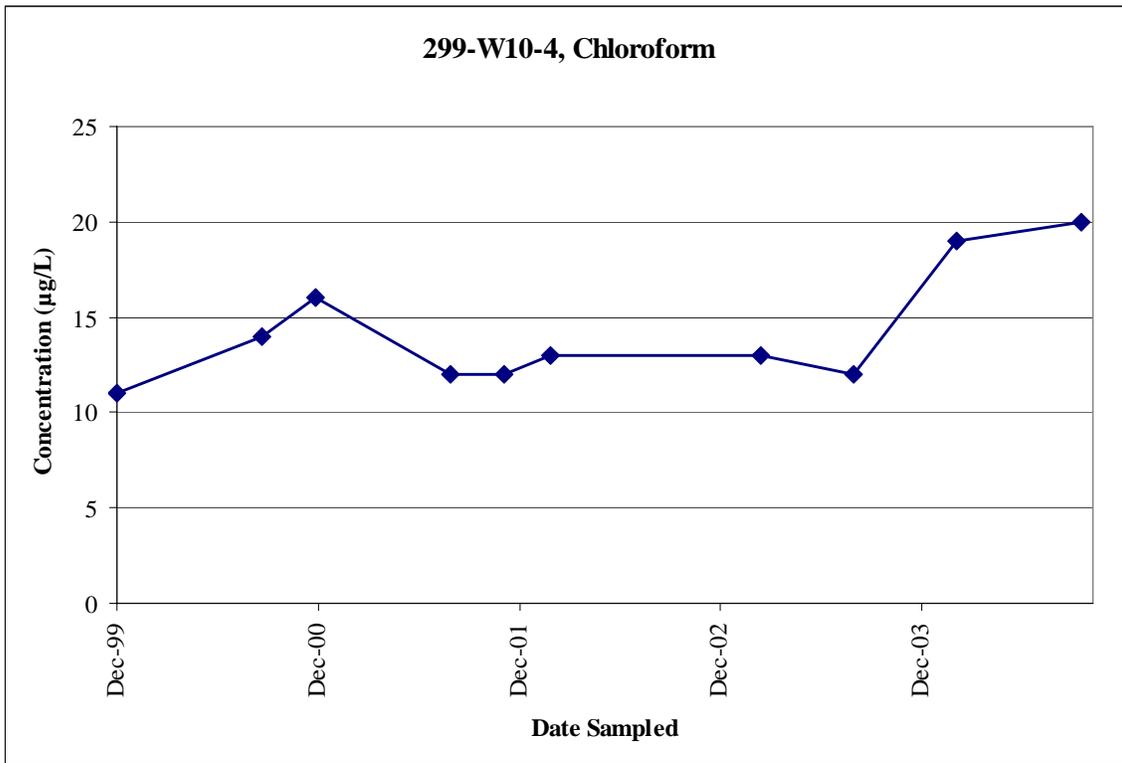


Figure H-2. 200-ZP-1 Groundwater Operable Unit, Chloroform Concentration Trends at Selected Monitoring Wells. (17 sheets)

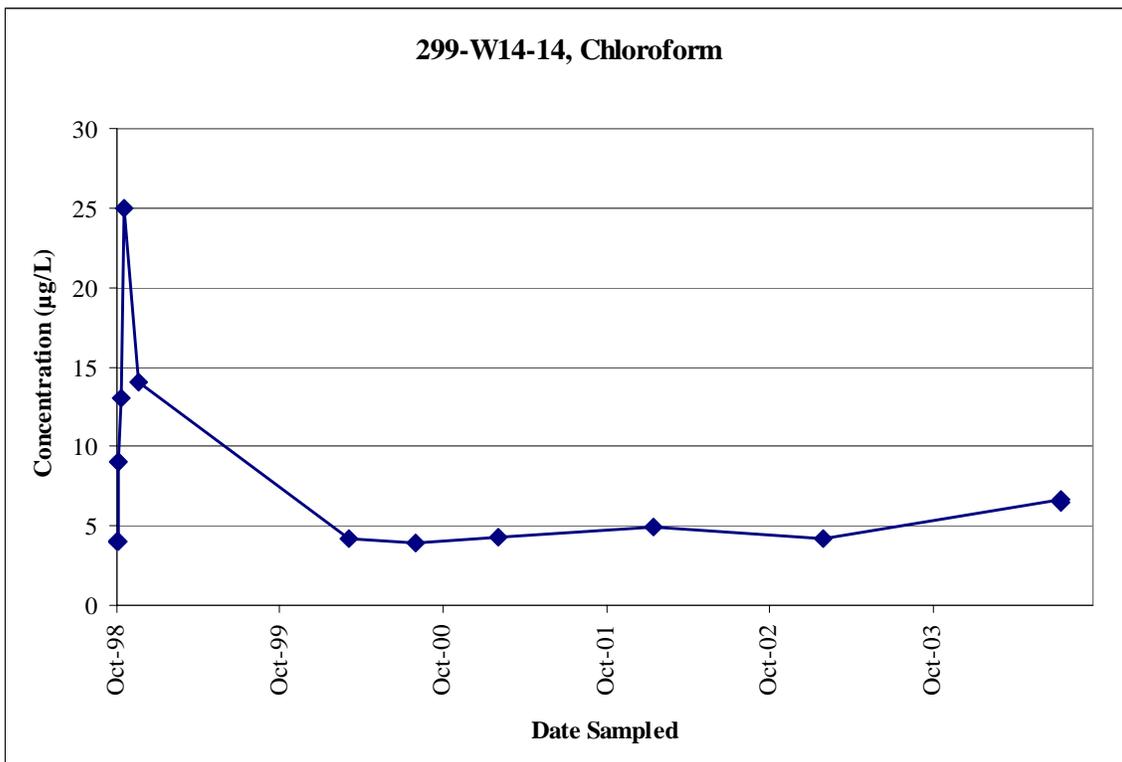
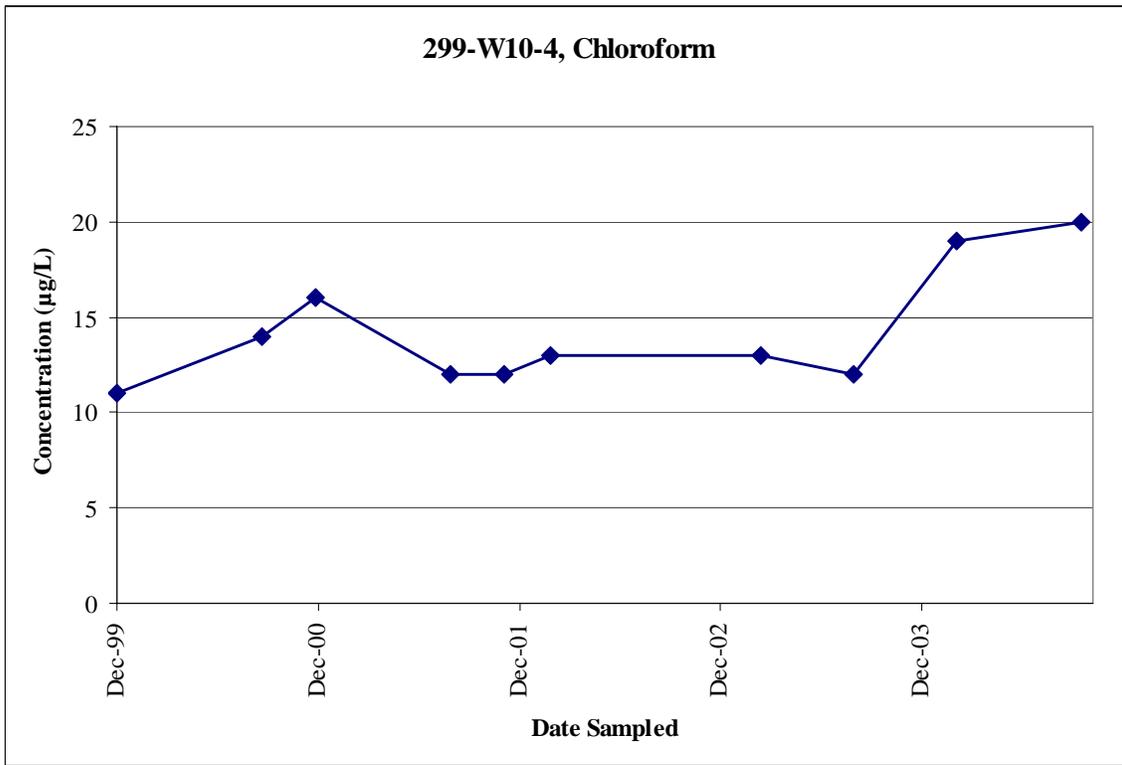


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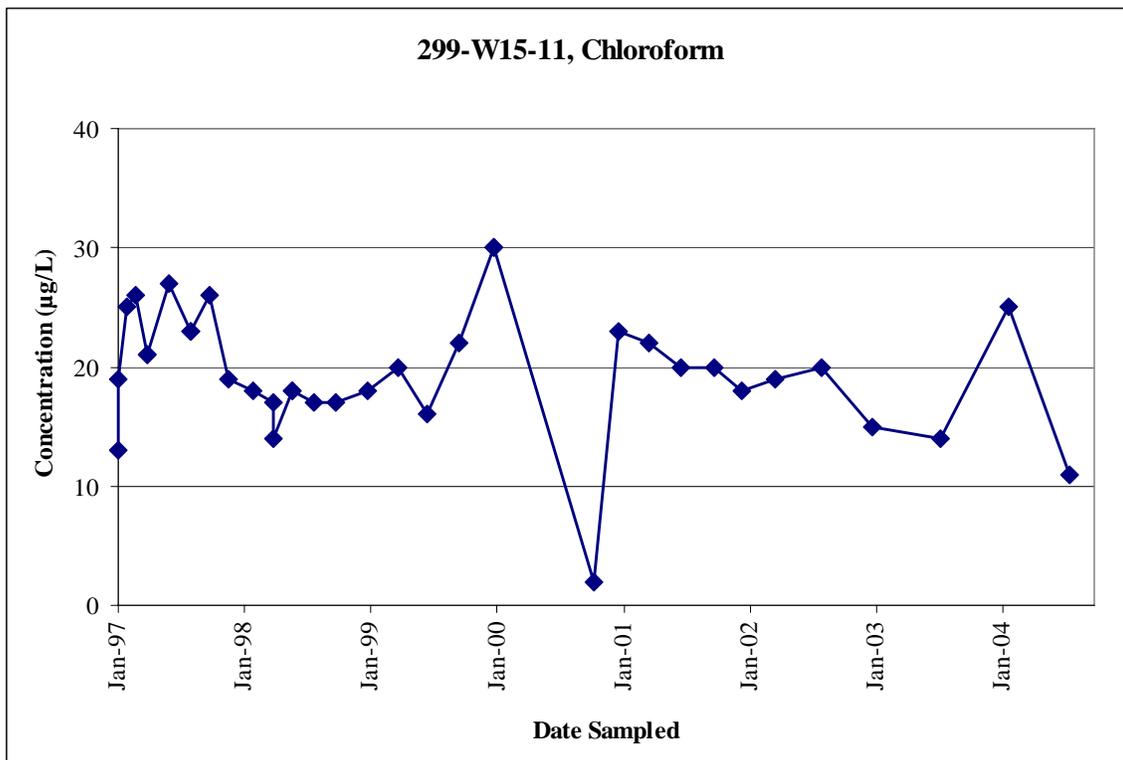
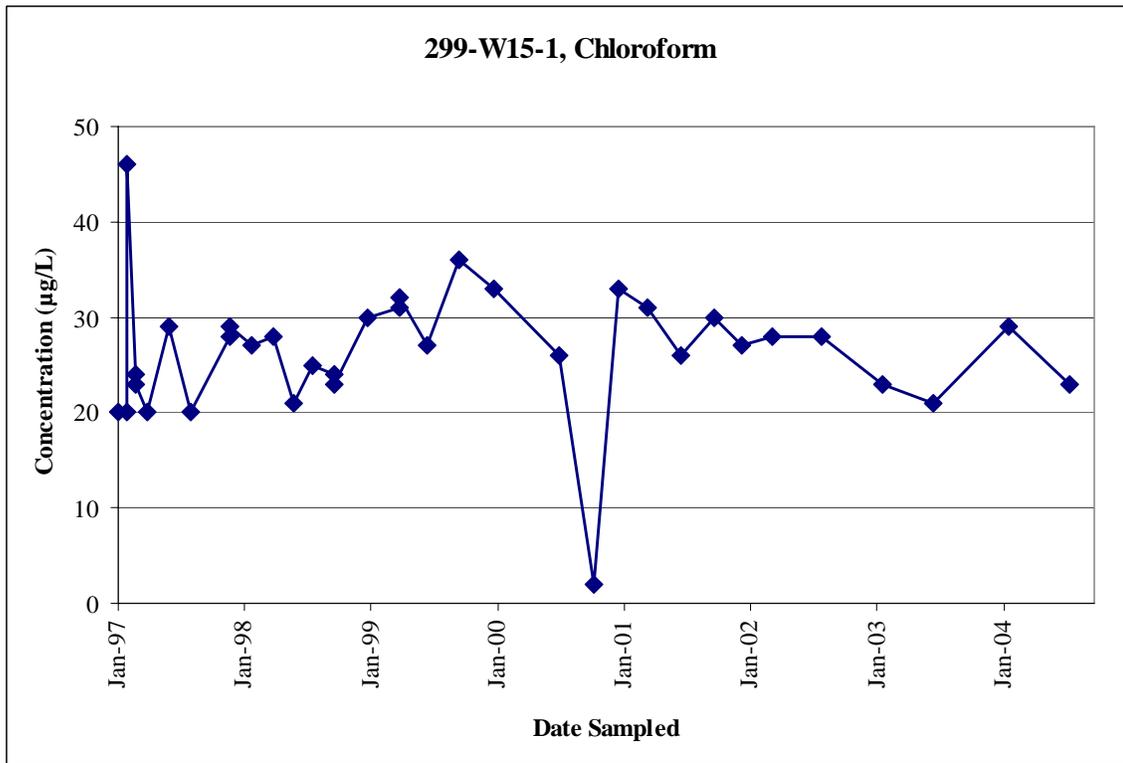


