0082055

DOE/RL-2009-15
Revision 0

Calendar Year 2008 Annual Summary Report for the 100-HR-3, 100-KR-4, and 100-NR-2 Operable Unit Pump-and-Treat Operation

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

United States Department of Energy
P.O. Box 550
Richland, Washington 99352

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letter - 0082054
Appendices A-G - 0082056

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ME Bratton 5/27/2009
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LIST OF TERMS

bgs	below ground surface
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CEM	capture efficiency map
CFM	capture frequency map
CHPRC	CH2M Hill Plateau Remediation Company
COC	contaminant of concern
CY	calendar year
DOE	U.S. Department of Energy
DWS	drinking water standard
EPA	U.S. Environmental Protection Agency
FY	fiscal year
gpm	gallons per minute
HEIS	Hanford Environmental Information System
ISRM	In Situ Redox Manipulation
IX	ion exchange
MCL	maximum contaminant level
OU	operable unit
PNNL	Pacific Northwest National Laboratory
PRB	permeable reactive barrier
QC	quality control
RAO	remedial action objective
RD/RA	remedial design/remedial action
RI/FS	remedial investigation/feasibility study
ROD	Record of Decision
RPO	remedial process optimization
RUM	Ringold Upper Mud (Unit)
TPH	total petroleum hydrocarbon
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order*
WAC	*Washington Administrative Code*
WCH	Washington Closure Hanford, LLC
WSCF	Waste Sampling and Characterization Facility

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METRIC CONVERSION CHART

Into Metric Units			Out of Metric Units		
If You Know	*Multiply By*	*To Get*	*If You Know*	*Multiply By*	*To Get*
Length			**Length**		
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
Area			**Area**		
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
Mass (weight)			**Mass (weight)**		
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
Volume			**Volume**		
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			
Temperature			**Temperature**		
Fahrenheit	subtract 32, then multiply by 5/9	Celsius	Celsius	multiply by 9/5, then add 32	Fahrenheit
Radioactivity			**Radioactivity**		
picocuries	37	millibecquerels	millibecquerels	0.027	picocuries

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1.0 INTRODUCTION

CH2M Hill Plateau Remediation Company (CHPRC) is currently operating seven groundwater pump-and-treat systems across the Hanford Site. Five systems address groundwater in the 100 Areas, which include two systems to treat hexavalent chromium in the 100-HR-3 Operable Unit (OU); two systems to treat hexavalent chromium in the 100-KR-4 OU; and the 100-NR-2 system, which treats strontium-90 and is in cold-standby status. Two pump-and-treat systems are remediating groundwater in the 200 West Area: the 200-UP-1 OU system, and the 200-ZP-1 OU system (which is actively treating carbon tetrachloride, chloroform, and trichloroethene).

This annual summary report discusses the groundwater remedial actions in the 100 Areas, including interim remedial actions at the 100-HR-3, 100-KR-4, and 100-NR-2 OUs (Figure 1-1). A detailed description of the progress and performance of the In Situ Redox Manipulation (ISRM) barrier was reported separately in the *Fiscal Year 2008 Annual Summary Report for the In Situ Redox Manipulation Operations* (DOE/RL-2009-01). The ISRM barrier is located in the southwestern portion of the 100-D Area. Additional information addressing source investigation activities, system modifications to existing pump-and-treat systems, and special projects are presented in *Hanford Site Groundwater Monitoring for Fiscal Year 2008* (DOE/RL-2008-66).

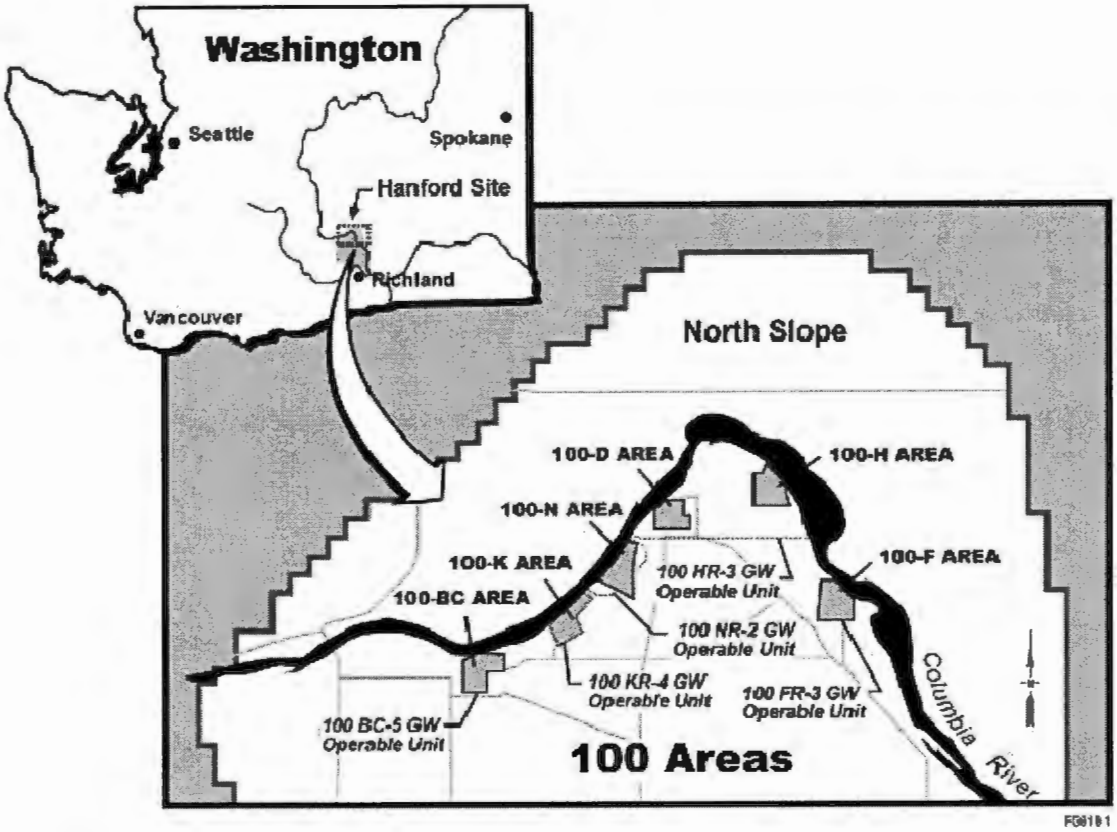
The interim remedial actions chosen for the 100-HR-3 and 100-KR-4 OUs are pump-and-treat systems that use an ion-exchange (IX) medium for contaminant removal. The systems were designed to achieve three remedial action objectives (RAOs), as well as specific operational and aquifer performance criteria described in the interim remedial action Record of Decision (ROD), *Declaration of the Record of Decision for the 100-HR-3 and 100-KR-4 Operable Units at the Hanford Site (Interim Remedial Actions)* (EPA et al. 1996). The three RAOs are identified as follows:

- RAO #1: Protect aquatic receptors in the river bottom substrate from contaminants in groundwater entering the Columbia River.
- RAO #2: Protect human health by preventing exposure to contaminants in the groundwater.
- RAO #3: Provide information that will lead to a final remedy.

The interim remedial action initially chosen for the 100-NR-2 OU was a pump-and-treat system using an IX medium for removal of strontium-90. In 2005, the RAOs were reviewed and it was determined that the pump-and-treat system was ineffective and inefficient in reducing the flux of strontium-90 to the Columbia River. In accordance with the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al. 2003), the 100-NR-2 pump-and-treat system was placed in cold-standby status on March 9, 2006, in accordance with Tri-Party Agreement Milestone M-16-06-01 ("Complete a Permeable Reactive Barrier [PRB] at 100-N"). The U.S. Department of Energy (DOE) began emplacement of a PRB along the 100-N Area shoreline in 2007 with the goal of sequestering strontium-90 in the aquifer (DOE/RL-2005-96, *Strontium-90 Treatability Test Plan for the 100-NR-2 Groundwater Operable Unit*). Progress on the barrier will be reported in a separate report.

This report describes the annual summary and performance evaluation for the three respective OUs. Section 2.0 discusses the 100-HR-3 OU, Section 3.0 discusses the 100-KR-4 OU and KW Reactor, and Section 4.0 discusses the 100-NR-2 OU. An evaluation of costs is presented in Section 5.0, and the references cited in this report are included as Section 6.0. Additional supporting information is included in Appendices A through G.

Figure 1-1. Location of 100 Area Groundwater Operable Units.



1.1 SUMMARY OF OPERABLE UNIT ACTIVITIES

The following subsections provide a summary of associated activities and remedial actions in the 100-HR-3, 100-KR-4, and 100-NR-2 OUs. Additional detailed information is also presented in DOE/RL-2008-66. The primary metrics for monitoring the performance of the pump-and-treat systems are the volume of water treated, amount of chromium removed, removal efficiency, system availability, and chromium concentrations in the compliance and monitoring wells.

1.1.1 100-HR-3 Operable Unit Activities

- Chromium investigation in the Horn area: A report on investigation monitoring results for fiscal year 2008 (FY08) was released (DOE/RL-2008-42, *Hydrogeological Summary Report for 600 Area Between 100-D and 100-H for the 100-HR-3 Groundwater Operable Unit*) in response to Issue #9 of the *Second CERCLA Five-Year Review Report for the Hanford Site* (DOE/RL-2006-20).
- The 100-D pump-and-treat expansion (DX) and 100-HR-3 pump-and-treat system expansion: Remedial process optimization (RPO) is being conducted for the 100-HR-3 OU to provide for expanded treatment capacity and enhanced remediation. A separate treatment facility will be installed in the 100-D Area for expanded capacity to 2,271 L/min (600 gallons per minute [gpm]). Additional capacity will also be installed in the 100-H Area for a total capacity of 1,514 L/min (400 gpm). The existing DR-5 system will be incorporated into the 100-D Area system expansion.

- Chromium source area refinement: A final report summarizing the findings for chromium source area refinement is scheduled for release during 2009. An injection test was conducted with zero-valent iron as a potential ISRM barrier amendment. The objective was met of injecting to a radius of 7 m (23 ft) from the injection well, and reducing conditions appear to have been established.
- Aquifer test at the 100-H Area: Deep wells screened in the Ringold Upper Mud (RUM) Unit will be joined to the 100-HR-3 system and pumped to estimate their hydraulic connectivity with the unconfined aquifer and to estimate the persistence of hexavalent chromium in the RUM near the wells.
- RPO/modeling: The RPO for pump-and-treat expansion in the 100-D and 100-H Areas was designed. The DX expansion will supersede the current DR-5 system and expand the treatment capacity to 2,271 L/min (600 gpm). The 100-HR-3 expansion will bring that system's capacity to 1,136 L/min (300 gpm).

1.1.2 100-KR-4 Operable Unit Activities

- 116-K-2 pump-and-treat system expansion: The existing 100-KR-4 pump-and-treat system will be expanded to increase the treatment capacity to approximately 3,407 L/min (900 gpm) from the current 1,136 L/min (300 gpm). The expansion will involve adding 11 extraction wells, 9 injection wells, and a new 2,271 L/min (600 gpm) treatment facility. A revised remedial design/remedial action (RD/RA) work plan, *Supplement to the 100-HR-3 and 100-KR-4 Remedial Design Report and Remedial Action Work Plan for the Expansion of the 100-KR-4 Pump-and-Treat System* (DOE/RL-2006-75), was released during the fall of 2008.
- KW Reactor pump-and-treat system: The KW Reactor pump-and-treat system continued to operate in FY08 with the objective of controlling and remediating the hexavalent chromium plume in the KW Reactor area. It includes four extraction wells and two injection wells and is operating at approximately 379 L/min (100 gpm). The existing system is being expanded to a 757-L/min (200-gpm) capacity with the addition of a second treatment train, four new extraction wells, and two new injection wells. A revision to the *KW Pump-and-Treat System Remedial Design and Remedial Action Work Plan, Supplement to the 100-KR-4 Groundwater Operable Unit Interim Action* (DOE/RL-2006-52) is in progress.

1.1.3 100-NR-2 Operable Unit Activities

- 100-NR-2 pump-and-treat system: This system went into cold-standby status in March 2006, which continued throughout calendar year 2008 (CY08).
- Permeable reactive barrier (PRB): A PRB was installed along the 100-N Area shoreline and had its first full year of operation in FY08. The system is used to inject a calcium-citrate-phosphate solution, with in situ biodegradation of the citrate resulting in apatite precipitation, adsorption of strontium-90 to the apatite, and then apatite recrystallization (with strontium-90 substituting for calcium). The net effect is that strontium-90 is held immobile in the apatite crystal structure while it decays naturally. The process is described in detail in the treatability test plan (DOE/RL-2005-96).

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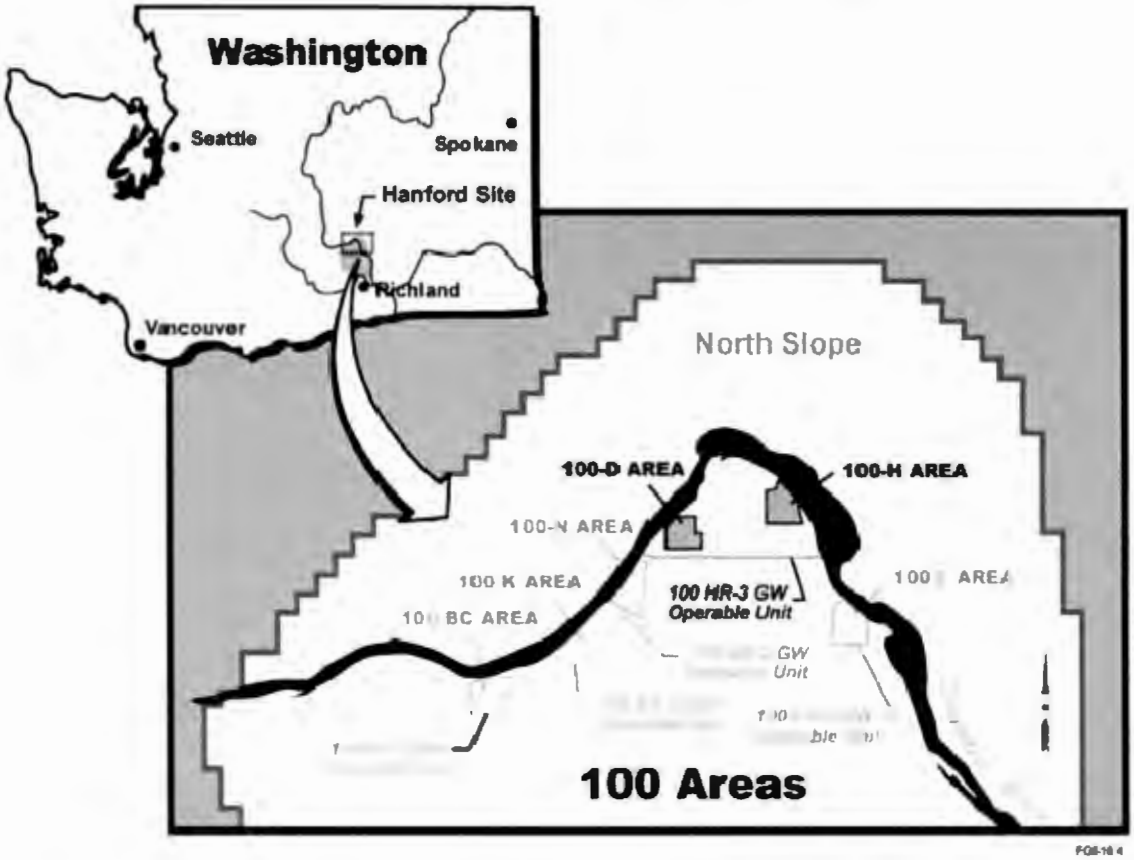
2.0 100-HR-3 OPERABLE UNIT PUMP-AND-TREAT SYSTEM

The 100-HR-3 OU consists of the groundwater underlying the source OUs that is associated with the D and H Reactor areas and the adjacent 600 Area (Figure 2-1). The 100-HR-3 groundwater extraction system was installed at the D and H Reactor areas in June 1997, with a common treatment facility in a surplus building located near H Reactor. Water is pumped from the 100-D Area to the 100-H Area for treatment and injection. A system was installed in 2004 at the 100-D Area (i.e., the DR-5 pump-and-treat system) to extract and treat high levels of chromium in the central portion of the 100-D Area; however, water from the 100-HR-3 system is still piped from the 100-D Area to the 100-H Area for treatment. The RPO is being designed to implement consolidated extraction, treatment, and injection capability within each area and to expand treatment capacity via a new facility in the 100-D Area and upgrade the facility in the 100-H Area. New extraction and injection wells will be added in each area, and water will no longer be piped between the areas for treatment and reinjection.

Figure 2-1. Location of the 100-HR-3 Operable Unit.



The current configuration of extraction, injection, and monitoring well locations for the 100-D Area is shown in Figure 2-2, and 100-H Area well locations are shown in Figure 2-3. Appendix A provides the history of operations and identifies the supporting documents used to develop the 100-HR-3 pump-and-treat system.

Figure 2-2. 100-HR-3 Operable Unit – 100-D Area Wells and Aquifer Sampling Tubes.

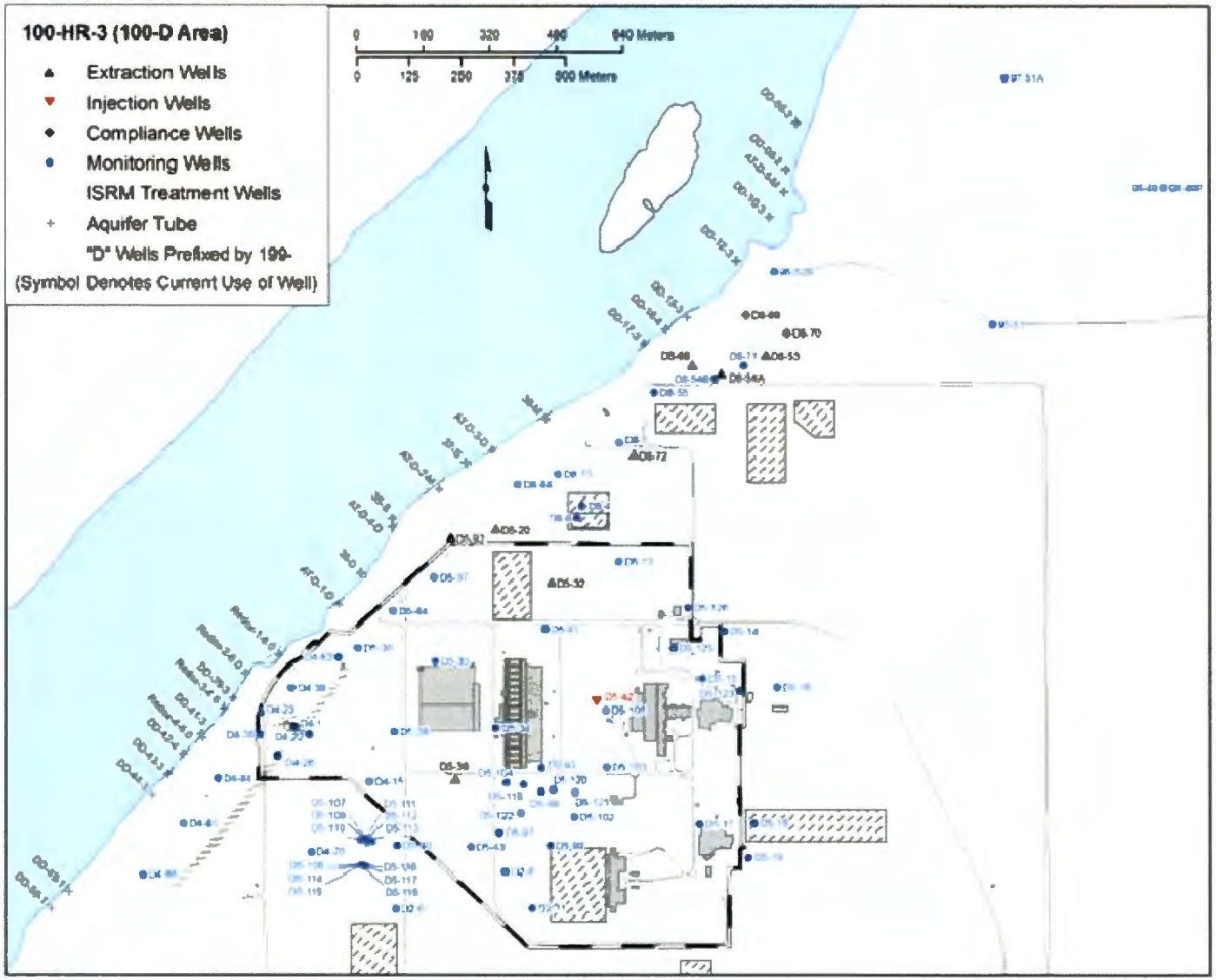
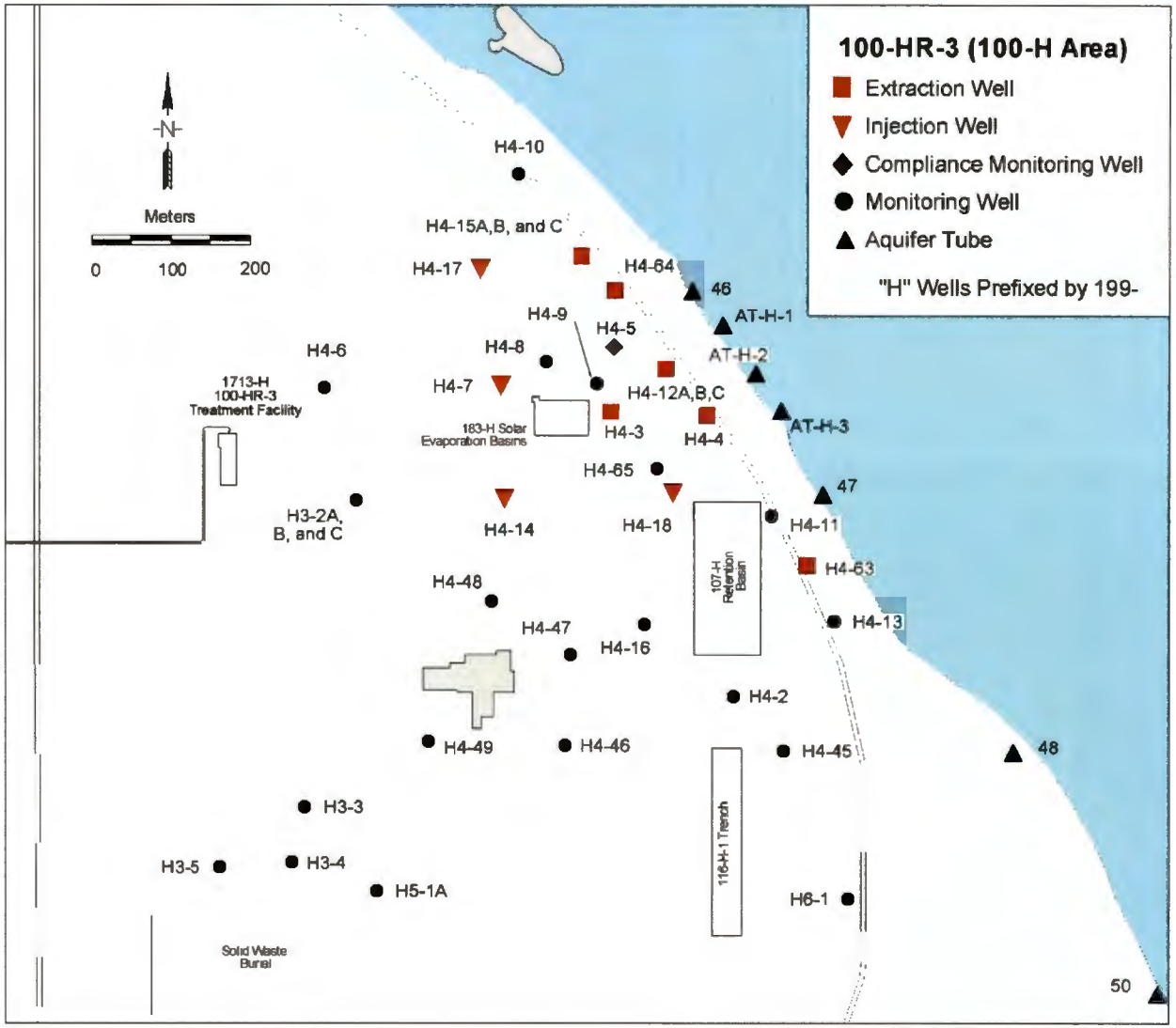


Figure 2-3. 100-HR-3 Operable Unit – 100-H Area Wells and Aquifer Sampling Tubes.



2.1 100-HR-3 OPERABLE UNIT TREATMENT SYSTEM PERFORMANCE

Groundwater treatment in the 100-HR-3 Groundwater OU includes the active 100-HR-3 and DR-5 pump-and-treat systems and the passive ISRM treatment system. The ISRM system performance is reported separately for FY08 (DOE/RL-2009-01).

2.1.1 DR-5 Pump-and-Treat System

The DR-5 pump-and-treat system consists of four extraction wells and one injection well. The flow volumes and various operational parameters for extraction and injection wells are available in the project-specific database. Figure 2-4 provides a schematic of the current DR-5 pump-and-treat system. Table 2-1 identifies the current extraction and injection wells, including the average extraction pumping rates for CY08.

A summary of operational parameters and total system performance for the DR-5 pump-and-treat system for CY08 is presented in the Table 2-2. The operational details for CY08 can be summarized as follows:

- A total of 70.8 million L (16.7 million gal) of groundwater was processed in CY08. The total volume of water treated since startup of the operational phase of the pump-and-treat system is 280.8 million L (74.2. million gal). In CY08, 46.4 kg of hexavalent chromium were removed, resulting in a total of 207.1 kg processed since startup.
- The average removal efficiency for CY08 was 99.9%. The average hexavalent chromium influent concentration was 655 μg/L, while the average effluent concentration was <1 μg/L (Figure 2-5).
- Scheduled system availability for CY08 was 92.7%, which was lower than the 99.7% reported in CY07. The total availability was 91.6% (Figure 2-6). The lower system and total availability are related to (1) reduced injection capacity at well 199-D5-42 (113.5 L/min [30 gpm] versus 189.3 L/min [50 gpm]), and (2) Washington Closure Hanford, LLC (WCH) conducting cleanup activities in the area of the transfer lines. Planned plant modifications and tie-in activities that were completed in CY08 also contributed to lower availability of the system.

2.1.2 100-HR-3 Pump-and-Treat Operations

The 100-HR-3 pump-and-treat system consists of 10 extraction wells and 4 injection wells. A system schematic of the current 100-HR-3 pump-and-treat is presented in Figure 2-7. Table 2-3 identifies the current extraction, compliance, and injection wells, as well as the average pumping rates for the extraction wells in CY08. Summaries of operational parameters and total system performance for the 100-HR-3 pump-and-treat system in CY08 are presented in Tables 2-4 and 2-5.

The operational and system highlights for CY08 discussed below pertain to the original 100-HR-3 (100-D and 100-H) pump-and-treat system:

- A combined total of 308.7 million L (81.6 million gal) of groundwater was processed in CY08, which was a 2% decrease in volume when compared to 315.4 million L (83.3 million gal) processed in CY07. The 24.3 kg of hexavalent chromium removed in CY08 was an increase of 10% in mass removed when compared to 21.8 kg processed in CY07.
- The average removal efficiency for CY08 was 96.0%, which is essentially the same as the 95.7% reported in CY07 (Figure 2-8).
- The 100-D Area influent hexavalent chromium concentration average (after separating the process streams) was approximately 127 μg/L. This was an 11% increase when compared to 114 μg/L reported early in CY07.

Figure 2-4. DR-5 Pump-and-Treat System Schematic.

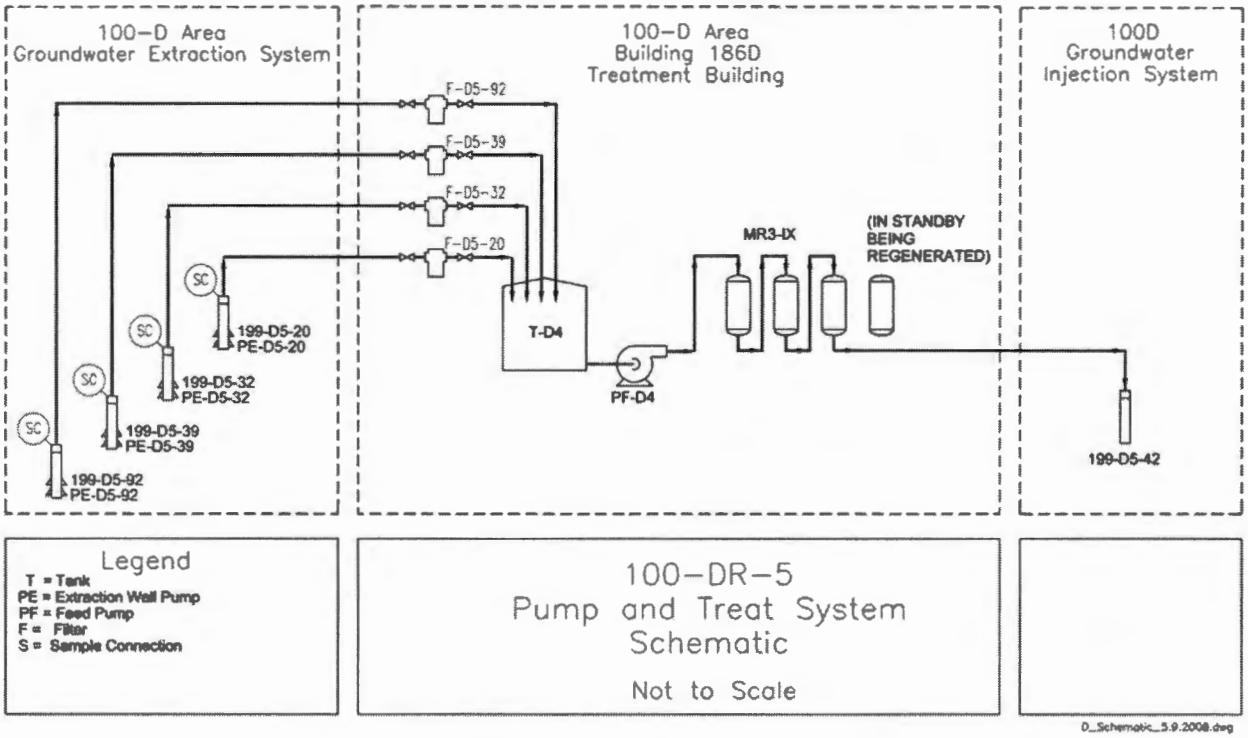


Table 2-1. DR-5 Average Pumping Rates for Calendar Year 2008.

Well	Use in CY08	Avg. Pumping Rate, gpm (L/min)	
		High River[a]	Low River[b]
199-D5-20	Extraction	6.4 (24.1)	5.6 (21.3)
199-D5-32	Extraction	13.7 (52.0)	12.0 (45.6)
199-D5-39	Extraction	14.1 (53.4)	12.1 (46.0)
199-D5-92	Extraction	8.4 (31.9)	8.3 (31.5)
199-D5-42	Injection	NC	NC

[a] Beginning of March to end of August.
[b] Beginning of September to end of February.
CY = calendar year
gpm = gallons per minute
NC = values not calculated

- The average 100-H influent hexavalent chromium concentration in CY08 (after separating the process streams) was 15.6 µg/L, which was approximately the same as the CY07 average of 15.8 µg/L. Trend plots of CY08 influent and effluent concentrations are presented in Figure 2-9.
- The combined effluent concentrations for the CY08 reporting period were predominantly <20 µg/L.

Table 2-2. DR-5 Operating Parameters and System Performance for Calendar Years 2007 and 2008.

Total DR-5 Processed Groundwater	CY07	CY08
Total amount of groundwater treated (since December 2004) (million L)	211.0	280.8
Total amount of groundwater treated during CY (million L)	79.3	70.8
Mass of Hexavalent Chromium Removed	**CY07**	**CY08**
Total amount of hexavalent chromium removed (since August 2004 startup) (kg)	160.7	207.1
Total amount of hexavalent chromium removed in CY (kg)	53.9	46.4
Summary of Operational and System Availability	**CY07**	**CY08**
Removal efficiency (% by mass)	99.9%	99.9%
Total possible run-time (hours)	8,760	8,784
Scheduled downtime (hours)	22.8	110.7
Planned operations (hours)	8,737.2	8,673
Unscheduled downtime (hours)	181.6	629.8
Total time on-line (hours)	8,555.6	8,043.5
Total availability (%)	97.7%	91.6%
Scheduled system availability (%)	99.7%	92.7%

CY = calendar year

- Scheduled system availability for CY08 was 94.6%, which was lower than the 99.4% reported in CY07. The total availability for CY08 was 93.4%, which was lower than the 98.9% on-line availability reported for CY07. The monthly on-line percentages and method used to calculate scheduled and on-line availability are presented in Figure 2-10. The lower system and total availability were the result of forced shutdown of the treatment system due to WCH conducting cleanup activities in the area of the transfer lines and frozen lines in December 2008.
- Resin changeouts were performed on 27 vessels in CY08. New resin installed totaled 0.6 m^3 (21.2 ft^3), while regenerated resin totaled 60.6 m^3 (2,139.8 ft^3).

A historical presentation of operational parameters, total system performance, and extraction well chromium concentration and extraction rates are included in Appendix B.

2.2 AQUIFER RESPONSE IN THE 100-D AREA

This section describes the general hydrogeologic conditions in the 100-D Area, the water-level mapping and numerical modeling conducted to evaluate the extent of capture by the pump-and-treat activities, and the changes in contaminant concentrations measured in monitoring wells.

2.2.1 Hydrogeologic Conditions in the 100-D Area

Groundwater flow in the 100-D Area occurs in sands and gravels of variable conductivity and is influenced by the injection and extraction well networks for the pump-and-treat system, as well as seasonal fluctuations in the Columbia River. Regional groundwater flow in the vicinity of the 100-D Area is toward the Columbia River.

Figure 2-5. Calendar Year 2008 DR-5 Pump-and-Treat Trends of Influent and Effluent Hexavalent Chromium Concentrations.

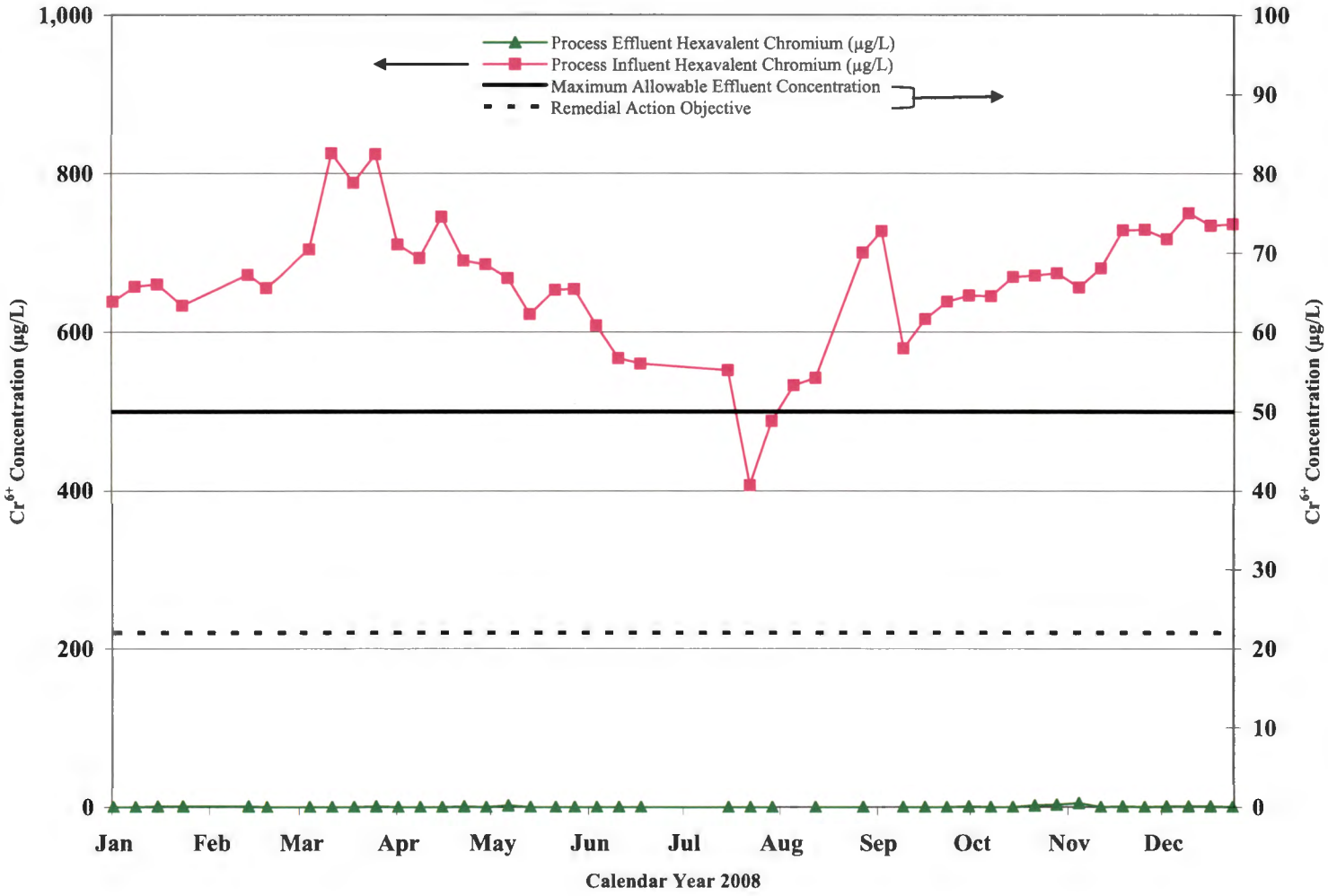
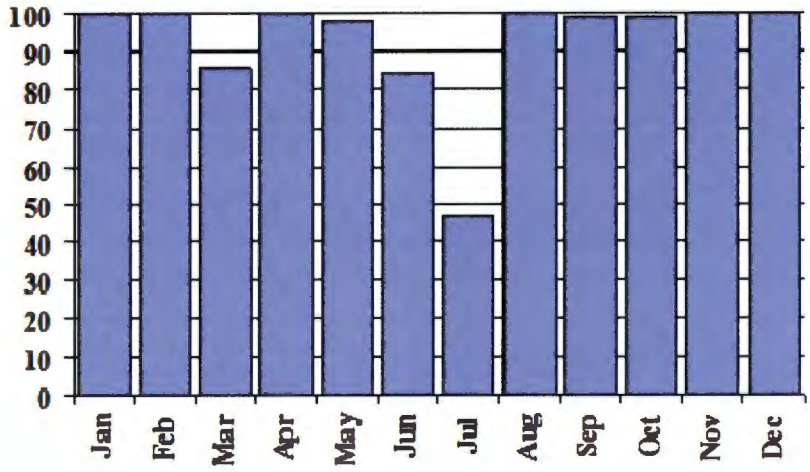


Figure 2-6. DR-5 System Availability and On-Line Percentages for Calendar Year 2008.



DR-5 System Availability[a]:	CY08
Total possible run-time (hours)	8,784
Scheduled downtime (hours)	110.7
Planned operations (hours)	8,673
Unscheduled downtime (hours)	629.8
Total time on-line (hours)	8,043.5
Total availability (%)	91.6%
Scheduled system availability (%)	92.7%

[a] Scheduled system availability [(total possible run-time – scheduled downtime)/ total possible run-time].
Total availability [(total possible run-time – scheduled and unscheduled downtime) / total possible run-time)].

The aquifer in the vicinity of 100-D Area is located mostly in the sands and gravels of Ringold Unit E, pinching out to the east where the Hanford formation constitutes most of the aquifer. Average aquifer thickness is about 5.2 m (17 ft), and transmissivities obtained from aquifer tests of wells 199-D5-14, 199-D5-15, and 199-D5-16 range from approximately 100 to 200 m^2/day (1,076 to 2,153 ft^2/day).

Groundwater mounding in response to historic leakage from the 182-D reservoir and injection of treated water at well 199-D5-42 creates a local hydraulic divide that separates the chromium contamination into two areas: northeast and southwest of the divide, respectively (Figure 2-11). Operation logs indicate no observable leakage from the 182-D reservoir during CY08. The western plume (Figure 2-11) flows toward and, in some places, through the ISRM barrier, while the eastern plume located to the north and east is intercepted by a series of extraction wells. Groundwater flow is generally toward the river between the injection well field and the river.

Groundwater flow in the 100-D Area fluctuates in response to the river stage in the Columbia River, which is 2 to 3 m (6.6 to 9.8 ft) higher during high water level in the late spring and early summer versus the fall. As a result, the dynamics of groundwater flow near the river change seasonally. This aquifer response is the most pronounced near the shoreline but extends inland of the shore. A comparison of fall and spring groundwater levels (Figure 2-12) suggests that the rise in the river stage due to the spring run-off causes changes in groundwater levels up to several hundreds of meters inland in the aquifer that attenuate further inland; most of the large-scale changes are within several tens of meters of the river.

Figure 2-7. 100-HR-3 Pump-and-Treat System Schematic.

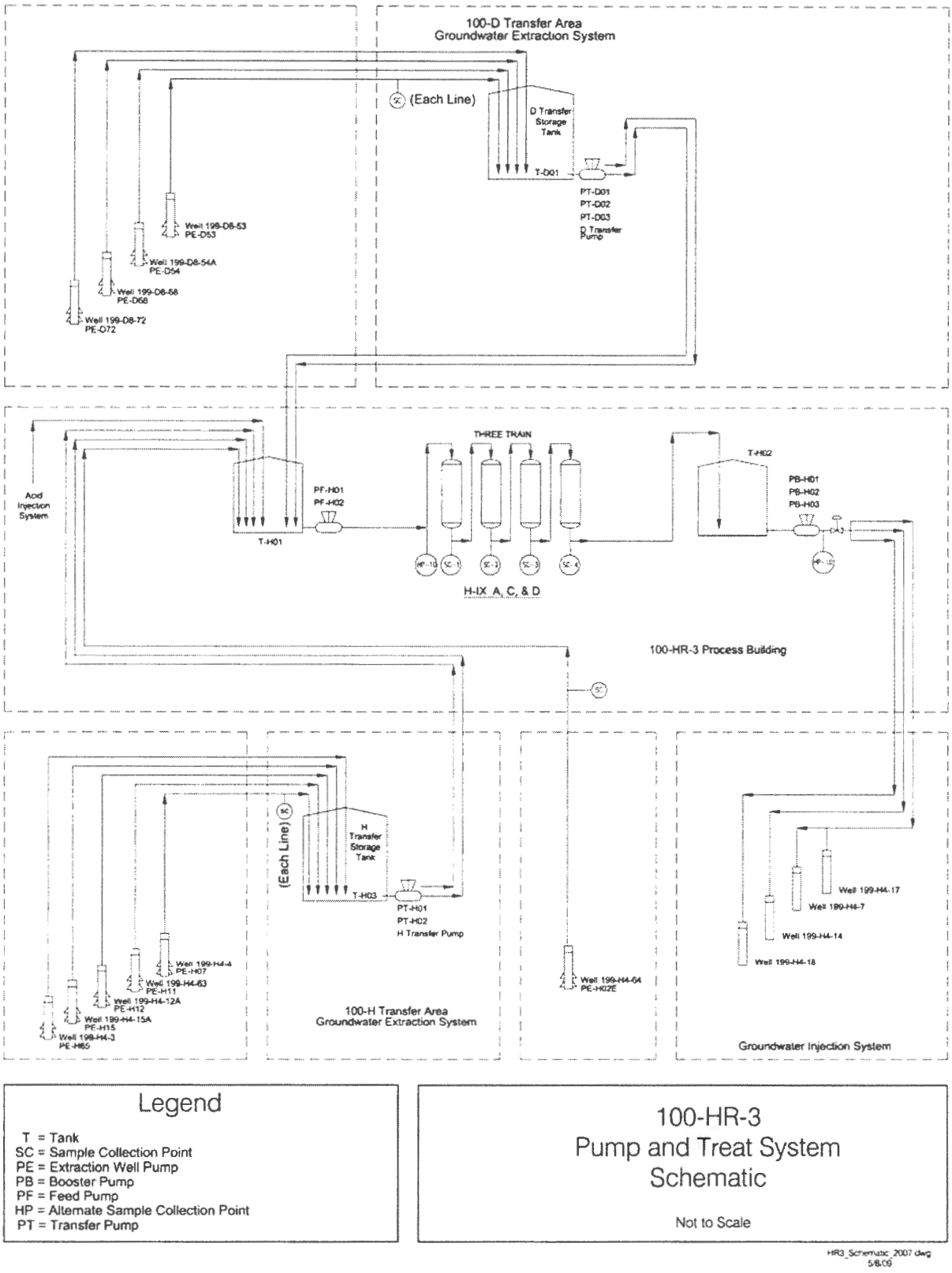


Table 2-3. 100-HR-3 Average Pumping Rates for Calendar Year 2008.

Well	Use in CY08	Avg. Pumping Rate, gpm (L/min)	
		High River[a]	Low River[b]
199-D8-53	Extraction	22.5 (85.2)	11 (41.5)
199-D8-54A	Extraction	18.6 (70.4)	11.3 (42.7)
199-D8-68	Extraction	53.9 (204.0)	51.3 (194.3)
199-D8-72	Extraction	11.7 (44.2)	9.9 (37.4)
199-D8-69	Compliance	NA	NA
199-D8-70	Compliance	NA	NA
199-H4-3	Extraction	9.5 (35.8)	6.3 (24.0)
199-H4-4	Extraction	9.8 (37.0)	6.4 (24.1)
199-H4-12A	Extraction	8.0 (30.3)	6.1 (23.2)
199-H4-15A	Extraction	19.1 (72.4)	18.6 (70.5)
199-H4-63	Extraction	23.8 (90.3)	23.6 (89.0)
199-H4-64	Extraction	15.5 (58.8)	10.3 (39.0)
199-H4-17	Injection	NC	NC
199-H4-7	Injection	NC	NC
199-H4-18	Injection	NC	NC
199-H4-14	Injection	NC	NC
199-H4-5	Compliance	NC	NC

[a] Beginning of March to end of August.
[b] Beginning of September to end of February.
CY = calendar year
gpm = gallons per minute
NA = not available
NC = values not calculated

During low river stage in the fall and winter, the flow is toward the river, whereas during high river stage in the spring and summer, the flow is locally from the river inland. These observations suggest that the Columbia River is primarily a gaining reach during times of low flow and may become primarily a losing reach during times of high flow. This interpretation is supported by concentration contours presented in Figure 2-12. These indicate that during spring run-off when the river stage is high, chromium concentrations are <22 μg/L along the entire shoreline, whereas during late fall when the river stage is low, chromium concentrations are >22 μg/L at several locations along the shoreline.

Table 2-4. 100-HR-3 Processed Groundwater and Hexavalent Chromium Removed for Calendar Year 2008.

Total 100-HR-3 Processed Groundwater (L)[a]			
	CY07[b]	**CY08[b]**	**Since 1997 Startup[c]**
100-D Area	170.5	174.9	1.9635
100-H Area	144.9	133.8	1.6461
Total:	**315.4**	**308.7**	**3.6096**
Mass of Hexavalent Chromium Removed (kg)			
	CY07[b]	**CY08[b]**	**Since 1997 Startup[c]**
100-D Area	19.5	22.2	NA
100-H Area	2.3	2.1	NA
Total:	**21.8**	**24.3**	**346.0**

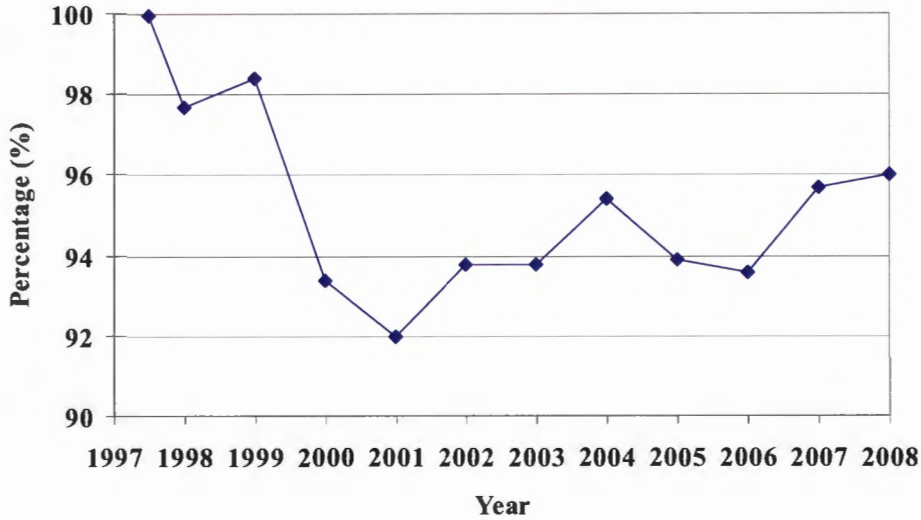
[a] Does not include system parameters for the DR-5 pump-and-treat system.
[b] Million liters.
[c] Billion liters.
CY = calendar year
NA = not available; running individual total not possible due to previous combination of process flow streams

Table 2-5. 100-HR-3 Summary of Operational Parameters for Calendar Years 2007 and 2008.

100-HR-3 operational parameters:[a]	**CY07**	**CY08**
Removal efficiency (% by mass)	95.7%	96.0%
Waste generation (m^3)[b]	0	0
Regenerated resin installed (m^3)	47.6	60.6
New resin installed (m^3)	20.4	0.6
Number of resin vessel changeouts	21	27
100-HR-3 system availability:[a]	**CY07**	**CY08**
Total possible run-time (hours)	8,760	8,784
Scheduled downtime (hours)	54.6	118.4
Planned operations (hours)	8,705.4	8,665.6
Unscheduled downtime (hours)	41.4	463.8
Total time on-line (hours)	8,664.0	8,201.8
Total availability (%)	98.9%	93.4%
Scheduled system availability (%)	99.4%	94.6%

[a] Does not include system parameters for the DR-5 pump-and-treat system.
[b] Each ion-exchange vessel contains 2.3 m^3 of ion-exchange resin.
CY = calendar year

Figure 2-8. 100-HR-3 Pump-and-Treat Trend of Average Removal Efficiencies.[a]



NOTE: The 100-HR-3 pump-and-treat trends of average removal efficiencies do not include the DR-5 pump-and-treat system.

[a] Average removal efficiency is calculated as (% by mass) = [(influent – effluent) / influent].

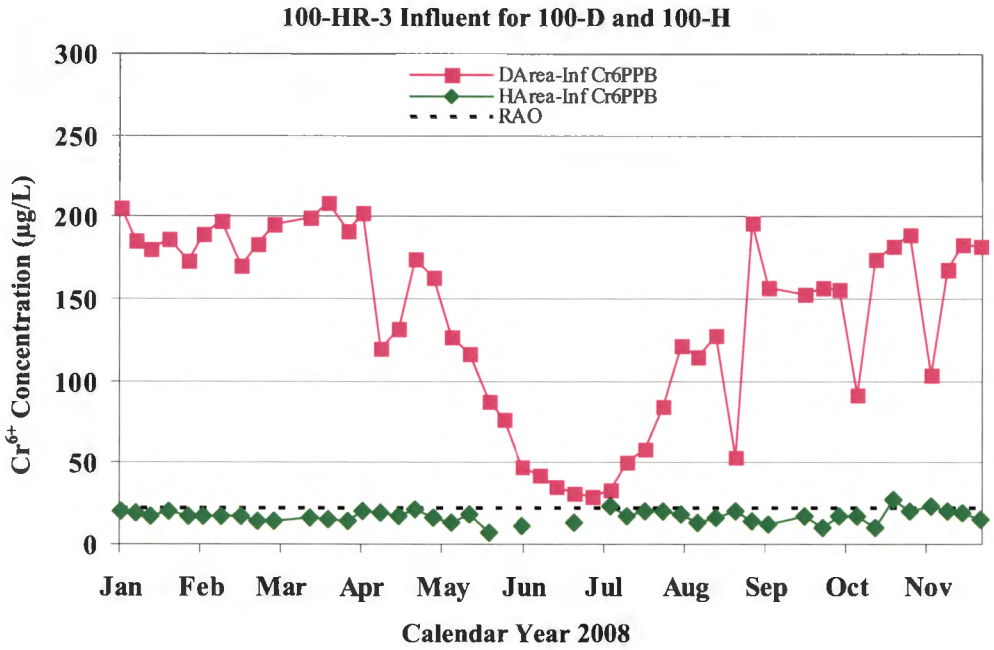
2.2.2 Hydraulic Capture Evaluation

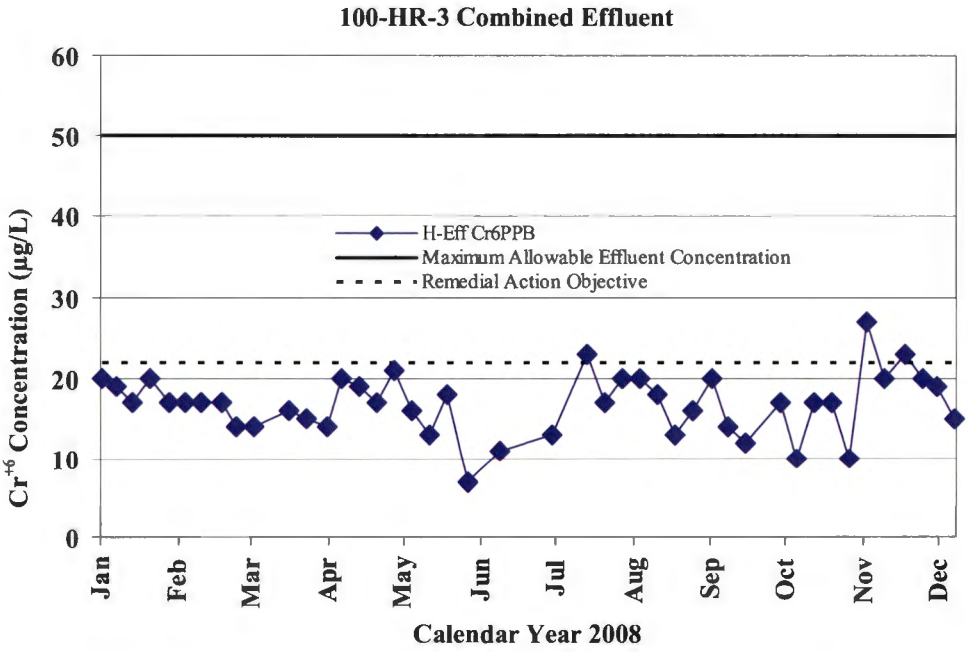
Consistent with recommendations in *A Systemic Approach for Evaluation of Capture Zones at Pump and Treat Systems* (EPA 600/R-08/003), multiple lines of evidence are used to estimate capture. Two methods are used to estimate the extent of hydraulic capture developed by pump-and-treat activities during CY08. These methods are briefly described here and are described in detail in Appendix C:

- Water-level mapping: Uses a method that incorporates the effects of extraction and injection at wells, and the effects of changing river stage, on groundwater levels. Particle tracking on each mapped surface is used to calculate approximate capture zones. The process is repeated for multiple sampling events throughout FY08 and combined into a capture frequency map (CFM), which provides an ensemble estimate of the extent of capture.
- Groundwater modeling: Uses the 100 Areas groundwater model that encompasses the 100-D, 100-H, 100-K, and 100-N Areas (DOE/RL-2006-52). The model was used to simulate monthly stress periods and depict the approximate extent of capture using a capture efficiency map (CEM).

Figure 2-13 depicts the CFM calculated using the mapping approach. This figure represents the combination of 49 water elevation and capture maps, generated using weekly average water elevation and extraction rates throughout CY08. Figure 2-14 depicts the CEM calculated using the modeling approach. This figure represents the combination of 12 capture zone estimates based on monthly average river stage and pumping rates. Comparison of Figures 2-13 and 2-14 suggests that some gaps likely exist in capture, which is depicted in terms of low capture frequency, low capture efficiency, or both. These gaps are most evident as follows:

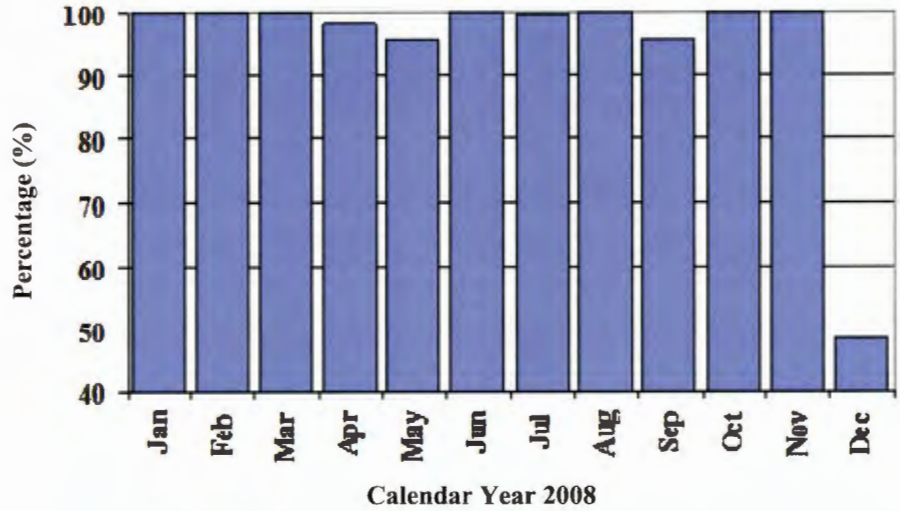
Figure 2-9. Calendar Year 2008 100-HR-3 Pump-and-Treat Trends of Influent and Effluent Hexavalent Chromium Concentrations.





NOTE: The calendar year 2008 100-HR-3 pump-and-treat trends of influent and effluent hexavalent chromium concentrations do not include the DR-5 pump-and-treat system.

Figure 2-10. 100-HR-3 System Availability and On-Line Percentages for Calendar Year 2008.



2008 system availability[a]:	
Total possible run-time (hours)	8,784
Scheduled downtime (hours)	118.4
Planned operations (hours)	8,665.6
Unscheduled downtime (hours)	463.8
Total time on-line (hours)	8,201.8
Total availability (%)	93.4
Scheduled system availability (%)	94.6

NOTE: The 100-HR-3 system availability and on-line percentages for calendar year 2008 do not include the DR-5 pump-and-treat system.

[a] Scheduled system availability [(total possible run-time – scheduled downtime) / total possible run-time].
Total availability [(total possible run-time – scheduled and unscheduled downtime) / total possible run-time)].

- Between well 199-D-39 and wells 199-D5-20/199-D5-32/199-D5-92 (mapped and modeled capture)
- Between wells 199-D5-20/199-D5-32/199-D5-92 and wells 199-D8-53/199-D8-54/199-D8-68/ 199-D8-72 (modeled capture only).

The following observations are based on the modeling results:

- A large portion of the hexavalent chromium plume extending from the D and DR Reactors, north to the Columbia River, is within the capture zone of the 100-HR-3 extraction well network. Based on the 100-D chromium plume in 2008, flow lines to the east of the reactor areas that reach the river trend through areas that are mapped as exhibiting concentrations of <22 µg/L chromium.
- A portion of the hexavalent chromium plume north of the decommissioned D Pond with concentrations >22 µg/L is not captured by the existing 100-HR-3 and DR-5 extraction well network. This area extends from well 199-D8-88 to well 199-D8-55 and, based on the modeled flow-line analyses, it appears likely to comprise a fairly small groundwater flux compared to that captured by the 100-HR-3 and DR-5 wells (Figure 2-12).

Figure 2-11. 100-D-Area November 2008 Chromium Plume Map.

2.2.3 Contaminant Monitoring in the 100-D Area

The *Interim Action Monitoring Plan for the 100-HR-3 and 100-KR-4 Operable Units* (DOE/RL-96-90) and *Sampling Changes to the 100-HR-3 and 100-KR-4 Operable Units* (DOE-RL 1998) define the sampling protocols implemented for CY08. The principal contaminant of concern (COC) in the 100-D Area is hexavalent chromium. The RAO is to reduce the chromium concentration to 22 µg/L at the compliance wells. Strontium-90, tritium, and nitrate are co-contaminants that are actively monitored but generally are present in concentrations that result in low ecological risk (DOE/RL-94-43, *Limited Field Investigation Report for the 100-HR-3 Operable Unit*). In addition, sulfate is a contaminant of interest because the secondary drinking water standard (DWS) has been exceeded in the past in a limited number of wells since the installation of the ISRM barrier. Institutional controls, implemented to satisfy RAO #2, limit human exposure to hexavalent chromium and the co-contaminants.

The contaminant monitoring results presented in the following subsections indicate fall 2008 results compared to baseline sampling results. Maximum contaminant concentrations detected in CY08 are discussed in Section 2.2.3.7.

