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Revision 0

Calendar Year 2007 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
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LIST OF TERMS

CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
COC	contaminant of concern
CY	calendar year
DOE	U.S. Department of Energy
DWS	drinking water standard
EPA	U.S. Environmental Protection Agency
FH	Fluor Hanford, Inc.
FY	fiscal year
gpm	gallons per minute
HEIS	Hanford Environmental Information System
ISRM	In Situ Redox Manipulation
IX	ion exchange
MCL	maximum contaminant level
MDA	minimum detectable activity
MDL	method detection limit
OU	operable unit
PRB	permeable reactive barrier
QC	quality control
RAO	remedial action objective
ROD	Record of Decision
RPD	relative percent difference
S&GRP	Soil & Groundwater Remediation Project
TPH	total petroleum hydrocarbon
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order*
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

Fluor Hanford, Inc. (FH) is currently operating seven groundwater pump-and-treat systems across the Hanford Site. Five systems address groundwater in the 100 Areas: two systems treat hexavalent chromium in the 100-HR-3 Operable Unit (OU); two systems also treat hexavalent chromium in the 100-KR-4 OU; and the 100-NR-2 system, which treats strontium-90, is in cold-standby status. Two pump-and-treat systems are remediating groundwater in the 200 West Area: the 200-UP-1 OU system, which is going through a rebound investigation after treating technetium-99, uranium, carbon tetrachloride, and nitrate; 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 2007 Annual Summary Report for the In Situ Redox Manipulation Operations* (DOE/RL-2008-10). 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-treats and special projects are presented in *Hanford Site Groundwater Monitoring for Fiscal Year 2007* (DOE/RL-2008-01).

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. 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) specified this selected remedy. The implementation of the existing pump-and-treat system was authorized in the *Action Memorandum: N-Springs Expedited Response Action Cleanup Plan, U.S. Department of Energy Hanford Site, Richland, Washington* (Ecology and EPA 1994). The 100-NR-2 RAOs are summarized as follows:

- **RAO #1:** Maintain beneficial uses of the Columbia River and protect the aquifer by reducing contaminant concentrations in the 100-NR-2 groundwater.
- **RAO #2:** Obtain information to evaluate technologies for strontium-90 removal and evaluate ecological receptor impacts from contaminated groundwater.

- **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.

In 2005, the RAO actions 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. As a result of this review and via approval 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 support of 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 to emplace a PRB along the 100-N Area shoreline in 2007 with the goal of sequestering strontium-90 in the aquifer (*Strontium-90 Treatability Test Plan for the 100-NR-2 Groundwater Operable Unit* [DOE/RL-2005-96]). Progress on that barrier will be reported separately.

This report is organized into three major sections, each presenting 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 K.

1.1 SUMMARY OF ASSOCIATED 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-2008-01.

1.1.1 100-HR-3 Operable Unit Activities

- **Chromium investigation in the "horn" area:** Twenty-one wells and 18 aquifer tubes were installed during calendar year 2007 (CY07) to characterize groundwater underlying the area between the 100-D and 100-H Areas. A report summarizing the findings is scheduled for release by the end of fiscal year 2007 (FY07).
- **Electrocoagulation tests:** This project involved pumping hexavalent chromium-contaminated groundwater from existing monitoring wells in the 100-D Area, precipitating the hexavalent chromium and other contaminants using an electrical field, and returning treated groundwater to the aquifer via injection wells. The process operated for several months during the summer of 2007 at approximately 190 L/min (approximately 50 gallons per minute [gpm]). A treatability test report is currently scheduled for release by the end of FY08.
- **Chromium source area refinement:** Seven wells were installed in the 100-D Area in February and March 2007 with the goal of locating remaining concentrated sodium dichromate sources in the vadose zone. Sampling was conducted in the vadose zone while the wells were being advanced, and groundwater samples were collected for several months. The field investigation plan is summarized in *Field Investigation Plan for the Source of the Southwestern Chromium Plume in the 100-D Area*

(DOE/RL-2006-74), and a final report summarizing the finding is scheduled for release during the fall of 2008.

- **DR-5 facility performance evaluation:** This study was conducted with the objective of optimizing the waste stream associated with the resin regeneration. The immediate goal is to verify that total chromium in the waste stream discharged to the ISRM pond is below the dangerous waste threshold established by the regulatory agencies. The long-term objective is to eliminate discharge to the IRSM pond.

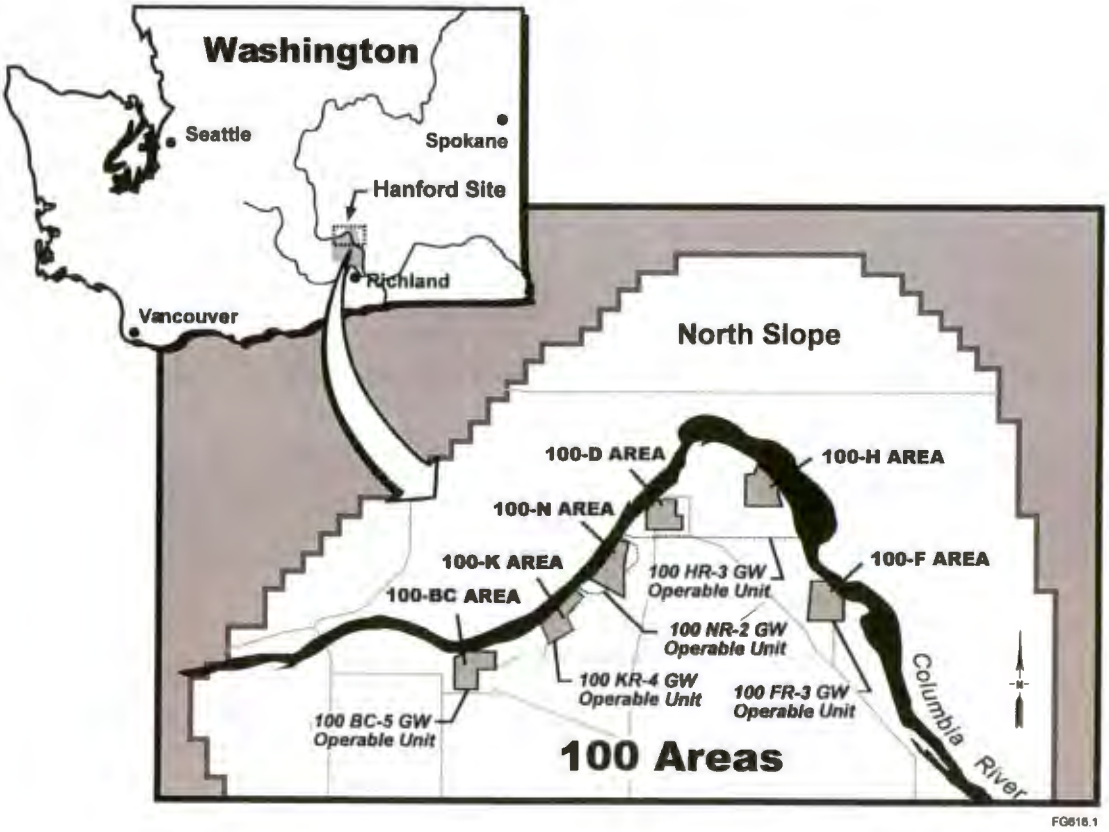
1.1.2 100-KR-4 Operable Unit Activities

- **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 and 9 injection wells. A revised remedial design/remedial action work plan is scheduled for release during fall 2008.
- **KW Reactor pump-and-treat system:** The KW Reactor pump-and-treat system became operational in January 2007 with the objective of controlling and remediating the hexavalent chromium plume in the area of the KW Reactor. It includes four extraction wells and two injection wells and is operating at approximately 379 L/min (100 gpm).

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, and this status continued throughout CY07.
- **Permeable reactive barrier (PRB):** A PRB was installed along the 100-N Area shoreline during 2006 and 2007. The system involves injection of 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).

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



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

The 100-HR-3 pump-and-treat facility is located in the north-central portion of the Hanford Site along the Columbia River. The 100-HR-3 OU represents the groundwater underlying the source OUs that are associated with the D and H Reactor areas and the adjacent 600 Area (Figure 2-1). Groundwater extraction systems were installed at the D and H Reactor areas in June 1997, with a common treatment facility in a surplus building located near H Reactor. A stand-alone pump-and-treat system, 100-DR-5 (hereinafter referred to as DR-5), began testing in July 2004 and became fully operational in December 2004 to treat a new contaminant source located in the central portion of the 100-D Area.

Monitoring and extraction well locations for the 100-D Area are shown in Figure 2-2 and 100-H Area well locations are shown in Figure 2-3. Appendix A provides a history of operations and identifies the supporting documents used in the development of the 100-HR-3 pump-and-treat system.

This section provides the CY07 annual summary report for pump-and-treat operations in the 100-HR-3 OU, as required by the *Remedial Design Report and Remedial Action Work Plan for the 100-HR-3 and 100-KR-4 Groundwater Operable Units Interim Action* (DOE/RL-96-84). Section 2.1 summarizes the treatment system's performance. Sections 2.2 and 2.3 discuss aquifer responses in the 100-D Area and 100-H Area, respectively, as well as reviewing the hydraulic conditions, capture zone analysis through numerical modeling, and the contaminant concentrations for the 100-D and 100-H Areas, as well as the "horn" area between the 100-D and 100-H Areas. Section 2.4 discusses the quality control (QC) results for groundwater samples. Sections 2.5 and 2.6 provide conclusions and recommendations for the pump-and-treat system. Cost information is presented in Section 5.0.

2.1 100-HR-3 OPERABLE UNIT TREATMENT SYSTEM PERFORMANCE

This section describes the 100-HR-3 pump-and-treat system's operational and related sampling activities. Information presented includes system availability, changes to system configuration, mass of contaminants removed during operations, contaminant removal efficiencies, quantity and quality of extracted and disposed groundwater, waste generation, and short-term contaminant comparisons. Additional operational details are provided in the associated appendices, as specified in this report. Figures 2-2 and 2-3 present the most recent 2007 well configurations for the 100-D and 100-H Areas. Well symbols in these figures represent the use of the well at the end of 2007.

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. The table below identifies the current extraction and injection wells:

Well	Use in CY07	Avg. Pumping Rate gpm (L/min)	
		High River[a]	Low River[b]
199-D5-20	Extraction	8.0 (30.2)	6.8 (25.7)
199-D5-32	Extraction	19.5 (73.8)	15.8 (59.8)
199-D5-39	Extraction	14.4 (54.5)	15.1 (57.1)
199-D5-92	Extraction	8.4 (31.7)	8.1 (30.6)
199-D5-42	Injection	NA	NA

[a] Beginning of March to end of August.
[b] Beginning of September to end of February.
gpm = gallons per minute
L/min = liters per minute
NA = values not calculated

A summary of operational parameters and total system performance for the DR-5 pump-and-treat system in CY07 is presented in the table below:

Total DR-5 processed groundwater:	
Total amount of groundwater treated (since December 2004) (million L)	211.0
Total amount of groundwater treated during CY07 (million L)	79.3
Mass of hexavalent chromium removed:	
Total amount of hexavalent chromium removed (since August 2004 startup) (kg)	160.7
Total amount of hexavalent chromium removed in CY07 (kg)	53.9
Summary of operational and system availability:	
Removal efficiency (% by mass)	99.9%
Total possible run-time (hours)	8,760
Scheduled downtime (hours)	22.8
Planned operations (hours)	8,737.2
Unscheduled downtime (hours)	181.6
Total time on-line (hours)	8,555.6
Total availability (%)	97.7%
Scheduled system availability (%)	99.7%

Operational details for CY07 are as follows:

- A total of 79.3 million L (20.9 million gal) of groundwater was processed in CY07. The total volume of water treated since startup of the operational phase of the pump-and-treat system is 211.0 million L (55.7 million gal). In CY07, 53.9 kg of hexavalent chromium were removed, resulting in a total of 160.7 kg processed since startup.
- The average removal efficiency for CY07 was 99.9%. The average hexavalent chromium influent concentration was 680 μg/L, while the average effluent concentration was <1 μg/L (Figure 2-5).

- Scheduled system availability for CY07 was 99.7%, which was higher than the 96.4% reported in CY06. The total availability was 97.7%. The higher system availability values can be attributed to increased system efficiencies associated with the completion of testing and system modification activities near the end of CY06 (Figure 2-6). These changes involved modifications to the flow rates for extraction wells and system control improvements to the regeneration system and control software.

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. The table below identifies the current extraction, compliance, and injection wells:

Well	Use in CY07	Avg. Pumping Rate gpm (L/min)	
		High River[a]	Low River[b]
199-D8-53	Extraction	9.9 (37.5)	8.8 (33.3)
199-D8-54A	Extraction	18.7 (70.8)	12.9 (48.8)
199-D8-68	Extraction	52.2 (197.6)	51.5 (194.9)
199-D8-72	Extraction	16.9 (64.0)	9.8 (37.1)
199-D8-69	Compliance	NA	NA
199-D8-70	Compliance	NA	NA
199-H4-3	Extraction	7.0 (26.5)	7.3 (27.6)
199-H4-4	Extraction	7.9 (29.9)	6.8 (25.7)
199-H4-12A	Extraction	12.5 (47.3)	6.4 (24.2)
199-H4-15A	Extraction	16.6 (62.8)	17.1 (64.7)
199-H4-63	Extraction	24.4 (92.4)	24.0 (90.8)
199-H4-64	Extraction	14.3 (54.1)	12.2 (46.2)
199-H4-17	Injection	NA	NA
199-H4-7	Injection	NA	NA
199-H4-18	Injection	NA	NA
199-H4-14	Injection	NA	NA
199-H4-5	Compliance	NA	NA

[a] Beginning of March to end of August.
[b] Beginning of September to end of February.
gpm = gallons per minute
L/min = liters per minute
NA = values not calculated

Summaries of operational parameters and total system performance for the 100-HR-3 pump-and-treat system in CY07 are presented in the tables below.

Total 100-HR-3 processed groundwater (million L):[a]		
	CY07	**Since 1997 Startup**
100-D Area	170.5	1,788.6
100-H Area	144.9	1,512.4
Total	**315.4**	**3,301.0[b]**
Mass of hexavalent chromium removed 2007 (kg)		
100-D Area	19.5	NA
100-H Area	2.3	NA
	CY07	**Since 1997 Startup**
Total	21.8	321.7

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

2007 100-HR-3 operational parameters:[a]	
Removal efficiency (% by mass)	95.7%
Waste generation (m^3)[b]	0
Regenerated resin installed (m^3)	47.6
New resin installed (m^3)	20.4
Number of resin vessel changeouts	21
2007 100-HR-3 system availability:[a]	
Total possible run-time (hours)	8,760
Scheduled downtime (hours)	54.6
Planned operations (hours)	8,705.4
Unscheduled downtime (hours)	41.4
Total time on-line (hours)	8,664.0
Total availability (%)	98.9%
Scheduled system availability (%)	99.4%

[a] Does not include system parameters for the DR-5 pump-and-treat system.
[b] Each IX vessel contains 2.3 m^3 of IX resin.

The operational and system highlights for CY07 discussed below pertain to the original 100-HR-3 (100-D and 100-H) pump-and-treat system:

- A combined total of 315.4 million L (83.3 million gal) of groundwater was processed in CY07, which was a 20% decrease in volume when compared to the 394 million L (104.1 million gal) processed in CY06. The 21.8 kg of hexavalent chromium removed in CY07 was a decrease of 24% in mass removed when compared to the 28.5 kg processed in CY06. This decrease in total mass removed is attributed to lower extraction well concentrations from the 100-H and 100-D Areas and the smaller volume of water extracted in CY07.
- The average removal efficiency for CY07 was 95.7%, which is more than the 93.6% reported in CY06 (Figure 2-8).

- The 100-D Area influent hexavalent chromium concentration average (after separating the process streams) was approximately 119 μg/L. This was a 7% decrease when compared to the 128 μg/L reported early in CY06.
- The average 100-H influent hexavalent chromium concentration in CY07 (after separating the process streams) was 16 μg/L. This was 11% less than the 18 μg/L reported in early CY06. Trend plots of CY07 influent and effluent concentrations are presented in Figure 2-9.
- The effluent concentrations for the CY07 reporting period were predominantly below 10 μg/L.
- Scheduled system availability for CY07 was 99.4%, which was slightly higher than the 99.3% reported in CY06. The total availability for CY07 was 98.9%, which was lower than the 99.1% on-line availability reported for CY06. The monthly on-line percentages and method used to calculate scheduled and on-line availability are presented in Figure 2-10.
- Resin changeouts were performed on 21 vessels in CY07. New resin installed totaled 20.4 m^3 (720 ft^3), while regenerated resin totaled 47.6 m^3 (1,680.9 ft^3).

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 numerical modeling conducted to evaluate the extraction well network, and the changes in contaminant concentrations in monitoring wells.

2.2.1 Hydrogeologic Conditions at 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 well 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. Changes in the stage of the Columbia River lead to changes in groundwater elevation within the aquifer. This aquifer response is most pronounced near the shoreline but extends several hundred meters inland of the shore. During low river stage in the fall and winter, flow is locally from the aquifer to the river, whereas during high river stage in the spring and summer the flow is locally from the river inland.

The aquifer in the vicinity of 100-D Area is located in the sands and gravels of Ringold Unit E. 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). Consequently, the aquifer is transmissive enough to support the 189 to 378.5 L/min (50 to 100 gpm) combined pumping rates of injection wells 199-D5-42 and 199-D5-106. Appendix C provides hydrographs for select 100-HR-3 Area wells.

Groundwater mounding in response to injection of treated water at wells 199-D5-42 and 199-D5-106 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 that the 182-D reservoir did not leak during CY07. The western plume (Figure 2-11) flows

through the ISRM barrier, while the eastern plume to the north and east is intercepted by a series of extraction wells. Flow is generally toward the river between the injection well field and the river and generally parallel to the river for only about 200 m (656 ft), both up and downriver of the injection well field before becoming approximately perpendicular to the river further away from the injection wells.

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; consequently, the dynamics of groundwater flow in the vicinity of the river change seasonally. A comparison of fall and spring groundwater levels in Figure 2-11 suggests that the seasonal water-level rise in the river due to the spring run-off causes changes in groundwater levels up to several hundreds of meters inland in the aquifer. However, wells near the river exhibit the most water-level change, with the magnitude of this effect attenuating farther 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 corroborated by concentration contours presented in Figure 2- 11. These indicate that during spring run-off when the river stage is high, chromium concentrations are <20 μg/L along the entire shoreline, whereas during late fall when the river stage is low, chromium concentrations are >20 μg/L at several locations along the shoreline.

2.2.2 Numerical Modeling and Field Validation of Zone of Influence

Figures illustrating groundwater elevations in this section were prepared by contouring water levels measured in monitoring, extraction, and injection wells. Water levels measured in extraction and injection wells are affected by the efficiency of the well; therefore, corrections are made to these measured water levels to provide a value that is more representative of the water level in the aquifer immediately adjacent to the well for inclusion in the contouring (see Appendix D). However, on some occasions, this approach can exaggerate the amount and extent of drawdown and mounding that actually occur in the vicinity of extraction and injection wells, respectively. In future reports, a rigorous water-level mapping method that accounts explicitly for the drawdown and mounding due to extraction and injection wells, respectively, will be used for this purpose to produce more representative maps of actual field conditions.

Numerical modeling was conducted to evaluate whether the locations and pumping rates of the extraction wells provide effective capture of the contaminant plume. Flow lines reaching the Columbia River indicate incomplete capture. The following conclusions/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, as shown in Figure 2-12 (100-D Area capture zone). Based on the 100-D chromium plume in 2007, 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 shown in Figure 2-12.

- Figure 2-12 displays time markers spaced 1 year apart on the flow lines based on the high November steady-state velocities. The fastest velocities appear to be related to the increased gradient around injection well 199-D5-42.
- The current numerical model grid is areally limited to the 100-D Area. In future modeling efforts, the 100-D Area will be incorporated into a more areally extensive grid that includes the geographic area from the 100-KR-4 OU up to and including the "horn" area and the 100-H Area.

Table 2-1 presents a comparison of the measured and modeled water table elevations, as well as the average flow rates used in the numerical model. A detailed discussion of the numerical model is presented in Appendix D.

2.2.3 Contaminant Monitoring in the 100-D Area

This section summarizes and interprets the analytical results obtained from groundwater wells and aquifer tubes specified in the interim remedial action and OU monitoring programs in the 100-D Area. The *Interim Action Monitoring Plan for the 100-HR-3 and 100-KR-4 Operable Unit* (DOE/RL-96-90) and *Sampling Changes to the 100-HR-3 and 100-KR-4 Operable Unit* (DOE-RL 1998) define the sampling protocols implemented for CY07. The results presented below compare the 2007 hexavalent and total chromium concentrations in wells and aquifer tubes to baseline concentrations, unless otherwise specified. Chromium results include both hexavalent chromium and total filtered chromium. Where more than one result is available for the time interval represented, the results are averaged in accordance with the protocol described in Appendix E. Data are stored in the Hanford Environmental Information System (HEIS) database. Appendix E contains tables of average annual contaminant concentrations for CY01 through CY07.

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 are present in concentrations that result in low ecological risk (*Limited Field Investigation Report for the 100-HR-3 Operable Unit* [DOE/RL-94-43]). 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. Institutional controls, implemented to satisfy RAO #2, limit human exposure to hexavalent chromium and the co-contaminants.

Section 2.3.3.1 discusses the results of chromium monitoring, and Section 2.3.3.2 discusses the results of co-contaminant monitoring. The discussion of sampling results for the sections presented below excludes the results from those wells within and downgradient of the ISRM barrier. The locations of the monitoring wells and aquifer sampling tubes are shown in Figure 2-2. Appendix F presents trend charts for wells in the 100-D Area.

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. The 100-D Area hexavalent chromium plume for fall 2007 and associated historical trends in individual wells is presented in Figure 2-13. Hexavalent chromium plumes for the period from 1995 through 2007 are displayed in Figure 2-14. Hexavalent chromium concentrations in wells along the ISRM shoreline are discussed in the FY07 ISRM annual summary report (DOE/RL-2008-10).

As shown in Figure 2-14, the shape and extent of the 100-D Area hexavalent chromium plume varied significantly from 1995 to 1999 as additional wells and aquifer tubes were added to the monitoring network. Since 2003, the general plume configuration has remained nearly the same. The major plumes are in the area of the ISRM barrier, extending upgradient to well 199-D2-8; and the other plumes are located in the area the reactors. These plumes have likely remained separated because of injection into wells 199-D5-42 and 199-D5-106, previous leakage from the 182-D reservoir, and other water discharges. The 182-D reservoir operation logs indicate that the reservoir is no longer leaking; also, well 199-D5-106 was no longer being used as an injection well after the fall of 2007. The southern area of the plume is being remediated by the ISRM barrier. The northern plume area is under remediation by the DR-5 pump-and-treat system and the original 100-HR-3 pump-and-treat system that was installed in 1997.

Table 2-2 compares the 2007 hexavalent and total chromium concentrations in wells and aquifer tubes relative to the baseline concentrations. Baseline samples 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.
- The 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 2007 hexavalent chromium results and total chromium samples were collected on the same day.

A goal of the interim remedial action is to reduce concentrations in 100-D Area wells to below the 22 μg/L RAO. A comparison of baseline hexavalent chromium concentrations in compliance and extraction wells and aquifer tubes and a summary of 2007 chromium source investigation results is presented below.

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

- **Compliance wells:**
  - Baseline hexavalent chromium concentrations were above the RAO in all three compliance wells, ranging from 80 μg/L in well 199-D8-69 to 200 μg/L in well 199-D8-70 (Figure 2-13).
  - Fall 2007 hexavalent chromium concentrations were above the RAO in all three compliance wells, ranging from 46.8 μg/L in well 199-D8-69 to 122 μg/L in well 199-D8-68. Concentrations in all three wells have decreased since the startup of operations in 1997.

- **Extraction wells:**
  - Baseline hexavalent chromium concentrations in the four 100-D Area extraction wells ranged from 436 μg/L in well 199-D8-72 to 130 μg/L in well 199-D8-53.
  - Fall 2007 hexavalent chromium concentrations in 100-D Area extraction wells increased 55% to 676 μg/L in well 199-D8-72 and decreased 36.2% to 83 μg/L in well 199-D8-53 and 37.3% to 94 μg/L in well 199-D8-54A. The fourth 100-D Area well currently in use for extraction purposes is well 199-D8-68, which is a compliance well currently in the extraction network.

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:**
  - Baseline hexavalent chromium concentrations in DR-5 extraction wells ranged from 486 μg/L in well 199-D5-92 to 1,500 μg/L in well 199-D5-32.
  - Fall 2007 total filtered chromium concentrations increased 53.4% to 1,810 μg/L in DR-5 extraction well 199-D5-39. Baseline hexavalent chromium concentrations were not available for this well. In addition, baseline hexavalent chromium concentrations increased 2,788.9% to 260 μg/L in well 199-D5-20. Fall hexavalent chromium concentrations decreased almost 80% to 97.9 μg/L in well 199-D5-92 and 90.5% to 143 μg/L in well 199-D5-32.