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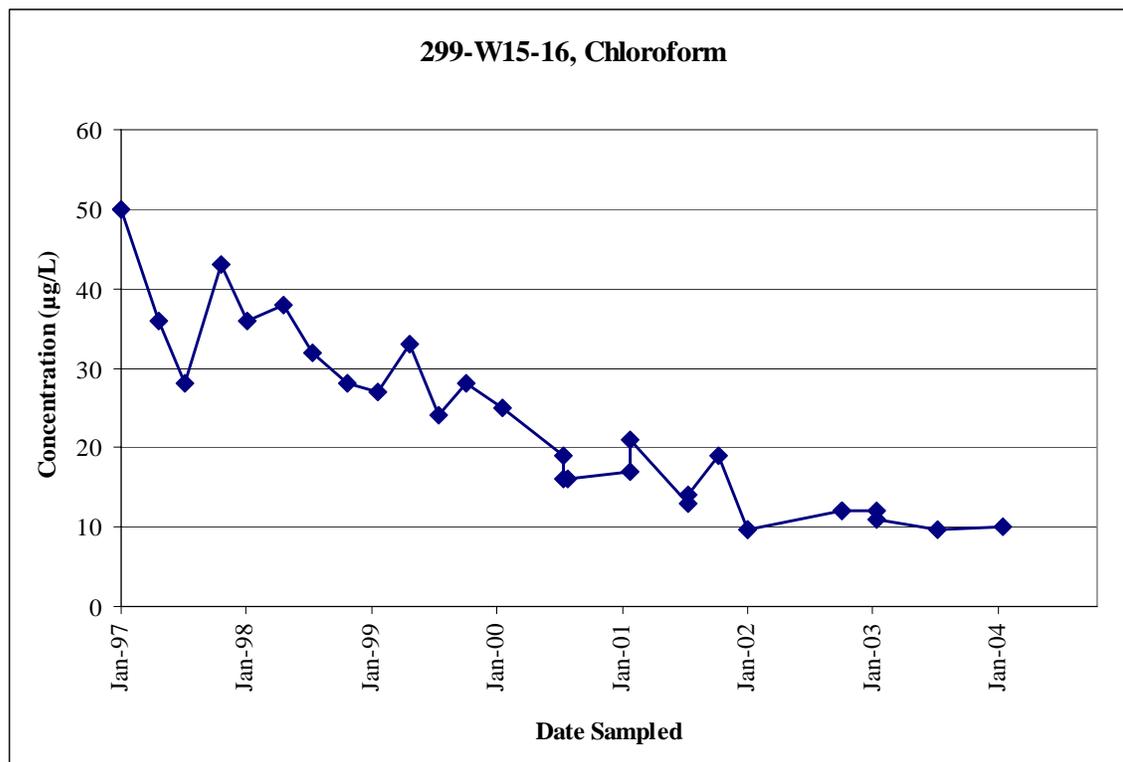
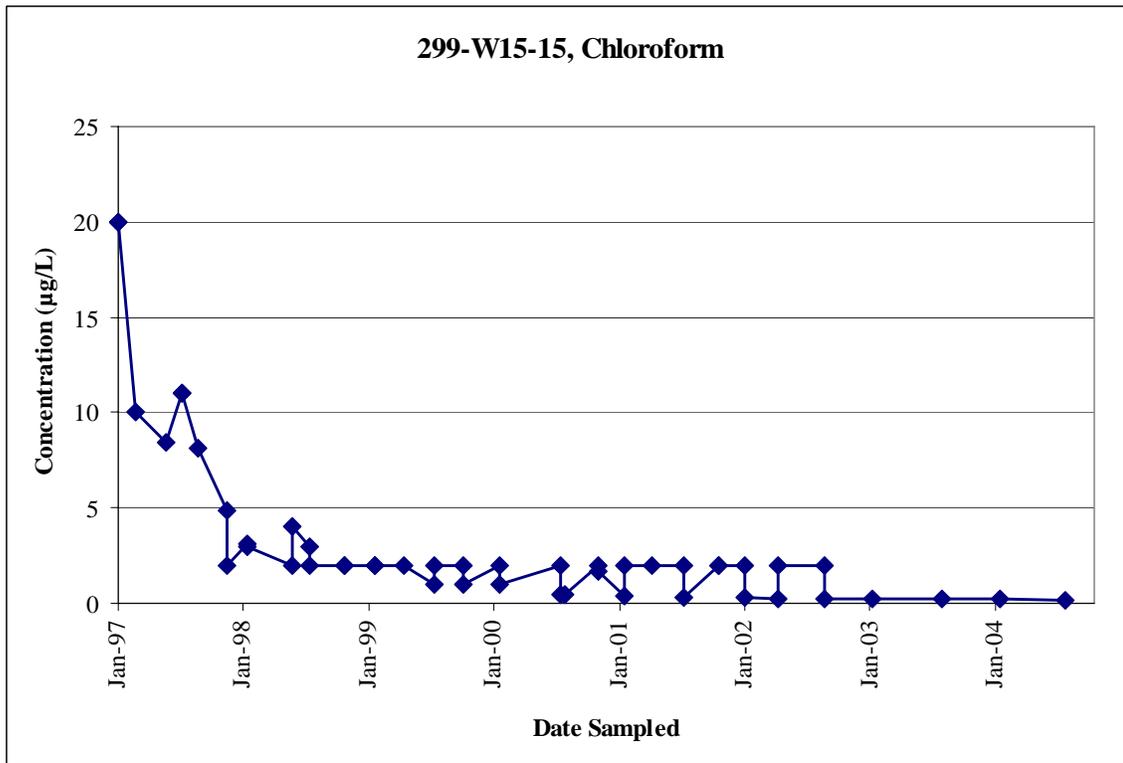


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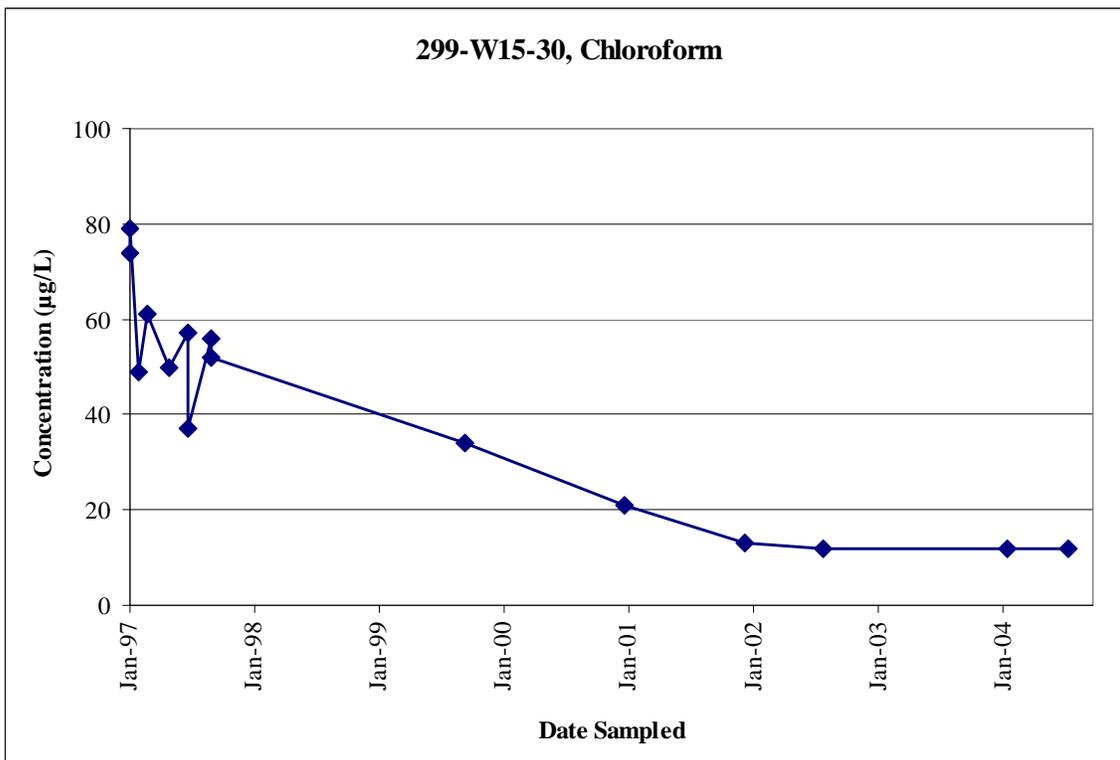
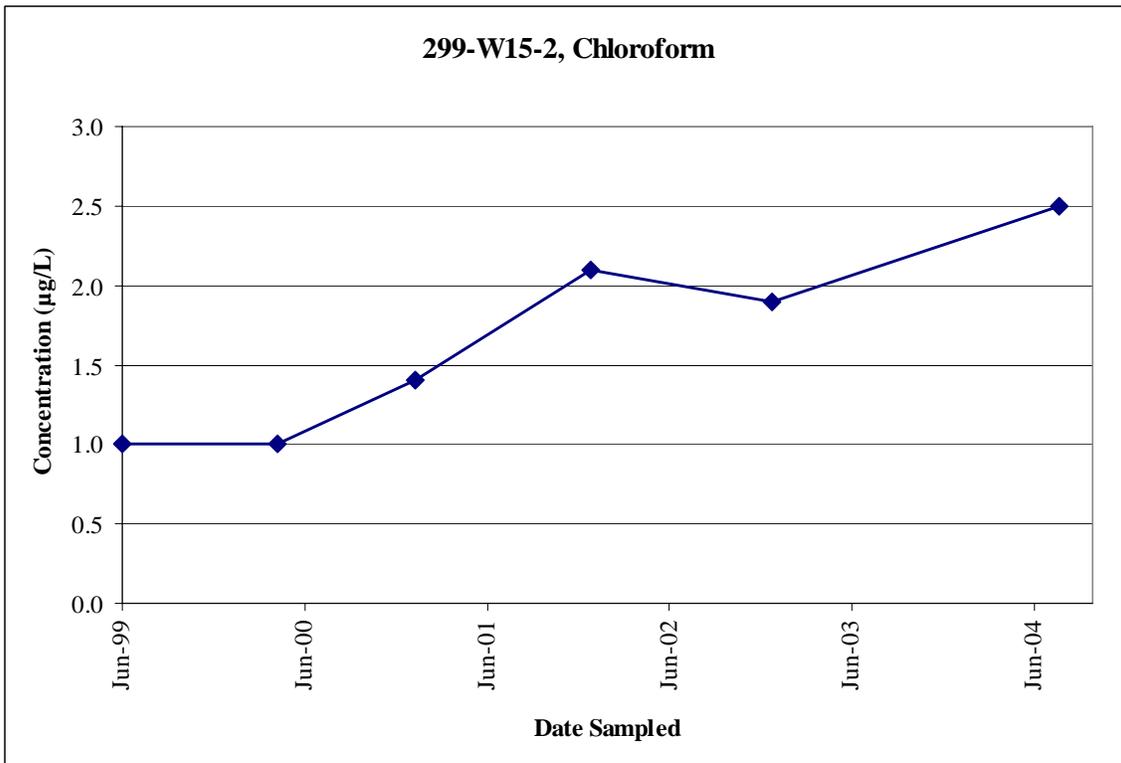




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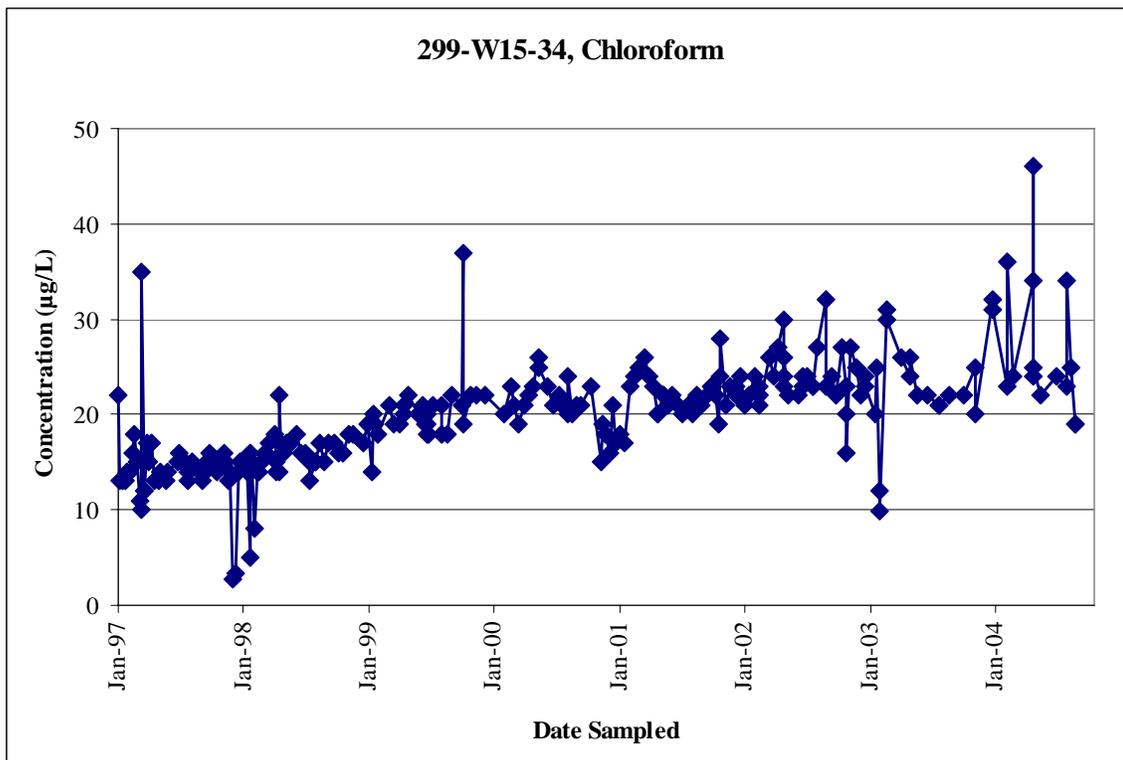
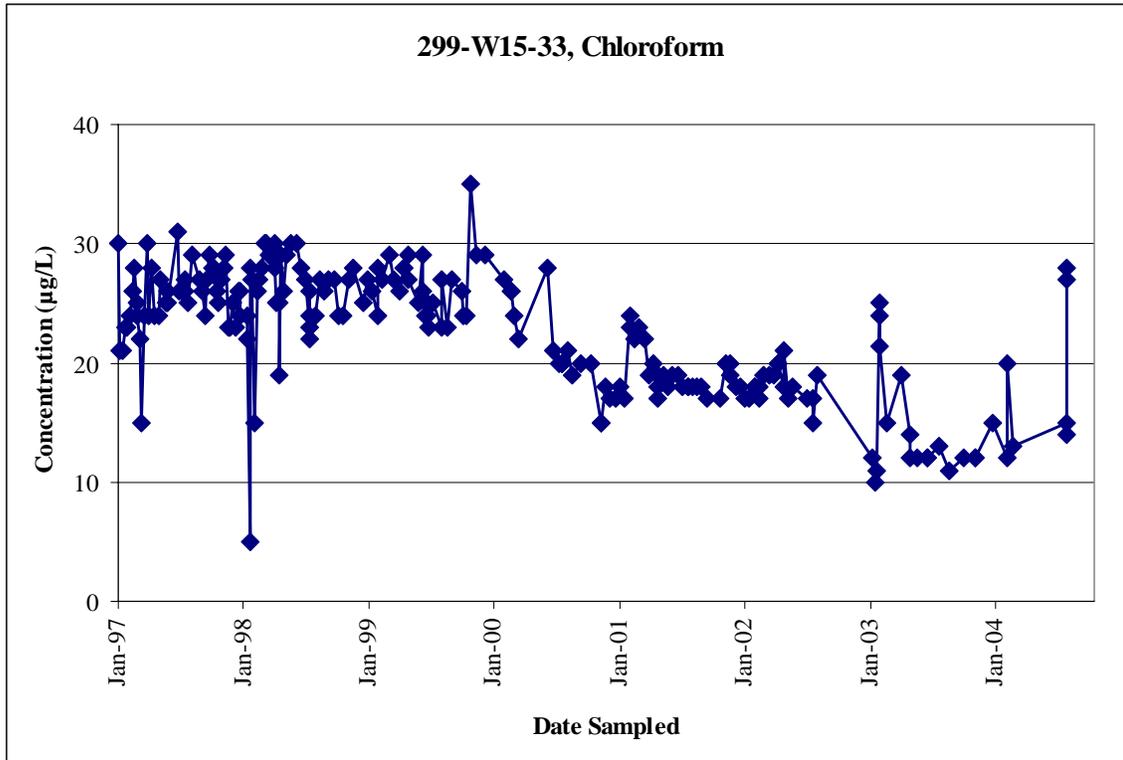