2.2.3.1 100-D Area Chromium Monitoring Results. Hexavalent chromium concentrations are monitored in extraction wells, compliance wells, monitoring wells, and aquifer tubes in the 100-D and DR-5 pump-and-treat operational areas (Figure 2-2). The 100-D Area hexavalent chromium plumes for fall 2008 are shown in Figure 2-11. Hexavalent chromium plume maps for the period from 1995 through 2007 are provided in Appendix A, with associated contaminant concentration trend plots provided in Appendix E. Concentration changes for selected wells within the pump-and-treat system configuration used since 2004 are presented in Figure 2-15. A separate discussion concerning the hexavalent chromium concentrations in wells along the ISRM shoreline is provided in the FY08 ISRM annual summary report (DOE/RL-2009-01).

Table 2-6 compares baseline concentrations (i.e., prior to influence by pump-and-treat operations) to levels detected in 2008 for hexavalent and total chromium concentrations in wells and aquifer tubes comprising both the DR-5 and 100-HR-3 well network. The table also provides the percent change in concentration that has occurred at each well during this period. The changes in chromium concentrations for the same well set between CY07 and CY08 are provided in Appendix E. The changes in concentration provide an indication of both the long-term (Table 2-6) and short-term (Appendix E, Tables E-1 through E-5) impact on chromium levels resulting from the pump-and-treat operations.

Baseline sample results for each well were selected using as many of the following criteria as possible:

- The sample selected should represent groundwater conditions before implementation of the 100-D pump-and-treat system in June 1997.
- The sample should have been minimally affected by pump-and-treat operations because of distance from the 100-D Area extraction wells.
- Samples analyzed for hexavalent chromium and total chromium should have been collected on the same day. If not possible, the sampling dates should be as close as possible.
- For newer wells, the baseline sample should be collected soon after well construction, and the hexavalent chromium and total chromium samples should have been collected on the same day, if possible.
- The fall 2008 hexavalent chromium results and total chromium samples were collected on the same day.

Figure 2-12. 100-D Area June and November 2008 Measured Water Table Comparison.

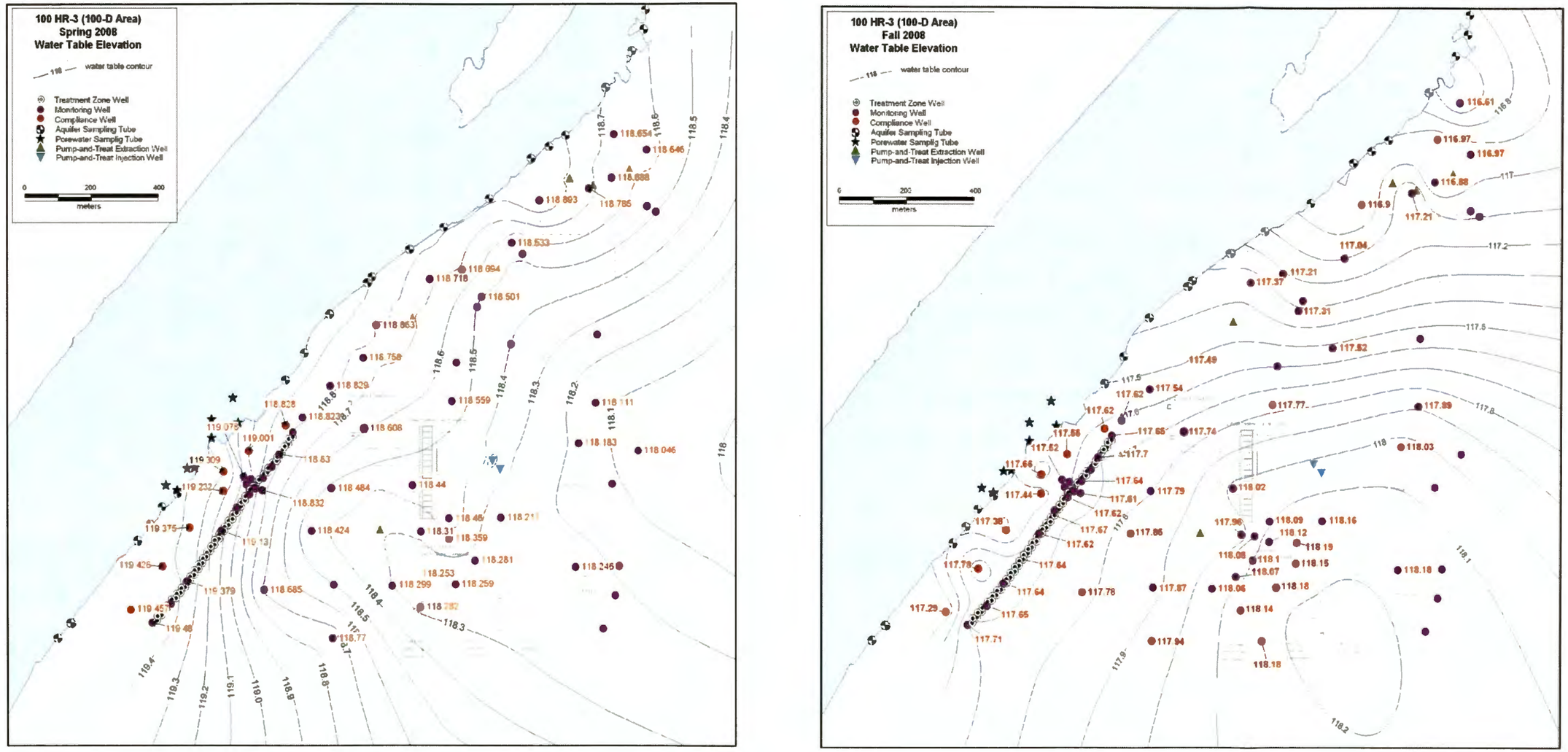
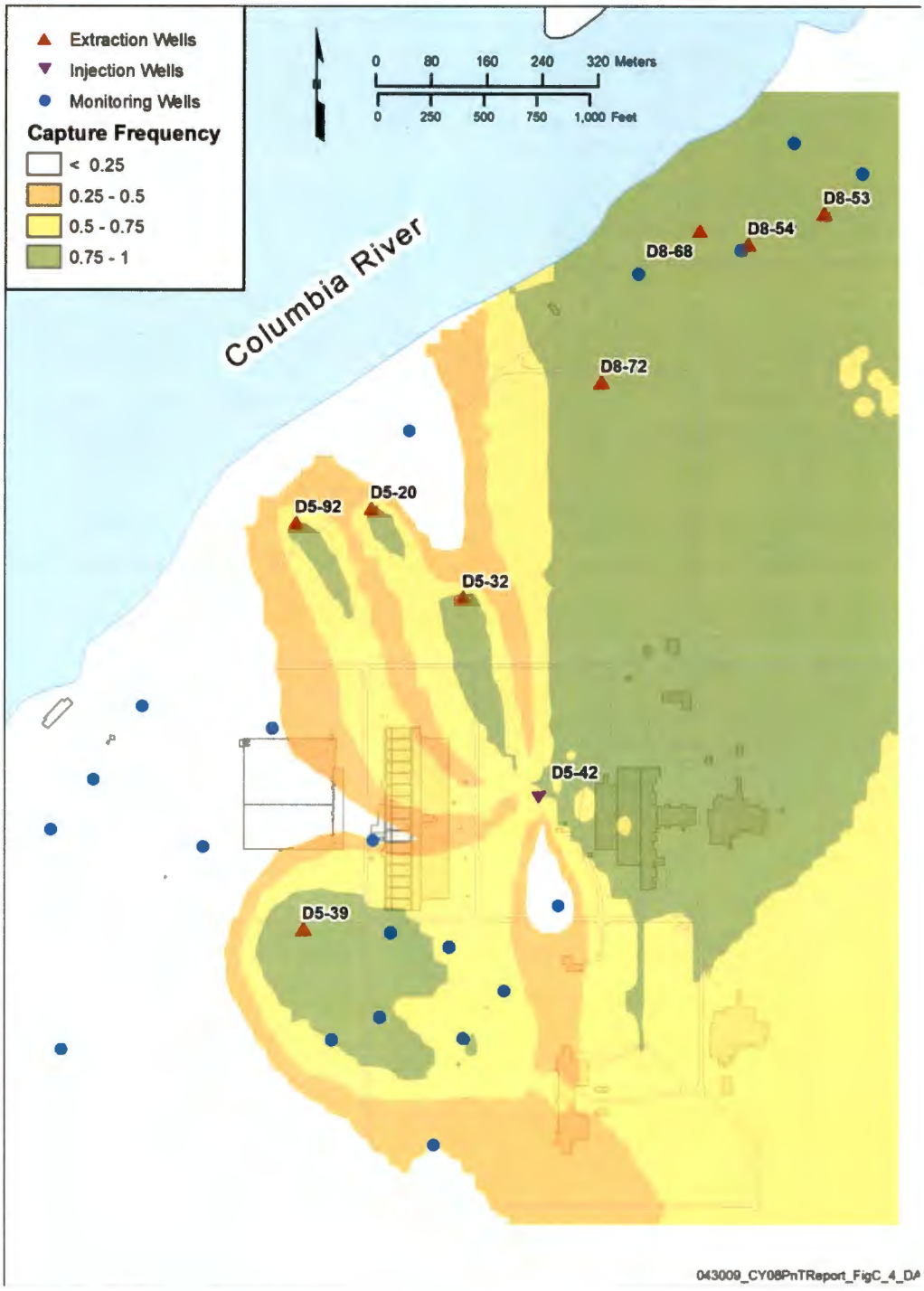


Figure 2-13. 100-D Area Capture Frequency Map (Mapped).



A goal of the interim remedial action is to reduce concentrations in 100-D Area wells to below the 22 µg/L RAO. Figure 2-15 shows hexavalent chromium concentration plots for selected wells within the plumes. Trend lines have been added to the graphs connecting maximum chromium levels for individual wells. Maximum chromium levels generally coincide with low river conditions and occur in the late fall to early spring. The trend lines indicate whether the seasonal maximum concentrations have been increasing or decreasing over the last few years at each well location. A discussion concerning hexavalent chromium concentration trends in compliance, extraction wells, and aquifer tubes is presented below. A summary of the recent chromium source monitoring results is also provided.

Figure 2-14. 100-D Area Capture Efficiency Map (Modeled).

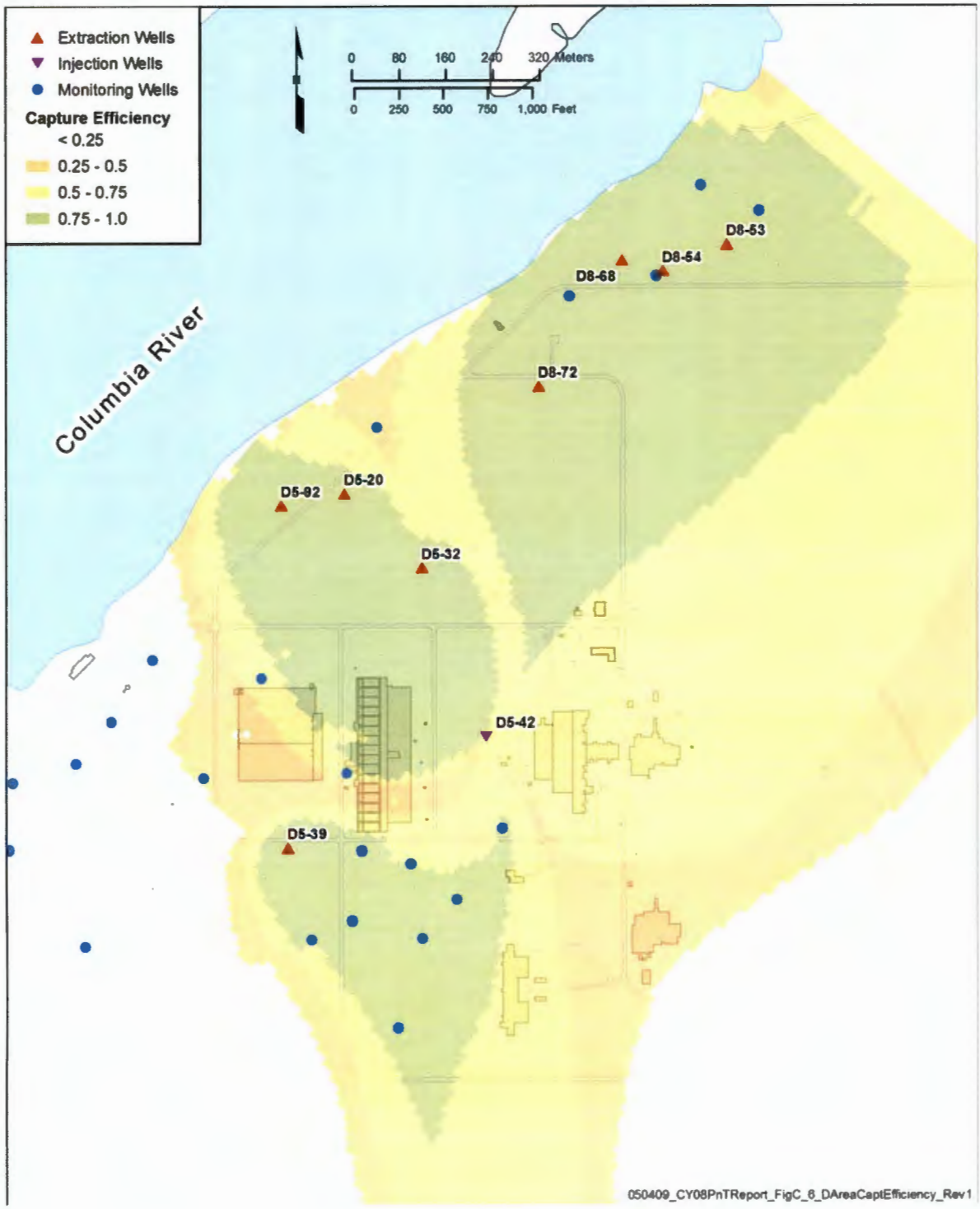


Figure 2-15. 100 D Area Hexavalent Chromium Trend Plots, Fall 2008.

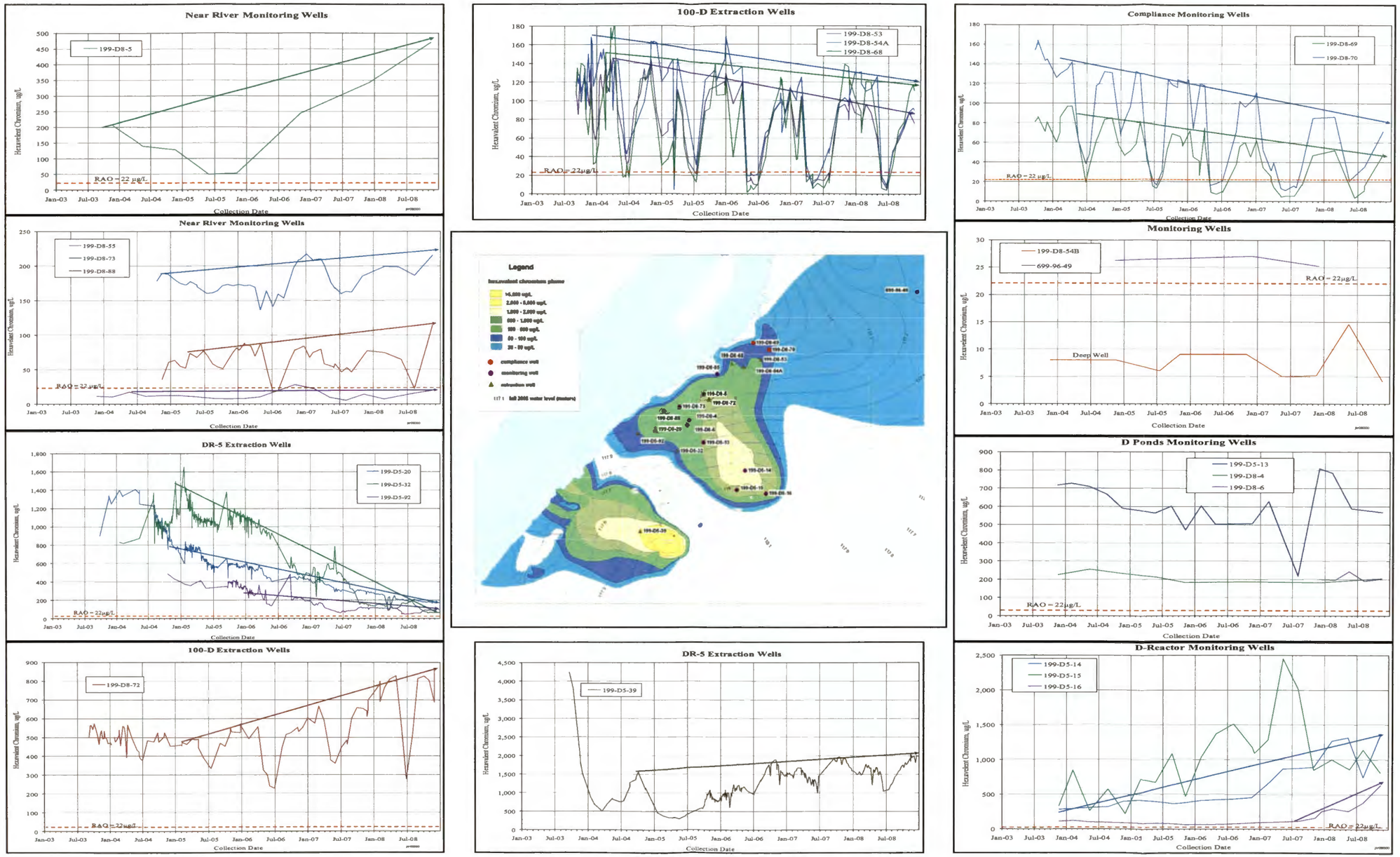


Table 2-6. Hexavalent and Total Chromium Concentrations in Baseline and 2008 for Wells and Aquifer Tubes Monitoring the 100-HR-3 (D) and DR-5 Pump-and-Treat Systems. (2 pages)

System	Well or Aquifer Tube Name	Well Use or Aquifer Tube	Baseline Sample					Fall 2008 Sample					Percent Change in Conc. (Negative = Decrease)		
			Filtered and Unfiltered Cr^{+6}		Total Chromium			Unfilt. Cr^{+6}		Total Chromium					
			Date Collected	Conc. (µg/L)	Date Collected	Unfilt. (µg/L)	Filt. (µg/L)	Date Collected	Conc. (µg/L)	Date Collected	Unfilt. (µg/L)	Filt. (µg/L)	Cr^{+6}	Total Chromium	
														Unfilt.	Filt.
	199-D5-13	E/M	11/18/98	293	10/21/96	366	300	11/23/08	568	11/23/08	505	486	93.9	38.0	62.0
	199-D5-14	M	3/20/97	673	11/4/96	741	727	11/23/08	1,370	11/23/08	1,230	1,170	103.6	66.0	60.9
	199-D5-15	M	11/19/97	700	11/5/96	20.7	18.3	11/19/08	815	11/19/08	766	781	16.4	3,600.5	4,167.8
	199-D5-16	M	11/18/98	422	4/1/96	347	NA	11/20/08	633	11/20/08	600.5	606.5	50.0	73.1	
	199-D5-17	M	--	--	11/18/97	36.3	20.4	--	--	11/23/08	--	15.5 (B)	--	--	--
	199-D5-18	M	--	--	11/5/96	21.3	19.2	--	--	--	--	--	--	--	--
	199-D5-19	M	--	--	5/27/98	36.1	31.5	--	--	--	--	--	--	--	--
DR-5	199-D5-20	E	11/19/97	9	10/22/96	15.8	10.2	11/20/08	178	11/20/08	168	163	1,877.8	963.3	1,498.0
DR-5	199-D5-32	E	9/14/00	1,024	12/8/04		1,410	11/20/08	64	--	--	--	-93.8	--	--
	199-D5-33	M/I	**3/2/04**	5 (U)	11/18/04		3.3 (U)	11/20/08	2.5	--	--	--	--	--	--
	199-D5-36	M	7/6/99	5 (U)	11/17/99	1.3	1.2	11/20/08	3.8	11/20/08	13 (U)	13 (U)	--	--	--
DR-5	199-D5-37	**E/M**	7/6/99	24	11/16/99	35.3	37.2	11/24/08	67.6	11/24/08	66	63.6 (B)	181.7	87.0	71.0
DR-5	199-D5-39	**M/E**	7/7/99	88	11/15/99	1,170	1,180	11/20/08	2,035	11/20/08	1,840	1,865	2,212.5	57.3	58.1
	199-D5-41	E/M	7/7/99	5 (U)	12/1/99	35.1	30	11/20/08	10.4	11/20/08	13.2 (B)	13 (U)	--	--	--
	199-D5-42	M/I	7/7/99	5 (U)	12/1/99	1.8 (B)	1.6 (B)	--	--	--	--	--	--	--	--
	199-D5-44	M	7/6/99	5 (U)	11/17/99	0.97	0.78	11/20/08	7.7	11/20/08	13 (U)	13 (U)	--	--	--
DR-5	199-D5-92	**M/E**	**10/21/04**	486	1/16/06		256	11/20/08	90.8	--	--	--	-81.3	--	--
	199-D8-3	M	10/28/96	180	10/28/96	164	193	--	--	--	--	--		--	--
	199-D8-4	M	**5/19/04**	255	10/21/96	24.9	5.5 (B)	11/20/08	205	11/20/08	208	195	-19.6	735.3	3445.5
	199-D8-5	M	**5/19/04**	140	10/21/96	51.9	34.2	11/20/08	471	11/20/08	475	464	236.4	815.2	1,256.7
	199-D8-6	M	--	--	2/28/96	26.2	8.2 (L)	11/20/08	202	--	--	--		--	--
100-HR-3	199-D8-53	E	10/29/96	130	10/29/96	140	126	11/3/08	87	--	--	--	-33.1	--	--
100-HR-3	199-D8-54A	E	10/25/96	150	10/25/96	152	140	11/3/08	88	--	--	--	-41.3	--	--
	199-D8-54B	M	10/25/96	10	10/25/96	17.4	5.7	11/23/08	4.1 (B)	11/23/08	13 (U)	13 (U)	-59.0	--	--
	199-D8-55	M	2/2/99	21	10/22/96	48	21.4	11/20/08	19	11/20/08	19.1 (B)	20.7 (B)	-9.5	-60.2	-3.3
100-HR-3	199-D8-68	**C/E**	10/15/96	104	11/30/00	--	349	11/24/08	117	--	--	--	12.5	--	--
	199-D8-69	C	10/14/96	80	--	--	--	11/20/08	48	--	--	--	-40.0	--	--
	199-D8-70	C	10/15/96	200	4/22/99	--	203	11/20/08	71.1	--	--	--	-64.5	--	--
	199-D8-71	M	10/15/96	340	1/28/99	--	205	11/20/08	157	--	--	--	-53.8	--	--
100-HR-3	199-D8-72	E	**6/17/02**	436	11/3/05	--	548 (N)	11/3/08	804	--	--	--	84.4	--	--
	199-D8-73	M	10/21/04	178	11/9/05	--	166	11/20/08	215	--	--	--	20.8	--	--
	199-D8-88	M	11/17/04	35	12/27/05	--	78.5	11/20/08	111	--	--	--	217.1	--	--
	699-96-49	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Table 2-6. Hexavalent and Total Chromium Concentrations in Baseline and 2008 for Wells and Aquifer Tubes Monitoring the 100-HR-3 (D) and DR-5 Pump-and-Treat Systems. (2 pages)

System	Well or Aquifer Tube Name	Well Use or Aquifer Tube	Baseline Sample					Fall 2008 Sample					Percent Change in Conc. (Negative = Decrease)		
			Filtered and Unfiltered Cr^{+6}		Total Chromium			Unfilt. Cr^{+6}		Total Chromium					
			Date Collected	Conc. (µg/L)	Date Collected	Unfilt. (µg/L)	Filt. (µg/L)	Date Collected	Conc. (µg/L)	Date Collected	Unfilt. (µg/L)	Filt. (µg/L)	Cr^{+6}	Total Chromium	
														Unfilt.	Filt.
Chromium Source Investigation Wells															
	199-D5-97	M	2/21/07	758	--	--	--	11/19/08	434	--	--	--	-42.7	--	--
	199-D5-98	M	2/27/07	465	--	--	--	11/17/08	182	--	--	--	-60.9	--	--
	199-D5-99	M	2/28/07	10,580	--	--	--	11/17/08	4,860	--	--	--	-54.1	--	--
	199-D5-102	M	4/24/07	231	--	--	--	11/23/08	439	--	--	--	90.0	--	--
	199-D5-103	M	3/23/07	393	--	--	--	11/19/08	135	--	--	--	-65.6	--	--
	199-D5-104	M	3/24/07	6,840	--	--	--	12/3/08	8,080	--	--	--	18.1	--	--
	199-D5-115	M	8/31/07	16	--	--	--	--	--	--	--	--		--	--
Aquifer Sampling Tubes															
	36-S/D	AT	11/17/97	5 (U)	10/21/98	8.1	--	12/10/08	83.8	--	--	--	--	--	--
	38-M/D	AT	11/18/97	5 (U)	10/21/98	10.8	--	12/10/08	5.5	--	--	--	--	--	--
	AT-D-1-M/D	AT	3/4/04	6.5	3/4/04	--	4.4 (U)	12/9/08	2 (U)	--	--	--	--	--	--
	AT-D-2-M	AT	3/14/05	25	3/4/04	--	156	12/9/08	8.8	--	--	--	-64.8	--	--
	AT-D-3-D	AT	4/25/05	134	3/4/04	--	294	12/9/08	13.2	--	--	--	-90.1	--	--
	AT-D-4-D	AT	--	--	3/4/04	--	24.7	--	--	--	--	--	--	--	--
	DD-12-2	AT	10/26/95	31	11/22/98	--	89.9	--	--	--	--	--	--	--	--
	DD-15-3	AT	10/31/95	90	10/26/98	--	85.8	--	--	--	--	--	--	--	--
	DD-16-3	AT	11/6/95	172	--	--		--	--	--	--	--	--	--	--
	DD-17-2/3	AT	10/24/95	42	10/27/98	--	216	--	--	--	--	--	--	--	--

NOTES:

1. Wells 199-D5-13 and 199-D5-41 were used as extraction wells for the electrocoagulation testing conducted during 2007. The well use has reverted to monitoring wells.
2. Change in hexavalent chromium or total chromium was calculated using only equivalent analytes.
3. Well use abbreviations: M = monitoring well, E = extraction well, C = compliance well, AT = aquifer tube.
4. Wells 199-D5-97 through 199-D5-104 are part of the chromium source investigation in the 100-D Area and the first available 2007 results (mostly spring 2007) are the baseline results.
5. Baseline hexavalent chromium results may be either filtered or unfiltered; the 2007 hexavalent chromium results are all unfiltered.
6. Laboratory qualifiers: U = undetected (shown with detection limit in parentheses); B = detected above instrument or method detection limit, but below contract-required detection; D = sample diluted; C = analyte detected in both the sample and associated quality control blank, and the sample concentration was ≤5 times the blank concentration; L = method detection limit ≤ value < contract-required detection limit.
7. Blank cells indicate that the sample was not collected, the analysis was not performed, or the change in concentration was not calculated.
8. If more than one sample was collected on the same date, the results were averaged.
9. Change in concentration not calculated if one result included an undetect (U) laboratory qualifier.

2.2.3.2 100-HR-3 Pump-and-Treat Wells in 100-D Area. The results for the 100-HR-3 pump-and-treat wells are as follows:

- Compliance wells:
  - Maximum detected concentrations have shown a decreasing trend in both compliance wells during the previous 4 years.
  - Fall 2008 hexavalent chromium concentrations continue to trend downward but were above the 22 µg/L RAO in compliance wells 199-D8-69 (48 µg/L) and 199-D8-70 (71.1 µg/L).
  - The baseline hexavalent chromium concentrations were 80 µg/L in compliance well 199-D8-69 and 200 µg/L in compliance well 199-D8-70. Values measured in the fall of 2008 represent a decrease of approximately 40% and 65%, respectively, in each well since startup of operations in 1997 (Table 2-6). Compliance well 199-D8-68 was converted to an extraction well in 2003 and is discussed with the extraction well results below.
- Extraction wells:
  - Fall 2008 hexavalent chromium concentrations were above the RAO in all four extraction wells. Concentrations ranged from 87 µg/L in well 199-D8-53 to 804 µg/L in well 199-D8-72.
  - In comparison to baseline levels, fall 2008 hexavalent chromium concentrations represent a decrease of 33% in extraction well 199-D8-53 and a 41% decrease in well 199-D8-54A(Figure 2-15).
  - The overall trend in well 199-D8-68 is downward, but the fall 2008 concentration of 117 µg/L was an increase of 12.5% from the baseline level. Extraction well 199-D8-72 has increased in concentration approximately 84% from the baseline level, indicating good capture of contaminated water.
  - From 2004 through 2008, maximum yearly concentrations have shown a decreasing trend for the three extraction wells located along the northwest margin of the northern plume (wells 199-D8-53, 199-D8-68, and 199-D8-54a). Maximum yearly hexavalent chromium concentrations have increased over this same period for extraction well 199-D8-72, which is located within a higher concentration portion of the northern plume. It is likely that there is a high-concentration zone upgradient, as noted in new wells 199-D5-125 and 199-D5-126, where concentrations reached 1,850 µg/L.

2.2.3.3 DR-5 Pump-and-Treat Wells. The results for the DR-5 pump-and-treat extraction wells are as follows:

- Extraction wells:
  - Fall 2008 hexavalent chromium concentrations were above the RAO in all four DR-5 extraction wells. Concentrations ranged from 64 µg/L in well 199-D5-32 to 2,035 µg/L in well 199-D5-39 (Table 2-6).
  - From 2005 through 2008, hexavalent chromium concentrations have been trending downward in the three DR-5 extraction wells located along the southwest margin of the northern plume (wells 199-D5-20, 199-D5-32, and 199-D5-92). Maximum yearly chromium concentrations have been increasing over this same period in extraction well 199-D5-39, which is located downgradient of former sodium dichromate transfer station and the high-concentration portion of the southern plume (approximately 44,000 µg/L in the hot spot at well 199-D5-99).

2.2.3.4 100-HR-3 Aquifer Tubes. For the fall of 2008, five aquifer tube locations were sampled, with a maximum concentration of 83.8 µg/L in aquifer tube 36-S/D. This was the only location with concentrations exceeding 22 µg/L. Baseline hexavalent chromium concentrations for 7 of 10 aquifer tube sites sampled along the shoreline in the northern plume had chromium concentrations above the 22 µg/L RAO (Table 2-6). Baseline concentrations ranged from nondetectable (36-S/D and 38-M/D) to 172 µg/L (DD-16-3).

2.2.3.5 Chromium Source Investigation. The 2008 monitoring results for the chromium source investigation are summarized below:

- Fall 2008 concentrations remained above the 22 µg/L RAO in all six wells sampled in the chromium source investigation area (Table 2-6).
- In fall 2008, concentrations were 439 µg/L in well 199-D5-102 and 8,080 µg/L in well 199-D5-104.
- Vertical sampling was conducted in the northern plume. In two of three wells tested with a Solinst® sampler, concentrations were somewhat higher in the upper portion of the saturated thickness. Wells 199-D5-123, 199-D5-125, and 199-D5-126 all showed hexavalent chromium levels >1,500 µg/L.
- A report summarizing the findings of the source area investigation will be published in FY09.

2.2.3.6 100-D Area Co-Contaminant Monitoring Results. The 100-D Area co-contaminants for interim action are strontium-90, tritium, and nitrate (DOE/RL-96-90). Sulfate is also monitored as a contaminant of interest. Table 2-7 provides a summary of baseline co-contaminant concentrations versus the fall 2008 results. A comparison between fall 2007 and fall 2008 co-contaminant concentrations is provided in Appendix E. Where co-contaminant analyses are from more than one sampling event, all sample dates are listed to ensure traceability. A summary of the results for each co-contaminant is provided below:

- Strontium-90: Eleven wells were sampled in fall 2008, with two wells having strontium-90 concentrations above the 8 pCi/L maximum contaminant level (MCL). Concentrations of 45 pCi/L and 59 pCi/L were detected in wells 199-D8-54A and 199-D8-68, respectively. These two results appear anomalous and are undergoing further review. Baseline samples were collected from 21 wells and aquifer tubes, with no strontium-90 results reported above the MCL.
- Tritium: Fall 2008 tritium concentrations in the 23 wells sampled were all below the 20,000 pCi/L MCL. Baseline samples were collected from 31 wells and aquifer tubes, with no tritium concentrations reported above the MCL.
- Nitrate: Nitrate concentrations were >45mg/L in 12 of the 33 wells and aquifer tubes sampled in fall 2008. Baseline samples were collected from 40 wells and aquifer tubes, with 12 sites characterized by nitrate concentrations above the 45 mg/L MCL (equivalent to 10 mg/L NO_3-N). Areas with the highest nitrate concentrations generally coincide with higher concentration portions of the chromium plumes.
- Sulfate: Fall 2008 sulfate concentrations remained below the 250 mg/L DWS. The highest concentration measured was 205 mg/L at well 199-D5-102. The highest baseline sulfate concentration from the 31 wells sampled was 215 mg/L in well 199-D5-39. The source of the sulfate is likely aluminum sulfate used as a flocculent in the water treatment process during reactor operations to reduce turbidity.

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Table 2-7. Change in Co-Contaminants from Baseline Through 2008 for Wells and Aquifer Tubes Monitoring the 100-HR-3 (D) and DR-5 Pump-and-Treat Systems. (2 pages)

Well or Aquifer Tube Name	Well Use or Aquifer Tube	Baseline Sample					Fall 2008 Sample					Percent Change in Conc. Since Baseline Sampling (Negative = Decrease)			
		Dates Collected	Sr-90 (pCi/L)	Tritium (pCi/L)	Nitrate (mg/L)	Sulfate (mg/L)	Date Collected	Sr-90 (pCi/L)	Tritium (pCi/L)	Nitrate (mg/L)	Sulfate (mg/L)	Sr-90	Tritium	Nitrate	Sulfate
199-D5-13	E/M	3/14/96	0.0196 (U)	283	36	79	11/23/08	--	790	64.6	91.4	--	179.2	79.4	0.0
199-D5-14	M	2/27/95; 12/2/99	0.104 (U)	1,460	63	94.2	11/23/08	--	3,900	66.4	117	--	167.1	5.4	24.2
199-D5-15	M	2/27/95; 12/6/99	0.677 (U)	4,720	17	86	11/19/08	--	2,200	66	116	--	-53.4	0.0	34.9
199-D5-16	M	2/27/95; 12/2/99	0.0266 (U)	12,100	87	132	11/20/08	--	8,000	69.5	133.5	--	-33.9	-20.1	1.1
199-D5-17	M	2/15/95; 11/16/99	0.0221 (U)	14,800 (J)	83	51.5	11/23/08	--	12,000	59.3	98.8	--	0.0	-28.6	91.8
199-D5-18	M	11/5/96; 1/3/01	--	10,300	74.1	94.7	--	--	--	--	--	--	--	--	--
199-D5-19	M	11/16/99; 5/27/98	--	11,600	81	178	--	--	--	--	--	--	--	--	--
199-D5-20	E	2/7/95; 11/16/99	-0.0266 (U)	92.9 (UJ)	21	59.2	11/20/08	--	260	22	56.4	--	--	4.8	-4.7
199-D5-32	E	12/8/04	--	--		58.5	11/20/08	--	280	27.7	72.2	--	--		23.4
199-D5-33	M/I	11/18/04	--	--	1.86	12.5		--				--	--		
199-D5-36	M	11/19/99; 11/17/99	--	310 (J)	4.5	30	11/20/08	--	48 (U)	6.15	19.5	--	--	36.7	-35.0
199-D5-37	E	11/16/99; 7/6/99	0.207 (U)	17.4 (U)	15	42	11/24/08	-0.29 (U)	--	15.4	39.6	--	--	--	-5.7
199-D5-39	E	11/15/99; 7/7/99	--	50.1 (U)	21	215	11/20/08	-1.2 (U)	76 (U)	46.4	105.5	--	--	121.0	-50.9
199-D5-41	E/M	12/1/99; 7/7/99	--	426	23	46	11/20/08	--	340	31	70.4	--	-20.2	34.8	53.0
199-D5-42	M/I	12/1/99; 7/7/99	--	7.68 (U)	21	84	--	--	--	--	--	--	--	--	--
199-D5-44	M	11/17/99; 7/6/99	--	12.5 (U)	4.3	22	11/20/08		-18 (U)	5.89	19	--	--	37.0	-13.6
199-D5-92	E	11/23/04; 1/16/06	--	115 (U)		24.6	11/20/08	-1.8 (U)	500	18.4	47.4	--	--		92.7
199-D8-3	M	10/28/96; 2/7/95	2.77	5,120		136	--	--	--	--	--	--	--		
199-D8-4	M	3/14/95	0.275 (U)	123 (U)	1.6	16	11/20/08	--	280	85	121	--	--	5,212.5	656.3
199-D8-5	M	3/14/95	-0.173 (U)	208	2	17	11/20/08	--	1,100	48.3	93.1	--	428.8	2,315.0	447.6
199-D8-6	M	3/14/95	0.178 (U)	--	2.3	21	--	--		--	--	--	--	--	--
199-D8-53	E	2/2/95;	3.53	12,000	59.8	123	12/2/08	2	4,500	--	--	--	-62.5	--	--
199-D8-54A	E	2/1/95	7.12	16,000	59.8	128	11/24/08	45	8,000	--	--	532.0	0.0	--	--
199-D8-54B	M	2/1/95	0.134 (U)	-112 (UJ)	1.95 (J)	67.4	11/23/08	--	25 (U)	2.28	65.2	--	--	16.9	-3.3

Table 2-7. Change in Co-Contaminants from Baseline Through 2008 for Wells and Aquifer Tubes Monitoring the 100-HR-3 (D) and DR-5 Pump-and-Treat Systems. (2 pages)

Well or Aquifer Tube Name	Well Use or Aquifer Tube	Baseline Sample					Fall 2008 Sample					Percent Change in Conc. Since Baseline Sampling (Negative = Decrease)			
		Dates Collected	Sr-90 (pCi/L)	Tritium (pCi/L)	Nitrate (mg/L)	Sulfate (mg/L)	Date Collected	Sr-90 (pCi/L)	Tritium (pCi/L)	Nitrate (mg/L)	Sulfate (mg/L)	Sr-90	Tritium	Nitrate	Sulfate
199-D8-55	M	2/2/95	0.104	40.6 (U)	6.42 (J)	31	11/20/08		-23 (U)	7.15	17.1	--	--	11.4	-44.8
199-D8-68	E	10/15/96; 5/27/98; 11/30/00	5.36	2,530	5.93	130	11/24/08	59	4,200	34.6	89.1	1,000.7	66.0	483.5	-31.5
199-D8-69	C	11/3/98; 10/15/96	1.01 (J)	6,390	13.3		11/20/08	-0.66 (U)	1,800	--	--	--	-71.8	--	--
199-D8-70	C	11/3/98; 10/15/96; 3/26/97	1.55 (J)	7,610	33.5	63.8	11/20/08	0.3 (U)	3,900	29	92.4	--	-48.8	-13.4	44.8
199-D8-71	M	10/15/96; 1/28/99	--	1,200	59.8	82.1	--	--	--	--	--	--	--	--	--
199-D8-72	E	11/19/02; 11/3/05	--	913	42.6	90.2	12/2/08	1.6	1,600	54.9	100	--	75.2	28.9	10.9
199-D8-73	M	11/17/04; 11/9/05	0.0305 (U)	118 (U)	38.1	77.3	11/20/08	-0.33 (U)	160 (U)	34	71.8	--	--	-10.8	-7.1
199-D8-88	M	11/17/04; 12/27/05	0.0959 (U)	29.5 (U)	32.8	74.4	11/20/08	-0.48	90 (U)	28.7	59.2	--	--	-12.5	-20.4
Chromium Source Investigation Wells															
199-D5-97	M	4/4/07	--	--	52	--	11/19/08	--	--	56.2	109	--	--	8.1	--
199-D5-98	M	4/4/07	--	--	58	--	11/17/08	--	--	50.9	110	--	--	-12.2	--
199-D5-99	M	4/5/07	--	--	43	--	11/17/08	--	--	26.9	81.4	--	--	-37.4	--
199-D5-102	M	4/9/07	--	--	24	--	11/23/08	--	--	66.8	205	--	--	178.3	--
199-D5-103	M	4/10/07	--	--	54	--	11/19/08	--	--	65.2	140	--	--	20.7	--
199-D5-104	M	4/9/07	--	--	78	--	11/23/08	--	--	44	103.5	--	--	-43.6	--
Aquifer Sampling Tubes															
36-S/D	AT	11/7/97; 11/19/98	0.12 (U)	243 (U)	--	--	12/10/08	--	--	0.1 (U)	16.2	--	--	--	--
38-M/D	AT	11/18/97	--	88.5 (U)	3 (U)	--	12/10/08	--	--	0.1 (U)	10	--	--	--	--
AT-D-1-M/D	AT	3/4/04; 4/25/05	--	--	8.85	--	12/9/08	--	--	6.68	16.3	--	--	-24.5	--
AT-D-2-M	AT	3/14/05	--	--	0.288	--	12/9/08	--	--	0.4 (B)	18.4	--	--	38.9	--
AT-D-3-D	AT	4/25/05; 3/4/04	--	--	23.5	--	12/9/08	--	--	0.1 (U)	25.6	--	--	--	--
AT-D-4-D	AT	3/4/04	--	--	1.2	--	--	--	--	--	--	--	--	--	--

NOTES:
1 Blank cells indicate no sample collected, or analysis not performed, or change in concentration not calculated.
2. Wells 199-D5-13 and 199-D5-41 were utilized as extraction wells for the electrocoagulation testing conducted during 2007. The well use has reverted to monitoring wells.
3. Well use abbreviations: M = monitoring well, E = extraction well, I = injection well, C = compliance well, AT = aquifer tube.
4. Laboratory qualifiers: U = undetected, J = reported value is an estimate (analyte was detected but has potentially higher error values associated with the result.).

2.2.3.7 Maximum 2008 Contaminant Concentrations in the 100-D Area. Although the maximum contaminant concentrations often occur in the fall of the year when river influences are smallest, this is not always the case, particularly for inland wells. A summary of the maximum 2008 and 2007 contaminant and co-contaminant concentrations in the 100-D Area, including results in the vicinity of the ISRM barrier, are presented in Table 2-8, which includes gross alpha and gross beta.

2.3 AQUIFER RESPONSE IN THE 100-H AREA

This section describes the general hydrogeologic conditions in the 100-H Area, water-level mapping, numerical modeling conducted to evaluate the extent of capture developed by the pump-and-treat activities, and the changes in contaminant concentrations measured in monitoring wells.

2.3.1 Hydrogeologic Conditions in the 100-H Area

Groundwater flow in the 100-H Area occurs in sands and gravels of variable conductivity and is influenced by the injection and extraction well networks for the pump-and-treat system, as well as seasonal fluctuations in the Columbia River. Regional groundwater flow in the vicinity of the 100-H Area is toward the Columbia River. The aquifer in the vicinity of 100-H Area is located in the sands and gravels of the Hanford formation.

Locally, groundwater flow in the 100-H Area is generally radially outward from the injection wells (199-H4-7, 199-H4-14, 199-H4-17, and 199-H4-18) toward a series of extraction wells (199-H4-15A, 199-H4-64, 199-H4-12A, 199-H4-4, and 199-H4-63). Flow is generally toward the river between the injection well field and the river, parallel to the river for <200 m (656 ft) both up and downriver of the injection wells, and then perpendicular to the river further away from the injection wells (Figure 2-16).

Groundwater flow in the 100-H Area is responsive to the river stage of the Columbia River. As shown in Figure 2-16, the river stage is 2 to 3 m (6.6 to 9.8 ft) higher during high water level in the late spring and early summer versus the fall.

As a result, the dynamics of groundwater flow near the river change seasonally. This aquifer response is the most pronounced near the shoreline but extends inland of the shore. During the low river stage in the fall and the winter, the flow is toward the river, whereas during high river stage in the spring and summer, the flow is locally from the river inland. These observations suggest that the Columbia River is primarily a gaining reach during times of low flow and may become a losing reach during times of high flow.

2.3.2 Hydraulic Capture Evaluation

Consistent with recommendations in EPA 600/R-08/003, multiple lines of evidence are used to estimate capture. Two methods are used to estimate the extent of hydraulic capture developed by pump-and-treat activities during FY08. These methods are briefly described here and are described in detail in Appendix C:

- Water-level mapping: Uses a method that incorporates the effects of extraction and injection at wells, and the effects of changing river stage, on groundwater levels. Particle tracking on each mapped surface is used to calculate approximate capture zones. The process is repeated for multiple sampling events throughout FY08 and combined into a CFM, which provides an ensemble estimate of the extent of capture.
- Groundwater modeling: Uses the 100 Areas groundwater model that encompasses the 100-D, 100-H, 100-K, and 100-N Areas (DOE/RL-2006-52). The model was used to simulate monthly stress periods and depict the approximate the extent of capture using a CEM.

Inference from the mapping and modeling should focus on the relative extents and distribution of the low and high frequencies and efficiencies, respectively. In the 100 Areas, the principal causes for capture frequencies and/or efficiencies that lie between 0 (i.e., likely not captured) and 1 (i.e., likely always captured) are changing pumping rates and the effects of the changing river stage.

Figure 2-17 depicts the CFM calculated using the mapping approach (details are provided in Appendix C). This figure represents the combination of 36 water elevation and capture maps, generated using weekly average water elevation and extraction rates measured while the system was operating. Figure 2-18 depicts the CEM calculated using the modeling approach. This figure represents the combination of 12 capture zone estimates based on monthly average river stage and pumping rates. Comparison of Figures 2-17 and 2-18 suggests that the general extents of capture depicted using the two methods are comparable, although the individual capture extent for each well differs between the methods. The mapping method appears to depict more effective capture than is depicted by modeling. Both methods suggest that some gaps likely exist in capture, which are depicted in terms of low capture frequency, low capture efficiency, or both. These gaps are most evident as follows:

- Between well 199-H4-12A and well 199-H4-64 (mapped and modeled capture)
- Between well 199-H4-4 and well 199-H4-63 (mapped and modeled capture)
- Between well 199-H4-4 and well 199-H4-12A (modeled capture only).

The numerical modeling results supporting the 100-HR-3 pump-and-treat system in the 100-H Area can be summarized as follows:

- The original 100-H Area hexavalent chromium pump-and-treat target plume has been greatly reduced in area. Most of the remainder of the shoreline plume (>22 μg/L) is within the capture zones of extraction wells 199-H4-12A, 199-H4-15A, and 199-H4-64.
- The numerical model shows an apparent gap in the capture zone between extraction wells 199-H4-4 and 199-H4-63 (Figure 2-18); however, the chromium plume concentrations in this area were <22 μg/L. A detailed discussion of the numerical model is presented in Appendix C.
- The east Horn area plume (discussed below), which has reached well 199-H3-5, is not within the capture zone of the existing extraction well network. Based on the capture zone analysis, contamination may bypass the pump-and-treat system to the south.
- The model revisions for 2008 include the development of a comprehensive model data package for each OU as part of the RPO. The first of these model data packages is for the 100-HR-3 OU (SGW-40781, *100-HR-3 Remedial Process Optimization Model Data Package*). Major components of each data package include the geology, aquifer properties and water levels, vadose zone properties, river bathymetry, recharge data, contamination sources, contaminant transport properties, and aquifer tube information.
- The numerical model grid has been revised to extend from the 100-HR-3 OU to the 100-KR-3 OU. Consequently the modeling has been integrated across the northern portion of the Hanford Site.

Table 2-8. Maximum Contaminant and Co-Contaminant Concentrations for 2008 and 2007 in the 100-D Area.

Constituent	Maximum Value Detected (µg/L) or (pCi/L)	Filter (F) or Unfiltered (UF)	Date Sampled	Well Name	Location/Comment
2008					
Hexavalent chromium	39,900 (D)	UF	3/26/08	199-D5-99	Adjacent to former sodium dichromate transfer station.
Chromium	1,870	UF	11/20/08	199-D5-39	Downgradient of former sodium dichromate transfer station.
Chromium	1,880	F	11/20/08	199-D5-39	Downgradient of former sodium dichromate transfer station.
Nitrate (as N)	116,000	UF	8/15/08	199-D2-6	Adjacent to solid waste burial ground.
Strontium-90	59	UF	11/24/08	199-D8-68	100-HR-3 (D) extraction well.
Tritium	25,000	UF	11/24/08	199-D4-78	Within ISRM treatment zone.
Technetium-99	87	UF	2/6/08	199-D8-72	100-HR-3 (D) extraction well.
Sulfate	549,000 (D)	UF	8/24/08	199-D4-84	Downgradient of ISRM treatment zone.
Uranium	3.4	UF	11/19/08	199-D4-22	Upgradient of ISRM treatment zone.
Gross beta	130	UF	11/14/08	199-D4-19	Within ISRM treatment zone.
Gross alpha	2.83	UF	11/19/08	199-D4-22	Upgradient of ISRM treatment zone.
2007					
Hexavalent chromium	12,560	UF	3/19/07	199-D5-99	Adjacent to former sodium dichromate transfer station.
Chromium	9,970	UF	11/29/07	199-D5-104	Adjacent to former sodium dichromate transfer station.
Chromium	10,500	F	11/29/07	199-D5-104	Adjacent to former sodium dichromate transfer station.
Nitrate (as N)	85,900 (D)	UF	10/31/07	199-D2-6	Adjacent to solid waste burial ground.
Nitrate (as N)	85,900 (D)	UF	12/6/07	199-D8-4	North of former D pond.
Strontium-90	7.7	UF	11/27/07	199-D8-68	100-HR-3 (D) extraction well.
Tritium	27,000	UF	11/7/07	199-D4-78	Within ISRM treatment zone.
Technetium-99	2.2 (U)	UF	11/27/07	199-D8-53	100-HR-3 (D) extraction well.
Sulfate	558,000 (D)	UF	11/7/07	199-D4-78	Within ISRM treatment zone.
Uranium	3.89	UF	10/30/07	199-D4-22	Upgradient of ISRM treatment zone.
Gross beta	152	UF	10/30/07	199-D4-19	Within ISRM treatment zone.
Gross alpha	6	UF	2/26/07	199-D5-16	East of former D Reactor.

NOTE: Laboratory qualifiers: U = undetected; D = sample diluted.
ISRM = In Situ Redox Manipulation

Figure 2-16. 100-H Area May and November 2008 Measure Water Table Comparison.

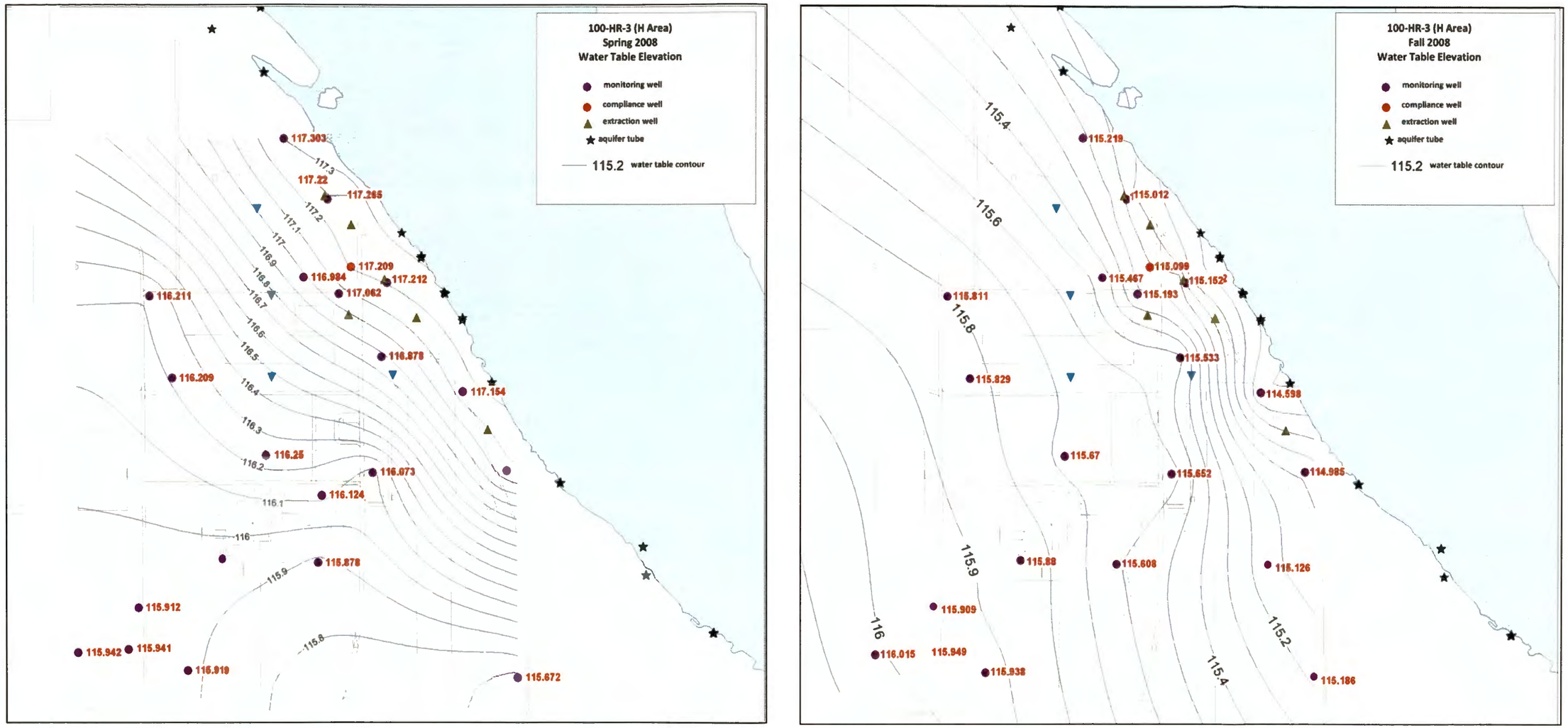
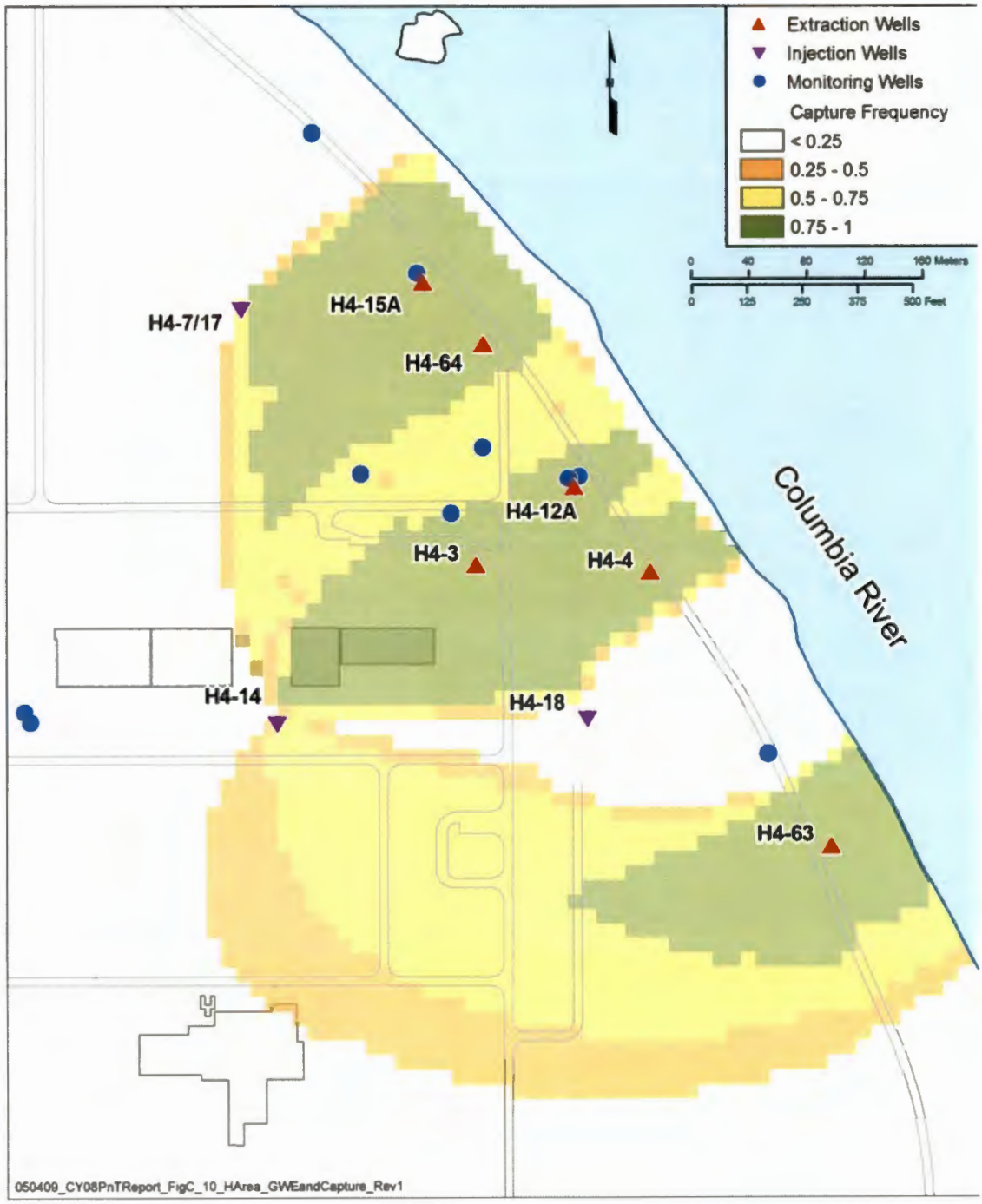


Figure 2-17. 100-H Area Capture Frequency (Mapped).



2.3.3 Contaminant Monitoring in the 100-H Area

This section summarizes the analytical results obtained from groundwater monitoring wells and aquifer sampling tubes supporting the 100-H Area pump-and-treat remedial action and the 100-HR-3 OU *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) monitoring program. DOE/RL-96-90 and DOE-RL (1998) define the sampling protocols implemented for CY08. The results have been organized for comparison of both baseline levels to the fall 2008 results, and fall 2007 to fall 2008 concentrations (which are provided in Appendix E). These comparisons highlight the impact from both long-term and short-term interim remedial action on groundwater contamination. The 2008 results represent the data that were available in the Hanford Environmental

Information System (HEIS) database at the time this report was prepared. For some sampled locations, fall 2008 results were not available.

2.3.3.1 100-H Area Chromium Monitoring Results. Hexavalent chromium concentrations are monitored in extraction wells, compliance wells, monitoring wells, and aquifer tubes in the 100-H pump-and-treat operational area. The 100-H Area fall 2008 hexavalent chromium plume map with the wells used to contour the concentration data is provided in Figure 2-19. The configuration of the hexavalent chromium plume for the period 1995 through 2007 area is provided in Appendix A.

Figure 2-18. 100-H Area Capture Efficiency Map (Modeled).