2.2.3.4 100-HR-3 Aquifer Tubes. The results for the aquifer tubes at 100-HR-3 are listed below:

- Fall hexavalent chromium concentrations were above the 22 μg/L RAO in 5 of 13 aquifer tube sites along the 100-D Area shoreline. The maximum concentration measured was 71.4 μg/L in aquifer tube AT-D-3-D. This tube was characterized by a 2004 baseline filtered total chromium concentration of 294 μg/L when the DR-5 pump-and-treat system began operation.
- Fall hexavalent chromium concentrations in aquifer tubes downgradient of the 100-D Area compliance wells remained higher than the 22 μg/L RAO in two of four aquifer tubes, namely DD-16-3 (24.2 μg/L) and DD-17-3 (37 μg/L). However, from 1997 to 2007, the hexavalent chromium concentrations in these aquifer tubes have decreased approximately 86% from 172 μg/L in aquifer tube DD-16-3 and approximately 12% from 42 μg/L in aquifer tube DD-17-3.

2.2.3.5 2007 Chromium Source Investigation. The results for the 2006 chromium source investigation are summarized below:

- Persistent hexavalent chromium concentrations in groundwater after 10 years of pump-and-treat interim actions have resulted in a further effort to locate the remaining highly concentrated chromium sources. Seven additional groundwater monitoring wells were added during 2007 to the area northwest of the 100-DR water treatment facilities to search for continuing sources. Concentrated sodium dichromate solution was unloaded and distributed to the reactors in this area, and spills or discharges at this site may be responsible for continuing high concentrations. Table 2-2 provides the results of two

sampling rounds. The investigation was successful in locating very highly contaminated groundwater with maximum hexavalent chromium concentrations of 10,900 µg/L in well 199-D5-104 and 10,580 µg/L in well 199-D5-99. A report summarizing the findings of the investigation will be published by the end of FY08.

2.2.3.6 100-D Area Co-Contaminant Monitoring Results. The 100-D Area co-contaminants for the interim action are strontium-90, tritium, and nitrate (DOE/RL-96-90). Sulfate is also monitored as a contaminant of interest. The average annual results for co-contaminants are summarized in Appendix E. Table 2-3 provides a summary of baseline co-contaminant concentrations versus the fall 2007 results. Where 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:** Baseline samples were collected from 21 wells and aquifer tubes, and none of the strontium-90 results were above the 8 pCi/L maximum contaminant level (MCL). Seven wells were sampled in the fall of 2007, and none of the strontium-90 results were above the 8 pCi/L MCL. The maximum fall 2007 strontium-90 result was 7.65 pCi/L in well 199-D8-68.
- **Tritium:** Baseline samples were collected from 31 wells and aquifer tubes, and none of the tritium concentrations were above the 20,000 pCi/L MCL. Twenty-two wells were sampled in the fall of 2007, and the maximum tritium concentration was 12,000 pCi/L in well 199-D5-17.
- **Nitrate:** Baseline samples were collected from 40 wells and aquifer tubes, and 12 sites were characterized by nitrate concentrations above the 45 mg/L MCL (equivalent to 10 mg/L NO_3-N). Twenty-seven wells and aquifer tubes were sampled in the fall of 2007, and nine sites were characterized by >45 mg/L nitrate. A potential source of the nitrate is fertilizer used in pre-Hanford agricultural operations. The maximum fall 2007 nitrate concentration was 85.9 mg/L in well 199-D8-4, which was a 5,268.8% increase from the 1.6 mg/L baseline sample. It appears that this increase in concentration is due to a nitrate plume that has moved into the decommissioned 120-D-1 Pond area from the D Reactor area.
- **Sulfate:** Sulfate is a contaminant of interest in the 100-D Area and has a secondary DWS of 250 mg/L. The highest baseline sulfate concentration was 215 mg/L in well 199-D5-39, and the highest fall 2007 result was 140 mg/L in well 199-D5-16. The source of the sulfate is likely aluminum sulfate [$Al_2(SO_4)_3$] used in the water treatment process during reactor operations as a flocculant to reduce turbidity.

2.3 AQUIFER RESPONSE IN THE 100-H AREA

Hydrogeologic conditions for groundwater flow in the 100-H Area are generally outward from the injection field, which is comprised of wells 199-H4-7, 199-H4-14, 199-H4-17, and 199-H4-18. The plume is intercepted by a series of injection wells (199-H4-15A, 199-H4-64, 199-H4-12A, 199-H4-4, and 199-H4-63) (see Figure 2-15). Flow is generally toward the river between the injection well field and the river and is generally parallel to the river for <200 m (656 ft) both up and downriver of the injection wells before becoming approximately parallel to the river further away from the injection wells. Less head disturbance is observed in the vicinity

of the extraction wells, likely due to a significant contribution of pumping from surface water in the river being captured by the extraction well's cone of depression.

Groundwater flow in the 100-H Area is responsive to the river stage in the Columbia River. As shown in Figure 2-15, 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. Consequently, the dynamics of groundwater flow in the vicinity of the river change seasonally.

A comparison of fall and spring water levels suggests that the seasonal water-level rise in the river due to the spring run-off causes the water level to rise several hundreds of meters inland in the aquifer. This would 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. Consequently, the gradient during times of high flow tends to hold water longer in the aquifer, which would be expected to increase the efficiency of the extraction wells.

Appendix C provides hydrographs for select 100-HR-3 Area wells. Appendix D presents a detailed discussion of the aquifer response in the 100-HR-3 pump-and-treat system.

2.3.1 Numerical Modeling

Figures illustrating groundwater elevations in this section were prepared by contouring water levels measured in monitoring, extraction, and injection wells. Water levels measured in extraction and injection wells are affected by the efficiency of the well; therefore, corrections are made to these measured water levels to provide a value that is more representative of the water level in the aquifer immediately adjacent to the well for inclusion in the contouring (see Appendix D). However, on some occasions, this approach can exaggerate the amount and extent of drawdown and mounding that actually occur in the vicinity of extraction and injection wells, respectively. In future reports, a rigorous water-level mapping method that accounts explicitly for the drawdown and mounding due to extraction and injection wells, respectively, will be used for this purpose to produce more representative maps of actual field conditions.

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 hexavalent chromium pump-and-treat target plume has been greatly reduced in area. Most of the remainder of the shoreline plume (>20 μg/L) is within the capture zones of extraction wells 199-H4-12A, 199-H4-15A, and 199-H4-64, as shown in Figure 2-16.
- The numerical model shows an apparent gap in the capture zone between extraction wells 199-H4-4 and 199-H4-63 (Figure 2-16). However, the chromium plume concentrations in this area were <20 μg/L. A detailed discussion of the numerical model is presented in Appendix D. Table 2-1 presents a comparison of the measured and modeled water table elevations and the average flow rates used in the numerical model.
- 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.
- Figure 2-16 shows time markers spaced 90 days apart on the flow lines based on the high November steady-state velocities. The fastest velocities are displayed by flow lines in the high-conductivity region in the southernmost portion of Figure 2-16, where the pore

velocities are as high as 6 m/day (19.7 ft/day) from injection well 199-H3-5 to past monitoring well 199-H6-1. The groundwater velocities are as low as 1.7 m/day (5.6 ft/day) upgradient from well 199-H4-11.

- The current numerical model grid is limited in area to the 100-H Area. In future modeling efforts, the 100-H Area will be incorporated into a more area-extensive grid that includes the geographic area from the 100-KR-4 OU up to and including the "horn" area and the 100-H Area.

2.3.2 Contaminant Monitoring in the 100-H Area

This section summarizes and interprets 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. 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 CY07. The results presented in Tables 2-4 and 2-5 have been organized so baseline fall 2007 results can be compared to help evaluate the impact of the interim remedial action on groundwater contamination. The results represent the data that were available in the HEIS database when this report was prepared and may include some early 2008 data if the results provide completeness for the discussion.

2.3.2.1 100-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 2007 hexavalent chromium plume map and plots of chromium concentration versus time are presented in Figure 2-17. Hexavalent chromium plumes for the period 1995 through 2007 area shown in Figure 2-18.

The hexavalent chromium plume has changed dramatically since pump-and-treat operations began in 1997 (see Figure 2-18). The areal extent of the 2007 plume consists of a narrow strip along the 100-H Area shoreline downgradient of H Reactor and the former liquid effluent disposal facilities. The hexavalent chromium concentrations in the plume are in the range of 20 to 50 μg/L. The "horn" area hexavalent chromium plume appears to be moving into the 100-H Area and has been detected in former injection wells 199-H3-3, 199-H3-4, and 199-H3-5 (see Figure 2-19).

Baseline hexavalent and total chromium concentrations are compared to fall 2007 concentrations in Table 2-4. Baseline samples for each well were selected using as many of the following criteria as possible:

- The sample selected should represent groundwater conditions before the implementation of the 100-H pump-and-treat system in June 1997.
- The sample should have been minimally affected by pump-and-treat operations because of the distance from the 100-H Area extraction wells.
- The samples analyzed for hexavalent chromium and total chromium should have been collected on the same day. If this was 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.

A goal of the interim remedial action is to reduce concentrations in 100-H Area wells to below the 22 μg/L RAO. A comparison of baseline hexavalent chromium concentrations in compliance and extraction wells and aquifer tubes is as follows (see Table 2-4):

- Baseline hexavalent chromium concentrations were above the RAO in all four compliance wells, ranging from 60 μg/L in well 199-H4-64 to 90 μg/L in well 199-H4-5.
- Fall 2007 hexavalent chromium concentrations decreased below the RAO in all four compliance wells since startup, ranging from 5.9 μg/L in well 199-H4-5 to 19.7 μg/L in well 199-H4-64.
- The decrease in hexavalent chromium concentrations in these compliance wells ranged from 67.2% in well 199-H4-64 to 93.4% in well 199-H4-5.
- Baseline hexavalent chromium concentrations in the original five 100-H Area extraction wells were all above the RAO, ranging from 49 μg/L in well 199-H4-12A to 90 μg/L in well 199-H4-7.
- Fall 2007 hexavalent chromium concentrations in original 100-H Area extraction wells 199-H4-11 and 199-H4-12A were below the RAO, at 8.4 μg/L and 19.7 μg/L, respectively. These concentrations represent decreases of 89.5% in well 199-H4-11 and 75.4% in well 199-H4-12A.
- The fall 2007 hexavalent chromium concentration in original 100-H Area extraction well 199-H4-15A was 25 μg/L, which is above the RAO but is a decrease of 49% since the baseline measurement.
- The fall 2007 total filtered chromium concentration in well 199-H3-2A was 9.3 μg/L, which is a decrease of 89.8% since the baseline measurement. A hexavalent chromium analysis was not conducted for this well in the fall of 2007.
- Well 199-H4-7, an original 100-H Area extraction well, was converted to an injection well in recent years as part of the design optimization process to accelerate plume remediation. Therefore, no sampling was conduced in this well during 2007.
- Baseline hexavalent chromium concentrations were below the RAO in all 100-H Area aquifer tubes.
- Fall 2007 hexavalent chromium concentrations were below the RAO in six of seven aquifer tubes sampled. Aquifer tube site AT-H-1-D, where hexavalent chromium was measured at 22.4 μg/L, was the only site where the contaminant was above the RAO. This site is downgradient of well 199-H4-12A.

The discussion of deeper groundwater contamination in the 100-H Area requires a brief introduction of well construction details of the few deeper wells in the H Reactor area. Monitoring wells 199-H4-12A,B,C and 199-H4-15A,B,C are nested wells about 7.6 m (25 ft) apart and were drilled in 1986 to provide information on groundwater head and potential contamination from the Hanford formation through various semi-confined Ringold Formation units to the basalt, downgradient of the former 183-H solar evaporation basins.

The "A" wells are screened in the Hanford formation's uppermost unconfined aquifer across the entire thickness of the aquifer. The "B" wells include 1.5–m (5-ft)-long screens at the bottom of the Hanford formation's uppermost unconfined aquifer. Well 199-H4-12C is screened within the Ringold Upper Mud Unit, in a water-producing layer, from 21.9 to 25 m (72 to 82 ft) below ground surface. Well 199-H4-15C (see Figure 2-20) contains four 5.1–cm (2-in.)-diameter, 0.6-m (2-ft)-long piezometers that were screened at various depths, including 23.8 to 24.4 m (78 to 80 ft) (199-H4-15CS) in the Ringold Upper Mud Unit, 59.1 to 59.7 m (194 to 196 ft) (199-H4-15CR) in Ringold Unit B, 89.9 to 90.5 m (295 to 297 ft) (199-H4-15CQ) in the Ringold Lower Mud Unit, and 99.1 to 99.7 m (325 to 327 ft) (199-H4-15CP) in the basalt. The shallowest wells in each nest, wells 199-H4-12A and 199-H4-15A, are extraction wells in the 100-H pump-and-treat network.

A comparison of hexavalent and total chromium results from baseline sampling to the fall 2007 sampling in two deeper groundwater monitoring wells in the 100-H Area are presented below. It is understood that concentrations between long-screened extraction wells and shorter-screened piezometers are not directly comparable and are considered qualitative in comparison.

- Baseline hexavalent chromium and total chromium concentrations in wells 199-H4-12A,B,C appear to be highest in the deepest completion, namely well 199-H4-12C. The screen for this well is located at approximately 21.9- to 25-m (72- to 82-ft) depth, which is about 6.1 m (20 ft) below the top of the Ringold Upper Mud Unit based on the borehole log of the well.
- Baseline hexavalent chromium concentrations appear to be higher in well 199-H4-15CS screened at 23.8– to 24.4–m (78- to 80-ft) depth in the Ringold Upper Mud Unit than well 199-H4-15A screened in uppermost aquifer of the Hanford formation. Baseline total chromium concentrations appear to decrease with depth, with filtered total chromium undetected ("U") in the bottom two screened intervals, namely wells 199-H4-15CQ (89.9 to 90.5 m [295 to 297 ft]) and 199-H4-15CP (99.1 to 99.7 m [325 to 327 ft]).
- Since baseline sampling, total filtered chromium has increased to 49.9 μg/L in well 199-H4-15CR, which is an increase of 137.6%. This piezometer is screened from 59.4- to 60-m (195- to 197-ft) depth.
- The January 2008 hexavalent chromium and total chromium concentrations in well 199-H4-15CS are 157 μg/L and 100 μg/L, respectively. These results are in review because the hexavalent chromium concentration is significantly higher than the total chromium concentration.

2.3.2.2 100-H Area Co-Contaminant Monitoring Results. The 100-H Area co-contaminants are strontium-90, technetium-99, tritium, uranium, and nitrate. The average annual results for co-contaminants are summarized in Appendix E. Table 2-5 provides a summary of baseline co-contaminant concentrations versus the fall 2007 results. Where 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:** Baseline strontium-90 concentrations were above the 8 pCi/L MCL in wells in four wells and one aquifer tube, ranging 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 is thought to be the potential source of the elevated strontium-90 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 is thought to be the potential source of the elevated strontium-90 in well 199-H4-45.

The fall 2007 strontium-90 concentrations remain above the 8 pCi/L MCL in wells 199-H4-45 (10.1 pCi/L), 199-H4-63 (24.8 pCi/L), and aquifer tube 47-D (11 pCi/L). Wells 199-H4-13 and 199-H4-11 were not sampled during the fall of 2007.

- **Technetium-99:** The maximum baseline technetium-99 concentration was 921 pCi/L in well 199-H4-3, 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 an aquifer tube was 56 pCi/L(B) (i.e., analyte detected at concentration below the contract-required detection limit, but above the method of instrument detection limit) at aquifer tube site 47-D.

  The maximum fall 2007 technetium-99 concentration was again in well 199-H4-3, dropping to 31 pCi/L. The MCL for technetium-99 is 900 pCi/L.

- **Tritium:** The maximum baseline tritium concentration was 15, 800 pCi/L in well 199-H5-1A. The MCL for tritium is 20,000 pCi/L. The maximum fall 2007 tritium concentration was 4,400 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" to the 100-H Area.

- **Uranium:** The maximum baseline uranium concentration was 95.7 μg/L in well 199-H4-3, located downgradient of the former 183-H solar evaporation basins. This well also had the highest fall 2007 uranium concentration of 7.6 μg/L. The MCL for uranium is 30 μg/L.

- **Nitrate:** 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. A total of 10 wells had baseline concentrations higher than 45 mg/L, which is the MCL for nitrate. There were no wells or aquifer tubes that had fall 2007 nitrate concentrations above the 45 mg/L MCL.

2.3.3 Contaminant Monitoring in the "Horn" Area

The "horn" area includes the 600 Area, between the D/DR Reactor area and the H Reactor area. This area is important to the interim action because it appears that groundwater flow is northeast to east from the D/DR Reactor area toward the 100-H Area, at least during high river stage (see the summer 2007 water table map provided in Figure 2-11). Therefore, the D/DR Reactor area may act as a contaminant source for the "horn" area and the 100-H Area.

2.3.3.1 "Horn" Area Hexavalent and Total Chromium Monitoring Results. Eighteen wells and 13 aquifer tubes were installed across the "horn" area during 2007. Figure 2-19 shows the fall 2007 plume map for the "horn" area, which incorporates hexavalent chromium concentrations from the new wells and aquifer tubes, and it clearly shows the plume extending across the "horn," from the D/DR Reactor area to the 100-H Area. Table 2-6 summarizes the fall 2007 results. Some of the wells were sampled in January 2008, and these data were included for completeness, even though the collection dates fall outside of the time interval normally included in this CY report.

The characterization wells and aquifer tubes installed in 2007 provided many additional details regarding the hexavalent chromium plume in the "horn" area, namely the following:

- The hexavalent chromium plume is continuous across the "horn" area at low concentrations typically below the MCL. The plume has reached the shoreline north of the H Reactor.
- Fall 2007 hexavalent chromium concentrations in the tubes directly north of the H Reactor area ranged from 46 to 64 μg/L, and hexavalent chromium concentrations were higher than 22 μg/L in 13 of 18 aquifer tube sites monitoring the "horn" area.
- Several wells were screened within the Ringold Upper Mud Unit, and sampling results confirmed hexavalent chromium concentrations of 42 μg/L at 22.9– to 24.4–m (75- to 80-ft) depth in well 699-97-48C, located approximately 6.1 m (20 ft) below the top of the Ringold Upper Mud Unit. However, hexavalent chromium concentrations in downgradient well 699-97-43C, screened at 24.7– to 26.2–m (81- to 86-ft) depth, approximately 9.1 m (30 ft) below the top of the Ringold Upper Mud Unit, was characterized by 8 μg/L hexavalent chromium. A report providing additional stratigraphic details and a discussion of the vertical variation in hexavalent chromium concentrations in the new "horn" area wells is scheduled for release by the end of FY08.
- Although the hexavalent chromium plume in the "horn" area is areally extensive, only one result was above the 100 μg/L DWS (well 699-97-43B at 117 μg/L).

Co-contaminants nitrate, tritium, and sulfate are monitored in selected "horn" area wells. As shown in Table 2-6, the fall 2007 concentrations were less than MCLs for all three co-contaminants.

2.4 QUALITY CONTROL RESULTS FOR 100-D AND 100-H MONITORING DATA

Field QC results for 100-HR-3 included field duplicates, split samples, and full trip blanks for the following analytes: alkalinity, anions, metals (including hexavalent chromium and total chromium), gross alpha, gross beta, strontium-90, technetium-99, tritium, and uranium. 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. The CY07 highlights of the QC data for 100-D and 100-H Area sampling are summarized below. Tables providing the complete QC results are provided in Appendix G.

The U.S. Environmental Protection Agency's (EPA's) *Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Analyses* (EPA/540/R-94/083) states that the guideline for field duplicate precision is ±20%. Only field duplicates with at least one result greater than five times the method detection limit (MDL) or minimum detectable activity (MDA) are evaluated. A summary of evaluated field duplicates with relative percent difference (RPD) >20% is provided in the table below. Of the 154 field duplicate pairs of data evaluated, 92.2% were within acceptable limits. Nine of the out-of-limit results (approximately 75%) are for metals data generated at the Waste Sampling and Characterization Facility (WSCF) laboratory in the October to December timeframe. During this period, the WSCF laboratory altered the calibration strategy used for metals analysis by inductively coupled plasma, which resulted in degradation of results reported at the low end of the calibration curve. This issue was identified

by Soil & Groundwater Remediation Project (S&GRP) staff in late December and, following the review, the laboratory returned to the previously implemented calibration strategy. Data generated during the timeframe during which the alternative calibration was in use demonstrate high variability at the low levels, as is observed in the out-of-limit duplicates in the table below. This issue has since been corrected at the laboratory and is not expected to be observed in future sampling events. Metals analyzed by inductively coupled plasma/mass spectrometry and hexavalent chromium were not affected by this calibration issue; however, the field duplicate reported for hexavalent chromium had extremely poor precision. An investigation into the cause was inconclusive. This appears to be an isolated issue, and is not anticipated to affect the usability of 100-D and 100-H Area sampling data. A complete list of the field duplicates performed is provided in Appendix G.

Summary of Field Duplicates Exceeding Quality Control Limits

Constituent	Number of Duplicates	Number Evaluated	Number >20% RPD	Percent >20% RPD	Range of RPDs >20%
Fluoride	5	3	3	100.0	33.2 to 111.1
Hexavalent chromium	18	6	1	16.7	169.7
Iron	10	7	3	42.9	22.4 to 77.4
Nickel	10	10	1	10.0	27.6
Vanadium	10	6	3	50.0	20.8 to 32.4
Zinc	10	10	1	10.0	34.2

While there are no EPA functional guidelines for the performance of laboratory split samples, results are typically evaluated against the criteria of precision ±20%. Only split samples where results are greater than five times the MDL or MDA at both laboratories were evaluated. A summary of split samples with an RPD >20% is provided in the table below. Of the 168 split sample pairs evaluated, 85% were within acceptable limits. Twenty of the out-of-limit pairs (77%) were associated with metals analysis at the WSCF laboratory. These data were affected by the calibration issue discussed above, which resulted in high variability at the low levels. Several anions also showed variability at slightly higher than 20%. This will be monitored to determine if corrective action is needed. A complete list of split samples performed is provided in Appendix G.

Summary of Field Splits Exceeding Quality Control Limits

Constituent	Number of Split Samples	Number Evaluated	Number Splits >20% RPD	Percent >20% RPD	Range of RPDs >20%
Chloride	6	6	1	16.7	27.8
Fluoride	6	4	2	50.00	25.8 to 26.7
Nitrogen in nitrate	6	6	1	33.3	26.8
Sulfate	14	14	1	7.14	26.7
Calcium	16	16	3	18.7	23.5 to 26.4
Chromium	16	11	7	63.64	22.4 to 92.5

Constituent	Number of Split Samples	Number Evaluated	Number Splits >20% RPD	Percent >20% RPD	Range of RPDs >20%
Hexavalent chromium	43	34	4	11.76	21.9 to 126.9
Iron	16	3	3	100.00	54.4 to 86.1
Manganese	16	1	1	100.00	41.7
Sodium	16	16	1	6.2	20.5
Zinc	16	2	1	50.00	57.7

For most chemical constituents, field trip blank results above two times the MDL 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 MDL. Metals are evaluated against two times the MDL. Radiological data are evaluated against two times the total MDA. The table below summarizes the blanks that exceed the QC criteria. Of the 237 results for blanks, 71.3% were within acceptance criteria. All 68 of the out-of-limit results (100%) are associated with metals analysis at the WSCF, which were affected by the calibration issue that was previously discussed. This issue resulted in high variability at the low level, including low-level detections in the blanks. Similar levels of detection are also identified in the laboratory blanks; therefore, these detections are most likely false positives due to the change in calibration. A complete list of the field trip blanks is provided in Appendix G.

Summary of Out-of-Limit Field Trip Blanks

Constituent	Number of Blanks	Number Out-of-Limit	Percent Out-of-Limit	Range of Out-of-Limit Results
Calcium	10	2	20	90.5 to 108 µg/L
Chromium	10	6	60	25.3 to 35.1 µg/L
Cobalt	10	6	60	20.6 to 27.2 µg/L
Copper	10	5	50	8.3 to 17.1 µg/L
Iron	10	6	60	22.1 to 46.9 µg/L
Magnesium	10	7	70	14.9 to 41.8 µg/L
Manganese	10	6	60	12.1 to 16.4 µg/L
Nickel	10	6	60	21.1 to 24.3 µg/L
Potassium	10	6	60	357 to 599 µg/L
Silver	10	6	60	24.6 to 29.1 µg/L
Vanadium	10	6	60	15 to 26.5 µg/L
Zinc	10	6	60	23.9 to 30.6 µg/L

In conclusion, while most of the QC for 100-D and 100-H Area sampling was within acceptance criteria, a notable exception is the metals data. Based on the QC sampling, low-level detections of metals in the 100-D and 100-H Areas from the October and November sampling events should be considered as estimates only. Higher levels of detection (i.e., 10 times the MDL) are not affected by this issue. In addition, future anion data are being closely monitored by S&GRP staff to ensure data quality. Corrective actions are not anticipated at this time, and no adverse

impact to 100-D and 100-H Area anions data is expected. All other data met the expectations of the QC program, and QC indicates that the groundwater monitoring data are reliable and defensible.