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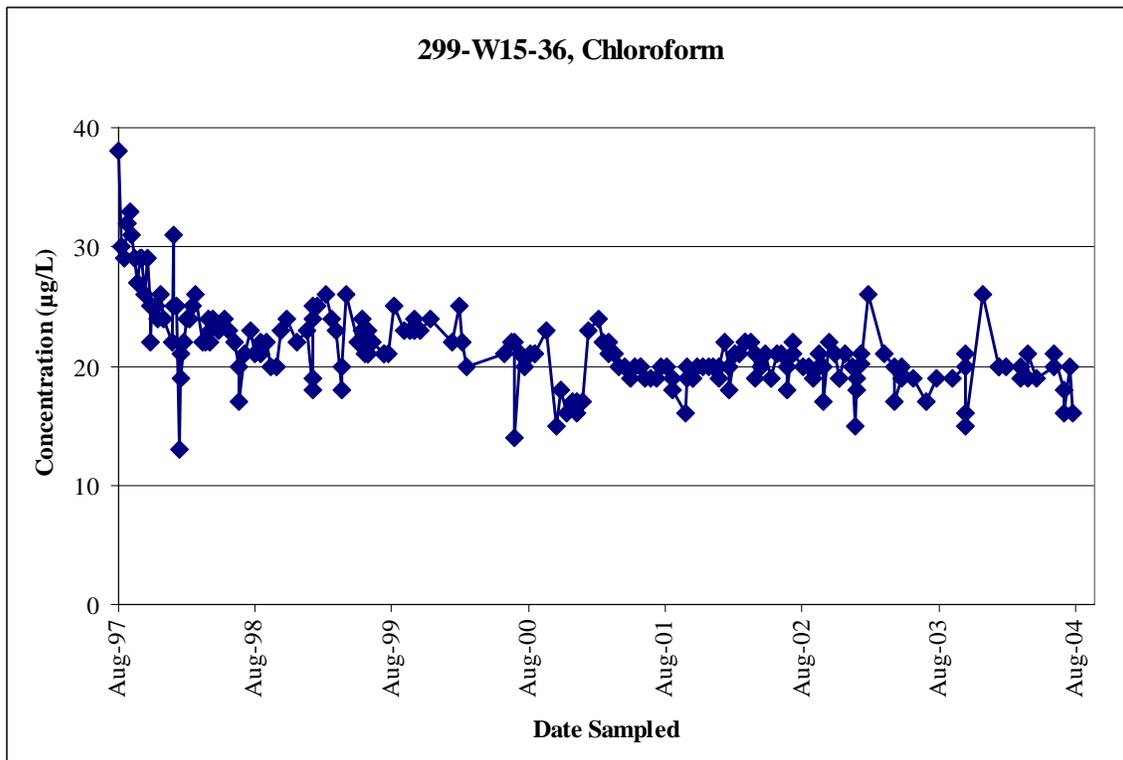
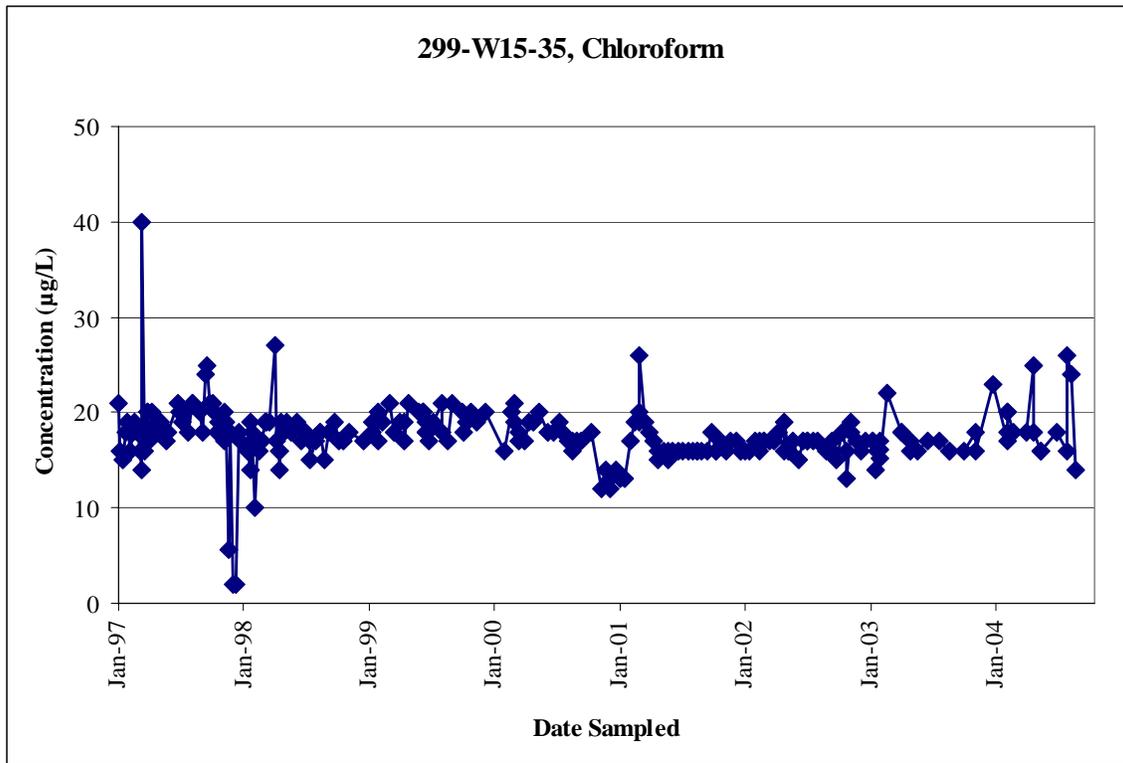




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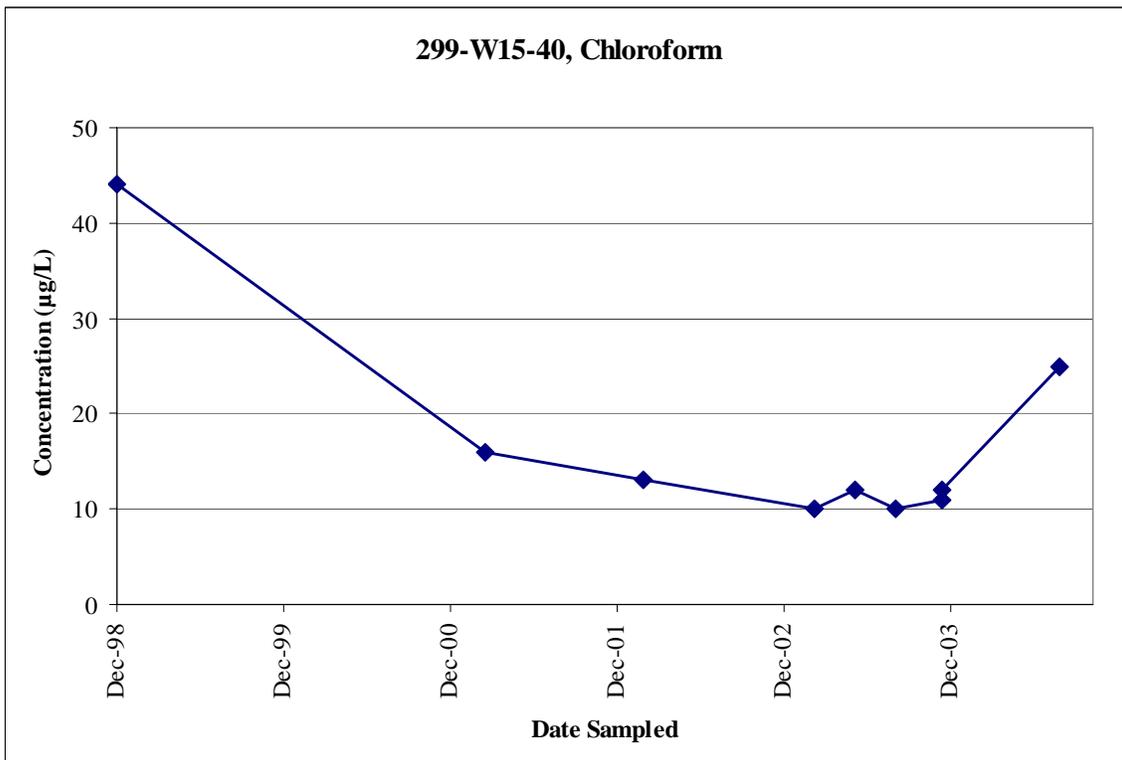
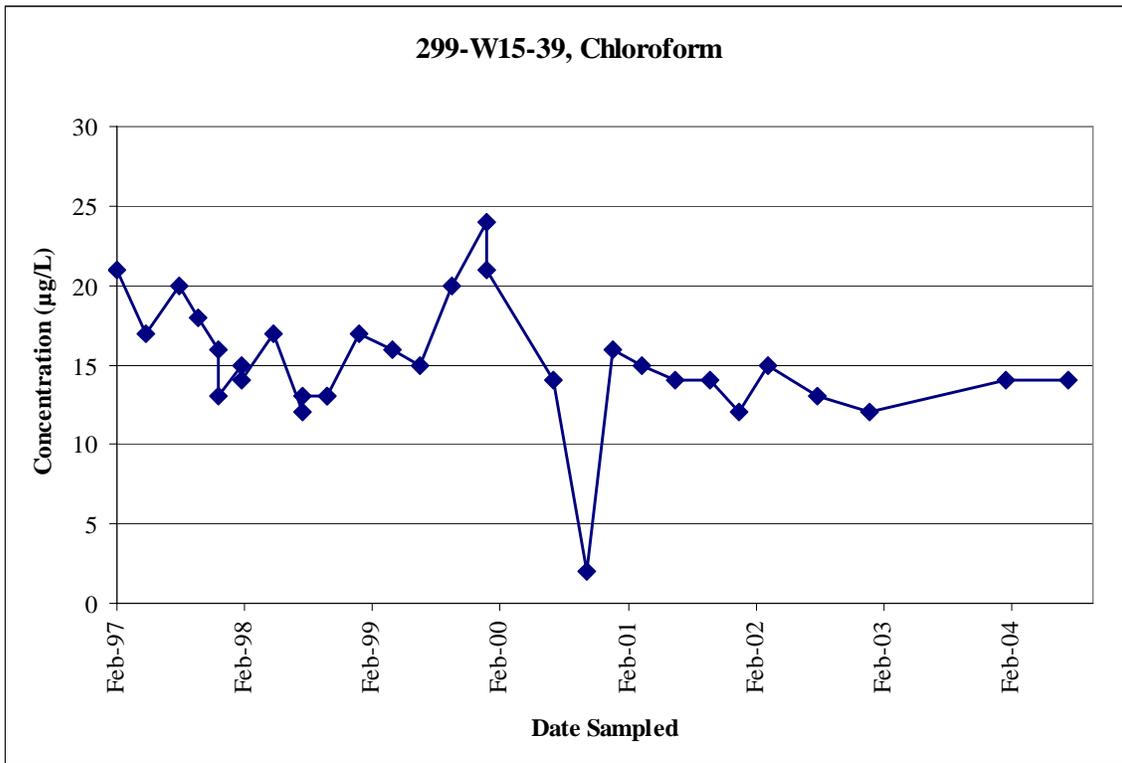


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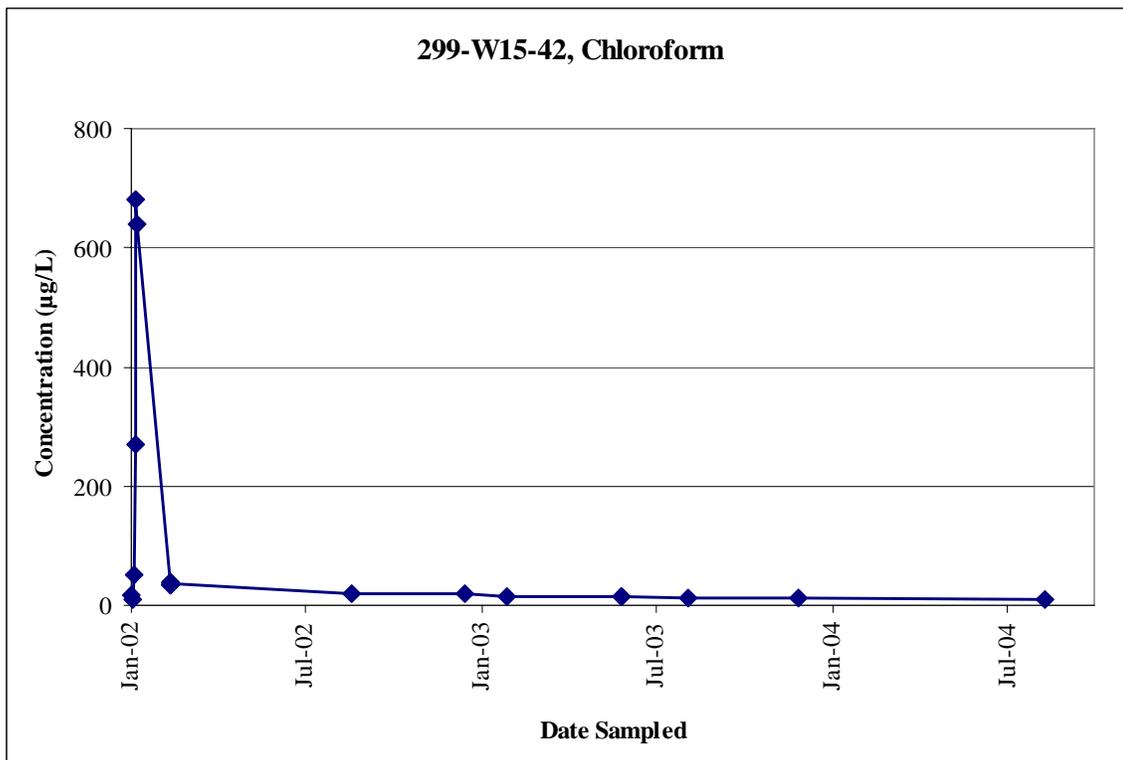
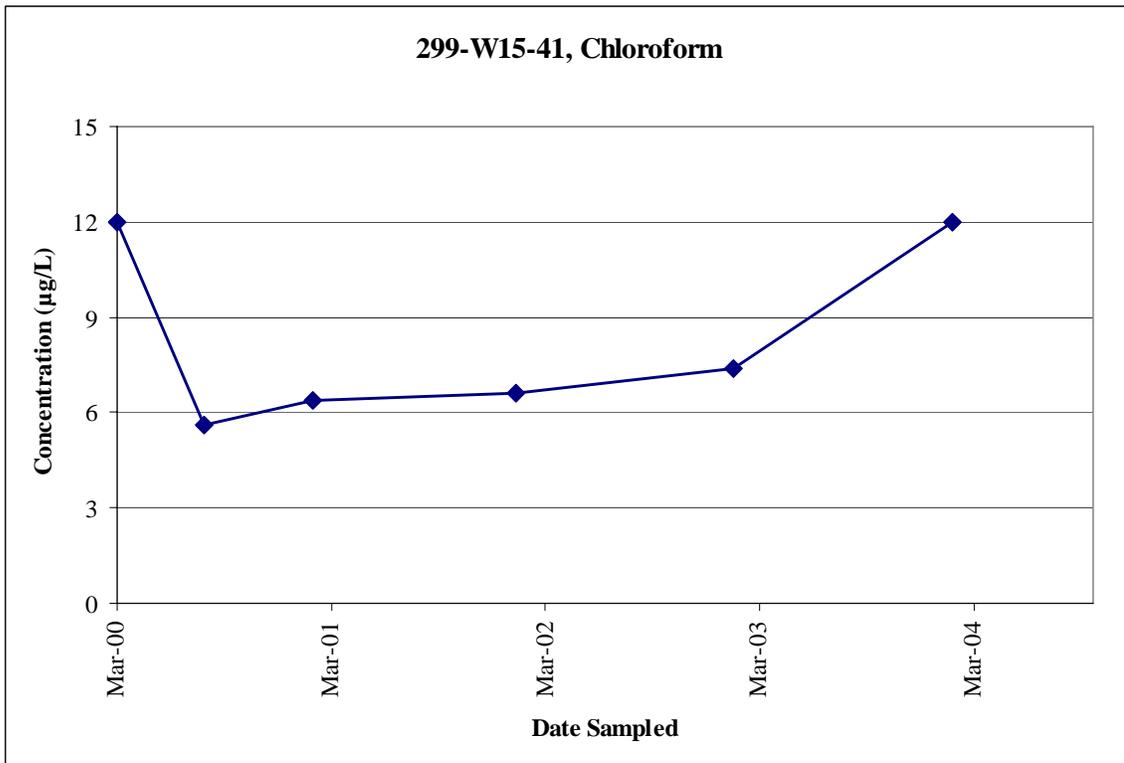