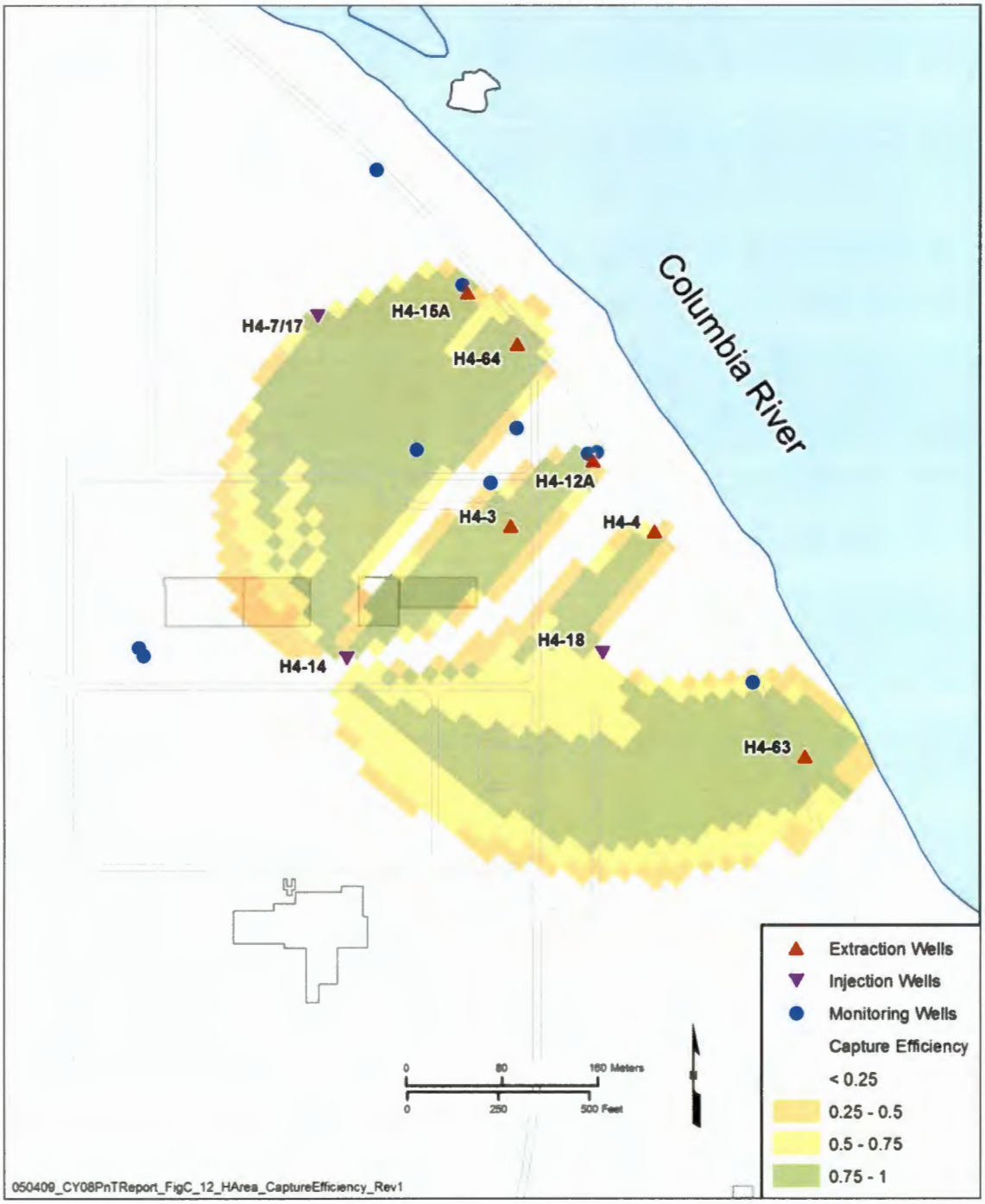
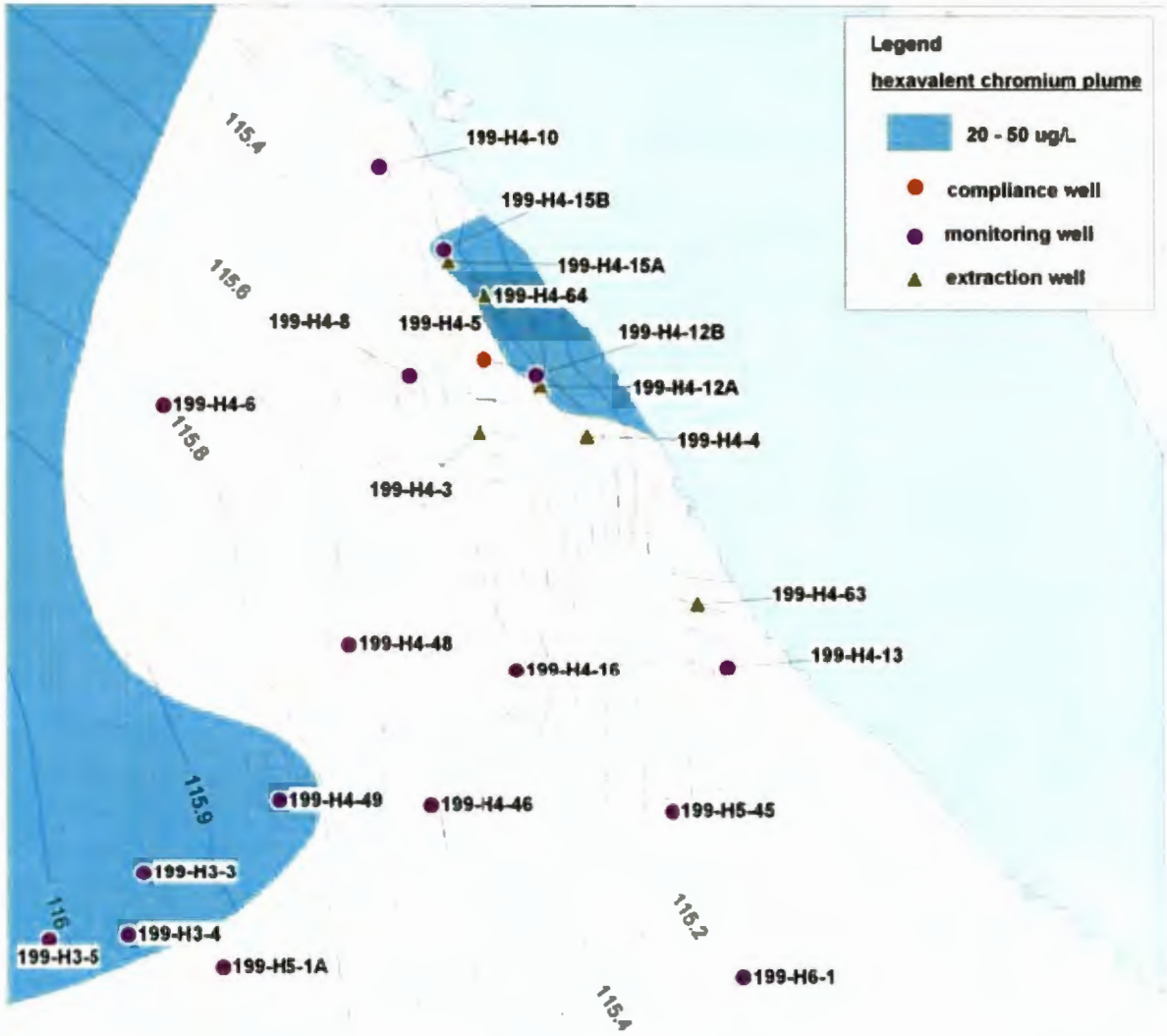


Figure 2-19. 100-H-Area November 2008 Chromium Plume Map.



The chromium plume has changed dramatically since pump-and-treat operations began in 1997 (see Appendix A). The areal extent of the fall 2008 plume is now limited to an elongated zone along the 100-H Area shoreline, north of the 107-H retention basin. The hexavalent chromium concentrations in the plume are currently in the range of 20 to 30 µg/L. The Horn area study (DOE/RL-2008-42) confirmed that the hexavalent chromium plume extends from the 100-D Area to the 100-H Area and has been detected in former injection wells 199-H3-3, 199-H3-4, and 199-H3-5 (see Appendix A and Figure 2-19).

Baseline hexavalent and total chromium concentrations are compared to fall 2008 concentrations in Table 2-9. The table also indicates the percent change in concentration that has occurred at each well during this period. Appendix E shows the changes in chromium concentrations for the monitoring network between fall 2007 and fall 2008.

A goal of the interim remedial action is to reduce concentrations in 100-H Area wells to below the 22 µg/L RAO. Figure 2-20 presents hexavalent chromium concentration trend plots for selected wells in the 100-H Area. Trend lines have been added to the graphs connecting maximum chromium levels for individual wells. For some wells, the maximum chromium levels coincide with low river conditions and occur in the late fall to early spring, while elevated chromium levels for other wells occur during high river stage in the summer. The trend lines indicate whether the seasonal maximum concentrations have

been increasing or decreasing over the last few years at each well location. A summary of the hexavalent chromium concentration trends in compliance wells, extraction wells, and aquifer tubes is presented below. The use for monitoring, compliance, extraction, or injection has changed for some of the 100-H Area wells over the last few years to accelerate plume remediation, which is part of the design optimization process. Historical uses for each well are indicated in Table 2-8. The results for compliance and extraction wells in the 100-H Area pump-and-treat system are as follows:

- Compliance wells:
  - Fall 2008 hexavalent chromium concentrations in the four original 100-H Area compliance wells ranged from 5.6 µg/L in well 199-H4-5 to 22 µg/L in well 199-H4-64. Three of four wells were below the 22 µg/L RAO. Well 199-H4-5 is the only compliance well that is not currently being used for extraction.
  - Fall 2008 concentrations have decreased approximately 85% to 12 µg/L in well 199-H4-4, 75% to 18 µg/L in well 199-H4-63, and 63% to 22 µg/L in well 199-H4-64 in comparison to baseline levels. Concentrations have decreased approximately 94% in compliance well 199-H4-5 (to 5.6 µg/L) since startup of operation in 1997 (Table 2-9). Levels have generally been below the RAO since 2006 (Figure 2-20).
  - Baseline hexavalent chromium concentrations in 1996 were above the 22 µg/L RAO in all four original compliance wells, ranging from 60 µg/L in well 199-H4-64 to 90 µg/L in well 199-H4-5. Compliance wells 199-H4-4, 199-H4-63, and 199-H4-64 were converted to extraction wells in 2005.
- Extraction wells:
  - Fall 2008 hexavalent chromium concentrations in four of six current 100-H Area extraction wells (199-H4-3, 199-H4-4,199-H4-12A, and 199-H4-63) were below the RAO.
  - For fall 2008, wells 199-H4-64 and 199-H4-15A were the only extraction wells located within the 100-H Area plume that exceeded the RAO (22 and 24 µg/L, respectively). Concentrations measured within the plume were only slightly above the RAO.
  - Although fall concentrations for extraction well 199-H4-3 have been below the RAO over the last several years, hexavalent chromium concentrations have consistently exceeded the RAO in the summer, coinciding with the high river stage. These seasonal highs have had a decreasing trend between 2006 and 2008.
  - Fall 2008 concentrations represent decreases compared to baseline levels of approximately 90% in well 199-H45-11, 78% in well 199-H4-12A, and 93% in well 199-H3-2A. Baseline hexavalent chromium concentrations in the original five 100-H Area extraction wells (199-H4-11, 199-H4-12A, 199-H4-15A, 199-H4-7, and 199-H3-2A) were all above the RAO, ranging from 70 µg/L in well 199-H4-12A to 90 µg/L in well 199-H4-7.
- Aquifer tubes:
  - Fall 2008 hexavalent chromium concentrations at the four aquifer tube sites sampled were below the RAO, ranging from undetected to a concentration of 8.7 µg/L (AT-H-1-D).
  - Baseline hexavalent chromium concentrations were below the RAO in the eight 100-H Area aquifer tubes sampled (Table 2-8).

Table 2-9. Hexavalent and Total Chromium Concentrations in Baseline and 2008 for Wells and Aquifer Tubes Monitoring the 100-HR-3 (H) Pump-and-Treat System. (2 pages)

Well or Aquifer Tube Name	Well Use or Aquifer Tube	Baseline Sample					Fall 2008 Sample					Percent Change in Conc. (Negative = Decrease)		
		Filtered and Unfiltered Cr^{+6}		Total Chromium			Unfilt. Cr^{+6}		Total Chromium					
		Date Collected	Conc. (µg/L)	Date Collected	Unfilt. (µg/L)	Filt. (µg/L)	Date Collected	Conc. (µg/L)	Date Collected	Unfilt. (µg/L)	Filt. (µg/L)	Cr^{+6}	Unfilt. Total Cr	Filt. Total Cr
199-H3-2A	E/I/M	9/12/97	70	10/18/96	95	90.9	11/21/08	5	--	--	--	-92.9	--	--
199-H3-2B	M	--	--	5/13/96	78	73	--	--	--	--	--	--	--	--
199-H3-2C	M	--	--	9/5/96	75	64	--	--	--	--	--	--	--	--
199-H3-3	I/M	10/25/96	50	--	--	--	--	--	--	--	--	--	--	--
199-H3-4	I/M	10/25/96	80	--	--	--	--	--	--	--	--	--	--	--
199-H3-5	I/M	10/25/96	120	--	--	--	--	--	--	--	--	--	--	--
199-H4-2	M	--	--	5/21/96	1.8 (U)	1.8 (U)	--	--	--	--	--	--	--	--
199-H4-3	M/E	10/21/96	150	10/21/96	160	146	11/3/08	9	11/10/08	10 (U)	11.3 (B), 10 (U)	-94.0	--	-92.3
199-H4-4	C/E	12/12/96	80	10/18/96	108	105	12/1/08	12				-85.0	-100.0	-100.0
199-H4-5	C	10/17/96	90	6/20/95	92.4	97	11/21/08	5.6	11/21/08	18.4 (B)	13 (U)	-93.8	-80.1	--
199-H4-6	M	10/21/96	100	10/21/96	103	105	11/21/08	5.8	11/21/08	13 (U)	13 (U)	-94.2	--	--
199-H4-7	E/I	10/17/96	90	3/15/95	90	--	--	--	--	--	--	--	--	--
199-H4-8	M	11/23/97	166	10/18/96	111	85.4	11/10/08	3.7	11/10/08	21.9	10 (U)	-97.8	-80.3	
199-H4-9	M	NS	--	11/4/96	68	--	11/10/08	3.6	11/10/08	38.4	10 (U), 6.4 (B)	--	-43.5	--
199-H4-10	M	10/21/96	30	10/21/96	23.1	23.5	11/21/08	11.4	11/21/08	19.1 (B)	15.8 (B)	-62.0	-62.3	-65.5
199-H4-11	E/M	10/18/96	80	12/20/95	51.5	40	11/10/08	8				-90.0	--	--
199-H4-12A	E	10/18/96	80	11/4/96	75.5 (N)		11/3/08	18	11/10/08	15.9 (B)	15.6 (B)	-77.5	-78.9	--
199-H4-12B	M	10/18/96	90	3/17/95	97	91	11/21/08	26.7	--	--	--	-70.3	--	--
199-H4-12C (deep well)	M	10/22/96	260	10/22/96	264	260	11/10/08	86.6	11/10/08	87.2	88.8	-66.7	-67.0	-65.8
199-H4-13	M	10/22/96	50	10/22/96	48.2	45.7	11/21/08	12	11/21/08	13.6 (B)	13 (U)	-76.0	-71.8	--
199-H4-14	M/I	10/22/97	60	10/22/96	72.5	72.8			--	--	--		--	--
199-H4-15A	E	10/24/96	49	12/18/95	49	32.7	11/3/08	24	--	--	--	-51.0	--	--
199-H4-15B	M	10/18/96	80	5/13/96	120	33	11/21/08	28.9	--	--	--	-63.9	--	--
199-H4-15CP (deep well)	M	NS	--	10/24/96	4.4 (U)	4 .4 (U)	11/24/08	8.7	--	--	--	--	--	--
199-H4-15CQ (deep well)	M	NS	--	10/24/96	37	4.4 (U)	11/24/08	2 (U)	--	--	--	--	--	--
199-H4-15CR (deep well)	M	NS	--	5/28/96	32	21	11/24/08	2.3 (B)	--	--	--	--	--	--
199-H4-15CS (deep well)	M	10/28/96	100	12/18/95	86.8	--	11/24/08	98	--	--	--	-2.0	--	--
199-H4-16	M	10/23/96	50	10/23/96	60.7	53.2	11/11/08	4.6	--	--	--	76.9	--	--
199-H4-17	M/I	10/23/96	80	10/23/96	90.2	75.5	--	--	--	--	--	--	--	--
199-H4-18	M/I	10/23/96	70	10/23/96	77.7	89.2	--	--	--	--	--	--	--	--

Table 2-9. Hexavalent and Total Chromium Concentrations in Baseline and 2008 for Wells and Aquifer Tubes Monitoring the 100-HR-3 (H) Pump-and-Treat System. (2 pages)

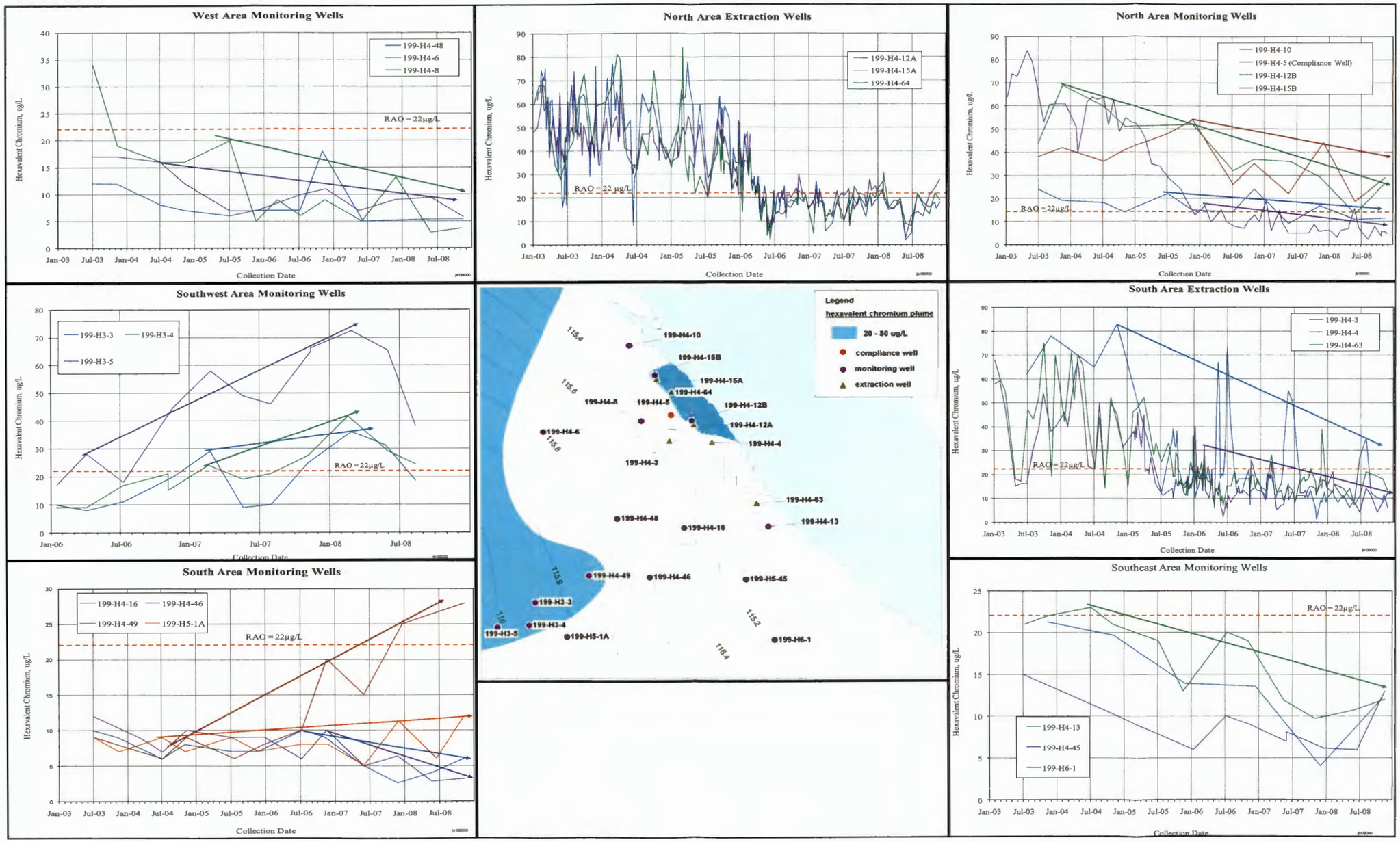
Well or Aquifer Tube Name	Well Use or Aquifer Tube	Baseline Sample					Fall 2008 Sample					Percent Change in Conc. (Negative = Decrease)		
		Filtered and Unfiltered Cr^{+6}		Total Chromium			Unfilt. Cr^{+6}		Total Chromium					
		Date Collected	Conc. (µg/L)	Date Collected	Unfilt. (µg/L)	Filt. (µg/L)	Date Collected	Conc. (µg/L)	Date Collected	Unfilt. (µg/L)	Filt. (µg/L)	Cr^{+6}	Unfilt. Total Cr	Filt. Total Cr
		--	--	--	--	--	--	--	11/21/08	13 (U)	13 (U)	--	--	--
199-H4-46	M	10/24/96	30	10/24/96	34.1	29.9	11/21/08	3.2	11/21/08	13 (U)	13 (U)	-89.3	--	--
199-H4-47	M	NS	--	12/14/95	49.3	45.6	--	--	--	--	--	--	--	--
199-H4-48	M	10/17/96	150	10/17/96	56.2	51.3	11/21/08	5.3	--	--	--	-96.5	--	--
199-H4-49	M	10/29/96	60	12/12/95	50.5	50.7	11/21/08	27.9	--	--	--	-53.5	--	--
199-H4-63	C/E	10/16/96	71	11/2/98	94.3	93.8	11/3/08	18	--	--	--	-74.6	--	--
199-H4-64	C/E	10/16/96	60	11/2/98	143	78.6	11/3/08	22	--	--	--	-63.3	--	--
199-H4-65	E/M	7/8/99	5 (U)	--	--	--	11/21/08	5.6	--	--	--	--	--	--
199-H5-1A	M	10/16/96	100	12/14/95	84.9	75.9	11/10/08	11.7	--	--	--	-88.3	--	--
199-H6-1	M	NS	--	10/24/96	29.9	29.1	--	--	11/9/08	17.3 (B)	12.2 (B)	--	--	--
Aquifer Tubes														
45-D	AT	11/12/07	9.7	--	--	--	--	--	--	--	--	--	--	--
46-D	AT	10/21/97	10	10/14/95	--	36.9	--	--	--	--	--	--	--	--
47-M/D	AT	10/21/97	5	10/14/95	--	72.6	--	--	--	--	--	--	--	--
48-S/M	AT	10/30/97	3 (U)	10/15/98	--	39.4	12/11/08	8	--	--	--	--	--	--
49-D/S	AT	11/13/97	16	10/15/98	--	28.4	--	--	--	--	--	--	--	--
50-M/D	AT	11/13/97	13	10/15/98	--	28.4	--	--	--	--	--	--	--	--
AT-H-1-D/S	AT	3/4/04	14	3/11/04	--	11.9	12/8/08	8.7	--	--	--	-37.9	--	--
AT-H-2-D/M	AT	11/17/04	3	3/11/98	--	7.6	12/8/08	2 (U)	--	--	--	--	--	--
AT-H-3-D	AT	3/11/04	19.5	3/11/04	--	12.5	12/8/08	7.7	--	--	--	-60.5	--	--

NOTES:

1. Blank cells indicate sample not collected, analysis not performed, or no percent change calculated.
2. Laboratory qualifier s: U = undetected (shown with detection limit in parentheses); B = detected above instrument or method detection limit, but below contract-required detection limit; C = analyte detected in both the sample and associated quality control blank and the sample concentration was ≤5 times the blank concentration; N = spike recovery is outside control limits.
3. Baseline hexavalent chromium concentrations may be from either filtered or unfiltered samples; fall 2007 chromium analyses represent only unfiltered samples.
4. Well use abbreviations: M = monitoring well, C = compliance well, E = extraction well, AT = aquifer tube.

NS = not sampled

Figure 2-20. 100-H Area Hexavalent Chromium Trend Plots, Fall 2008.



2.3.3.1.1 Deep Well Monitoring Results. The discussion of deeper groundwater contamination in the 100-H Area requires a brief introduction of well construction details for the deeper wells in the H Reactor area. Monitoring wells 199-H4-12A,B,C and 199-H4-15A,B,C are nested wells, with the three wells in each nest positioned approximately 7.6 m (25 ft) apart. These wells were drilled in 1986 in the area east-northeast and north of the former 183-H solar evaporation basins to provide information on groundwater head and potential contamination from the Hanford formation through various semi-confined Ringold Formation units to the underling basalt.

The "A" wells are screened in the unconfined aquifer across the entire thickness of the aquifer, which is primarily the Hanford formation in the 100-H Area. Wells 199-H4-12A and 199-H4-15A are currently used for extraction in the 100-H Area pump-and-treat network. The "B" wells include 1.5–m (5-ft)-long screens at the bottom of the unconfined aquifer.

Well 199-H4-12C is screened from 21.9 to 25 m (72 to 82 ft) below ground surface (bgs) in a water-producing layer within the RUM. Well 199-H4-15C (Figure 2-21) contains four, 5.1-cm (2-in.)-diameter, 0.6-m (2-ft)-long piezometers. Three of the piezometers are screened at increasing depths in the Ringold Formation. A fourth piezometer is located within the basalt directly underlying the Ringold Formation. Piezometer numbers and screened intervals (from shallowest to deepest) consist of 199-H4-15CS from 23.8 to 24.4 m (78 to 80 ft) bgs within the RUM, 199-H4-15CR from 59.1 to 59.7 m (194 to 196 ft) bgs within Ringold Unit B, 199-H4-15CQ from 89.9 to 90.5 m (295 to 297 ft) bgs within the Ringold Lower Mud, and 199-H4-15CP from 99.1 to 99.7 m (325 to 327 ft) bgs within the basalt.

A comparison of chromium concentrations between baseline and fall 2008 for the deeper groundwater monitoring wells in the 100-H Area is presented in Table 2-9. Concentrations within the long-screened extraction wells and shorter-screened piezometers are representative of concentrations in different formations and should be considered qualitatively for comparison purposes. A summary of the deep well results is provided below:

- Fall 2008 hexavalent chromium and total chromium concentrations in well nest 199-H4-12A,B,C were the highest in well 199-H4-12C (screened in the RUM) and were the lowest in well 199-H4-12A (screening across the entire upper unconfined aquifer).
- In comparison to baseline levels in 1996, the 2008 concentrations have decreased approximately 78% in well 199-H4-12A to 18 μg/L, 70% in well 199-H4-12B to 26.7 μg/L, and 67% to 86.6 μg/L in well 199-H4-12C.
- Fall 2008 and baseline hexavalent chromium concentrations were higher in piezometer 199-H4-15CS (screened in the RUM) than in wells 199-H4-15A or 199-H4-15B (screened in the uppermost aquifer of the Hanford formation).
- Fall 2008 hexavalent chromium values ranged from undetected for piezometer 199-H4-15CQ to 8.7 μg/L for piezometer 199-H4-15CP.
- The fall 2008 hexavalent chromium concentration sampled at piezometer 199-H4-15CS was 98 μg/L.
- Hexavalent chromium values have shown year-to-year variability in piezometer 199-H4-15CS since 1996 (Figure 2-22) but generally have been trending in a range between about 90 and 115 μg/L. An anomalous high value of 157 μg/L was measured in January 2008.
- Additional aquifer testing and rebound studies are needed to further understand the hydraulic parameters and connectivity of the RUM. Testing is planned in FY09 at the 100-H Area.

2.3.3.2 100-H Area Co-Contaminant Monitoring Results. The 100-H Area co-contaminants are strontium-90, technetium-99, tritium, uranium, and nitrate. Table 2-10 provides a summary of baseline co-contaminant concentrations versus the fall 2008 results. A comparison between fall 2007 and fall 2008 values is provided in Appendix E. When the co-contaminant analyses are from more than one sampling event, all sample dates are listed to ensure traceability. The highlights for each co-contaminant are listed below:

- Strontium-90:
  - For fall 2008, eight wells and one aquifer tube were sampled, with a maximum strontium-90 activity of 20.9 pCi/L in well 199-H4-63. This well is located downgradient of the former 107-H retention basin. Well 199-H4-11 (8.5 pCi/L) was the only other well or aquifer tube characterized by strontium-90 above the 8 pCi/L MCL.
  - In comparison to baseline levels, fall 2008 strontium-90 concentrations have decreased 59% in well 199-H4-63. Well 199-H4-11 has a 52% reduction from the baseline level.
  - Baseline strontium-90 concentrations were above the 8 pCi/L MCL in 4 of 32 wells and 1 of 8 aquifer tubes sampled. Concentrations ranged from a maximum of 51.2 pCi/L in well 199-H4-63 to 9.3 pCi/L in well 199-H4-45. Aquifer tube 47-D was characterized by a baseline strontium-90 concentration of 31 pCi/L. The former 107-H retention basin may be the potential source of the elevated strontium-90 that has historically been detected in wells 199-H4-11, 199-H4-63, and 199-H4-13, as well as aquifer tube 47-D. The former 107-H liquid waste disposal trench may be the potential source of the elevated strontium-90 previously noted in well 199-H4-45.
- Technetium-99:
  - For fall 2008, 11 wells and 3 aquifer tubes were sampled for technetium-99, and all results were less than the MCL of 900 pCi/L. The maximum activity was 45 pCi/L in well 199-H4-3.
  - Of the 40 baseline samples, only well 199-H4-3 exceeded the MCL, with a baseline technetium-99 concentration of 921 pCi/L. Well 199-H4-3 is located downgradient of the former 183-H solar evaporation basins, which received liquid waste from 300 Area fuel fabrication processes. The maximum baseline technetium-99 concentration in the six aquifer tube sampled was at aquifer tube site 47-D, with a value of 56 pCi/L.
- Tritium:
  - Fall 2008 concentrations for the 16 wells sampled were all below the 20,000 pCi/L tritium MCL. The maximum concentration detected was 2,800 pCi/L in well 199-H4-11.
  - The maximum baseline tritium concentrations measured in the 40 wells sampled included 16,100 pCi/L in well 199-H3-4; 15,800 pCi/L in well 199-H5-1A; and 14,400 pCi/L in well 199-H4-49. These wells are located upgradient of most 100-H Area facilities, and it is postulated that the tritium has migrated from the 100-D Area, across the Horn area into the 100-H Area.
- Uranium:
  - The maximum fall 2008 uranium concentrations were 7.6 and 7.7 μg/L measured at well 199-H4-3. The MCL for uranium is 30 μg/L.
  - Of the 36 baseline samples, only well 199-H4-3 (with a baseline concentration 95.7 μg/L) exceeded the MCL. This well is located downgradient of the former 183-H solar evaporation basins.

Figure 2-21. Well 199-H4-15C Construction Detail and Chromium Concentration Trends.

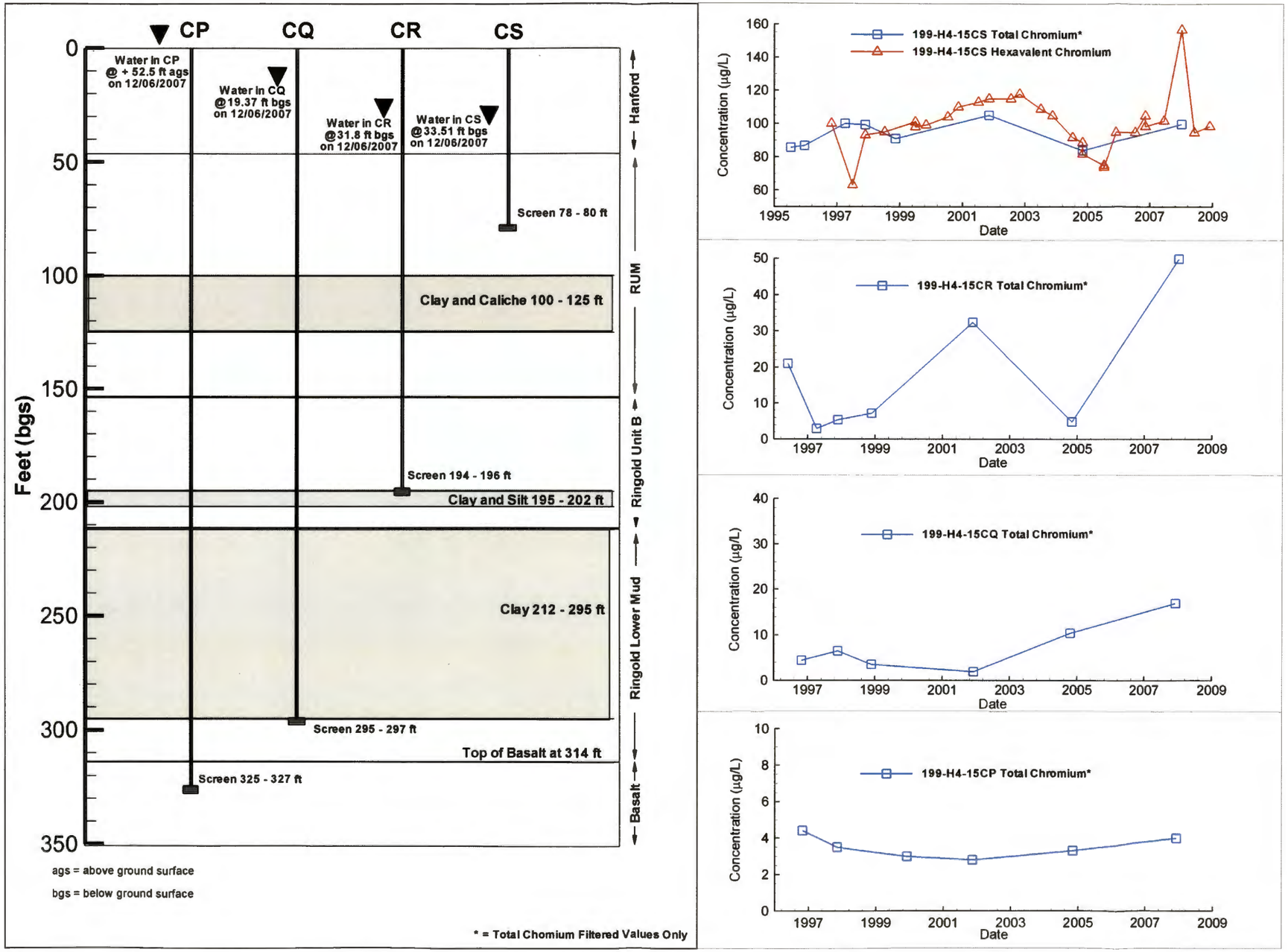


Figure 2-22. Horn Area November 2008 Chromium Plume Map.

Table 2-10. Change in Co-Contaminant Concentrations from Baseline to 2008 for Wells and Aquifer Tubes Monitoring the 100-HR-3 (H) Pump-and-Treat System. (2 pages)

	Well Use or Aquifer Tube	Baseline Sample						Fall 2008 Sample						Percent Change in Conc. Since Baseline Sampling (Negative = Decrease)				
		Dates Collected	Sr-90 (pCi/L)	Tc-99 (pCi/L	Tritium (pCi/L)	Uranium (µg/L)	Nitrate (mg/L)	Date(s) Collected	Sr-90 (pCi/L)	Tc-99 (pCi/L	Tritium (pCi/L)	Uranium (µg/L)	Nitrate (mg/L)	Sr-90	Tc-99	Tritium	Uranium	Nitrate
199-H3-2A	E/I/M	11/4/96; 6/15/95	0.0267 (U)	1.53 (U)	5,660	3.76	22.8	11/21/08	-1.2 (U)	-3.5	1,800	0.449	20.5	--	--	-68.2	-88.1	-10.1
199-H3-2B	M	5/13/96; 3/9/95		6.801	3,724	3.98	17	--	--	--	--	--	--	--	--	--	--	--
199-H3-2C	M	9/5/96; 6/15/95	0.232 (U)	0.854 (U)	-3.6 (U)	1.07	18	--	--	--	--	--	--	--	--	--	--	--
199-H3-3	I/M	10/25/96		1 (U)	7,790	5.18	21.4	--	--	--	--	--	--	--	--	--	--	--
199-H3-4	I/M	10/25/96		0.117 (U)	16,100	5.01	27.2	--	--	--	--	--	--	--	--	--	--	--
199-H3-5	I/M	10/25/96	-0.133 (U)	1.15 (U)	8,693	5.63	15.5	--	--	--	--	--	--	--	--	--	--	--
199-H4-2	M	9/3/97; 3/17/95; 5/21/95	-0.0973	-0.224	-22.009 (U)		10.4	--	--	--	--	--	--	--	--	--	--	--
199-H4-3	M/E	10/21/96; 6/19/95	0.756 (J)	921	3,350	95.7	393	11/10/08	-1.4 (U)	45	2,850	7.7	39.2	--	-95.1	-14.9	-92.0	-90.0
199-H4-4	C/E	10/18/96; 6/20/95	0.832 (J)	6.55	503	1.84	522	11/10/08	0.158 (U)	17	2,220	5.48	28.6	--	159.5	341.4	197.8	-94.5
199-H4-5	C	10/17/96; 6/20/95	-0.0441 (U)	-0.292 (U)	3,310	3.79	39.4	11/21/08	0.28 (U)	0.8 (U)	2,000	0.943	24.8	--	--	-39.6	-75.1	-37.1
199-H4-6	M	10/21/96; 6/20/95	0.366 (U)	0.106 (U)	4,150	6.92	30.8	11/21/08	--	--	2,200	--	24.9	--	--	-47.0	--	-19.2
199-H4-7	E/I	10/17/96; 11/17/98	0.282 (U)	0.168 (U)	4,010	4.61	25.4	--	--	--	--	--	--	--	--	--	--	--
199-H4-8	M	10/18/96; 3/15/95; 11/4/98	--	-0.898 (U)	3,070	4.23	33.3	11/10/08	--	0.2 (U)	--	0.761	27.5	--	--	--	-82.0	-17.4
199-H4-9	M	10/2/96; 11/4/97	--	43.4	2,100	8.58	77	11/10/08	--	--	--	--	27.6	--	--	--	--	--
199-H4-10	M	10/21/96; 6/28/95	0.0751 (U)	-0.614 (U)	531	1.11	7.8	11/21/08	--	--	980	--	--	--	--	--	--	--
199-H4-11	E/M	10/18/96; 3/17/95	17.7	10.9	987	3.25	109	11/10/08	8.5	-2.6 (U)	2,880	1.1	29.5	-52.0	--	191.8	-66.2	-72.9
199-H4-12A	E	10/18/96; 6/21/95	0.295 (U)	0.158 (U)	1,180	1.75	50	11/10/08	-1.0 (U)	23	2,155	6.28	29.6	--	--	82.6	258.9	-40.8
199-H4-12B	M	10/18/96	0.21 (U)	13.8	2,525	5.83	33.3	--	--	--	--	--	--	--	--	--	--	--
199-H4-12C (deep well)	M	10/22/96; 6/21/95	0.0097	-0.856 (U)	67.3 (U)	1.27	6	11/10/08	--	-1.2 (U)	57.6 (U)	1.8	4.9	--	--	--	41.7	-18.3
199-H4-13	M	10/22/96; 3/17/95	27.7	0.833	812	3.83	67.3	11/21/08	--	--	2,200	--	32.9	--	--	170.9	--	-51.1
199-H4-14	M	10/22/96; 6/19/95	0.0494	0.149 (U)	1,040	1.82	22.8	--	--	--	--	--	--	--	--	--	--	--
199-H4-15A	E	10/24/96; 6/29/95	0.21 (U)	-0.614 (U)	1,920	1.91	17.6	11/10/08	--	-2 (U)	2,600	0.614	23.3			35.4	-67.9	32.4
199-H4-15B	M	10/18/96	0.0347 (U)	1.01 (U)	1,070	1.94	13.9		--	--	--	--	--	--	--	--	--	--
199-H4-15CP (deep well)	M	10/24/96	--	0.663 (U)	-13.3 (U)	1.47	19.3	11/24/08	--	--	--	--	--	--	--	--	--	--
199-H4-15CQ (deep well)	M	10/24/96	--	2.43 (U)	-35.4 (U)	0.2	0.6	11/24/08	--	--	--	--	--	--	--	--	--	--
199-H4-15CR (deep well)	M	11/23/98; 5/28/96	--	1.122	71.7	0.102	2	11/24/08	--	--	--	--	--	--	--	--	--	--
199-H4-15CS (deep well)	M	10/28/96; 7/7/95	0.631 (U)	6.47 (J)	-49.9 (U)	4.39	6.3	11/24/08	--	--	--	--	--	--	--	--	--	--
199-H4-16	M	10/23/96; 3/7/95; 6/20/95	3.16	0.002 (U)	511	4.14	31.3	11/11/08	--	--	--	--	--	--	--	--	--	--
199-H4-17	M/I	10/23/96; 7/7/95; 6/20/95	0.198 (U)	-0.297 (U)	3,840	4.32	39.1	--	--	--	--	--	--	--	--	--	--	--
199-H4-18	M/I	10/23/96; 4/1/97	3.28	243	2,470	24	90.7	--	--	--	--	--	--	--	--	--	--	--
199-H4-45	M	10/24/96; 6/23/95	9.3	-1.5 (U)	379	2.89	45.2	11/21/08	--	--	1,400	--	27.3	--	--	269.4	--	-39.6

Table 2-10. Change in Co-Contaminant Concentrations from Baseline to 2008 for Wells and Aquifer Tubes Monitoring the 100-HR-3 (H) Pump-and-Treat System. (2 pages)

Well or Aquifer Tube Name	Well Use or Aquifer Tube	Baseline Sample						Fall 2008 Sample						Percent Change in Conc. Since Baseline Sampling (Negative = Decrease)				
		Dates Collected	Sr-90 (pCi/L)	Tc-99 (pCi/L	Tritium (pCi/L)	Uranium (µg/L)	Nitrate (mg/L)	Date(s) Collected	Sr-90 (pCi/L)	Tc-99 (pCi/L	Tritium (pCi/L)	Uranium (µg/L)	Nitrate (mg/L)	Sr-90	Tc-99	Tritium	Uranium	Nitrate
199-H4-46	M	10/24/96; 6/20/95	1.8 (J)	-2.28 (U)	5,360	5.51	58.9	11/21/08	--	--	470	--	37.3	--	--	-91.2	--	-36.7
199-H4-47	M	12/14/95; 6/22/95; 5/28/96	0.128 (U)	-2.43 (U)	2,500	4.039	15.1	--	--	--	--	--	--	--	--	--	--	--
199-H4-48	M	10/17/96; 6/22/95	-0.16 (U)	-1.73 (U)	2,220	--	24.5	11/21/08	--	--	--	--	--	--	--	--	--	--
199-H4-49	M	10/29/96; 7/13/95	0.438 (U)	0.874 (U)	14,400	6.59	32.3	11/21/08	--	--	--	--	--	--	--	--	--	--
199-H4-63	C/E	10/16/96; 4/7/97; 11/3/97	51.2	74	1,070	5.27	70.4	11/10/08	20.9	-0.9 (U)	1,870	2.15	24.3	-59.2	--	74.8	-59.2	-65.5
199-H4-64	C/E	10/16/96; 11/2/98	0.0793 (U)	0.00648 (U)	1,730	2.94	27.9	11/24/08	-1.6 (U)	-4 (U)	1,800	2.73	21.2	--	--	4.0	-7.1	-24.0
199-H4-65	E/M	5/15/00	3.62	166 (B)	3,780	0.19	--	11/21/08	--	--	--	--	--	--	--	--	--	--
199-H5-1A	M	10/16/96; 6/30/95	0.0118 (U)	-0.595 (U)	15,800	--	25.9	11/10/08	--	--	--	--	--	--	--	--	--	--
199-H6-1	M	10/24/96; 6/23/95	5.39	0.58 (U)	4,670	--	26.8	11/9/08	--	--	2,000	--	40.2	--	--	-57.2	--	50.0
Aquifer Tubes																		
45-D	AT	9/5/97	--	--	122 (U)	--	--	--	--	--	--	--	--	--	--	--	--	--
46-D	AT	10/14/98; 10/21/97	2.42	14 (U)	691	--	8	--	--	--	--	--	--	--	--	--	--	--
47-M/D	AT	10/14/99; 10/21/97; 10/25/99	31	56 (B)	391 (J)	1.3	25	--	--	--	--	--	--	--	--	--	--	--
48-M/S	AT	10/26/99; 10/30/97	0.16 (U)	2 (BJ)	1,240	6.87	7	12/11/08	--	--	--	--	28.3	--	--	--	--	304.3
49-D/S	AT	10/26/99; 10/19/98; 11/13/97	-0.073 (U)	--	2,830	--	9	--	--	--	--	--	--	--	--	--	--	--
50-M/D	AT	10/15/98; 11/13/97	0.019	--	2,480	--	9	--	--	--	--	--	--	--	--	--	--	--
AT-H-1-D	AT	3/11/04	0.366 (U)	-1.79 (U)	--	0.976	--	12/8/08	--	-3.2 (U)	--	0.834	10.5	--	--	--	-14.5	--
AT-H-2-D/M	AT	3/11/04	1.15 (U)	-1.55 (U)	--	0.748	--	12/8/08	--	-1.3 (U)	--	0.585	2.8	--	--	--	-21.8	--
AT-H-3-D/S	AT	3/11/04; 11/16/05	2.35	35.4	--	0.54	--	12/8/08	1	0.7 (U)	--	1.73	10.7	-57.4	--	--	220.4	--

NOTES:

1. Blank cells indicate that the sample was not collected, the analysis was not performed, or the change in concentration was not calculated.
2. Well use abbreviations: M = monitoring well, E = extraction well, C = compliance well, I = injection well, AT = aquifer tube.
3. Laboratory qualifiers: U = undetected; B = detected above instrument or method detection limits, but less than the contract required quantitation limit; D = sample diluted, J = the reported result is estimated (the analyte was detected but the result has higher potential error factors associated with the result).

- Nitrate:
  - Fall 2008 results showed no wells or aquifer tubes with nitrate concentrations above the 45 mg/L MCL.
  - A total of 10 of the 40 wells sampled had baseline concentrations higher than 45 mg/L. The maximum baseline nitrate concentrations were 393 mg/L and 522 mg/L in wells 199-H4-4 and 199-H4-3, respectively. These wells are both located downgradient of the former 183-H solar evaporation basins.

2.3.3.3 Maximum 2008 Contaminant and Co-Contaminant Concentrations in the 100-H Area. A summary of the maximum 2008 and 2007 contaminant and co-contaminant concentrations detected in the 100-H Area wells or aquifer tubes are provided in Table 2-11. The results include gross alpha and gross beta.

2.3.4 Contaminant Monitoring in the Horn Area

The Horn area includes the 600 Area, between the D/DR Reactor area and the H Reactor area. The Horn area is important to the interim action because groundwater flow is northeast to east from the D/DR Reactor area toward the 100-H Area, at least during high river stage. Thus, the D/DR Reactor area may act as a contaminant source for the Horn area and the 100-H Area. In November 2006, the CERCLA 5-year review of the Hanford Site (DOE/RL-2006-20) identified the need for additional characterization of the aquifer in the Horn area for chromium contamination.

2.3.4.1 Horn Area Hexavalent and Total Chromium Monitoring Results. Twenty-one wells and 18 aquifer tubes were installed across the Horn area in early 2008 and during 2007. DOE/RL-2008-42 presents data obtained as part of this field investigation. The report describes the extent of hexavalent chromium contamination and provides an assessment of the potential source of the plume. The report also includes updated information concerning the geology and general hydrology of the Horn area.

Figure 2-22 shows the fall 2008 plume map for the Horn area, which incorporates hexavalent chromium concentrations from the monitoring wells and aquifer tubes. Monitoring data collected in 2007 and 2008 indicate that the plume extends across the Horn area, from the D/DR Reactor area to the 100-H Area. Table 2-12 compares fall 2008 concentrations with baseline values obtained in fall 2007 for hexavalent and total chromium results.

The characterization wells and aquifer tubes installed during the last 2 years have provided additional information regarding the hexavalent chromium plume in the Horn area:

- Fall 2008 monitoring data show that the hexavalent chromium plume present across the Horn area consists of low concentrations, but 8 of 24 samples were above the Washington State *Model Toxics Control Act* (*Washington Administrative Code* [WAC] 173-340, "Model Toxics Control Act – Cleanup") standard of 48 μg/L. Aquifer tube data indicate that the plume has reached the shoreline north of the H Reactor.
- Sixteen of the 19 wells used to sample the upper unconfined aquifer in 2008 showed that hexavalent chromium concentrations decreased from 2007 levels (Table 2-12).
- In 2008, for the two wells screened within the RUM (wells 699-97-43C and 699-97-48C), hexavalent chromium concentrations decreased from 2007 levels. Concentrations in well 699-97-48C decreased from 42 to 17 μg/L. Hexavalent chromium values in downgradient well 699-97-43C decreased from 8 μg/L to undetected. DOE/RL-2008-42 provides detailed stratigraphic relationships for the two well completed in RUM and other wells completed in the Horn area.

Table 2-11. Maximum Contaminant and Co-Contaminant Concentrations for 2008 and 2007 in the 100-H Area. (2 pages)

Constituent	Maximum Value Detected (µg/L) or (pCi/L)	Filter (F) or Unfiltered (UF)	Date Sampled	Well Name	Location/ Comment
2008					
Hexavalent chromium	157	UF	1/3/08	199-H4-15CS	Adjacent to extraction well H4-15A; piezometer screened in upper RUM.
Chromium	92.8	UF	1/3/08	199-H4-15CS	Adjacent to extraction well H4-15A; piezometer screened in upper RUM.
Chromium	100	F	1/3/08	199-H4-15CS	Adjacent to extraction well H4-15A; piezometer screened in upper RUM.
Nitrate (as N)	39,800 (D)	UF	11/10/08	199-H4-3	Currently used as extraction well; downgradient of former 183-H basins.
Total beta radiostrontium	24	UF	2/6/08	199-H4-63	Currently used as extraction well; downgradient of former 107-H retention basin.
Tritium	3,200	UF	2/6/08	199-H4-3	Currently used as extraction well; downgradient of former 183-H basins.
Technetium-99	45	UF	11/10/08	199-H4-3	Currently used as extraction well; downgradient of former 183-H basins.
Sulfate	72,300 (D)	UF	11/21/08	199-H4-46	Southeast and downgradient of former H Reactor.
Uranium	7.98	UF	2/6/08	199-H4-3	Currently used as extraction well; downgradient of former 183-H basins.
Gross beta	74	UF	11/21/08	199-H4-13	East and downgradient of former 107-H retention basin.
Gross alpha	3.7	UF	11/21/08	199-H4-46	Southeast and downgradient of former H Reactor.
2007					
Hexavalent chromium	102	F	6/14/07	199-H4-15CS	Adjacent to extraction well H4-15A; piezometer screened in upper RUM.
Hexavalent chromium	84.9	UF	11/30/07	199-H4-12C	Adjacent to extraction well H4-12A; well screened in upper RUM.
Chromium	90.3	UF	11/30/07	199-H4-12C	Adjacent to extraction well H4-12A; well screened in upper RUM.
Chromium	84.6	F	11/30/07	199-H4-12C	Adjacent to extraction well H4-12A; well screened in upper RUM.
Nitrate (as N)	602,000 (D)	UF	2/6/07	AT-H-1-S	Aquifer tube downgradient of 199-H4-12A-C wells.
Nitrate (as N)	66,400 (D)	UF	5/8/07	199-H4-3	Currently used as extraction well; downgradient of former 183-H basins.
Strontium-90	24.8	UF	11/30/07	199-H4-63	Currently used as extraction well; downgradient of former 107-H retention basin.
Tritium	4,400	UF	12/27/07	199-H4-49	Southwest of former H Reactor.

Table 2-11. Maximum Contaminant and Co-Contaminant Concentrations for 2008 and 2007 in the 100-H Area. (2 pages)

Constituent	Maximum Value Detected (µg/L) or (pCi/L)	Filter (F) or Unfiltered (UF)	Date Sampled	Well Name	Location/ Comment
Technetium-99	99	UF	5/8/07	199-H4-3	Currently used as extraction well; downgradient of former 183-H basins.
Sulfate	80,000 (D)	UF	11/30/07	199-H4-46	Southeast and downgradient of former H Reactor.
Uranium	22.1	UF	5/8/07	199-H4-3	Currently used as extraction well; downgradient of former 183-H basins.
Gross beta	57.2	UF	11/7/07	199-H4-13	East and downgradient of former 107-H retention basin.
Gross alpha	4	UF	1/31/07	48-M	Aquifer tube downgradient of former 116-H-1 Trench.
Gross alpha	2.72	UF	11/7/07	199-H4-13	East and downgradient of former 107-H retention basin.

D = sample diluted
U = undetected

Table 2-12. Hexavalent and Total Chromium Concentrations in 2007 and 2008 for Wells and Aquifer Tubes Monitoring the "Horn" Area Between the 100-D and 100-H Areas. (3 pages)

Well or Aquifer Tube Name	Fall 2007 Sample				Fall 2008 Sample				Percent Change in Conc. (Negative = Decrease)		
	Unfiltered Cr^{+6}		Total Chromium		Unfiltered Cr^{+6}		Total Chromium				
	Dates Collected	Conc. (µg/L)	Unfilt. (µg/L)	Filt. (µg/L)	Dates Collected	Conc. (µg/L)	Unfilt. (µg/L)	Filt. (µg/L)	Cr^{+6}	Total Chromium	
										Unfiltered	Filtered
699-98-49A	1/25/08	2 (U)	--	--	11/25/08	2 (U)	--	--	--	--	--
699-96-49	12/7/07	25.2	15.2	20.4	--	--	--	--	--	--	--
699-97-43	12/7/07	80.8	72.1	71.6	--	--	--	--	--	--	--
699-96-43	1/31/08	82.8	70.4	64.3	11/23/08	76.8	75.8	79.3	-7.2	7.67	23.3
699-100-43B	11/9/07	24	--	--	11/10/08	8.8	10 (U)	13.7 (B)	-63.3	--	--
699-99-42B	11/9/07	42	--	--	11/7/08	45.1	34.9	36.9	7.4	--	--
699-99-41	11/2/07	74	--	--	11/7/08	50.5	47.2	43.4	-31.8	--	--
699-99-44	11/30/07	49	--	--	11/13/08	43.8	37.9	37.2	-10.6	--	--
699-98-43	10/18/07	73	--	--	11/7/08	66.7	60.9	56.9	-8.6	--	--
699-97-41	9/26/07	80	--	--	11/4/08	57.7	10 (U)	77.1	-27.9	--	--
699-98-46	10/19/07	67	--	--	11/7/08	50.4	41.1	42.8	-24.8	--	--
699-97-45	1/10/08	66	--	--	11/7/08	60	50	50.4	-9.1	--	--
699-95-45	9/28/07	64	--	--	11/4/08	37	62	56.3	-42.2	--	--
699-94-43	9/28/07	28	--	--	11/4/08	37.7	37	36.6	34.6	--	--
699-97-48	--	--	--	--	11/06/08	32.1	--	--	--	--	--
699-97-48B	10/22/07	42	--	--	11/7/08	37.9	--	--	-9.8	--	--
699-95-48	--	--	--	--	--	--	--	--		--	--
699-95-51	10/22/07	34	--	--	11/7/08	24.5	18 (B)	21	-27.9	--	--
699-97-43B	10/17/07	117	--	--	11/7/08	91.5	82.5	79.3	-21.8	--	--
699-94-41	9/26/07	17	--	--	11/6/08	13.3	10 (U)	10.5 (B)	-21.8	--	--
699-101-45	11/15/07	34	--	--	11/7/08	37.4	23.2	31.3	10.0	--	--
699-96-52B	10/24/07	79	--	--	11/7/08	53	50	42.2	-32.9	--	--

Table 2-12. Hexavalent and Total Chromium Concentrations in 2007 and 2008 for Wells and Aquifer Tubes Monitoring the "Horn" Area Between the 100-D and 100-H Areas. (3 pages)

Well or Aquifer Tube Name	Fall 2007 Sample				Fall 2008 Sample				Percent Change in Conc. (Negative = Decrease)		
	Unfiltered Cr^{+6}		Total Chromium		Unfiltered Cr^{+6}		Total Chromium		Cr^{+6}	Total Chromium	
	Dates Collected	Conc. (µg/L)	Unfilt. (µg/L)	Filt. (µg/L)	Dates Collected	Conc. (µg/L)	Unfilt. (µg/L)	Filt. (µg/L)		Unfiltered	Filtered
699-98-51	12/28/07	17	--	--	11/7/08	8.1	10 (U)	10 (U)	-52.4	--	--
699-97-43C (deep well)	10/9/07	8	--	--	11/7/08	2 (U)	10 (U)	10 (U)	--	--	--
699-97-45B	12/20/07	10 (UX)	--	--	11/13/08	2.8 (U)	13 (U)	13 (U)	--	--	--
699-97-48C (deep well)	9/27/07	42	--	--	11/7/08	17	13.1 (B)	10.1 (B)	-59.5	--	--
699-97-51A	12/7/07	30.2	21.6	23.5	11/24/08	22.8	22.1 (B)	23.0 (B)	-24.5	--	--
Aquifer Tubes											
43-M	11/12/07	42.4	--	--	12/11/08	9.4	--	--	-77.8	--	--
44-M	11/12/07	46.4	--	--	--	--	--	--	--	--	--
C5632	11/1/07	4	--	--	--	--	--	--	--	--	--
C5633	11/1/07	14	--	--	--	--	--	--	--	--	--
C5634	11/1/07	2 (U)	--	--	--	--	--	--	--	--	--
C5635	11/1/07	4 (B)	--	--	--	--	--	--	--	--	--
C5636	11/1/07	24	--	--	--	--	--	--	--	--	--
C5637	11/1/07	20	--	--	--	--	--	--	--	--	--
C5638	11/8/07	27	--	--	--	--	--	--	--	--	--
C5644	11/7/07	53	--	--	--	--	--	--	--	--	--
C5673	11/7/07	64	--	--	--	--	--	--	--	--	--
C5674	11/7/07	38	--	--	--	--	--	--	--	--	--
C5676	11/7/07	60	--	--	--	--	--	--	--	--	--
C5677	11/7/07	46	--	--	--	--	--	--	--	--	--

Table 2-12. Hexavalent and Total Chromium Concentrations in 2007 and 2008 for Wells and Aquifer Tubes Monitoring the "Horn" Area Between the 100-D and 100-H Areas. (3 pages)

Well or Aquifer Tube Name	Fall 2007 Sample				Fall 2008 Sample				Percent Change in Conc. (Negative = Decrease)		
	Unfiltered Cr^{+6}		Total Chromium		Unfiltered Cr^{+6}		Total Chromium		Cr^{+6}	Total Chromium	
	Dates Collected	Conc. (µg/L)	Unfilt. (µg/L)	Filt. (µg/L)	Dates Collected	Conc. (µg/L)	Unfilt. (µg/L)	Filt. (µg/L)		Unfiltered	Filtered
C5678	11/7/07	34	--	--	--	--	--	--	--	--	--
C5679	11/7/07	8	--	--	--	--	--	--	--	--	--
C5680	11/7/07	11	--	--	--	--	--	--	--	--	--
C5681	11/7/07	17	--	--	--	--	--	--	--	--	--
C5682	11/7/07	11	--	--	--	--	--	--	--	--	--

NOTE:

1. Blank cells indicate that the sample was not collected, the analysis was not performed, or the change in concentration was not calculated.
2. Laboratory qualifiers: U = not detected in sample above detection limit; B = analyte detected at concentration below the contract-required detection limit, but above the method of instrument detection limit; D = sample diluted.

- Only 1 of the 19 aquifer tubes located directly north of the H Reactor area that are used to monitor the Horn area was sampled in the fall of 2008. The hexavalent chromium concentrations for aquifer tube 43M decreased to 9.4 µg/L in 2008 (from 42.4 µg/L in 2007). Baseline 2007 concentrations ranged from 8 to 46.4 µg/L, with 11 of 19 aquifer tube sites having concentrations >22 µg/L (Table 2-12).

Co-contaminants nitrate, tritium, and sulfate were monitored in selected Horn area wells in the spring (baseline) and fall of 2008.

2.4 100-HR-3 OPERABLE UNIT QUALITY CONTROL

Highlights of the 100-HR-3 quality control (QC) program for the reporting period are summarized below. Appendix D contains more specific information to assess the overall project quality, as well as to assist in evaluating project-specific data quality. Data related to QC issues have been flagged in the database or are undergoing further review.

- Over 94% of the QC results for this quarter were within the acceptance limits, suggesting that the analyses were in control and that reliable data were generated.
- Analytical support staff are working with the analytical laboratories to troubleshoot the methods for chromium and hexavalent chromium. Review of field QC data indicates potential problems with these analytical methods. In particular, poor precision and reported hexavalent chromium concentrations higher than total chromium concentrations were identified as issues during data reviews.
- Forty-three field duplicates were collected which generated 493 pairs of data. Over 99% were within acceptance limits. Most of the unacceptable results were associated with hexavalent chromium analysis at the Waste Sampling and Characterization Facility (WSCF) and are associated with potential analytical issues.
- Thirty-two split samples were collected to evaluate data comparability between laboratories. After taking into account differences in analytical methods and detection limits, 88% of the evaluated results were comparable. The majority of the differences were associated with non-COCs, with the exception of chromium and hexavalent chromium.
- Forty-four field blanks were collected, which generated 529 data results. Over 94% of the results were within the acceptance limits. One-third of the blank failures were associated with one sampling event. The data are under review to determine the cause of the QC failures.

2.5 CONCLUSIONS

The conclusions with respect to each RAO are as follows:

- **RAO #1:** Protect aquatic receptors in the river bottom substrate from contaminants in the groundwater entering the Columbia River.

  The RAO cleanup goal for compliance wells is 22 µg/L based on the 11 µg/L ambient water quality criterion in place at the signing of the ROD (EPA et al. 1996). Even though this RAO has not yet been achieved (based on the following observations), progress has been made.