2.5 CONCLUSIONS

The conclusions have been described as they pertain to the interim response measure RAOs:

- **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). This objective has not yet been achieved based on the following observations; however, progress has been made, as noted below:

  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, with the most variability occurring around the 182-D reservoir.
  - Fall 2007 hexavalent chromium concentrations are above the 22 μg/L RAO in all three compliance wells (199-D8-68, 199-D8-69, and 199-D8-70). However, concentrations have decreased since the startup of operations.
  - Fall 2007 hexavalent chromium concentrations were above the 22 μg/L RAO in five of nine aquifer sampling tubes along the 100-D Area shoreline. However, the pump-and-treat systems have made significant progress in aquifer tubes located downgradient of the 100-D Area compliance wells, where hexavalent chromium in aquifer tube DD-16-3 has been reduced approximately 86% (from 172 to 24.2 μg/L). In addition, hexavalent chromium concentrations in aquifer tube AT-D-3-D have decreased approximately 47%, from 134 μg/L in 2005 to 71.4 μg/L in the fall of 2007. The total chromium concentration in this aquifer tube was 294 μg/L in 2004.
  - 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.

  100-H Area:

  - Fall 2007 hexavalent chromium concentrations are the below the 22 μg/L RAO in four of four compliance wells. Three of the four compliance wells are currently in use as extraction wells.
  - Fall 2007 hexavalent chromium concentrations are above the 22 μg/L RAO only in extraction well 199-H4-15A at 25 μg/L.
  - Of seven aquifer tubes along the 100-H Area shoreline, only aquifer tube AT-H-1-D had hexavalent chromium concentrations above 22 μg/L (22.4 μg/L).

- Hexavalent chromium appears to be higher in deeper completion wells 199-H4-12C and 199-H4-15CS than in wells 199-H4-12A and 199-H4-15A, respectively. The shallow wells are in the Hanford formation's uppermost unconfined aquifer; The deeper completions are in slightly confined groundwater-producing horizons within the Ringold Upper Mud Unit.
- Total filtered chromium concentrations generally decrease with depth in wells when comparing samples collected from wells screened in the Ringold Upper Mud Unit, Ringold Unit B, Ringold Lower Mud Unit, and basalt.
- Total filtered chromium of approximately 50 μg/L was detected January 2008 in well 199-H4-15CR, screened at a depth of 59.1 to 59.7 m (194 to 196 ft) in Ringold Unit B; however, the higher concentrations may be due to well construction methods.
- 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.

"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 in the "horn" area trends are listed below:

- Characterization wells and aquifer tubes completed during 2007 have confirmed that a low concentration hexavalent chromium plume probably forms a continuous band across the "horn" area from the 100-D to the 100-H Areas.
- New aquifer tubes completed during 2007 have confirmed that the "horn" area hexavalent chromium plume has reached the shoreline directly north of the 100-H Area. The maximum fall 2007 hexavalent chromium concentration detected in this area was 64 μg/L in aquifer tube C5673.
- Hexavalent chromium was detected at 42 μg/L about 6.1 m (20 ft) below the top of the Ringold Upper Mud Unit in well 699-97-48C. However, hexavalent chromium concentrations were much lower (8 μg/L) at the same approximate elevation in downgradient well 699-97-43C.

- **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 some of 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 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.

  Evaluation of the pump-and-treat technology to date:

  - The size of the 100-H Area plume has been reduced significantly.
  - Significant contaminant mass has been reduced in both the 100-D and 100-H Areas.
  - Contaminant concentrations in 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. Part of the reason for this are remaining highly concentrated sources within the vadose zone that are still contributing to the plume. In addition, the drilling and installation of new characterization and monitoring wells has aided in better defining the extent of contamination.
  - The ISRM barrier is in place to protect the Columbia River downgradient of the south plume.
  - A spring 2007 chromium source investigation located a highly concentrated plume in the general vicinity of the former sodium dichromate transfer station. Fall hexavalent chromium concentrations reached 10,900 μg/L in well 199-D5-104.

2.6 RECOMMENDATIONS

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

- Use systematic planning to identify data needs for the integrated (source and groundwater) work plan being developed in FY08 and FY09. This will include updates to numerical models and overall conceptual models.
- Use remedial process optimization:
  - Use a systematic plan to 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).
  - 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.
- 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.
- Apply appropriate open-source models to evaluate remedial process optimization.
- Review and revise, as necessary, existing well sampling frequency and constituent lists to reflect new data needs and trend development.
- Install additional aquifer tubes to evaluate river shore impacts.

Specific recommendations for the 100-HR-3 pump-and-treat system in the 100-D, 100-H, and "horn" areas 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.
  - 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 (approximately 71 μg/L). Closure of the gap in capture should be addressed during remedial process optimization.
- **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 optimization study to see whether chromium concentrations rebound.
  - Drill the 100-H wells proposed for FY09 to at least 61 m (200 ft) to provide additional data regarding deeper contamination at the 100-H Area. This recommendation is in response to approximately 50 μg/L total chromium detected in well 199-H4-15CR, screened from 59.1 to 59.7 m (194 to 196 ft) below ground surface.
  - Evaluate remediation possibilities in the "horn" area as part of the remedial process optimization effort.

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

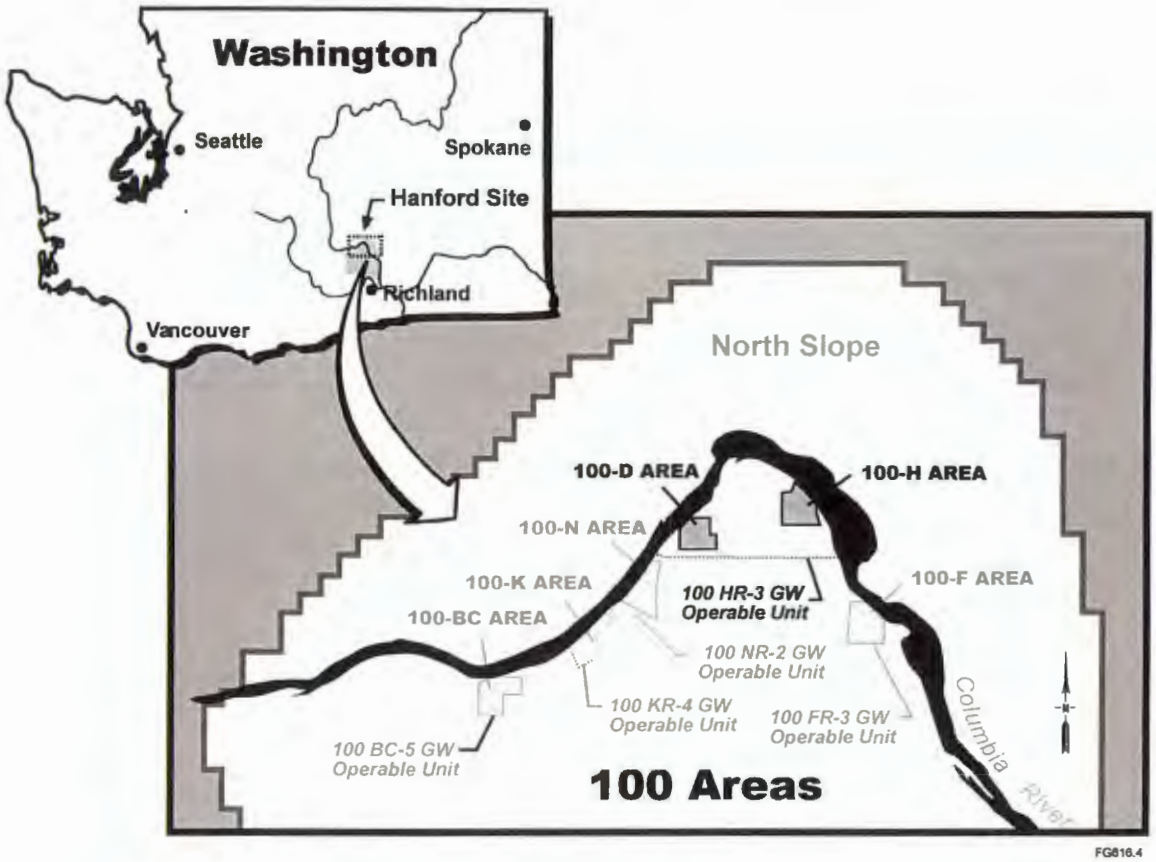


Figure 2-2. 100-HR-3 Operable Unit – 100-D Area Wells and Aquifer Sampling Tubes.

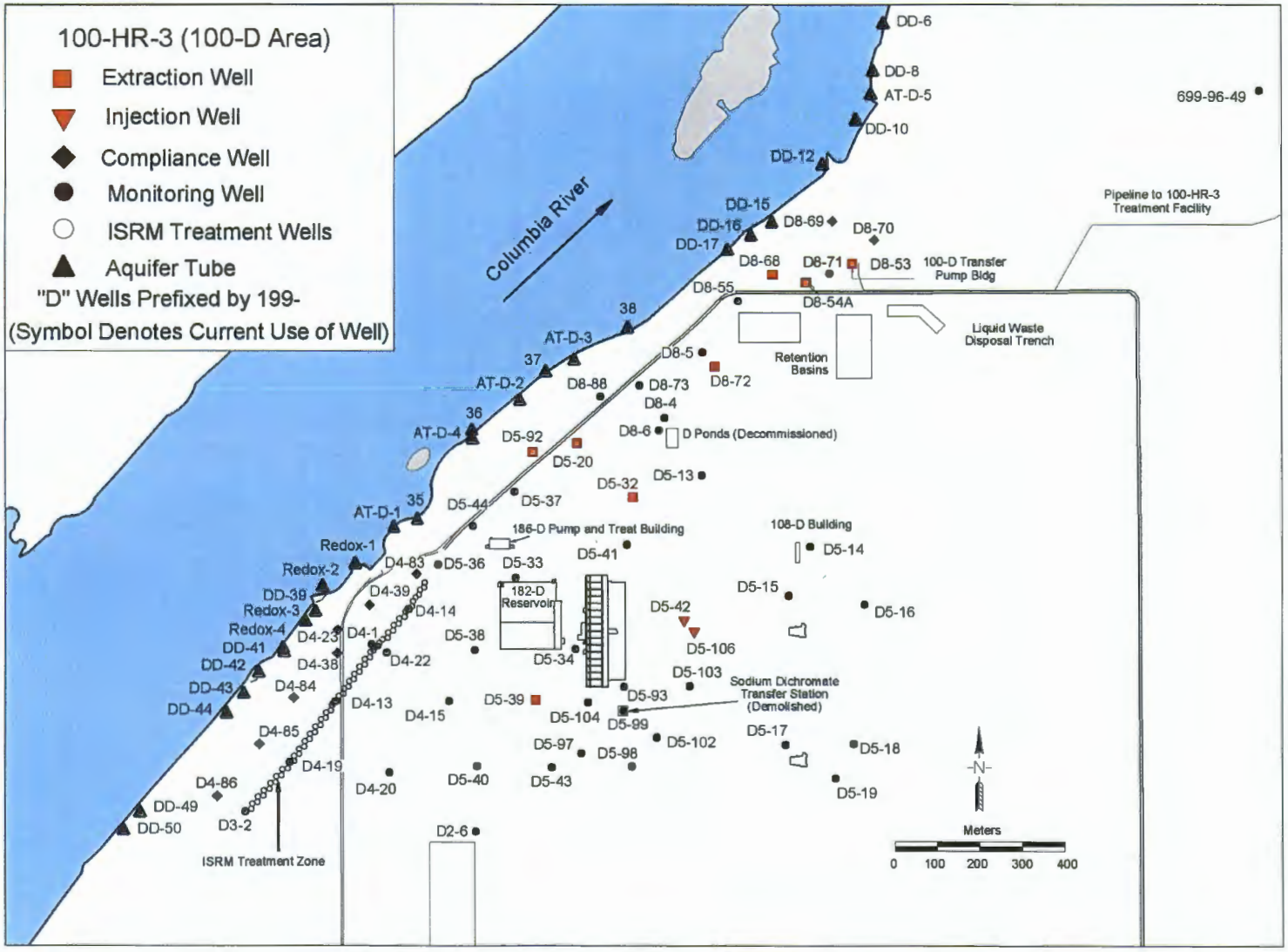


Figure 2-3. 100-HR-3 Operable Unit – 100-H Area Wells and Aquifer Sampling Tubes.

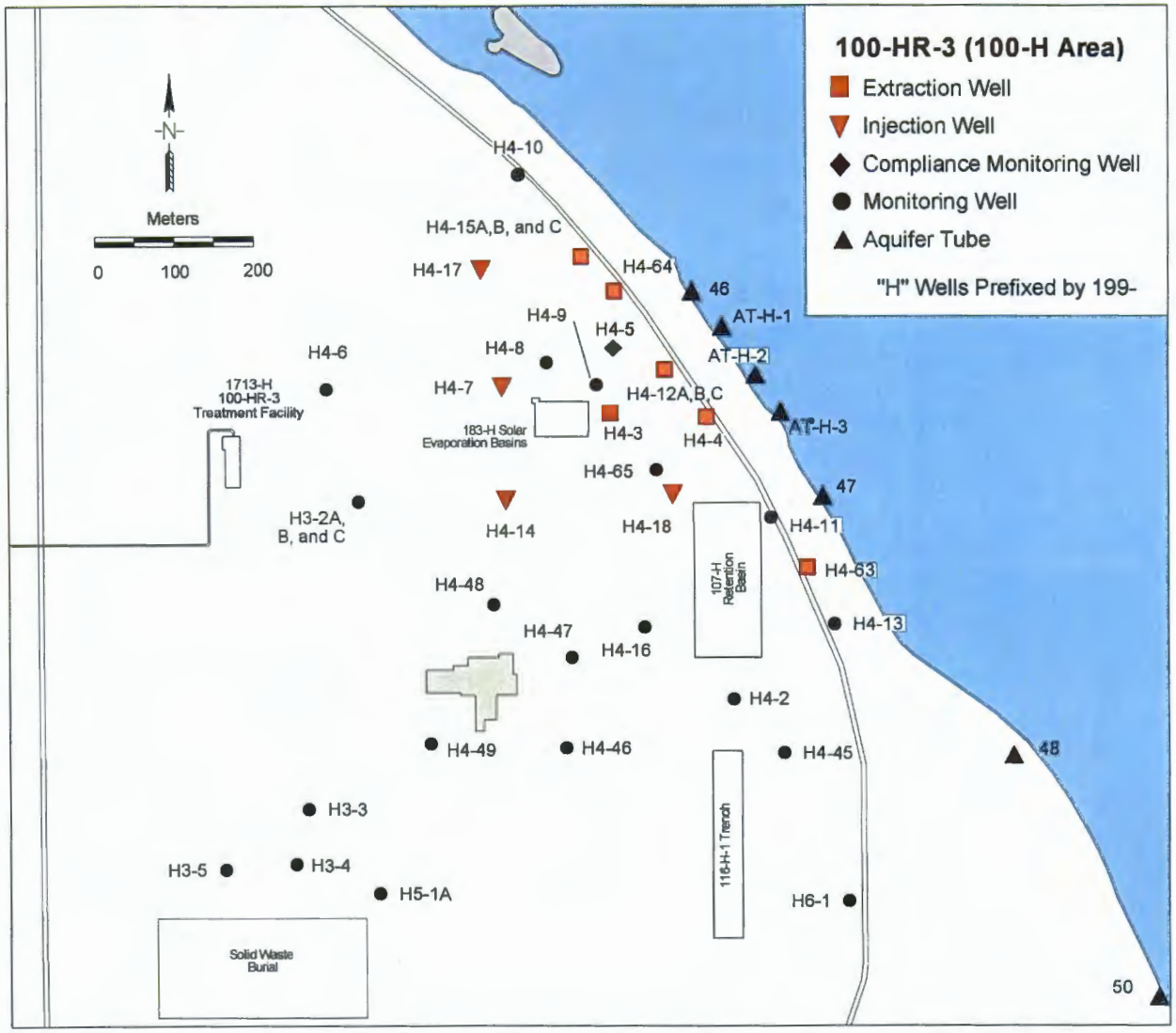


Figure 2-4. DR-5 Pump-and-Treat System Schematic.

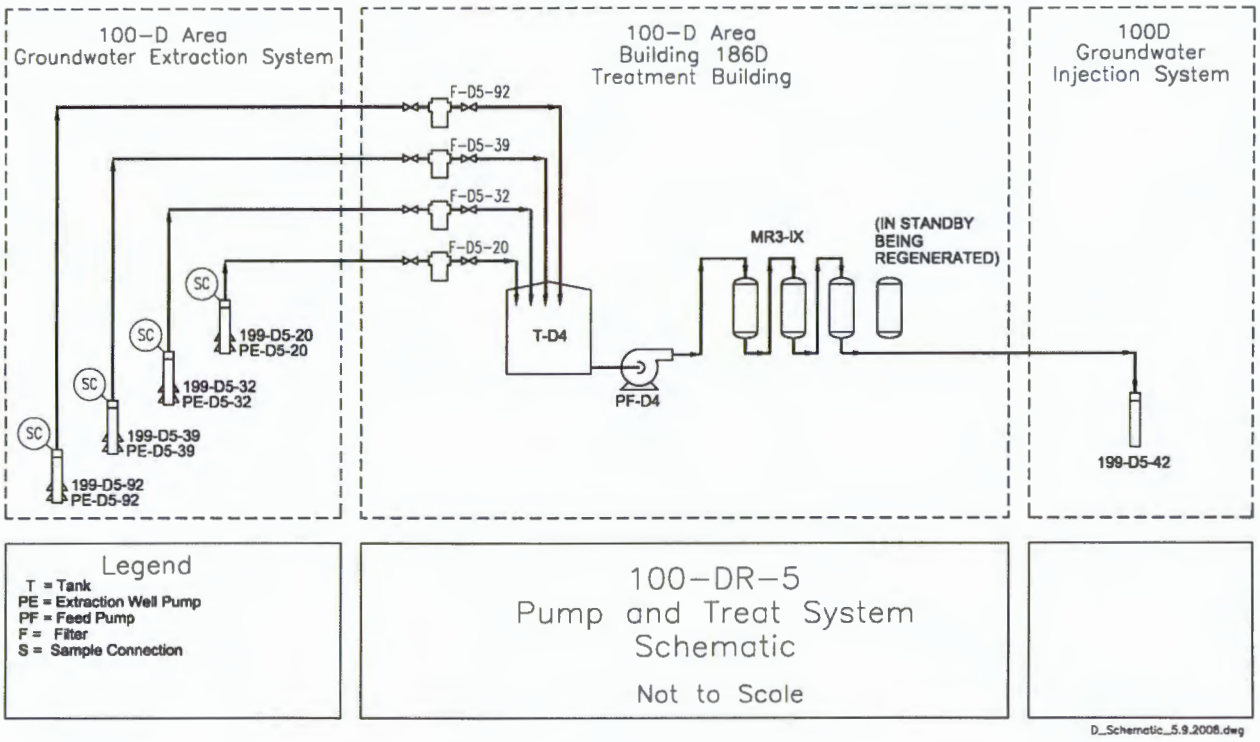
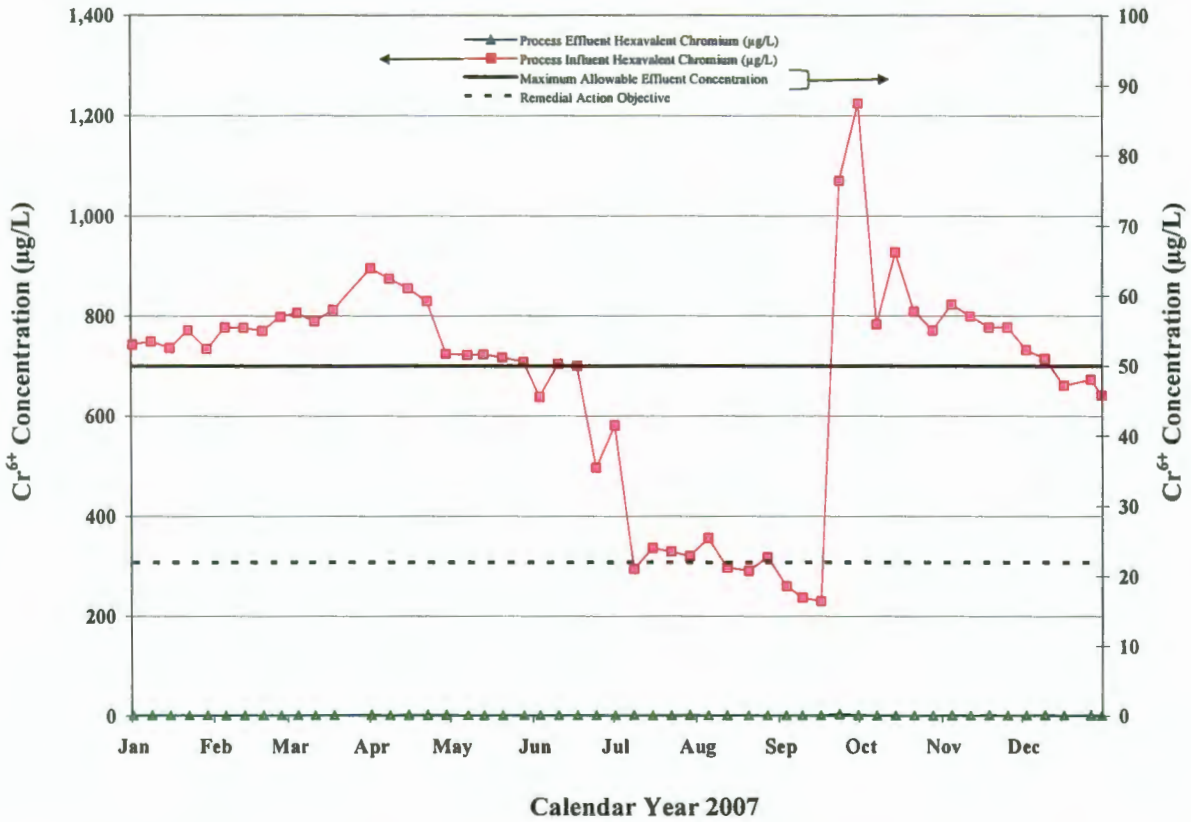
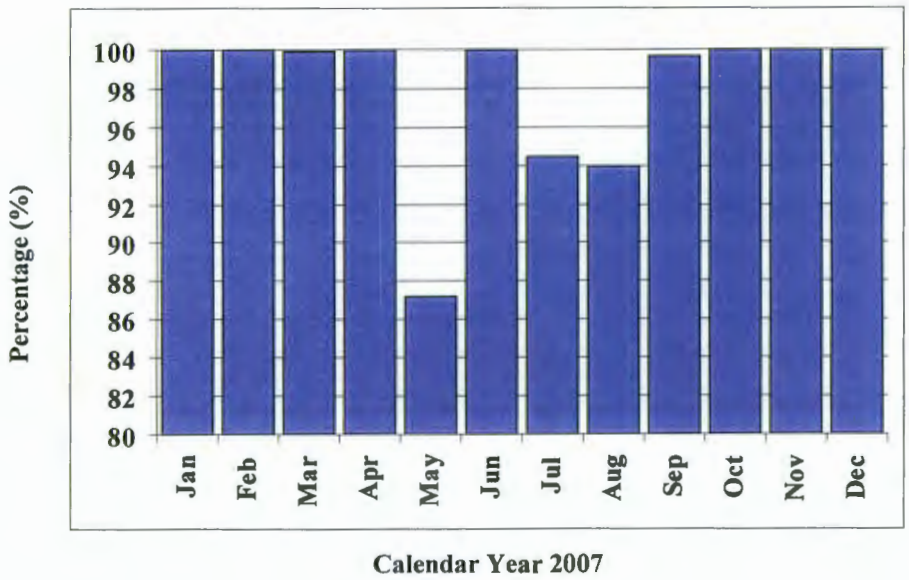


Figure 2-5. Calendar Year 2007 DR-5 Pump-and-Treat Trends of Influent and Effluent Hexavalent Chromium Concentrations.



NOTE: Changes in effluent concentrations from May to end of September maybe attributed to periodic down-time for extraction wells 199-D5-39 and 199-D5-92 and seasonal river stage fluctuations.

Figure 2-6. DR-5 System Availability and On-Line Percentages for Calendar Year 2007.



2007 DR-5 system availability:[a]	
Total possible run-time (hours)	8,760
Scheduled downtime (hours)	22.8
Planned operations (hours)	8,737.2
Unscheduled downtime (hours)	181.6
Total time on-line (hours)	8,555.6
Total availability (%)	97.7
Scheduled system availability (%)	99.7

[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)].