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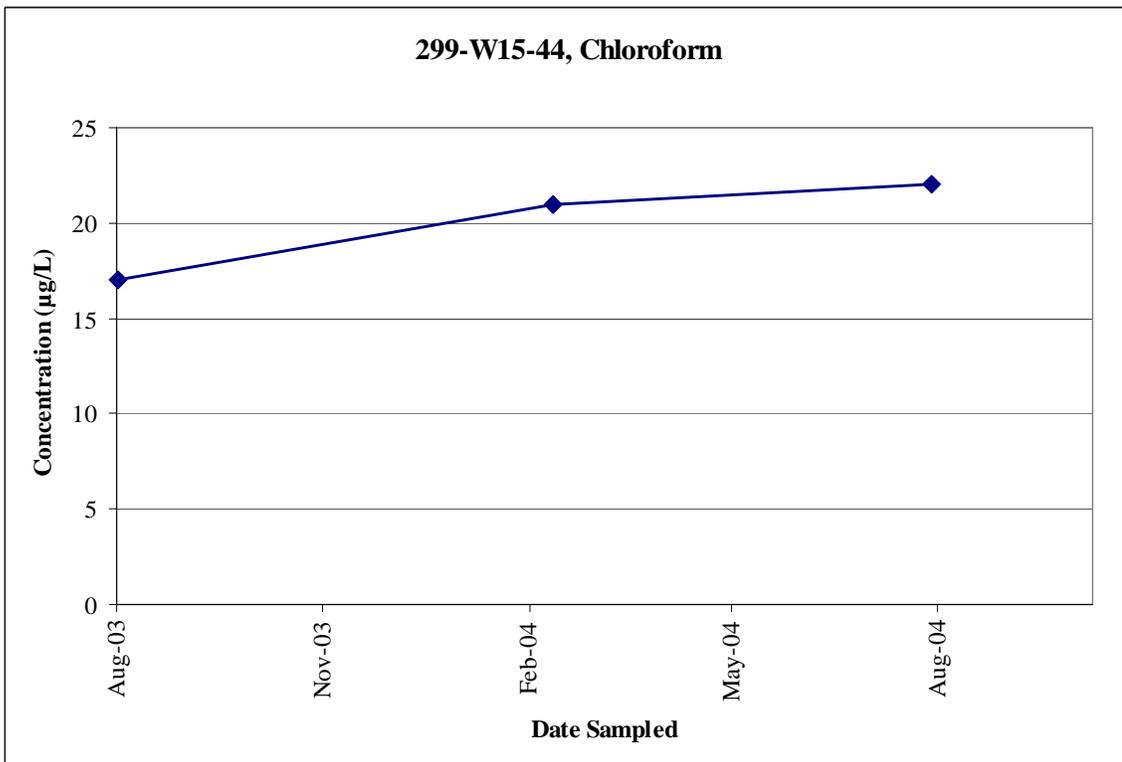
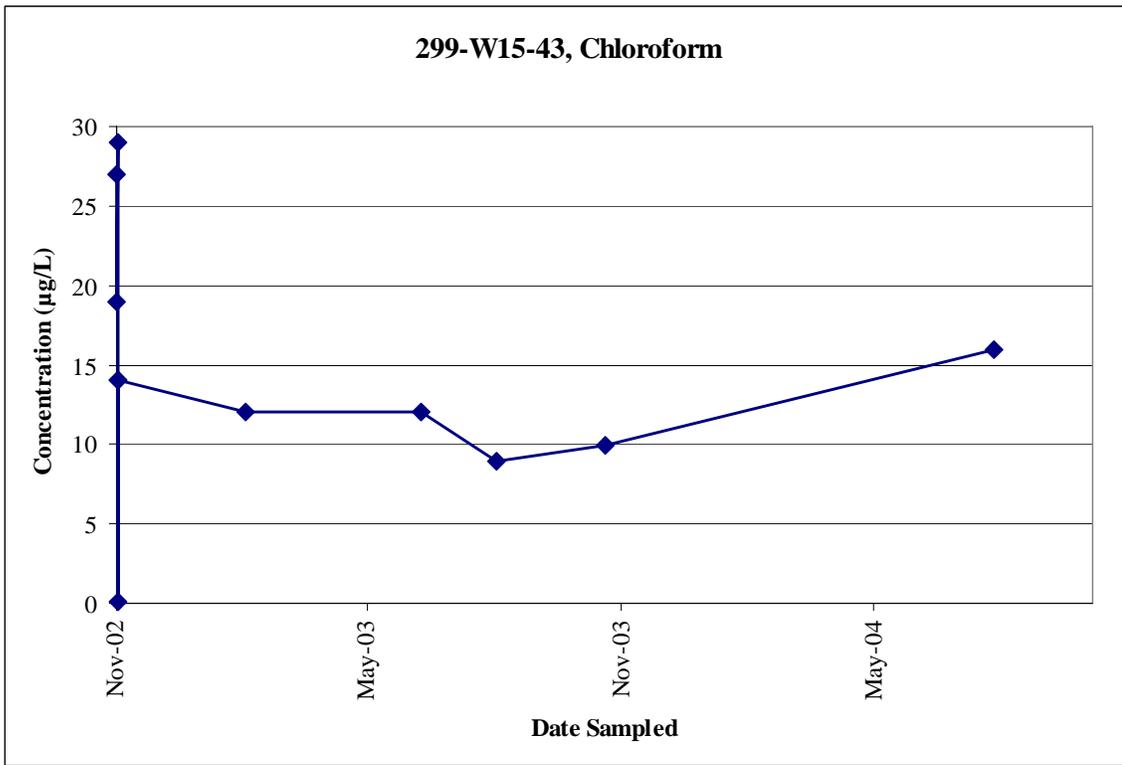


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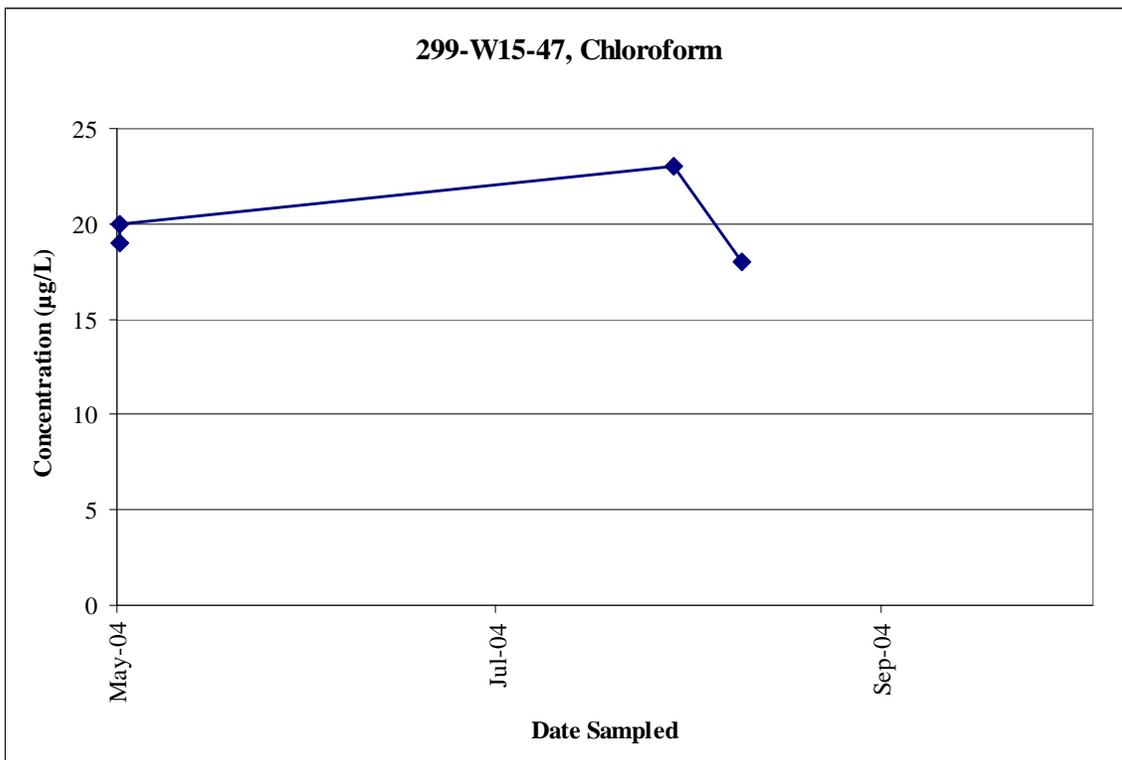
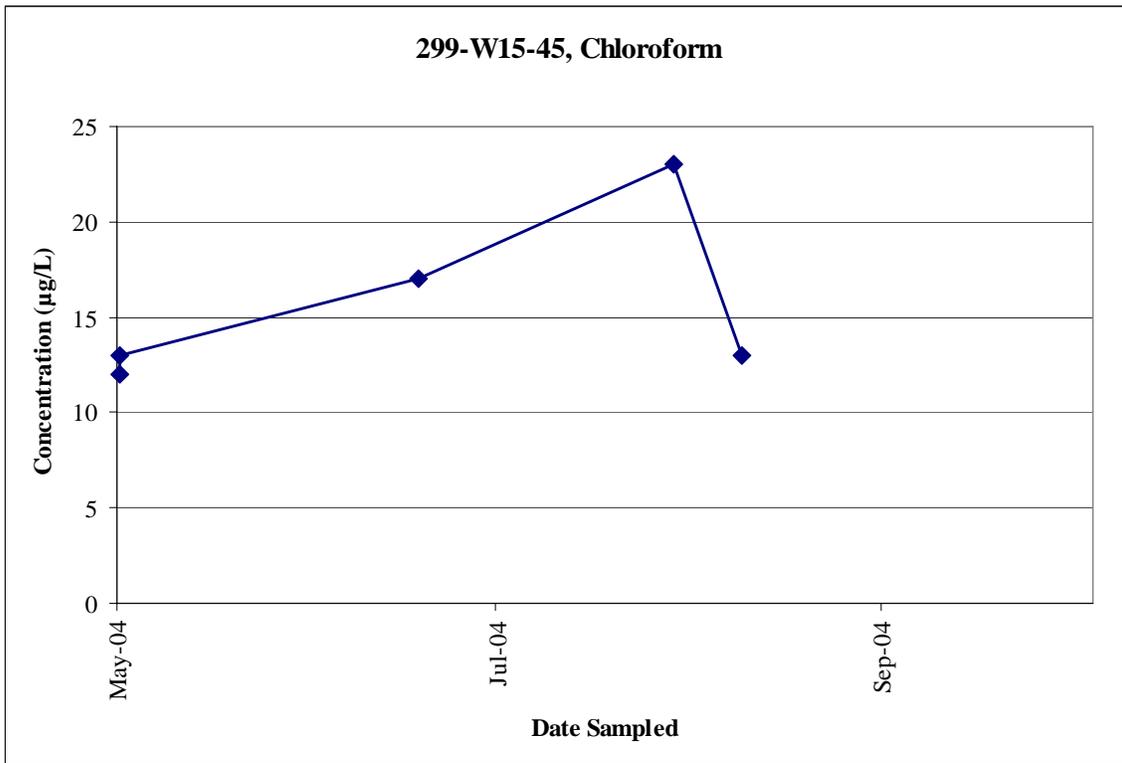


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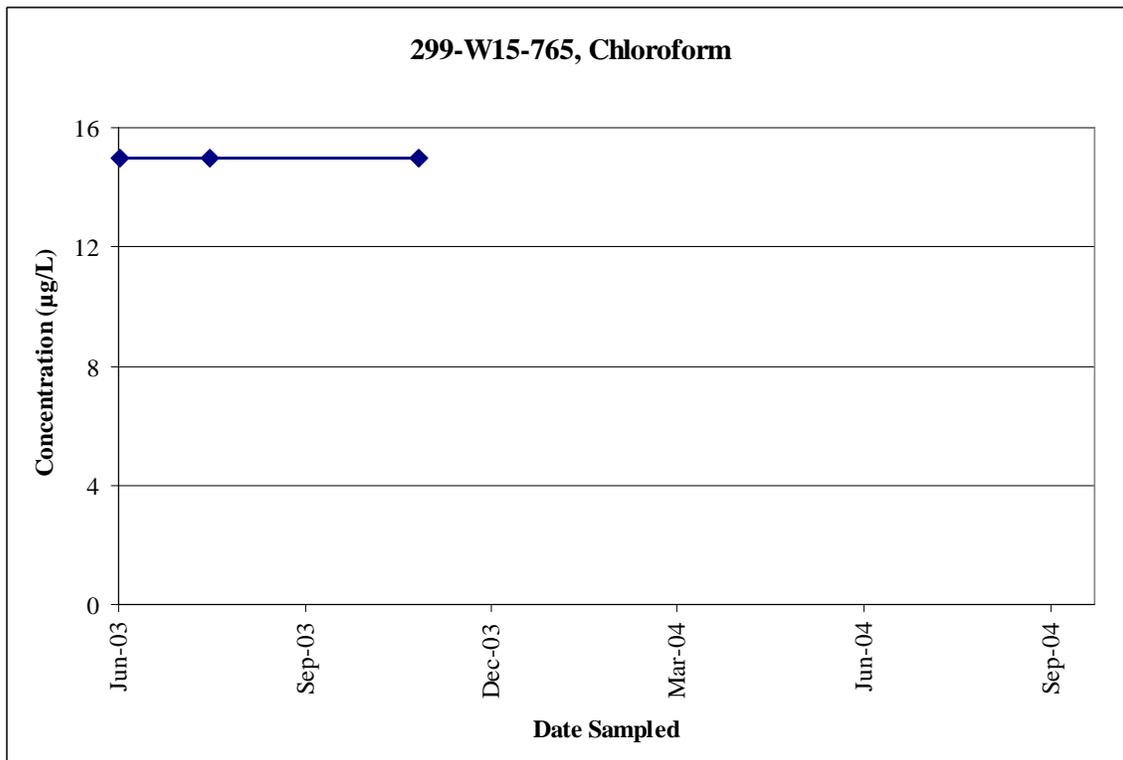
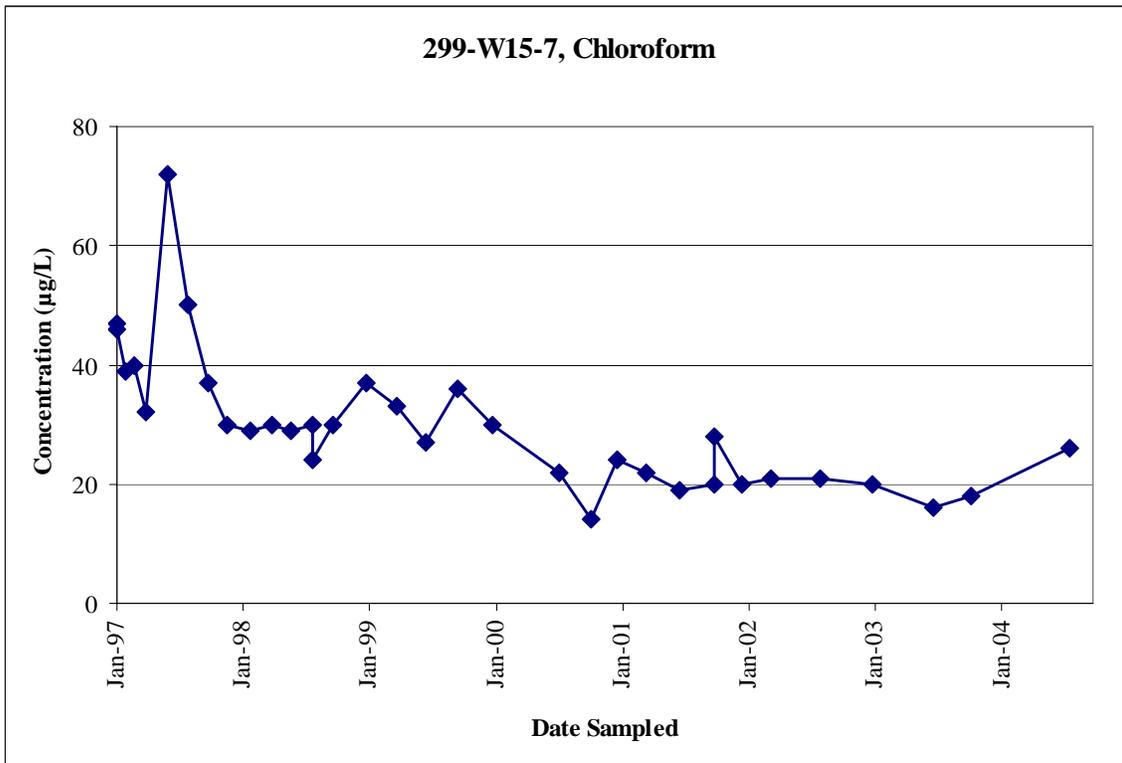