  100-D Area:

  - The areal extent of the hexavalent chromium north of the 182-D reservoir has not changed significantly over the last few years.
  - Fall 2008 hexavalent chromium concentrations were above the 22 µg/L RAO in all three compliance wells (199-D8-68, 199-D8-69, and 199-D8-70); however, concentrations have been steadily decreasing since the startup of operations.

- Fall 2008 hexavalent chromium concentrations were only >22 μg/L in one of five aquifer sampling tubes along the 100-D Area shoreline.
- The effect of a high river stage during summer months provides a natural hydraulic barrier to movement of the hexavalent chromium plume to the Columbia River.
- The chromium source investigation has identified two highly concentrated source areas: one area adjacent to the former sodium-dichromate transfer station, and other an area northwest of the D Reactor. Short-term remediation options include connecting new wells in these high-concentration areas to the existing DR-5 system and eventually incorporating the wells into the DX system.

100-H Area:

- Fall 2008 hexavalent chromium concentrations were the below the 22 μg/L RAO in three of the four original compliance wells. Three of the compliance wells are currently used as extraction wells.
- Fall 2008 hexavalent chromium concentrations were ≥22 μg/L RAO in extractions wells 199-H4-64 (22 μg/L) and 199-H4-15A (25 μg/L).
- None of the four aquifer tubes sampled along the 100-H Area shoreline in the fall of 2008 had hexavalent chromium concentrations >22 μg/L.
- Hexavalent chromium concentrations were higher in deeper wells 199-H4-12C and 199-H4-15CS than in wells 199-H4-12A and 199-H4-15A, respectively. The shallow wells are screened in the Hanford formation. The deeper completions are in slightly confined groundwater-producing horizons within the RUM.
- The effect of a high river stage during the summer months provides a natural hydraulic barrier to movement of the hexavalent chromium plume to the Columbia River.

Horn area:

Although the Horn area is not part of the interim action that includes the 100-D and 100-H Areas, the highlights regarding hexavalent chromium monitoring in the Horn area are as follows:

- Characterization wells and aquifer tubes completed during the past several years have confirmed that a low-concentration hexavalent chromium plume likely forms a continuous band across the Horn area, from the 100-D to the 100-H Areas.
- New aquifer tubes sampled during 2008 and 2007 have confirmed that the Horn area hexavalent chromium plume has reached the shoreline directly north of the 100-H Area.
- Hexavalent chromium concentrations detected below the top of the RUM in wells 699-97-48C and 699-97-43C have decreased in 2008.

- **RAO #2:** Protect human health by preventing exposure to contaminants in groundwater.

  Results: The interim remedial action ROD (EPA et al. 1996) establishes a variety of institutional controls that must be implemented and maintained throughout the interim action period. These provisions include the following:

  - Access control and visitor escorting requirements
  - Signage providing visual identification and warning of hazardous or sensitive areas
  - Excavation permit process to control all intrusive work (e.g., well drilling and soil excavation)
  - Regulatory agency notification of any trespassing incidents.

The effectiveness of institutional controls was presented in the *2004 Final Institutional Controls (IC) Assessment Report* (DOE/RL-2004-56). The findings of this report indicate that institutional controls were maintained to prevent public access, as required.

- **RAO #3:** Provide information that will lead to a final remedy.

  Results: An evaluation of the pump-and-treat technology to date is provided below:

  - The size of the 100-H Area plume has been significantly reduced.
  - Significant contaminant mass has been reduced in both the 100-D and 100-H Areas.
  - Contaminant concentrations in the aquifer tubes have been reduced.
  - The size of the 100-D Area hexavalent chromium plume has not been affected significantly by pump-and-treat-operations, due in part to remaining highly concentrated sources within the vadose zone still contributing to the plume. In addition, drilling and installing new characterization and monitoring wells has aided in a better defining the extent of contamination.
  - The ISRM barrier is in place to protect the Columbia River downgradient of the southern plume in the 100-D Area.

2.6 RECOMMENDATIONS

General recommendations for the 100-HR-3 OU are as follows:

- Continue to update modeling to optimize well location in the RPO. This includes updates to numerical models and the overall conceptual model, as well as Columbia River/groundwater interaction and the model data package.
- Conduct long-term pumping tests at wells 199-H3-2C, 199-H4-12C, and 199-H4-15CS by connecting these wells to the 100-HR-3 system and monitoring hexavalent chromium concentrations and the hydraulic response in adjacent wells.
- Implement RPO and DX:
  - Identify opportunities to optimize the performance and operation of existing components of the remediation systems (e.g., use the full design treatment capacity of the current pump-and-treat systems) and design DX to clean up to the aquatic standard (22 µg/L) at compliance points.
  - Optimize the pump-and-treat capture strategy at the 100 H Area to consider diminishing returns with respect to capture of the 20 µg/L isopleth.
  - Develop a transition strategy between the interim action and the final remedy via a technology screening process that includes identifying system improvements that should be incorporated into future pump-and-treat design. The results should feed back into the systematic plan. Continue to integrate with the remedial investigation/feasibility study (RI/FS) activities.
- Generate an explanation of significant difference against the interim ROD to address lifecycle costs of the current pump-and-treat systems applicable to 100-HR-3.
- Continue to apply appropriate open-source models to evaluate RPO.
- Review and revise (as necessary) existing well sampling frequency and constituent lists to reflect new data needs and trend development. Include the changes in a revised interim action monitoring plan in FY09.
- Plan and develop a consistent network of compliance wells to measure the effectiveness of the remedy for each OU, taking advantage of existing wells to the extent practicable.

Specific recommendations for the 100-HR-3 pump-and-treat system in the 100-D Area, 100-H Area, and Horn area are as follows:

- 100-D Area:
  - Continue to integrate source and groundwater contractor efforts to help locate the remaining hexavalent chromium sources within the vadose zone.
  - Connect high-concentration wells to either the DR-5 or 100-HR-3 system in FY09.
  - Monitor 100-HR-3 effluent quality and reduce effluent variability.
  - Initiate hexavalent chromium analysis in wells around the former DR Reactor to provide data regarding plume movement from the D/DR Reactor area into the Horn area. These wells are currently analyzed for total chromium.
  - The 100-D and DR-5 extraction well networks have a gap in capture that may contribute to elevated hexavalent chromium concentrations in aquifer tube AT-D-3. Closure of the gap in capture should be addressed during RPO.
  - Use existing capacity at 100-HR-3 and DR-5 more effectively. In particular, add injection capacity at DR-5 by connecting a second injection well.
- 100-H/Horn Areas:
  - In the 100-H Area, the capture east of the H Reactor appears nearly complete, and chromium concentrations in wells and aquifer tubes are below or very close to the 22 μg/L RAO. Perform a rebound study in the 100-H Area as part of the RPO study to determine if chromium concentrations rebound.
  - Integrate the 100-H Area wells proposed for FY09 into the RI/FS activity; the wells are scheduled to be drilled in FY10.
  - Evaluate remediation possibilities in the Horn area as part of the RPO effort.
  - Continue to work closely with the Tribes and cultural resource specialists to incorporate cultural concerns into expanded pump-and-treat operations, particularly north of the 100-H Area.
  - Connect the RUM wells to determine persistence of hexavalent chromium.

3.0 100-KR-4 AND KW REACTOR AREA PUMP-AND-TREAT SYSTEM

The 100-KR-4 OU includes the groundwater underlying the 100-KR-1 and 100-KR-2 source OUs (Figure 3-1). The OU contains the 100-KR-4 treatment system and injection/extraction well field located adjacent to the 116-K-2 Mile-Long Trench and the KW Reactor pump-and-treat system located in the KW Reactor area.

A map of wells and aquifer tube locations in the 100-K Area is presented in Figure 3-2. Appendix A provides a history of operations and supporting documents used in the development of the 100-KR-4 and KW Reactor pump-and-treat systems.

The 100-KR-4 interim action is similar to the 100-HR-3 interim action in that the primary COC is hexavalent chromium. The interim action co-contaminants in the 100-KR-4 OU include tritium and strontium-90. Carbon-14 and nitrate are target analytes because they are present above MCLs in some wells, notably around the KW Reactor. The KW Reactor area pump-and-treat system was constructed after 2005 hexavalent chromium concentrations in near-river monitoring wells increased to >100 µg/L, and were detected in aquifer tubes at >40 µg/L. The facility became operational on January 29, 2007. Additional information on the source area and groundwater are presented in DOE/RL-2008-66.

Figure 3-1. Location of the 100-KR-4 Operable Unit.

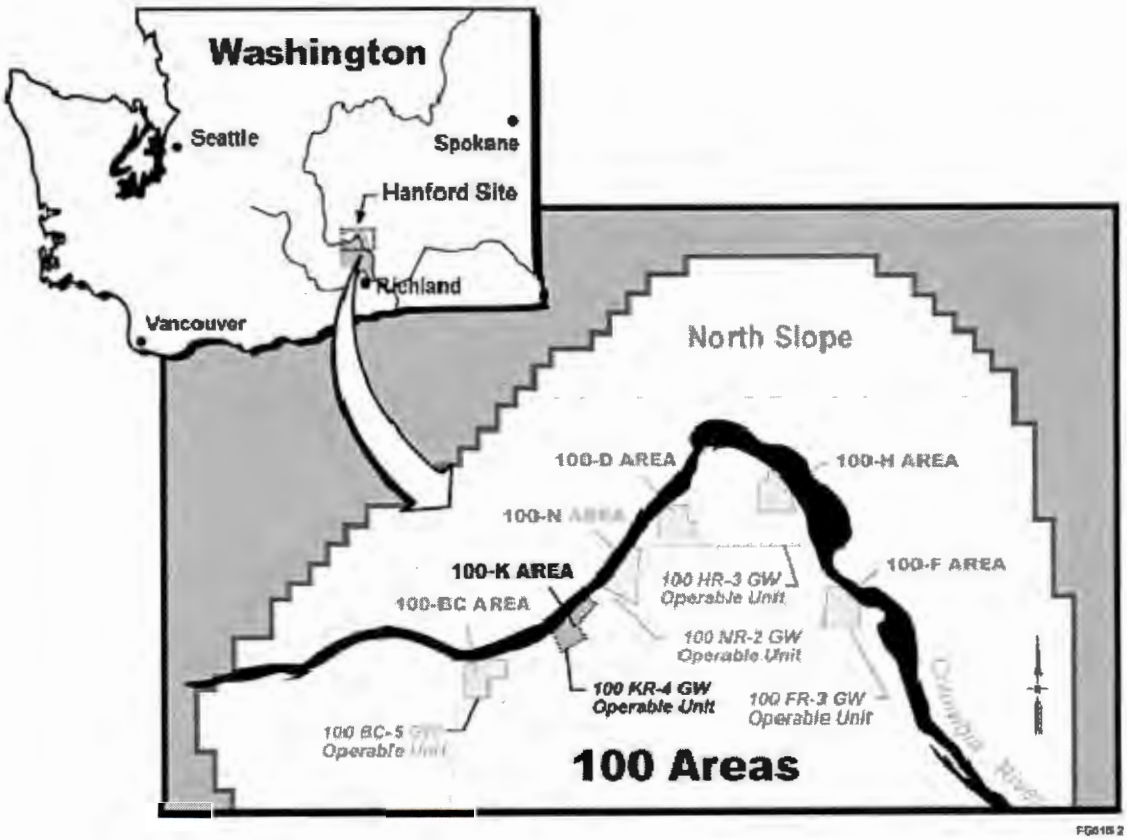
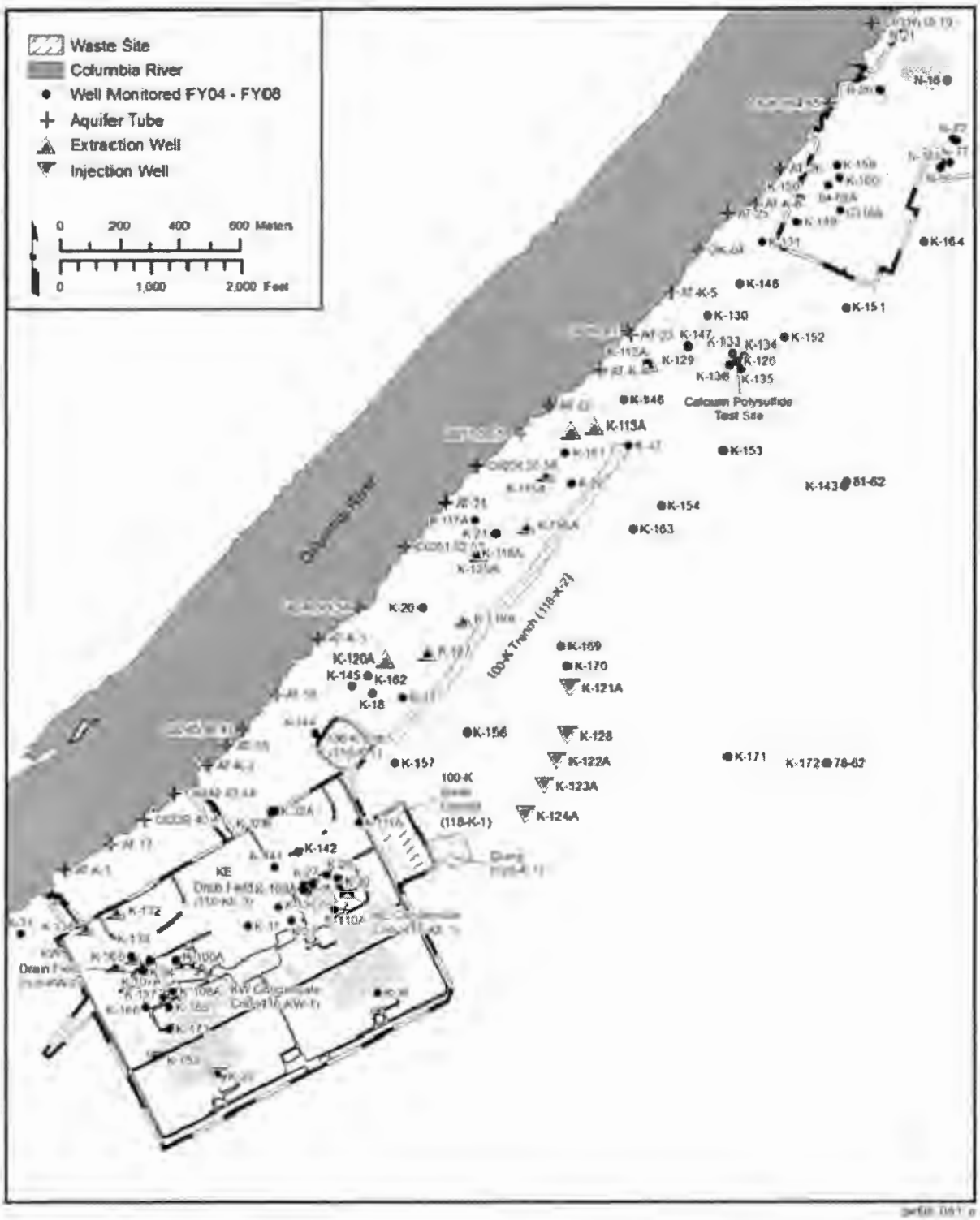


Figure 3-2. 100-KR-4 Operable Unit Wells and Aquifer Sampling Tubes.



As indicated in Section 1.1.2, a 2,271-L/min (600-gpm) expansion (KX) to the 100-KR-4 pump-and-treat system was under construction and acceptance testing at the end of CY08. The operation is expected to host at least 12 extraction wells and nine injection wells, which extend the coverage of the hexavalent chromium groundwater contamination at the 100-K Area.

Additional changes to the 100-KR-4 and KX systems are under way to meet contaminant conditions found in the field. For example, new wells will be drilled in FY09 to provide better extraction coverage. Well 199-K-171, originally planned as an injection well, will be converted to an extraction well due to unexpectedly high (79 μg/L) chromium concentrations. In addition, wells 199-K-144, 199-K-145, and 199-K-162 will be connected to the 100-KR-4 pump-and-treat system to prevent injecting tritium-bearing groundwater near the N Reactor area. Operational data for CY08 were not available because the KX system did not come on-line until 2009.

A 387.5-L/min (100-gpm) addition to the existing 387.5-L/min (100-gpm) KW Reactor pump-and-treat system is also being constructed and will join the 100-KR-4 expansion, with startup in 2009. Four extraction wells (199-K-137, 199-K-65, 199-K-166, and 199-K-168) will be brought on-line and will, in part, replace extraction wells 199-K-39 and 199-K-140. Two new injection wells to be drilled in 2009 will replace well 199-K-35 and provide additional injection capacity with well 199-K-158.

The three treatment systems, which total to 4,164-L/min (1,100-gpm) treatment capacity, will be optimized in 2009 by adjusting flows at extraction and injection wells to control the 116-K-2, KE Reactor, and KW Reactor chromium plumes and adding new wells if necessary. In addition, a RPO project will evaluate the following methods to assist in meeting the 2012 goal of preventing chromium from reaching the river:

- Further expansions to the pump-and-treat systems
- Bioremediation or chemical reduction
- Plume manipulation
- Alternate IX resins
- New pump-and-treat systems
- Realignment of extraction and injection wells.

Other technologies or measures may be identified during implementation of the work plan (DOE/RL-2008-46, *Integrated 100 Area Remedial Investigation/Feasibility Study Work Plan*, Addendum 2) for the report of investigation, feasibility study, and proposed plan process, which will lead to a final ROD. The RPO project began in April 2009.

Twenty-nine (out of 30 planned) new aquifer tubes were installed during CY08 along the shoreline in the 100-K Area (26 of the aquifer tubes are shown in Figure 3-2). One tube (C6262) was not completed when it met refusal above the design depth, and one three-tube location lies upstream of the mapped area.

3.1 100-K AREA TREATMENT SYSTEM PERFORMANCE

The 100-KR-4 pump-and-treat system performed very well during CY08. Specific details of performance assessment include changes to system configuration, system availability, mass of contaminants removed during operation, contaminant removal efficiencies, quantity and quality of extracted and disposed groundwater, waste generation, and contaminant trends.

3.1.1 100-KR-4 Treatment System Performance

As a result of action items identified in the second CERCLA 5-year review report (DOE/RL-2006-20), several new wells were constructed or reconfigured in CY08 to support plume remediation and delineation. Figure 3-2 presents the wells completed through CY08. To improve the efficiency for the 100-KR-4 pump-and-treat system, flow rates for selected extraction and injection wells were adjusted to prevent over-pumping and associated system shutdown during freezing conditions, which resulted in slightly reduced scheduled system availability. Figure 3-3 presents a schematic of the current 100-KR-4

pump-and-treat system. A summary of operational parameters and total system performance for CY08 is presented in Table 3-1.

Key operational and system highlights for the 100-KR-4 pump-and-treat system for CY08 are as follows:

- 488 million L (129 million gal) of groundwater were treated and approximately 15 kg of hexavalent chromium were removed.
- The mass removal efficiency for CY08 was 99.8%, which is somewhat higher than the 91.9% reported for CY07 (Figure 3-4).
- The average 100-KR-4 influent hexavalent chromium concentration of 30.7 µg/L in CY08 was lower than the CY07 average of 38.6 µg/L.
- The average effluent hexavalent chromium concentration of 3.8 µg/L for CY08 was slightly higher than the 3.4 µg/L reported in CY07. Trend plots of CY08 influent and effluent concentrations are presented in Figure 3-5.
- The maximum hexavalent chromium concentration analyzed effluent was 12 µg/L.
- Scheduled system availability for CY08 was 98.2%, which was slightly lower than the 99.6% reported in CY07. The total on-line availability, a measure of unscheduled downtime, was 96.7%, slightly lower than the on-line availability of 98.9% reported for CY07. Figure 3-6 presents the monthly on-line percentages and method used to calculate availability and on-line percentage for the reporting period.
- Resin changeouts were performed on 24 vessels in CY08. No new resin was installed in CY08, and regenerated resin totaled 54.4 m^3 (1,921.1 ft^3).

Table 3-2 presents the pumping flow rates and total run-time (total flow hours / total possible run-time) for extraction wells currently at use in the 100-KR-4 pump-and-treat system. Except where noted, the recommended flow rates were based upon initial estimated extraction rates from short-term pumping tests conducted after the wells were drilled. Additional wells were added after 1997 to support the first CERCLA 5-year review design modification. The yearly average flow rates are calculated from total volumes divided by the number of hours in a year.

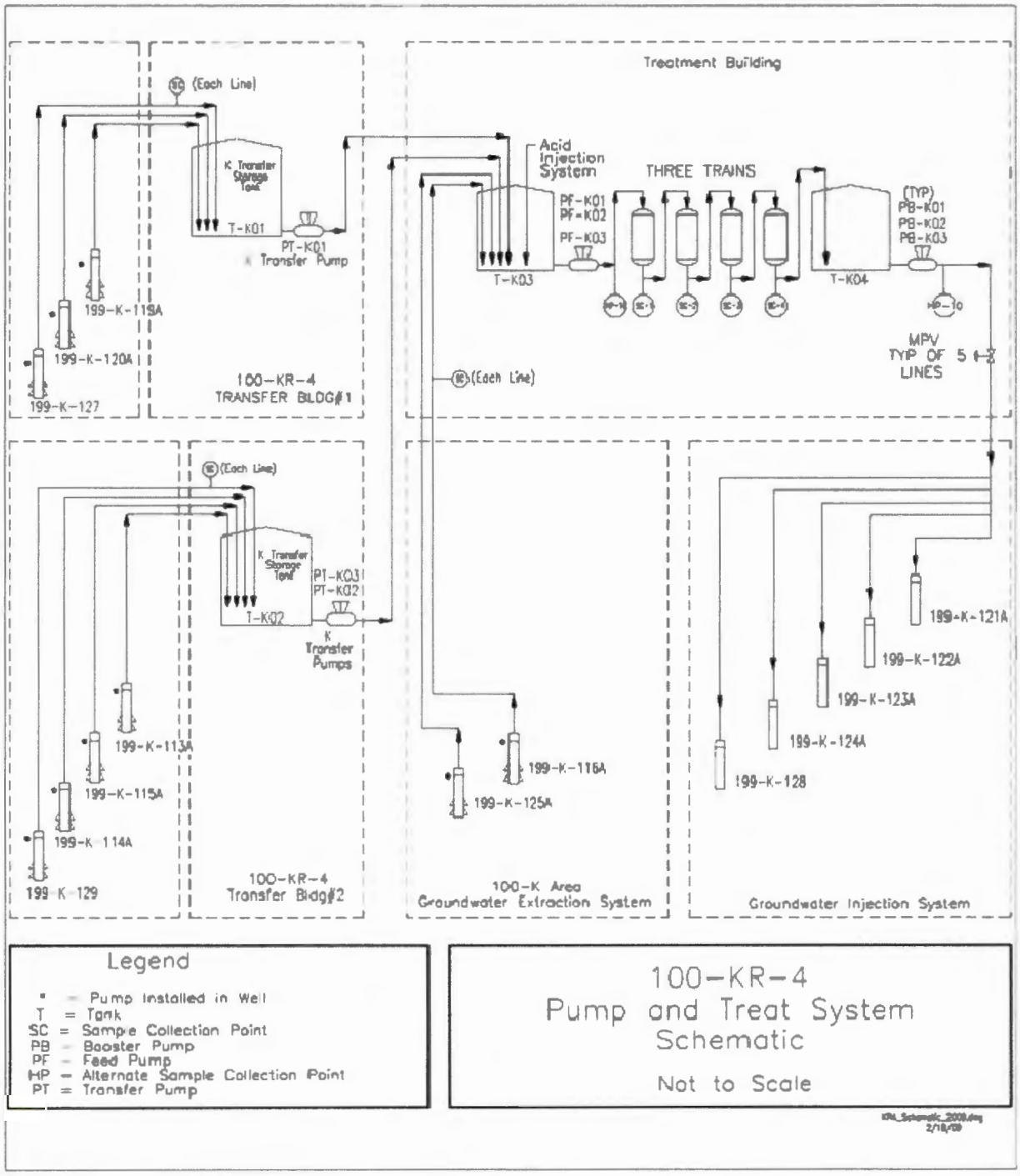
A comparison of extraction rates shows that wells 199-K-114A, 199-K-115A, 199-K-116A, 199-K-120A, and 199-K-125A were pumped at greater flow rates than initially estimated. These wells were able to sustain higher yields during the reporting period and were, therefore, used to offset lower rates from wells 199-K-113A, 199-K-127, and 199-K-129.

The lower-than-recommended flow rates at wells 199-K-113A, 199-K-119A, 199-K-127, and 199-K-129 may be attributed to a locally thin aquifer and fluctuations in river levels throughout the year, which frequently limited the available drawdown in these wells. During the year, all wells were subject to downtime because of area power-grid outages, equipment failures, and/or maintenance. This downtime is reflected in the yearly average flow rate calculations and the total run-time percentages for each extraction well.

The 100-KR-4 pump-and-treat system was designed to receive and process up to 1,135.6 L/min (300 gpm). The system is currently processing at an average annual pumping rate of approximately 957.1 L/min (252.8 gpm).

Operational parameters, total system performance, and extraction well chromium concentrations and extraction rates are provided in Appendix B.

Figure 3-3. 100-KR-4 Operable Unit Pump-and-Treat System Schematic.



3.1.2 KW Reactor Area Pump-and-Treat System Performance

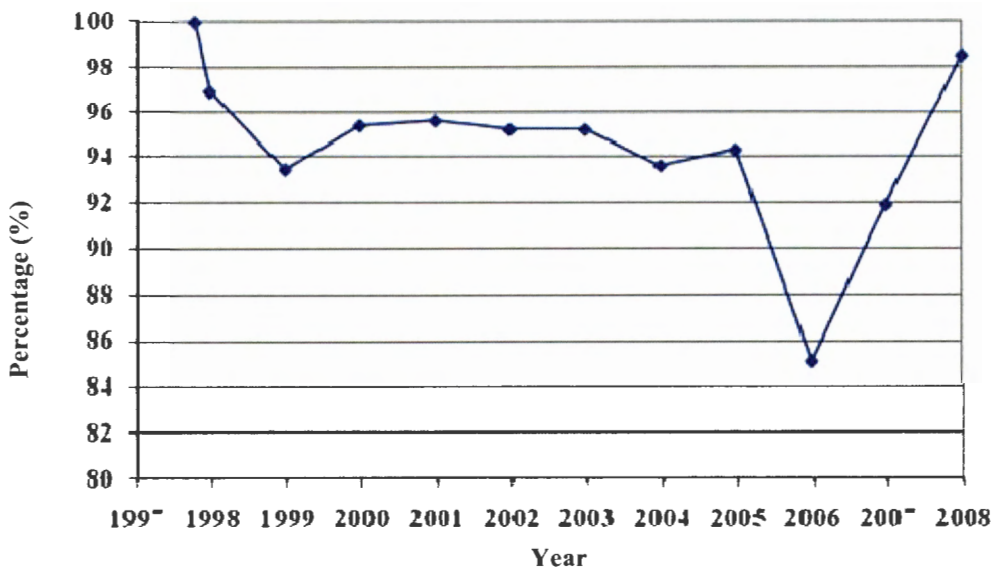
This section describes the KW Reactor pump-and-treat system's operation and sampling activities for CY08. Specific details present the system configuration, system availability, mass of contaminants removed during operation, contaminant removal efficiencies, quantity, and quality of extracted and disposed groundwater, waste generation, and contaminant trends.

Table 3-1. Operation Parameters and System Performance for Calendar Year 2008.

Total Processed Groundwater	**CY07**	**CY08**
Total amount of groundwater treated (since October 1997 startup) (billion L)	4.41	4.9
Total amount of groundwater treated during CY (million L)	529.2	488.0
Mass of Hexavalent Chromium Removed	**CY07**	**CY08**
Total amount of hexavalent chromium removed since October 1997 startup (kg)	324.7	339.7
Total amount of hexavalent chromium removed in CY (kg)	20.4	14.98
Summary of Operational Parameters	**CY07**	**CY08**
Removal efficiency (% by mass)	91.9%	99.8%
Waste generation (m^3)	0	0
Regenerated resin installed (m^3)	67.9	54.4
New resin installed (m^3)	31.7	0
Number of resin vessel changeouts	30	24
Summary of System Availability	**CY07**	**CY08**
Total possible run-time (hours)	8,760	8,784
Scheduled downtime (hours)	28.8	159.5
Planned operations (hours)	8,731.2	8,624.5
Unscheduled downtime (hours)	67.6	126.7
Total time on-line (hours)	8,663.6	8,497.8
Total availability (%)	98.9%	96.4%
Scheduled system availability (%)	99.6%	98.5%

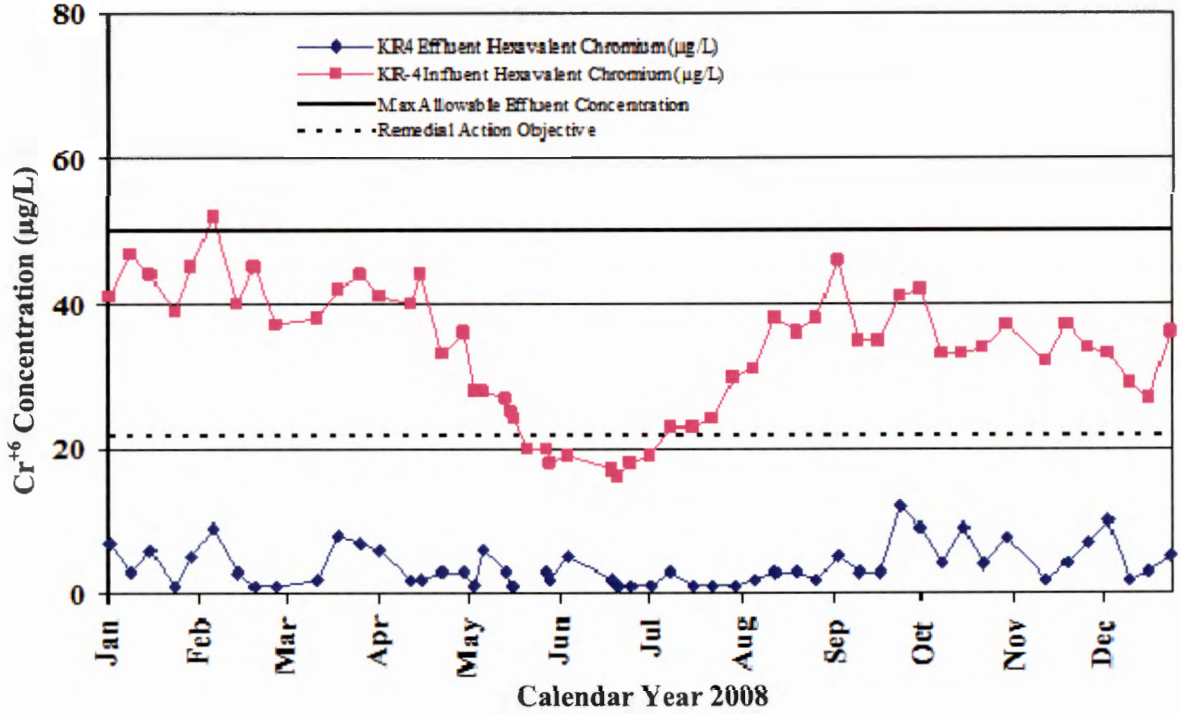
CY = calendar year

Figure 3-4. 100-KR-4 Pump-and-Treat System Average Removal Efficiencies.



Average removal efficiency (% by mass) = [(influent – effluent) / influent].

Figure 3-5. 100-KR-4 Pump-and-Treat Trends of Influent and Effluent Hexavalent Chromium Concentrations, Calendar Year 2008.

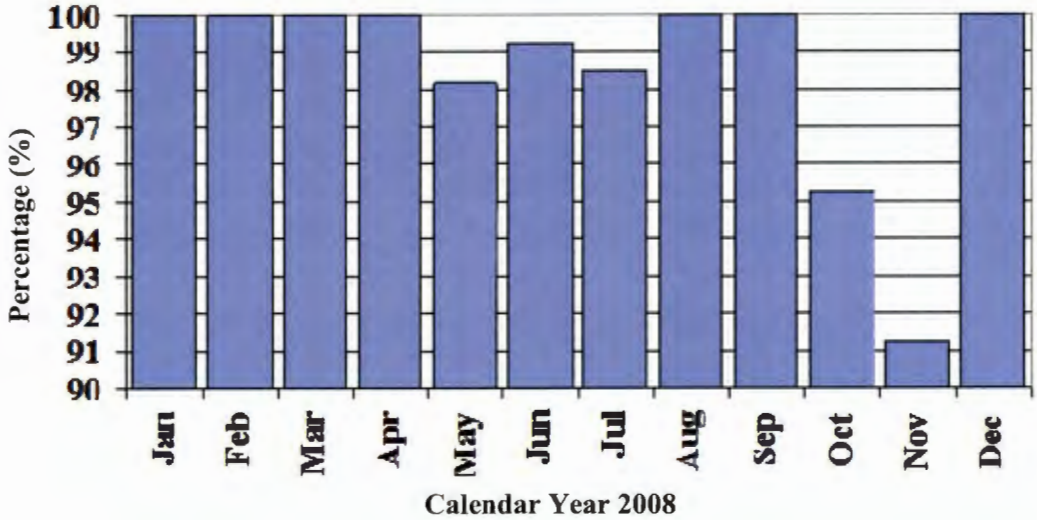


The KW Reactor pump-and-treat system became operational on January 29, 2007. The pump-and-treat system was installed to address chromium contamination near the reactor at well 199-K-107A that had reached aquifer tube AT-K-1 in CY05. The system currently consists of four extraction wells (199-K-132, 199-K-138, 199-K-139, and 199-K-140), two injection wells (199-K-35 and 199-K-158), and an IX treatment system similar in design to that used in the 100-KR-4 and 100-HR-3 OUs. The system schematic drawing for the KW Reactor pump-and-treat system is presented in Figure 3-7. Operational parameters for the start of operations through the end of December 2008 are presented in Table 3-3. This system will be expanded in CY09 to a treatment capacity of up to 757 L/min (200 gpm).

Key operational and system highlights for the KW Reactor pump-and-treat system for CY08 are as follows:

- 196.87 million L (52.01 million gal) of groundwater were treated and 13 kg of hexavalent chromium were removed.
- The mass removal efficiency for CY08 was 98.9%, which is slightly lower than the mass removal efficiency reported for CY07 (100%). Figure 3-8 presents the trend of the effluent and influent concentrations for the year.
- The average influent hexavalent chromium concentration for CY08 was 66.0 µg/L, which is approximately one-half of the average concentration of 122.3 µg/L reported for CY07.
- The average hexavalent concentration in the effluent during CY08 was 0.8 µg/L, which is lower than the average effluent concentration of 1.4 µg/L reported for CY07.
- The maximum effluent concentration reported in CY08 was 6 µg/L.

Figure 3-6. 100-KR-4 Pump-and-Treat Systems Availability and On-Line Percentages for Calendar Year 2008.



100-KR-4 pump-and-treat system availability for 2008:[a]	
Total possible run-time (hours)	8,784
Scheduled downtime (hours)	159.5
Planned operations (hours)	8,624.5
Unscheduled downtime (hours)	126.7
Total time on-line (hours)	8,497.8
Total availability (%)	96.7
Scheduled system availability (%)	98.5

[a] Scheduled system availability [(total possible run-time – scheduled downtime) / total possible run-time].
Total availability [(total possible run-time – scheduled and unscheduled downtime) / total possible run-time)].

- The scheduled system availability for CY08 was 99.4%, which is the same as the system availability of 99.4% reported in CY07. The total availability was 99.4%, which was slightly higher than the on-line availability of 97% reported in CY07. Figure 3-9 presents the monthly on-line percentages and method used to calculate availability and on-line percentage for the reporting period.

Table 3-4 presents the pumping flow rates and total run-time (total flow hours / total possible run-time) for extraction and injections wells at the KW Reactor pump-and-treat system. Figure 3-10 presents the monthly on-line percentages and methods used to calculate system availability and on-line percentages for the reporting period.

Table 3-2. Pumping Flow Rates and Total Run-Time for Calendar Year 2008.

Well	Recommended[b] Flow Rate, L/min (gpm)	Yearly Avg. Flow Rate, L/min (gpm)	Total Flow Hours in CY08	Total Run-Time (%)[c]	Purpose
199-K-129[a]	94.6 (25.0)	48.5 (12.8)	7,919.6	90.4%	Extraction
199-K-113A	56.8 (15.0)	49.6 (13.1)	8,598.0	98.2%	Extraction
199-K-114A[d]	94.6 (25.0)	106.0 (28)	8,140.6	92.9%	Extraction
199-K-115A	94.6 (25.0)	149.5 (39.5)	8,475.6	96.8%	Extraction
199-K-116A	151.4 (40.0)	173.0 (45.7)	8,020.2	91.6%	Extraction
199-K-119A	113.6 (30.0)	81.4 (21.5)	7,390.4	84.4%	Extraction
199-K-120A	113.6 (30.0)	178.7 (47.2)	8,625.2	98.5%	Extraction
199-K-125A	113.6 (30.0)	161.6 (42.7)	8,151.2	93.1%	Extraction
199-K-127	151.4 (40.0)	118.9 (31.4)	8,629.2	98.5%	Extraction
199-K-121A	NA	132.9 (35.1)	8,441.0	96.1%	Injection
199-K-122A	NA	309.0 (81.6)	8,450.4	96.2%	Injection
199-K-123A	NA	128.3 (33.9)	8,485.3	96.6%	Injection
199-K-124A	NA	71.8 (19.0)	7,322.4	83.4%	Injection
199-K-128	NA	293.9 (77.6)	8,416.4	95.8%	Injection

[a] Extraction well 199-K-112A was replaced with well 199-K-129, which began operating as an extraction well on July 10, 2003.
[b] Recommended flow rate based upon drawdown analysis.
[c] Total flow hours in CY08/ total hours in CY08 x 100%.
[d] Monitoring well 199-K-114A was converted to an extraction well and began operation in November 2004.
gpm = gallons per minute
NA = not available

The KW Reactor pump-and-treat system has a design capacity of 378.5 L/min (100 gpm). The system is currently processing at an average annual pumping rate of approximately 375.7 L/min (99.3 gpm).

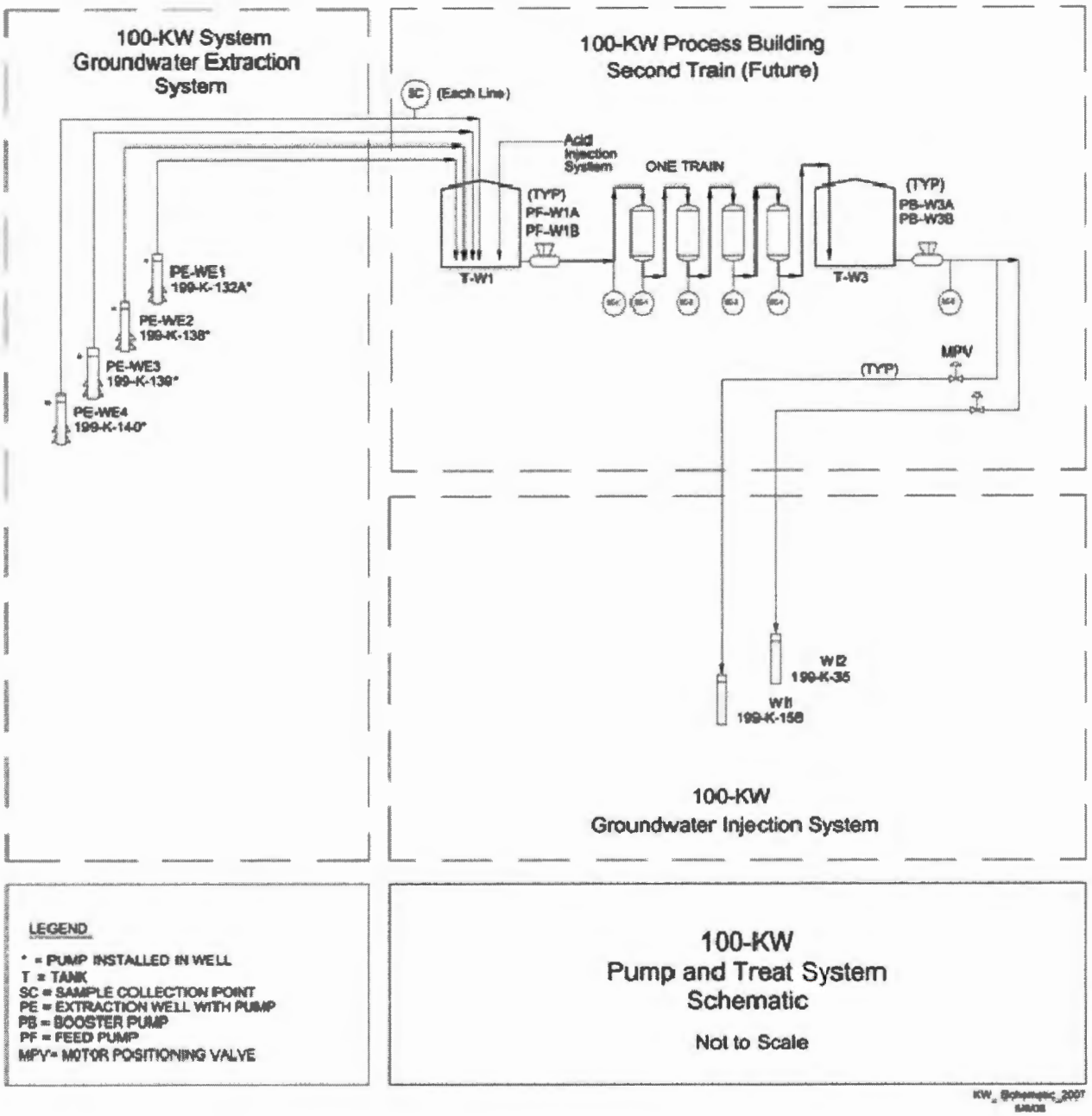
3.2 AQUIFER RESPONSE IN THE 100-K AREA

This section describes the general hydrogeologic conditions in the 100-K Area, numerical modeling conducted to evaluate the extraction well network, and changes in contaminant concentrations in monitoring wells.

3.2.1 Hydrogeologic Conditions at the 100-K Area

Groundwater flow in the 100-K Area occurs in moderately permeable sands and gravels and is influenced by the injection and extraction well networks for the pump-and-treat system, as well as seasonal fluctuations in the Columbia River. Regional groundwater flow in the vicinity of the 100-K Area is toward the Columbia River. A portion of the aquifer close to the river is influenced by river stage, with local flow from inland toward the Columbia River during low river flow in the fall and winter and from the Columbia River inland during spring run-off. The effects of the pump-and-treat system are in addition to these broad seasonal fluctuations.

Figure 3-7. KW Reactor Pump-and-Treat System Schematic.



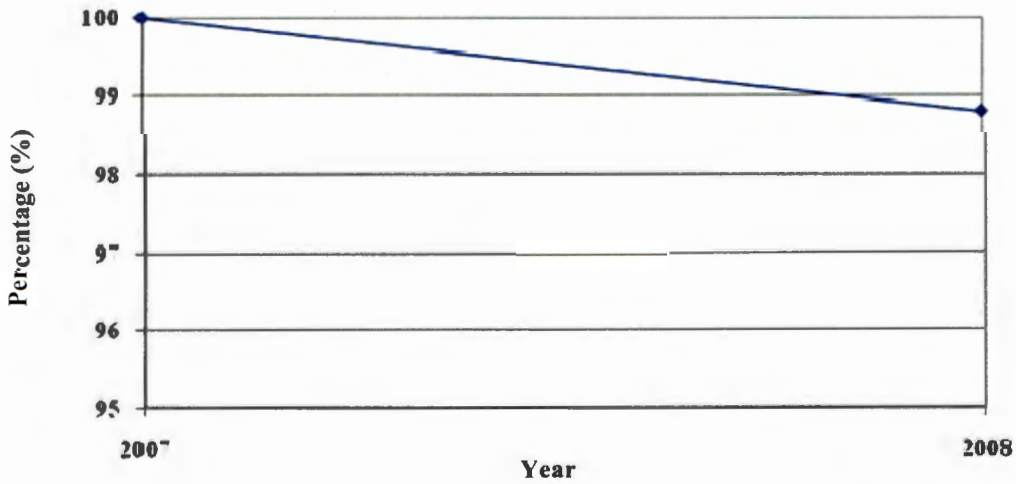
The aquifer in the vicinity of 100-K Area is located in the sands and gravels of Ringold Unit E. Aquifer saturated thickness ranges from 5.2 m (17 ft) to more than 32 m (105 ft), and mean transmissivity obtained from constant discharge tests in 100-KR-4 injection wells was approximately 90 m^2/day (969 ft^2/day). Consequently, the aquifer is transmissive enough to support the approximately 1,136 L/min (300 gpm) combined pumping rates into the injection well network. Appendix C discusses aquifer parameters.

Table 3-3. Operational Parameters from Startup Through December 2008.

Total Processed Groundwater	CY07	CY08
Total amount of groundwater treated since January 2007 startup (million L)	172.49	369.36
Total amount of groundwater treated in CY (million L)	172.49	196.87
Mass of Hexavalent Chromium Removed	**CY07**	**CY08**
Total amount of hexavalent chromium removed since January 2007 startup (kg)	21.03	34.03
Total amount of hexavalent chromium removed in CY (kg)	21.03	13.0
Summary of Operational Parameters	**CY07**	**CY08**
Removal efficiency (% by mass)	100%	98.8%
Summary of System Availability	**CY07**	**CY08**
Total possible run-time (hours)	8,088	8,784
Scheduled downtime (hours)	45.2	50.0
Planned operations (hours)	8,042.8	8,734
Unscheduled downtime (hours)	194.5	0.0
Total time on-line (hours)	7,848.3	8,734
Total availability (%)	97.0%	99.4%
Scheduled system availability (%)	99.4%	99.4%

CY = calendar year

Figure 3-8. KW Reactor Pump-and-Treat System Average Removal Efficiencies.



Average removal efficiency (% by mass) = [(influent – effluent) / influent].

Figure 3-9. KW Reactor Pump-and-Treat Trends of Influent and Effluent Hexavalent Chromium Concentrations, Calendar Year 2008.

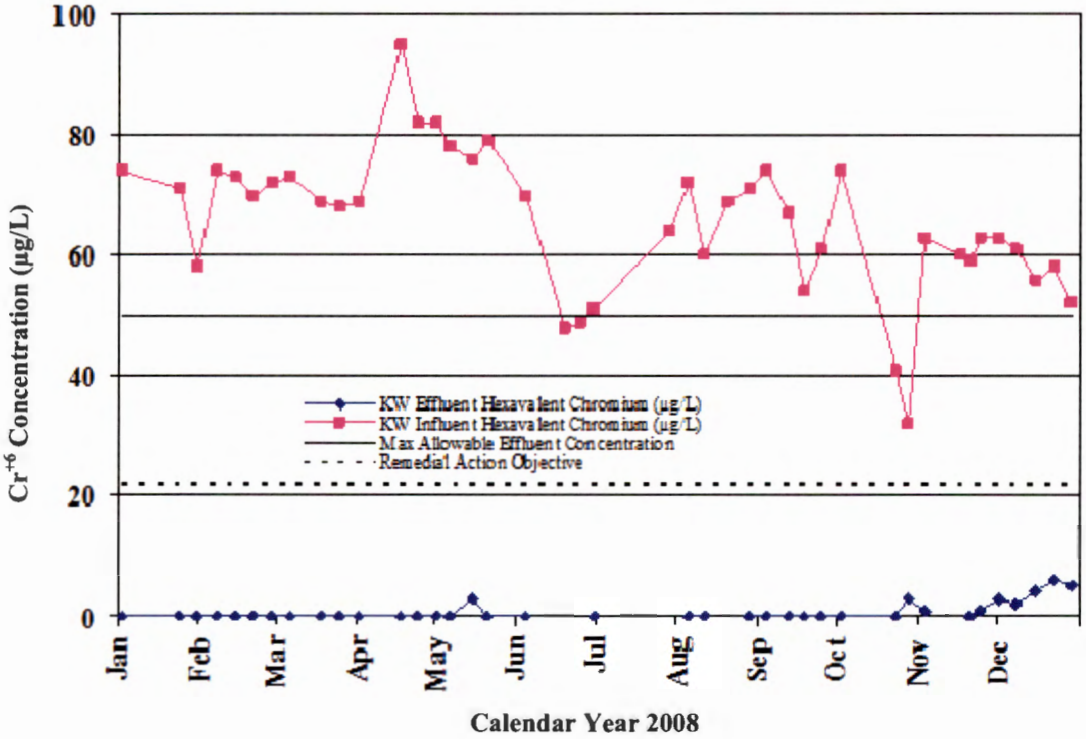


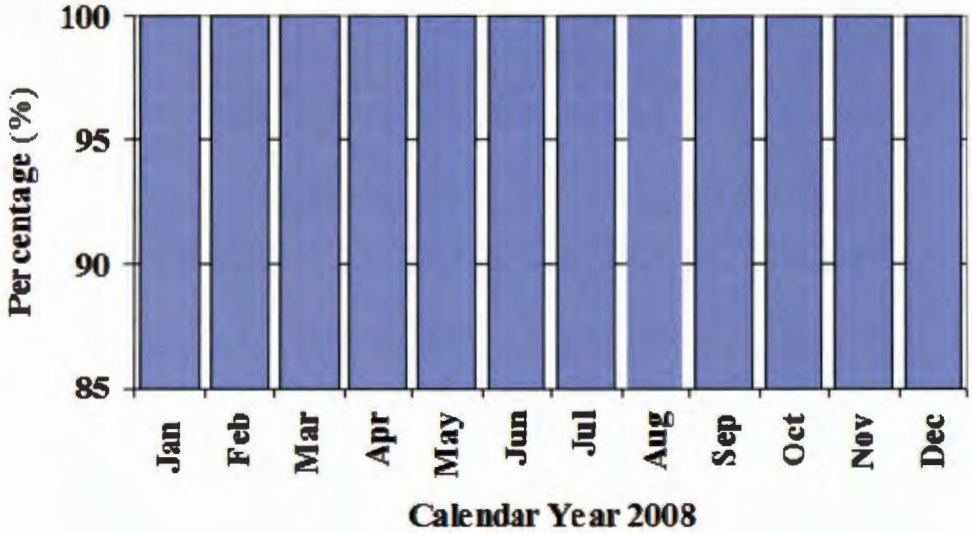
Table 3-4. Pumping Flow Rates and Run-Time for Extraction and Injection Wells.

Well	Yearly Avg. Flow Rate, L/min (gpm)	Total Flow Hours in CY08	Total Run-Time %[a]	Purpose
199-K-132	104.6 (27.7)	8,615.8	98.1%	Extraction
199-K-138	97.3 (25.7)	8,728.1	99.4%	Extraction
199-K-139	107.8 (28.5)	8,508.7	96.9%	Extraction
199-K-140	74.9 1(9.8)	8,269.1	94.0%	Extraction
199-K-35	72.3 (19.1)	8,594.0	97.8%	Injection
199-K-158	298.6 (78.9)	8,739.2	99.5%	Injection

[a] Percentage total run-time calculated by (total flow hours/total possible run time.
CY = calendar year

Mounding occurs around the five existing 100-KR-4 injection wells (199-K-121A, 199-K-122A, 199-K-123A, 199-K-124A, and 199-K-128) and the two existing KW Reactor injection wells (199-K-35 and 199-K-158) (see Figure 3-11). The head displayed around the injection wells is measured in the injection wells and has not been corrected for well losses; therefore, the true head in the aquifer is significantly lower around the injection wells and higher around the extraction wells than that displayed in Figure 3-11. Existing monitoring wells are being instrumented with water-level data loggers to record water levels to create a correction factor that can be applied to more accurately measure the head.

Figure 3-10. KW Reactor Pump-and-Treat System Availability and On-Line Percentages for Calendar Year 2008.



KW Reactor pump-and-treat system availability for 2008:[a]	
Total possible run-time (hours)	8,784
Scheduled downtime (hours)	50.0
Planned operations (hours)	8,734
Unscheduled downtime (hours)	0.0
Total time on-line (hours)	8,734
Total availability (%)	99.4
Scheduled system availability (%)	99.4

[a] Scheduled system availability [(total possible run-time – scheduled downtime) / total possible run-time].
Total availability [(total possible run-time – scheduled and unscheduled downtime) / total possible run-time)].

3.2.2 Hydraulic Capture Evaluation

Consistent with recommendations in EPA 600/R-08/003, multiple lines of evidence are used to estimate capture. Two methods are used to estimate the extent of hydraulic capture developed by pump-and-treat activities during CY08. These methods are briefly described here and in detail in Appendix C:

- Water-level mapping: Uses a method that incorporates the effects of extraction and injection at wells, and the effects of changing river stage, on groundwater levels. Particle tracking on each mapped surface is used to calculate approximate capture zones. The process is repeated for multiple sampling events throughout FY08 and combined into a mapped CFM (Figure 3-12), which provides an ensemble estimate of the extent of capture.
- Groundwater modeling: Uses the 100 Area groundwater model that encompasses the 100-D, 100-H, 100-K, and 100-N Areas (DOE/RL-2006-52). The model was used to simulate monthly stress periods and depict the approximate the extent of capture using a modeled CEM (Figure 3-13).

Inference from the mapping and modeling should focus on the relative extents and distribution of the low and high frequencies and the efficiencies, respectively. In the 100 Areas, the principal causes for capture frequencies and/or efficiencies that lie between 0 (i.e., likely not captured) and 1 (i.e., likely always captured) are changing pumping rates and the effects of the changing river stage.

Extraction at the 100-K Area pump-and-treat system operated intermittently from February to December 2008. Groundwater levels were measured continuously using pressure transducers and data loggers and on a regular basis using manual depth-to-water measurements. A stream gauge is located relatively close to the 100-K Area shoreline. Appendix C provides extraction rates throughout CY08 for all 100-K Area wells, as well as data on selected monitoring wells.

Figure 3-12 depicts the CFM calculated using the mapping approach (details provided in Appendix C). This figure represents the combination of 76 water elevation and capture maps, generated using daily average water elevation and extraction rates measured when the system was operating. Figure 3-13 depicts the capture efficiency calculated using the modeling approach (see Appendix B). This figure represents the combination of 12 capture zone estimates based on monthly average river stage and pumping rates.

Comparison of Figures 3-12 and 3-13 suggests that the general extents of capture depicted using the two methods are comparable, although the individual capture extent for each well differs between the methods. This difference may be primarily due to the absence of continuous water-level data upgradient (inland) of the extraction wells in the vicinity of the injection wells to confidently determine gradients, and/or the assumed (calibrated) aquifer properties used in the model. The figures suggest that some gaps likely exist in capture (depicted in terms of low capture frequency, low capture efficiency, or both). These gaps are most evident as follows:

- Between well 199-K-113A and well 199-K-129 (mapped and modeled capture)
- Between well 199-K-119A and well 199-K-127 (mapped and modeled capture)
- Between well 199-K-119A and well 199-K-125A (modeled capture only).

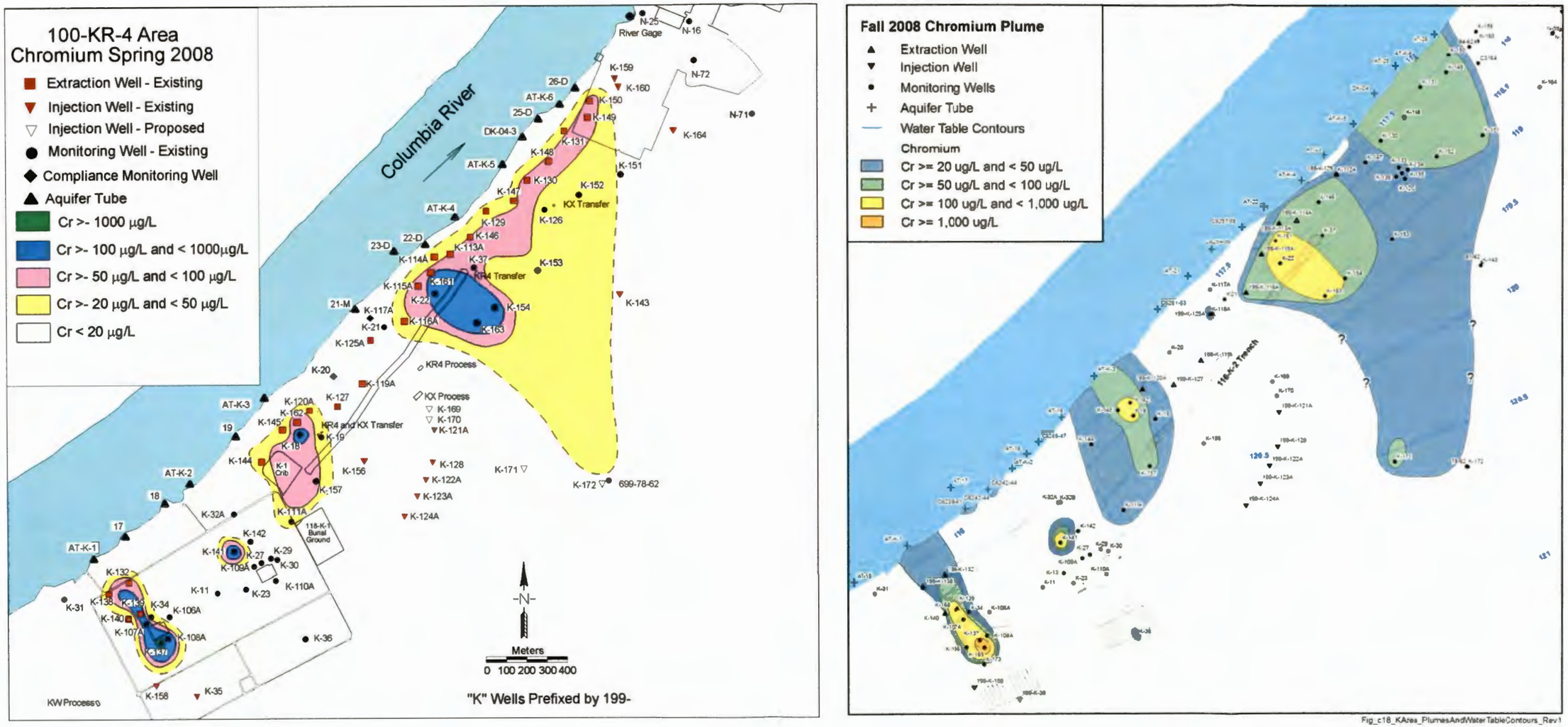
3.2.3 Contaminant Monitoring

This section summarizes and interprets the CERCLA analytical results obtained from groundwater monitoring wells supporting the 100-K Area pump-and-treat remedial action and other areas in the 100-KR-4 OU. DOE/RL-96-90 and DOE-RL (1998) define the sampling protocols implemented for CY08. The results presented in the following subsections include the individual or average fall concentrations for CY08, unless otherwise specified. Section 3.2.3.1 includes a discussion on chromium monitoring results, and Section 3.2.3.2 includes a discussion on the monitoring results for remedial action target analytes strontium-90 and tritium. Nitrate and carbon-14 are also target analytes. Contaminant trend charts are presented in Appendix F.

3.2.3.1 Chromium Monitoring Results and Plume Descriptions. The fall 2008 hexavalent chromium groundwater plume in the 100-K Area is presented in Figure 3-14 and may be depicted as four separate plumes based on the probable principal sources. Two of the largest plumes are likely the result of reactor coolant discharges to the 116-K-2 Mile-Long Trench between 1955 and 1971. These discharges filled the 116-K-2 Trench and resulted in a groundwater mound that raised the water table up to 3 m (10 ft) at well 699-78-62, located approximately 1,170 m (3,840 ft) inland from the trench. This plume is currently being remediated by the 100-KR-4 pump-and-treat system.