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

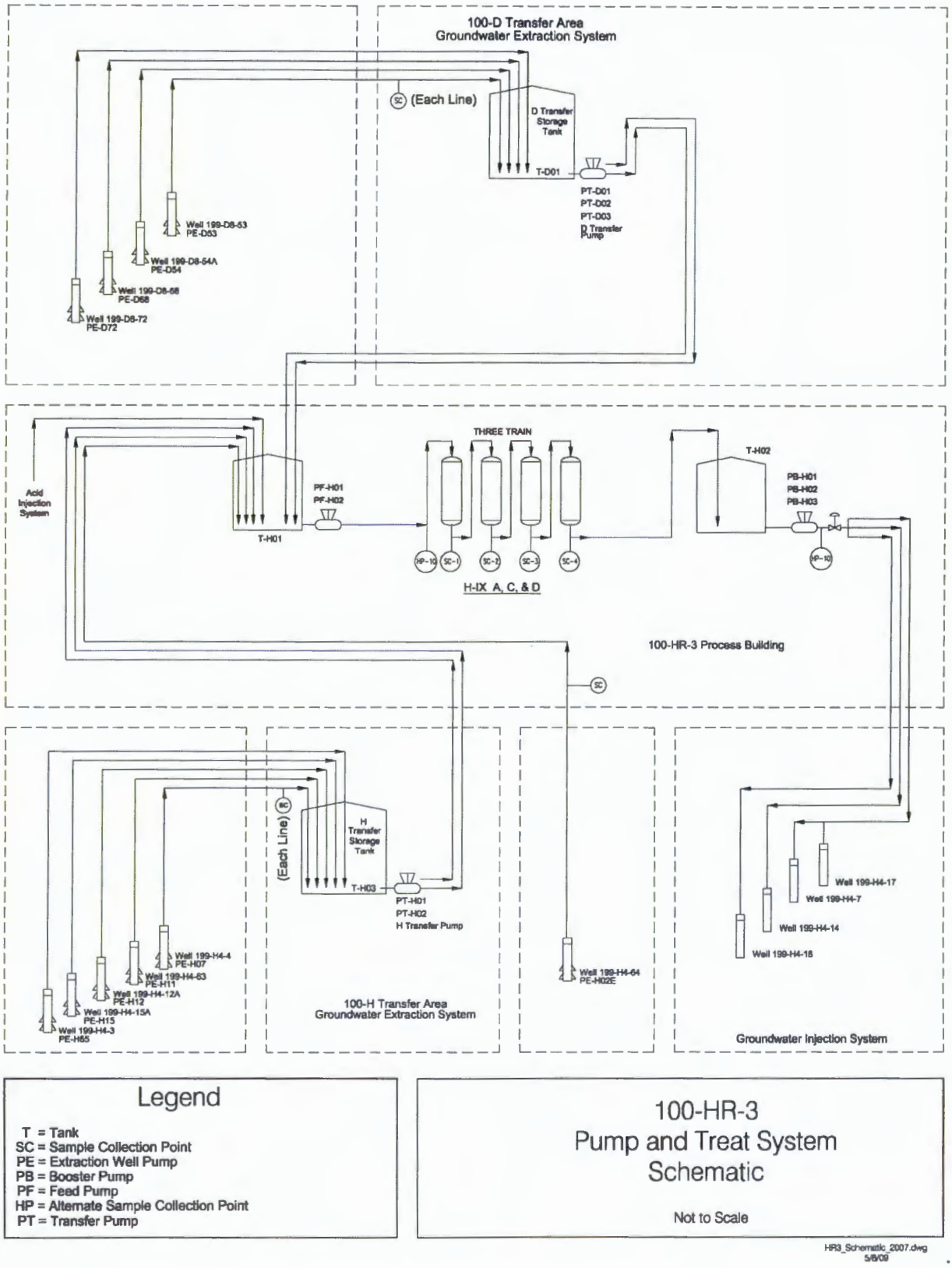
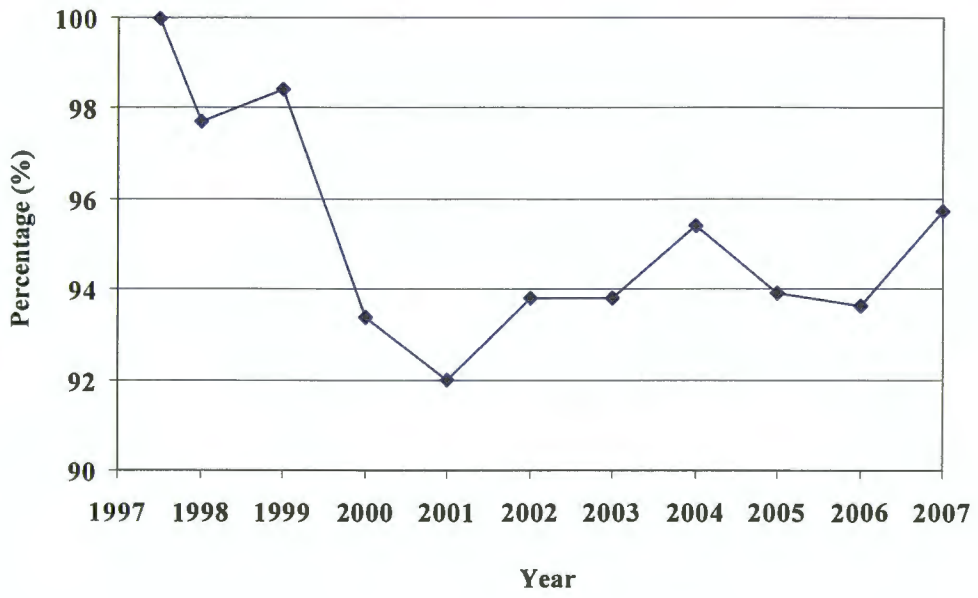


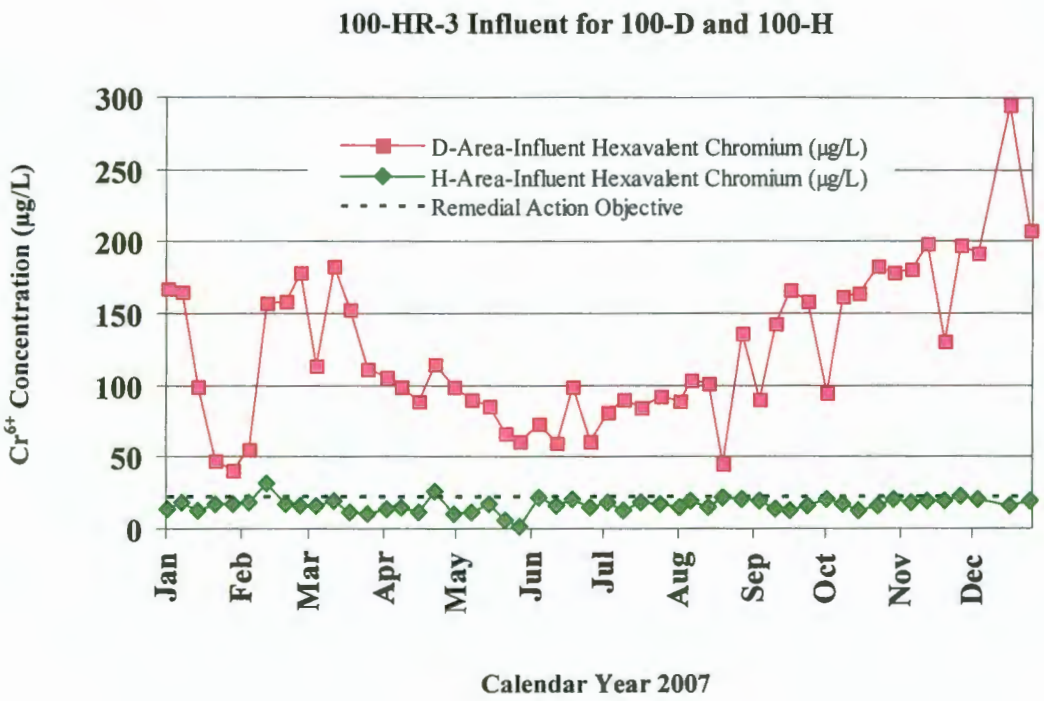
Figure 2-8. 100-HR-3 Pump-and-Treat Trend of Average Removal Efficiencies.[a]

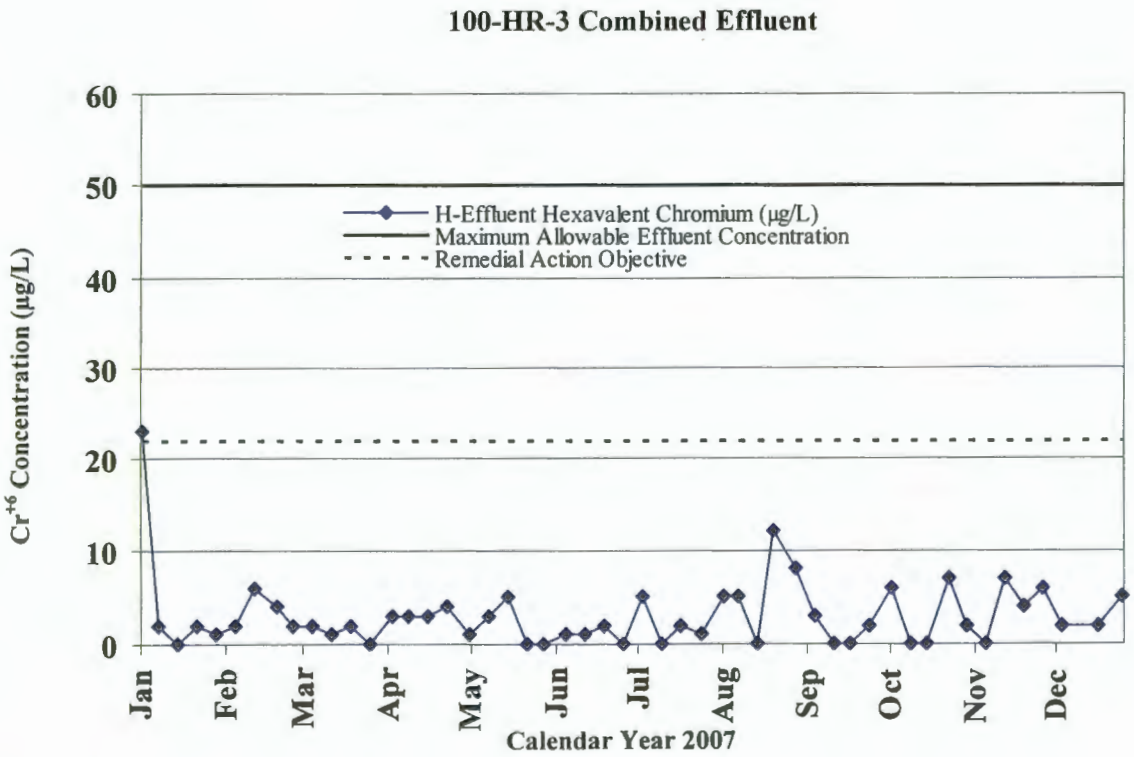


NOTE: The 100-HR-3 pump-and-treat trends of average removal efficiencies do not include the DR-5 pump-and-treat system.

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

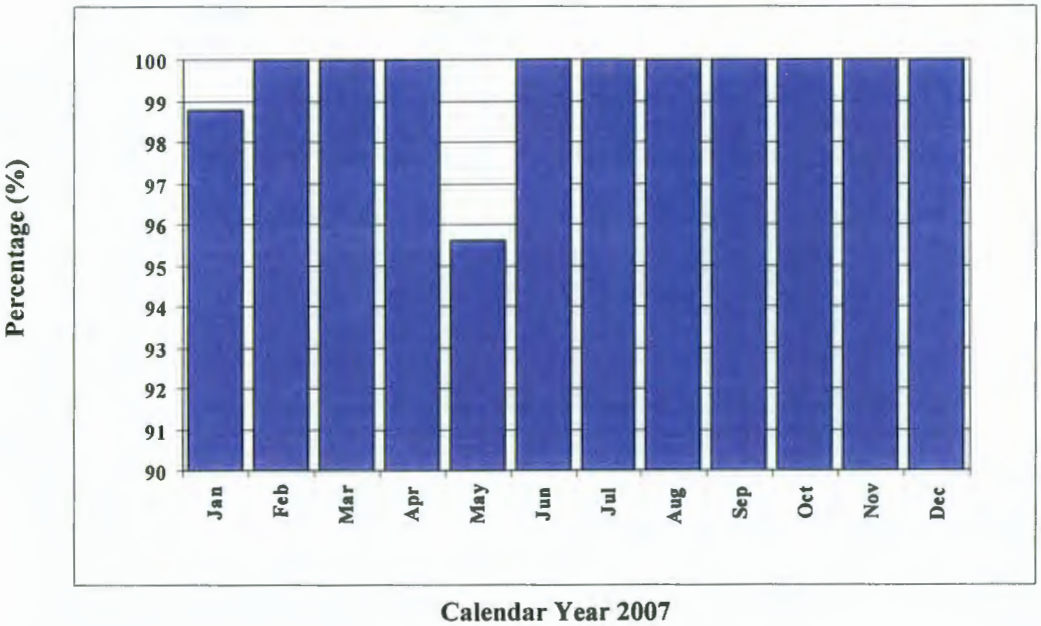
Figure 2-9. Calendar Year 2007 100-HR-3 Pump-and-Treat Trends of Influent and Effluent Hexavalent Chromium Concentrations.





NOTE: Calendar year 2007 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 2007.

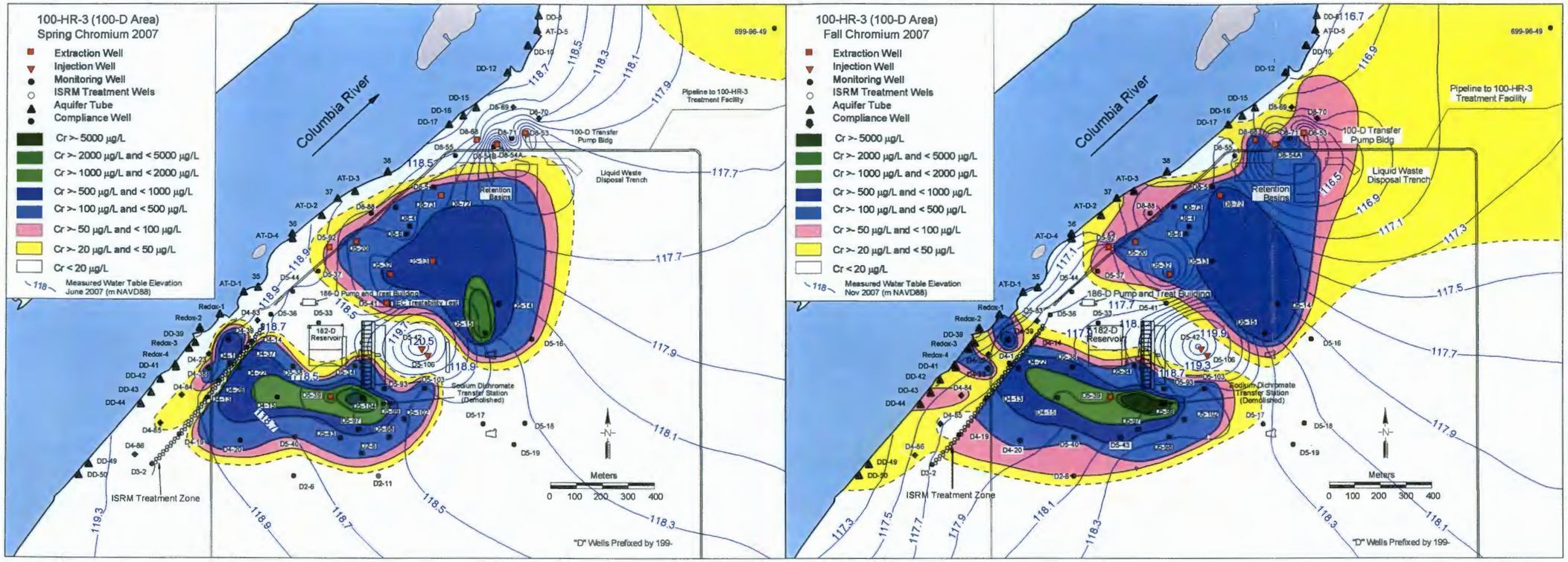


100-HR-3 pump-and-treat system availability for 2007:[a]	
Total possible run-time (hours)	8,760
Scheduled downtime (hours)	54.6
Planned operations (hours)	8,705.4
Unscheduled downtime (hours)	41.4
Total time on-line (hours)	8,664
Total availability (%)	98.9
Scheduled system availability (%)	99.4

NOTE: The 100-HR-3 system availability and on-line percentages for calendar year 2007 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)].

Figure 2-11. 100-D Area June and November 2007 Measured Water Table and Chromium Plume.



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

Figure 2-12. Estimated Steady-State Hydraulic Capture Zone Development for 100-D and DR-5 Extraction Wells.

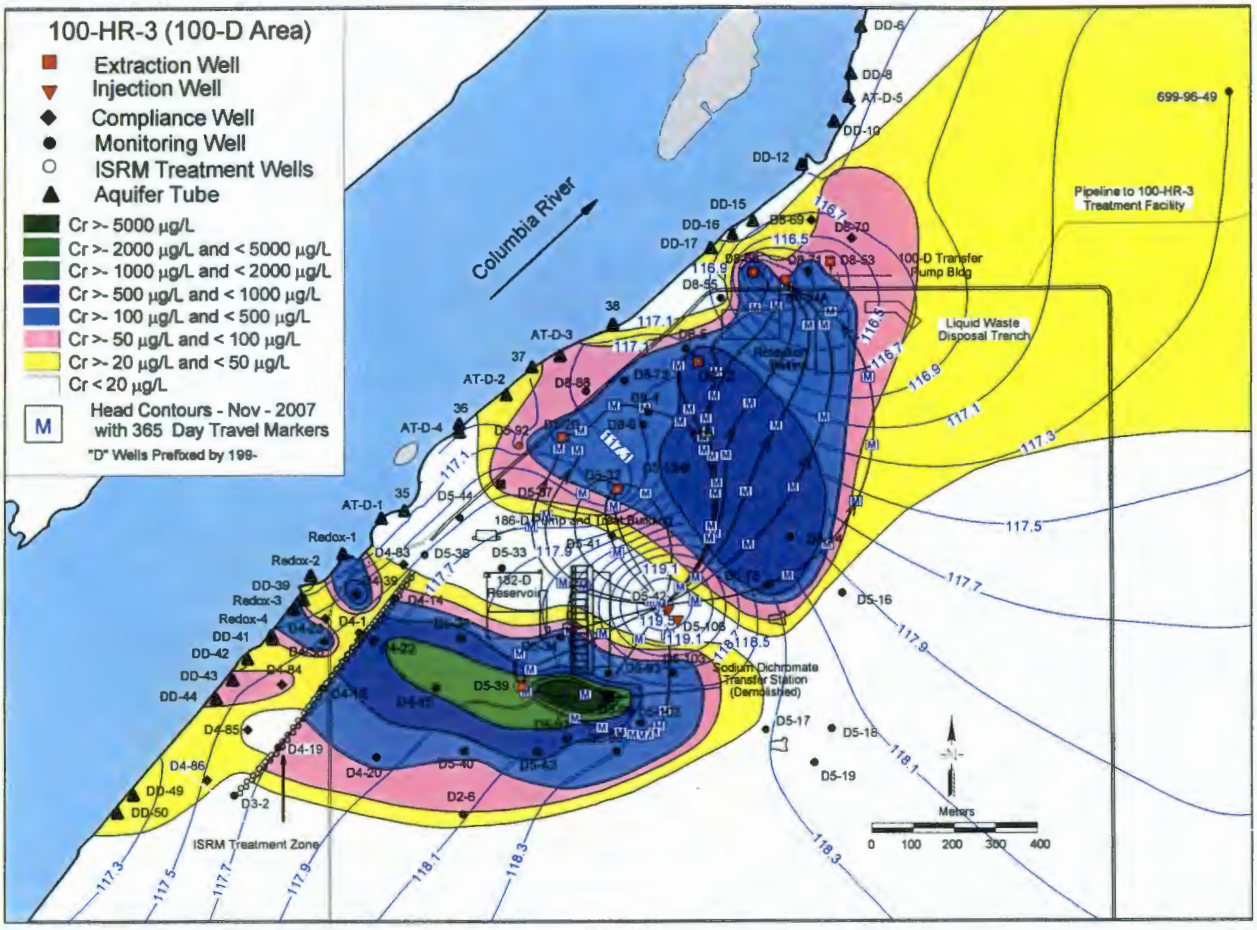


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Figure 2-13. 100-D Area Chromium Plume Map, Fall 2007.

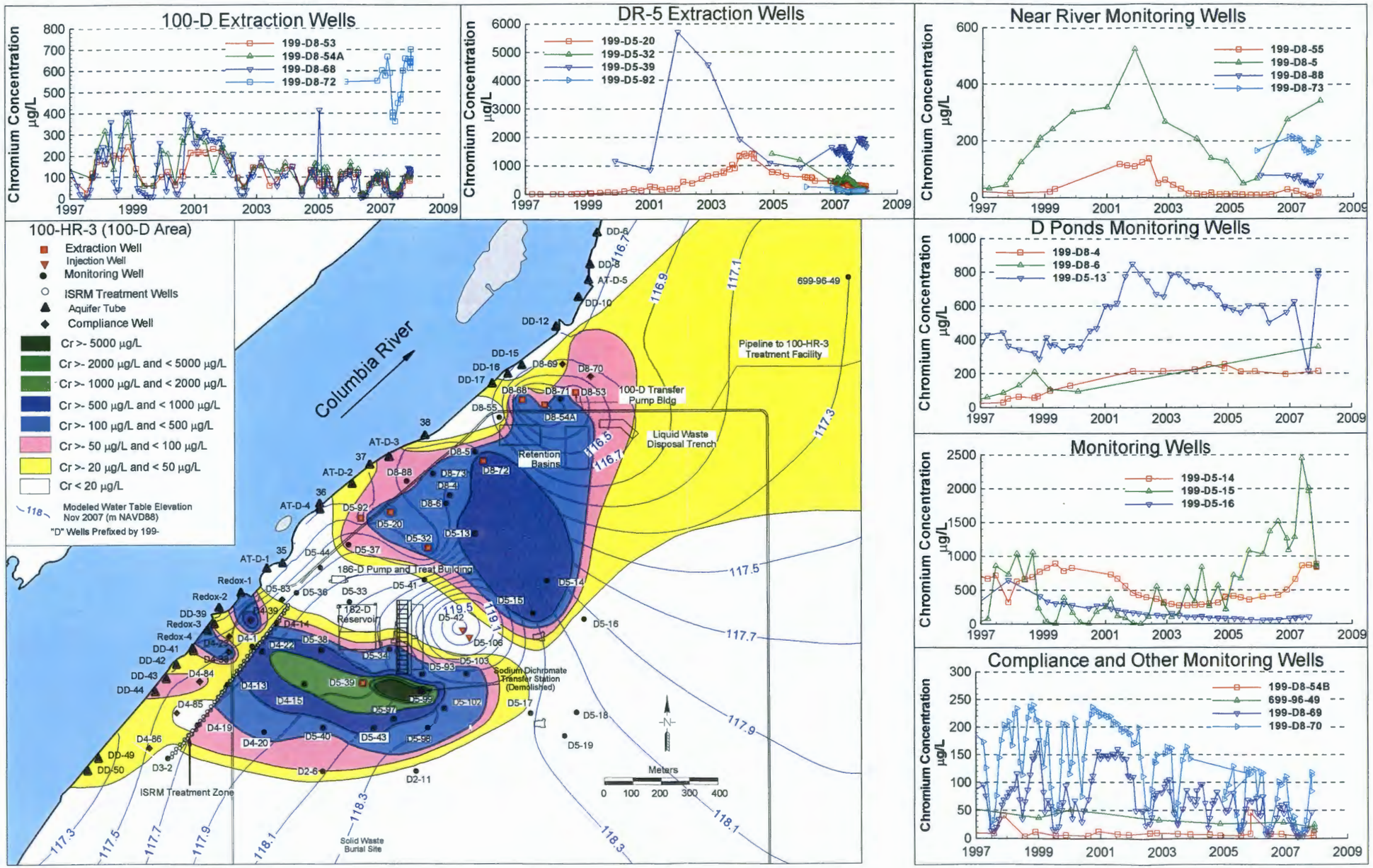
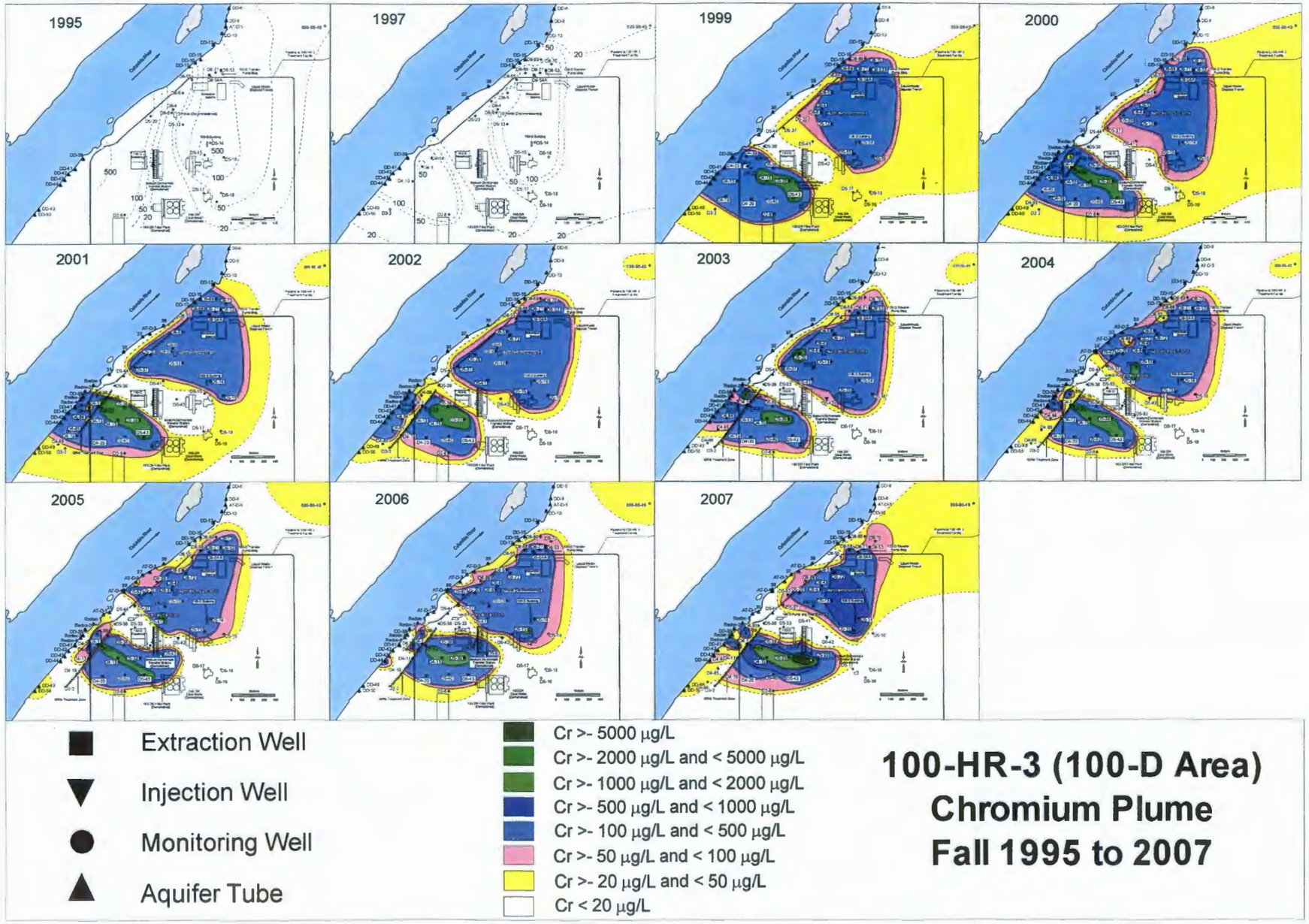
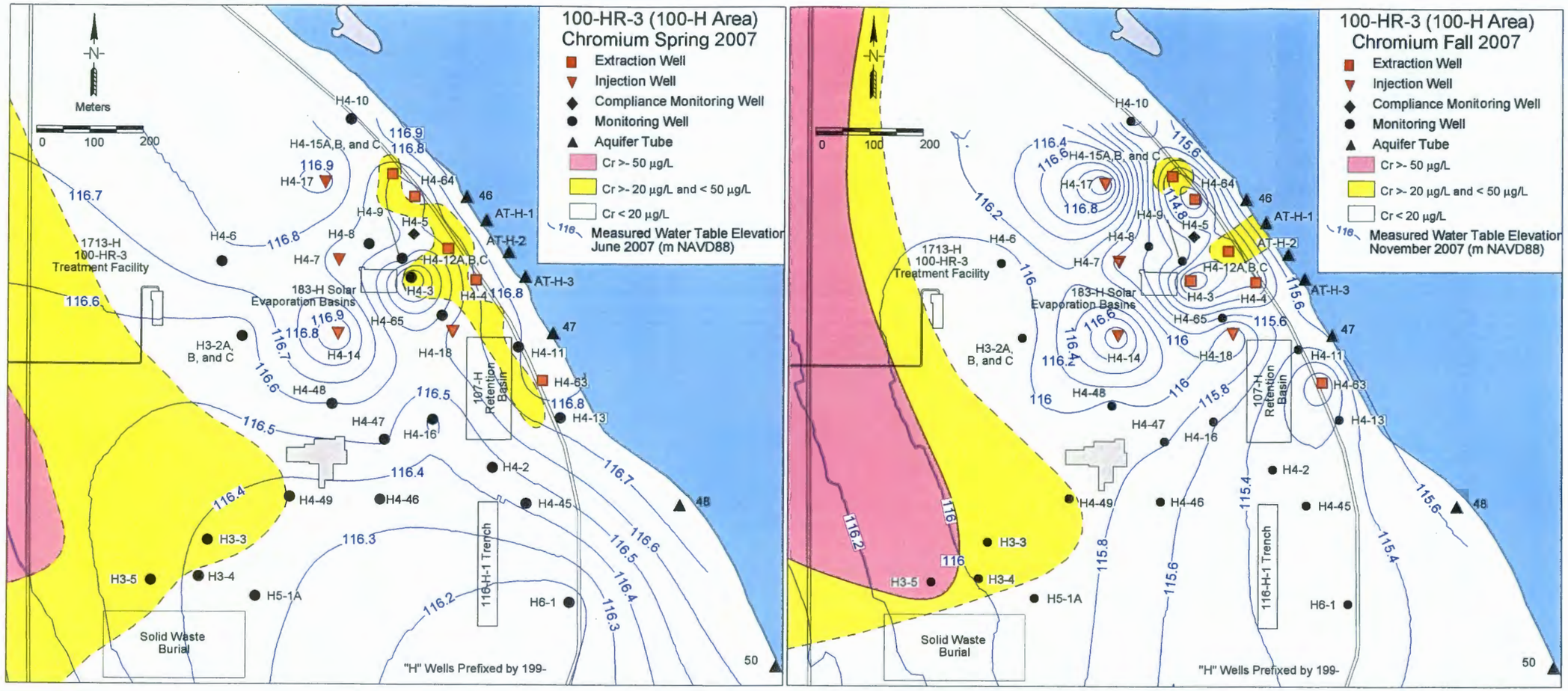