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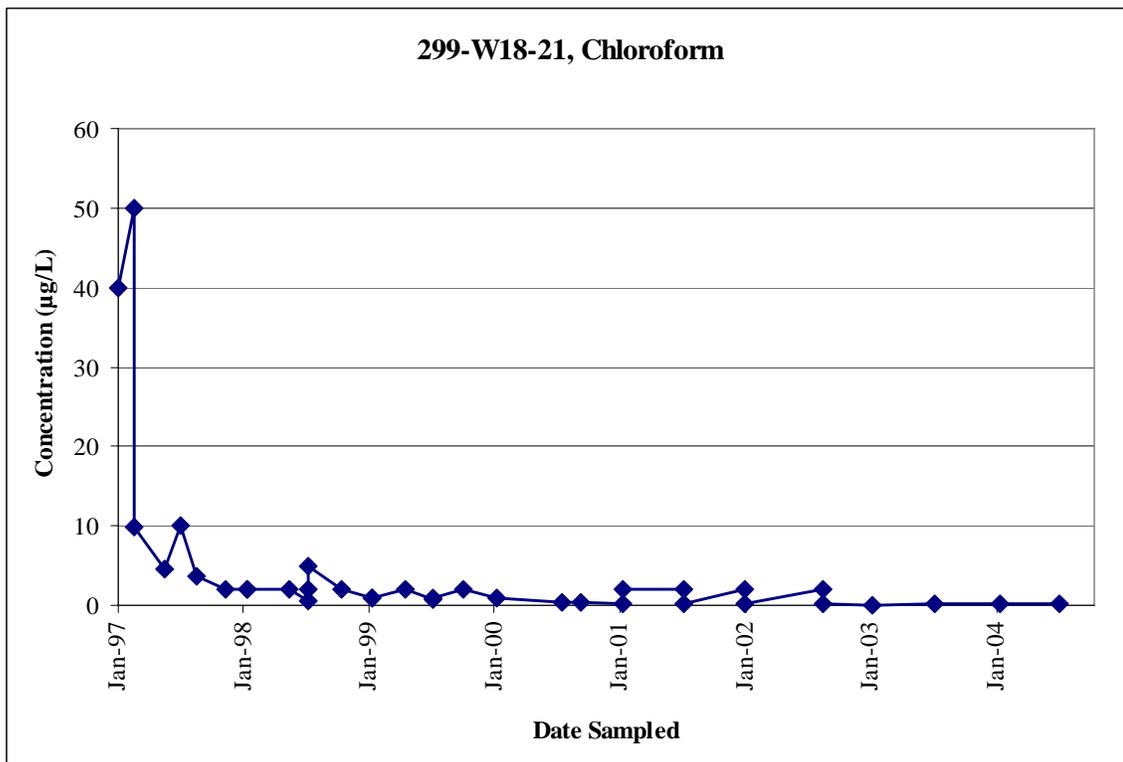
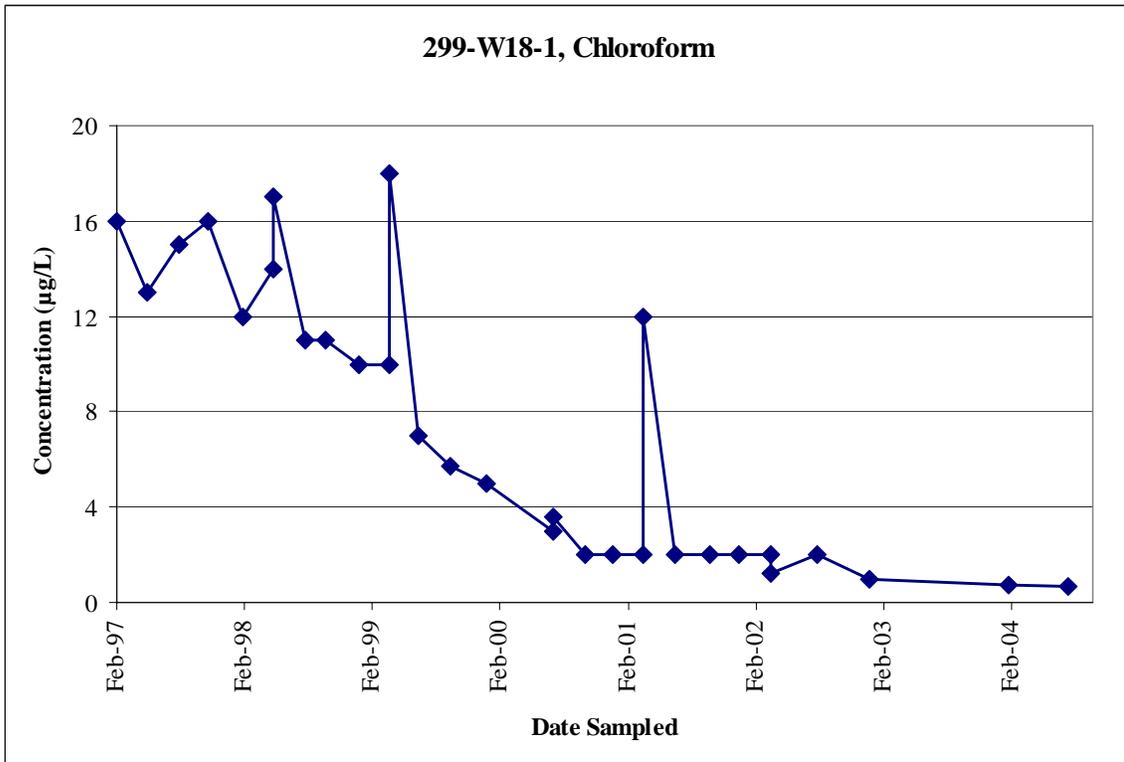




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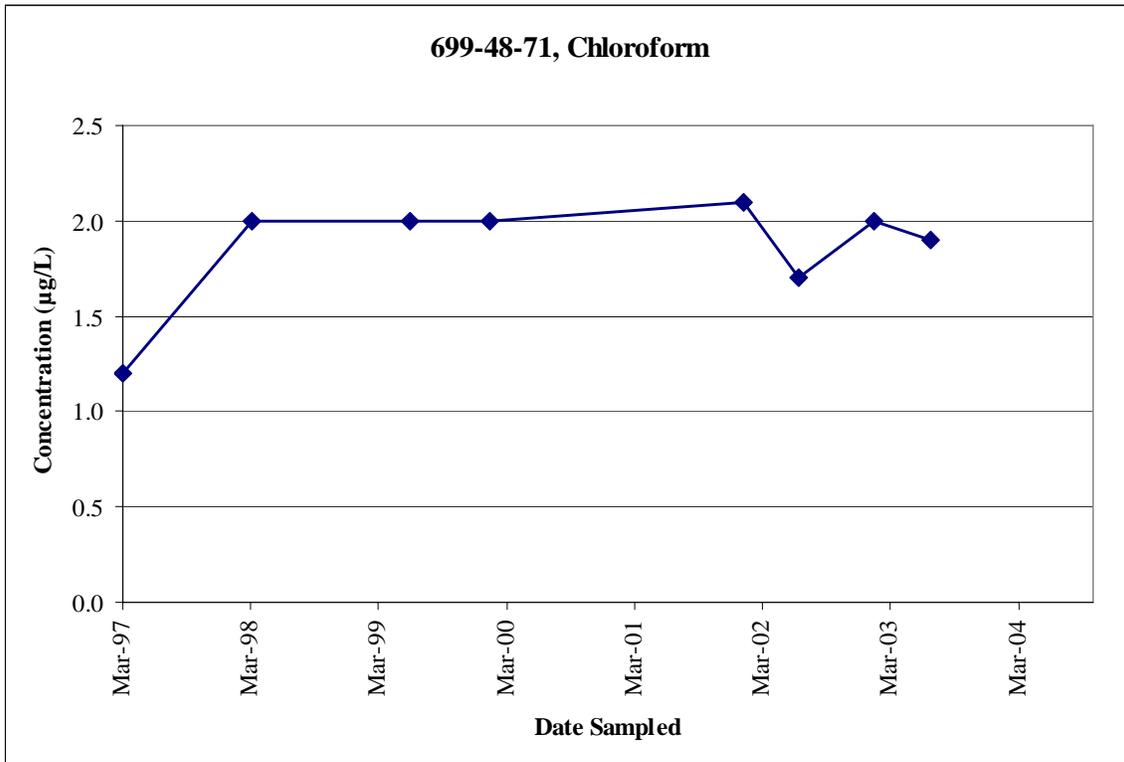


Figure H-3. 200-ZP-1 Groundwater Operable Unit, Trichlorethene Concentration Trends at Selected Monitoring Wells. (17 sheets)

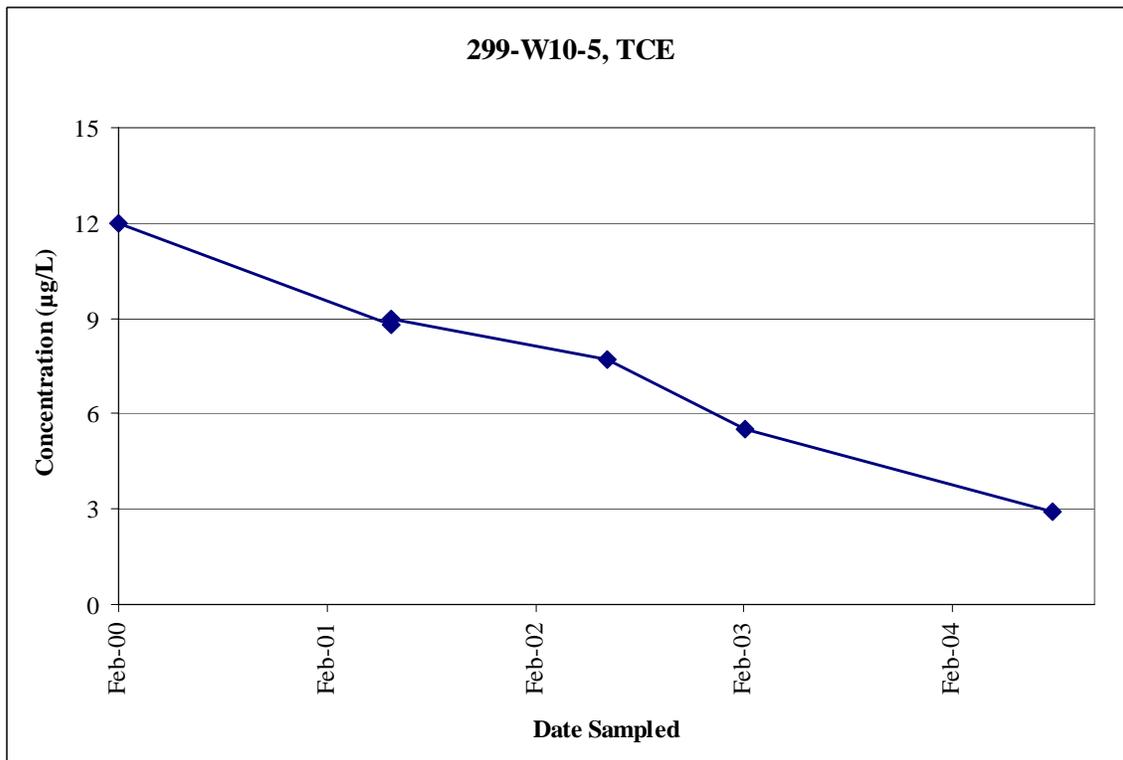
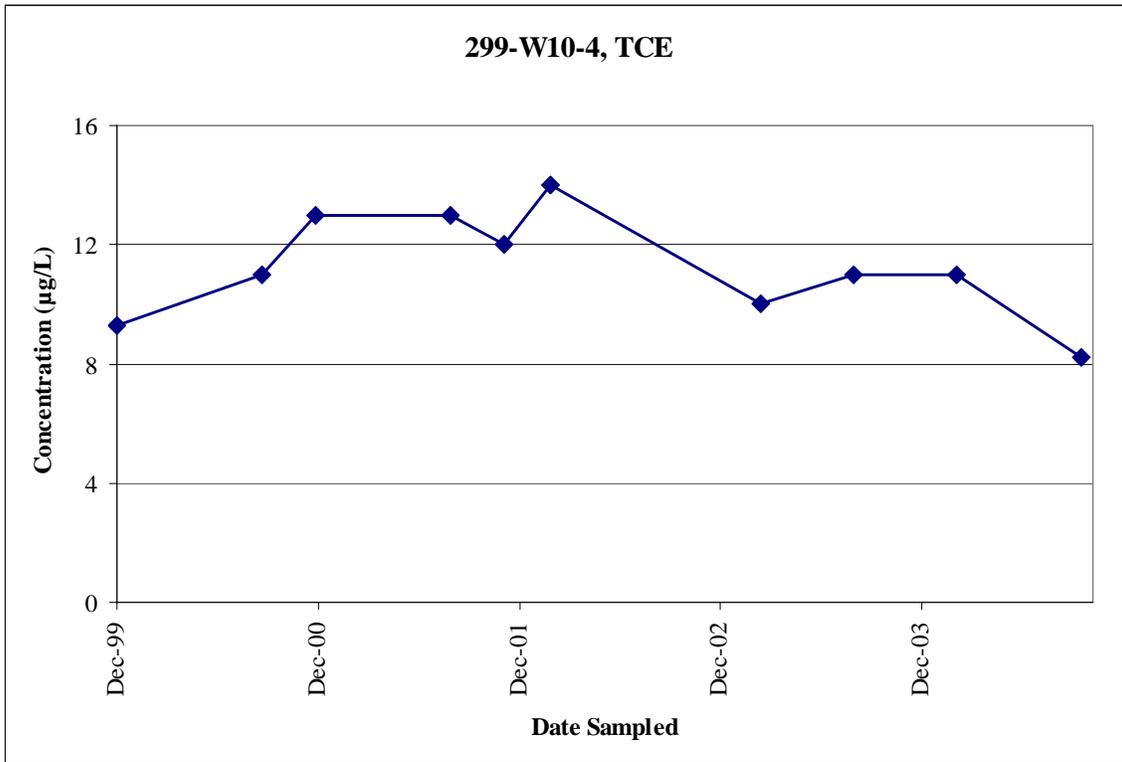


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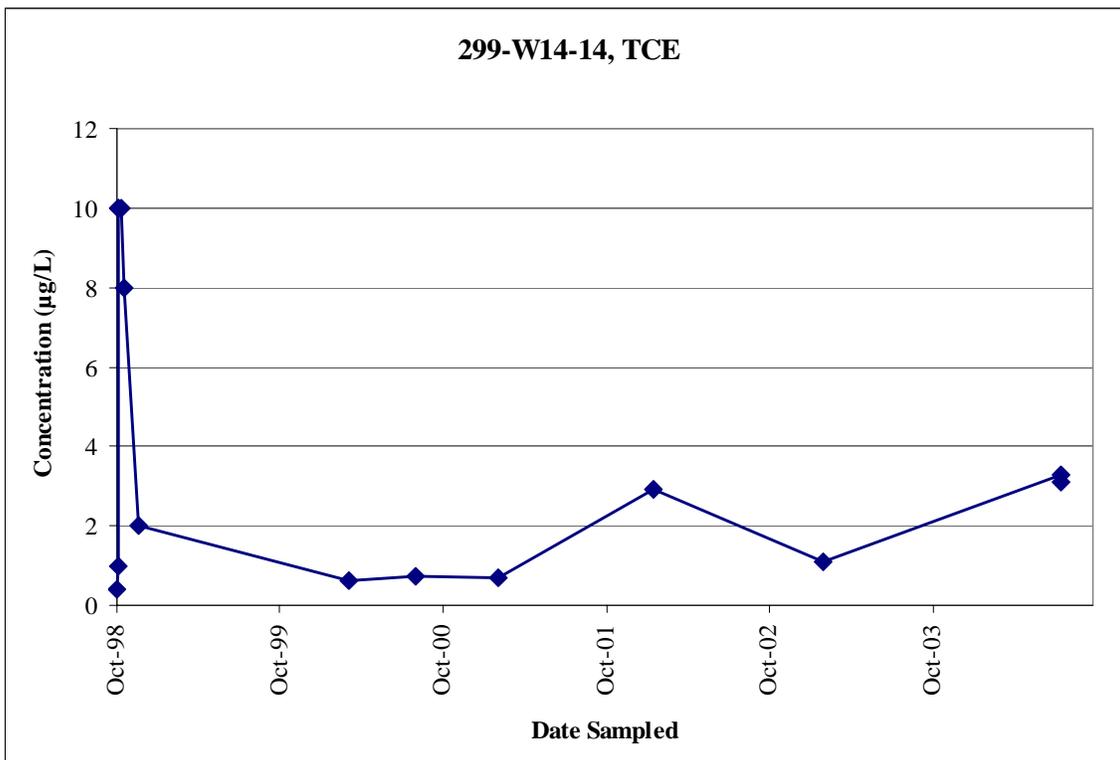
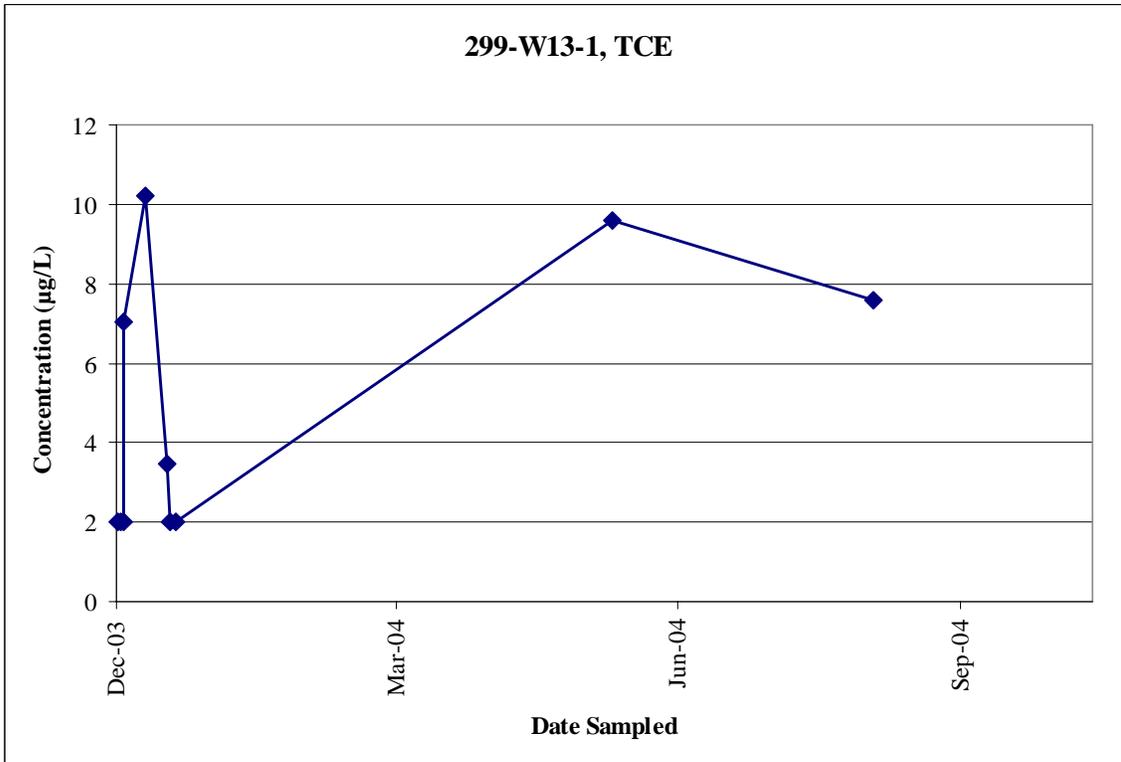