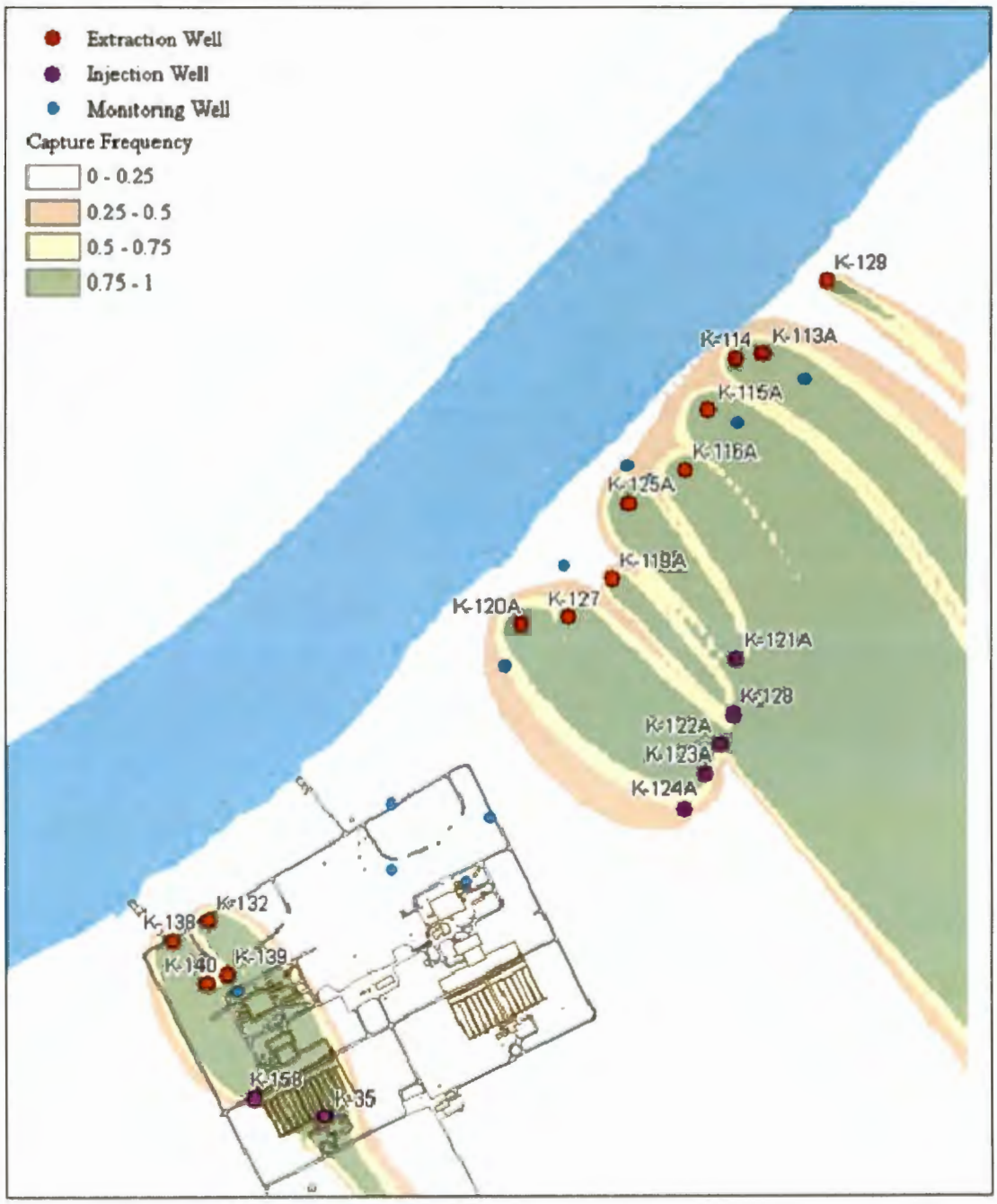
The third hexavalent chromium plume is located downgradient of the KE Reactor and is confined to the area around monitoring well 199-K-141. The source of this plume is most likely leakage from water treatment facilities serving the KE Reactor. The hexavalent chromium plume map for CY07 showed this plume to be contiguous with the plume located near the southwest end of the 116-K-2 Trench. Data from CY08 (although somewhat limited) do not support this interpretation, and the plume downgradient of the KE Reactor is interpreted as a separate entity, which is in-line with the available CY08 data.

Figure 3-11. 100-K Area June and November 2008 Measured Water Table and Chromium Plumes.



NOTE: Contoured water levels may exaggerate the amount and extent of drawdown and mounding in the vicinity of extraction and injection wells, respectively.

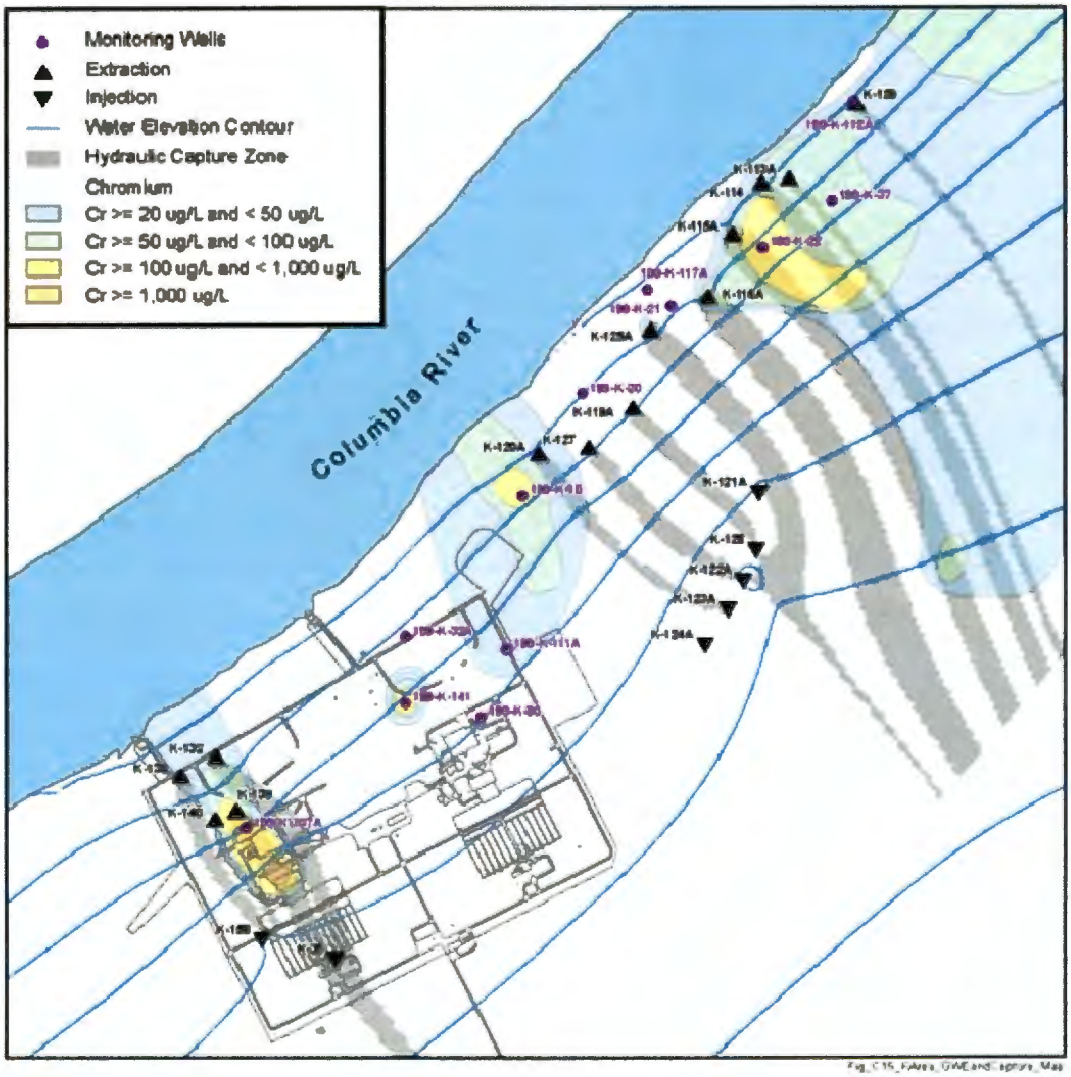
Figure 3-12. 100-KR-4 Capture Frequency Map (Mapped).



NOTE: Not all extraction wells and injection wells were installed or used in the capture zone development.

The fourth hexavalent chromium plume is located near the KW Reactor. High hexavalent chromium concentrations in wells 199-K-137 and 199-K-165 (located upgradient of the KW Reactor) suggest that the plume may have been caused by a leak or spill of concentrated sodium dichromate solution. The KW Reactor's hexavalent chromium plume is being remediated by the KW Reactor pump-and-treat system.

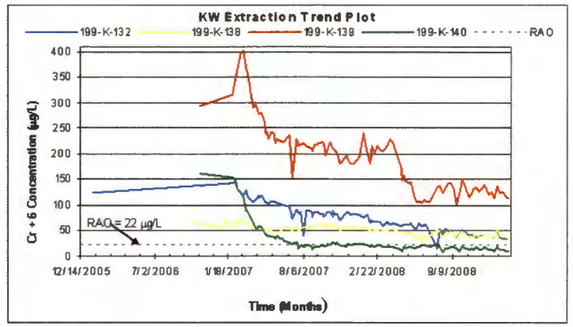
Figure 3-13. 100-KR-4 Area Capture Efficiency Map (Modeled), Including Hexavalent Chromium Plume.

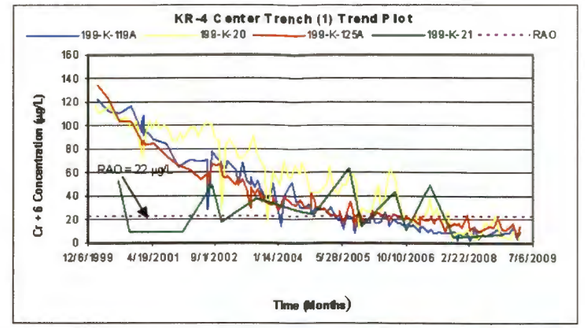


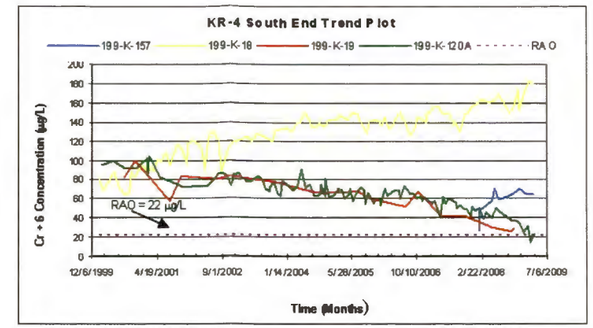
Small, one-well plumes are depicted in Figure 3-14 at wells 199-K-36 (hexavalent chromium at 21.4 µg/L) and extraction well 199-K-125A (hexavalent chromium at 21 µg/L). These values represent the fall 2008 peak concentrations in trends that are normally <22 µg/L. New aquifer tube C6241 (hexavalent chromium at 32.1 µg/L), located midway between the KE and KW Reactors, requires additional sampling to establish a trend at this location. The source of this hexavalent chromium may be from either of the two reactors.

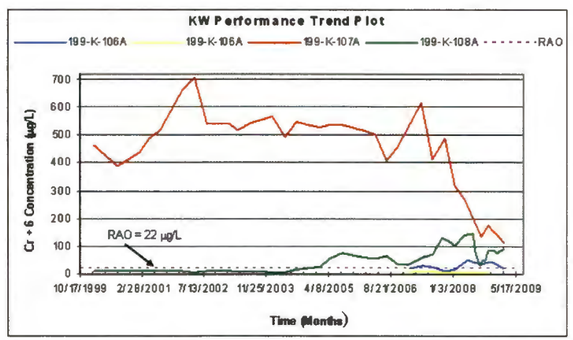
3.2.3.1.1 116-K-2 Trench Chromium Plumes. Two hexavalent chromium plumes are associated with the 116-K-2 Trench. The larger plume is located near the northeast end of the trench, and the smaller plume is located near the southwest end of the trench. Both plumes are larger in size than other plumes in the 100-K Area, and both plumes are currently being remediated by the 100-KR-4 pump-and-treat system. Table 3-5 compares hexavalent chromium concentrations in samples collected from wells in fall CY08 and aquifer tubes to concentrations in the baseline samples. Baseline concentrations for wells in the 100-K Area were selected following the criteria previously outlined in Section 2.2.3.1. The maximum 2008 hexavalent chromium concentration in the 116-K-2 Trench area was 128 µg/L in well 199-K-163, located upgradient of the trench. This well was installed in 2007 as part of the 100-KR-4 pump-and-treat system expansion.

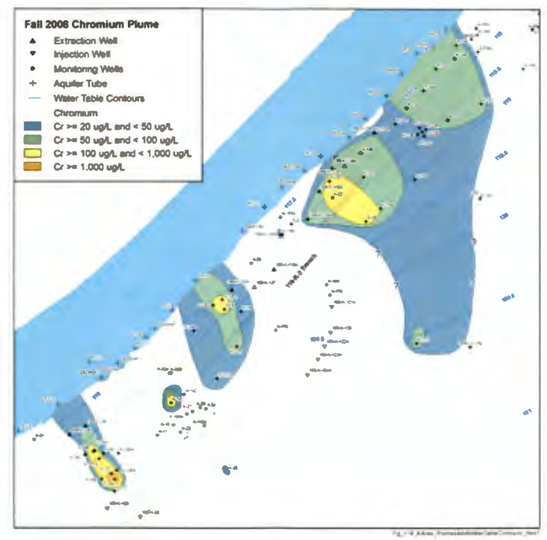
Figure 3-14. 100-KR-4 Chromium Plume, Fall 2008.

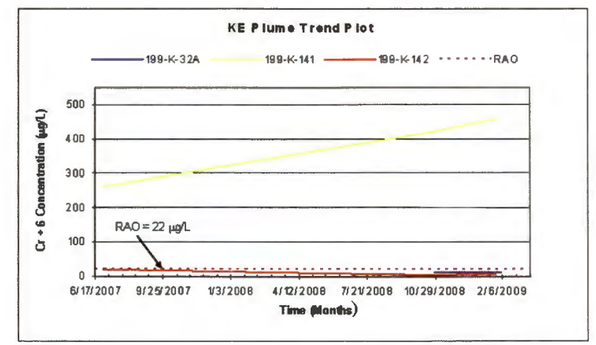


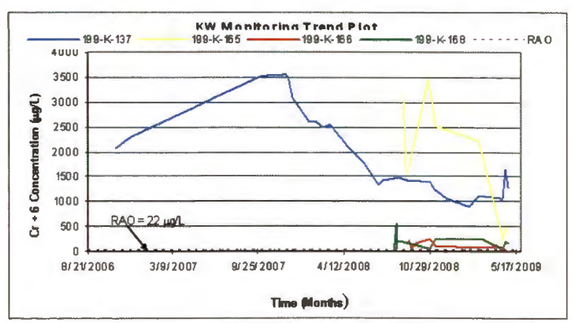


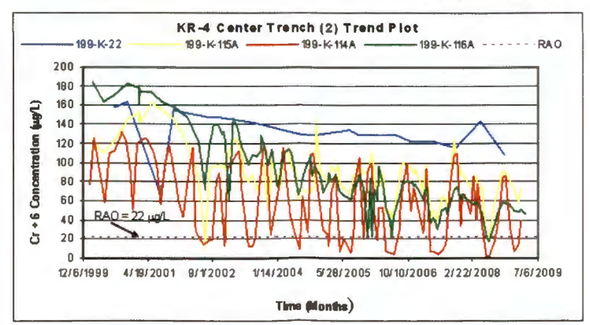












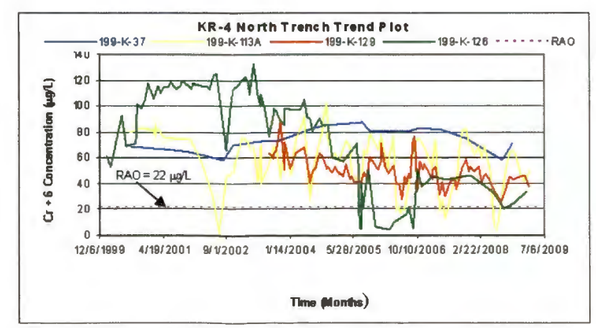


Table 3-5. Change in Hexavalent Chromium and Total Chromium Concentrations from Baseline Through 2008 for Wells and Aquifer Tubes Monitoring the 116-K-2 Trench. (4 pages)

Well or Aquifer Tube Name	Use	Baseline Sample					Fall 2008 Sample					Percent Change in Conc. Since Baseline Sampling (Negative = Decrease)		
		Filtered & Unfiltered Cr^{+6}		Total Chromium			Filtered & Unfiltered Cr^{+6}		Total Chromium					
		Date Collected	Conc. (µg/L)	Date Collected	Unfilt. (µg/L)	Filt. (µg/L)	Date Collected	Conc. (µg/L)	Date Collected	Unfilt. (µg/L)	Filt. (µg/L)	Cr^{+6} (µg/L)	Total Chromium	
													Unfilt.	Filt.
199-K-111A	M	3/7/06	33	11/15/96	25.4	8.4	--	--	10/6/08	26.1 (B)	28.9 (B)	--	2.8	244.0
199-K-116A	E	11/20/96	190	--	--	--	12/1/08	54.5	--	--	--	-71.3	--	--
199-K-117A	C	11/21/96	200	5/27/98	--	81.9	10/6/08	2 (U)	10/6/08	13 (U)	13 (U)	--	--	--
199-K-118Aa	E	11/20/96	150	--	--	--	11/4/08	--	--	--	--	--	--	--
199-K-119A	E	11/21/96	120	--	--	--	11/4/08	7			--	-94.2	--	--
199-K-120A	E	11/26/96	90	--	--	--	11/4/08	38			--	-57.8	--	--
199-K-121A	I	11/13/96	150	--	--	--	--	--	--	--	--	--	--	--
199-K-122A	I	11/13/96	90	--	--	--	--	--	--	--	--	--	--	--
199-K-123A	I	11/14/96	71.3	--	--	--	--	--	--	--	--	--	--	--
199-K-124A	I	11/14/96	50	--	--	--	--	--	--	--	--	--	--	--
199-K-125A	E	11/10/98	161	--	--	--	11/4/08	12	--	--	--	-92.5	--	--
199-K-126	C/E/M	7/26/99	75.6	3/14/05	58.9	--	--	--	11/9/08	32.8	29.7		-44.3	
199-K-127	E	5/14/02	76	--	--	--	11/4/08	14	--	--	--	-81.6	--	--
199-K-129/K-112Ab	E	11/12/96	120	6/13/06	20.6	--	11/4/08	43	--	--	--	-64.2	--	--
199-K-130	M	3/26/03	50	3/7/06	79.2	--	--	--	--	--	--	--	--	--
199-K-131	M	10/20/04	63	--	--	--	--	--	--	--	--	--	--	--
199-K-143	M	2/23/07	22.2	2/23/07	23.3	20.2	--	--	--	--	--	--	--	--
199-K-144	E	4/7/08	38	--	--	--	10/7/08	34	--	--	--	-10.5	--	--
199-K-145	E	4/15/08	25 (N)	--	--	--	--	--	--	--	--	--	--	--
199-K-146	E	1/4/08	110	--	--	--	--	--	--	--	--	--	--	--
199-K-147	E	11/15/07	38	--	--	--	--	--	--	--	--	--	--	--

Table 3-5. Change in Hexavalent Chromium and Total Chromium Concentrations from Baseline Through 2008 for Wells and Aquifer Tubes Monitoring the 116-K-2 Trench. (4 pages)

Well or Aquifer Tube Name	Use	Baseline Sample					Fall 2008 Sample					Percent Change in Conc. Since Baseline Sampling (Negative = Decrease)		
		Filtered & Unfiltered Cr^{+6}		Total Chromium			Filtered & Unfiltered Cr^{+6}		Total Chromium					
		Date Collected	Conc. (µg/L)	Date Collected	Unfilt. (µg/L)	Filt. (µg/L)	Date Collected	Conc. (µg/L)	Date Collected	Unfilt. (µg/L)	Filt. (µg/L)	Cr^{+6} (µg/L)	Total Chromium	
													Unfilt.	Filt.
199-K-148	E	11/14/07	74	--	--	--	--	--	--	--	--	--	--	--
199-K-149	E	11/14/07	64	--	--	--	--	--	--	--	--	--	--	--
199-K-150	E	4/23/08	54	--	--	--	--	--	--	--	--	--	--	--
199-K-151	M	12/14/07	44	--	--	--	11/24/08	60.7	--	--	--	38.0	--	--
199-K-152	M	2/1/08	61.5	--	--	--	9/24/08	75.5	--	--	--	22.8	--	--
199-K-153	M	1/31/08	52.0	--	--	--	9/24/08	38.4	--	--	--	-26.2	--	--
199-K-154	M	11/20/07	99	--	--	--	9/24/08	97.5	--	--	--	-1.5	--	--
199-K-156	I	2/13/08	2 (U)	--	--	--	--	--	--	--	--	--	--	--
199-K-157	M	1/31/08	47.0	--	--	--	9/24/08	64	--	--	--	36.2	--	--
199-K-159	I	11/12/07	7	--	--	--	--	--	--	--	--	--	--	--
199-K-160	I	11/13/07	10	--	--	--	--	--	--	--	--	--	--	--
199-K-161	E	1/4/08	44.0	--	--	--	--	--	--	--	--	--	--	--
199-K-162	E	4/4/08	88.0	--	--	--	--	--	--	--	--	--	--	--
199-K-163	M	11/16/07	129	--	--	--	9/24/08	128	--	--	--	-0.8	--	--
199-K-164	I	4/16/08	2 (U)	--	--	--	--	--	--	--	--	--	--	--
199-K-169	I	7/31/08	4 (B)	--	--	--	--	--	--	--	--	--	--	--
199-K-170	I	8/1/08	4.0	--	--	--	--	--	--	--	--	--	--	--
199-K-171	I	8/18/08	77.0	--	--	--	9/5/08	79.0	--	--	--	2.6	--	--
199-K-172	I	8/26/08	18.0	--	--	--	9/5/08	15.0	--	--	--	-16.7	--	--
199-K-18	C	12/16/96	40	12/16/96	40	40.1	10/23/08	156	10/23/08	139	152	290.0	247.5	279.1
199-K-19	M	12/16/96	40	12/16/96	84.8	85.8	10/23/08	28.7	10/23/08	27.4	22.7	-28.3	-67.7	-73.5

Table 3-5. Change in Hexavalent Chromium and Total Chromium Concentrations from Baseline Through 2008 for Wells and Aquifer Tubes Monitoring the 116-K-2 Trench. (4 pages)

Well or Aquifer Tube Name	Use	Baseline Sample					Fall 2008 Sample					Percent Change in Conc. Since Baseline Sampling (Negative = Decrease)		
		Filtered & Unfiltered Cr^{+6}		Total Chromium			Filtered & Unfiltered Cr^{+6}		Total Chromium					
		Date Collected	Conc. (µg/L)	Date Collected	Unfilt. (µg/L)	Filt. (µg/L)	Date Collected	Conc. (µg/L)	Date Collected	Unfilt. (µg/L)	Filt. (µg/L)	Cr^{+6} (µg/L)	Total Chromium	
													Unfilt.	Filt.
199-K-20	C	2/25/97	129	11/15/96	148	--	10/27/08	5.5	10/27/08	18.5 (B)	11.3 (B)	-95.7	-87.5	--
199-K-21	M	11/18/96	120	11/18/96	122	111	10/23/08	6.7	10/23/08	19.4 (B)	10 (U)	-94.4	-84.1	--
Aquifer Tubes														
C6248	AT	9/30/08	3.7	--	--	--	--	--	--	--	--	--	--	--
C6249	AT	9/30/08	10.1	--	--	--	--	--	--	--	--	--	--	--
C6250	AT	9/30/08	25.7	--	--	--	--	--	--	--	--	--	--	--
C6252	AT	11/6/08	2 (U)	--	--	--	--	--	--	--	--	--	--	--
C6253	AT	11/6/08	18	--	--	--	--	--	--	--	--	--	--	--
C6254	AT	11/5/08	2 (UN)	--	--	--	--	--	--	--	--	--	--	--
C6255	AT	11/5/08	2 (UN)	--	--	--	--	--	--	--	--	--	--	--
C6256	AT	11/5/08	13 (N)	--	--	--	--	--	--	--	--	--	--	--
19-D	AT	12/2/97	5 (U)	--	--	--	--	--	--	--	--	--	--	--
21-M	AT	11/24/97	41	--	--	--	--	--	--	--	--	--	--	--
22-M/D	AT	12/2/97	59	--	--	--	--	--	--	--	--	--	--	--
23-D	AT	12/2/97	81	--	--	--	--	--	--	--	--	--	--	--
26-D	AT	11/19/97	5 (U)	--	--	--	--	--	--	--	--	--	--	--
DK-04-2	AT	12/4/97	25	--	--	--	--	--	--	--	--	--	--	--
AT-K-3-D	AT	3/2/04	37	--	--	--	--	--	--	--	--	--	--	--
AT-K-4-M	AT	3/29/06	1 (U)	--	--	--	--	--	--	--	--	--	--	--

Table 3-5. Change in Hexavalent Chromium and Total Chromium Concentrations from Baseline Through 2008 for Wells and Aquifer Tubes Monitoring the 116-K-2 Trench. (4 pages)

Well or Aquifer Tube Name	Use	Baseline Sample					Fall 2008 Sample					Percent Change in Conc. Since Baseline Sampling (Negative = Decrease)		
		Filtered & Unfiltered Cr^{+6}		Total Chromium			Filtered & Unfiltered Cr^{+6}		Total Chromium					
		Date Collected	Conc. (µg/L)	Date Collected	Unfilt. (µg/L)	Filt. (µg/L)	Date Collected	Conc. (µg/L)	Date Collected	Unfilt. (µg/L)	Filt. (µg/L)	Cr^{+6} (µg/L)	Total Chromium	
													Unfilt.	Filt.
AT-K-5-D	AT	3/2/04	58.7	--	--	--	--	--	--	--	--	--	--	--
AT-K-6-M	AT	3/2/04	34.2	--	--	--	--	--	--	--	--	--	--	--

NOTES:

1. Well use: C = compliance, E = extraction, I = injection, M = monitoring; X = 100-KR-4 expansion well, use to be determined.
2. Abbreviations: NA = not available, UF = unfiltered, µg/L= micrograms/liter (parts per billion [ppb]).
3. Aquifer tube nomenclature regarding relative depth: D = deepest, M = middle, S = shallowest.
4. Change in hexavalent chromium concentration at site #22 included sample results from both the middle and deep tube in cluster because all tubes not sampled each year.
5. Change in hexavalent chromium concentration is not calculated when "U" (undetected) values are used in calculation. Where both values have a "U" qualifier, the values are assumed not to have changed significantly.
6. The 2007 results for injection wells are treated effluent hexavalent chromium concentrations.
7. Laboratory qualifiers: U = undetected (shown with detection limit in parentheses); B = detected above instrument or method detection limit, but below contract-required detection; D = sample diluted.
8. Hexavalent chromium results from well 199-K-126 have been influenced by the calcium polysulfide treatability test that changed the color of the groundwater and so strongly influence the colorimetric EPA Method 7196 results. High out-of-trend results from this well have been rejected because of the lingering calcium polysulfide influence.
9. Blank cells indicate that the sample was not collected, the analysis was not performed, or the change in concentration was not calculated.

[a] Well 199-K-118A was replaced with well 199-125A in 1998 after it was determined that the well could no longer adequately support pumping operations

[b] Well 199-K-119A was replaced with well 199-129 in 2003 after it was determined that the well could no longer adequately support pumping operations

The largest decrease in hexavalent chromium concentration from baseline concentrations has generally occurred in the central portion of the 116-K-2 Trench plume, where fall 2008 hexavalent chromium concentrations remained <22 μg/L in wells 199-K-20, 199-K-21, 199-K-117A, 199-K-119A, and 199-K-127. The 2008 concentrations represent a decrease of approximately 82% to 96% in hexavalent chromium in these wells since the start of pump-and-treat operations in 1997. Wells 199-K-20 and 199-K-117A are interim action compliance wells.

Hexavalent chromium concentrations ranged from 2 to 18 μg/L in new aquifer tubes located near the central portion of the 116-K-2 Trench. Six new aquifer tubes were installed in this area (including tubes C6251 through C6256). Five of these aquifer tubes (excluding aquifer tube C6251) were sampled during the fall of CY08. Fall 2008 hexavalent chromium concentrations in new aquifer tube C6250 (25.7 μg/L) and aquifer tube AT-22 (59 μg/L) support the gaps in capture displayed in Figure 3-13.

The largest increase in hexavalent chromium concentration in CY08 was in well 199-K-18, which is a monitoring well located within the plume, near the southwestern limit of the 116-K-2 Trench. Concentrations in this well increased from 40 μg/L in 1996 to 156 μg/L in the fall of 2008 (an increase of 290%). As shown in the trend plot in Figure 3-14, concentrations in this well have generally increased since extraction was initiated in 1997 and are most likely due to extraction and migration of the contaminant plume toward the river. The effects of plume migration are clearly seen on the trend plots for well 199-K-18 and upgradient well 199-K-111A (note that CY08 data for well 199-K-111A are total chromium results only). The chromium trend in well 199-K-111A appears to have peaked between 2003 and 2005 and is gradually declining. Well 199-K-157, located further upgradient within the plume, similarly shows an increase in hexavalent chromium concentration to 64 μg/L, which is over the baseline value of 47 μg/L. Since the baseline value was only established in early 2008, this well will need to be monitored for a longer period of time to substantiate the trends.

The total chromium concentration (for filtered samples) in well 199-K-18 has also increased 279% since the baseline concentration was established. Well 199-K-151, located in the upgradient portion of the plume to the north of the 116-K-2 Trench, shows an increase of 38% between the total chromium concentration established as the baseline in late 2007. Well 199-K-151 will also need to be monitored for a longer period of time before valid conclusions regarding trends can be drawn.

Hexavalent chromium concentrations have stabilized and continue to remain below the 22 μg/L RAO in compliance well 199-K-117A and in extraction wells 199-K-119A and 199-K-125A (Figure 3-14). Based on these monitoring results, the sampling frequency and use of these wells in the pump-and-treat network could be optimized in the future.

3.2.3.1.2 KW Reactor Hexavalent Chromium Plume. The KW Reactor hexavalent chromium plume has been monitored since the early 1990s when many of the CERCLA monitoring wells were installed. The KW Reactor pump-and-treat system, consisting of four extraction wells and two injection wells, became operational in January 2007 to remediate this plume after elevated hexavalent chromium concentrations were detected in aquifer tube AT-K-1. Table 3-6 compares the hexavalent chromium concentrations of fall CY08 samples collected from wells and aquifer tubes to baseline samples.

The highest fall 2008 hexavalent chromium concentration was 3,020 μg/L, taken while drilling new monitoring well 199-K-165, which is located a short distance upgradient of the KW Reactor.

The hexavalent chromium plume in the vicinity of well 199-K-165 (and proximally downgradient well 199-K-137, which had a fall 2008 hexavalent chromium concentration of 1,390 μg/L) is assumed to be caused by a nearby sodium dichromate leak or spill because of the high hexavalent chromium concentrations detected in samples from these wells. This plume is also thought to be limited in area because fall 2008 hexavalent chromium concentrations in nearby upgradient well 199-K-173 and adjacent wells 199-K-108A and 199-K-166 are much lower. Downgradient wells 199-K-107A, 199-K-139, and 199-K-168 also had relatively low hexavalent chromium concentrations in the fall of 2008. Lower concentrations of chromium in the downgradient wells may be attributed to a liquid effluent source rather than a concentrated sodium dichromate source.

Table 3-6. Change in Hexavalent Chromium and Total Chromium from Baseline Through 2008 in Wells and Aquifer Tubes Monitoring the KW Reactor Area. (2 pages)

Well or Aquifer Tube Name	Use	Baseline Sample					Fall 2008 Sample					Percent Change in Conc. Since Baseline Sampling (Negative = Decrease)		
		Filtered & Unfiltered Cr^{+6}		Total Chromium			Filtered & Unfiltered Cr^{+6}		Total Chromium					
		Date Collected	Conc. (µg/L)	Date Collected	Unfilt. (µg/L)	Filt. (µg/L)	Date Collected	Conc. (µg/L)	Date Collected	Unfilt. (µg/L)	Filt. (µg/L)	Cr^{+6} (µg/L)	Total Chromium	
													Unfilt.	Filt.
199-K-34	M	1/22/07	22	11/15/96	12.9	8.4 (C)	10/27/08	44.1	10/27/08	50.2	45	100.5	289.1	435.7
199-K-35	M	--	--	12/4/96	34.6	8.7 (B)	--	--	--	--	--	--	--	--
199-K-106A	M	1/18/07	10.7	12/5/96	4.4 (U)	4.4 (U)	10/6/08	4.8	10/6/08	13 (U)	13 (U)	-55.1	--	--
199-K-107A	M	3/20/97	168	12/5/96	197	190	10/6/08	172	10/6/08	175	175	2.4	-11.2	-7.9
199-K-108A	M	3/20/97	197	12/9/96	160	154	10/6/08	81.5	10/6/08	85.7	81.6	-58.6	-46.4	-47.0
199-K-31	M	--	--	12/2/96	14.4	9 (B)	--	--	10/27/08	10 (U)	13.7 (B)	--	--	52.2
199-K-132	E	10/12/06	180	1/5/05		123	10/23/08	41	10/28/08	45.9	41.2	-77.2	--	-66.5
199-K-137	M	10/24/06	1,942	10/24/06	2,130	2,170	10/28/08	1,390	10/28/08	1,260	1,230	-28.4	-40.8	-43.3
199-K-138	E	10/12/06	68	10/12/06	63	59.3	10/28/08	40.5	--	--	--	-40.4	--	--
199-K-139	E	10/31/06	293.5	10/31/06	284	284	10/31/08	124	--	--	--	-57.8	--	--
199-K-140	E	10/31/06	161	10/31/06	149	148	10/28/08	14.1	--	--	--	-91.2	--	--
199-K-165	M	9/11/08	1,710	9/11/08	1,380	--	11/10/08	2,530 (D)	--	--	--	47.9	--	--
199-K-166	M	9/25/08	172	9/25/08	167	--	11/10/08	101	--	--	--	-45.7	--	--
199-K-168	M	8/23/08	206	8/7/08	175	--	11/10/08	241	--	--	--	-41.2	--	--
199-K-173	M	9/27/08	55	9/27/08	54.5	--	12/1/08	7.3	--	--	--	-85.4	--	--
199-K-158	M	1/19/07	6.5	--	--	--	--	--	--	--	--	--	--	--

Table 3-6. Change in Hexavalent Chromium and Total Chromium from Baseline Through 2008 in Wells and Aquifer Tubes Monitoring the KW Reactor Area. (2 pages)

Well or Aquifer Tube Name	Use	Baseline Sample					Fall 2008 Sample					Percent Change in Conc. Since Baseline Sampling (Negative = Decrease)		
		Filtered & Unfiltered Cr^{+6}		Total Chromium			Filtered & Unfiltered Cr^{+6}		Total Chromium					
		Date Collected	Conc. (µg/L)	Date Collected	Unfilt. (µg/L)	Filt. (µg/L)	Date Collected	Conc. (µg/L)	Date Collected	Unfilt. (µg/L)	Filt. (µg/L)	Cr^{+6} (µg/L)	Total Chromium	
													Unfilt.	Filt.
Aquifer Tubes														
17-D	AT	12/1/97	6	10/28/98	--	10.5	--	--	--	--	--	--	--	--
AT-K-1-D/M	AT	3/2/04	2	3/2/04	--	4.4 (U)	--	--	--	--	--	--	--	--

NOTES:

1. Laboratory qualifiers: B = detected above instrument or method detection limit, but below contract-required detection limit; D = sample diluted; C = analyte detected in both the sample and the associated quality control blank, and the sample concentration was less than or equal to five times the blank concentration; U = analyte undetected and the detection limit is included within parentheses.
2. Well use: C = compliance, E = extraction, I= injection, M = monitoring.
3. Abbreviations: NA = not available, NC = not calculated, UF = unfiltered, µg/L= micrograms/liter (parts per billion [ppb]); AT=aquifer tube.
4. Aquifer tube nomenclature regarding relative depth: D = deepest, M = middle, S = shallowest.
5. Change in hexavalent chromium concentration at site AT-K-1 included sample results from both the middle and deep tube in cluster because all tubes not sampled each year.
6. Change in hexavalent chromium concentration is not calculated when "U" (undetected) values are included in comparison. Where both values have "U" qualifier, the values are assumed not to have changed significantly.
7. Blank cells indicate that the sample was not collected, the analysis was not performed, or the change in concentration was not calculated.
8. For wells 199-K-165, 199-K-166, 199-K-168 and 199-K-173, baseline results taken from well development sample. Fall 2008 sample values represent scheduled quarterly samples. Vertical profile sample results taken during well drilling and during late-October 2008 vertical profile sampling activities were not considered for this table.

The largest increase in hexavalent chromium concentration over the baseline in the KW Reactor area was 47.9% in well 199-K-165. Concentrations increased from 1,710 µg/L in September 2008 (when the baseline sample was collected during well development) to 2,530 µg/L in the November 2008. Since the baseline was only recently established, this well will need to be monitored for a longer period to establish a valid trend. Another relatively large increase was seen in monitoring well 199-K-34, which is located a short distance downgradient from the KW Reactor building. The baseline hexavalent chromium concentration in this well was 22 µg/L in 1996 and the fall 2008 concentration was 44.1 µg/L, which is an increase of 100%.Changes in total chromium concentration over baseline, where available, are generally comparable to hexavalent chromium changes when filtered data are considered. An exception is seen in well 199-K-34, which shows an approximate 436% increase in fall 2008 filtered total chromium concentration over the baseline.

Most other wells located near the KW Reactor plume show decreases in concentration ranging from 28% to 91% when fall 2008 concentrations are compared to baseline concentrations. Two monitoring wells show relatively stable trends: well 199-K-168 was only recently installed and the trend is developing; and well 199-K-107A is centrally located within the plume, downgradient of the KW Reactor.

3.2.3.1.3 KE Reactor Hexavalent Chromium Plume. The KE Reactor hexavalent chromium plume has been monitored since the early 1990s when many of the CERCLA monitoring wells were installed. Table 3-7 compares hexavalent and total chromium concentrations of fall CY08 samples collected from wells and aquifer tubes to the baseline samples. The source of this plume may be a combination of localized spills or leaks associated with the KE Reactor water treatment facilities combined with the large plume created by previous mounding around the 116-K-2 Trench. A high hexavalent chromium concentration attributable to concentrated sodium dichromate solution has not been observed in the KE Reactor area since a 1,332 µg/L chromium spike was detected in August 2001.

The highest fall 2008 hexavalent chromium concentration in this plume was 421 µg/L in well 199-K-141, located about 200 m (656 ft) downgradient of the KE Reactor. This well also had the highest filtered total chromium concentration (402 µg/L) in the fall of 2008. Two monitoring wells located 200 m (656 ft) downgradient (199-K-32A and 199-K-32B) show little evidence of downgradient transport, but new aquifer tubes C6240 and C6241 showed concentrations of 20.5 and 32.1 µg/L, respectively. The current configuration of downgradient monitoring wells is not optimal. Two new wells located downgradient of well 199-K-141 and upgradient of wells 199-K-32A/B will be drilled in CY 2009 to bound the 199-K-141 plume and to provide extraction control on this plume as it moves toward the Columbia River. Additionally, this well could be converted for use as an extraction well.

A small plume is defined by well 199-K-36, located near the 183-KE sedimentation basin. Historic chromium trends at this well have spiked to 1,330 µg/L in the January 2001 to August 2002 timeframe. This well is located near the primary vadose zone contamination site, the 183-KE sodium dichromate storage tank (120-KE-6) and its associated unloading pad/sump. This location, and its twin at the 183-KW sedimentation basin, will be characterized following recommendations in the 100-K Area RI/FS work plan.

The maximum hexavalent chromium concentration in an aquifer tube downgradient of the KE Reactor area was 32.1 µg/L in aquifer tube C6241. This tube is located midway between the KE and KW Reactors and could be the result of KW Reactor groundwater plume migration parallel to the river.

The largest increase in hexavalent chromium from the baseline to fall 2008 was 86.3% in well 199-K-141. In addition, well 199-K-32B showed an increase in filtered total chromium over the baseline concentration of nearly 220%, although both concentration values are <22 µg/L. In any case, it should be noted that this well monitors a water-bearing interbed within the RUM rather than the overlying unconfined aquifer.

Table 3-7. Change in Hexavalent Chromium and Total Chromium from Baseline Through 2008 in Wells and Aquifer Tubes Monitoring the KE Reactor Area. (2 pages)

Well or Aquifer Tube Name	Use	Baseline Sample					Fall 2008 Sample					Percent Change in Conc. Since Baseline Sampling (Negative = Decrease)		
		Filtered & Unfiltered Cr^{+6}		Total Chromium			Filtered & Unfiltered Cr^{+6}		Total Chromium					
		Date Collected	Conc. (µg/L)	Date Collected	Unfilt. (µg/L)	Filt. (µg/L)	Date Collected	Conc. (µg/L)	Date Collected	Unfilt. (µg/L)	Filt. (µg/L)	Cr^{+6} (µg/L)	Total Chromium Unfilt.	Total Chromium Filt.
199-K-32A	M	--	--	12/9/96	25.3	21.7	10/27/08	13.1	10/27/08	21.6	21.4	--	-14.6	-1.4
199-K-32B	M	--	--	12/9/96	27.6	8.6	--	--	10/27/08	32.2	27.5	--	16.7	219.8
199-K-30	M	--	--	11/26/96	6.2 (B)	5.6 (B)	10/27/08	3.3	10/27/08	10 (U)	10 (U)	--	--	--
199-K-29	M	--	--	4/27/99	--	4.8 (U)	--	--	--	--	--	--	--	--
199-K-27	M	--	--	10/27/97	3.5 (U)	3.5 (U)	--	--	--	--	--	--	--	--
199-K-23	M	--	--	12/6/96	219	38.3	10/27/08	2 (U)	10/27/08	20.8	11.3 (B)	--	-90.5	-70.5
199-K-11	M	--	--	12/4/96	12.4	8.9 (B)	10/6/08	2 (U)	10/6/08	13 (U)	13 (U)	--	--	--
199-K-110A	M	--	--	1/19/96	37.3	4.4 (U)	--	--	10/6/08	22.1 (B)	13 (U)	--	-40.8	--
199-K-36	M	10/27/97	17.5	12/4/96	1,120	501	10/27/08	21.4	10/27/08	47.1	31.7	22.3	-95.8	-93.7
199-K-141	M	6/29/07	226	4/27/07	245	--	10/28/08	421	10/28/08	427	402	86.3	74.3	--
199-K-142	M	6/29/07	17.5 (G)	4/27/07	7.8	--	10/28/08	5.8	10/28/08	14.1 (B)	10 (U)	-66.9	80.8	--
Aquifer Tubes														
C6239	AT	9/30/08	11.4	--	--	--	--	--	--	--	--	--	--	--
C6240	AT	9/30/08	16.6	--	--	--	--	--	--	--	--	--	--	--
C6241	AT	9/30/08	32.1	--	--	--	--	--	--	--	--	--	--	--
C6242	AT	9/30/08	17.9	--	--	--	--	--	--	--	--	--	--	--
C6243	AT	9/30/08	20.5	--	--	--	--	--	--	--	--	--	--	--
C6244	AT	9/30/08	14	--	--	--	--	--	--	--	--	--	--	--
C6245	AT	9/30/08	16.6	--	--	--	--	--	--	--	--	--	--	--

Table 3-7. Change in Hexavalent Chromium and Total Chromium from Baseline Through 2008 in Wells and Aquifer Tubes Monitoring the KE Reactor Area. (2 pages)

Well or Aquifer Tube Name	Use	Baseline Sample					Fall 2008 Sample					Percent Change in Conc. Since Baseline Sampling (Negative = Decrease)		
		Filtered & Unfiltered Cr^{+6}		Total Chromium			Filtered & Unfiltered Cr^{+6}		Total Chromium					
		Date Collected	Conc. (µg/L)	Date Collected	Unfilt. (µg/L)	Filt. (µg/L)	Date Collected	Conc. (µg/L)	Date Collected	Unfilt. (µg/L)	Filt. (µg/L)	Cr^{+6} (µg/L)	Total Chromium	
													Unfilt.	Filt.
C6246	AT	9/30/08	14	--	--	--	--	--	--	--	--	--	--	--
C6247	AT	9/30/08	12.7	--	--	--	--	--	--	--	--	--	--	--
18-S	AT	12/1/97	5 (U)	10/28/98	--	5.85	--	--	--	--	--	--	--	--
19-D	AT	12/2/97	5 (U)	4/26/05	--	3.8 (B)	--	--	--	--	--	--	--	--
AT-K-2-D	AT	3/2/04	5.3	--	--	--	--	--	--	--	--	--	--	--

NOTES:

1. Well 199-K-32B is screened within the RUM, and well 199-K-32A is screened within the Ringold Unit E.
2. Well and aquifer tube use: M = monitoring, AT = aquifer tube.
3. Aquifer tube nomenclature regarding relative depth: D = deepest, M = middle, S = shallowest.
4. F = filtered, UF = unfiltered.
5. Laboratory qualifiers: U = undetected (shown with detection limit in parentheses); B = detected above instrument or method detection limit but below contract-required detection limit; C = analyte detected in both the sample and the associated quality control blank, and the sample concentration was less than or equal to five times the blank concentration.
6. Change in hexavalent chromium concentration is not calculated when "U" (undetected) values are involved in calculation. Where both values have a "U" qualifier, the values are assumed not to have changed significantly.
7. Blank cells indicate that the sample was not collected, the analysis was not performed, or the change in concentration was not calculated.

RUM = Ringold Upper Mud (Unit)

3.2.3.2 Co-Contaminant Monitoring Results. Strontium-90 and tritium are listed in the 100-KR-4 ROD (EPA et al. 1996) as target analytes. Nitrate and carbon-14 are target analytes that are also monitored as part of the CERCLA monitoring program because they have been detected above MCLs in certain wells or because of a previous qualitative risk assessment documented in the *100-KR-4 Operable Unit Focused Feasibility Study* (DOE/RL-94-48).

- Strontium-90: Tables 3-8, 3-9, and 3-10 display the strontium-90 results for extraction wells, compliance wells, monitoring wells, and aquifer tubes in the 100-KR-4 operational area around the 116-K-2 Trench and the KW and KE Reactor areas. The fall 2008 results are compared to baseline pre-pump-and-treat results collected mostly in 1996, where available.

  Samples were collected from 13 aquifer tubes located along the shoreline downgradient of the 116-K-2 Trench in the fall of 2008. All aquifer tube analytical results for strontium-90 were less than detection. The strontium-90 results for the 116-K-2 Trench area are summarized below:

  - Baseline samples collected from 40 wells and 22 aquifer tubes indicated that 8 wells had strontium-90 concentrations above the 8 pCi/L MCL. The maximum reading was 76 pCi/L in well 199-K-127 from a sample collected in 2002.
  - Fall 2008 samples were collected from 10 wells, with only one well above the 8 pCi/L MCL for strontium-90. Well 199-K-21 had a fall 2008 strontium-90 concentration of 26.7 pCi/L, which is approximately the same value as the 1996 value of 28.2 pCi/L.
  - Before well 199-K-109A was decommissioned in spring 2008 to support the KE Reactor fuel rod storage basin cleanup, strontium-90 concentrations of 700 to 1,120 pCi/L were reported. This plume is currently confined to this well. A replacement well is planned for FY10 following basin remediation.

  Fall 2008 samples for the KW Reactor area were collected from 12 wells, with the maximum strontium-90 concentration of 36.4 pCi/L found in well 199-K-34, also located downgradient of the KW Reactor. The strontium-90 results for the KW Reactor area are summarized as follows:

  - Baseline samples were collected from 16 wells and 1 aquifer tube, and the results indicated that two wells had strontium-90 concentrations above the 8 pCi/L MCL. The maximum strontium-90 concentration was 41.7 pCi/L in well 199-K-107A, located downgradient of the KW Reactor. Strontium-90 has decreased 42% in this well from the 1997 baseline value.
  - Aquifer tube AT-K-1 was not sampled in the fall of 2008.

  Fall 2008 samples for the KE Reactor area were collected from four wells, with all reported values below the detection limit. Although well 199 K-109A was not sampled in the fall of 2008, sampling in April 2008 indicated 1,120 pCi/L strontium-90. The strontium-90 results are summarized as follows:

  - Baseline samples were collected from 13 wells and 12 aquifer tubes, with the maximum strontium-90 concentration of 3,180 pCi/L found in well 199-K-109A, which is located downgradient of the KE Reactor and monitors the 116-KE-3 french drain disposal system. This was the only well or aquifer tube baseline sample with a strontium-90 concentration above the 8 pCi/L MCL.
  - Nine aquifer tubes located along the shoreline downgradient of the KE Reactor area were sampled. Eight tubes reported strontium-90 below the detection limit and one tube reported a concentration of 3.3 pCi/L.

Table 3-8. Change in Strontium-90 Concentrations from Baseline Through 2008 for Wells and Aquifer Tubes Monitoring the 116-K-2 Trench. (2 pages)

Well or Aquifer Tube	Use	Baseline Sample		Fall 2008 Sample		Change in Sr-90 Conc. Since Baseline Sampling (%) (Negative = Decrease)
		Date Collected	Sr-90 (pCi/L)	Date Collected	Sr-90 (pCi/L)	
199-K-18	C	12/16/96	0.0627 (U)	10/23/08	-1.38 (U)	--
199-K-19	M	12/16/96	12.9	--	--	--
199-K-20	C	11/15/96	11.2	10/27/08	3.05	-72.8
199-K-21	M	11/18/96	28.2	10/23/08	26.7	-5.3
199-K-22	M	11/25/96	9.1	10/23/08	6.78	-25.5
199-K-37	M	11/25/96	5.19	--	--	--
199-K-111A	M	1/19/96	0.25 (U)	--	--	--
199-K-113A	E	11/12/96	6.57	--	--	--
199-K-114A	C/E	11/14/96	20.1	--	--	--
199-K-115A	E	11/12/96	15.5	--	--	--
199-K-116A	E	11/20/96	3.29 (J)	--	--	--
199-K-117A	C	11/21/96	1.57 (J)	10/6/08	0.18 (U)	--
199-K-119A	E	11/21/96	0.925 (J)	--	--	--
199-K-120A	E	11/26/96	0.576 (U)	--	--	--
199-K-121A	I	11/13/96	0.174 (U)	--	--	--
199-K-122A	I	11/13/96	0.0691 (U)	--	--	--
199-K-123A	I	11/14/96	0.1425 (U)	--	--	--
199-K-124A	I	11/14/96	0.186 (U)	--	--	--
199-K-118A/125A	E	11/20/96	-0.0238 (U)	--	--	--
199-K-127	E	5/14/02	76	--	--	--
199-K-129/K-112A	E	12/3/03	-0.236 (U)	--	--	--
199-K-130	M	10/14/03	0.402 (U)	--	--	--
199-K-131	M	10/20/04	0.0217 (U)	--	--	--
699-78-62	M	9/22/1992	0.11 (U)	--	--	--
199-K-144	E	4/23/08	7.7	--	--	--
199-K-145	E	4/23/08	0.217 (U)	--	--	--
199-K-146	E	5/1/08	0.237 (U)	--	--	--
199-K-150	E	4/23/08	0.199 (U)	--	--	--
199-K-151	M	9/24/08	-2.9 (U)	11/24/08	-7.2 (U)	--
199-K-152	M	6/30/08	-2.8 (U)	9/24/08	3.0	--
199-K-153	M	6/30/08	-1.4 (U)	9/24/08	-1.2 (U)	--
199-K-154	M	6/30/08	0.0681 (U)	9/24/08	0.53 (U)	--
199-K-156	I	5/6/08	0.162 (U)	--	--	--
199-K-157	M	5/1/08	0.189 (U)	11/18/08	0.6 (U)	--
199-K-161	E	4/23/08	20.1	--	--	--
199-K-162	E	5/1/08	-0.123 (U)	--	--	--

Table 3-8. Change in Strontium-90 Concentrations from Baseline Through 2008 for Wells and Aquifer Tubes Monitoring the 116-K-2 Trench. (2 pages)

Well or Aquifer Tube	Use	Baseline Sample		Fall 2008 Sample		Change in Sr-90 Conc. Since Baseline Sampling (%) (Negative = Decrease)
		Date Collected	Sr-90 (pCi/L)	Date Collected	Sr-90 (pCi/L)	
199-K-164	I	4/23/08	-0.0895 (U)	--	--	--
199-K-169	I	8/20/08	-0.14 (U)	--	--	--
199-K-170	I	8/20/08	-0.68 (U)	--	--	--
199-K-171	I	9/5/08	-0.49 (U)	--	--	--
199-K-172	I	9/5/08	-2 (U)	--	--	--
Aquifer Tubes						
C6248	AT	9/30/08	-2.7 (U)	--	--	--
C6249	AT	9/30/08	-0.39 (U)	--	--	--
C6250	AT	9/30/08	0.73 (U)	--	--	--
C6252	AT	11/6/08	-0.578 (U)	--	--	--
C6253	AT	11/6/08	-1.03 (U)	--	--	--
C6254	AT	11/5/08	0.964 (U)	--	--	--
C6255	AT	11/5/08	-0.599 (U)	--	--	--
C6256	AT	11/5/08	-0.209 (U)	--	--	--
C6257	AT	11/10/08	0.545 (U)	--	--	--
C6258	AT	11/10/08	-2.35 (U)	--	--	--
C6259	AT	11/10/08	-2.19 (U)	--	--	--
C6260	AT	11/10/08	-1.41 (U)	--	--	--
C6261	AT	11/10/08	-1.86 (U)	--	--	--
19-D/M	AT	10/30/00	0.26 (U)	--	--	--
21-M	AT	12/2/97	1.73 (J)	--	--	--
22-M/D	AT	12/2/97	17.9	--	--	--
23-D	AT	12/2/97	0.20 (U)	--	--	--
DK-04-2	AT	11/2/98	-0.04 (U)	--	--	--
AT-K-3-D/M	AT	5/2/05	0.0374 (U)	--	--	--
AT-K-4-M	AT	3/29/06	0.55	--	--	--
AT-K-5-D/M	AT	3/2/04	-0.07 (U)	--	--	--
AT-K-6-M	AT	3/2/04	-0.06 (U)	--	--	--

NOTES:

1. Well use: C = compliance, E = extraction, I = injection, M = monitoring; AT = aquifer tube.
2. Abbreviations: NA = not available, NC = not calculated.
3. Aquifer tube nomenclature indicates relative depth: D = deepest, M = middle, S = shallowest.
4. Laboratory qualifiers: U = undetected, J = value reported is estimated.
5. Change in strontium-90 concentration at some aquifer tube clusters may include sample results from both the middle and deep tube in cluster because all tubes not sampled each year.
6. Change in stontium-90 concentration not calculated when "U" (undetected) values are compared.
7. Blank cells indicate that the sample was not collected, the analysis was not performed, or the change in concentration was not calculated.
8. Negative values are acceptable statistical artifacts of radiological counting techniques and indicate non-detectable amounts of the target radionuclide.

Table 3-9. Change in Strontium-90 in Wells and Aquifer Tubes Monitoring the KW Reactor Area.

Well or Aquifer Tube	Use	Baseline Sample		Fall 2008 Sample		Change in Sr-90 Conc. Since Baseline Sampling (%) (Negative = Decrease)
		Date Collected	Sr-90 (pCi/L)	Date Collected	Sr-90 (pCi/L)	
199-K-34	M	4/28/97	23.8	10/27/08	36.4	52.9
199-K-35	M	1/15/96	-0.02 (U)	--	--	--
199-K-106A	M	10/15/97	1.59 (U)	--	--	--
199-K-107A	M	10/15/97	41.7	10/6/08	24	-42.4
199-K-108A	M	4/24/97	1.30 (U)	11/18/08	-1.03 (U)	--
199-K-31	M	1/9/96	0.09 (U)	--	--	--
199-K-132	E	1/27/05	0.03 (U)	10/28/08	-2.38 (U)	--
199-K-137	M	NS	NA	10/28/08	-0.686 (U)	--
199-K-138	E	4/12/07	0.00 (U)	10/28/08	-0.602 (U)	--
199-K-139	E	4/12/07	0.12 (U)	10/30/08	0.717 (U)	--
199-K-140	E	4/27/07	1.51	10/28/08	0.026 (U)	--
199-K-165	M	8/28/08	-4.2 (U)	11/10/08	-1.89 (U)	--
199-K-166	M	9/11/08	1.1	11/10/08	-1.41 (U)	--
199-K-168	M	8/7/08	-1.9 (U)	11/10/08	-1.87 (U)	--
199-K-173	M	9/20/08	0.29 (U)	9/27/08	-4 (U)	--
199-K-158	M	1/19/07	-1.5 (U)	--	--	--
Aquifer Tubes						
AT-K-1-D/M	AT	4/26/05	-0.02 (U)	--	--	--

NOTES:

1. Well use: C = compliance, E = extraction, I = injection, M = monitoring.
2. Abbreviations: AT = aquifer tube, NA = not available, NC = not calculated, NS = not sampled
3. Aquifer tube nomenclature regarding relative depth: D = deepest, M = middle, S = shallowest.
4. Laboratory qualifiers: U = not detected in sample above detection limit.
5. Change in strontium-90 concentration at site AT-K-1 included sample results from both the middle and deep tube in cluster because all tubes not sampled each year.
6. Change in strontium-90 concentration is approximate when "U (undetected) values are used in calculation. Where both values have "U" qualifier, the values are assumed not to have changed significantly.
7. Blank cells indicate that the sample was not collected, the analysis was not performed, or the change in concentration was not calculated.
8. Negative values are acceptable statistical artifacts of radiological counting techniques and indicate non-detectable amounts of the target radionuclide.

Table 3-10. Change in Strontium-90 in Wells and Aquifer Tubes Monitoring the KE Reactor Area.

Well or Aquifer Tube	Use	Baseline Sample		Fall 2008 Sample		Change in Sr-90 Conc. Since Baseline Sampling (%) (Negative = Decrease)
		Date Collected	Sr-90 (pCi/L)	Date Collected	Sr-90 (pCi/L)	
199-K-32A	M	1/26/96	1.76 (J)	--	--	--
199-K-32B	M (see note 1)	1/26/96	0.29 (U)	--	--	--
199-K-30	M	1/18/96	0.19 (U)	10/27/08	-2.49 (U)	--
199-K-29	M	10/15/97	0.95 (U)	--	--	--
199-K-27	M	10/15/97	1.43 (U)	--	--	--
199-K-23	M	7/30/97	0.11 (U)	10/27/08	0.406 (U)	--
199-K-11	M	1/17/96	0.73 (U)	--	--	--
199-K-109A	M	10/28/96	3,180	--	--	--
199-K-110A	M	4/23/97	1.61 (J)	--	--	--
199-K-36	M	1/16/96	-0.13 (U)	--	--	--
199-K-141	M	10/8/07	0.01 (U)	10/28/08	-0.498 (U)	--
199-K-142	M	10/8/07	-0.07 (U)	10/28/08	-1.42 (U)	--
Aquifer Tubes						
C6239	AT	9/30/08	-1 (U)	--	--	--
C6240	AT	9/30/08	0.29 (U)	--	--	--
C6241	AT	9/30/08	-0.61 (U)	--	--	--
C6242	AT	9/30/08	-1.5 (U)	--	--	--
C6243	AT	9/30/08	-1.9 (U)	--	--	--
C6244	AT	9/30/08	-1.3 (U)	--	--	--
C6245	AT	9/30/08	0.4 (U)	--	--	--
C6246	AT	9/30/08	3.3	--	--	--
C6247	AT	9/30/08	0.87 (U)	--	--	--
18-S	AT	11/5/99	0.06 (U)	--	--	--
19-D	AT	10/30/00	0.26 (U)	--	--	--
AT-K-2-M	AT	5/2/05	0.02 (U)	--	--	--

NOTES:

1. Well 199-K-32B is screened within the Ringold Upper Mud Unit and well 199-K-32A is screened within Ringold Unit E.
2. Well and aquifer tube use: M = monitoring, AT = aquifer tube.
3. Abbreviations: NA = not available, NC = not calculated.
4. Aquifer tube nomenclature regarding relative depth: D = deepest, M = middle, S = shallowest.
5. Laboratory qualifiers: J = reported value is an estimate; U = not detected in sample above detection limit.
6. Change in strontium-90 concentration is approximate when "U" (undetected) values are used in calculation. Where both values have "U" qualifier, the values are assumed not to have changed significantly.
7. Negative values are acceptable statistical artifacts of radiological counting techniques and indicate non-detectable amounts of the target radionuclide.

- Tritium: Tables 3-11, 3-12, and 3-13 list the tritium results for extraction wells, compliance wells, monitoring wells, and aquifer tubes in the 100-KR-4 operational area around the 116-K-2 Trench and the KW and KE Reactor areas. The fall 2008 results are compared to baseline pre-pump-and-treat results collected mostly in 1996, where available. Several new aquifer tubes had baseline concentrations established in 2008.