Figure 2-14. 100-D Chromium Plumes, 1995 to 2007



NOTE: Changes in the 20 µg/L contour represent variation in interpretations and data point density at the time of preparation.

Figure 2-15. 100-H June and November 2007 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,

Figure 2-16. Estimated Steady-State Hydraulic Capture Zone Developed for 100-HR-3 Operable Unit, 100-H Area Extraction Wells.

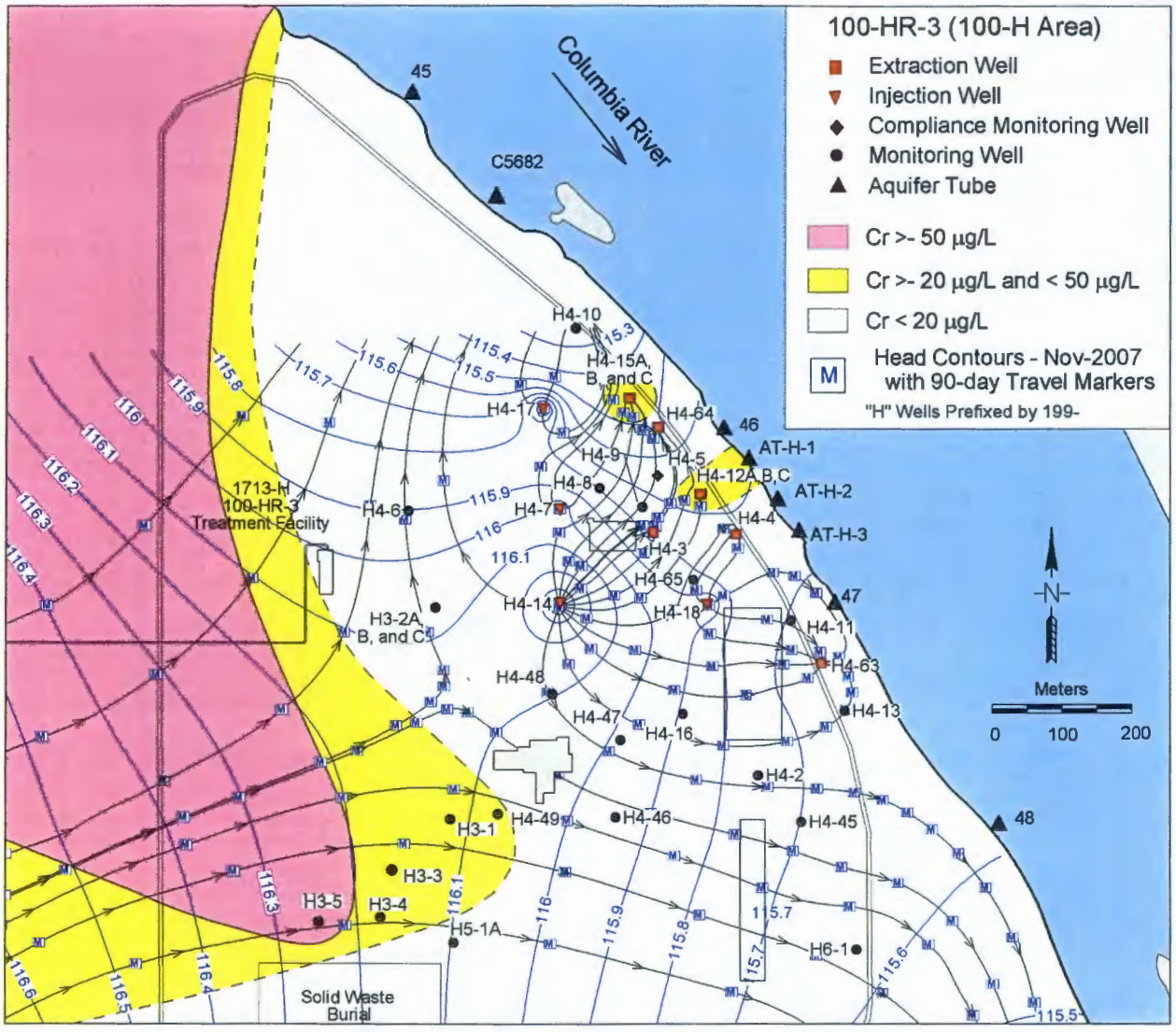


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Figure 2-17. 100-H Area Chromium Plume, Fall 2007.

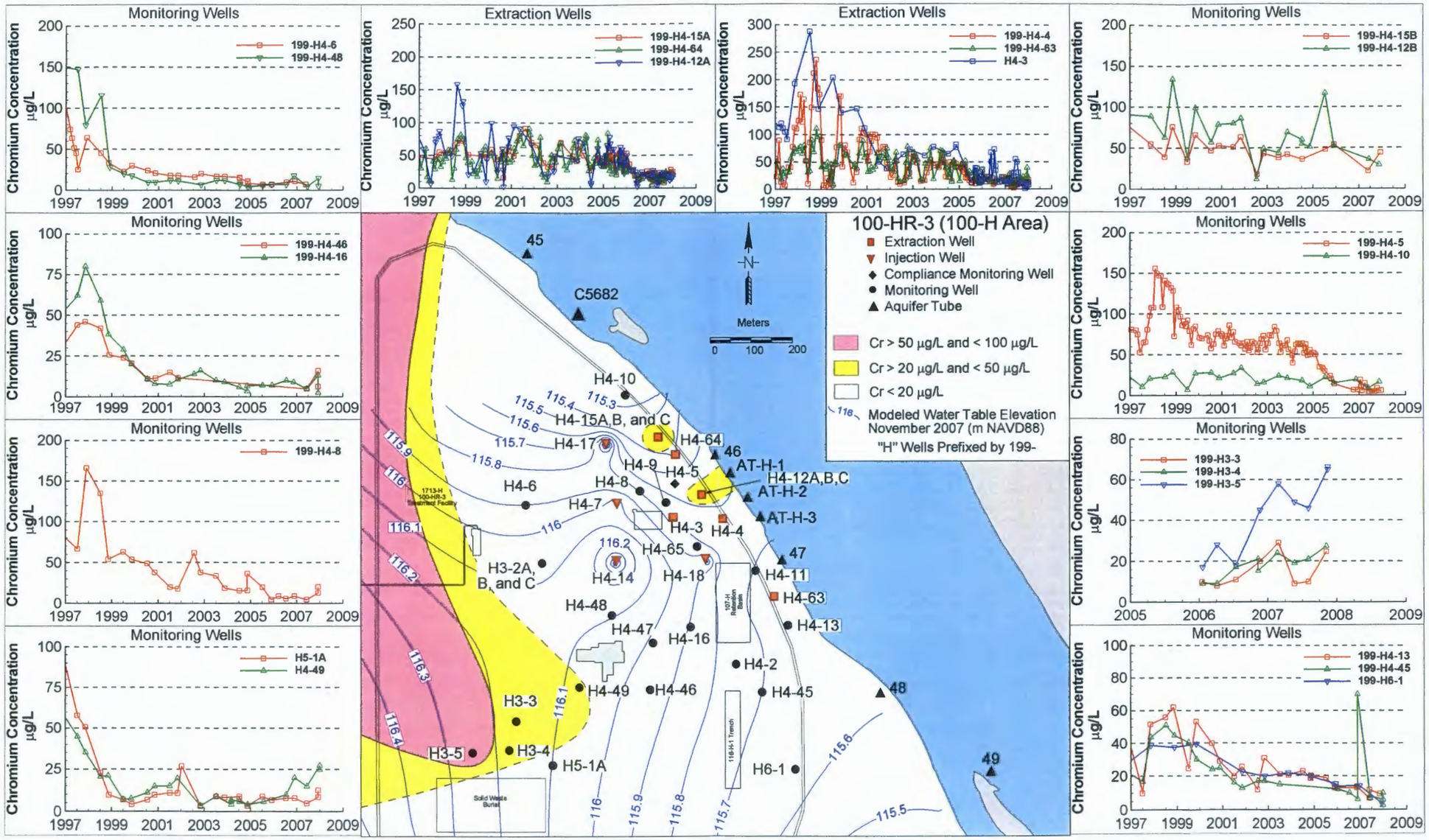

Figure 2-18. 100-H Chromium Plume, 1995 to 2007.

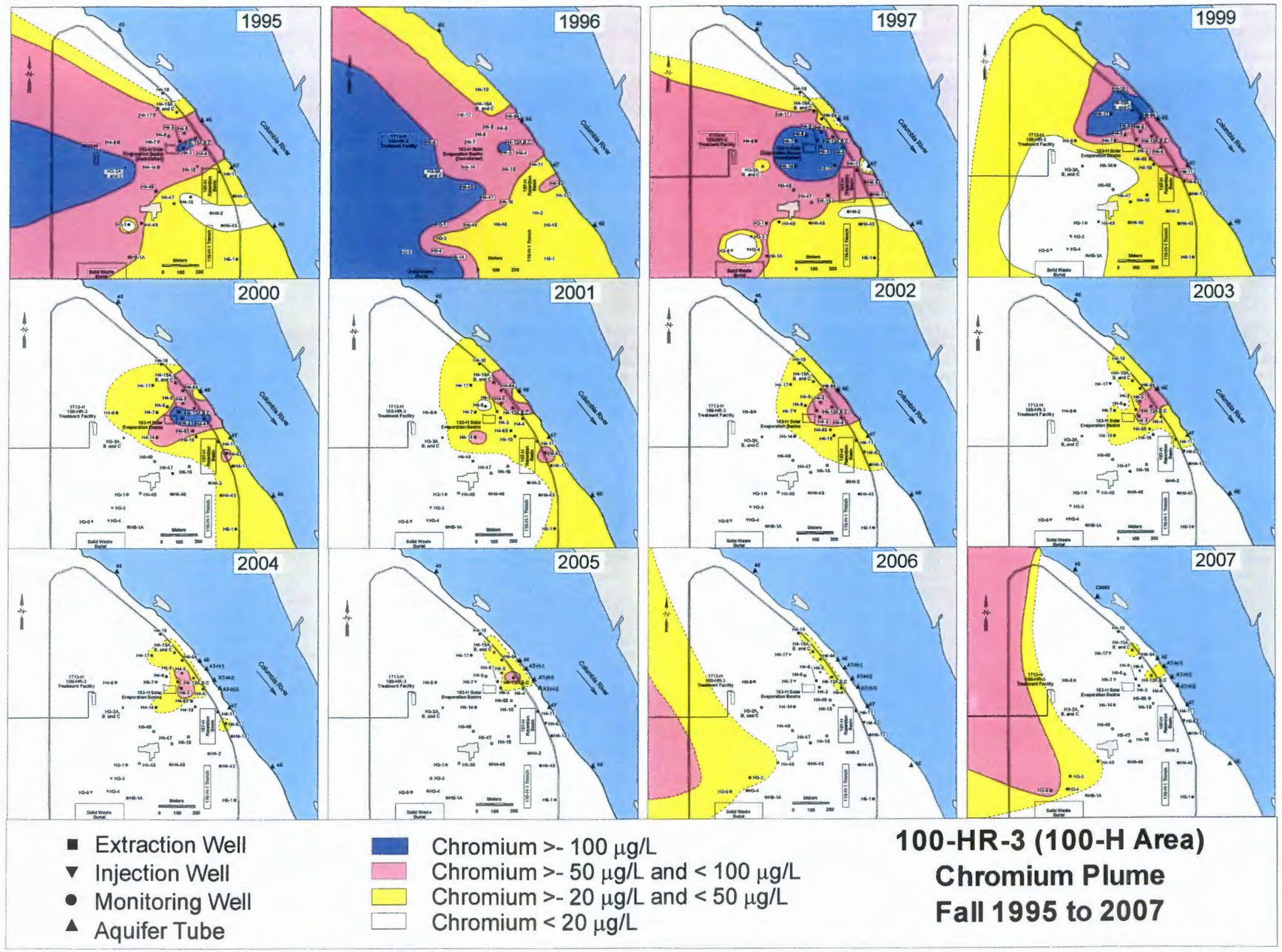

Figure 2-19. "Horn" Area Chromium Plume, 2007.

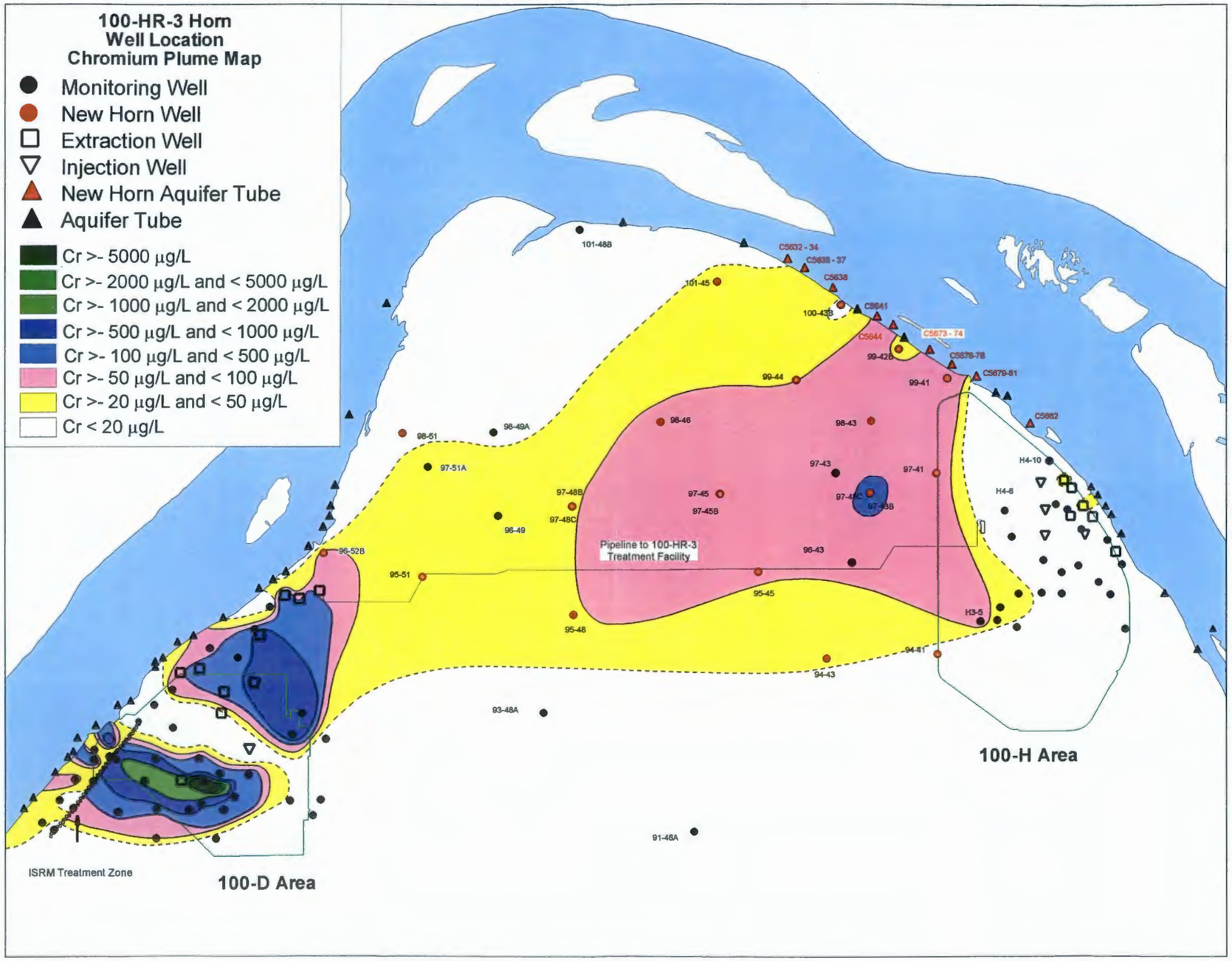

Figure 2-20. Well 199-H4-15C Construction Detail.

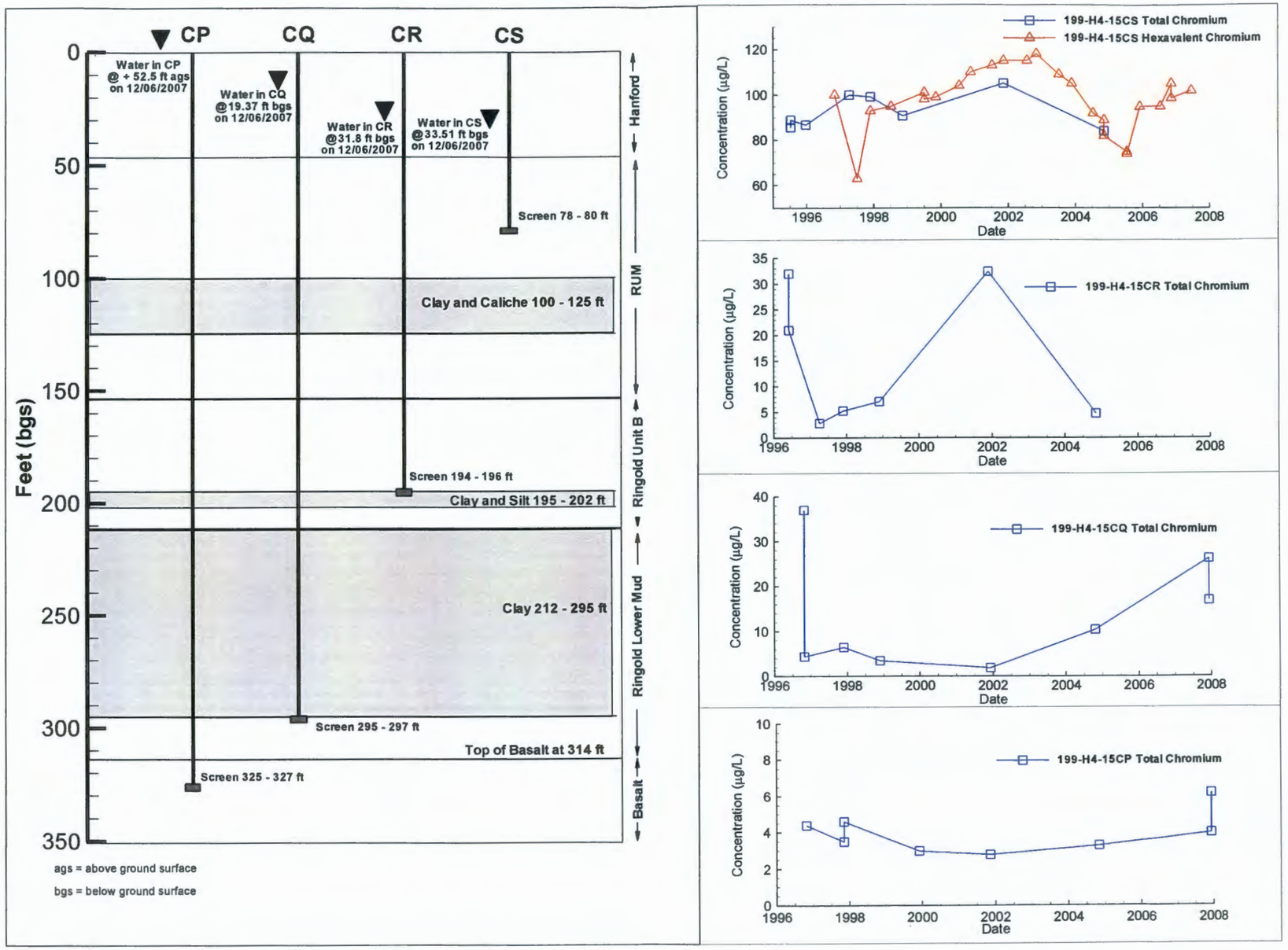

Table 2-1. 100-HR-3 (100-D Areas Water-Level Data Used to Develop and Calibrate Numerical Groundwater Flow Models. (2 sheets)

Well	Model Analysis. Nov. 2007		Measured Water-Level Elevation, Nov. 2007 (m NAVD88[a])	Modeled Water-Level Elevation, Nov. 2007 (m NAVD88[a])
	Extraction Rate, L/min	Injection Rate, L/min		
100-D Area				
199-D5-13	—	—	117.61	117.63
199-D5-14	—	—	118.00	117.98
199-D5-15	—	—	118.12	118.29
199-D5-16	—	—	117.96	117.96
199-D5-17	—	—	118.33	118.31
199-D5-18	—	—	118.14	118.18
199-D5-19	—	—	118.25	118.24
199-D5-41	—	—	117.84	117.94
199-D5-43	—	—	118.13	118.13
199-D5-44	—	—	117.61	117.61
199-D8-5	—	—	117.07	117.11
199-D8-6	—	—	117.40	117.31
199-D8-55	—	—	117.09	116.80
199-D8-53	33.5	—	115.47	115.82
199-D8-54A	39.7	—	114.59	115.26
199-D8-68	191.7	—	116.90	113.03
199-D8-72	33.1	—	117.78	116.55
199-D5-20	25.9	—	—	116.17
199-D5-32	54.9	—	—	115.95
199-D5-37	—	—	117.61	117.42
199-D5-39	54.2	—	117.42	117.17
199-D5-42	—	163.4	120.86	122.48
199-D5-92	28.4	—	117.17	116.47
199-D8-69	—	—	117.02	116.66
199-D8-70	—	—	117.04	116.61
199-D8-71	—	—	117.00	116.14
100-D River	—	—	116.95	116.97
100-H Area				
199-H3-2A	—	0	115.88	116.07
199-H4-7	—	45.4	115.70	116.25
199-H4-17	—	136.2	117.47	116.44
199-H4-11	—	—	115.40	115.70
199-H4-14	—	297.8	116.97	116.68
199-H4-18	—	64.2	116.16	116.13
199-H4-12A	23.4	—	114.88	115.63
199-H4-15A	72.6	—	114.63	115.40
199-H4-65	—	—	115.64	115.84
199-H3-3	—	0	115.94	116.16
199-H3-4	—	0	115.99	116.18
199-H3-5	—	0	116.08	116.18
199-H3-2C	—	—	115.91	116.08
199-H4-3	24.9	—	114.33	115.72

Table 2-1. 100-HR-3 (100-D Areas Water-Level Data Used to Develop and Calibrate Numerical Groundwater Flow Models. (2 sheets)

Well	Model Analysis. Nov. 2007		Measured Water-Level Elevation, Nov. 2007 (m NAVD88[a])	Modeled Water-Level Elevation, Nov. 2007 (m NAVD88[a])
	Extraction Rate, L/min	Injection Rate, L/min		
199-H4-4	27.4	—	114.96	115.68
199-H4-5	—	—	115.16	115.65
199-H4-8	—	—	115.60	115.79
199-H4-10	—	—	115.11	115.20
199-H4-63	89.7	—	114.78	115.51
199-H4-64	49.2	—	114.36	115.42
199-H5-1A	—	—	115.96	116.10
100-H River	—	—	115.82	115.40

[a] NAVD88, 1983, *North American Vertical Datum of 1988*, National Geodetic Survey, Federal Geodetic Control Committee, Silver Springs, Maryland.