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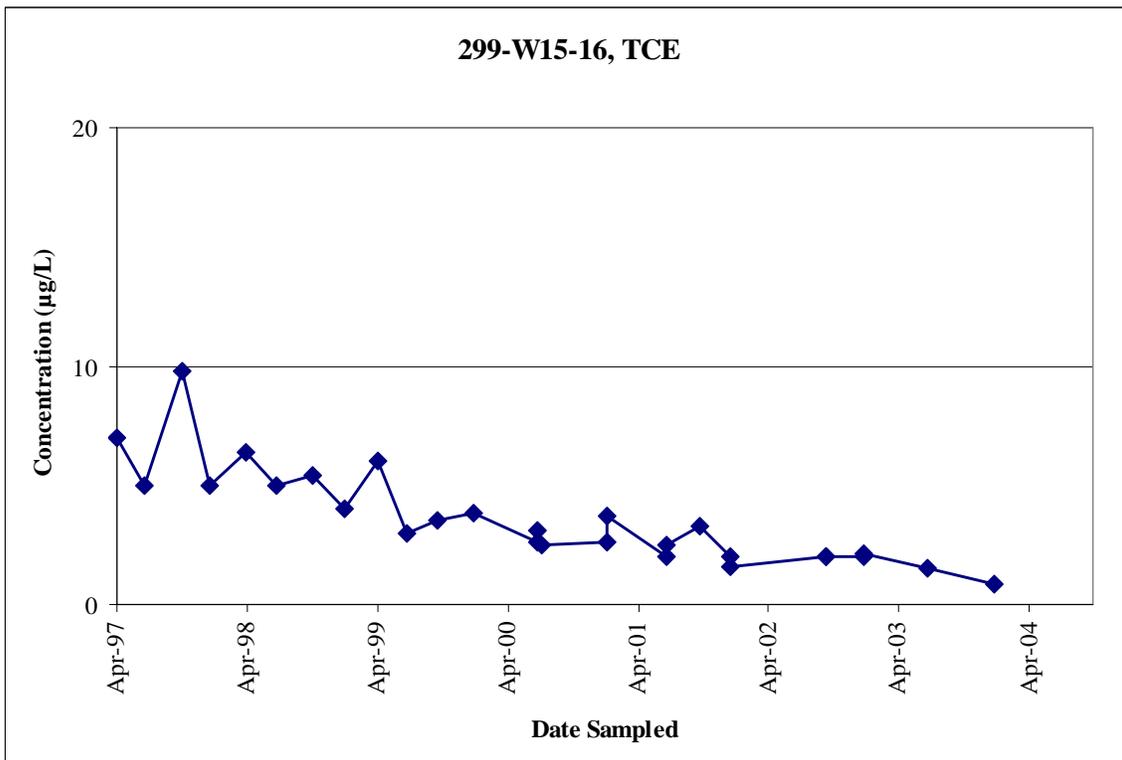
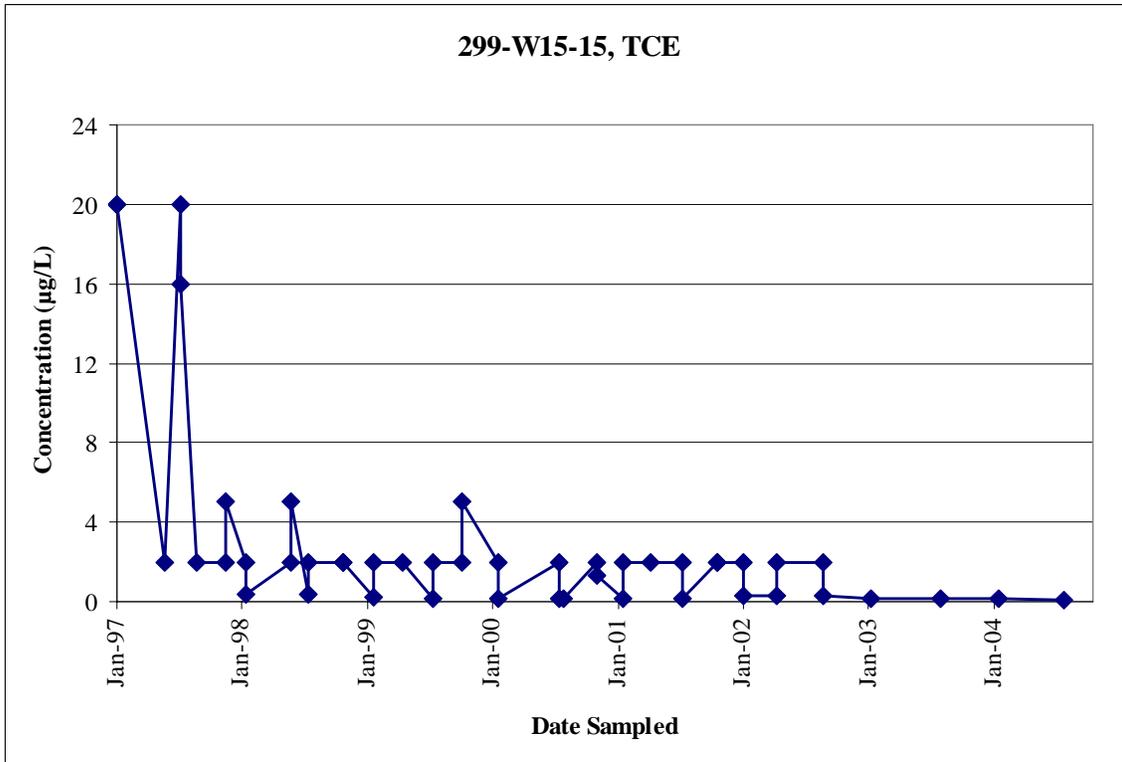


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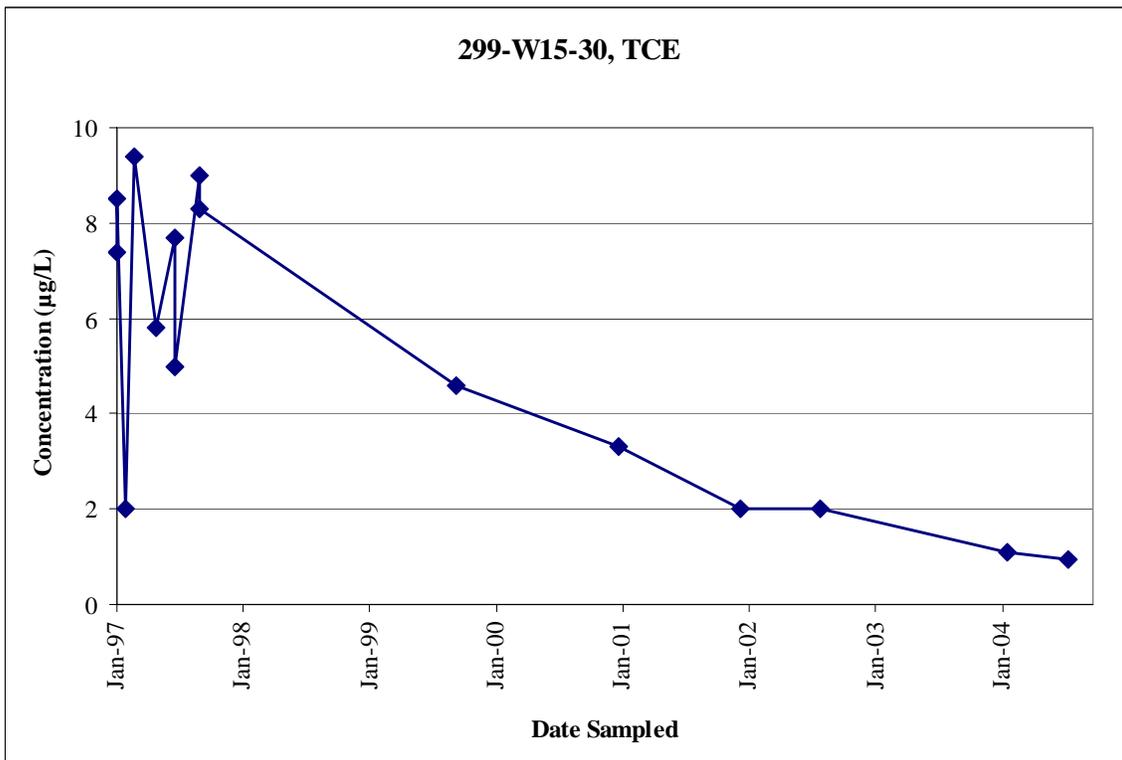
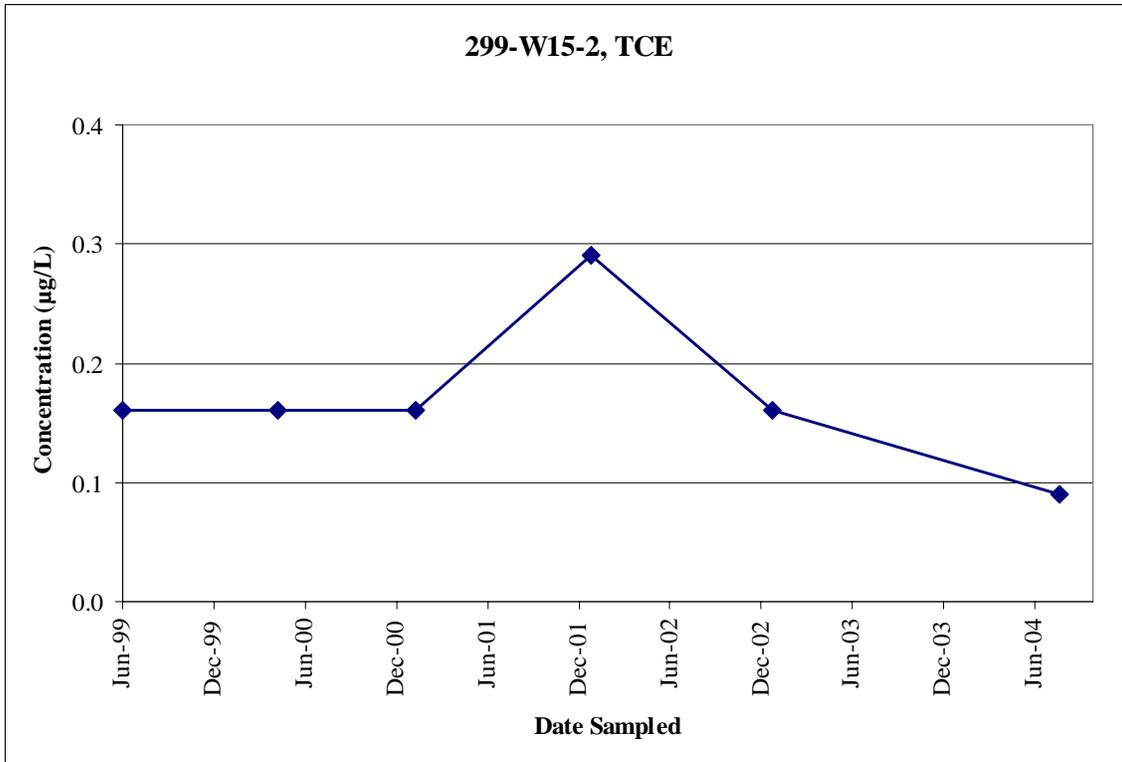






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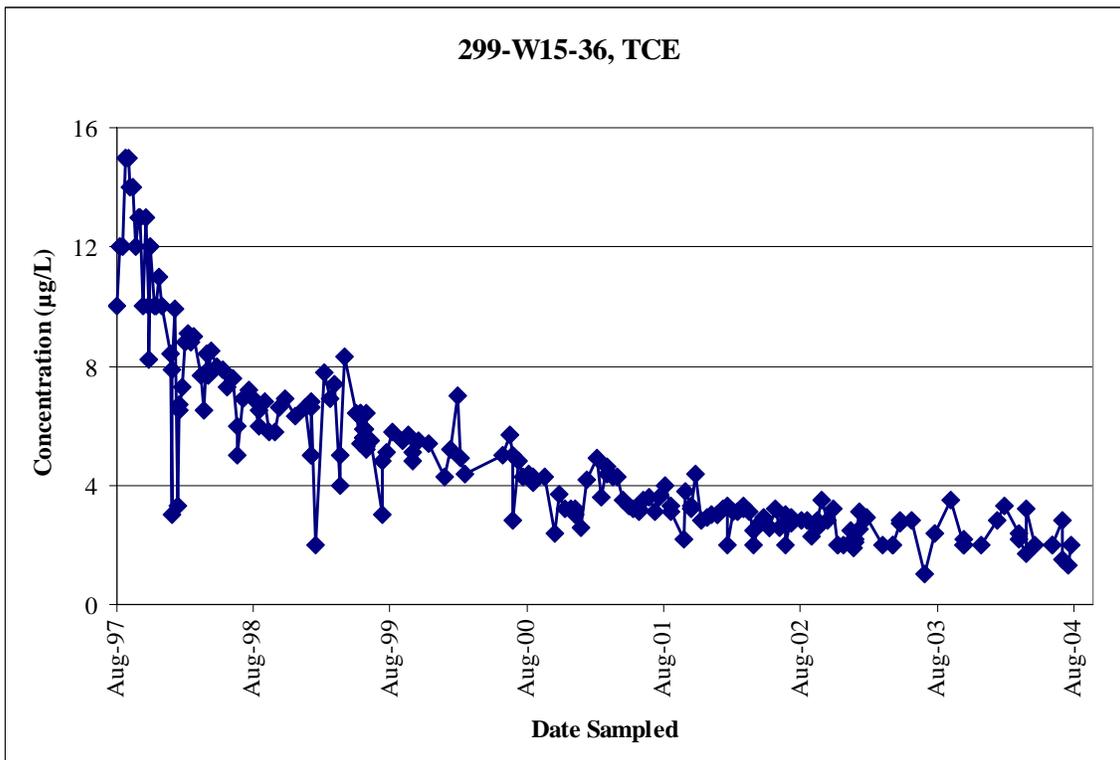
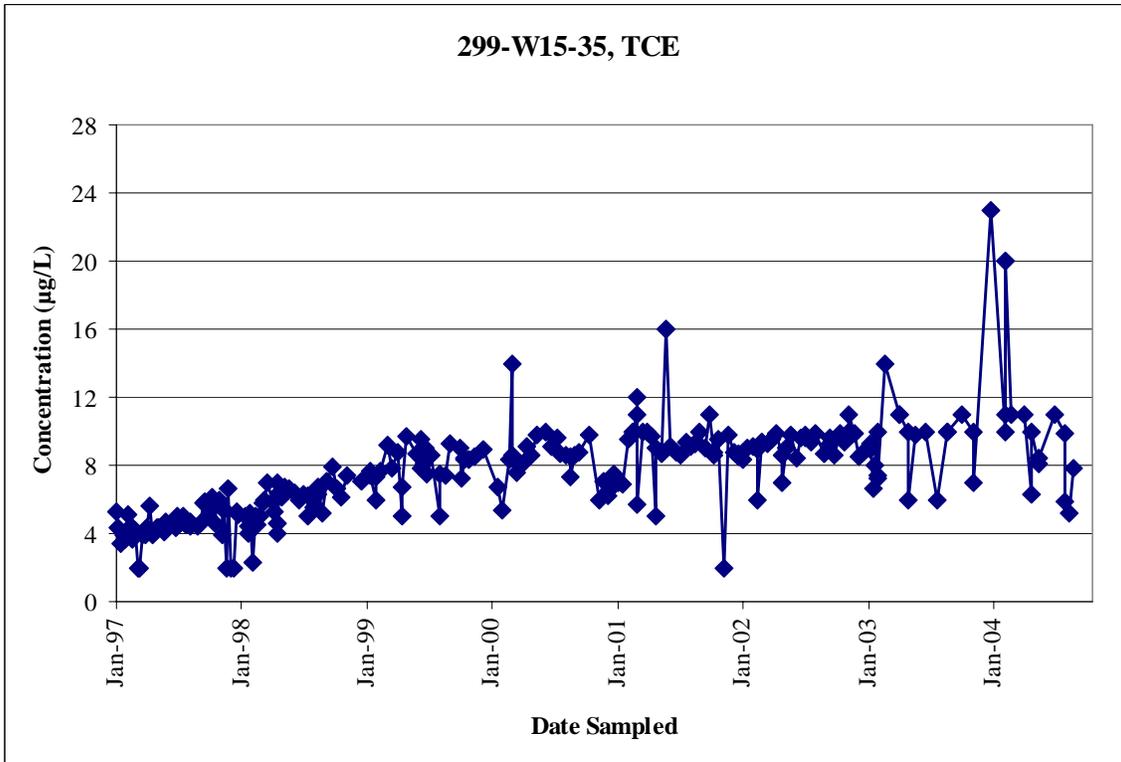