Table 3-11. Change in Tritium Concentrations from Baseline Through 2008 for Wells and Aquifer Tubes Monitoring the 116-K-2 Trench. (3 pages)

Well or Aquifer Tube	Use	Baseline Sample		Fall 2008 Sample		Change in Tritium Conc. Since Baseline Sampling (%) (Negative = Decrease)
		Date Collected	H-3 (pCi/L)	Date Collected	H-3 (pCi/L)	
199-K-18	C	7/31/96	24,597	10/23/08	29,000	17.9
199-K-19	M	12/16/96	11,000	10/23/08	2,900	-73.6
199-K-20	C	11/15/96	431	10/27/08	5,400	1,152.9
199-K-21	M	11/18/96	841	10/23/08	240	-71.5
199-K-22	M	11/25/96	463	10/23/08	250	-46.0
199-K-37	M	11/25/96	268 (U)	10/27/08	188 (U)	--
199-K-111A	M	11/15/96	280 (U)	10/6/08	6,000	--
199-K-113A	E	11/12/96	104 (U)	--	--	--
199-K-114A	C/E	11/14/96	302 (U)	--	--	--
199-K-115A	E	11/12/96	334 (J)	--	--	--
199-K-116A	E	11/20/96	536	--	--	--
199-K-117A	C	11/21/96	587	10/6/08	200 (U)	--
199-K-119A	E	11/21/96	547	--	--	--
199-K-120A	E	11/26/96	85,100	--	--	--
199-K-118A/125A	E	11/20/96	551	--	--	--
199-K-127	E	5/14/02	364 (J)	--	--	--
199-K-129/K-112A	E	11/12/96	150 (U)	--	--	--
199-K-130	M	10/14/03	3,990	--	--	--
199-K-131	M	10/20/04	3,800	--	--	--
699-78-62	M	9/22/1992	-81 (U)	11/23/08	1,700	--
199-K-121A	I	11/13/96	350 (J)	--	--	--
199-K-122A	I	11/13/96	212 (U)	--	--	--
199-K-123A	I	11/14/96	260 (J)	--	--	--
199-K-124A	I	11/14/96	67.3 (U)	--	--	--
199-K-144	E	4/23/08	286,000	10/7/08	200,000	-30.1
199-K-145	E	4/23/08	5,970	--	--	--
199-K-146	E	5/1/08	25.5 (U)	--	--	--
199-K-150	E	4/23/08	3,060	--	--	--
199-K-152	M	6/30/08	490	12/8/08	800	--
199-K-153	M	6/30/08	44 (U)	12/1/08	0.9 (U)	--
199-K-156	I	5/6/08	6,380	--	--	--

Table 3-11. Change in Tritium Concentrations from Baseline Through 2008 for Wells and Aquifer Tubes Monitoring the 116-K-2 Trench. (3 pages)

Well or Aquifer Tube	Use	Baseline Sample		Fall 2008 Sample		Change in Tritium Conc. Since Baseline Sampling (%) (Negative = Decrease)
		Date Collected	H-3 (pCi/L)	Date Collected	H-3 (pCi/L)	
199-K-157	M	5/1/08	621,000	11/18/08	320,000	-48.5
199-K-161	E	4/23/08	71.5 (U)	--	--	--
199-K-162	E	5/1/08	28,000	--	--	--
199-K-164	I	4/23/08	106 (U)	--	--	--
199-K-169	I	8/20/08	7,200	--	--	--
199-K-170	I	8/20/08	7,400	--	--	--
199-K-171	I	9/5/08	670	--	--	--
199-K-172	I	9/5/08	-9.5 (U)	--	--	--
Aquifer Tubes						
C6248	AT	9/30/08	120 (U)	--	--	--
C6249	AT	9/30/08	240.0	--	--	--
C6250	AT	9/30/08	580.0	--	--	--
C6252	AT	11/6/08	-78 (U)	--	--	--
C6253	AT	11/6/08	98 (U)	--	--	--
C6254	AT	11/5/08	-4 (U)	--	--	--
C6255	AT	11/5/08	4.9 (U)	--	--	--
C6256	AT	11/5/08	32 (U)	--	--	--
C6257	AT	11/10/08	24.8 (U)	--	--	--
C6258	AT	11/10/08	45.5 (U)	--	--	--
C6259	AT	11/10/08	-58.1 (U)	--	--	--
C6260	AT	11/10/08	37.8 (U)	--	--	--
C6261	AT	11/10/08	85.1 (U)	--	--	--
19-D/M	AT	12/2/97	10.7 (U)	--	--	--
21-M	AT	12/2/97	244 (U)	--	--	--
22-M/D	AT	12/2/97	95.1 (U)	--	--	--
23-D	AT	12/2/97	284 (U)	--	--	--
26-D	AT	11/13/01	4,690	8/19/08	1,900	--
DK-04-2	AT	12/4/97	5,620	--	--	--
AT-K-3-D/M	AT	5/2/05	2,980	--	--	--
AT-K-4-M	AT	3/29/06	96.5 (U)	--	--	--
AT-K-5-D/M	AT	3/2/04	951	--	--	--
AT-K-6-M	AT	3/2/04	5,240	--	--	--

Table 3-11. Change in Tritium Concentrations from Baseline Through 2008 for Wells and Aquifer Tubes Monitoring the 116-K-2 Trench. (3 pages)

Well or Aquifer Tube	Use	Baseline Sample		Fall 2008 Sample		Change in Tritium Conc. Since Baseline Sampling (%) (Negative = Decrease)
		Date Collected	H-3 (pCi/L)	Date Collected	H-3 (pCi/L)	

NOTES:
1. Well use: C = compliance, E = extraction, I = injection, M = monitoring, AT = aquifer tube.
2. Aquifer tube nomenclature indicates relative depth: D = deepest, M = middle, S = shallowest.
3. Abbreviations: N/A = not available, NC = not calculated.
4. Change in tritium concentration at some aquifer tube clusters may include sample results from both the middle and deep tube in cluster because all tubes not sampled each year.
5. Laboratory qualifiers: J = value reported is an estimate, U = not detected in sample above detection limit.
6. Change in tritium concentration not calculated when "U" (undetected) values are involved in calculation.
7. November 2007 tritium concentrations in injection wells represent samples of treated effluent.
8. Negative values are acceptable statistical artifacts of radiological counting techniques and indicate non-detectable amounts of the target radionuclide.

Table 3-12. Change in Tritium in Wells and Aquifer Tubes Monitoring KW Reactor Area. (2 pages)

Well or Aquifer Tube	Use	Baseline Sample		Fall 2008 Sample		Change in Tritium Conc. Since Baseline Sampling (%) (Negative = Decrease)
		Date Collected	H-3 (pCi/L)	Date Collected	H-3 (pCi/L)	
199-K-34	M	10/29/96	5,750	10/27/08	1,300	-77.4
199-K-35	M	12/4/96	1,470	--	--	--
199-K-106A	M	10/15/97	3,260	10/6/08	21,000	544.2
199-K-107A	M	10/15/97	1,380	10/6/08	760	-44.9
199-K-108A	M	10/28/96	524	10/6/08	920	75.6
199-K-31	M	10/29/97	1,370	10/27/08	1,300	-5.1
199-K-132	E	1/27/05	910	10/28/08	5,850	542.9
199-K-137	M	10/26/06	320	10/28/08	1,600	400.0
199-K-138	E	10/12/06	520	10/28/08	1,200	130.8
199-K-139	E	10/31/06	680	10/30/08	1,500	120.6
199-K-140	E	10/31/06	680	10/28/08	1,475	116.9
199-K-165	M	8/28/08	430	9/11/08	550	27.9
199-K-166	M	9/11/08	1,000	9/25/08	1,200	20.0
199-K-168	M	8/7/08	700	10/29/08	1,293	84.6
199-K-173	M	9/20/08	260	9/27/08	910	250.0
199-K-158	M	1/19/07	1,000	--	--	--

Table 3-12. Change in Tritium in Wells and Aquifer Tubes Monitoring KW Reactor Area. (2 pages)

Well or Aquifer Tube	Use	Baseline Sample		Fall 2008 Sample		Change in Tritium Conc. Since Baseline Sampling (%) (Negative = Decrease)
		Date Collected	H-3 (pCi/L)	Date Collected	H-3 (pCi/L)	
Aquifer Tubes						
AT-K-1-D	AT	3/2/04	198 (U)	--	--	--

NOTES:
1. Well use: C = compliance, E = extraction, I = injection, M = monitoring.
2. Aquifer tube nomenclature regarding relative depth: D = deepest, M = middle, S = shallowest.
3. Abbreviations: AT = aquifer tube, NC = not calculated.
4. Laboratory qualifiers: U = not detected in sample above detection limit.
5. Change in tritium concentration not calculated when "U" (undetected) values are used in calculation. Where both values have "U" qualifier, the values are assumed not to have changed significantly.

Table 3-13. Change in Tritium in Wells and Aquifer Tubes Monitoring the KE Reactor Area. (2 pages)

Well or Aquifer Tube	Use	Baseline Sample		Fall 2008 Sample		Change in Tritium Conc. Since Baseline Sampling (%) (Negative = Decrease)
		Date Collected	H-3 (pCi/L)	Date Collected	H-3 (pCi/L)	
199-K-32A	M	10/29/96	7,200	10/27/08	4,200	-41.7
199-K-32B	M (see note 1)	12/9/96	115 (U)	10/27/08	140 (U)	--
199-K-30	M	10/29/96	328,000	10/27/08	410,000	25.0
199-K-29	M	10/28/96	11,400	9/29/08	7,100	-37.7
199-K-27	M	10/28/96	42,200	--	--	--
199-K-23	M	12/6/96	219 (U)	10/27/08	120 (U)	--
199-K-11	M	12/4/96	804	10/6/08	140 (U)	--
199-K-110A	M	10/28/96	391 (J)	10/6/08	160 (U)	--
199-K-36	M	12/4/96	2,100	10/27/08	172 (U)	--
199-K-141	M	4/27/07	4,500	11/9/08	4,500	0.0
199-K-142	M	4/27/07	377	10/28/08	1,200	218.3
Aquifer Tubes						
C6239	AT	9/30/08	460	--	--	--
C6240	AT	9/30/08	300	--	--	--
C6241	AT	9/30/08	490	--	--	--
C6242	AT	9/30/08	200 (U)	--	--	--
C6243	AT	9/30/08	340	--	--	--
C6244	AT	9/30/08	740	--	--	--
C6245	AT	9/30/08	1,900	--	--	--
C6246	AT	9/30/08	2,500	--	--	--

Table 3-13. Change in Tritium in Wells and Aquifer Tubes Monitoring the KE Reactor Area. (2 pages)

Well or Aquifer Tube	Use	Baseline Sample		Fall 2008 Sample		Change in Tritium Conc. Since Baseline Sampling (%) (Negative = Decrease)
		Date Collected	H-3 (pCi/L)	Date Collected	H-3 (pCi/L)	
C6247	AT	9/30/08	4,400	--	--	--
18-S	AT	12/1/97	38.3 (U)	--	--	--
19-D	AT	12/2/97	10.7 (U)	--	--	--
AT-K-2-M	AT	5/2/05	177 (U)	--	--	--

NOTES:
1. Well 199-K-32B is screened within the Ringold Upper Mud Unit and well 199-K-32A is screened within Ringold Unit E.
2. Well and aquifer tube use: M = monitoring, AT = aquifer tube.
3. Aquifer tube nomenclature regarding relative depth: D = deepest, M = middle, S = shallowest.
4. Laboratory qualifiers: J = reported value is an estimate, U = not detected in sample above detection limit.
5. Change in tritium concentration is approximate when "U" (undetected) values are used in calculation. Where both values have "U" qualifier, the values are assumed not to have changed significantly.

Twelve wells and 14 aquifer tubes for the 116-K-2 Trench area were sampled in the fall of 2008. Three wells exceeded the MCL (199-K-157, 199-K-144, and 199-K-18). All of the newly installed aquifer tube samples were below the MCL, except aquifer tube 26-D (which was characterized by a fall 2008 tritium value of 1,900 pCi/L). The tritium results are summarized as follows:

- Baseline samples were collected from 38 wells and 17 aquifer tubes, with the maximum tritium concentration of 621,000 pCi/L found in well 199-K-157, located near the southwest (head) end of the 116-K-2 Trench. Other baseline tritium samples above the MCL of 20,000 pCi/L include wells 199-K-144 (286,000 pCi/L), 199-K-120A (85,100 pCi/L), 199-K-162 (28,000 pCi/L), and 199-K-18 (24,597 pCi/L). All of the wells with high baseline tritium values are located near and downgradient of the head end of the 116-K-2 Trench and are presumed to be related to a plume downgradient from the 118-K-1 Burial Ground.
- The increase in the tritium concentration in well 199-K-20 may be attributed, at least in part, to tritiated groundwater that has been injected and migrated from the injection field to well 199-K-20.

Fourteen wells in the KW Reactor area were sampled in the fall of 2008, where the maximum tritium concentration detected was 21,000 pCi/L in well 199-K-106A, located downgradient of the 116-KW-1 condensate crib. All other samples were below the MCL. The tritium results for wells and aquifer tubes are summarized as follows:

- Baseline samples were collected from 16 wells and 1 aquifer tube, with the maximum tritium concentration of 5,750 pCi/L found in well 199-K-34, located downgradient of the KW Reactor.
- The aquifer tube along the shoreline was not sampled in the fall of 2008.

Eleven wells and three aquifer tubes in the KE Reactor area were sampled in the fall of 2008. In addition, nine new aquifer tubes were sampled on September 30, 2008, and are considered with the fall data for this report. The maximum tritium concentration was 410,000 pCi/L in well

199-K-30. No other wells or aquifer tubes exceeded the MCL for tritium. The tritium results for wells and aquifer tubes are summarized as follows:

- Baseline samples were collected from 12 wells and 13 aquifer tubes, with the maximum tritium concentration of 328,000 pCi/L found in well 199-K-30, located downgradient of the 116-KE-1 condensate crib. One other well (199-K-27) was above the 20,000 pCi/L MCL.
- The maximum tritium concentration encountered in an aquifer tube during the fall of 2008 was 4,400 pCi/L at aquifer tube C6247.

- Carbon-14: Tables 3-14, 3-15, and 3-16 display the carbon-14 results for extraction wells, compliance wells, monitoring wells, and aquifer tubes in the 100-KR-4 operational area around the 116-K-2 Trench and the KW and KE Reactor areas. The fall 2008 results are compared to baseline pre-pump-and-treat results collected mostly in 1996, where available. A number of new wells and aquifer tubes were installed in 2008 and the baseline for these installations dates from that time. The MCL for carbon-14 is 2,000 pCi/L.

  Five wells and 14 aquifer tubes for the 116-K-2 Trench area were sampled for carbon-14 in the fall of 2008. Two aquifer tubes were sampled on September 30, 2008, and are considered with the fall data collection for this report. The maximum carbon-14 concentration detected in the wells that were sampled was 140 pCi/L in well 199-K-157. All aquifer tubes were below the detection limit. The carbon-14 results are summarized as follows:

  - Baseline samples were collected from 22 wells and 17 aquifer tubes. The maximum baseline carbon-14 concentration was 168 pCi/L in well 199-K-157, located downgradient of the 118-K-1 Burial Ground.
  - Fourteen wells in the KW Reactor area were sampled for carbon-14 in the fall of 2008. The maximum concentration was 4,680 pCi/L in well 199-K-34, located downgradient of the KW Reactor. Two other wells were above the MCL of 2,000 pCi/L, including wells 199-K-106A and 199-K-132. Well 199-K-132 is an extraction well located downgradient of the most likely carbon-14 source (116-KW-1 condensate crib).

  The carbon-14 results for wells and aquifer tubes are as follows:

  - Baseline samples were collected from 16 wells and one aquifer tube. The maximum baseline carbon-14 concentration was 18,000 pCi/L in well 199-K-106A, located downgradient of the 116-KW-1 condensate crib. Five wells had baseline carbon-14 concentrations above the 2,000 pCi/L MCL.
  - The aquifer tube along the shoreline was not sampled in the fall of 2008.
  - Five wells and 14 aquifer tubes in the KE Reactor area were sampled in the fall of 2008. Three aquifer tubes were sampled on September 30, 2008, and are considered with the fall data for this report. The maximum carbon-14 concentration detected in this sampling was 6,130 pCi/L in well 199-K-30. None of the other wells were above the MCL. The highest concentration detected in the aquifer tubes was 701 pCi/L in aquifer tube C6247. The carbon-14 results for wells and aquifer tubes are summarized as follows:
  - Baseline samples were collected from 11 wells and 12 aquifer tubes. The maximum baseline carbon-14 concentration was 12,500 pCi/L in well 199-K-30, located downgradient of the KE Reactor and the 116-KE-1 condensate crib. One other well located in this area (199-K-29) was also above the MCL when the baseline was established.

Table 3-14. Change in Carbon-14 Concentrations from Baseline Through 2008 for Wells and Aquifer Tubes Monitoring the 116-K-2 Trench. (2 pages)

Well or Aquifer Tube	Use	Baseline Sample		Fall 2008 Sample		Change in C-14 Conc. Since Baseline Sampling (%) (Negative = Decrease)
		Date Collected	C-14 (pCi/L)	Date Collected	C-14 (pCi/L)	
199-K-111A	M	1/19/96	66.5 (J)	10/6/08	185	178.2
199-K-18	C	1/24/96	18.6 (J)	10/23/08	26.5	42.5
199-K-19	M	1/25/96	13.8 (J)	--	--	--
199-K-20	C	1/25/96	13.3 (J)	10/29/08	4.73 (U)	--
199-K-21	M	1/23/96	15.4 (J)	--	--	--
199-K-22	M	1/9/96	7.84 (J)	--	--	--
199-K-37	M	1/10/96	5.5 (J)	--	--	--
699-78-62	M	1/23/96	0.92 (U)	--	--	--
199-K-144	E	4/23/08	150.0	--	--	--
199-K-145	E	4/23/08	9.1	--	--	--
199-K-146	E	5/1/08	5.13 (U)	--	--	--
199-K-150	E	4/23/08	8.46 (U)	--	--	--
199-K-152	M	6/30/08	8.6	9/24/08	17.1	--
199-K-153	M	6/30/08	0.741 (U)	9/24/08	1.85 (U)	--
199-K-156	I	5/6/08	10.9	--	--	--
199-K-157	M	5/1/08	168.0	11/18/08	140	--
199-K-161	E	4/23/08	1.49 (U)	--	--	--
199-K-162	E	5/1/08	26.6	--	--	--
199-K-164	I	4/23/08	0.815 (U)	--	--	--
199-K-169	I	8/20/08	13.4	--	--	--
199-K-170	I	8/20/08	14.6	--	--	--
199-K-171	I	9/5/08	-1.24 (U)	--	--	--
Aquifer Tubes						
C6248	AT	9/30/08	3.9 (U)	--	--	--
C6249	AT	9/30/08	18.5 (U)	--	--	--
C6250	AT	9/30/08	0.971 (U)	--	--	--
C6251	AT	11/6/08	-6.79 (U)	--	--	--
C6252	AT	11/6/08	2.47 (U)	--	--	--
C6253	AT	11/6/08	20.8 (U)	--	--	--
C6254	AT	11/5/08	5.12 (U)	--	--	--
C6255	AT	11/5/08	4.5 (U)	--	--	--
C6256	AT	11/5/08	40 (U)	--	--	--
C6257	AT	11/10/08	-1.9 (U)	--	--	--
C6258	AT	11/10/08	-11.4 (U)	--	--	--
C6259	AT	11/10/08	-7.53 (U)	--	--	--

Table 3-14. Change in Carbon-14 Concentrations from Baseline Through 2008 for Wells and Aquifer Tubes Monitoring the 116-K-2 Trench. (2 pages)

Well or Aquifer Tube	Use	Baseline Sample		Fall 2008 Sample		Change in C-14 Conc. Since Baseline Sampling (%) (Negative = Decrease)
		Date Collected	C-14 (pCi/L)	Date Collected	C-14 (pCi/L)	
C6260	AT	11/10/08	-29.1 (U)	--	--	--
C6261	AT	11/10/08	-4.44 (U)	--	--	--
18-S	AT	10/28/98	100	--	--	--
19-D/M	AT	10/30/00	2.14 (U)	--	--	--
AT-K-3-D/M	AT	5/2/05	20	--	--	--

NOTES:
1. Well use: C = compliance, M = monitoring, AT = aquifer tube.
2. Abbreviations: NA = not available, NC = not calculated.
3. Aquifer tube nomenclature indicates relative depth: D = deepest, M = middle, S = shallowest.
4. Laboratory qualifiers: J = reported value is an estimate, U = not detected in sample above detection limit.
5. Change in carbon-14 concentration at some aquifer tube clusters may include sample results from both the middle and deep tube in cluster because all tubes not sampled each year.
6. Change in carbon-14 concentration not calculated when "U" (undetected) values are involved in calculation.
7. Negative values are acceptable statistical artifacts of radiological counting techniques and indicate non-detectable amounts of the target radionuclide.

Table 3-15. Change in Carbon-14 in Wells and Aquifer Tubes Monitoring the KW Reactor Area. (2 pages)

Well or Aquifer Tube	Use	Baseline Sample		Fall 2008 Sample		Change in Carboon-14 Conc. Since Baseline Sampling (%) (Negative = Decrease)
		Date Collected	C-14 (pCi/L)	Date Collected	C-14 (pCi/L)	
199-K-34	M	11/15/96	3,460	10/27/08	4,680	35.3
199-K-35	M	1/15/96	25.7 (J)	--	--	--
199-K-106A	M	12/5/96	18,000	10/6/08	2,860	-84.1
199-K-107A	M	1/16/96	395	10/6/08	302	-23.5
199-K-108A	M	12/9/96	3,470	10/6/08	1,755	-49.4
199-K-31	M	1/9/96	43.2 (J)	10/27/08	240	455.6
199-K-132	E	10/3/05	3,150	10/28/08	2,560	-18.7
199-K-137	M	10/24/06	2,545	10/28/08	1,830	-28.1
199-K-138	E	10/12/06	67.3	10/28/08	192	185.3
199-K-139	E	10/31/06	105.4	10/30/08	387	267.2
199-K-140	E	10/31/06	51.3	10/28/08	692.5	1249.9
199-K-165	M	9/11/08	309.0	11/10/08	330.0	6.80
199-K-166	M	9/11/08	673.0	11/10/08	506.0	-24.81
199-K-168	M	8/11/08	615.5	10/29/08	626.0	1.71
199-K-173	M	9/27/08	424.0	12/1/08	215.0	-49.29
199-K-158	M	1/19/07	13.8 (U)	--	--	--

Table 3-15. Change in Carbon-14 in Wells and Aquifer Tubes Monitoring the KW Reactor Area. (2 pages)

Well or Aquifer Tube	Use	Baseline Sample		Fall 2008 Sample		Change in Carboon-14 Conc. Since Baseline Sampling (%) (Negative = Decrease)
		Date Collected	C-14 (pCi/L)	Date Collected	C-14 (pCi/L)	
Aquifer Tubes						
AT-K-1-D	AT	3/2/04	22.5	--	--	--

NOTES:
1. Well use: E = extraction, M = monitoring, AT = aquifer tube.
2. Abbreviations: NA = not available, NC = not calculated.
3. Aquifer tube nomenclature regarding relative depth: D = deepest, M = middle, S = shallowest.
4. Laboratory qualifiers: J = value reported is an estimate.

Table 3-16. Change in Carbon-14 in Wells and Aquifer Tubes Monitoring the KE Reactor Area. (2 pages)

Well or Aquifer Tube	Use	Baseline Sample		Fall 2008 Sample		Change in C-14 Conc. Since Baseline Sampling (%) (Negative = Decrease)
		Date Collected	C-14 (pCi/L)	Date Collected	C-14 (pCi/L)	
199-K-32A	M	12/9/96	192 (J)	10/27/08	205	6.8
199-K-32B	M (see note 1)	1/26/96	-0.18 (U)	--	--	--
199-K-30	M	11/26/96	12,500	10/27/08	6,130	-51.0
199-K-29	M	4/23/97	4,610	--	--	--
199-K-27	M	3/24/97	320	--	--	--
199-K-23	M	1/25/96	60.1 (J)	--	--	--
199-K-11	M	1/17/96	319	10/6/08	106	-66.8
199-K-110A	M	1/19/96	112 (J)	--	--	--
199-K-36	M	1/16/96	261	--	--	--
199-K-141	M	4/27/07	69.4	10/28/08	84.4	21.6
199-K-142	M	4/27/07	227	10/28/08	291	28.2
Aquifer Tubes						
C6239	AT	9/30/08	79.5	--	--	--
C6240	AT	9/30/08	113	--	--	--
C6241	AT	9/30/08	336	--	--	--
C6242	AT	9/30/08	127	--	--	--
C6243	AT	9/30/08	156	--	--	--
C6244	AT	9/30/08	408	--	--	--
C6245	AT	9/30/08	369	--	--	--
C6246	AT	9/30/08	510	--	--	--
C6247	AT	9/30/08	701	--	--	--

Table 3-16. Change in Carbon-14 in Wells and Aquifer Tubes Monitoring the KE Reactor Area. (2 pages)

Well or Aquifer Tube	Use	Baseline Sample		Fall 2008 Sample		Change in C-14 Conc. Since Baseline Sampling (%) (Negative = Decrease)
		Date Collected	C-14 (pCi/L)	Date Collected	C-14 (pCi/L)	
18-S	AT	10/28/98	100	--	--	--
19-D	AT	10/30/00	2.14 (U)	--	--	--
AT-K-2-M	AT	5/2/05	39.8	--	--	--

NOTES:
1. Well 199-K-32B is screened within the Ringold Upper Mud Unit and well 199-K-32A is screened within the Ringold Unit E.
2. Well and aquifer tube use: M = monitoring, AT = aquifer tube.
3. Abbreviations: NA = not available, NC = no change in concentration.
4. Aquifer tube nomenclature regarding relative depth: D = deepest, M = middle, S = shallowest.
5. Laboratory qualifiers: J = value reported is an estimate, U = not detected in sample above detection limit.
6. Change in carbon-14 concentration not calculated when "U" (undetected) values are used in comparison. Where both values have "U" qualifier, the values are assumed not to have changed significantly.

- Nitrate: Tables 3-17, 3-18, and 3-19 list the nitrate results for extraction wells, compliance wells, monitoring wells, and aquifer tubes in the 100-KR-4 operational area around the 116-K-2 Trench and the KW and KE Reactor areas. Nitrate is widely distributed in the 100-K Area and the source is not known, although may be related to the use of septic systems (WHC-SD-EN-TI-239, *100-K Area Technical Baseline Report*), in addition to pre-Hanford agricultural activities or the use of nitric acid in more recent decommissioning and demolition activities. The fall 2008 results are compared to the baseline pre-pump-and-treat results collected mostly in 1996 (where available). A number of wells and aquifer tubes were installed in 2008, and the baseline values date from that time. The MCL for nitrate analyzed as NO_3 is 45 mg/L, which is equivalent to 10 mg/NO_3-N.

  Eight wells and 14 aquifer tubes in the 116-K-2 Trench area were sampled in the fall of 2008, and only well 199-K-18 exceeded the MCL, with a reported concentration of 66 mg/L. Nitrate has decreased in concentration approximately 33% since the baseline sampling in 1996 in well 199-K-18. The nitrate results are summarized as follows:

  - Baseline samples were collected from 12 wells and 23 aquifer tubes, and the maximum baseline nitrate concentrations were 98.3 mg/L in well 199-K-18 and 54.4 mg/L in well 199-K-19. Both of these wells are located near the head end of the 116-K-2 Trench. No other baseline samples had nitrate concentrations above the MCL.
  - The maximum detected CY08 nitrate concentration in an aquifer tube was 4.38 mg/L in aquifer tube C6250.

  Ten wells in the KW Reactor area were sampled in the fall of 2008, with four wells returning nitrate concentrations above the MCL. These include well 199-K-166 (193 mg/L), well 199-K-106A (89.9 mg/L), well 199-K-108A (67.3 m/L), and well 199-K-34 (53.1 mg/L). Two of these wells are located immediately upgradient of the KW Reactor and two are immediately downgradient. The nitrate results are summarized as follows:

  - Baseline samples were collected from 15 wells and one aquifer tube. Four wells had baseline nitrate concentrations >45 mg/L, including wells 199-K-34 (50 mg/L), 199-K-106A (84 mg/L), 199-K-138 (94.3 mg/L), and 199-K-140 (73 mg/L).

Table 3-17. Change in Nitrate Concentrations from Baseline Through 2008 for Wells and Aquifer Tubes Monitoring the 116-K-2 Trench. (2 pages)

Well or Aquifer Tube	Use	Baseline Sample		Fall 2008 Sample		Change in Nitrate Conc. Since Baseline Sampling (%) (Negative = Decrease)
		Date Collected	NO_3 (µg/L)	Date Collected	NO_3 (µg/L)	
199-K-18	C	12/16/96	98,300	10/23/08	66,000 (D)	-32.9
199-K-19	M	12/16/96	54,400	10/23/08	38,550 (D)	-29.1
199-K-20	C	11/15/96	21,000	10/27/08	15,200 (D)	-27.6
199-K-21	M	11/18/96	18,500	10/23/08	17,700 (D)	-4.3
199-K-22	M	11/25/96	21,600	10/23/08	16,550 (D)	-23.4
199-K-37	M	11/25/96	5,360	10/27/08	10,200 (D)	90.3
199-K-111A	M	11/15/96	54,400	10/6/08	42,900 (DN)	-21.1
199-K-117A	C	5/26/99	2,630	10/6/08	6,020 (D)	128.9
199-K-129	E	10/10/06	16,200	--	--	--
199-K-130	M	9/21/06	23,500	--	--	--
699-78-62	M	1/23/96	8,150	11/23/08	6,990 (D)	-14.2
199-K-150	E	4/23/08	15,900 (D)	--	--	--
Aquifer Tubes						
C6248	AT	9/30/08	1,400	--	--	--
C6249	AT	9/30/08	2,900	--	--	--
C6250	AT	9/30/08	4,380	--	--	--
C6251	AT	11/6/08	2,150	--	--	--
C6252	AT	11/6/08	748	--	--	--
C6253	AT	11/6/08	3,440	--	--	--
C6254	AT	11/5/08	447	--	--	--
C6255	AT	11/5/08	735	--	--	--
C6256	AT	11/5/08	2,640	--	--	--
C6257	AT	11/10/08	372 (B)	--	--	--
C6258	AT	11/10/08	336 (B)	--	--	--
C6259	AT	11/10/08	274 (B)	--	--	--
C6260	AT	11/10/08	2,380	--	--	--
C6261	AT	11/10/08	1,070	--	--	--
19-D/M	AT	12/2/97	3,000 (U)	--	--	--
21-M	AT	12/2/97	3,000 (U)	--	--	--
22-M/D	AT	12/2/97	4,000	--	--	--
23-D	AT	12/2/97	3,000 (U)	--	--	--
DK-04-2	AT	12/4/97	3,000 (U)	--	--	--
AT-K-3-D/M	AT	5/2/05	-0.04 (U)	--	--	--
AT-K-4-M	AT	3/29/06	0.55	--	--	--

Table 3-17. Change in Nitrate Concentrations from Baseline Through 2008 for Wells and Aquifer Tubes Monitoring the 116-K-2 Trench. (2 pages)

Well or Aquifer Tube	Use	Baseline Sample		Fall 2008 Sample		Change in Nitrate Conc. Since Baseline Sampling (%) (Negative = Decrease)
		Date Collected	NO_3 (µg/L)	Date Collected	NO_3 (µg/L)	
AT-K-5-D/M	AT	3/2/04	-0.07 (U)	--	--	--
AT-K-6-M	AT	3/2/04	-0.06 (U)	--	--	--

NOTES:
1 Well use: C = compliance, E = extraction, I = injection, M = monitoring; AT = aquifer tube.
2. Abbreviations: NA = not available, NC = not calculated.
3. Aquifer tube nomenclature indicates relative depth: D = deepest, M = middle, S = shallowest.
4. Laboratory qualifiers: B = analyte detected at concentration below the contract-required detection limit, but above the method of instrument detection limit; U = not detected in sample above detection limit.
5. Change in nitrate concentration at some aquifer tube clusters may include sample results from both the middle and deep tube in cluster because all tubes not sampled each year.
6. Change in nitrate concentration not calculated when "U" (undetected) values are compared.

Table 3-18. Change in Nitrate in Wells and Aquifer Tubes Monitoring the KW Reactor Area. (2 pages)

Well or Aquifer Tube	Use	Baseline Sample		Fall 2008 Sample		Change in Nitrate Conc. Since Baseline Sampling (%) (Negative = Decrease)
		Date Collected	NO_3 (µg/L)	Date Collected	NO_3 (µg/L)	
199-K-34	M	10/29/96	50,000	10/27/08	53,100 (D)	6.2
199-K-35	M	1/20/94	8,700	--	--	--
199-K-106A	M	7/30/96	84,000	10/6/08	89,900 (DN)	7.0
199-K-107A	M	10/28/96	22,500	10/6/08	22,200 (DN)	-1.3
199-K-108A	M	7/30/96	33,000	10/6/08	67,300 (DN)	103.9
199-K-31	M	12/2/96	10,900	10/27/08	24,000 (D)	120.2
199-K-132	E	1/27/05	36,300 (D)	10/28/08	28,300 (D)	-22.0
199-K-137	M	10/24/06	17,600	10/28/08	16,500 (D)	-6.3
199-K-138	E	8/14/06	94,300	--	--	--
199-K-139	E	8/28/06	32,300	--	--	--
199-K-140	E	9/6/06	73,000	--	--	--
199-K-165	M	8/28/08	13,800	9/11/08	17,400	26.1
199-K-166	M	9/11/08	18,400	9/25/08	193,000 (D)	948.9
199-K-168	M	8/7/08	26,300 (DN)	--	--	--
199-K-173	M	9/20/08	17,700	9/27/08	17,400	-1.7

Table 3-18. Change in Nitrate in Wells and Aquifer Tubes Monitoring the KW Reactor Area. (2 pages)

Well or Aquifer Tube	Use	Baseline Sample		Fall 2008 Sample		Change in Nitrate Conc. Since Baseline Sampling (%) (Negative = Decrease)
		Date Collected	NO_3 (µg/L)	Date Collected	NO_3 (µg/L)	
Aquifer Tubes						
AT-K-1-D/M	AT	3/2/04	753	--	--	--

NOTES:
1 Well use: C = compliance, E = extraction, I = injection, M = monitoring; AT = aquifer tube.
2. Aquifer tube nomenclature indicates relative depth: D = deepest, M = middle, S = shallowest.
3. Change in nitrate concentration at some aquifer tube clusters may include sample results from both the middle and deep tube in cluster because all tubes not sampled each year.
4. Change in nitrate concentration not calculated when "U" (undetected) values are compared.

Table 3-19. Change in Nitrate in Wells and Aquifer Tubes Monitoring the KE Reactor Area. (2 pages)

Well or Aquifer Tube	Use	Baseline Sample		Fall 2008 Sample		Change in Nitrate Conc. Since Baseline Sampling (%) (Negative = Decrease)
		Date Collected	NO_3 (µg/L)	Date Collected	NO_3 (µg/L)	
199-K-32A	M	12/9/96	28,800	10/27/08	20,900 (D)	-27.4
199-K-32B	M (see note 1)	12/9/96	9,690	--	--	--
199-K-30	M	10/29/96	52,200	10/27/08	79,700 (D)	52.7
199-K-29	M	10/28/96	25,800	--	--	--
199-K-27	M	8/28/96	24,000	--	--	--
199-K-23	M	12/6/96	58,400	10/27/08	63,700 (D)	9.1
199-K-11	M	12/4/96	27,300	10/6/08	69,100 (D)	153.1
199-K-110A	M	10/28/96	17,000	10/6/08	9,960 (DN)	-41.4
199-K-36	M	12/4/96	29,700	10/27/08	22,100 (D)	-25.6
199-K-141	M	4/27/07	24,800	10/28/08	30,000 (D)	21.0
199-K-142	M	4/27/07	3,540	10/28/08	3,130 (D)	-11.6
Aquifer Tubes						
C6239	AT	9/30/08	4,370	--	--	--
C6240	AT	9/30/08	16,100	--	--	--
C6241	AT	9/30/08	52,700 (D)	--	--	--
C6242	AT	9/30/08	31,400 (D)	--	--	--
C6243	AT	9/30/08	18,100	--	--	--
C6244	AT	9/30/08	31,600 (D)	--	--	--
C6245	AT	9/30/08	24,500	--	--	--
C6246	AT	9/30/08	24,600	--	--	--
C6247	AT	9/30/08	18,500	--	--	--

Table 3-19. Change in Nitrate in Wells and Aquifer Tubes Monitoring the KE Reactor Area. (2 pages)

Well or Aquifer Tube	Use	Baseline Sample		Fall 2008 Sample		Change in Nitrate Conc. Since Baseline Sampling (%) (Negative = Decrease)
		Date Collected	NO_3 (µg/L)	Date Collected	NO_3 (µg/L)	
18-S	AT	12/1/97	3,000 (U)	--	--	--
19-D	AT	12/2/97	3,000 (U)	--	--	--
AT-K-2-D	AT	3/2/04	319	--	--	--

NOTES:
1. Well 199-K-32B is screened within the Ringold Upper Mud Unit and well 199-K-32A is screened within Ringold Unit E.
2. Well and aquifer tube use: M = monitoring, AT = aquifer tube.
3. Abbreviations: NC = no change in concentration.
4. Aquifer tube nomenclature regarding relative depth: D = deepest, M = middle, S = shallowest.
5. Laboratory qualifiers: B = analyte detected at concentration below the contract-required detection limit, but above the method of instrument detection limit; U = not detected in sample above detection limit.
6. Change in nitrate concentration is not calculated when "U" (undetected) values are used in comparison. Where both values have "U" qualifier, the values are assumed not to have changed significantly.

- Nitrate has increased in concentration by approximately 104% (to 67.3 g/L) in well 199-K-108A since the baseline sampling in 1996. The cause is not known.
- The shoreline aquifer tube was not sampled during the fall of 2008.

Nine wells and nine aquifer tubes for the KE Reactor area were sampled during the fall of 2008. Three wells had nitrate concentrations above the MCL, including wells 199-K-30 (79.7 mg/L), 199-K-23 (63.7 mg/L), and 199-K-11 (69.1 mg/L). Except for well 199-K-11, which is located midway between the KE and KW Reactors, these wells are located near the KE Reactor. The nitrate results are summarized as follows:

- Baseline samples were collected from 11 wells and 12 aquifer tubes. Two wells had baseline nitrate concentrations above the MCL, including wells 199-K-30 (52.2 mg/L) and 199-K-23 (58.4 mg/L). In addition, one new aquifer tube (C6241) was above the MCL at 52.7 mg/L.
- The maximum nitrate concentration detected in an aquifer tube was 52.7 mg/L in aquifer tube C6241 when sampled on September 30, 2008. This value is reported as the baseline for this aquifer tube.

3.2.3.3 Maximum 2008 Contaminant and Co-Contaminant Concentrations in the 100-K Area. A summary of the maximum 2008 and 2007 contaminant and co-contaminant concentrations detected in the 100-K Area wells or aquifer tubes are provided in Table 3-20. The results include gross alpha and gross beta.

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Table 3-20. Maximum 2008 and 2007 Contaminant and Co-Contaminant Concentrations in the 100-K Area Wells and Aquifer Tubes. (2 pages)

Maximum 2008 Contaminant Concentrations in 100-KR-4 Area						Contaminant	Value Rpt. by Lab	Anal Units (Lab)	Filt (F) or Unfilt (UF)	Lab Qualifier	Review Qualifier	Analytical Method	Lab	Location/Comment
	Well Name	HEIS #	Date Sampled	Std. Value Rpt.	Units									
Hexavalent chromium	199-K-18	B1XKH2	11/24/08	173	µg/L	Hexavalent chromium	0.173	mg/L	UF	--	--	7196_CR6	WSCF	--
Total chromium (UF)	199-K-18	B1X5X5	10/23/08	139	µg/L	Chromium	139	µg/L	UF	--	--	6010_METALS_ICP	WSCF	Downgradient of west end 116-K-1 Trench
Total chromium (F)	199-K-18	B1X5X4	10/23/08	152	µg/L	Chromium	152	µg/L	F	--	--	6010_METALS_ICP	WSCF	Downgradient of west end 116-K-1 Trench
Nitrate	199-K-18	B1X5X5	10/23/08	66,000	µg/L	Nitrogen in nitrate	14.9	µg/mL	UF	D	--	300.0_ANIONS_IC	WSCF	Downgradient of west end 116-K-1 Trench
Sr-90	199-K-21	B1X5R7	10/23/08	26.7	pCi/L	Total beta radiostrontium	26.7	pCi/L	UF	--	--	SRTOT_SEP_PRECIP_GPC	WSCF	Downgradient of center of 116-K-1 Trench
Tritium	199-K-157	B1VC58	5/1/08	621,000	pCi/L	Tritium	621,000	pCi/L	UF	--	G	906.0_H3_LSC	TARL	Upgradient of west (head) end of 116-K-1 Trench
Tc-99	199-K-146	B1XTF5	11/24/08	17.1	pCi/L	Technetium-99	0.001	µg/L	UF	--	--	RADISOTOPES_ICPMS	WSCF	Expansion extraction well north of downstream end of 116-K-1 Trench
Sulfate	199-K-133	B1V9N8	5/28/08	433,000	µg/L	Sulfate	433	mg/L	UF	D	--	300.0_ANIONS_IC	WSCF	Calcium polysulfide injected into well during 2005 treatability test
	199-K-159	B1V224	4/23/08	99,800	µg/L	Sulfate	99.8	mg/L	UF	D	--	300.0_ANIONS_IC	RLNP	Well outside area influenced by CaS_x treatability test.
Uranium	No 2008 uranium data in the 100-KR-4 pump-and-treat operational area.													
Gross beta	199-K-21	B1X5R7	10/23/08	64.9	--	Gross beta	64.9	pCi/L	UF	--	--	BETA_GPC	WSCF	Downgradient of center of 116-K-1 Trench
Gross alpha	199-K-111A	B1TKH0	3/11/08	4.8	--	Gross alpha	4.8	pCi/L	UF	--	--	ALPHA_GPC	WSCF	Monitoring well adjacent to 118-K-1 Burial Ground
C-14	199-K-111A	B1X6C2	10/6/08	185	--	Carbon-14	185	pCi/L	UF	--	--	C14_LSC	TARL	Monitoring well adjacent to 118-K-1 Burial Ground

Table 3-20. Maximum 2008 and 2007 Contaminant and Co-Contaminant Concentrations in the 100-K Area Wells and Aquifer Tubes. (2 pages)

Maximum 2007 Contaminant Concentrations in 100-KR-4 Area						Contaminant	Value Rpt. by Lab	Anal Units (Lab)	Filt (F) or Unfilt (UF)	Lab Qualifier[a]	Review Qualifier[b]	Analytical Method	Lab	Location/Comment
	Well Name	HEIS #	Date Sampled	Std. Value Rpt.	Units									
Hexavalent chromium	199-K-18	B1RBD5	12/11/07	156	µg/L	Hexavalent chromium	0.156	mg/L	UF	--	--	7196_CR6	WSCF	Downgradient of west end 116-K-1 Trench
	199-K-18	B1MD94	3/28/07	156	µg/L	Hexavalent chromium	0.156	mg/L	F	--	--	7196_CR6	WSCF	Downgradient of west end 116-K-1 Trench
Total chromium (UF)	199-K-18	B1PTX3	10/11/07	147	µg/L	Chromium	147	µg/L	UF	--	--	6010_METALS_ICP	TASL	Downgradient of west end 116-K-1 Trench
Total chromium (F)	199-K-18	B1PTX2	10/11/07	145	µg/L	Chromium	145	µg/L	F	--	--	6010_METALS_ICP	TASL	Downgradient of west end 116-K-1 Trench
Nitrate	199-K-18	B1PTX3	10/11/07	69,100	µg/L	Nitrogen in nitrate	15.6	mg/L	UF	D	--	300.0_ANIONS_IC	WSCF	Downgradient of west end 116-K-1 Trench
	199-K-18	B1PTX5	10/11/07	72,600	µg/L	Nitrogen in nitrate	16.4	mg/L	UF	DX	QH	300.0_ANIONS_IC	WSCF	Downgradient of west end 116-K-1 Trench
Sr-90	199-K-21	B1PW10	10/16/07	32.5	pCi/L	Total beta radiostrontium	32.5	pCi/L	UF	--	--	SRISO_SEP_PRECIP_GPC	TARL	Downgradient of center of 116-K-1 Trench
Tritium	199-K-120A	B1RF48	11/26/07	34,000	pCi/L	Tritium	34,000	pCi/L	UF	--	--	TRITIUM_EIE_LSC	WSCF	Extraction well downgradient of upstream (head) end of 116-K-1 Trench.
Tc-99	199-K-111A	B1MPV2	4/27/07	2.27	pCi/L	Technetium-99	2.27	pCi/L	UF	U	--	TC99_ETVDSK_LSC	STLRL	Monitoring well adjacent to 118-K-1 burial ground
Sulfate	199-K-133	B1NJR8	5/24/07	370,000	µg/L	Sulfate	370	mg/L	UF	--	--	COLOR_TK_SO4_FLD	FIELD	Calcium polysulfide injected into well during 2005 treatability test
	199-N-72	B1RJP2	12/18/07	126,000	µg/L	Sulfate	126	mg/L	UF	D	--	300.0_ANIONS_IC	WSCF	Well outside area influenced by CaS_x treatability test.
Uranium	No 2007 uranium data in the 100-KR-4 pump-and-treat operational area.													
Gross beta	199-K-21	B1PV00	10/16/07	61.9	--	--	61.9	pCi/L	UF	--	--	9310_ALPHABETA_GPC	TARL	Downgradient of center of 116-K-1 Trench
Gross alpha	199-K-111A	B1MDT0	4/2/07	4.05	--	--	4.05	pCi/L	UF	--	--	9310_ALPHABETA_GPC	STLRL	Monitoring well adjacent to 118-K-1 Burial Ground
C-14	199-K-111A	B1MPV2	4/27/07	186	--	--	186	pCi/L	UF	--	--	C14_LSC	STLRL	Monitoring well adjacent to 118-K-1 Burial Ground

[a] Laboratory qualifier key:
- D = analyte was identified in an analysis at a secondary dilution factor
- U = analyzed for but not detected above limiting criteria; limiting criteria may be any of the following: value reported <0, value reported < counting error: value reported < total analytical error, value reported <= contract minimum detection level
- X = other specific flags and notes required to properly qualify the result are described in HEIS in the hardcopy sample data summary package and/or case narrative

[b] Review qualifer key:
- G = record has been reviewed and determined to be correct, or the record has been modified to make it correct
- H = laboratory holding time exceeded before the sample was analyzed
- Q = associated quality control sample is out of limits

HEIS = Hanford Environmental Information System
TARL = TestAmerica Laboratories, Richland, Washington
WSCF = Waste Sampling and Characterization Facility

4.0 100-NR-2 INTERIM ACTION STATUS

The 100-NR-2 Groundwater OU is located along the Columbia River, between the 100-KR-4 and the 100-HR-3 OUs (Figure 4-1). The 100-NR-2 OU consists of the groundwater underlying and near the source OUs associated with the 100-N Area. The 100-NR-2 pump-and-treat system was placed in cold-standby status in March 2006 to facilitate the interpretation of a treatability test for a 91.4-m (300-ft)-long apatite PRB constructed along the 100-N Area shoreline. Figure 4-2 shows the location of the OU wells in relation to the primary facilities, as well as the area of the apatite PRB in relation to these wells (inset). Figure 4-3 provides an enlargement of the inset PRB area of Figure 4-2. The authorization for the pump-and-treat status change in the 100-NR-2 interim action is documented in Tri-Party Agreement Change Request M-16-06-01, dated February 15, 2006. Appendix A provides a history of operations and supporting documents used to develop the 100-NR-2 pump-and-treat system.

This section provides the annual performance report for the 100-NR-2 pump-and-treat system, as required by the *Interim Remedial Action Record of Decision (ROD) Declaration, USDOE Hanford 100 Area, 100-NR-1 and 100-NR-2 Operable Units, Hanford Site* (EPA et al. 1999). The purpose of this section is to report groundwater monitoring data collected in CY08 and to describe the observed effects of the pump-and-treat system's cold-standby status on the aquifer. A general overview of the effects of the apatite PRB are also discussed in this section, along with progress on other remediation activities currently taking place in the 100-NR-2 OU.

Section 4.1 provides a brief overview of activities pertaining to the 100-NR-2 pump-and-treat system and the source area remedial actions that have occurred within the OU for CY08. Section 4.2 describes the changes in groundwater conditions before, during, and after the pump-and-treat system was active. Section 4.3 discusses QC chemical analysis. Section 4.4 provides a general overview of the strontium-90 remediation technologies being implemented and/or tested in the 100-NR-2 OU. A general overview of the petroleum hydrocarbon remediation technologies testing in the 100-NR-2 OU is included in Section 4.5. Conclusions and recommendations are presented in Sections 4.6 and 4.7, respectively.

4.1 OVERVIEW

The progress on source removal and groundwater remediation activities for CY08 is summarized in the following subsections.

4.1.1 100-NR-1 Operable Unit

The interim action ROD (EPA et al. 1999) requires that the most significant soil contamination in the 100-NR-1 OU be addressed first. Cleanup (i.e., excavation) of the strontium-90 source areas (the 116-N-1 and 116-N-3 Cribs) was completed in 2005 and 2006, and the sites were backfilled in 2006. Some strontium-90 vadose zone contamination remains throughout the 100-NR-1 OU. No excavation work was performed in CY08, but the draft design for remediation of the approximately 80 remaining waste sites was completed and is currently in review.

In addition, plans were initiated to install seven wells to test bioremediation technologies and perform bioventing pilot tests within the shallow and deep vadose zone. Two wells will be installed in the shallow vadose zone to a depth of 9 m (30 ft), with one well serving as a monitoring well and the other as an injection well. The remaining five wells will be installed in the deep vadose zone to a depth of 22 m (72 ft), with one injection well and four monitoring wells. Drilling is planned to start in early FY09, with bioventing tests to follow well installation (WCH-323, *Sampling and Analysis Instruction for Installation of UPR-100-N-17 Bioremediation Wells and Performance of Bioventing Pilot Tests*).

Figure 4-1. 100-N Operable Unit Location.

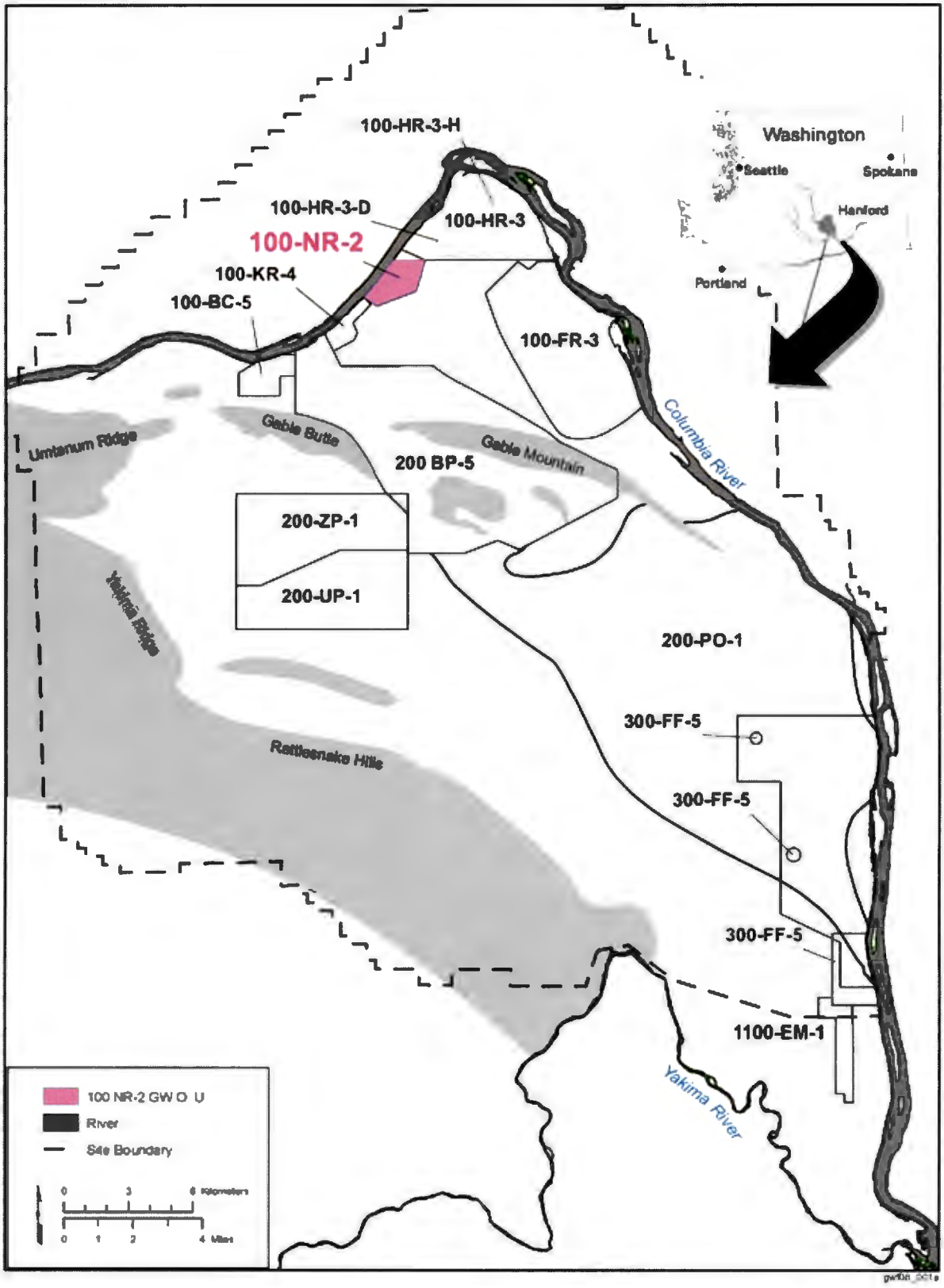
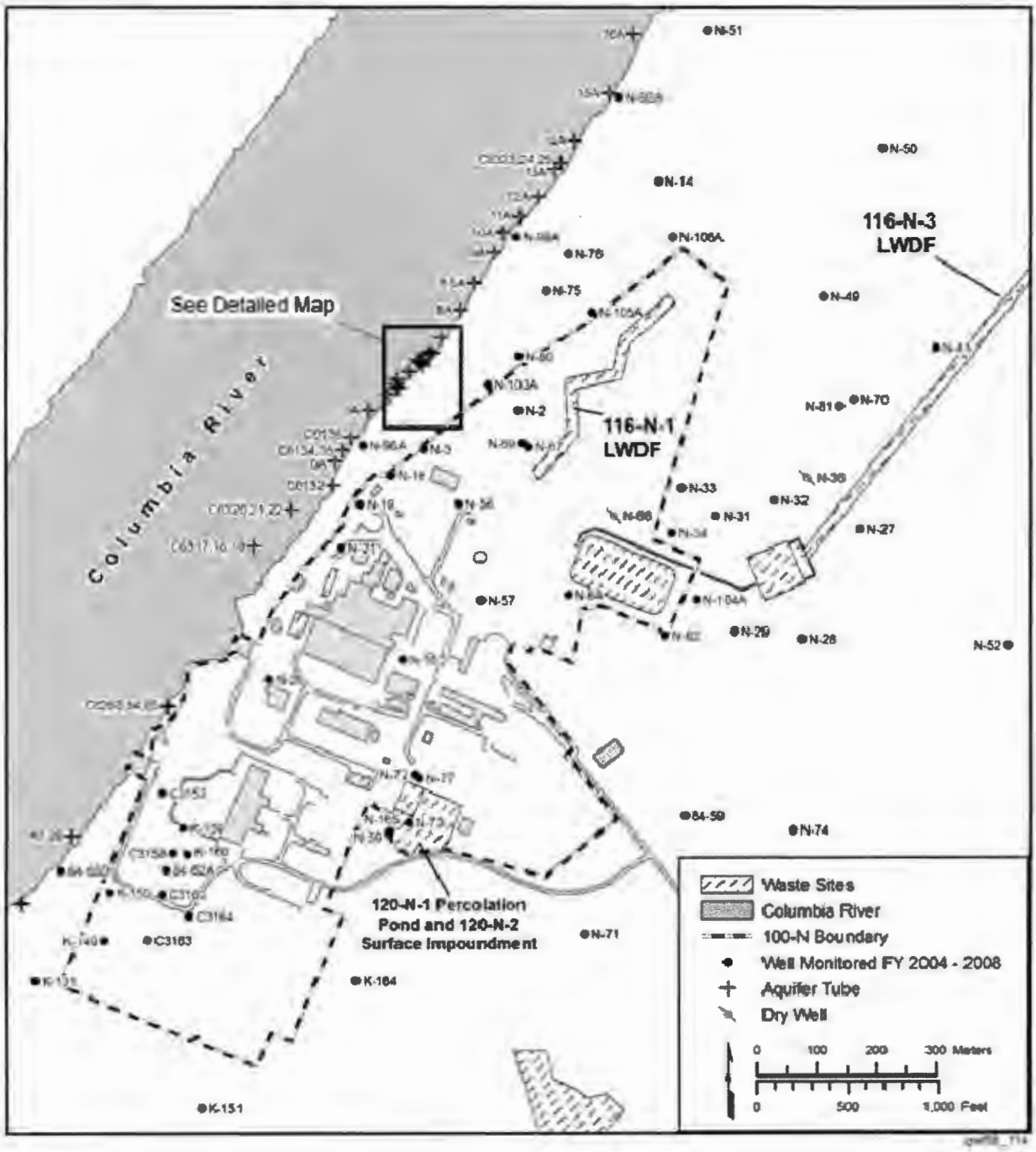


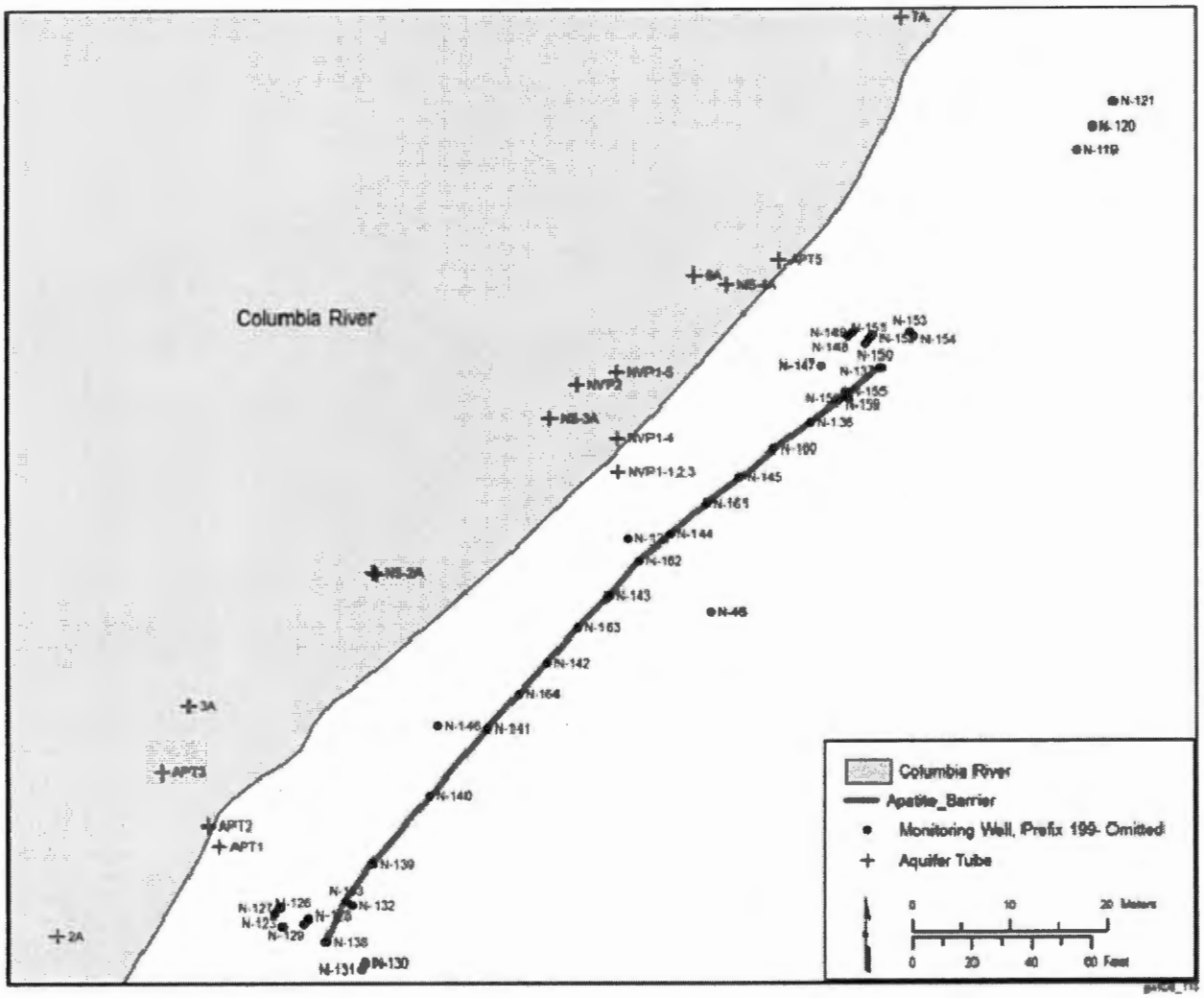
Figure 4-2. 100-N Operable Unit Wells.