Table 2-2. Change in Hexavalent and Total Chromium Concentrations from Baseline Through 2007 for Wells and Aquifer Tubes Monitoring the 100-HR-3 (D) and DR-5 Pump-and-Treat Systems. (3 sheets)

Well or Aquifer Tube Name	Well Use or Aquifer Tube	Baseline Sample					Fall 2007 Sample					Percent Change in Concen. Since Baseline Sampling (Negative = Decrease)		
		Filt. and Unfilt. 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.	Total Chromium Filt.
199-D5-13	E/M	11/18/98	293	10/21/16	366	300	12/5/07	808	12/5/07	795	774	175.8	117.2	158.0
199-D5-14	M	3/20/97	673	11/4/96	741	727	11/6/07	888	11/6/07	852	841	26.6	15.0	15.7
199-D5-15	M	11/19/97	700	11/5/96	20.7	18.3	11/6/07	852	11/6/07	848	878	21.7	3,996.6	4,697.8
199-D5-16	M	11/18/98	422	4/1/96	347	NA	11/14/07	156	11/14/07	177	177	-58.1	-49.0	
199-D5-17	M			11/18/97	36.3	20.4			11/14/07	21.1	12.4		-41.9	-39.2
199-D5-18	M			11/5/96	21.3	19.2								
199-D5-19	M			5/27/98	36.1	31.5								
199-D5-20	E	11/19/97	9	10/22/96	15.8	10.2	11/14/07	260	11/14/07	276	283	2,788.9	1,646.8	2,674.5
199-D5-32	E	9/14/00	1024	12/8/04		1410	11/27/07	143	11/27/07	122 (C)	131 (C)	-86.0	-91.3	-90.7
199-D5-33	M/I	3/2/04	5 (U)	11/18/04		3.3 (U)	12/4/07	4.2 (B)						
199-D5-36	M	7/6/99	5 (U)	11/17/99	1.3	1.2	11/16/07	2.6 (B)	11/16/07	6.6	4.1		407.7	241.7
199-D5-37	E	7/6/99	24	11/16/99	35.3	37.2	11/27/07	57.9	NS			141.3		
199-D5-39	E	7/7/99	88	11/15/99	1170	1180	11/6/07	1,770	11/6/07	1,770	1,810	1,911.4	51.3	53.4
199-D5-41	E/M	7/7/99	5 (U)	12/1/99	35.1	30	12/6/07	20.1	12/6/07	13.2	23.2		-62.4	-22.7
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	11/6/07	3.7 (B)	11/6/07	35.4	29.9		3,549.5	3,733.3
199-D5-92	E	10/21/04	486	1/16/06		256	11/28/07	97.9	11/28/07	89.6	95.6	-79.9		-62.7
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)			12/6/07	215	182		763.5	3,209.1
199-D8-5	M	5/19/04	140	10/21/96	51.9	34.2								
199-D8-6	M			2/28/96	26.2	8.2 (L)	12/5/07	280						
199-D8-53	E	10/29/96	130	10/29/96	140	126	11/27/07	83				-36.2		
199-D8-54A	E	10/25/96	150	10/25/96	152	140	11/27/07	94				-37.3		

Table 2-2. Change in Hexavalent and Total Chromium Concentrations from Baseline Through 2007 for Wells and Aquifer Tubes Monitoring the 100-HR-3 (D) and DR-5 Pump-and-Treat Systems. (3 sheets)

Well or Aquifer Tube Name	Well Use or Aquifer Tube	Baseline Sample					Fall 2007 Sample					Percent Change in Concen. Since Baseline Sampling (Negative = Decrease)		
		Filt. and Unfilt. 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.	Total Chromium Filt.
199-D8-54B	M	10/25/96	10	10/25/96	17.4	5.7	11/28/07	5.2 (B)	11/28/07	11.1	5.8	-48.0	-36.2	1.8
199-D8-55	M	2/2/99	21	10/22/96	48	21.4	11/16/07	13.9	11/16/07	19	14.8	-33.8	-60.4	-30.8
199-D8-68	E	10/15/96	104	11/30/00		349	12/4/07	122	12/4/07	116	111	17.3		-68.2
199-D8-69	C	10/14/96	80				11/7/07	46.8				-41.5		
199-D8-70	C	10/15/96	200	4/22/99		203	11/7/07	84.8	11/7/07	119 (C)	114 (C)	-57.6		-43.8
199-D8-71	M	10/15/96	340	1/28/99		205	12/4/07	156				-54.1		
199-D8-72	E	6/17/02	436	11/3/05		548 (N)	12/4/07	676	12/4/07	636	644	55.0	16.1	17.5
199-D8-73	M	10/21/04	178	11/9/05		166	11/7/07	185	11/7/07	207		3.9		
199-D8-88	M	11/17/04	35	12/27/05		78.5	12/4/07	76.7	12/4/07	76.3	76.6	119.1	119.1	-2.4
Chromium Source Investigation Wells														
199-D5-97	M	2/21/07	758				11/29/07	550	11/29/07	541	531	-27.4		
199-D5-98	M	2/27/07	465				11/29/07	419	11/29/07	401	402	-9.9		
199-D5-99	M	2/28/07	10,580				12/27/07	7,900	11/29/07	6,440	6,200	-25.3		
199-D5-102	M	4/24/07	231				11/29/07	502	11/29/07	482	475	117.3		
199-D5-103	M	3/23/07	393				11/29/07	158	11/29/07	144	148	-59.8		
199-D5-104	M	3/24/07	6,840				11/29/07	10,900	11/29/07	9,970	10,500	59.4		
199-D5-115	M	8/31/07	16				9/5/07	2 (U)						

Table 2-2. Change in Hexavalent and Total Chromium Concentrations from Baseline Through 2007 for Wells and Aquifer Tubes Monitoring the 100-HR-3 (D) and DR-5 Pump-and-Treat Systems. (3 sheets)

Well or Aquifer Tube Name	Well Use or Aquifer Tube	Baseline Sample					Fall 2007 Sample					Percent Change in Concen. Since Baseline Sampling (Negative = Decrease)		
		Filt. and Unfilt. 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.	Total Chromium Filt.
Aquifer Sampling Tubes														
36-S/D	AT	11/17/97	5 (U)	10/21/98	8.1		11/14/07	61.2						
38-M/D	AT	11/18/97	5 (U)	10/21/98	10.8		11/15/07	27.6						
AT-D-1-M/D	AT	3/4/04	6.5	3/4/04		4.4 (U)	11/14/07	11.5	11/14/07	5.5	4 (U)	76.9		
AT-D-2-M	AT	3/14/05	25	3/4/04		156	11/14/07	40.8				63.2		
AT-D-3-D	AT	4/25/05	134	3/4/04		294	11/14/07	71.4				-46.7		
AT-D-4-D	AT			3/4/04		24.7								
DD-12-2	AT	10/26/95	31	11/22/98		89.9	11/15/07	16.4				16.4		
DD-15-3	AT	10/31/95	90	10/26/98		85.8	11/14/07	10.2				10.2		
DD-16-3	AT	11/6/95	172				11/14/07	24.2				24.2		
DD-17-2/3	AT	10/24/95	42	10/27/98		216	11/14/07	37				37		

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.

Table 2-3. Change in Co-Contaminants from Baseline Through 2007 for Wells and Aquifer Tubes Monitoring the 100-HR-3 (D) and DR-5 Pump-and-Treat Systems. (3 sheets)

Well or Aquifer Tube Name	Well Use or Aquifer Tube	Baseline Sample					Fall 2007 Sample					Percent Change in Conc. Since Baseline Sampling (Negative = Decrease)			
		Date(s) 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	12/5/07		1,200	47.4	91.4		324.0	31.7	15.7
199-D5-14	M	2/27/95; 12/2/99	0.104 (U)	1,460	63	94.2	11/6/07		5,100	70.4	124		249.3	11.7	31.6
199-D5-15	M	2/27/95; 12/6/99	0.677 (U)	4,720	17	86	11/6/07		2,800	66	112		-40.7	288.2	30.2
199-D5-16	M	2/27/95; 12/2/99	0.0266 (U)	12,100	87	132	11/14/07		9,600	74.8	140		-20.7	-14.0	6.1
199-D5-17	M	2/15/95; 11/16/99	0.0221 (U)	14,800 (J)	83	51.5	11/14/07		12,000	64.8	98.2		-18.9	-21.9	90.7
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	11/14/07		370	19.9	48.4			-5.2	-108.8
199-D5-32	E	12/8/04				58.5	11/27/07			26.6	66.5				13.7
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	11/16/07		21 (U)	4.1	16.8			-8.9	-44.0
199-D5-37	E	11/16/99; 7/6/99	0.207 (U)	17.4 (U)	15	42	11/27/07				27.1				-35.5
199-D5-39	E	11/15/99; 7/7/99		50.1 (U)	21	215	11/6/07	0.251 (U)	74 (U)	42.5	98.6			102.4	-54.1
199-D5-41	E/M	12/1/99; 7/7/99		426	23	46	12/6/07		940	31.4	69.9		120.7	36.5	52.0
199-D5-42	M/I	12/1/99; 7/7/99		7.68 (U)	21	84									

Table 2-3. Change in Co-Contaminants from Baseline Through 2007 for Wells and Aquifer Tubes Monitoring the 100-HR-3 (D) and DR-5 Pump-and-Treat Systems. (3 sheets)

Well or Aquifer Tube Name	Well Use or Aquifer Tube	Baseline Sample					Fall 2007 Sample					Percent Change in Conc. Since Baseline Sampling (Negative = Decrease)			
		Date(s) 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-D5-44	M	11/17/99; 7/6/99		12.5 (U)	4.3	22	11/6/07		130 (U)	7.13	21.2			65.8	-3.6
199-D5-92	E	11/23/04; 1/16/06		115 (U)		24.6	11/28/07			15	37.2				51.2
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	12/6/07		610	85.9	128			5,268.8	700.0
199-D8-5	M	3/14/95	-0.173 (U)	208	2	17	12/4/07		980	50.5	87.3		371.2	2425.0	413.5
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	11/27/07		4,400	28.9			-63.3	-51.7	-51.7
199-D8-54A	E	2/1/95	7.12	16,000	59.8	128	11/27/07		8,000	46.5			-50.0	-22.2	-22.2
199-D8-54B	M	2/1/95	0.134 (U)	-112 (UJ)	1.95 (J)	67.4	11/28/07		8.1 (U)	2.25	64.9			15.4	-3.7
199-D8-55	M	2/2/95	0.104	40.6 (U)	6.42 (J)	31	11/16/07	0.448 (U)	96 (U)	5.93	15.3			-7.6	-50.6
199-D8-68	E	10/15/96; 5/27/98; 11/30/00	5.36	2,530	5.93	130	11/27/07; 12/4/07	7.65	3,750	32.8	83	42.7	48.2	453.1	-36.2
199-D8-69	C	11/3/98; 10/15/96	1.01 (J)	6,390	13.3		11/7/07	0.207 (U)	1,900				-70.3		
199-D8-70	C	11/3/98; 10/15/96; 3/26/97	1.55 (J)	7,610	33.5	63.8	11/7/07	1.09	5,200	32.3	98.1	-29.7	-31.7	-3.6	53.8
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	11/27/07		1,700	57.1	99.2		86.2	34.0	10.0

Table 2-3. Change in Co-Contaminants from Baseline Through 2007 for Wells and Aquifer Tubes Monitoring the 100-HR-3 (D) and DR-5 Pump-and-Treat Systems. (3 sheets)

Well or Aquifer Tube Name	Well Use or Aquifer Tube	Baseline Sample					Fall 2007 Sample					Percent Change in Conc. Since Baseline Sampling (Negative = Decrease)			
		Date(s) 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-D8-73	M	11/17/04; 11/9/05	0.0305 (U)	118 (U)	38.1	77.3	11/7/07	-0.0314 (U)	200 (U)	37.2	74.7			-2.4	-3.4
199-D8-88	M	11/17/04; 12/27/05	0.0959 (U)	29.5 (U)	32.8	74.4	12/4/07	0.109 (U)	102.5 (U)	31.9	60.7			-2.7	-18.4
Chromium Source Investigation Wells															
199-D5-97	M	4/4/07			52		11/29/07				101				
199-D5-98	M	4/4/07			58		11/29/07				113				
199-D5-99	M	4/5/07			43		12/27/07				110				
199-D5-102	M	4/9/07			24		11/29/07				156				
199-D5-103	M	4/10/07			54		11/29/07				123				
199-D5-104	M	4/9/07			78		11/29/07				145				
Aquifer Sampling Tubes															
36-S/D	AT	11/7/97; 11/19/98	0.12 (U)	243 (U)			11/14/07			0.092 (B)					
38-M/D	AT	11/18/97		88.5 (U)	3 (U)										
AT-D-1-M/D	AT	3/4/04; 4/25/05			8.85		11/14/07			6.64				-25.0	
AT-D-2-M	AT	3/14/05			0.288		11/14/07			1.84				538.9	
AT-D-3-D	AT	4/25/05; 3/4/04			23.5		11/14/07			2.29				-90.3	
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.).

Table 2-4. Change in Hexavalent and Total Chromium Concentrations from Baseline Through 2007 for Wells and Aquifer Tubes Monitoring the 100-HR-3 (H) Pump-and-treat System. (3 sheets)

Well or Aquifer Tube Name	Well Use or Aquifer Tube	Baseline Sample					Fall 2007 Sample					Percent Change in Conc. Since Baseline Sampling (Negative = Decrease)		
		Filt. and Unfilt. 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			11/28/07	14.2	9.3		-85.1	-89.8
199-H3-2B	M			5/13/96	78	73								
199-H3-2C	M			9/5/96	75	64			11/28/07	45.4			-39.5	
199-H3-3	I/M	10/25/96	50				11/7/07	24.8				-50.4		
199-H3-4	I/M	10/25/96	80				11/7/07	27.4				-65.8		
199-H3-5	C	10/25/96	120				11/14/07	65.6				-45.3		
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	11/27/07	5	12/18/07	11.6	12.3	-96.7	-92.8	-91.6
199-H4-4	C/E	12/12/96	80	10/18/96	108	105	12/6/07	17.6	12/6/07	13.5	6.6	-78.0	-87.5	-93.7
199-H4-5	C	10/17/96	90	6/20/95	92.4	97	11/7/07	5.9	11/7/07	41 (C)	40.3 (C)	-93.4	-55.6	-58.5
199-H4-6	M	10/21/96	100	10/21/96	103	105	11/28/07	9				-91.0		
199-H4-7	E/I	10/17/96	90	3/15/95	90		NS							
199-H4-8	M	11/23/97	166	10/18/96	111	85.4	11/30/07	4.6				-97.2		
199-H4-9	M	NS		11/4/96	68		11/7/07	19.3	11/30/07	28	12.8		-58.8	
199-H4-10	M	10/21/96	30	10/21/96	23.1	23.5	11/14/07	16.6	11/14/07	50.6 (C)	45.8 (C)	-44.7	119.0	94.9
199-H4-11	E/M	10/18/96	80	12/20/95	51.5	40	11/7/07	8.4				-89.5		
199-H4-12A	E	10/18/96	80	11/4/96	75.5 (N)		11/27/07	19.7	12/6/07	19.6	19.7	-75.4	-74.0	
199-H4-12B	M	10/18/96	90	3/17/95	97	91	11/14/07	29.3				-67.4		
199-H4-12C	M	10/22/96	260	10/22/96	264	260	11/30/07	84.9	11/30/07	90.3	84.6	-67.3	-65.8	-67.5
199-H4-13	M	10/22/96	50	10/22/96	48.2	45.7	11/7/07	9.7	11/7/07	42.7 (C)	41.7 (C)	-80.6	-11.4	-8.8
199-H4-14	M	10/22/97	60	10/22/96	72.5	72.8	NS		NS					
199-H4-15A	E	10/24/96	49	12/18/95	49	32.7	11/27/07	25	11/27/07	27.5 (C)	23.1 (C)	-49.0	-43.9	-29.4

Table 2-4. Change in Hexavalent and Total Chromium Concentrations from Baseline Through 2007 for Wells and Aquifer Tubes Monitoring the 100-HR-3 (H) Pump-and-treat System. (3 sheets)

Well or Aquifer Tube Name	Well Use or Aquifer Tube	Baseline Sample					Fall 2007 Sample					Percent Change in Conc. Since Baseline Sampling (Negative = Decrease)		
		Filt. and Unfilt. 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-H4-15B	M	10/18/96	80	5/13/96	120	33	12/6/07	44.1	NS			-44.9		
199-H4-15CP	M	NS		10/24/96	4.4 (U)	4 .4 (U)			12/6/07	6.2	4 U			
199-H4-15CQ	M	NS		10/24/96	37	4.4 (U)			12/6/07	26.2	16.9		-25.7	
199-H4-15CR	M	NS		5/28/96	32	21			1/3/08	51.7	49.9		61.6	137.6
199-H4-15CS	M	10/28/96	100	12/18/95	86.8		1/3/08	157	1/3/08	92.8	100	57.0	6.9	
199-H4-16	M	10/23/96	50	10/23/96	60.7	53.2	11/30/07	2.6 B	11/30/07	13.2			-54.7	
199-H4-17	M/I	10/23/96	80	10/23/96	90.2	75.5							-69.5	
199-H4-18	M/I	10/23/96	70	10/23/96	77.7	89.2							-64.6	
199-H4-45	M	10/24/96	20	10/24/96	28.4	24.9	12/27/07	2.7	12/27/07	10.1	6.2	-86.5	-3.2	-75.1
199-H4-46	M	10/24/96	30	10/24/96	34.1	29.9	11/30/07	6.4	11/30/07	16.1	15.6	-78.7	-19.4	-47.8
199-H4-47	M	NS		12/14/95	49.3	45.6	NS		11/30/07	20.5	11		-44.2	-75.9
199-H4-48	M	10/17/96	150	10/17/96	56.2	51.3	11/30/07	5.2	11/30/07	15	10.6	-96.5	-51.1	-79.3
199-H4-49	M	10/29/96	60	12/12/95	50.5	50.7	12/27/07	26.3	12/27/07	27.4	25	-56.2	-45.5	-50.7
199-H4-63	C/E	10/16/96	71	11/2/98	94.3	93.8	11/27/07	14.7	11/30/07	20.5	26.7	-79.3	-70.8	-71.5
199-H4-64	C/E	10/16/96	60	11/2/98	143	78.6	11/27/07	19.7				-67.2	-80.8	
199-H4-65	E/M	7/8/99	5 (U)				12/6/07	13.8						
199-H5-1A	M	10/16/96	100	12/14/95	84.9	75.9	12/6/07	11.3	12/6/07	4.1	4 (U)	-88.7	-67.6	
199-H6-1	M	NS		10/24/96	29.9	29.1			12/6/07	11.5	4 (U)		-8.0	

Table 2-4. Change in Hexavalent and Total Chromium Concentrations from Baseline Through 2007 for Wells and Aquifer Tubes Monitoring the 100-HR-3 (H) Pump-and-treat System. (3 sheets)

Well or Aquifer Tube Name	Well Use or Aquifer Tube	Baseline Sample					Fall 2007 Sample					Percent Change in Conc. Since Baseline Sampling (Negative = Decrease)		
		Filt. and Unfilt. 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
Aquifer Tubes														
43-M	AT			10/19/98		49.5								
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	11/13/07	13.5				170.0		
48-S	AT	10/30/97	3 (U)	10/15/98		39.4	11/13/07	14.8						
49-D/S	AT	11/13/97	16	10/15/98		28.4	11/13/07	9.7				-39.4		
50-M/D	AT	11/13/97	13	10/15/98		28.4	11/13/07	16				23.1		
AT-H-1-D	AT	3/4/04	14	3/11/04		11.9	11/12/07	22.4				60.0		
AT-H-2-D/M	AT	11/17/04	3	3/11/98		7.6	11/12/07	13.5				350.0		
AT-H-3-D	AT	3/11/04	19.5	3/11/04		12.5	11/13/07	19.8				1.5		

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.