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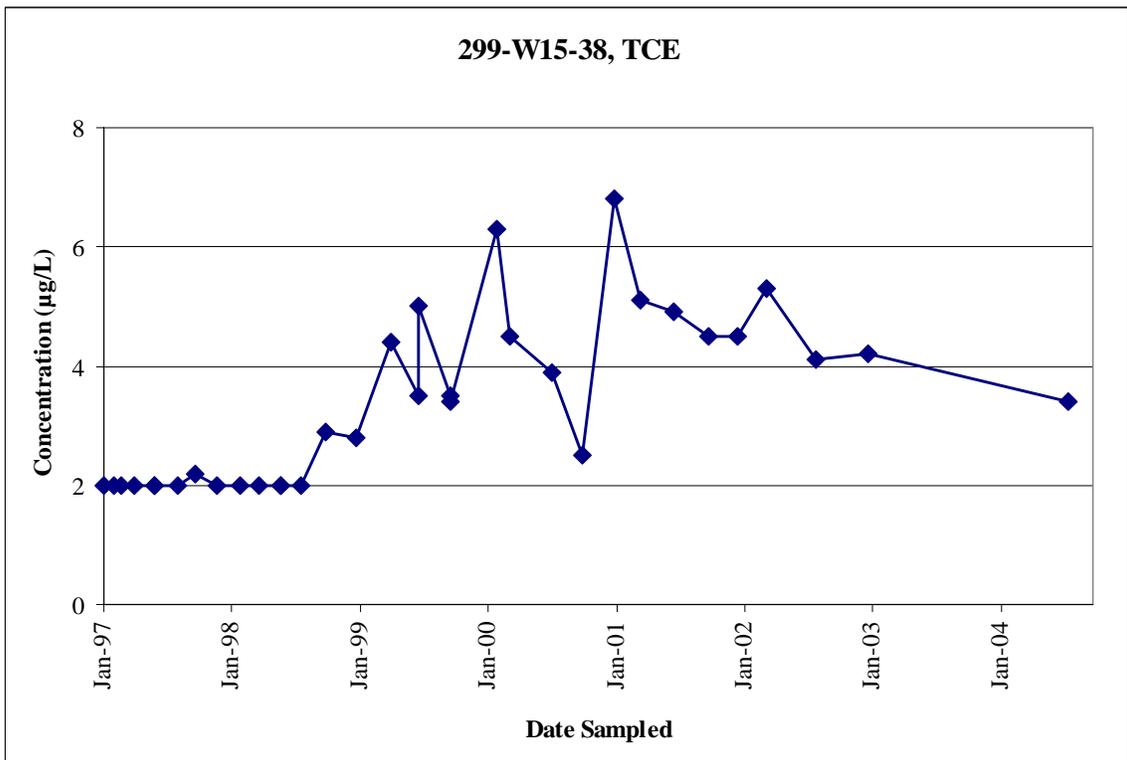
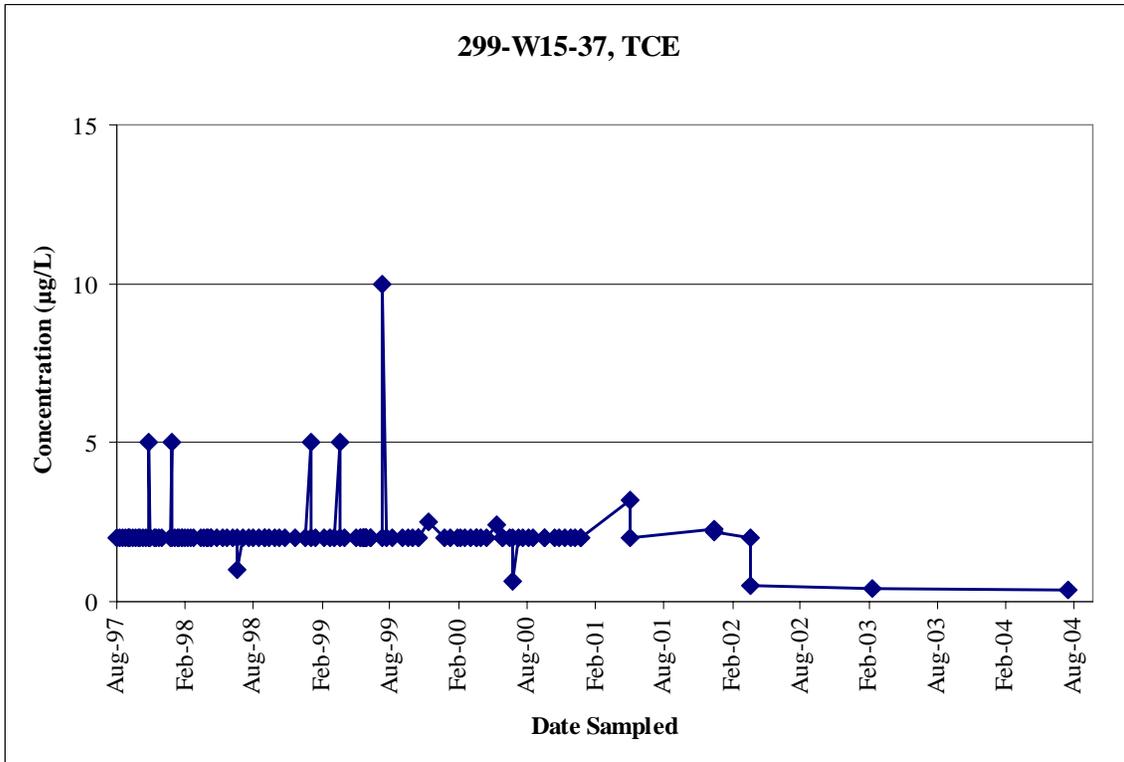




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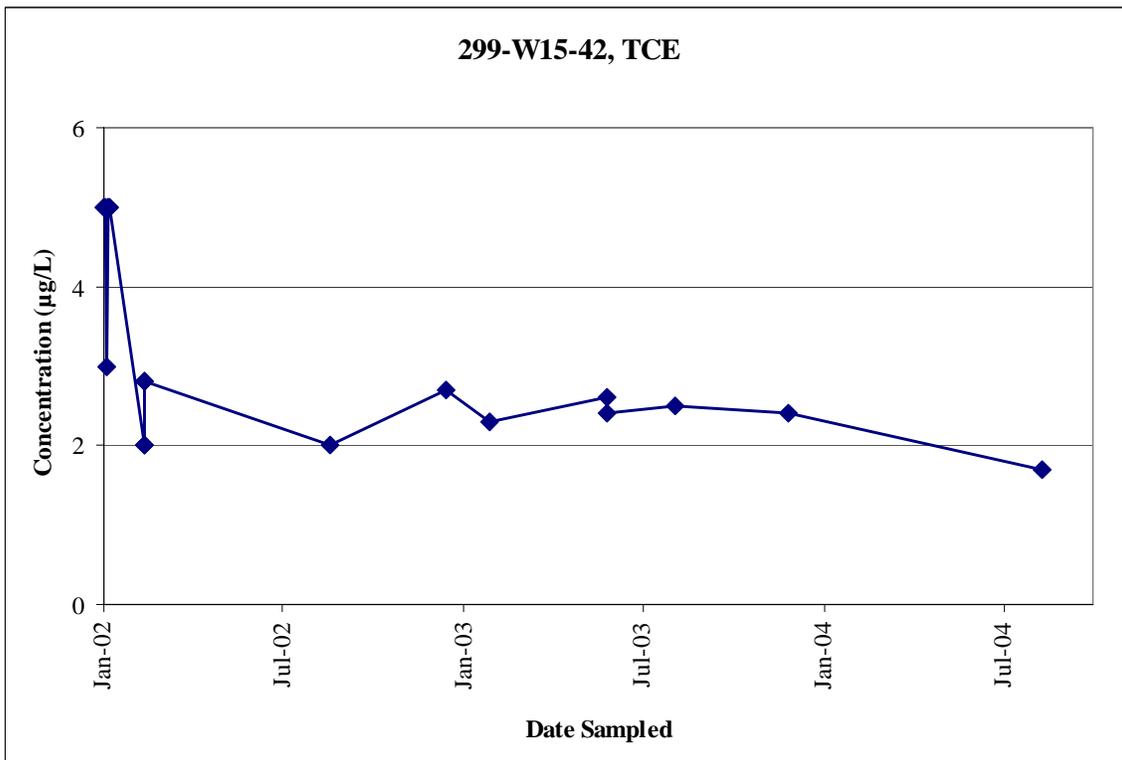
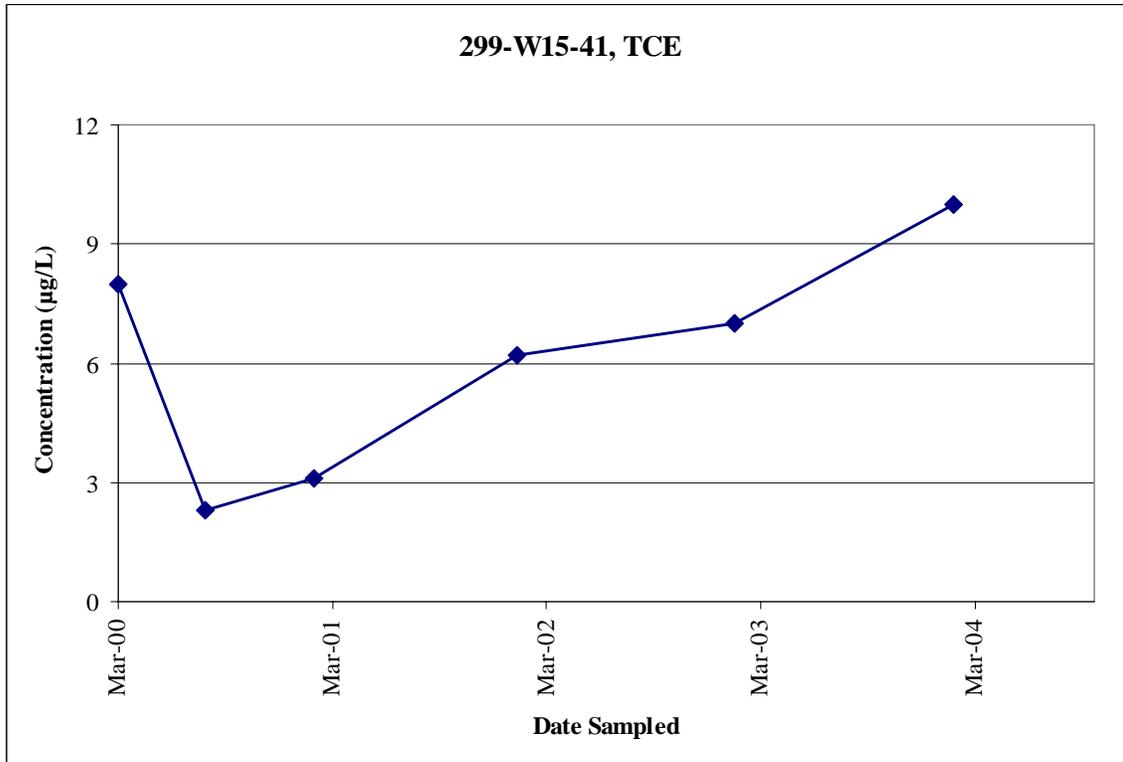


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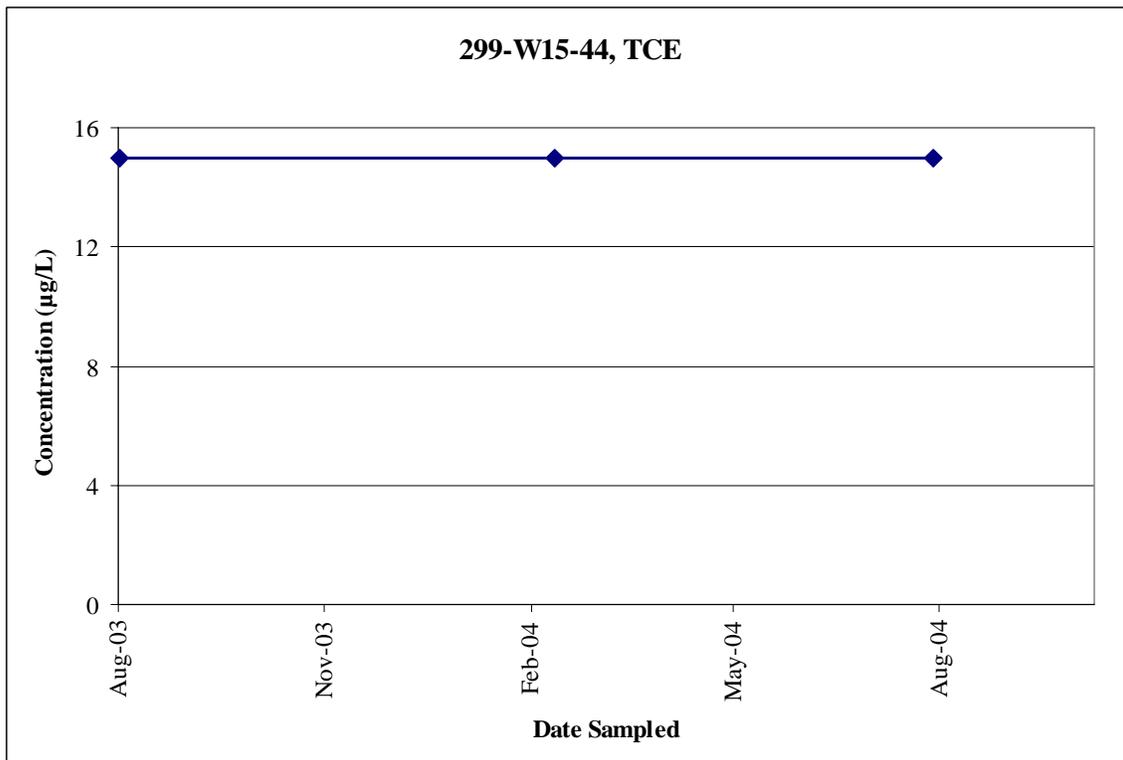
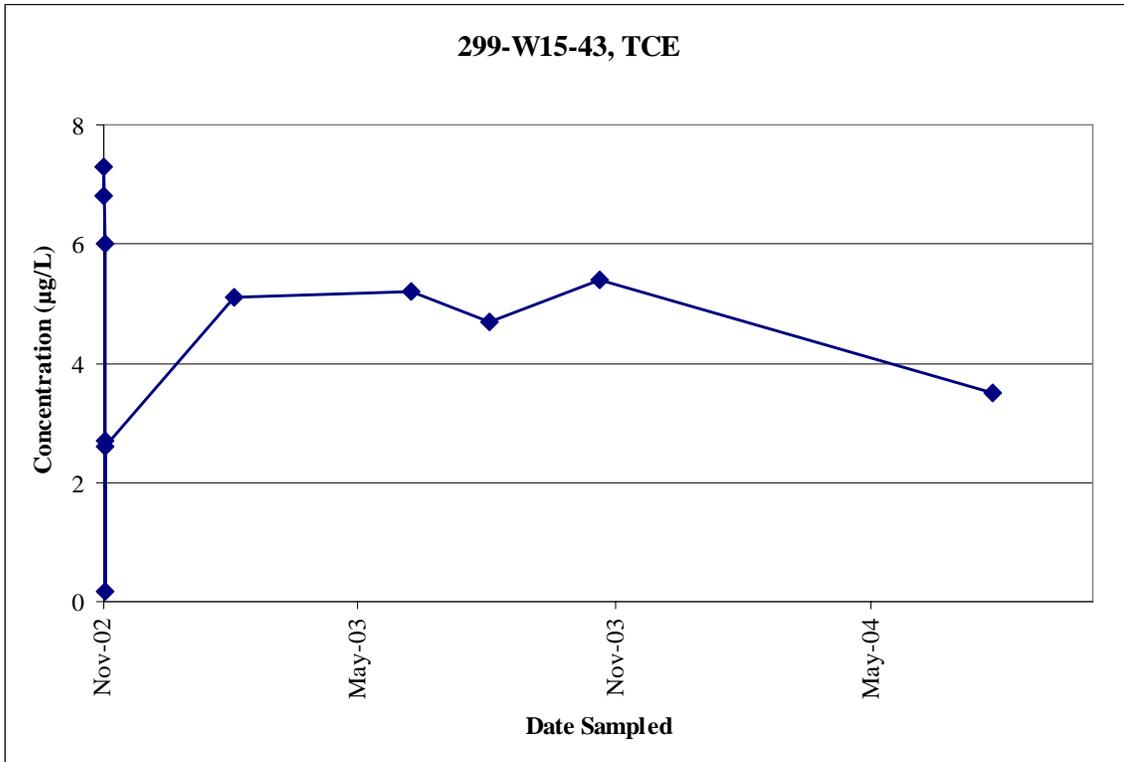