4.1.2 100-NR-2 Operable Unit

The activities required for the 100-NR-2 OU by the interim action ROD to address strontium-90 and other contaminants in groundwater near the source areas consist of (1) maintaining a groundwater monitoring network for tracking changes in contaminant concentrations, (2) investigating alternative treatment technologies (i.e., emplacing the apatite PRB and testing bioremediation technologies), (3) assessing ecological risk of contaminated groundwater, and (4) removing any free product (e.g., diesel) in monitoring wells.

Figure 4-3. Aquifer Tubes and Monitoring Wells Along the Columbia River Shoreline.



Because the pump-and-treat system was in cold-standby status during CY08, the total volume of water processed and activity of strontium-90 removed were unchanged from CY07 (Table 4-1).

Table 4-1. Total Process Activity for Calendar Year 2008.

Total Processed Groundwater	
Total since September 1995 startup (million L)	1,155.3
Mass of Strontium-90 Removed	
Total since September 1995 startup (Ci)	1.83

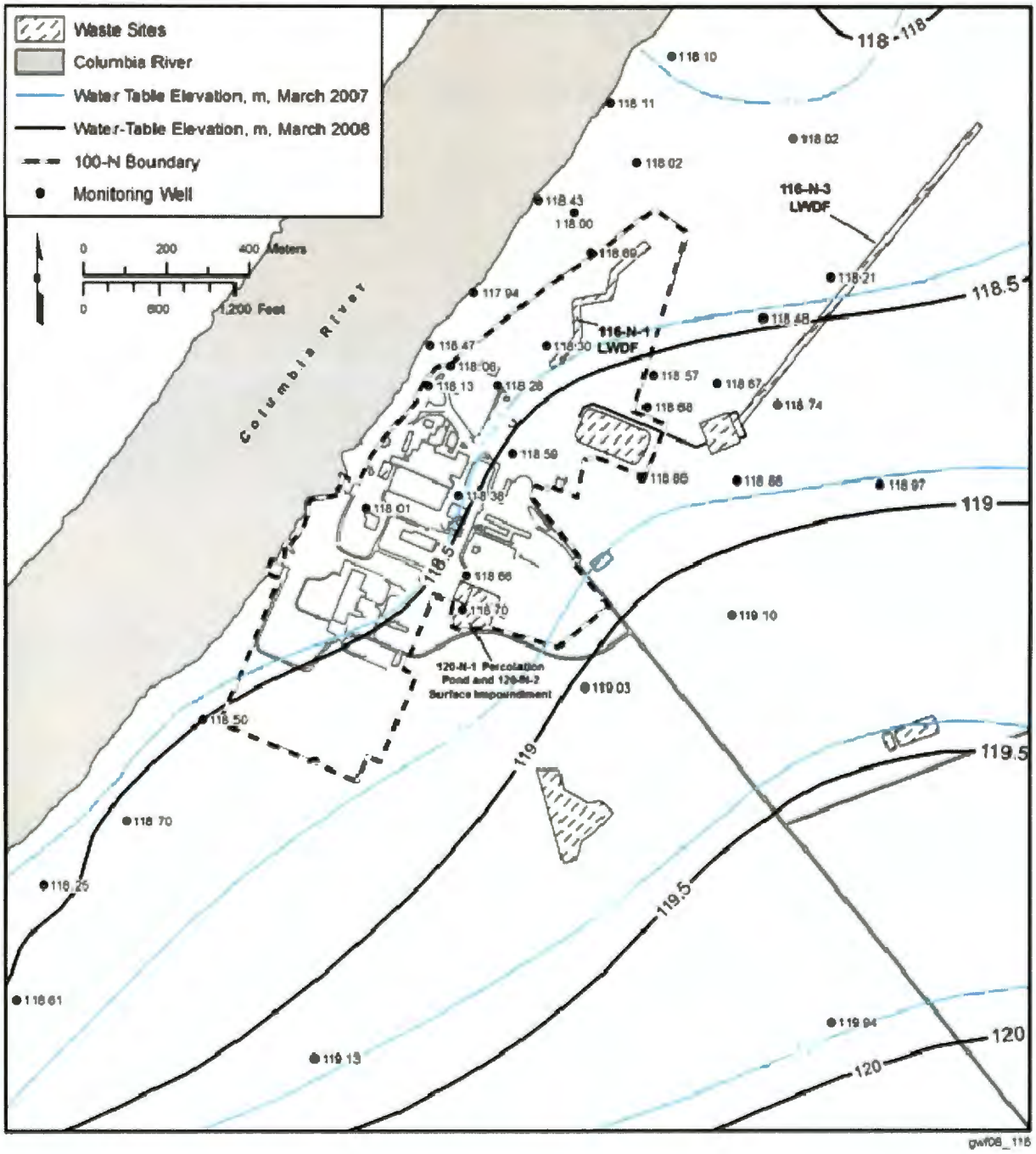
4.2 GROUNDWATER CONTAMINANTS IN THE 100-N AREA

This section describes the general hydrogeologic conditions in the 100-N Area and changes in contaminant concentrations in monitoring wells.

4.2.1 Hydrogeologic Conditions at the 100-N Area

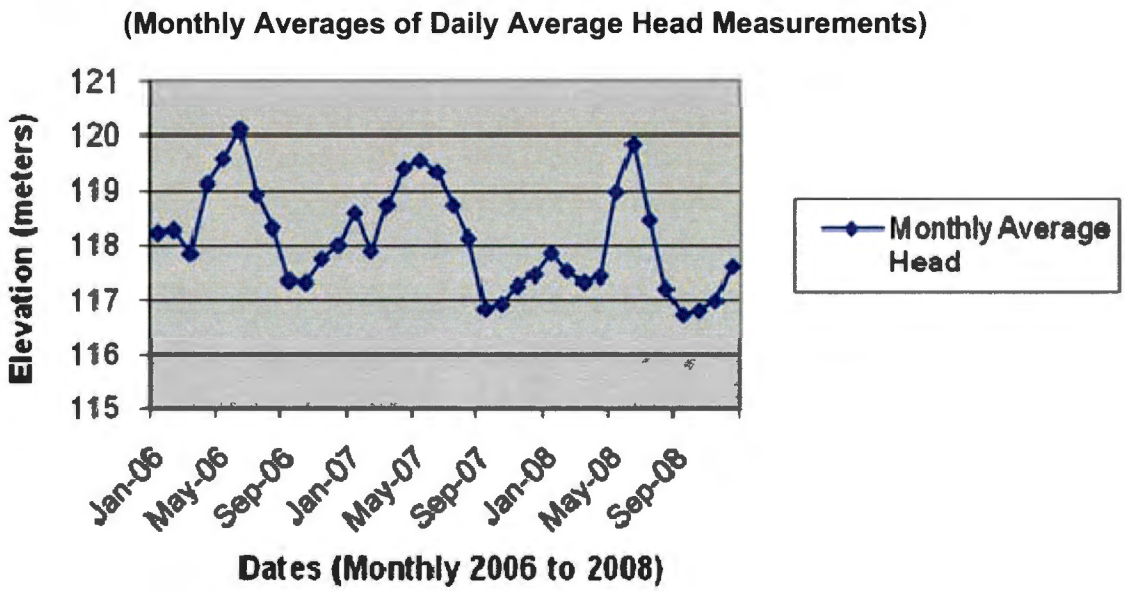
Groundwater generally flows to the northwest toward the Columbia River, beneath the 100-N Area. As the effects of extraction and injection dissipated after March 2006, the hydraulic gradient evened out. Figure 4-4 illustrates the March 2008 water table compared with March 2007. In 2008, the 118.5-m (388.8-ft), 119-m (390.4-ft), and 119.5-m (392.1-ft) contours moved further south, and the 118-m (387.1-ft) contour moved inland from the river to the northeast.

Figure 4-4. 100-N Area Water Table Map – March 2007 and 2008.



During the spring months, the Columbia River elevation generally increases due to additional flow from snowmelt run-off. Flow is regulated at the Priest Rapids Dam to provide irrigation water and aid in fish migration. Figure 4-5 shows daily average river stage at the 100-N Area gauging station from CY06 through CY08. The average river stage during CY08 was 118.20 m (387.80 ft), which is slightly lower than CY07 (118.24 m [387.93 ft]), CY06 (118.41 m [387.47 ft]), and CY05 (118.21 m [387.83 ft]). In CY08, the river stage was highest between mid-May and late June, with a peak daily average of 120.50 m (395.34 ft) on June 6. The river stage was lowest in September and October, with the lowest daily average of 116.29 m (381.53 ft) on September 28.

Figure 4-5. Elevation of Columbia River at 100-N Area.



Water levels in wells respond to changes in river stage. The response is more damped and delayed further inland from the river. For example, the highest daily average water level in well 199-N-34 was on July 22 and 23, which was 46 days after the peak river level.

4.2.2 Contaminant Monitoring

This section summarizes the results of CY08 interim action groundwater monitoring in the 100-N Area. Wells and constituents monitored are defined in *Modifications to the Groundwater Sampling and Analysis Schedules for the 100-NR-2 Operable Groundwater Sampling Project and 100-N Area RCRA Monitoring Program*, Change Control Form M-15-96-08, dated October 9, 1996 (Ecology and DOE 1996). The CERCLA sampling is conducted in March and September. Additional sampling to assess rebound after placing the pump-and-treat system into cold-standby status is conducted in accordance with the *100-N Shoreline Groundwater Monitoring Plan* (PNNL-15798). That plan also includes long-term monitoring focused on the shoreline area with the highest strontium-90 concentrations. The *Groundwater Monitoring Plan for 1301-N, 1324-N/NA, and 1325-N RCRA Facilities* (PNNL-13914) describes *Resource Conservation and Recovery Act of 1976* groundwater monitoring. Analytical results from these other monitoring programs are also presented in this report where the data are useful for assessing rebound or defining plumes.

The principal groundwater COCs in the 100-N Area are strontium-90, tritium, chromium, manganese, sulfate, and petroleum hydrocarbons (EPA et al. 1999). Appendix B presents the sample results for CY08, as well as a historical summary of contaminant and co-contaminant monitoring results for wells and aquifer tubes. Associated contaminant trend charts are presented in Appendix G.

4.2.2.1 Strontium-90 Monitoring Results. Strontium-90 was present in liquid effluent discharged to the 116-N-1 Facility (1963 to 1985) and the 116-N-3 Facility (1983 to 1991). In recent years, both facilities were excavated to remove highly contaminated soil and then backfilled with clean soil. The vadose zone and aquifer beneath the facilities remain contaminated with strontium-90, which binds to sediment grains and is moderately mobile in groundwater.

The size and shape of the strontium-90 plume change very little from year to year, except near the apatite PRB treatment site. The plume extends from beneath the 116-N-1 and 116-N-3 facilities to the Columbia River at levels above the DWS (8 pCi/L) (Figure 4-6).

Strontium-90 trends in monitoring wells near the 116-N-1 Facility show no obvious long-term decline in concentrations, but the wells do show significant variability related to water levels. Figures 4-7 and 4-8, respectively, show strontium-90 concentrations in wells 199-N-2 and 199-N-67 (which has the highest level of contamination). When the water table rises, strontium-90 from the vadose zone is mobilized and the concentrations in groundwater increase. Concentrations increased in the mid-1990s, which correlated with several years of high river stage. Concentration peaks in 2006, 2007, and 2008 were correlated with periods of high water table.

After the extraction wells were shut off in March 2006, strontium-90 concentrations increased in the former cone of depression. Concentrations had been lower during operation of the pump-and-treat system because groundwater extraction lowered the water table into a less-contaminated portion of the aquifer (the contamination is concentrated in the upper portion of the aquifer). As shown in Table 4-2, well 199-N-2 and two of the four former extraction wells showed increases in strontium-90 concentrations between 2005 and 2008.

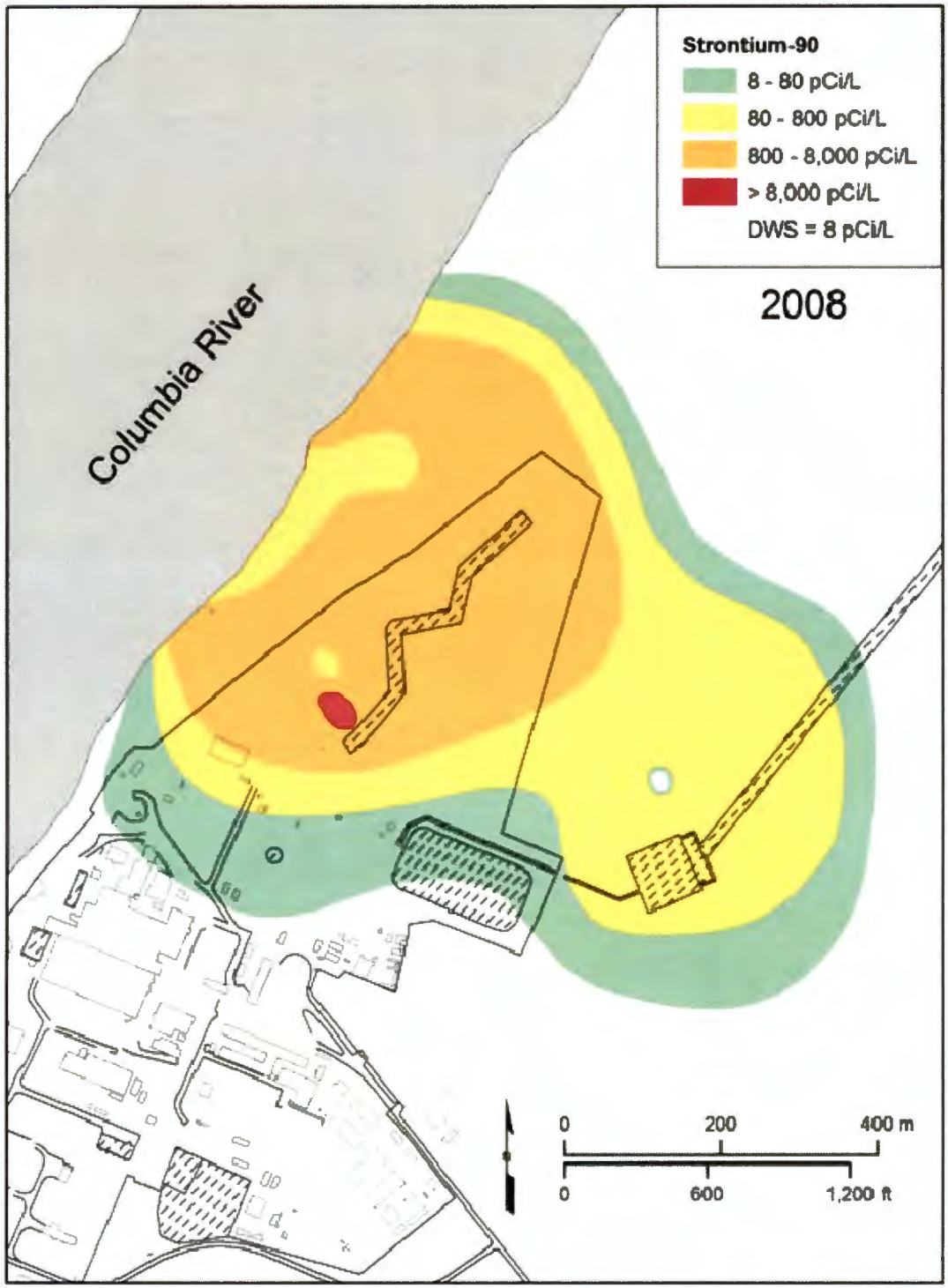
Strontium-90 concentrations in wells monitoring the 116-N-1 plume remained higher in 2007 than in 1994 before pump-and-treat began (see Table 4-2). As shown for well 199-N-67 in Figure 4-8, the increase occurred in the years following high water table in the mid-1990s. Strontium-90 levels have declined from the peak values of the late 1990s but remain higher than in 1994.

Figure 4-9 shows trend plots for the former extraction wells. Strontium-90 rebound was most evident in wells 199-N-75, 199-N-103A, and 199-N-105A, where concentrations increased from several hundred pCi/L in 2005 and 2006 to over 1,000 pCi/L after pumping ceased. Strontium-90 levels in 2007 and 2008 were also higher in well 199-N-105A than the previous few years, but the change was less distinct. Strontium-90 levels in well 199-N-106A, which has the highest concentrations of the four former extraction wells, continued a generally declining trend in 2006, 2007, and 2008.

Along the Columbia River shoreline, strontium-90 concentrations increased to new highs in several aquifer tubes in August 2008. These tubes are all located in the core of the plume between Array-4A and Arrray-6A. Tube NVP2-116.0 detected the highest strontium-90 concentration (75,000 pCi/L, estimated as one-half gross-beta concentration in July 2008). The apatite PRB injections temporarily increase strontium-90 concentrations due to the high ionic strength of the injection fluids. (For further discussion of this effect and apatite PRB data, see Section 4.4.)

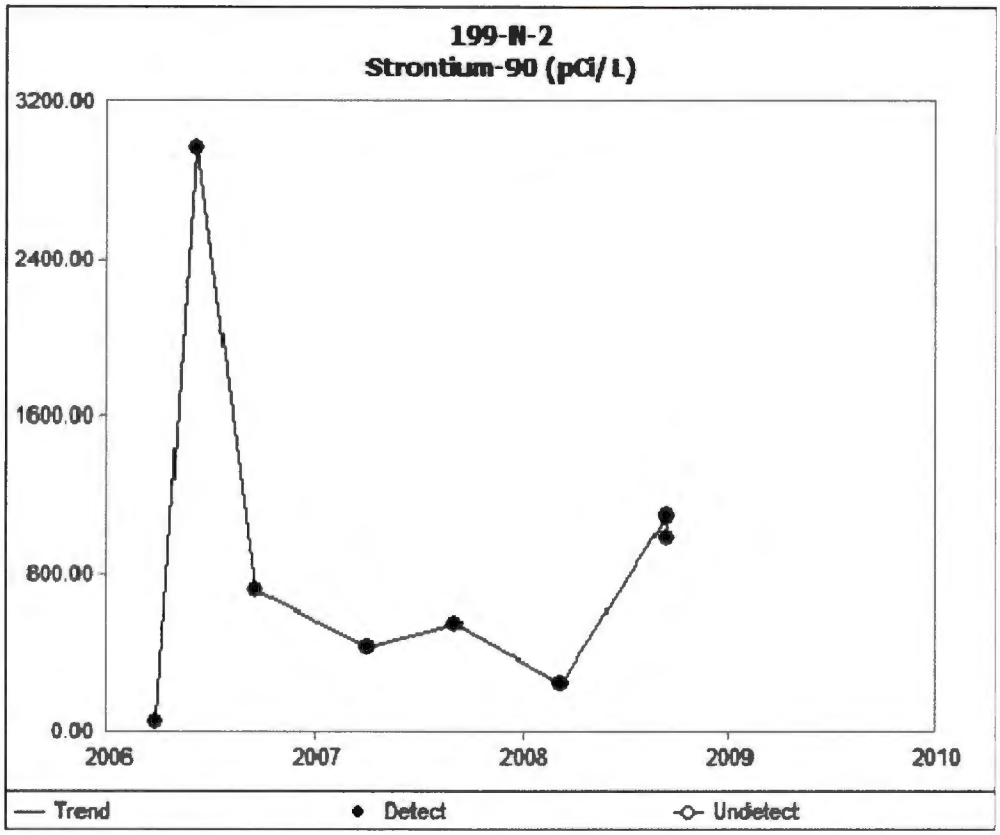
4.2.2.2 Tritium Monitoring Results. The tritium plume has diminished since 1991 when effluent discharge to the 116-N-3 Facility ceased. In CY08, no wells had concentrations exceeding the DWS (20,000 pCi/L). The maximum concentration was 19,000 pCi/L in well 199-N-32, located near the 116-N-3 Facility. Table 4-3 lists the tritium concentrations in fall 2007 and in 2008, as well as the percentage change between 2007 and 2008. Nearly all of the wells showed decreases in concentration. The shoreline aquifer tubes had very low or undetectable concentrations of tritium.

Figure 4-6. Strontium-90 Plume Map for the 100-N Area.



gw08_009b

Figure 4-7. Strontium-90 Trend Plot for Well 199-N-2.



4.2.2.3 Chromium Monitoring Results. Only one well in the 100-N Area has chromium concentrations above the DWS (100 µg/L). Well 199-N-80 (which is completed in a thin, confined aquifer in the Ringold Formation) had a chromium concentration in CY08 of 172 µg/L in a field-filtered sample, which is a typical level for this well. A down-hole video survey of this well in 2001 showed screen corrosion, which is the probable cause of the elevated chromium.

The highest chromium concentrations in the unconfined aquifer in CY08 were 12.1 µg/L in a filtered sample from well 199-N-64 (in the central 100-N Area) and 11.9 µg/L in a filtered sample from well 199-N-27 (located east of the head-end of 116-N-3). Well 199-N-64 is not located near any of the three major liquid waste sites, but chromium concentrations were even higher in this well in the 1990s and exceeded the DWS once. As with well 199-N-80, a down-hole video survey in 2000 showed screen corrosion, which likely the cause of the elevated chromium. It is unknown why well 199-N-27 has elevated chromium, but it is likely that well corrosion is also a factor.

The data presented in Table 4-4 are from wells that were sampled in CY08. The table includes four wells (199-N-122, 199-N-123, 199-N-146, and 199-N-147) that are monitoring wells for the apatite PRB. Sample results from these wells were taken as part of 100-NR-2 interim action monitoring in March 2008, before apatite injections were performed for CY08.

The data presented in Table 4-5 are from CY08 for wells that were sampled as part of the apatite PRB injection monitoring treatability test. This sampling is separate from the other monitoring programs performed at the 100-NR-2 OU and is directly related to tracking the progress of the apatite PRB treatability test. Samples were taken at these four monitoring wells prior to beginning the 2008 injections and throughout the remainder of the year as part of the post-injection monitoring required in the treatability test plan (DOE/RL-2005-96). The data are from the pre-injection background samples, highest level seen post-injection, and the final sample taken at the end of CY08. The values were

nondetects for chromium before injections, increased in only one well (199-N-146) after injections, and returned to background levels (nondetect) at the end of CY08. The high ionic strength of the injection solution puts many cations and anions into solution immediately following an injection. These increased levels drop off over time to pre-injection values for most constituents, especially metals.

Figure 4-8. Strontium-90 Trend Plot for Well 199-N-67.

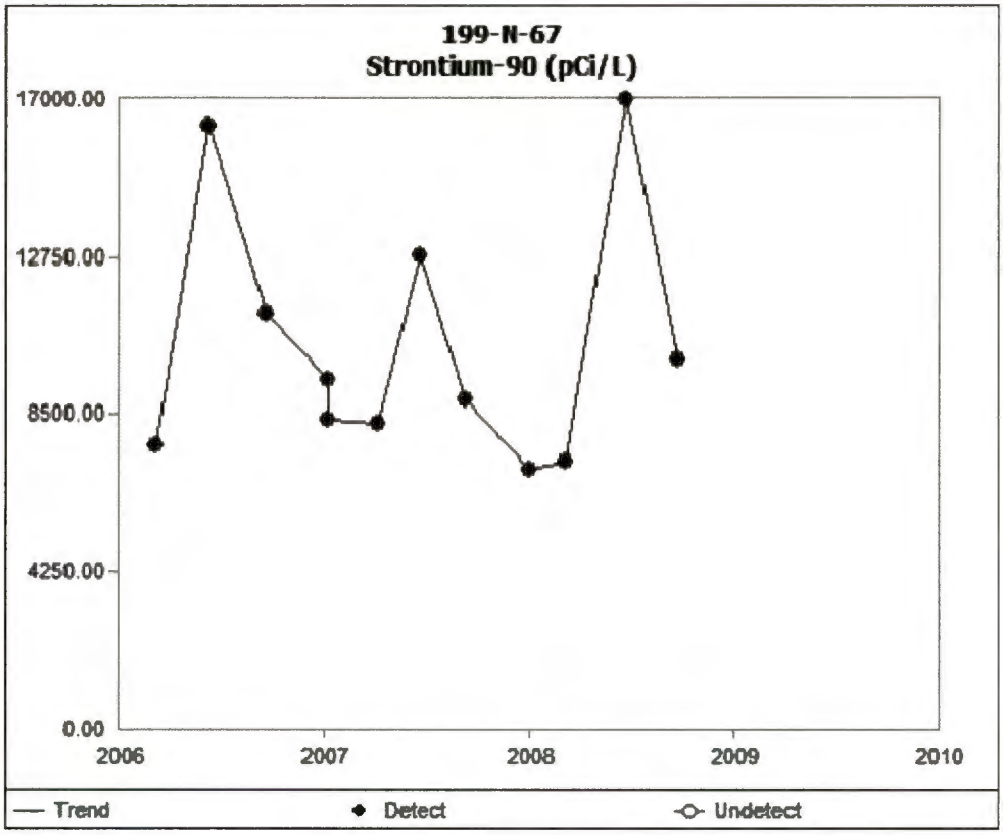


Table 4-2. Pump-and-Treat Concentrations. (2 pages)

Well/ Tube Name	Before Pump-and-Treat, Fall 1994 (pCi/L)	During Pump-and-Treat, Fall 2005 (pCi/L)	Pump-and-Treat in Cold-Standby Status, 2008	% Change 1994 to 2008	% Change 2005 to 2008
Wells and Aquifer Tubes Monitoring 116-N-1 Strontium-90 Plume					
199-N-2	121	81	248	105%	206%
199-N-3	927	1.310	1,230//1,180	33%	-6%
199-N-14	1,210	1.070	1,380/1,290	14%	29%
199-N-46	--	2.690	630	--	-77%
199-N-51	0.126 (U)/0.254 (U) (Aug. 1994)	--	0.0541 (U) (Sept. 2007)[c]	-79%	--
199-N-67	3,680	9.710	7,250	97%	-25%
199-N-75[a]	2,110	307	2,180	3%	610%
199-N-76	84.9	216	174	105%	-19%

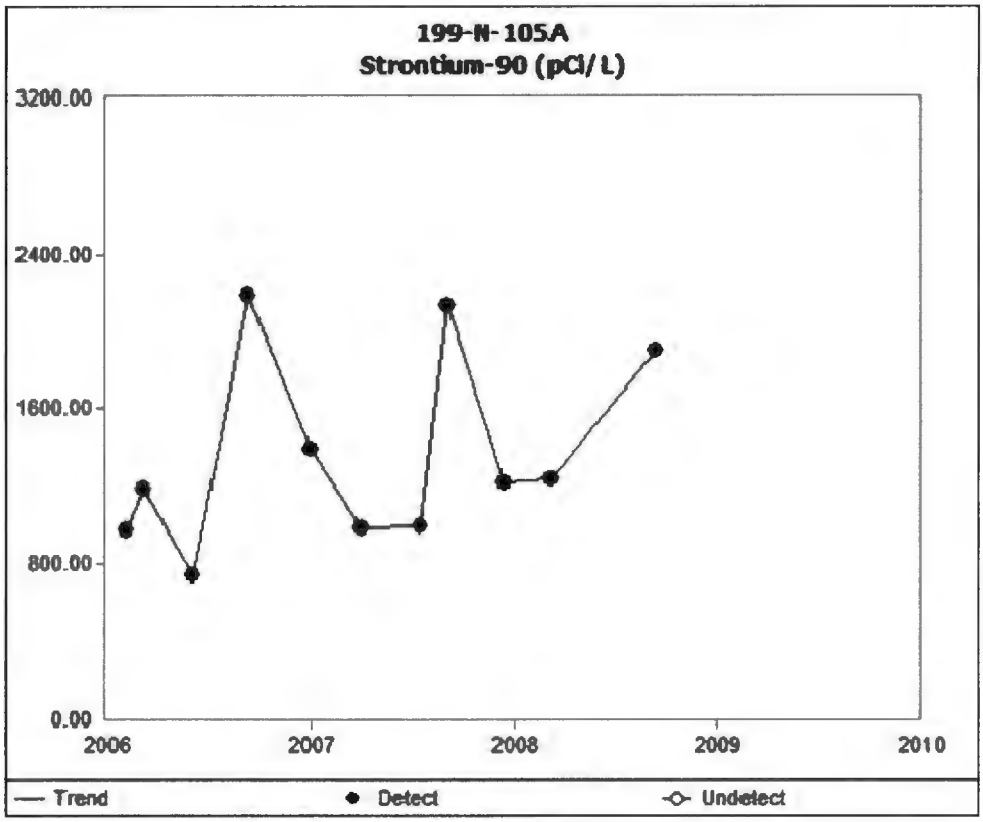
Table 4-2. Pump-and-Treat Concentrations. (2 pages)

Well/ Tube Name	Before Pump-and-Treat, Fall 1994 (pCi/L)	During Pump-and-Treat, Fall 2005 (pCi/L)	Pump-and-Treat in Cold-Standby Status, 2008	% Change 1994 to 2008	% Change 2005 to 2008
199-N-80[b]	0.654 (Q)/0.734 (Q) (Aug. 1994)	-0.154 (U)	0.479 (Sept. 2007)[c]	-35%	-411%
199-N-92A	--	0.92/0.416 (U)	1.22	--	33%
199-N-96A	--	5.74	5.77	--	1%
199-N-99A	--	1,270	1,120/1,130	--	-12%
199-N-103A	--	422	737	--	75%
199-N-105A	--	1,360	1,240	--	-9%
199-N-106A	--	3,260	2,200	--	-33%
199-N-119	--	280	309	--	10%
199-N-120[b]	--	10.1	6.55	--	-35%
199-N-121[b]	--	0.272 (U)	0.0169 (U)	--	-94%
199-N-122	--	--	1,160	--	NC
199-N-123	--	--	265	--	---
116m Array 3A	--	379	508	--	34%
116m Array 4A	--	1,260	672	--	-47%
116m Array 6A	--	477	325	--	-32%
NVP2-116.0	--	3,200	2,290	--	-28%
Wells Monitoring 116-N-3 Strontium-90 Plume					
199-N-27	171	--	155 (Apr. 2007)[c]	-9%	--
199-N-32	1.27	0.358 (U)	0.163 (U)	-87%	-54%
199-N-64	0.185 (UQ) (Aug. 1994)	--	0.256 (U)/ 0.246 (U)	38%	--
199-N-70[b]	0.321	0.156 (U)	0.31 (U) (Sept. 2007)[c]	-3%	NC
199-N-81	746	734	593/544 (Sept. 2007)[c]	-21%	-19%

NOTES: Data from September unless otherwise noted. Duplicates shown with "/" and splits shown with "//."
Lightly shaded cells show wells with concentrations above the drinking water standard (8 pCi/L).
[a] Former pump-and-treat extraction well.
[b] Screened at depth in Ringold Formation.
[c] Not sampled in 2008, last number available used for table.
U = undetected
Q = associated with out-of-limits quality control samples
NC = not calculated; concentrations are too low or both numbers are nondetects

4.2.2.4 Manganese. In CY08, manganese continued to exceed its secondary DWS (50 µg/L) in two wells affected by the petroleum contamination: 199-N-16 (371 µg/L) and 199-N-18 (4,130 µg/L). Natural biodegradation of the hydrocarbons creates reducing conditions, which increases the solubility of metals such as manganese and iron from the well casing and/or aquifer sediment.

Figure 4-9. Strontium-90 Trend Plots for the Four Former 100-NR-2 Pump-and-Treat Extraction Wells. (2 pages)



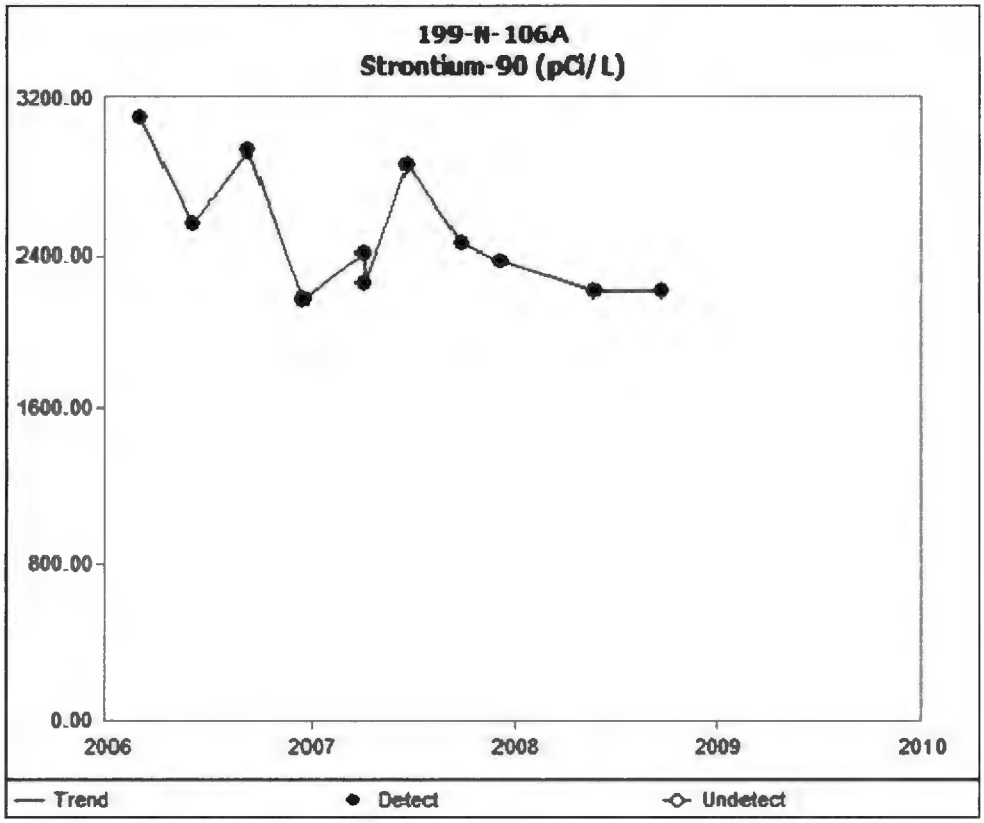


Table 4-3. Tritium Concentrations in Calendar Years 2007 and 2008 for 100-NR-2.

Well	Fall 2007 (pCi/L)	CY08 (pCi/L)	% Change
199-N-2	17,000	16,000/15,000	-6%
199-N-3	2,300/2,400	2,000	-17%
199-N-14	20,000	16,000	-20%
199-N-27	14,000/15,000	12,000	-20%
199-N-32	21,000	19,000/19,000	-10%
199-N-46	1,500	120	-92%
199-N-50	9.570/8,900	8,200	-14%
199-N-51	6,400	6,400/4,980	0%
199-N-64	11,000	12,000/13,000	18%
199-N-67	15,000	12,000	-20%
199-N-70	15,000	14,000	-7%-
199-N-75	16,000	14,000//12,900	-13%
199-N-76	16,000	14,000	-13%
199-N-80 [(a)]	18,000	15,000	-17%
199-N-81	16,000/16,000	14,000	-13%
199-N-92A	8,700	10,000//9500	25%
199-N-96A	1,600	1,800	13%
199-N-99A	2,000	7,400	270%
199-N-103A	13,000	12,000	-8%
199-N-105A	15,000	15,000	0%
199-N-106A	16,000	14,000	-13%
199-N-119	91 (U)	750	724%
199-N-120 [(a)]	130 (U)	2,400	1746%
199-N-121 [(a)]	2,600	4,400	69%
199-N-122 [(c)]	1,200	-43 (U)	-104%
199-N-123 [(c)]	75 (U)	310	313%
199-N-146 [(c)]	97 (U)	68 (U)	0%
199-N-147 [(c)]	66 (U)	9.5 (U)	0%

NOTES:

1. Data from September unless otherwise noted. Duplicates shown with "/".
2. Splits shown with "//". Lightly shaded cells show wells with concentrations above the drinking water standard (20,000 pCi/L)

[a] Screened at depth in Ringold Formation.
[b] Not sampled in 2008, last number available used for table.
[c] Apatite permeable reactive monitoring well.
NC = not calculated because no tritium detected
U = undetected

Table 4-4. Calendar Year 2008 Wells Sampled. (2 pages)

Well	Fall 2006 (µg/L)	Fall 2007 (µg/L)	Fall 2008[b] (µg/L)	% Change[c]
199-N-2	3.1 (U)	16.9 (CQ)	3.1 (B)/3.8 (B)	23%
199-N-3	3.1 (U)	8.5 (Q)/9.5 (Q)	3.1 (U)	NC
199-N-14	4.8 (B)	17.1 (CQ)	3.3 (B)	-31%
199-N-16	3.1 (U)	4.9 (UD)	3.7 (B)	19%
199-N-18	3.1 (U)	9.2	3.1 (U)	NC
199-N-27	4.6/4.2 (B)	14.8 (CQ)/18.7 (CQ)	11.9	159%
199-N-32	3.1 (U)	14.8 (CQ)	3.1 (U)/3.1 (U)	NC
199-N-46	3.1 (U)	4 (U)	13 (U) [Dec. 2008]	NC
199-N-64	32.6	20.7 (C)	10.5 (C)/12.1 (C) [Apr 2008]	-26%
199-N-67	6.4 (B)	7.7	6.9 (B)	-10%
199-N-70	10	20.8 (CQ)	7.9 (B)	-21%
199-N-74	15.7	23.8 (C)	23.8	52%
199-N-75	3.1 (U)	14.6 (CQ)	3.1 (U) // 13 (U)	NC
199-N-76	3.1 (U)	12.6 (C)	4 (B)	29%
199-N-80 [a]	163	172	172	0%
199-N-81	5.7 (B)	22 (CQ)/17.3 (CQ)	4.8 (B)	-16%
199-N-92A	7.3 (B)/7.6 (B)	4 (U)	7.2 (B)//14.5 (B)	91%
199-N-96A	3.1 (U)	9.9 (CQ)	3.1 (U)	NC
199-N-99A	3.1 (U)	4 (U)	3.1 (U)/3.1 (U)	NC
199-N-103A	5 (B)	11.7 (C)	3.1 (U)	-38%
199-N-105A	3.7 (B)	15 (CQ)	3.1 (U)	-16%
199-N-106A	3.1 (B)	9.3 (CQ)	3.8 (B)	23%
199-N-119	3.1 (U)	12.5 (CQ)	3.1 (U)	NC
199-N-120 [a]	3.1 (U)	14.3 (CQ)	4 (U) [Mar. 2008]	NC
199-N-121 [a]	3.1 (U)	14.3 (CQ)	4 (U) [Mar. 2008]	NC
199-N-122 [d]	3.1 (U)	16.4 (CQ)	4 (U) [Mar. 2008]	NC
199-N-123 [d]	3.1 (U)	13.4 (CQ)	6.1 [Mar. 2008]	NC
199-N-146 [d]	3.1 (U)	4 (U)	9.1 [Mar. 2008]	128%
199-N-147 [d]	3.1 (U)	4 (U)	10.2/5.7 [Mar. 2008]	155%

NOTES:

1. Data from September unless otherwise noted. Duplicates shown with "/" and splits shown with "//."
2. Lightly shaded cell (yellow) shows well with concentration above the drinking water standard (100 µg/L). Orange shaded cells are values with suspect QC data associated with them – chromium detected in QC blank and sample.

[a] Screened at depth in Ringold Formation.
[b] Sampled in fall 2008 unless otherwise listed.
[c] Percent changed calculated between 2007 and 2008, unless 2007 has QC issues (orange highlight) was used.
[d] Apatite permeable reactive barrier monitoring well.

Table 4-4. Calendar Year 2008 Wells Sampled. (2 pages)

Well	Fall 2006 (µg/L)	Fall 2007 (µg/L)	Fall 2008[b] (µg/L)	% Change[c]

B = analyte was detected at a value <RDL, but >IDL/MDL
C = contaminant detected in QC blank associated with sample
IDL = instrument detection limit
Q = result associated with suspect quality control data
MDL = method detection limit
NC = not calculated, both values were nondetects
QC = quality control
RCL = required detection limit
U = undetected

Table 4-5. Calendar 2008 Wells Sampled as Part of Apatite Permeable Reactive Barrier Monitoring Treatability Test.

Well	June 3, 2008 (µg/L)	Highest Value Following Injections (µg/L)	December 8, 2008 (µg/L)
199-N-122 [a]	4 (U)	60-65 (DU) [June to Nov. 2008]	13 (U)
199-N-123 [a]	4 (U)	36.1 (D) [6-7-08]	13 (U)
199-N-146 [a]	4 (U)	65 (DU) [June to Nov. 2008]	13 (U)
199-N-147 [a]	4 (U)	65 (DU) [June to Nov. 2008]	13 (U)

[a] Apatite permeable reactive barrier monitoring well.
D = sample was diluted before analysis
U = undetected

Manganese exceeded the secondary DWS in several wells near or part of the apatite PRB. The data presented in Table 4-6 are from CY08 for monitoring wells that were sampled as part of the apatite PRB injection monitoring treatability test. This sampling is separate from the other monitoring programs performed at the 100-NR-2 OU and is directly related to tracking the progress of the apatite PRB treatability test. Samples were taken at these four monitoring wells prior to beginning the 2008 injections and throughout the remainder of the year as part of the post-injection monitoring called for in the treatability test plan (DOE/RL-2005-96). The data are from the pre-injection background samples, highest level seen post-injection, and the final sample taken at the end of CY08. The values were nondetects for manganese before injections, increased in all wells after injections, and returned to lower levels or were non-detect at the end of last year. The high ionic strength of the injection solution puts many cations and anions into solution immediately following an injection. These increased levels drop off over time to pre-injection values for most constituents, especially metals.

4.2.2.5 Nitrate. Nitrate concentrations continued to exceed the DWS (45 µg/L as nitrate ion) in several wells in CY08. The highest concentrations continued to be in well 199-N-67, near the 116-N-1 Facility, with a maximum concentration of 220 µg/L in CY08. Table 4-7 lists the concentrations in fall 2008 compared with fall 2007. The wells showing the largest percentage change are near the shoreline, where concentrations are affected by mixing with river water. Wells with nitrate concentrations above the DWS showed steady (±20%) or decreasing concentrations, except for well 199-N-105A.

Table 4-6. Calendar Year 2008 for Monitoring Wells That Were Sampled as Part of Apatite Permeable Reactive Barrier Injection Monitoring Treatability Test.

Well	June 3, 2008 (µg/L)	Highest Value Following Injections (µg/L)	December 8, 2008 (µg/L)
199-N-122 [a]	4 (U)	7,900 (D) [June 2008]	196
199-N-123 [a]	4 (U)	2,410 (D) [June 2008]	7 (B)
199-N-146 [a]	4 (U)	5,460 (D) [July 2008]	240
199-N-147 [a]	4 (U)	8,130 (D) [June 2008]	4 (U)

NOTE: Lightly shaded cells show wells with concentrations above the secondary drinking water standard (50 µg/L).
[a] Apatite permeable reactive barrier monitoring well.
B = analyte was detected at a value <RDL, but >IDL/MDL
D = sample was diluted before analysis
IDL = instrument detection limit.
MDL = method detection limit
RDL = required detection limit
U = undetected

Table 4-7. Fall 2007 Versus Fall 2008 Nitrate Concentrations. (2 pages)

Well	Fall 2007 (mg/L)	Fall 2008 (mg/L)	% Change
199-N-2	798. (D)	97.4 (D)/96.9 (D)	25%
199-N-3	84.6 (D)/85.4 (D)	80.1 (D)	-6%
199-N-14	44.0 (D)	49.1 (D)	12%
199-N-16	12.8 (D)	5.78 (H) [May 2008]	-55%
199-N-18	0.118 (B)	0.319 (DU) [April 2008]	Nondetect
199-N-27	35.5 (D)/33.8 (D)	27.3 (D)	-23%
199-N-32	75.3 (D)	69.7 (D)/67.1 (D)	-7%
199-N-46	5.22 (N)	79.2 (D) [Dec. 2008]	1,417%
199-N-64	98.3 (D)	57.1 (D)/56.2 (D)	-42%
199-N-67	175 (DQ)	220 (D)	26%
199-N-70	28.6 (D)	30.7 (D)	7%
199-N-74	12.8 (D) [4-5-07]	14.4 (D) [Mar. 2008]	13%
199-N-75	66.0 (D)	58.9 (D)/55.4 (DH)	-11%
199-N-76	50.0 (D)	59.3 (D)	19%
199-N-80 [a]	9.9 (Q)	9.92 (D)	0%
199-N-81	39.4 (D)/40.1 (D)	41.3 (D)	3%
199-N-92A	16.8 (Q)	19.8 (D)/19.4 (D)	18%
199-N-96A	16.4 (D)	15.6 (D) [Dec. 2008]	-5%
199-N-99A	15.0 (Q)	24.1 (D) [Dec. 2008]	61%
199-N-103A	36.3 (D)	37.5 (D)	3%
199-N-105A	101 (D)	102 (D)	1%
199-N-106A	41.5 (D)	43.2 (D)	4%

Table 4-7. Fall 2007 Versus Fall 2008 Nitrate Concentrations. (2 pages)

Well	Fall 2007 (mg/L)	Fall 2008 (mg/L)	% Change
199-N-119	2.98	6.95 (D)	133%
199-N-120 [a]	5.49	28.7 (D) [Mar. 2008]	423%
199-N-121 [a]	30.3 (D)	41.7 (D) [Mar. 2008]	38%
199-N-122 [b]	6.15 (D)	6.77 (D) [Mar. 2008]	10%
199-N-123 [b]	0.496 (BD)	3.06 (D) [Mar. 2008]	517%
199-N-146 [b]	11.0 [12-12-07]	4.74 (D) [Mar. 2008]	-57%
199-N-147 [b]	0.318 (BQ)	2.28 (D)/2.18 (D) [Mar. 2008]	617%

NOTES:
1. Data from September unless otherwise noted. Duplicates shown with "/".
2. Lightly shaded (yellow) cells show wells with concentrations above the drinking water standard (45 µg/L).

[a] Screened at depth in Ringold Formation.
[b] Apatite permeable reactive barrier monitoring well.
B = analyte was detected at a value <RDL, but >IDL/MDL
D = sample was diluted for analysis
H = holding time exceeded before sample analyzed
IDL = instrument detection limit
MDL = method detection limit
N = spike sample outside limit
Q = associated with out-of-limit quality control data
RDL = required detection limit

4.2.2.6 Sulfate. None of the wells or aquifer tubes sampled for sulfate had CY08 concentrations above the 250 mg/L secondary DWS. The highest sulfate concentration in the 100-N Area in CY08 was 152 mg/L in well 199-N-3, located near the 116-N-1 Crib. Sulfate data are summarized in the Table 4-8 for wells in the 100-N Area.

The data presented in Table 4-9 are from CY08 for wells that were sampled as part of the apatite PRB injection monitoring treatability test. This sampling is separate from the other monitoring programs performed at the 100-NR-2 OU and is directly related to tracking the progress of the apatite PRB treatability test. Samples were taken at these four monitoring wells prior to beginning the 2008 injections and throughout the remainder of the year as part of the post-injection monitoring called for in the treatability test plan (DOE/RL-2005-96). The data reported in Table 4-9 are from the pre-injection background samples, the highest level seen post-injection, and the final sample taken at the end of CY08. Only one well exceeded the secondary DWS of 250 mg/L for sulfate (199-N-146) after injections. All wells were near pre-injection levels at the end of CY08. Five aquifer tubes in the vicinity of the apatite PRB are also shown in Table 4-9. The values increased in all aquifer tubes after injections and have returned to just above pre-injection levels in two of the tubes below. Values remain elevated in the other three tubes. The high ionic strength of the injection solution puts many cations and anions into solution immediately following an injection. These increased levels drop off over time to pre-injection values for most constituents, including anions.

Table 4-8. Fall 2007 Versus Fall 2008 Sulfate Concentrations.

Well	Fall 2007 (mg/L)	Fall 2008 (mg/L)	% Change
199-N-2	58.0 (D)	62.4 (D)/63.1(D)	9%
199-N-3	160 (DN)/161 (DN)	152 (D)	-6%
199-N-14	64.0 (D)	77.1 (D)	20%
199-N-16	74.7 (D)	48.0 (D)	-36%
199-N-18	2.03	0.154 (DU)	-92%
199-N-27	65.6 (D)/66.0 (D)	69.7 (D)	6%
199-N-32	63.3 (D)	70.2 (D)/63.5 (D)	11%
199-N-46	25.3 (D)	12.6 (D) [Apr. 2008]	-17%
199-N-64	103 (D)	119 (D)/117 (D)	16%
199-N-67	59.8 (D)	55.3 (D)	-8%
199-N-74	72.4 (D) [4-5-07]	78.7 (D) [Mar. 2008]	9%
199-N-75	80.4 (D)	99.6 (D)/90.7 (D)	24%
199-N-76	67.2 (D)	79.2 (D)	18%
199-N-80 [a]	51.4 (D)	54.1 (D)	5%
199-N-81	65.3 (D)/65.5 (D)	72.7 (D)	11%
199-N-92A	39.4	45.1 (D)/45.2 (D)	15%
199-N-96A	43.2 (D)	59.3 (D) [Dec. 2008]	37%
199-N-99A	14.1	24.5 (D) [Dec. 2008]	74%
199-N-103A	63.6 (D)	59.4 (D)	-7%
199-N-105A	71.9 (D)	77.1 (D)	7%
199-N-106A	65.8 (D)	70.1 (D)	7%
199-N-119	9.46	15.6 (D) [Dec. 2008]	65%
199-N-120 [a]	13.1	52.6 (D) [Mar. 2008]	302%
199-N-121 [a]	95.6 (CD)	132 (D) [Mar. 2008]	38%
199-N-122 [b]	22.6	11.5 (D) [Mar. 2008]	-49%
199-N-123 [b]	4.47	19.7 (D) [Mar. 2008]	341%
199-N-146 [b]	6.40	10.8 (D) [Mar. 2008]	69%
199-N-147 [b]	6.32	12.0 (D)/12.2 (D) [Mar. 2008]	93%

NOTE: Data from September unless otherwise noted. Duplicates shown with "/".
[a] Screened at depth in Ringold Formation.
[b] Apatite permeable reactive barrier monitoring well.
D = sample was diluted for analysis
N = spike sample outside limits

Table 4-9. Calendar Year 2007 Wells Sampled as Part of Apatite Permeable Reactive Barrier Injection Monitoring Treatability Test.

Well	June 3, 2008 (mg/L)	Highest Value Following Injections (mg/L)	December 8, 2008 (Wells), December 3, 2008 (AqT) (mg/L)
199-N-122 [a]	10.2	16.8 (D) [Aug. 2008]	13.7
199-N-123 [a]	7.88	32.9 (D) [June 2008]	23.3 (D)
199-N-146 [a]	8.46	292 (D) [Sept. 2008]	14.6 (D)
199-N-147 [a]	8.00	47.4 (D) [June 2008]	20.6 (D)
Array 3A-116.0	8.47	62.9 (D) [Sept. 2008]	8.82 (BD)
Array 4A-116.0	8.45	11.5 (D) [Dec. 2008]	11.5 (D)
Array 6A-116.0	7.72	11.9 (D) [Oct. 2008]	11.4 (D)
Array 7A-116.0	8.92	11.8 (D) [Dec. 2008]	11.8 (D)
NVP2-116.0	7.76	10.7 (D) [Oct. 2008]	9.37 (BD)

[a] Apatite permeable reactive barrier monitoring well.
B = analyte was detected at a value <RDL, but >IDL/MDL
D = sample was diluted for analysis
IDL = instrument detection limit
MDL = method detection limit
RDL = required detection limit

4.2.2.7 Petroleum Hydrocarbons. Well 199-N-18 monitors the portion of the 100-N Area where a 300,000-L (79,252-gal) petroleum leak occurred during the 1960s. The highest reported values for total petroleum hydrocarbon (TPH)-diesel range was 630,000 mg/L in March 2003, with 2.5 cm (1 in.) of free product in the well. Determining dissolved hydrocarbons in well 199-N-18 is difficult because of the way the well must be sampled. An open container is lowered into the well below the floating product; however, this disturbs the surface of the water, and nonaqueous liquid may become entrenched in the sample. Split samples were collected in April 2007 and analyzed at three laboratories, and the results varied widely (<0.13 mg/L, 26 mg/L, and 280 mg/L). A single sample collected in the September 2007 had a result of 190 mg/L. A single sample collected in April 2008 had a reported result of 150 mg/L.

A passive treatment method to remove diesel from well 199-N-18 was deployed in October 2003 and continues at present. The approach was chosen because the layer of floating petroleum was too thin for removal by active remediation methods. The passive method uses a polymer (Smart Sponge®) with a molecular structure that selectively absorbs petroleum from the surface of the water while the device floats in the air/hydrocarbon/water interface. A bundle of two Smart Sponge bilge skimmers (22.86 cm by 10.16 cm by 5.08 cm [9 in. by 4 in. by 2 in.]) are lowered into the well to soak in and absorb floating petroleum product. This assembly is changed out every two months, at which time the skimmers are removed, weighed, and replaced with a new pre-weighed bundle. All information collected from this operation is tracked in the work control system and available for evaluation.

Evidence of low levels of hydrocarbon contamination has been observed in wells 199-N-3, 199-N-19, and 199-N-96A in the past (PNNL-14187, *Hanford Site Groundwater Monitoring for Fiscal Year 2002*) but not in CY08. These wells are located near 199-N-18 and may be influenced by contamination from the same source.

Smart Sponge® is a registered trademark of ABTech Industries, Troutman, North Carolina.

Total organic carbon concentrations were slightly elevated in shoreline wells 199-N-96A and 199-N-123. Table 4-10 provides the CY08 results.

Near the N Reactor building, well 199-N-16 also has evidence of petroleum contamination, believed to be from a separate past source. The TPH-diesel range was measured at 7.2 mg/L in CY07, which was lower than measured in CY06 (nondetect). No measurement is available for CY08 for this well.

Table 4-10 Petroleum Hydrocarbon Concentrations for Calendar Year 2008.

Well	4th Qtr. CY07 (mg/L)	1st Qtr. CY08 (mg/L)	2nd Qtr. CY08 (mg/L)	3rd Qtr. CY08 (mg/L)	4th Qtr. CY08 (mg/L)
199-N-96A	4.29	6.06 (H)	1.18	6.40	5.61
199-N-123 [a]	1.12	9.55	--	--	--

[a] Apatite permeable reactive barrier monitoring well.
CY = calendar year
H = holding time exceeded before sample analyzed

4.3 100-NR-2 QUALITY CONTROL

Field QC results for 100-NR-2 include duplicates, split samples, and full trip blanks for the following analytes: alkalinity, anions, gamma energy analysis, gross alpha, gross beta, metals, oil and grease, total organic carbon, total organic halides, strontium-90, tritium, and volatile organic compounds. Field duplicates are used to assess sampling and measurement precision. Split samples are used to confirm out-of-trend results and for inter-laboratory comparisons. Field blanks provide an overall measure of contamination introduced during the sampling and analysis process. Tables showing the complete QC results are provided in Appendix D.

The U.S. Environmental Protection Agency's (EPA's) guideline *Laboratory Validation Functional Guidelines for Evaluating Inorganics Analyses* (EPA/540/R-94/083) for field duplicates is ±20%. Only field duplicates with at least one result greater than five times the method detection limit or minimum detectable activity are evaluated. A complete list of field duplicates performed is provided in Appendix D.

While there are no EPA functional guidelines for the performance of laboratory split samples, the results are typically evaluated against the criteria of precision within 20%. Only split samples where results are greater than five times the method detection limit or minimum detectable activity at both laboratories were evaluated. The complete list of split samples performed is provided in Appendix D.

For most chemical constituents, field trip blanks results above two times the method detection limit are identified as suspected contamination. However, for common laboratory contaminants such as acetone, methylene chloride, 2-butanone, toluene, and phthalate esters, the limit is five times the method detection limit. Metals are evaluated against two times the method detection limit. Radiological data are evaluated against two times the total minimum detectable activity. A complete list of the field trip blanks is provided in Appendix D.

4.4 OTHER STRONTIUM-90 TREATMENT TECHNOLOGIES PROGRESS

4.4.1 Apatite Injections at the Apatite Permeable Reactive Barrier

The DOE has agreed to construct and evaluate the effectiveness of a PRB using apatite sequestration technology as part of the CERCLA RI/FS process and consistent with the *Interim Remedial Action Record of Decision for the 100-NR-1 and 100-NR-2 Operable Units, Hanford Site, Benton County, Washington* (EPA/541/R-99/112; Tri-Party Agreement Change Control Form M-16-06-01).

Strontium-90 sequestration by this technology occurs through the injection of a calcium-citrate-phosphate solution. After injection, biodegradation of the citrate results in apatite precipitation and strontium-90 substitutes for calcium in the mineral matrix when apatite crystallization occurs.

The apatite treatability test site covers approximately 91.4 m (300 ft) along the 100-N Area shoreline (Figure 4-3). Forty-five monitoring points are associated with this site, including injection/barrier wells, monitoring wells, and aquifer tubes (Table 4-11). Sixteen wells comprise the PRB. Four monitoring wells are located along the PRB, between the river and the injection/barrier wells. Located at each end of the PRB, around the two end injection/barrier wells (199-N-138 and 199-N-137) are two pilot test sites (PT1 and PT2, respectively), which contain smaller-diameter monitoring wells surrounding the end injection/barrier wells (Figure 4-3).

Table 4-11. Apatite Permeable Reactive Barrier Sampling Points.

Well Name	Well Type	Well Name	Well Type	Well Name	Well Type
199-N-122	MW	199-N-141	IB	199-N-156	MW-PT2 [b]
199-N-123	MW	199-N-142	IB	199-N-159	IB
199-N-126	MW-PT1 [a]	199-N-143	IB	199-N-160	IB
199-N-127	MW-PT1 [a]	199-N-144	IB	199-N-161	IB
199-N-128	MW-PT1 [a]	199-N-145	IB	199-N-162	IB
199-N-129	MW-PT1 [a]	199-N-146	MW	199-N-163	IB
199-N-130	MW-PT1 [a]	199-N-147	MW	199-N-164	IB
199-N-131	MW-PT1 [a]	199-N-148	MW-PT2 [b]	APT-1	AT
199-N-132	MW-PT1 [a]	199-N-149	MW-PT2 [b]	APT-5	AT
199-N-133	MW-PT1 [a]	199-N-150	MW-PT2 [b]	Array 2A-116.0	AT
199-N-136	IB	199-N-151	MW-PT2 [b]	Array 3A-116.0	AT
199-N-137	IB	199-N-152	MW-PT2 [b]	Array 4A-116.0	AT
199-N-138	IB	199-N-153	MW-PT2 [b]	Array 6A-116.0	AT
199-N-139	IB	199-N-154	MW-PT2 [b]	Array 7A-116.0	AT
199-N-140	IB	199-N-155	MW-PT2 [b]	NVP2-116.0	AT

[a] PT1 = Pilot test 1 site.
[b] PT2 = Pilot test 2 site.

Strontium-90 contamination in the 100-N Area is primarily adsorbed to sediments by IX (99% absorbed and 1% in solution in the groundwater) in the upper portion of the unconfined aquifer and lower vadose zone. Although primarily absorbed, strontium-90 is still considered a high-mobility risk because it is mobilized by seasonal river stage increases and plumes of higher ionic strength water relative to groundwater (PNNL-16891, *Hanford 100N Area Apatite Emplacement Laboratory Results of Ca-Citrate-PO_4 Solution Injection and Sr-90 Immobilization in 100N Sediments*).

Field testing during the 2007 injections at the 100-NR-2 apatite treatability test site showed that the PRB can be categorized by two general hydrologic conceptual models based on the overall well capacity and contrast between the Hanford formation and Ringold Formation hydraulic conductivities. The upriver portion of the PRB between injection wells 199-N-138 and 199-N-141 has relatively low overall well-specific capacity[1] estimated from well development data and a lower contrast in hydraulic conductivity between the Hanford formation and Ringold Formation. The downriver portion of the PRB between

[1] Specific capacity is a measure of pumping rate per unit drawdown, and it relates to hydraulic conductivity of the aquifer.

injection wells 199-N-142 and 199-N-137 has generally higher well-specific capacity and a larger contrast between the Hanford and Ringold Formation hydraulic conductivities. The Hanford formation has higher hydraulic conductivity in the downriver portion than in the upriver portion of the PRB. This difference in hydrologic conditions between the upriver and downriver portions of the PRB resulted in changes to how the 2008 injections were performed. Upriver PRB well injections achieved adequate treatment by injecting a single well screened across both formations. Downriver PRB wells had to be injected in two phases: one phase to treat the Ringold Formation, and one phase to treat the Hanford formation.

There were five injection phases conducted in 2008, beginning with pilot test #1 and pilot test #2 sites in June. Four more injections in injection/barrier wells along the length of the PRB were completed starting in late June and ending in late July. Injections were timed to correspond with high-flow periods of the Columbia River, which enabled a better injection of the Hanford formation.