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Table 2-5. Change in Co-Contaminant Concentrations from Baseline Through 2007 for Wells and Aquifer Tubes Monitoring the 100-HR-3 (H) Pump-and-Treat System. (3 sheets)

Well or Aquifer Tube Name	Well Use or Aquifer Tube	Baseline Sample						Fall 2007 Sample						Percent Change in Conc. Since Baseline Sampling (Negative = Decrease)				
		Date(s) 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)	5660	3.76	22.8	11/28/07					20.8					-8.8
199-H3-2B	M	5/13/96; 3/9/95		6.801	3,723.8	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	11/28/07					14.7					-18.3
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)	921.000	3,350	95.7	393	11/27/07	1.4 (U)	31		7.6	34		-96.6		-92.1	-91.3
199-H4-4	C/E	10/18/96; 6/20/95	0.832 (J)	6.550	503	1.84	522	11/27/07; 12/6/07	3.16	21.2		6.18	25.9	279.8	223.7		235.9	-95.0
199-H4-5	C	10/17/96; 6/20/95	-0.0441 (U)	-0.292 (U)	3,310	3.79	39.4	11/7/07	0.182 (U)	0.6 U			20.7					
199-H4-6	M	10/21/96; 6/20/95	0.366 (U)	0.106 (U)	4,150	6.92	30.8											
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	11/30/07		-3.13 (U)		0.766	24.9				-81.9	-25.2
199-H4-9	M	10/2/96; 11/4/97		43.4	2,100	8.58	77	11/30/07		13.1		2.18	25.8		-69.8		-74.6	-66.5
199-H4-10	M	10/21/96; 6/28/95	0.0751 (U)	-0.614 (U)	531	1.11	7.8	11/14/07					21.2					171.8
199-H4-11	E/M	10/18/96; 3/17/95	17.7	10.900	987	3.25	109											
199-H4-12A	E	10/18/96; 6/21/95	0.295 (U)	0.158 (U)	1,180	1.75	50	11/27/07	2.2	15	1,400	4.88	21.7			18.6	178.9	-56.6
199-H4-12B	M	10/18/96	0.21 (U)	13.800	2,525	5.83	33.3											

Table 2-5. Change in Co-Contaminant Concentrations from Baseline Through 2007 for Wells and Aquifer Tubes Monitoring the 100-HR-3 (H) Pump-and-Treat System. (3 sheets)

Well or Aquifer Tube Name	Well Use or Aquifer Tube	Baseline Sample						Fall 2007 Sample						Percent Change in Conc. Since Baseline Sampling (Negative = Decrease)				
		Date(s) 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-H4-12C	M	10/22/96; 6/21/95	0.0097	-0.856 (U)	67.3 (U)	1.27	6	11/30/07		-3.73 (U)	180 (U)	1.45	5.1				14.2	-15.0
199-H4-13	M	10/22/96; 3/17/95	27.7	0.833	812	3.83	67.3	11/7/07			2,000		29.1			146.3		-56.8
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	11/27/07	-0.078 (U)	3.5 (U)	2,700	0.72	25.1			40.6	-28.0	42.6
199-H4-15B	M	10/18/96	0.0347 (U)	1.01 (U)	1,070	1.94	13.9											
199-H4-15CP	M	10/24/96		0.663 (U)	-13.3 (U)	1.47	19.3	12/6/07		8.21 (U)	-8.1 (U)	1.43	19.3				-2.7	0.0
199-H4-15CQ	M	10/24/96		2.43 (U)	-35.4 (U)	0.2	0.6	12/6/07					0.9					50.0
199-H4-15CR	M	11/23/98; 5/28/96		1.122	71.693	0.102	2											
199-H4-15CS	M	10/28/96; 7/7/95	0.631 (U)	6.47 (J)	-49.9 (U)	4.39	6.3											
199-H4-16	M	10/23/96; 3/7/95; 6/20/95	3.16	0.002 (U)	511	4.14	31.3	11/30/07	4.670				20.2	47.8				-35.5
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	243.000	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	12/27/07	10.100		1,600		25.6	8.6		322.2		-43.4
199-H4-46	M	10/24/96; 6/20/95	1.8 (J)	-2.28 (U)	5,360	5.51	58.9	11/30/07	2.340				43.2	30.0				-26.7
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	11/30/07	0.143 (U)		1,400		23.6			-44.0		56.3
199-H4-48	M	10/17/96; 6/22/95	-0.16 (U)	-1.73 (U)	2,220		24.5	11/30/07			1,900		22			-14.4		-10.2
199-H4-49	M	10/29/96; 7/13/95	0.438 (U)	0.874 (U)	14,400	6.59	32.3	12/27/07			4,400		42			-69.4		30.0
199-H4-63	C/E	10/16/96; 4/7/97; 11/3/97	51.2	74.000	1,070	5.27	70.4	11/27/07; 11/30/07	24.800	0.4 (U)	1,200	1.52	17.9	-51.6		12.1	-71.2	-74.6

Table 2-5. Change in Co-Contaminant Concentrations from Baseline Through 2007 for Wells and Aquifer Tubes Monitoring the 100-HR-3 (H) Pump-and-Treat System. (3 sheets)

Well or Aquifer Tube Name	Well Use or Aquifer Tube	Baseline Sample						Fall 2007 Sample						Percent Change in Conc. Since Baseline Sampling (Negative = Decrease)				
		Date(s) 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-H4-64	C/E	10/16/96; 11/2/98	0.0793 (U)	0.00648 (U)	1,730	2.94	27.9	11/27/07	-1.3 (U)	1.5 (U)	1,900	0.952	21.1			9.8	-67.6	-24.4
199-H4-65	E/M	5/15/00	3.62	166 (B)	3,780	0.19												
199-H5-1A	M	10/16/96; 6/30/95	0.0118 (U)	-0.595 (U)	15,800		25.9	12/6/07			2,835		26.2			-82.1		1.2
199-H6-1	M	10/24/96; 6/23/95	5.39	0.58 (U)	4,670		26.8	12/6/07	6.37		2,300		44.3	18.2		-50.7		65.3
Aquifer Tubes																		
45-D	AT	9/5/97			122 (U)			11/12/07					2.3					
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	11/13/07	11.00				20.6	-64.5				-17.6
48-M/S	AT	10/26/99; 10/30/97	0.16 (U)	2 (BJ)	1,240	6.87	7	11/13/07					38.3					447.1
49-D/S	AT	10/26/99; 10/19/98; 11/13/97	-0.073 (U)		2,830		9	11/13/07					29.7					230.0
50-M/D	AT	10/15/98; 11/13/97	0.019		2,480		9	11/13/07					44.7					396.7
AT-H-1-D	AT	3/11/04	0.366 (U)	-1.79 (U)		0.976		11/12/07		3.51 (U)		1.4	21				43.4	
AT-H-2-D/M	AT	3/11/04	1.15 (U)	-1.55 (U)		0.748		11/12/07		0.921 (U)		0.96	16.5				28.3	
AT-H-3-D/S	AT	3/11/04; 11/16/05	2.35	35.400		0.54		11/13/07		5 (U)		2.32	13					

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).

Table 2-6. Fall 2007Hexavalent and Total Chromium Concentrations for Wells and Aquifer Tubes Monitoring the "Horn" Area Between the 100-D and 100-H Areas. (2 sheets)

Well or Aquifer Tube Name	Fall 2007 Sample						
	Unfilt. Cr^{+6}		Total Chromium		Nitrate Unfilt. (mg/L)	Sulfate Unfilt. (mg/L)	Tritium Unfilt. (pCi/L)
	Date(s) Collected	Conc. (µg/L)	Unfilt. (µg/L)	Filt. (µg/L)			
699-98-49A	1/25/08	2 (U)					
699-96-49	12/7/07	25.2	15.2	20.4	22.2	76.6	1,700.0
699-97-43	12/7/07	80.8	72.1	71.6	22.7	66.4	4,300.0
699-96-43	1/31/08	82.8	70.4	64.3	29.6 (D)	59.6	5,000.0
699-100-43B	11/9/07	24					
699-99-42B	11/9/07	42					
699-99-41	11/2/07	74					
699-99-44	11/30/07	49					
699-98-43	10/18/07	73					
699-97-41	9/26/07	80					
699-98-46	10/19/07	67					
699-97-45	1/10/08	66					
699-95-45	9/28/07	64					
699-94-43	9/28/07	28					
699-97-48B	10/22/07	42					
699-95-51	10/22/07	34					
699-97-43B	10/17/07	117					
699-94-41	9/26/07	17					
699-101-45	11/15/07	34					
699-96-52B	10/24/07	79					
699-98-51	12/28/07	17					
699-97-43C	10/9/07	8					
699-97-45B	12/20/07	10 (UX)					
699-97-48C	9/27/07	42					
699-97-51A	12/7/07	30.2	21.6	23.5	19.8	62.0	1,760.0
Aquifer Tubes							
43-M	11/12/07	42.4			14.3	39.6	
44-M	11/12/07	46.4			20.7	46.9	
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					

Table 2-6. Fall 2007Hexavalent and Total Chromium Concentrations for Wells and Aquifer Tubes Monitoring the "Horn" Area Between the 100-D and 100-H Areas. (2 sheets)

Well or Aquifer Tube Name	Fall 2007 Sample						
	Unfilt. Cr^{+6}		Total Chromium		Nitrate Unfilt. (mg/L)	Sulfate Unfilt. (mg/L)	Tritium Unfilt. (pCi/L)
	Date(s) Collected	Conc. (µg/L)	Unfilt. (µg/L)	Filt. (µg/L)			
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					
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.

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 disposal 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. Interim action co-contaminants in the 100-KR-4 OU include tritium and strontium-90. Carbon-14 and nitrate are co-contaminants of interest because they are present above MCLs in some wells. A second area of contamination near the KW Reactor complex was included in the interim remedial action, and the KW Reactor area pump-and-treat was constructed. The new facility became operational on January 29, 2007. Additional information on the source area and groundwater are presented in DOE/RL-2008-01.

This section provides the annual performance report for the 100-KR-4 OU. Primary emphasis is on pump-and-treat operations for the reporting period of January 1 through December 31, 2007. Section 3.1 summarizes the treatment system's performance, system operations, extraction well operations, and operational sampling. An evaluation of the aquifer response (including hydraulic monitoring, numerical modeling, and contaminant monitoring in the area impacted by pump-and-treat operations and in the KW and KE Reactor areas) is discussed in Section 3.2. Section 3.3 presents conclusions on the progress toward achieving each RAO and the performance criteria. Sections 3.4 and 3.5 provide the conclusions and the recommendations to change/enhance the 100-KR-4 OU pump-and-treat system. Cost information for the 100-KR-4 pump-and-treat system is presented separately in Section 5.0.

3.1 100-KR-4 TREATMENT SYSTEM PERFORMANCE

This section describes the 100-KR-4 pump-and-treat system's operation and sampling activities for CY07. Specific details 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.

As a result of action items identified in the second CERCLA 5-year review (*The Second CERCLA Five-Year Review Report for the Hanford Site* [DOE/RL-2006-20]), several new wells were constructed or reconfigured in CY07 to support plume remediation and delineation. Figure 3-2 presents the wells completed through CY07 and the proposed wells to be installed in CY08 in support of the CERCLA 5-year review. To improve the efficiency for the 100-KR-4 pump-and-treat system, flow rates for select extraction and injection wells were adjusted to prevent over-pumping and associated system shutdown during freezing conditions, which resulted in greater scheduled system availability. Figure 3-3 presents a schematic drawing at the current 100-KR-4 pump-and-treat system.

A summary of operational parameters and total system performance for CY07 is presented in the table below:

Total processed groundwater:	
Total amount of groundwater treated (since October 1997 startup) (billion L)	4.41
Total amount of groundwater treated during CY07 (million L)	529.2
Mass of hexavalent chromium removed:	
Total amount of hexavalent chromium removed (since October 1997 startup) (kg)	324.7
Total amount of hexavalent chromium removed in CY07 (kg)	20.4
Summary of operational parameters:	
Removal efficiency (% by mass)	91.9%
Waste generation (m^3)	0
Regenerated resin installed (m^3)	67.9
New resin installed (m^3)	31.7
Number of resin vessel changeouts	30
Summary of system availability:	
Total possible run-time (hours)	8,760
Scheduled downtime (hours)	28.8
Planned operations (hours)	8,731.2
Unscheduled downtime (hours)	67.6
Total time on-line (hours)	8,663.6
Total availability (%)	98.9%
Scheduled system availability (%)	99.6%

Key operational and system highlights for CY07 are as follows:

- The 91.9% removal efficiency for CY07 is higher than the 85.1% reported for CY06 (Figure 3-4). The higher reported efficiency for CY07 may be attributed to improved process system management.
- The average 100-KR-4 influent hexavalent chromium concentration of 42.3 μg/L was slightly lower than the CY06 average of 46.5 μg/L.
- The average effluent hexavalent chromium concentration of 3.4 μg/L for CY07 was lower than the 5.7 μg/L in CY06. Trend plots of CY07 influent and effluent concentrations are presented in Figure 3-5.
- The maximum hexavalent chromium concentration in the effluent was 10 μg/L.
- Scheduled system availability for CY07 was 99.6%, which was slightly lower than the 99.7% reported in CY06. The total availability was 98.9%, which was slightly lower than the on-line availability of 99.9% reported for CY06. 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 30 vessels in CY07. New resin installed totaled 31.7 m^3 (1,120 ft^3), while regenerated resin totaled 67.6 m^3 (2,387.3 ft^3).

The following table 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 are based upon updated numerical modeling results that were prepared to support the CERCLA 5-year review design modification. The yearly average flow rates are calculated from actual totalized volumes divided by the total hours in a year:

Well	Recommended[b] Flow Rate, L/min (gpm)	Yearly Avg. Flow Rate, L/min (gpm)	Total Flow Hours in CY07	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	146.9 (38.8)	8,629.6	98.5%	Injection
199-K-122A	NA	316.8 (83.7)	8,663.6	98.9%	Injection
199-K-123A	NA	151.4 (40)	8,626.8	98.5%	Injection
199-K-124A	NA	73.1 (19.3)	8,530.4	97.4%	Injection
199-K-128	NA	301.3 (79.6)	8,664.2	98.9%	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 CY07/ total hours in CY07 x 100%.
[d] Monitoring well 199-K-114A was converted to an extraction well and began operation in November 2004.
gpm = gallons per minute
L/min = liters per minute
NA = not available

A comparison of the 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 recommended. 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 and 199-K-127.

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.

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

3.1.1 KW Reactor Area Pump-and-Treat System

This section describes the KW Reactor pump-and-treat system's operation and sampling activities for CY07. 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.

On January 29, 2007, the KW Reactor pump-and-treat system became operational. This pump-and-treat system was installed to address contamination discovered near the reactor in CY06. 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 equipment 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 2007 are presented in the table below:

Total processed groundwater:	
Total amount of groundwater treated (since January 2007 startup) (million L)	172.49
Mass of hexavalent chromium removed:	
Total amount of hexavalent chromium removed (since January 29, 2007 startup) (kg)	21.03
Summary of operational parameters:	
Removal efficiency (% by mass)	100
Summary of system availability:	
Total possible run-time (hours)	8,088
Scheduled downtime (hours)	45.2
Planned operations (hours)	8,042.8
Unscheduled downtime (hours)	194.5
Total time on-line (hours)	7,848.3
Total availability (%)	97.0
Scheduled system availability (%)	99.4

Key operational and system highlights for CY07 are as follows:

- 172.5 million L (45.6 million gal) of groundwater were treated and approximately 21 kg of chromium were removed.
- The average mass removal efficiency was 100% ([influent concentration – effluent concentration]/influent concentration). Figure 3-8 presents the trend of the effluent and influent concentrations for the year.
- The scheduled system availability was 99.4% and total availability was 97.0%. Figure 3-9 presents the monthly on-line percentages and method used to calculate availability and on-line percentage for the reporting period.

The following table 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:

Well	Yearly Avg. Flow Rate, L/min (gpm)	Total Flow Hours in CY07	Total Run-Time %[a]	Purpose
199-K-132	104.6 (27.7)	7,433.9	91.9	Extraction
199-K-138	97.3 (25.7)	7,271.7	89.9	Extraction
199-K-139	107.8 (28.5)	6,858.4	84.8	Extraction
199-K-140	74.9 1(9.8)	7,590.4	93.8	Extraction
199-K-35	72.3 (19.1)	7,526.8	93.1	Injection
199-K-158	298.6 (78.9)	7,824.3	96.7	Injection

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

The KW Reactor pump-and-treat system was designed to receive and process up to 378.5 L/min (100 gpm). The system is currently processing at an average annual pumping rate of approximately 327.8 L/min (86.6 gpm).

3.2 AQUIFER RESPONSE IN THE 100-K AREA

This section describes the general hydrogeologic conditions in the 100-K Area, the numerical modeling conducted to evaluate the extraction well network, and the 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 well 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 susceptible to 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.

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 D includes a detailed discussion of aquifer parameters.

Mounding occurs around the five existing injection wells (199-K-121A, 199-K-122A, 199-K-123A, 199-K-124A, and 199-K-128) (see Figure 3-10). 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 undoubtedly significantly lower around the injection wells and higher around the extraction wells than that displayed in Figure 3-10. A goal for future reports is to create a correction factor that can be applied to measured head to more accurately represent the head in the aquifer applied to particle travel times.

Groundwater flow in the 100-K Area fluctuates in response to the river stage in the Columbia River. 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; consequently, the dynamics of groundwater flow in the vicinity of the river change seasonally. A comparison of fall and spring groundwater levels in Figure 3-10 suggests that the seasonal water-level rise in the river due to the spring run-off causes changes in groundwater levels up to several hundreds of meters inland in the aquifer; however, wells near the river exhibit the most water-level change, with the magnitude of this effect attenuating farther 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.

3.2.2 Numerical Modeling

Figures illustrating groundwater elevations in this section were prepared by contouring water levels measured in monitoring, extraction, and injection wells. Water levels measured in extraction and injection wells are affected by the efficiency of the well; therefore, corrections are made to these measured water levels to provide a value that is more representative of the water level in the aquifer immediately adjacent to the well for inclusion in the contouring (see Appendix D). However, on some occasions, this approach can exaggerate the amount and extent of drawdown and mounding that actually occur in the vicinity of extraction and injection wells, respectively. In future reports, a rigorous water-level mapping method that accounts explicitly for the drawdown and mounding due to extraction and injection wells, respectively, will be used for this purpose to produce more representative maps of actual field conditions.

Numerical modeling was conducted to evaluate whether the locations and pumping rates of the extraction wells provide effective capture of the contaminant plume. Table 3-1 presents a comparison of measured and modeled water table elevations, as well as the average flow rates used in the numerical model. Flow lines reaching the extraction wells indicate capture. The following conclusions/observations are based on the modeling results:

- The original targeted plume from the 116-K-2 Trench, north to the Columbia River, is within the capture zone of the extraction well network.
- There is incomplete capture south of well 199-K-20, where hexavalent chromium concentrations have ranged from 75 to 85 μg/L in aquifer tube AT-K-3-D since May 2005.
- The plume north of extraction well 199-K-129 is not being captured by the existing extraction well network based on hexavalent chromium concentrations in aquifer tubes along the shoreline north of this well.
- The ongoing expansion of the 100-KR-4 pump-and-treat system is designed to reduce or eliminate the gaps in capture described above.

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. The *Interim Action Monitoring Plan for the 100-HR-3 and 100-KR-4 Operable Unit* (DOE/RL-96-90) and *Sampling Changes to the 100-HR-3 and 100-KR-4 Operable Unit* (DOE-RL 1998) define the sampling protocols implemented for CY07.

The results presented below include the individual or average fall 2007 concentrations for CY07, 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 co-contaminants strontium-90 and tritium. Nitrate and carbon-14 are also constituents of interest.

Complete contaminant monitoring results for CY07 and the historical results for CY02 through CY07 are presented in Appendix E. Contaminant trend charts are presented in Appendix I.

3.2.3.1 Chromium Monitoring Results and Plume Descriptions. The fall 2007 hexavalent chromium groundwater plume in the 100-K Area is presented in Figure 3-12 and may be depicted as three separate plumes based on the probable principal source. The largest plume is likely a result of reactor coolant discharges to the 116-K-2 mile-long trench from 1955 through 1971 that created a groundwater mound and raised the water table up to 3 m (10 ft) at inland well 699-78-62. This plume is being remediated by the100-KR-4 pump-and-treat system.

A second hexavalent chromium plume is located in the vicinity of the KW Reactor. The high hexavalent chromium concentration in well 199-K-137, located upgradient of the KW Reactor, suggests that the plume may have been caused by a leak or spill of concentrated sodium dichromate solution. The KW Reactor hexavalent chromium plume is being remediated by the KW pump-and-treat system.

The third hexavalent chromium plume is in the area of the KE Reactor and appears to extend east into the upgradient end of the 116-K-2 Trench area and plume. The source of this third plume is likely a combination of leakage from water treatment facilities serving the KE Reactor and also infiltrated reactor effluent from the 116-K-2 Trench.

The 100-K Area hexavalent chromium plume maps for many of the years since 100-KR-4 pump-and-treat operations began in 1997 are displayed in Figure 3-13.

3.2.3.1.1 116-K-2 Trench Chromium Plume. The 116-K-2 Trench chromium plume is the largest chromium plume in the 100-K Area and is being remediated by the 100-KR-4 pump-and-treat system that began operations in 1997. Table 3-2 compares hexavalent chromium concentrations of fall CY07 samples collected from wells and aquifer tubes to the baseline samples. The baseline sample of a well completed after the start of pump-and-treat operations is the first sample collected from that well.

The capacity of the pump-and-treat network remediating the 116-K-2 Trench chromium plume is currently being expanded to satisfy the requirements of the last CERCLA 5-year review. The hexavalent chromium concentrations provided in the table below list the preliminary hexavalent chromium concentrations in the wells that will be part of the system expansion. The final use of each well in the system design was being evaluated during preparation of this document; therefore, the wells that are part of the system expansion have been identified as "X" in the well use column rather than specifically extraction, injection, or monitoring wells.

The largest decrease in hexavalent chromium concentration from baseline concentrations has occurred in the center of the 116-K-2 Trench plume, where the 2007 hexavalent chromium concentrations decreased to <20 µg in wells 199-K-20, 199-K-21, 199-K-117A, 199-K-119A, and 199-K-125A. These 2007 concentrations represent a decrease of 89% to 98% 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.

Similarly, hexavalent chromium concentrations have dropped 81% to 97%, to <10 μg/L, in aquifer tubes at sites 21, 22, and 23 located along the shoreline downgradient of the central portion of the 116-K-2 Trench.

Hexavalent chromium concentrations have increased most in well 199-K-18 (which is an interim action compliance well), located near the upstream end of the 116-K-2 Trench. As shown in the trend plots in Figure 3-12, hexavalent chromium began increasing significantly in this well after the start of pump-and-treat operations. The reason for this increase is not known but may be related to a change in flow paths created by nearby extraction and injection wells. In addition, this well is located above a deep channel excavated into the Ringold Upper Mud Unit, resulting in a saturated aquifer thickness approximately 32 m (105 ft).

Other wells or aquifer tubes with fall 2007 hexavalent chromium more than 25% higher than baseline concentrations include wells 199-K-114A, 199-K-130, and 199-K-131 and aquifer tubes sites 26, DK-04, AT-K-4, and AT-K-6. These increases are likely due to movement of the plume to the northeast caused by a combination of groundwater mounding in the injection field area and groundwater flow affected by the Columbia River. The effect of plume migration may be seen on the trend plots of wells 199-K-111A and 199-K-132A (Figure 3-12).

Hexavalent chromium concentrations have stabilized at or below the 22 μg/L RAO in compliance well 199-K-117A and extraction wells 199-K-119A and 199-K-125A (Figure 3-12). 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 3-3 compares the hexavalent chromium concentrations of fall CY07 samples collected from wells and aquifer tubes to the baseline samples.

The highest fall 2007 hexavalent chromium concentration was 3,520 μg/L in new well 199-K-137, which is a 65% increase since the fall 2006 baseline sampling. This well was originally designed as an injection well and evaluated for this purpose by pumping in several thousands of gallons of water. The recent increase in hexavalent chromium may represent an equilibration after the effect of the injection testing dissipated.

The hexavalent chromium plume in the vicinity of well 199-K-137 is assumed to be caused by a nearby sodium dichromate leak or spill because of the high hexavalent chromium concentrations detected in samples from this well. This plume is also thought to be limited in area because fall 2007 hexavalent chromium concentrations in adjacent well 199-K-108A (128 μg/L) and downgradient wells were much lower than well 199-K-137 (e.g., 199-K-107A [487 μg/L], 199-K-139 [224 μg/L] and 199-K-140 [21 μg/L]). Low levels of chromium in these wells could be attributed to a liquid effluent source rather than a concentrated sodium dichromate source. The vertical and areal distribution of the source around well 199-K-137 will be the focus of additional characterization planned during FY08.

The largest percent increase in hexavalent chromium concentration in the KW Reactor area was approximately 190% in well 199-K-107A. Concentrations changed from 168 μg/L in 1997 (baseline sampling) to 487 μg/L in the fall of 2007.

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 3-4 compares hexavalent and total chromium concentrations of fall CY07 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 and the large plume created by mounding around the 116-K-2 Trench. A very high hexavalent chromium concentration that could definitely be attributed to concentrated sodium dichromate solution has not been discovered in the KE Reactor area.

The highest 2007 hexavalent chromium concentration in this plume was 278 μg/L in August 2007 in well 199-K-141, located downgradient of the KE Reactor. This well also produced a high total chromium concentration (400 μg/L) in January 2008. The downgradient extent of this plume is not known, other than it has reached well 199-K-32A, where fall 2007 hexavalent chromium was approximately 22 μg/L The high total chromium concentration detected in well 199-K-36 in 1996 (1,120 μg/L) has not been detected in downgradient wells or aquifer tube AT-K-2.

The largest percent increase in total chromium from baseline to fall 2007 was approximately 269% in well 199-K-30 (from 6.2 μg/L in 1996, to 22.9 μg/L in 2007). The largest percent decrease in total chromium from the baseline to fall 2007 was approximately 89% in well 199-K-110A (from 447 μg/L in 1997, to 47.5 μg/L in 2007).

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 co-contaminants. Nitrate and carbon-14 are contaminants of interest 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 3-5, 3-6, and 3-7 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 2007 results are compared to baseline pre-pump-and-treat results collected mostly in 1996, if available. The strontium-90 results for the 116-K-2 Trench area are summarized below:
  - Baseline samples collected from 32 wells or aquifer tubes indicated that eight wells or aquifer tubes had strontium-90 concentrations above the 8 pCi/L MCL. The maximum reading was 76 pCi/L in well 199-K-127, which was collected in 2002.
  - Fall 2007 samples collected from 24 wells or aquifer tubes indicated that three wells had strontium-90 concentrations above the 8 pCi/L MCL. The maximum 2007 value was 32 pCi/L in well 199-K-21.
  - Strontium-90 declined in well 199-K-127 from 76 pCi/L in 2002 to 22 pCi/L in 2007.
  - There was no detectable strontium-90 in aquifer tubes located along the shoreline downslope of the 116-K-2 Trench in 2007.

  The strontium-90 results for the KW Reactor area are summarized as follows:

  - Baseline samples were collected from 11 wells and aquifer tubes, 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, which is located downgradient of the KW Reactor.

- Fall 2007 samples were collected from eight wells and aquifer tubes, and the maximum sample concentration was 37.3 pCi/L in well 199-K-34, which is also located downgradient of the KW Reactor.
- Strontium-90 was not detected above the MCL in aquifer tubes either in baseline samples or the fall 2007 samples.