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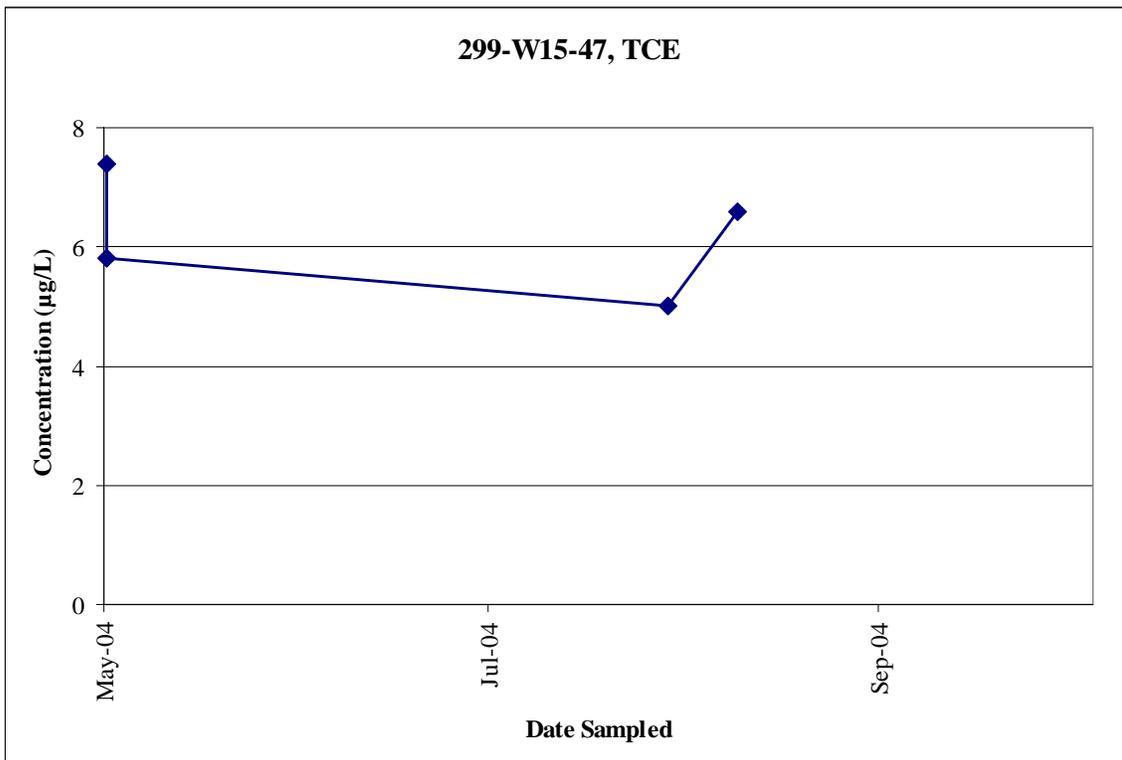
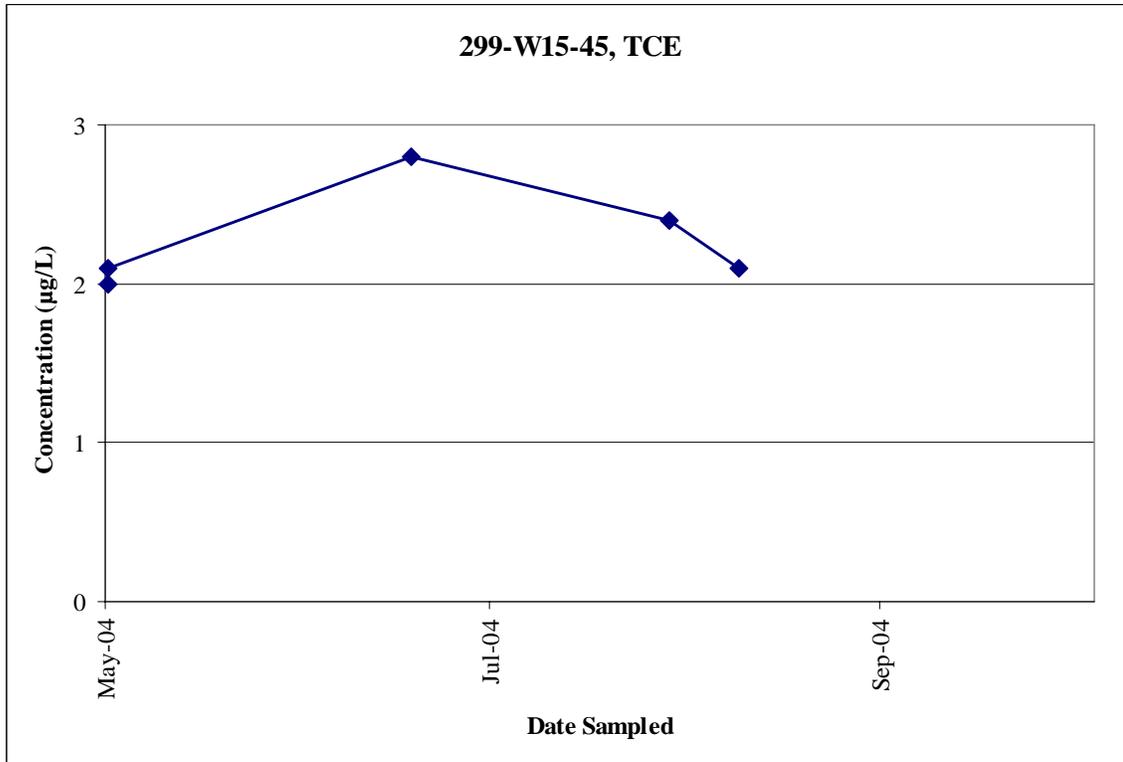


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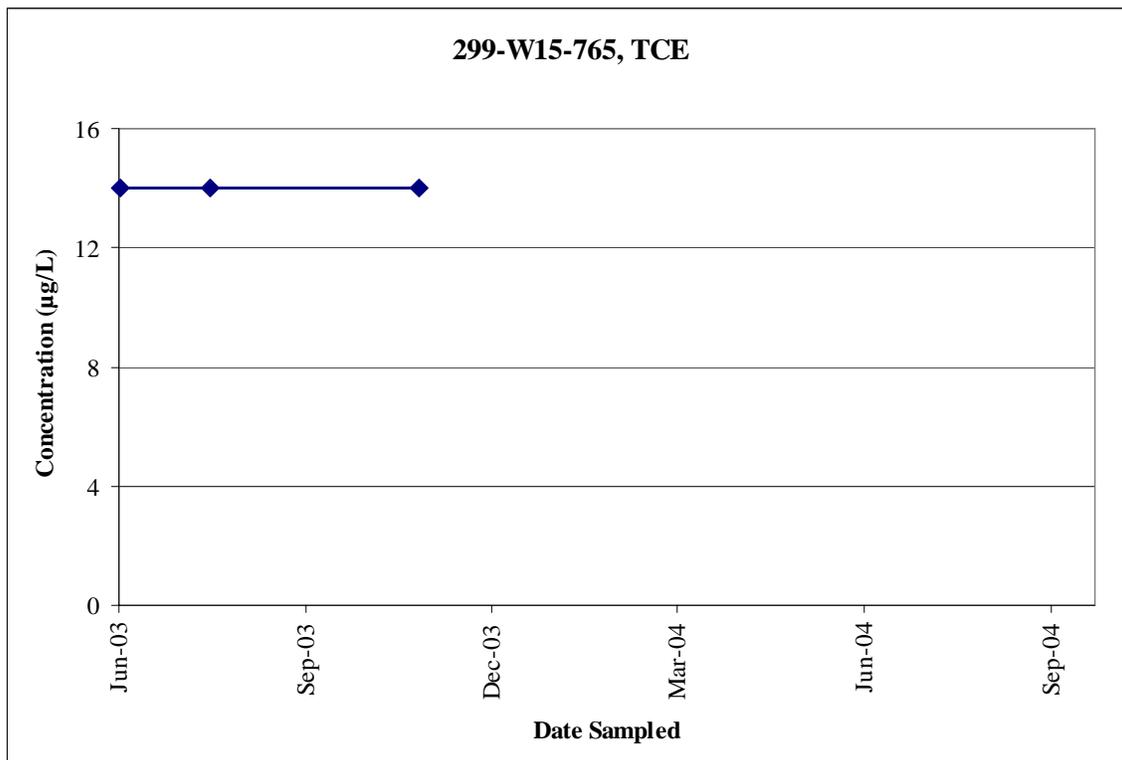
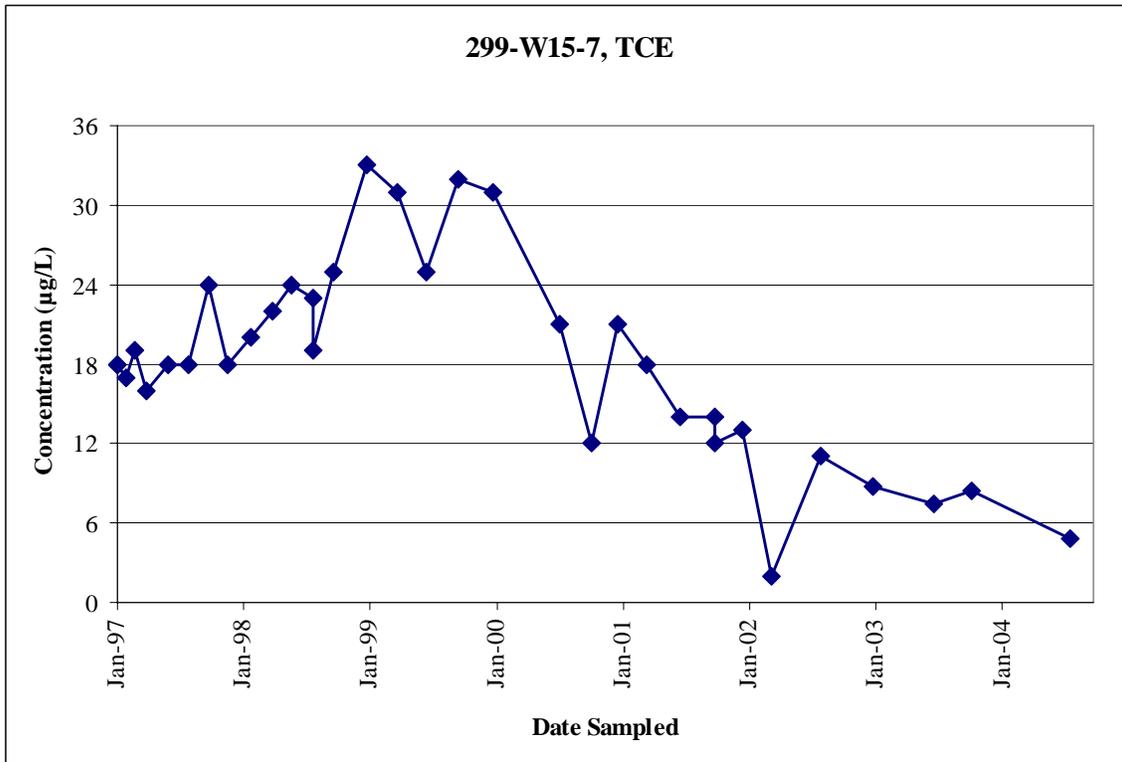
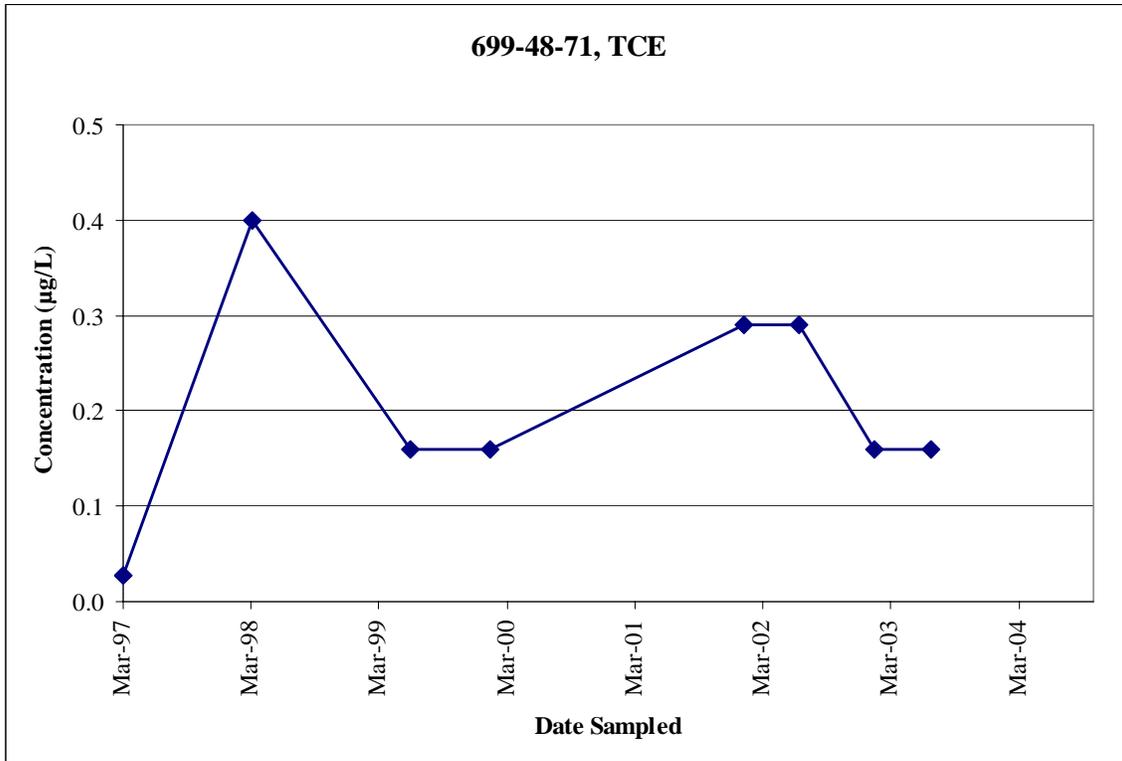






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