Post-injection samples were collected starting that the day the injection ceased. Specific monitoring points for each injection were sampled daily the first week, every other day the second week, and weekly thereafter for 4 additional weeks. Although the main COC is generally strontium-90 for this test site, samples for other target analytes were also taken. Sample sets included analysis for gross beta (for strontium-90 determinations), metals, and anions (Table 4-12 provides a complete list). Citrate samples were collected for only the first 2 weeks following an injection to track biodegradation of the citrate due to interaction with in situ soil microbes.

Table 4-12. Sampling Parameters for Apatite Permeable Reactive Barrier.

Water Samples Collected Post-Injection
Major cations/metals: aluminum, arsenic, barium, bismuth, calcium, cobalt, iron, potassium, magnesium, manganese, nickel, zinc, zirconium, phosphorus, strontium, sodium, silicon, sulfur, and antimony
Anions: chloride, bromide, sulfate, phosphate in phosphorus, nitrate in nitrogen, and nitrite in nitrogen
Small molecular weight organic acids: citrate and formate
Strontium-90
Gross beta

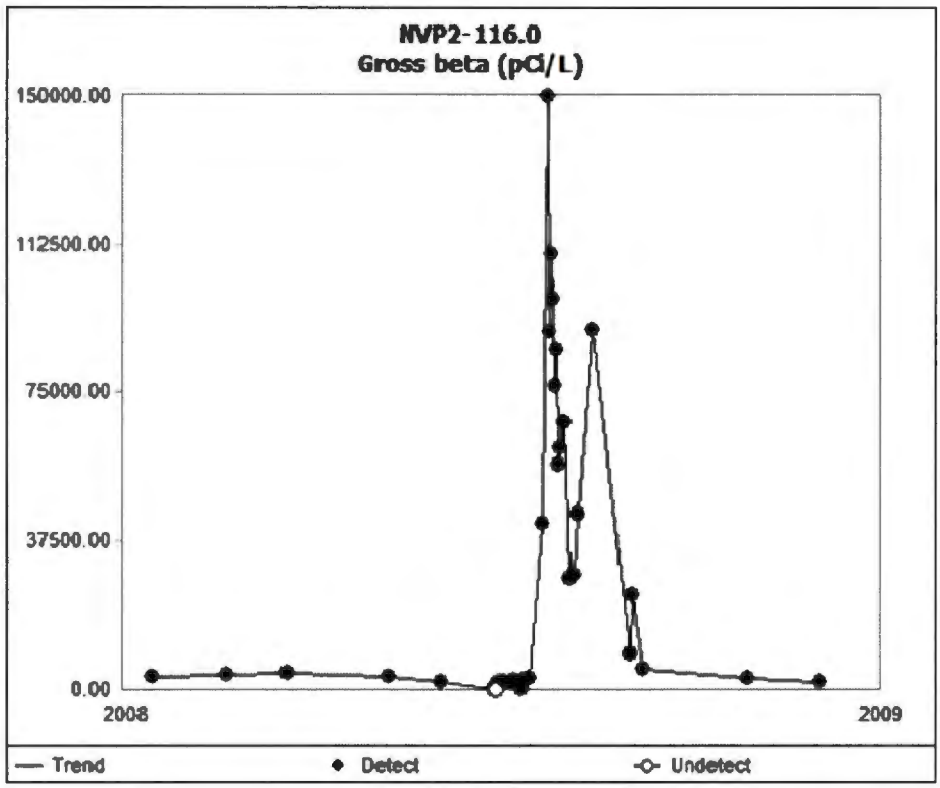
Field Parameters Collected for Every Water Sample
pH
Temperature (°C)
Specific conductance (µS/cm)
Oxidation-reduction potential (mV)
Dissolved oxygen (mg/L)

Most of the wells and aquifer tubes showed a significant increase in most cations/metals and anions in solution following an injection, which was due to the higher ionic strength solution that was injected. Cation/metal and anion concentrations generally decrease over time following an injection. There is some variability on how the different monitoring points react over the length of the PRB based on hydrologic conditions (as previously discussed).

The highest concentration of gross beta was seen in aquifer tube NVP2116.0 (Figure 4-10). The gross-beta concentration was a result of injections in nearby wells. High levels of total dissolved solids in injected solutions temporarily mobilized strontium-90 by IX. The maximum gross-beta concentration seen was 150,000 pCi/L in tube NVP2116.0 on July 24, equating to 75,000 pCi/L strontium-90.

Gross-beta concentrations dropped from their peak by early September but they remained higher than levels prior to the injections. The last measured gross beta value at NVP2 116.0 was 2,000 pCi/L on December 3, 2008. The highest gross-beta level in a well was 51,000 pCi/L in well 199-N-162 on July 15, 2008 (Figure 4-11). The last measured level in this well was 96.0 pCi/L on December 8, 2008. Figures 4-12 and 4-13 show plots of gross beta/strontium-90 for two injection/barrier wells and the nearest monitoring well. Both figures show the initial increase of gross beta in all wells, which was caused by the higher ionic strength injection solution. All wells show a general decrease in gross beta following the injection, except well 199-N-159. Declining gross-beta values are the general trend in most of the samples taken thus far, but there are exceptions. Many factors affect the chemistry of the soil and water interaction along the PRB, including changes in river level and differences in hydraulic conductivity and soil matrix both locally and over the length of the PRB.

Figure 4-9. Gross-Beta Concentration in Aquifer Tube NVP2-116.0.



Barrier injections completed prior to the spring of 2008 used low-concentration formulations of the calcium-citrate-phosphate solution to emplace approximately 0.136 mg PO_4/g of sediment, or 0.34 mg apatite/g of sediment. To determine if apatite was forming in the soil matrix, tests were conducted on actual PRB sediments collected when six additional wells (199-N-159 through 199-N-164) were installed in the spring of 2008. Samples were taken at 0.3-m (1-ft) intervals from 2.1 to 7.6 m (7 to 25 ft) bgs in each well, for a total of 120 samples. Phosphate profiles with depth in all six wells clearly showed a much greater proportion of apatite in the Hanford formation than the Ringold Formation, which was likely due to the larger volume of solution that permeated this formation during injections in the fully screened wells. Phosphate extraction data from these tests indicate that at a radial distance of approximately 4.6 m (15 ft) from the adjacent injection wells, the Hanford formation received an average treatment of 110% and the Ringold Formation an average treatment of 30% of the targeted apatite content (PNNL-17429, *100-NR-2 Apatite Treatability Test: Low-Concentration Calcium-Citrate-Phosphate Solution Injection for In Situ Strontium-90 Immobilization*). Further study is ongoing to determine the progress and mechanisms of strontium-90 attenuation.

Figure 4-10. Gross-Beta Concentration in Well 199-N-162.

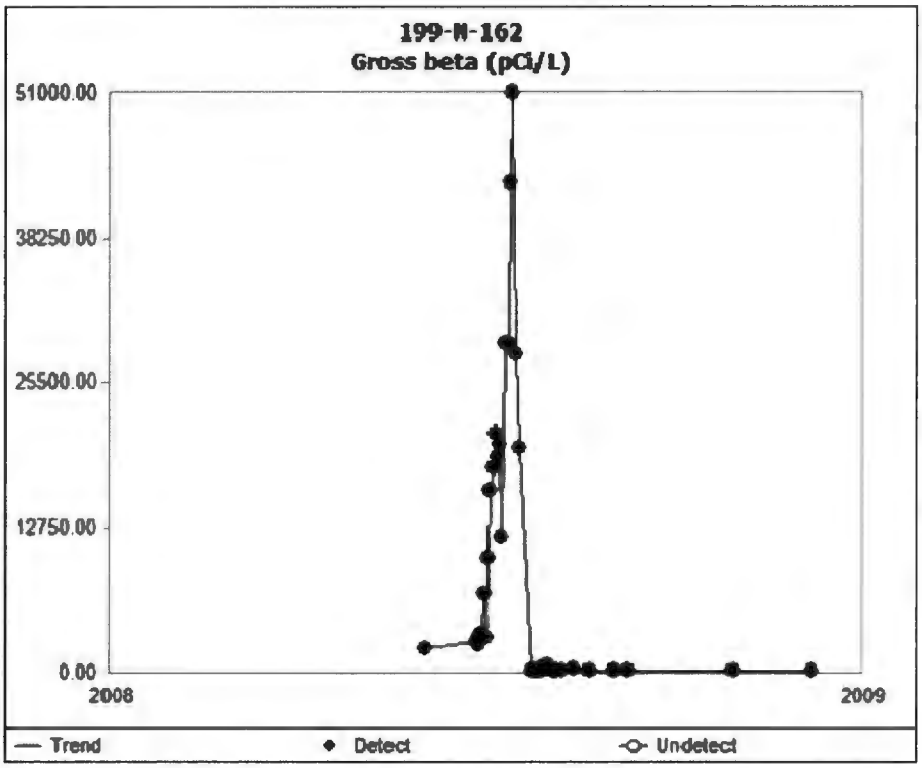


Figure 4-11. Gross-Beta Trend Plots for Wells 199-N-140, 199-N-141, and 199-N-146.

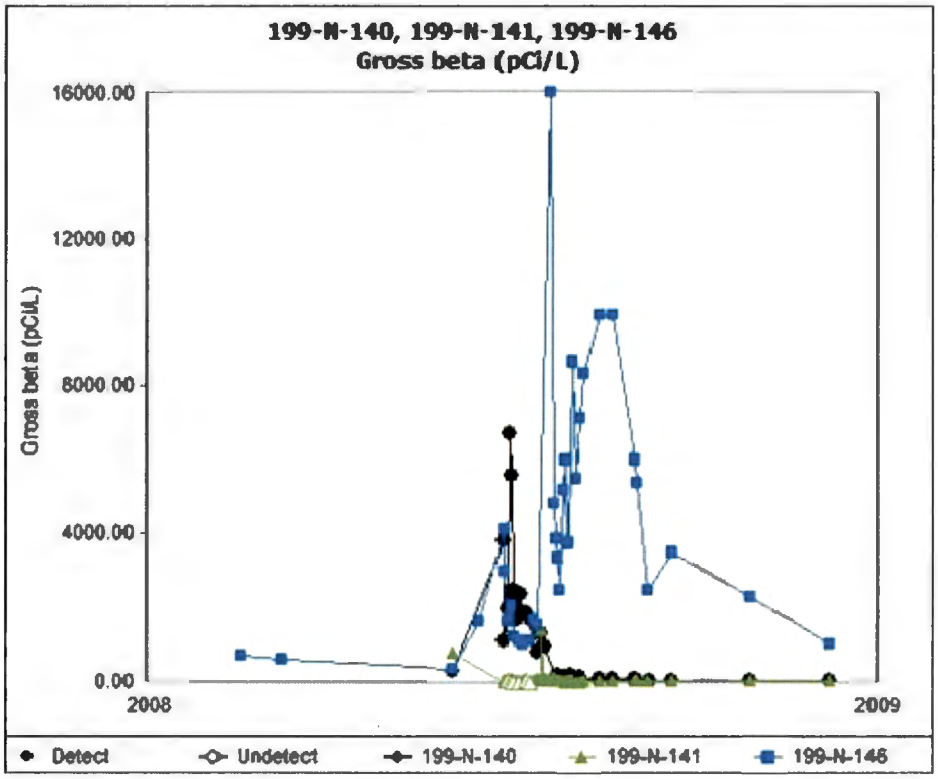
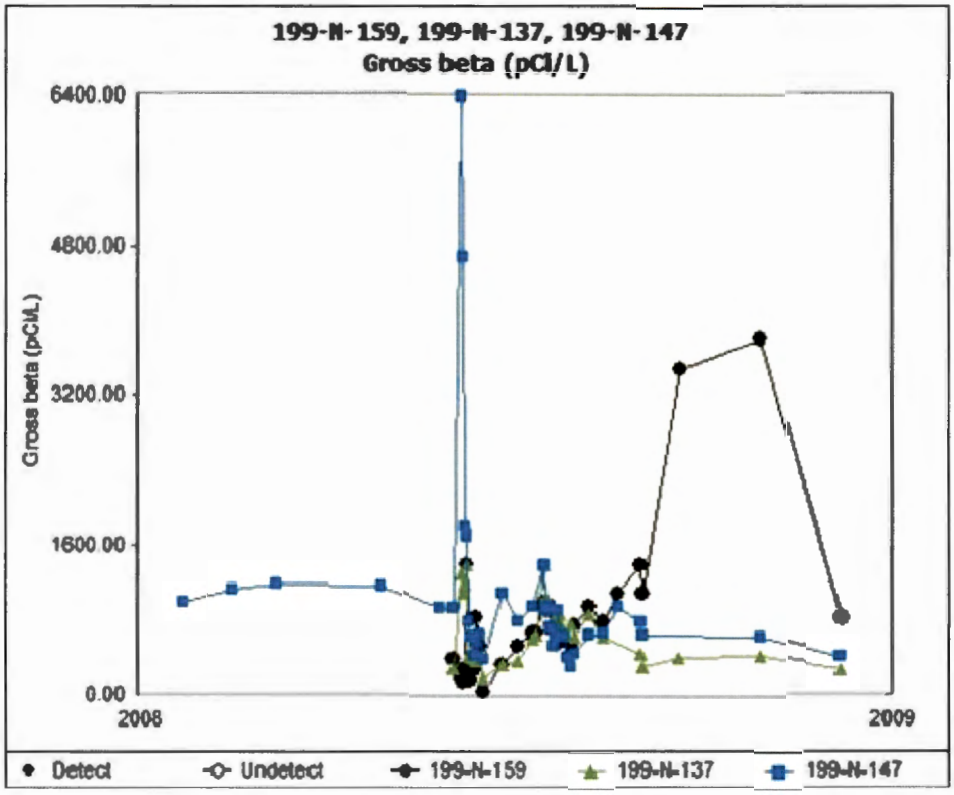


Figure 4-12. Gross-Beta Trend Plots for Wells 199-N-159, 199-N-137, and 199-N-147.



Monitoring at the PRB will be performed bi-monthly through the fall, winter, and early spring of 2008-2009. All 45 monitoring points listed in Table 4-11 will be sampled for the constituents listed in Table 4-12, weather and river-level permitting. The wells completed only in the Hanford formation do not contain water at low river stages, and aquifer tubes may not produce water during the winter due to freezing conditions. Sampling will be scheduled during periods of warmer weather, whenever possible, to ensure the best sample set is collected.

4.4.2 Apatite Infiltration Tests at the Apatite Permeable Reactive Barrier

Apatite injections treat the strontium-90 contamination in the aquifer and lower parts of the vadose zone, but much of the contamination is in the upper portion of the vadose zone. Pacific Northwest National Laboratory (PNNL) will conduct a study of apatite infiltration to treat vadose zone contamination under DOE's Environmental Management Technology (EM-22) program. The study will investigate the feasibility of emplacing apatite precipitate in the vadose zone with surface infiltration of a calcium-citrate-phosphate solution. Results of the study will be used to design an efficient and effective infiltration strategy that will be tested at a field scale. Field testing is planned for FY09 at a site immediately adjacent to the downriver end of the apatite PRB. An infiltration gallery of shallow piezometers will be installed approximately 3 m (10 ft) northeast of well 199-N-153 to facilitate testing of a passive reactive barrier using an infiltration method in the Hanford formation. Initial tests will be conducted with plain water.

4.4.3 Apatite Sequestration Using Phytoremediation

Phytoremediation has been identified as a potential technology for the removal of strontium-90 from the soil as a filter for groundwater along the Columbia River in the 100-N Area. Phytoremediation is a remediation technology in which plants are used to extract or sequester contaminants. Greenhouse

studies have demonstrated the viability of phytoremediation to remove strontium-90 from soil and water. The technology would be used in conjunction with the apatite PRB.

PNNL is conducting a study of phytoremediation under DOE's EM-22 program. A demonstration plot of coyote willow plants was established in March 2007 along the banks of the Columbia River at the 100-K Area. The area chosen for the test was not contaminated by strontium-90 or any other radionuclide. Objectives of the initial testing phase included determining how much biomass is produced, how strontium and calcium are partitioned in the plant, and the extent of leaf litter. The test plot was maintained in FY08 and the vegetation harvested in the late summer/early fall. Researchers will conduct tests on the harvested vegetation and will evaluate the results in FY09.

4.5 CHARACTERIZATION OF PETROLEUM CONTAMINATION

Petroleum hydrocarbons have been detected in some of the 100-N Area aquifer tubes. Appendix D of the *Assessment of the Strontium-90 Contaminant Plume Along the Shoreline of the Columbia River at the 100-N Area of the Hanford Site* (PNNL-16894) discusses evidence for this contamination. Low levels (<1 mg/L) of TPH in the diesel range were reported in several tubes around Array 0A. Workers observed small amounts of oil sheen during installation of these tubes in January 2007. During drilling of monitoring wells for the apatite PRB in 2005, diesel product was recovered from wells 199-N-122 and 199-N-123 (WMP-27771, *Borehole Summary Report for Wells 199-N-122 [C4954] and 199-N-123 [C4955]; 100-NR-2 Operable Unit*).

Drilling of new well 199-N-173, to be used for testing of petroleum hydrocarbon remediation technologies, is scheduled for early 2009. This well will be located approximately 120 m (394 ft) southwest (upriver) of the apatite PRB. The well will be located between the known diesel spill area and the aquifer tubes where low levels of petroleum hydrocarbon, dissolved oxygen, iron, and manganese have been detected. Samples will be collected to determine levels of contamination and to evaluate cleanup technologies.

WCH is also planning to drill and install seven bioremediation wells for performance of bioventing pilot tests in early 2009 (WCH-323).

4.6 CONCLUSIONS

- **RAO #1:** Maintain beneficial uses of the Columbia River and aquifer by reducing contaminant concentrations in the 100-NR-2 groundwater.

  The goal is to protect potential human and ecological receptors at the river from exposure to radiological and nonradiological contaminants present in the unconfined aquifer. The pump-and-treat system was not effective at reducing strontium-90 flux to the Columbia River. Therefore, the pump-and-treat system was placed in cold-standby status on March 9, 2006, when the pumps were shut off. The results of the shutdown are summarized below.

  Results:

  - Strontium-90 concentrations increased in former pump-and-treat extraction wells after the pumps were shut off. Levels remained much lower than peak values observed in the late 1980s and 1990s. The reason for the increase is likely because the water level rebounded and samples were collected from a shallower, more contaminated interval that had been dewatered by the pump-and-treat system.
  - Strontium-90 concentrations in some aquifer tubes and wells temporarily increased in the vicinity of the apatite PRB in both 2007 and 2008 in response to apatite barrier emplacement injections.

- Shutting off the pump-and-treat extraction wells did not result in higher tritium concentrations. Tritium concentrations continued to decrease throughout most of the plume. Concentrations in aquifer tubes were very low (from undetected to hundreds of pCi/L).
- Chromium, manganese, nitrate, sulfate, and TPH concentrations remained within previously established ranges.

- **RAO #2:** Obtain information to evaluate technologies for strontium-90 removal and evaluate ecological receptor impacts from contaminated groundwater.

  Results: The DOE installed a 91.4-m (300-ft) apatite RPB near the Columbia River shoreline in 2006, 2007, and 2008. The DOE is also investigating other technologies under the EM-22 program, including apatite infiltration and phytoremediation. Work is ongoing on all three projects, and the results will be published in FY09.

- **RAO #3:** Prevent destruction of sensitive wildlife habitat. Minimize disruption of cultural resources and wildlife habitat in general and prevent adverse impacts to cultural resources and threatened or endangered species.

  Results: The interim remedial action ROD (EPA et al. 1999) establishes a variety of institutional controls that must be implemented and maintained throughout the interim action period. These provisions include the following:

  - Access control and visitor escorting requirements.
  - Signage providing visual identification and warning of hazardous or sensitive areas (new signs were placed along the river and at major road entrances at each reactor area).
  - Excavation permit process to control all intrusive work (e.g., well drilling and soil excavation)
  - Regulatory agency notification of any trespassing incidents.

  The effectiveness of institutional controls established in the interim action ROD for the 100-NR-2 (EPA et al. 1999) was evaluated and summarized for implementation and effectiveness in 2003. DOE/RL-2004-56 presents the results for the current review. In summary, the report found that institutional controls were maintained to prevent public access, as required.

4.7 RECOMMENDATIONS

The recommendations for the 100-NR-2 OU are as follows:

- Continue to monitor strontium-90 plumes, focusing on the portion of the plume near the Columbia River, and evaluate remediation alternatives.
- Three years have passed since 100-N Area pump-and-treat extraction wells were placed in cold-standby status, so frequent monitoring for rebound is no longer required. The frequency of monitoring for former extraction wells was decreased to semi-annually or annually.
- Continue to monitor co-contaminants.
- Continue to evaluate the extent of possible shoreline water quality impacts related to the diesel spill that occurred circa 1963. Aquifer tubes at the upstream end of the array will continue to be sampled for TPH and related contaminants. Work has begun on characterization and testing of remediation technologies for the petroleum contamination plume. A well is being drilled upstream of the apatite PRB (near the aquifer tubes mentioned above) for characterization and testing of remediation technologies. WCH is installing seven wells to test bioventing technology.

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5.0 PUMP-AND-TREAT SYSTEM COST DATA

Actual costs for the 100-HR-3, 100-KR-4, and 100-NR-2 pump-and-treat systems were recorded in the CHPRC Hanford Data Integrator database. The data are used to determine the actual capital and expense costs associated with a specific activity during the FY. Specific activities are briefly described below:

- Capital design: Includes design activities to construct the pump-and-treat systems and designs for major system upgrades and modifications.
- Capital construction: Includes oversight labor, material, and subcontractor fees for capital equipment, initial construction, construction of new wells, redevelopment of existing wells, and modifications to the pump-and-treat system.
- 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: Represents facility supplies, labor, and craft supervision costs associated with operating the facility. It also includes the costs associated with routine field screening and engineering support as required during the course of pump-and-treat operation and periodic maintenance.
- Performance monitoring: Includes system and groundwater sampling and sample analysis, as required in accordance with the 100-HR-3 and 100-KR-4 interim action work plan (DOE/RL-96-84) and the 100-HR-3 and 100-KR-4 interim action monitoring plan (DOE/RL-96-90), as modified by sampling changes (DOE-RL 1998).
- Waste management: Includes the cost for the management of spent resin at 100-HR-3, 100-KR-4, and spent clinoptilolite in accordance with applicable laws for suspect hazardous, toxic, and regulated wastes. It includes waste designation sampling and analysis. Also included are resin regeneration costs and new resin purchase.

Costs are burdened and are based on actual operating costs incurred during FY08. A comparison between FY07 and FY08 costs is presented in the following sections.

5.1 100-HR-3 PUMP-AND-TREAT SYSTEM COSTS

The cost breakdown for the 100-HR-3 pump-and-treat system is presented in Figure 5-1. Total construction and operation costs for FY08 are higher than those for FY07. As shown in Figure 5-1, the cost breakdown indicates that the majority of the costs (in decreasing order) are charged to operations and maintenance (55.5%), performance monitoring (26.0%), waste management (9.8%), and project support (8.7%). Based on the total FY07 cost ($1,955,000), the yearly production rate of 321.1 million L (84.8 million gal), and 25.6 kg of hexavalent chromium removed, the annual treatment costs equate to $0.006/L, or $76/g of hexavalent chromium removed. These treatment costs are slightly higher than the FY07 treatment costs of $74/g of hexavalent chromium removed.

The cost breakdown for the DR-5 pump-and-treat system is presented in Figure 5-2. The total FY08 construction and operation costs are $1,269,200, which is higher than the $938,700 reported for FY07. The FY08 cost breakdown indicates that the majority of the cost was for operations and maintenance (69.7%), followed (in decreasing order) by project support (18.4%), performance monitoring (10.0%). and waste management (1.9%). Based on the total FY08 costs, the yearly production rate of 73.7 million L (19.5 million gal), and 50.6 kg of hexavalent chromium removed, the annual treatment costs equate to $0.017/L, or $25.00/g, of hexavalent chromium removed.

Figure 5-1. 100-HR-3 Pump-and-Treat System Costs. (2 pages)

Cost Breakdown for 100-HR-3 Pump-and-Treat Construction and Operations										
Description	**Actual Costs (Dollars x 1,000)**									
	1999	**2000**	**2001[a]**	**2002[b]**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
Design	--	--	97.7	15.4	8.1	196.1	196	55.00	92.0	--
Treatment system capital construction	--	57.7	(36.1)	750.3	--	496.6	10	0.0	0.0	--
Project support	265.3	276.7	225.8	309.3	229.8	211.8	722.6	697.6	171.9	169.5
Operations and maintenance	1,650.8	799.1	739.2	816.6	733.7	1,049.5	618.5	891.2	679.6	1,084.8
Performance monitoring	--	173.7	219.9	120	163.2	120.3	353	489.6	219.5	508.5
Waste management	--	895.3	424.9	720.1	877.2	501.7	202.2	217.6	434.7[c]	192.2
Totals	**$1,916**	**$2,202**	**$1,671**	**$2,732**	**$2,012**	**$2,576**	**$2,102**	**$2,351**	**$1,598**	**$1,955**

[a] 2001 costs corrected for project support and waste management. Initial expense calculations for 2001 were not properly categorized.
[b] 2002 accrual costs corrected for appropriate split between Bechtel Hanford, Inc. and Fluor Hanford, Inc.
[c] Additional waste management costs associated with drilling wastes and resin cleared for shipment and handling.
- = not available

100-HR-3 Pump-and-Treat System, Fiscal Year 2008 Cost Breakdown (by Percentage)

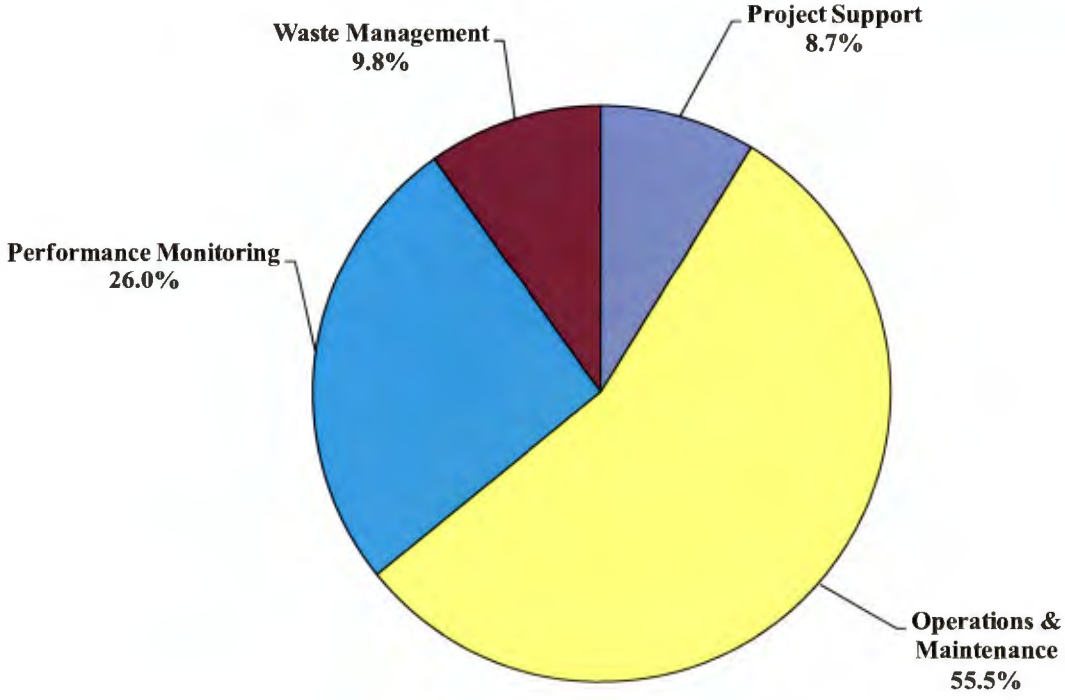
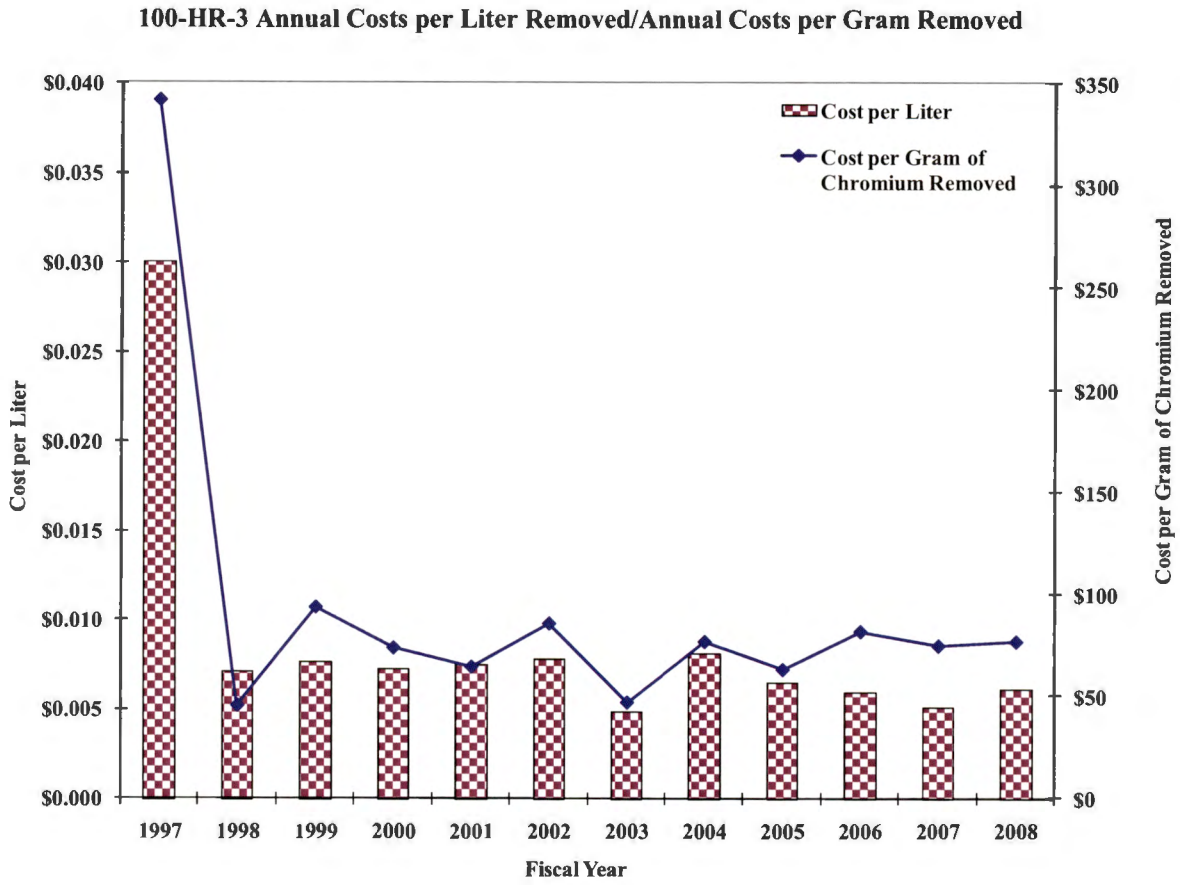


Figure 5-1. 100-HR-3 Pump-and-Treat System Costs. (2 pages)



5.2 100-KR-4 PUMP-AND-TREAT SYSTEM COSTS

The cost breakdown for the 100-KR-4 pump-and-treat system is shown in Figure 5-3. Compared to FY07, the total construction and operations costs were significantly higher in FY08. The higher costs can be attributed primarily to the expansion of the pump-and-treat system. As shown in Figure 5-3, the cost breakdown indicates that the majority of the costs (in decreasing order) are charged to treatment system capital construction (73.5%), project support (8.5%), operations and maintenance (8,0 %), performance monitoring (5.6%), waste management (3.8%), and design (0.6%). Based on the FY08 cost ($11,383,700), the yearly production rate of 501.9 million L (132.6 million gal), and 17.9 kg of hexavalent chromium removed, the annual treatment costs equate to $0.019/L, or $537/g of hexavalent chromium removed. These treatment costs are higher than the FY07 treatment costs of $204/g of hexavalent chromium removed.

The cost breakdown for the KW Reactor pump-and-treat system is presented in Figure 5-4. The total FY08 construction and operation costs are $2,161,900. The FY08 cost breakdown indicates that the majority of the cost was for treatment system capital construction (50.3%), followed (in decreasing order) by operations and maintenance (27.7%), waste management (7.6%), project support (7.2%), performance monitoring (5.9%), and design (1.3%). Based on the total FY07 cost of $2,161, the yearly production rate of 197.5 million L (52.2 million gal), and 15.3 kg of hexavalent chromium removed, the annual treatment costs equate to $0.011/L and $142/g of hexavalent chromium removed.

Figure 5-2. DR-5 Pump-and-Treat System Costs. (2 pages)

Cost Breakdown for DR-5 Pump-and-Treat Construction and Operations				
Description	**Actual Costs (Dollars x 1,000)**			
	2005	**2006**	**2007**	**2008**
Design	246.9	196.8	100.4	--
Treatment system capital construction	--	22.2	--	--
Project support	586.4	370.6	240.3	233.6
Operations and maintenance	459.6	605.7	541.3	884.7
Performance monitoring	106.2	1.6	11.3	127.1
Waste management	28.3	154.7	45.4	23.8
Totals	**$1427.4**	**$1,351.6**	**$938.7**	**$1,269.2**

DR-5 Pump-and-Treat System, Fiscal Year 2008 Cost Breakdown (by Percentage)

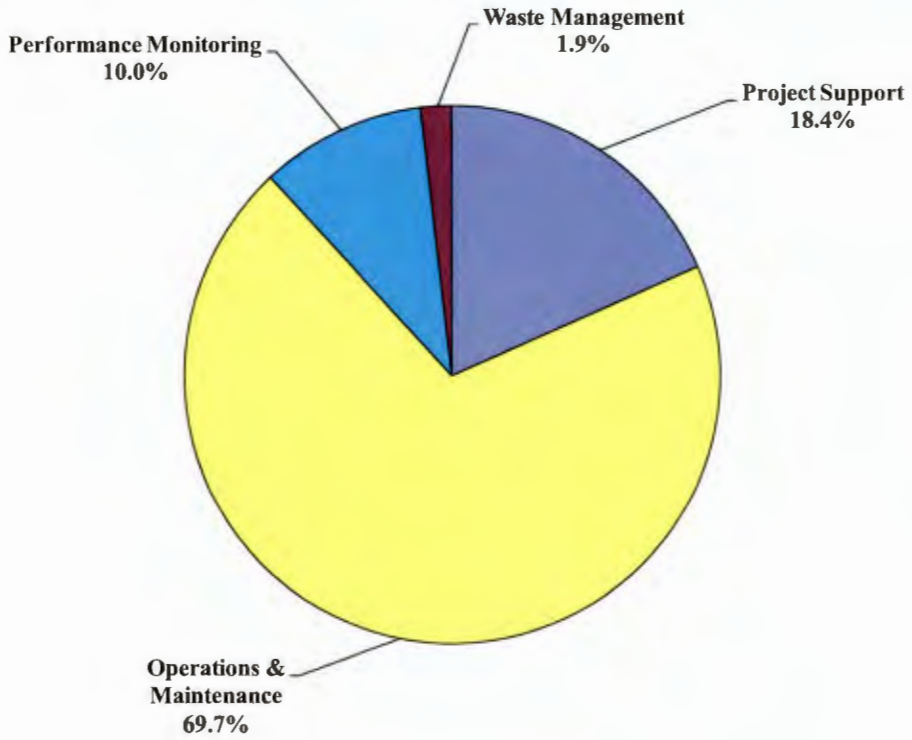
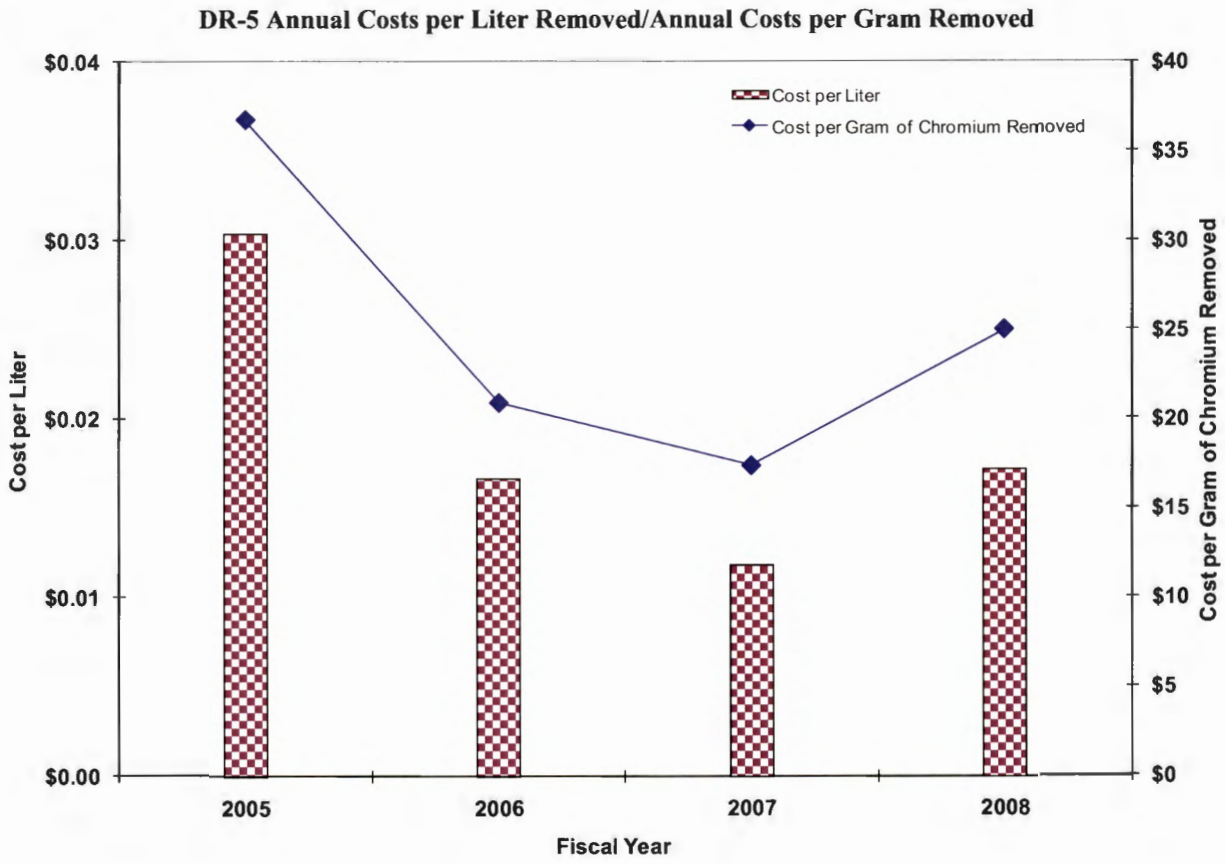


Figure 5-2. DR-5 Pump-and-Treat System Costs. (2 pages)



5.3 100-NR-2 PUMP-AND-TREAT SYSTEM COSTS

The 100-NR-2 pump-and-treat facility was placed in cold-standby status in FY06. Interim action activities are still being conducted as tasks are transitioned from the pump-and-treat to a chemical barrier. The costs presented in Figure 5-5 represent the processing of residual plant waste, performance monitoring and administrative activities associated with the pump-and treat facility while in cold-standby status; they do not include costs associated with the continued placement of the chemical barrier. As shown in Figure 5-5, the cost breakdown indicates that the majority of the costs (in decreasing order) are charged to operations (65.9%), performance monitoring (22.2%), project support (6.5%), and waste management (5.4%).

Figure 5-3. 100-KR-4 Pump-and-Treat System Costs. (2 pages)

Cost Breakdown for 100-KR-4 Pump-and-Treat Construction and Operations										
Description	**Actual Costs(Dollars x 1,000)**									
	1999	**2000**	**2001[a]**	**2002[b]**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
Design	0.2	--	96.5	55.2	70.8	163.9	190.8	97.8	187.0[c]	63.1
Treatment system capital construction	--	109.1	(0.1)	860.1	379.9	94.2	273.8	1,505.8	2,114.1[d]	8,368.5
Project support	157.2	143.0	188.2	257.8	171.0	211.8	851.9	530.5	489.8	963.0
Operations and maintenance	717.4	538.0	578.6	771.9	789.7	1,118.2	878.6	1,350.8	804.3	916.0
Performance monitoring	--	111.2	122.6	124.6	119.7	83.3	446.3	548.8	395.7	634.9
Waste management	--	481.8	367.5	343.3	684.7	475.8	198.3	230.2	458.9[e]	438.2
Totals	**$875**	**$1,383**	**$1,353**	**$2,413**	**$2,216**	**$2,147**	**$2,839.7**	**$4,263.9**	**$4,449.8**	**$11,383.7**

[a] 2001 costs corrected for project support and waste management. Initial expense calculations for 2001 were not properly categorized.
[b] 2002 accrual costs corrected for appropriate split between Bechtel Hanford, Inc. and Fluor Hanford, Inc.
[c] Additional design costs associated with pump-and-treat expansion.
[d] Additional treatment system capital construction costs associated with new wells and buildings to support pump-and-treat expansion.
[e] Additional costs associated with drilling wastes and resin cleared for shipment and handling.
- = not available

100-KR-4 Pump-and-Treat System, Fiscal Year 2008 Cost Breakdown (by Percentage)

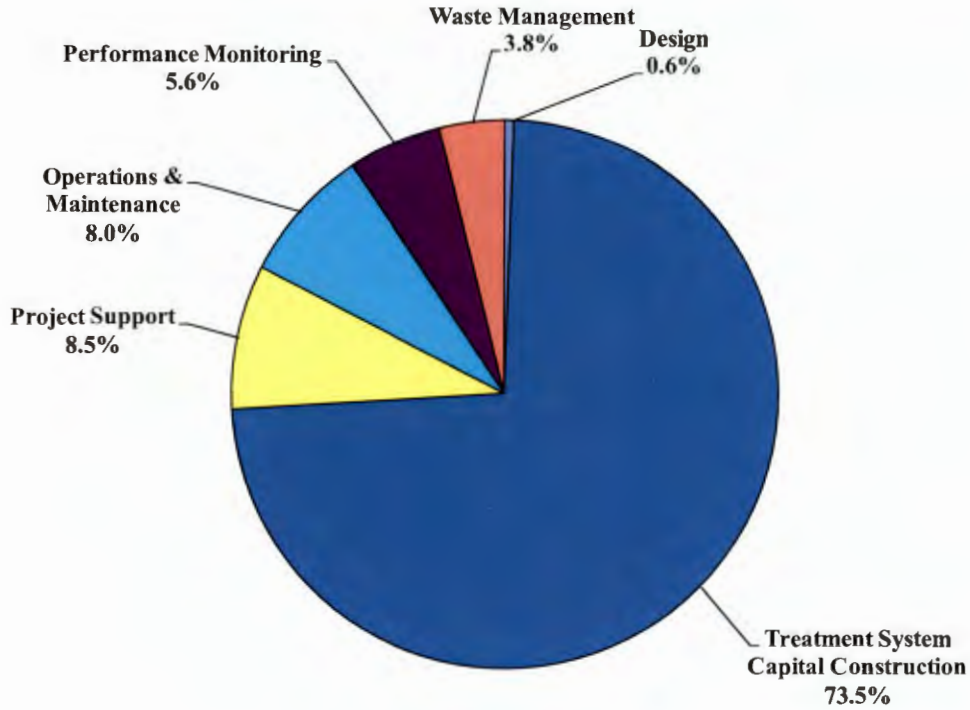


Figure 5-3. 100-KR-4 Pump-and Treat System Costs. (2 pages)

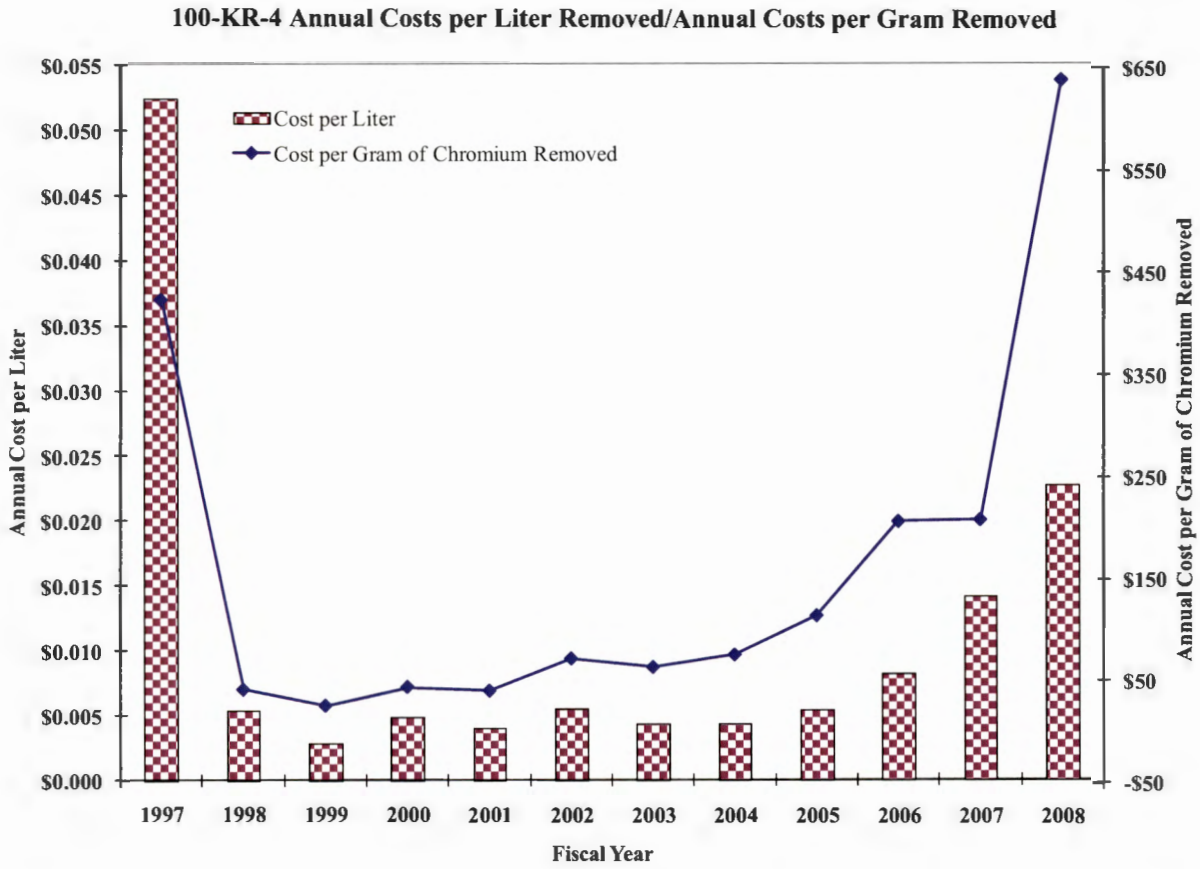


Figure 5-4. KW Reactor Pump-and-Treat System Costs. (2 pages)

Description	Actual Costs (Dollars x 1,000)	Actual Costs (Dollars x 1,000)
	2007	2008
Design	13.0	27.7
Treatment system capital construction	2,187.8	1,088.3
Project support	118.9	155.3
Operations and maintenance	402.4	599.6
Performance monitoring	9.7	126.6
Waste management	405.4	164.3
Total	**$3,137.2**	**$2,161.9**

KW Reactor Pump-and-Treat System, Fiscal Year 2008 Cost Breakdown (by Percentage)

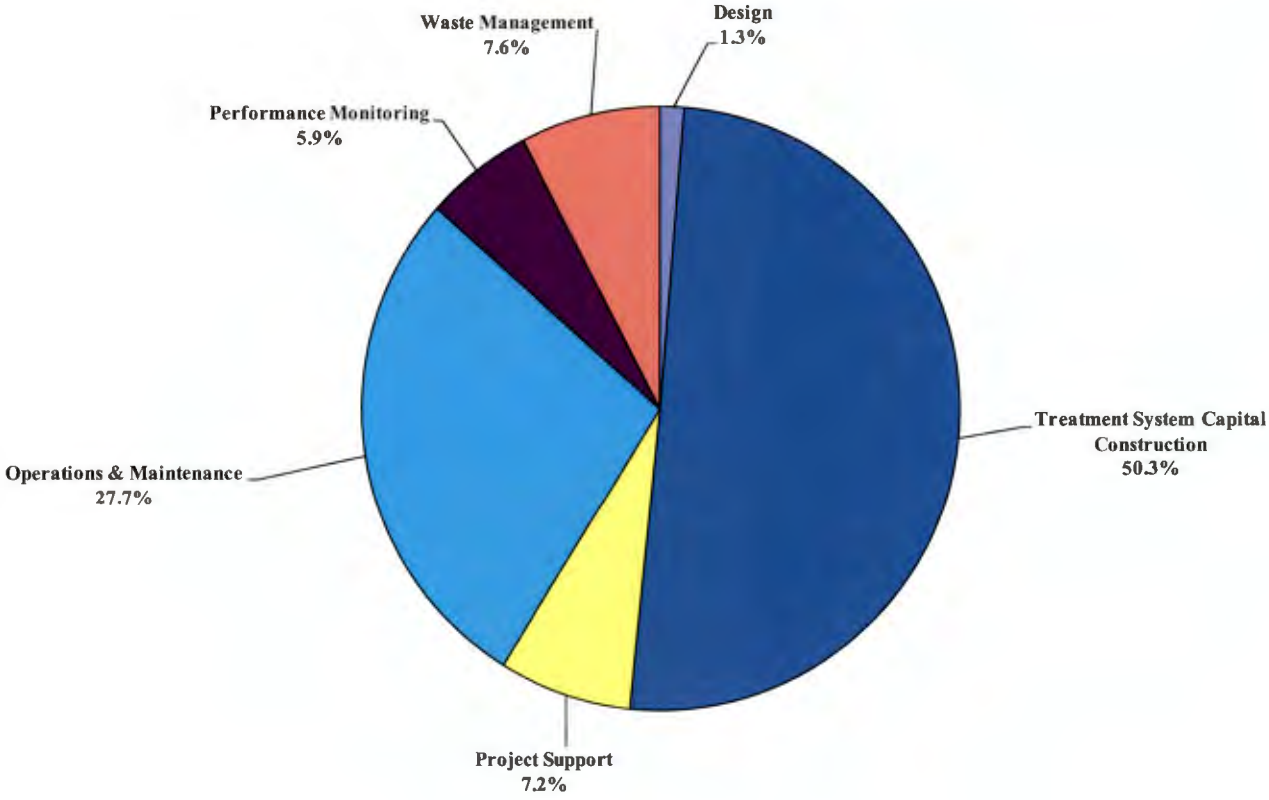


Figure 5-4. KW Reactor Pump-and-Treat System Costs. (2 pages)

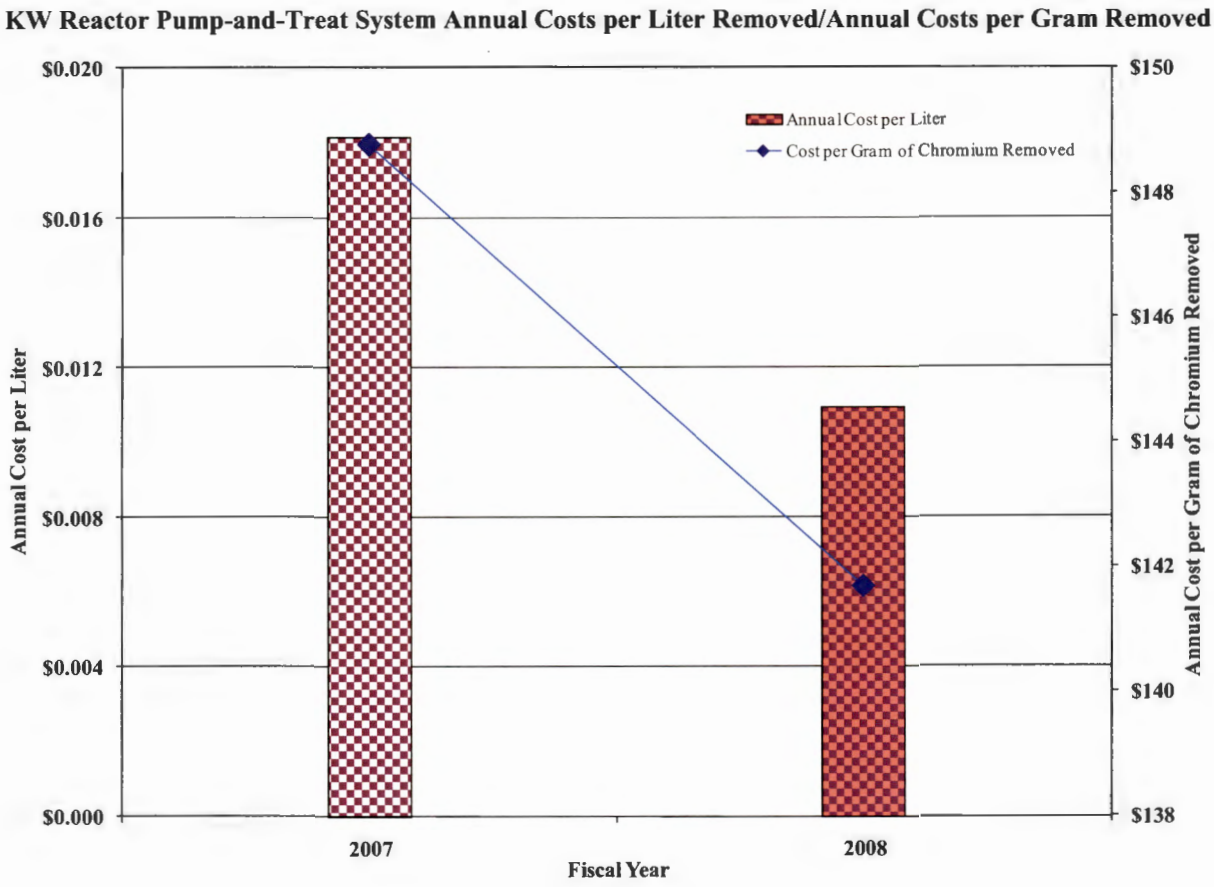


Figure 5-5. 100-NR-2 Pump-and Treat System Costs. (2 pages)

Cost Breakdown for 100-NR-2 Pump-and-Treat Construction and Operations										
Description	**Actual Costs (Dollars x 1,000)**									
	1999	**2000**	**2001[a]**	**2002[b]**	**2003**	**2004**	**2005**	**2006**	**2007**	**2007**
Design	0.2	--	--	--	--	--	447.9	--	--	--
Treatment system capital construction	--	--	--	--	--	--	161.9	922.6	--	--
Project support	113.1	96.3	183.5	219.4	133.0	329.7	416.5	284.4	79.8	10.7
Operations and maintenance	657.4	462.2	631.5	631.8	604.3	553.0	650.6	592.6	199.9	107.4
Performance monitoring	--	82.6	83.1	72.4	51.6	79.6	408.7	182.2	62.7	36.2
Waste management	--	131.6	112.5	100	45.4	27.4	7.6	13.0	43.4	8.9
Field studies	--	--	--	--	--	--	--	--	--	--
Barrier maintenance	--	--	--	--	--	--	--	--	--	--
Totals	**$771**	**$773**	**$1,011**	**$1,024**	**$834**	**$989.7**	**$2,093.2**	**$1,994.8**	**$385.8**	**$163.0**

[a] 2001 costs corrected for Project support and waste management. Initial expense calculations for 2001 were not properly categorized.
[b] 2002 accrual costs corrected for appropriate split between Bechtel Hanford, Inc. and Fluor Hanford, Inc.
- = not available

100-NR-2 Pump-and-Treat System, Fiscal Year 2008 Cost Breakdown (by Percentage)

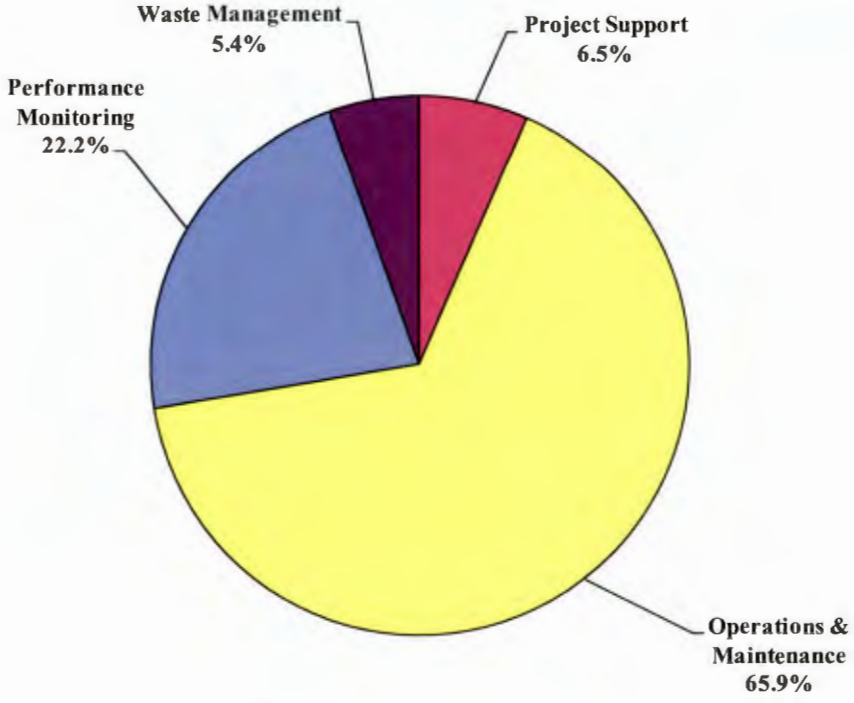
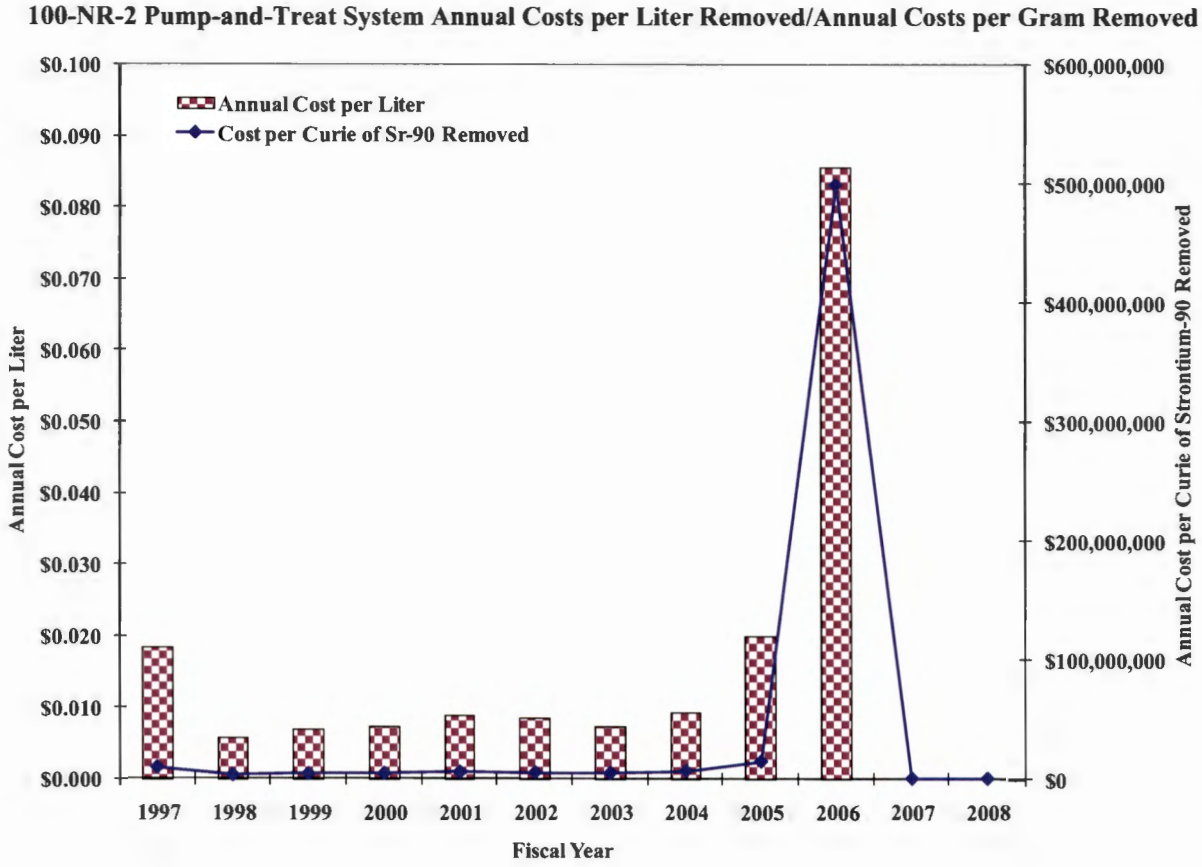


Figure 5-5. 100-NR-2 Pump-and Treat System Costs. (2 pages)



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