The strontium-90 results for the KE Reactor area are summarized as follows:

- Baseline samples were collected from 16 wells and aquifer tubes, and the maximum concentration was 3,180 pCi/L in well 199-K-109A, which is located downgradient of the KE Reactor. This was the only well or aquifer tube baseline sample with a strontium-90 concentration above the 8 pCi/L MCL.
- Fall 2007 samples were collected from seven wells and aquifer tubes, and the maximum strontium-90 concentration in a sample was 1,505 pCi/L from well 199-K-109A. This was the only well or aquifer tube sample with a strontium-90 concentration above the MCL.
- Strontium-90 was not detected in any aquifer tube samples either in the baseline samples or the sample collected in the fall 2007.

- **Tritium:** Tables 3-8, 3-9, and 3-10 display 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 2007 results are compared to baseline pre-pump-and-treat results collected mostly in 1996, if available. The tritium results for the 116-K-2 Trench area are summarized as follows:

  - Baseline samples were collected from 32 wells and aquifer tubes, and the maximum tritium concentration was 85,100 pCi/L in a sample from well 199-K-120A. The only other baseline well or aquifer tube sample with tritium above the 20,000 pCi/L MCL was collected from well 199-K-18 (24,597 pCi/L).
  - The same group of wells and aquifer tubes were sampled in the fall of 2007, and the same two wells were characterized by tritium above the MCL. The tritium sample concentration from well 199-K-120A declined 60% to 34,000 pCi/L, and the sample concentration from well 199-K-18 increased 27.3% to 31,300 pCi/L.
  - Tritium was not detected in six of nine aquifer tubes downgradient of the 116-K-2 Trench in the fall of 2007, and the maximum detected concentration was 3,800 pCi/L in aquifer tube DK-04-2.

  The tritium results for wells and aquifer tubes in the KW Reactor area are summarized as follows:

  - Baseline samples were collected from 12 wells and aquifer tubes, and the maximum tritium concentration was 5,750 pCi/L in a sample from well 199-K-34, which is located downgradient of the KW Reactor.

- The same group of wells and aquifer tubes were sampled in the fall of 2007, and the maximum tritium concentration was 10,000 pCi/L in well 199-K-106A, located downgradient of the 116-KW-1 condensate crib.
- Tritium was not detected in aquifer tube AT-K-1-D, which is located along the shoreline downgradient of the KW Reactor.

The tritium results for wells and aquifer tubes in the KE Reactor area are summarized as follows:

- Baseline samples were collected from 15 wells and aquifer tubes, and the maximum tritium concentrations were 328,000 pCi/L in well 199-K-30 and 42,200 pCi/L in well 199-K-27. These two wells are located downgradient of the KE Reactor, and well 199-K-30 is located downgradient of the 116-KE-1 condensate crib. No other baseline well or aquifer tube samples had tritium concentrations above the 20,000 pCi/L MCL.
- Fourteen wells and aquifer tubes were sampled in the fall of 2007. The maximum tritium concentration was 270,000 pCi/L in well 199-K-30. No other wells or aquifer tubes were characterized by tritium above the MCL.
- The maximum tritium concentration in an aquifer tube along the shoreline downgradient of the KE Reactor was 310 pCi/L in aquifer tube 18-S.

- **Carbon-14:** Tables 3-11, 3-12, and 3-13 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 2007 results are compared to baseline pre-pump-and-treat results collected mostly in 1996, if available. The MCL for carbon-14 is 2,000 pCi/L. The carbon-14 results for the 116-K-2 Trench area are summarized as follows:

  - Baseline samples were collected from 10 wells and aquifer tubes. The maximum carbon-14 concentration was 100 pCi/L in aquifer tube 18-S.
  - Four sites were sampled in the fall of 2007 and the maximum carbon-14 concentration detected was 31.1 pCi/L in aquifer tube 18-S.

  The carbon-14 results for wells and aquifer tubes in the KW Reactor area are as follows:

  - Baseline samples were collected from 12 wells and aquifer tubes. The maximum detected carbon-14 concentration was 18,000 pCi/L in well 199-K-106A, located downgradient of the 116-KW-1 condensate crib. Five wells were characterized with carbon-14 concentrations above the 2,000 pCi/L MCL.
  - Eleven sites were sampled in the fall of 2007. The maximum carbon-14 concentration was 5,400 pCi/L in well 199-K-106A, which is a decrease of 70% since the baseline sample was collected in 1996. Four wells were characterized with carbon-14 concentrations above the MCL.
  - The maximum carbon-14 concentration in an aquifer tube sample was 32.1 pCi/L in aquifer tube AT-K-1-D.

The carbon-14 results for wells and aquifer tubes in the KE Reactor area are summarized as follows:

- Baseline samples were collected from 15 wells and aquifer tubes. The maximum detected carbon-14 concentrations were 12,500 pCi/L in well 199-K-30 and 4,600 pCi/L in well 199-K-29. Both of these wells are located downgradient of the KE Reactor and the 116-KE-1 condensate crib. None of other wells or tubes had carbon-14 concentrations above the 2,000 pCi/L MCL.
- Thirteen of the baseline sites were sampled in the fall of 2007. The same two wells were characterized by carbon-14 above the MCL, namely wells 199-K-30 (6,400 pCi/L) and 199-K-29 (2,300 pCi/L). The carbon-14 concentration decreased close to 50% in each of these wells.
- The maximum carbon-14 concentration in an aquifer tube was 31.1 pCi/L in aquifer tube 18-S.

- **Nitrate:** Tables 3-14, 3-15, and 3-16 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 (*100-K Area Technical Baseline Report* [WHC-SD-EN-TI-239]). The fall 2007 results are compared to the baseline pre-pump-and-treat results collected mostly in 1996, if available. The MCL for nitrate analyzed as NO_3 is 45 mg/L, which is equivalent to 10 mg/L NO_3-N. The results are displayed in micrograms per liter (μg/L). The nitrate results for the 116-K-2 Trench area are summarized as follows:
  - Baseline samples were collected from 19 wells or aquifer tubes, and the maximum detected nitrate concentrations were 98,300 μg/L in well 199-K-18 and 54,400 μg/L in well 199-K-19. No other baseline samples had nitrate concentrations above the MCL.
  - Seventeen of the baseline sites were sampled in the fall of 2007, and wells 199-K-18 (70,850 μg/L) and 199-K-19 (40,200 μg/L) were the only sites with nitrate concentrations above the MCL.
  - The maximum detected nitrate concentration in an aquifer tube was 8,150 μg/L in aquifer tube 18-S.

  The nitrate results for the KW Reactor area are summarized as follows:
  - Baseline samples were collected from 12 wells or aquifer tubes, and 4 wells were characterized by nitrate concentrations above the 45,000 μg/L, namely wells 199-K-34 (50,000 μg/L), 199-K-106A (84,000 μg/L), 199-K-138 (94,300 μg/L), and 199-K-140 (73,000 μg/L).
  - The 12 baseline sites were sampled in the fall of 2007, and 3 wells were characterized by nitrate concentrations above the MCL, namely wells 199-K-34 (40,400 μg/L), 199-K-106A (79,700 μg/L), and 199-K-108A (68,600 μg/L).
  - The nitrate concentration detected in aquifer tube AT-K-1-D was 992 μg/L.

The nitrate results for the KE Reactor area are summarized as follows:

- Baseline samples were collected from 15 wells or aquifer tubes, and 3 wells were characterized by nitrate concentrations above the MCL, namely wells 199-K-30 (52,200 μg/L), 199-K-23 (58,400 μg/L), and 199-K-111A (54,400 μg/L).
- The baseline locations were all sampled in the fall of 2007, and three wells were characterized by nitrate above the MCL, namely wells 199-K-30 (54,000 μg/L), 199-K-23 (75,300 μg/L), and 199-K-11 (46,900 μg/L).
- The maximum nitrate concentration detected in an aquifer tube was 13,400 μg/L in aquifer tube 18-S.

3.3 QUALITY CONTROL RESULTS FOR 100-K AREA MONITORING DATA

Field QC results for 100-KR-4 including field duplicates, split samples, and full trip blanks for the following analytes: alkalinity, anions, metals (including hexavalent chromium and total chromium), gamma energy analysis, gross alpha, gross beta, carbon-14, strontium-90, technetium-99, total petroleum hydrocarbons (TPHs), tritium, and uranium. 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. The CY07 highlights of the QC data for 100-K Area sampling are summarized below. Tables showing the complete QC results are provided in Appendix G.

The EPA guideline (EPA/540/R-94/083) for field duplicates is ±20%. Only field duplicates with at least one result greater than five times the MDL or MDA are evaluated. A summary of evaluated field duplicates with RPDs >20% is provided in the table below. Of the 76 field replicate pairs of data evaluated, 98.7% were within acceptable limits. One of the field duplicates reported for fluoride was slightly above the acceptance criteria of 20% (24.6%). This is not anticipated to affect the usability of 100-K Area sampling data. A complete list of field duplicates performed is provided in Appendix G.

Summary of Field Duplicates Exceeding Quality Control Limits

Constituent	Number of Duplicates	Number Evaluated	Number >20% RPD	Percent >20% RPD	Range of RPDs >20%
Fluoride	6	6	1	16.7	24.6

While there are no EPA functional guidelines for the performance of laboratory split samples, results are typically evaluated against the criteria of precision within 20%. Only split samples where results are greater than five times the MDL or MDA at both laboratories were evaluated. A summary of split samples with RPDs >20% is provided in the table below. Of the 62 split sample pairs evaluated, 90.3% were within acceptable limits. Fluoride, chloride, iron, and carbon-14 showed variability higher than 20%. The anions with poor precision were split with the TestAmerica laboratory. This laboratory is no longer currently supporting S&GRP routine anion analyses due to ongoing quality issues. While those issues were predominantly regarding nitrite, it is likely that fluoride in particular may also be affected by a related issue. Additional information about this problem can be found in Section B-1 of the *Quarterly RCRA*

Groundwater Monitoring Data for the Period October through December 2006 (SGW-33492). The other QC split failures appear to be isolated incidents and are not expected to affect usability of the 100-K Area data. These methods will continue to be monitored to determine if corrective action is needed. The complete list of split samples performed is provided in Appendix G.

Summary of Split Samples Exceeding Quality Control Limits

Constituent	Number of Split Samples	Number Evaluated	Number Splits >20% RPD	Percent >20% RPD	Range of RPDs >20%
Chloride	4	4	1	25.00	21.2
Fluoride	4	4	3	66.67	21.5 to 57.7
Iron	4	2	2	100.00	23.4 to 61.5
Hexavalent Chromium	14	10	3	30.00	22.8 to 66.7
Carbon-14	1	1	1	100.00	50.9

For most chemical constituents, field trip blank results above two times the MDL 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 MDL. Metals are evaluated against two times the MDL. Radiological data are evaluated against two times the total MDA. The table below summarizes the blanks that exceed the QC criteria. Of the 206 results for blanks, 89.8% were within acceptance criteria. Most of the 21 out-of-limit results (81%) are associated with metals analysis at the WSCF, which were flagged as "C" by the laboratory, denoting that contamination was also found in the laboratory blank. This appears to be a laboratory contamination issue. Low-level metals data, which are "Q" qualified for contamination in the blank, should be treated as suspect. In addition, chloride, nitrogen in nitrate, and gross beta showed levels of contamination above the acceptance criteria. The chloride and nitrogen-in-nitrate levels of contamination are not expected to adversely affect usability of 100-K Area data, as the levels are typically below the levels of concern for this area. The gross-beta result appears to be an isolated instance, but this method will be monitored to determine if corrective actions are needed. A complete list of the field trip blanks is provided in Appendix G.

Summary of Out-of-Limit Field Trip Blanks

Constituent	Number of Blanks	Number Out-of-Limit	Percent Out-of-Limit	Range of Out-of-Limit Results
Chloride	8	1	12.50	109 µg/L
Nitrogen in nitrate	8	2	25.00	58 to 108 µg/L
Chromium	6	1	16.67	16.7 µg/L
Copper	6	1	16.67	8.2 µg/L
Iron	6	2	33.33	19.5 to 23 µg/L
Magnesium	6	4	66.67	15.1 to 24.2 µg/L

Constituent	Number of Blanks	Number Out-of-Limit	Percent Out-of-Limit	Range of Out-of-Limit Results
Nickel	6	2	33.33	10.9 to 12.7 µg/L
Silver	6	4	66.67	13.3 to 17.1 µg/L
Vanadium	6	1	16.67	14.8 µg/L
Zinc	6	2	33.33	9.1 to 9.9 µg/L
Gross beta	7	1	14.29	4.9 pCi/L

In conclusion, most of the QC for the 100-K Area sampling was within acceptance criteria. Metals methods at WSCF have already been evaluated and corrective actions appear to be effective (see 100-HR-3 Quality Control Results for more information). Future anion data is being closely monitored by S&GRP QC staff to ensure data quality. Corrective actions are not anticipated at this time, and no adverse impact to 100-K Area anions data is expected. With few exceptions, all other data meets the expectations of the quality control program, and QC indicates that the groundwater monitoring data are reliable and defensible.

3.4 CONCLUSIONS

The conclusions have been described as they pertain to the interim response measure RAOs:

- **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).

  - The simplest measure of performance of a water treatment system is the volume treated and contaminant mass removed from the plume. The 100-KR-4 pump-and-treat system removed 20.5 kg of hexavalent chromium and treated 529.2 million L (139.8 million gal) during CY07. The cumulative mass removed and volume treated since 1997 startup is 324.7 kg of hexavalent chromium and 4.41 billion L (1.2 billion gal), respectively.

  Other monitoring results that aid in evaluating pump-and-treat system performance are listed below:

  - The existing pump-and-treat network has been most effective in the center portion of the hexavalent chromium plume around the 116-K-2 Trench. Fall hexavalent chromium concentrations have dropped below 20 µg/L in wells 199-K-20, 199-K-21, 199-K-117A, 199-K-119A, and 199-K-125A. This represents a decrease of 89% to 98% in the concentration of hexavalent chromium in these wells since the start of pump-and-treat operations in 1997.
  - Hexavalent chromium concentrations have increased significantly in compliance monitoring well 199-K-18 since 1997. The reason for this increase is not known but may have been the result of changes in groundwater flow dynamics because of system operations. In addition, this well is located in or adjacent to a deeply eroded channel in the Ringold Upper Mud Unit, resulting in a saturated aquifer Ringold

Unit E thickness of approximately 32.5 m (105 ft). The vertical distribution of hexavalent chromium in this channel is not known but will be investigated in 2008.

- The hexavalent chromium plume appears to have migrated outside the capture zones of the existing system extraction wells, as indicated in >25% increases in chromium concentration in wells 199-K-114A, 199-K-130, and 199-K-131, as well as aquifer tubes #26, DK-04-2, AT-K-4, and AT-K-6. The northeast plume migration is likely influenced by high river stage, which results in groundwater flow parallel to the river channel. Also, the existing 100-KR-4 injection well field has also likely affected groundwater flow inland of the 116-K-2 Trench by creating a mound that increases the groundwater gradient radially, including northeast toward the 100-N Area.

KW Reactor Pump-and-Treat System:

- This system treated 172.5 million L (45.6 million gal) and removed 21.0 kg of hexavalent chromium during CY07.
- Well 199-K-137, located near the KW Reactor, was characterized by a fall 2007 hexavalent chromium concentration of 3,520 μg/L, which an increase of 65.3% since baseline sampling in 2006. The very high hexavalent chromium concentrations in this well suggest a nearby sodium dichromate source because downgradient wells are characterized by hexavalent chromium concentrations much less than the well 199-K-137 values.

KE Reactor Hexavalent Chromium Plume:

The highest 1996 total chromium concentration was in well 199-K-36 (1,120 μg/L). These concentrations have not been detected in downgradient wells. The maximum hexavalent chromium concentration in a well in the KE Reactor area was 278 μg/L in well 199-K-141. This well was also characterized by a 400 μg/L total chromium result in January 2008. There have been no elevated hexavalent chromium sample results to date from wells or aquifer tubes located around the KE Reactor area, suggesting a concentrated and localized sodium dichromate source.

The ROD (EPA et al. 1996) and the remedial design report/remedial action work plan for the 100-KR-4 OU (DOE/RL-96-84) list strontium-90 and tritium as co-contaminants. Carbon-14 and nitrate have also been monitored during the interim action as contaminants of interest.

Strontium-90 in concentrations above the 8 pCi/L MCL is very limited in distribution in the 100-KR-4 OU, as indicated by the summary below:

- The number of wells in the area of the 116-K-2 Trench with strontium-90 above the 8 pCi/L MCL has decreased from eight during baseline sampling to three in the fall of 2007. Thirty-three wells or aquifer tubes were sampled as part of baseline sampling, and 24 wells were sampled in the fall of 2007.
- The baseline and fall 2007 analyses of wells in the KW and KE Reactor areas indicated that two wells downgradient of the KW Reactor had strontium-90 concentrations >8 pCi/L, and one well downgradient of the KE Reactor had strontium-90 concentrations >8 pCi/L. A total of 28 wells and aquifer tubes were sampled for baseline conditions, and 16 were sampled in the fall of 2007.

- Strontium-90 was not detected above the 8 pCi/L MCL in any aquifer tube sample collected for baseline conditions or for the fall 2007 sampling round.

Tritium, in concentrations above the 20,000 pCi/L MCL is of limited areal extent in the 100-KR-4 OU, as indicated below:

- Two wells (199-K-18 and 199-K-120A) located downgradient of the 116-K-2 Trench were characterized by tritium concentrations above the 20,000 pCi/L MCL both for baseline sampling and the fall 2007 sampling round. The maximum fall 2007 tritium concentration was 34,000 pCi/L in well 199-K-120A.
- The fall 2007 tritium results indicated that one well (199-K-30 at 270,000 pCi/L), located downgradient of the KE Reactor, was characterized by a tritium concentration above the MCL. No wells downgradient of the KW Reactor had tritium concentrations above the MCL.
- Tritium was not detected above the MCL in any aquifer tube sample collected for baseline conditions or for the 2007 sampling round.

Carbon-14, in concentrations above the 2,000 pCi/L MCL, is limited in areal extent in the 100-KR-4 OU as indicated in the summary below:

- No wells downgradient of the 116-K-2 Trench were characterized by carbon-14 concentrations above the MCL.
- Four wells downgradient of the KW Reactor were characterized by carbon-14 above the MCL in the fall of 2007. The highest concentration was 5,400 pCi/L in well 199-K-106A.
- Two wells downgradient of the KE Reactor were characterized by carbon-14 above the MCL in the fall of 2007. The highest concentration was 6,400 pCi/L in well 199-K-30.

Nitrate is widespread in Hanford Site groundwater in general, possibly because of the widespread application of fertilizer for agricultural purposes before the start of operations in the 1940s. The number of wells with nitrate above the 45,000 µg/L (10 mg/L NO_3-N) MCL is limited, as described in the summary below:

- Two wells downgradient of the 116-K-2 Trench were characterized by nitrate above the MCL both in baseline sampling and the fall 2007 sampling round. These wells are 199-K-18 and 199-K-19.
- Three wells downgradient of the KW Reactor were characterized by fall 2007 nitrate concentrations above the MCL, and the maximum was 79,700 µg/L in well 199-K-106A.
- Three wells downgradient of the KE Reactor were characterized by fall 2007 nitrate concentrations above the MCL, and the maximum was 75,300 µg/L in well 199-K-23.
- Nitrate was not detected above the MCL in aquifer tube samples collected for baseline reading or the 2007 sampling round.

- **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 some of 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 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.
  - The pump-and-treat system concept of developing a recirculation network that flushes the plume area with treated water and contains the plume has been validated in the central portion of the plume.
  - The treatment system operates 98.9% of the time and is 91.9% effective in removing hexavalent chromium.
  - The expansion of the 100-KR-4 pump-and-treat network in 2008 through 2009 is designed to complete the capture of that portion of the plume that is outside the influence of the current extraction well network. The length of time necessary to create a recirculation cell that will allow flushing of the plume area containing the plume and reducing the hexavalent chromium concentration to the RAOs is unknown.

3.5 RECOMMENDATIONS

The recommendations for the 100-KR-4 Groundwater OU are listed below:

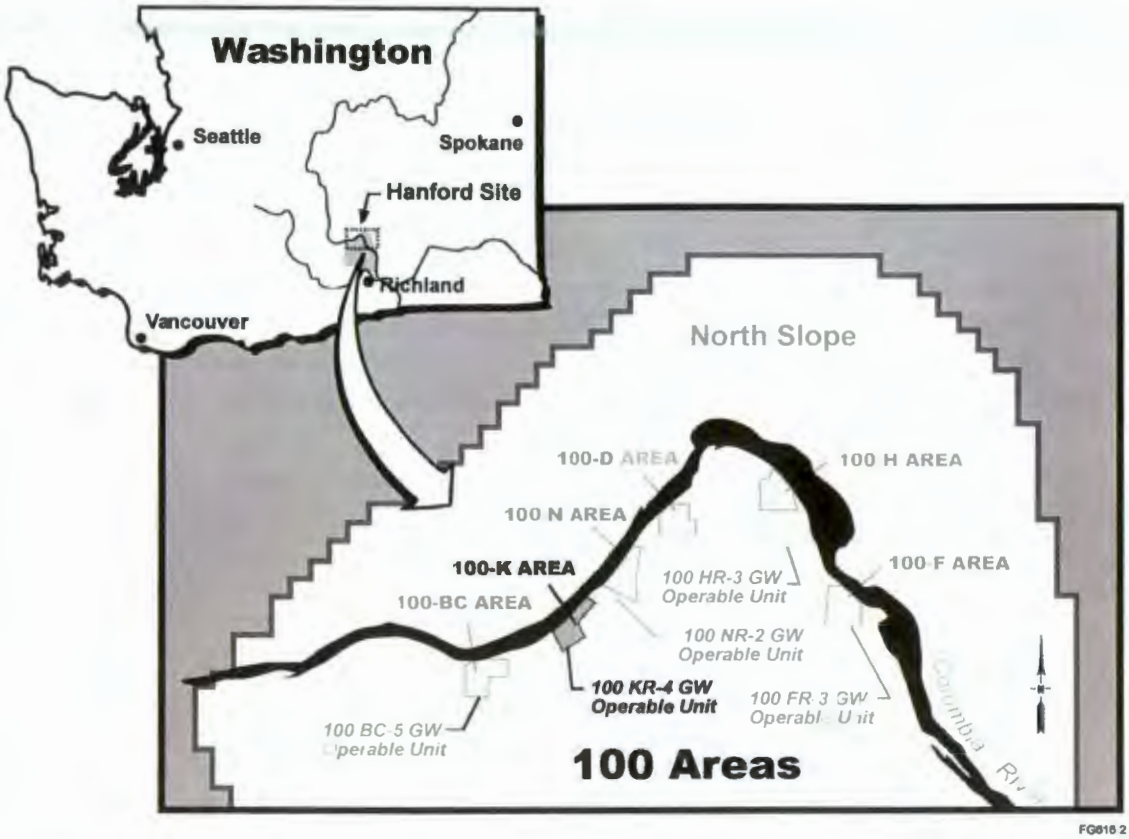
- Use systematic planning to identify data needs for the integrated (source and groundwater) work plan being developed in FY08 and FY09. This will include updates to numerical models and overall conceptual models.
- Use remedial process optimization:
  - Use systematic planning to identify opportunities to optimize the performance and operation of the existing components of the remediation systems (e.g., use the full design treatment capacity of the current pump-and-treat systems).
  - 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.
- Generate an explanation of significant difference against the Interim ROD to address lifecycle costs of the current pump-and-treat systems applicable to the 100-KR-4 OU.

- Apply appropriate open-source models to evaluate remedial process optimization.
- Review and revise, as necessary, existing well sampling frequency and constituent lists to reflect new data needs and trend development.
- Install additional aquifer tubes to evaluate river shore impacts.

Specific recommendations applicable to the 100-KR-4 pump-and-treat system, KW Reactor pump-and-treat system, and KE Reactor plume are as follows:

- **100-KR-4 pump-and-treat system:**
  - Depth-discrete sampling should be conducted in a profile across the 116-K-2 Trench to evaluate whether there is stratification in contaminant concentration within the aquifer. Incorporate the results into the remedial process optimization. This sampling will be completed during FY08.
  - Numerical modeling associated with the planning of the 100-KR-4 pump-and-treat system expansion has indicated that the additional extraction wells will capture the hexavalent chromium plume near the 100-NR-2 OU. Wells near the southern boundary of 100-NR-2 should be sampled for hexavalent chromium to provide data regarding plume migration.
- **KW Reactor pump-and-treat system:**
  - Well 199-K-137 located upgradient of the KW Reactor has been characterized with hexavalent chromium concentrations up to approximately 3,500 μg/L. These high concentrations have not been detected in downgradient wells, so the plume is assumed to be limited in extent and near a source (see Figure 3-12). Therefore, it is recommended that additional wells be drilled to define the plume and increase the KW Reactor pump-and-treat capacity, as required, and use the results in the remedial process optimization. The well drilling activity is planned for FY08.
- **KE Reactor hexavalent chromium plume:**
  - A sample collected in January 2008 from well 199-K-141 had 400 μg/L total chromium. Low total chromium concentrations have been detected downgradient in well 199-K-32A but not in aquifer tube AT-K-2. Add additional downgradient aquifer tubes to fill in gaps along the shoreline and analyze samples from wells 199-K-32A and 199-K-141 for hexavalent chromium. The extent of this plume may require further definition during the remedial optimization process.

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



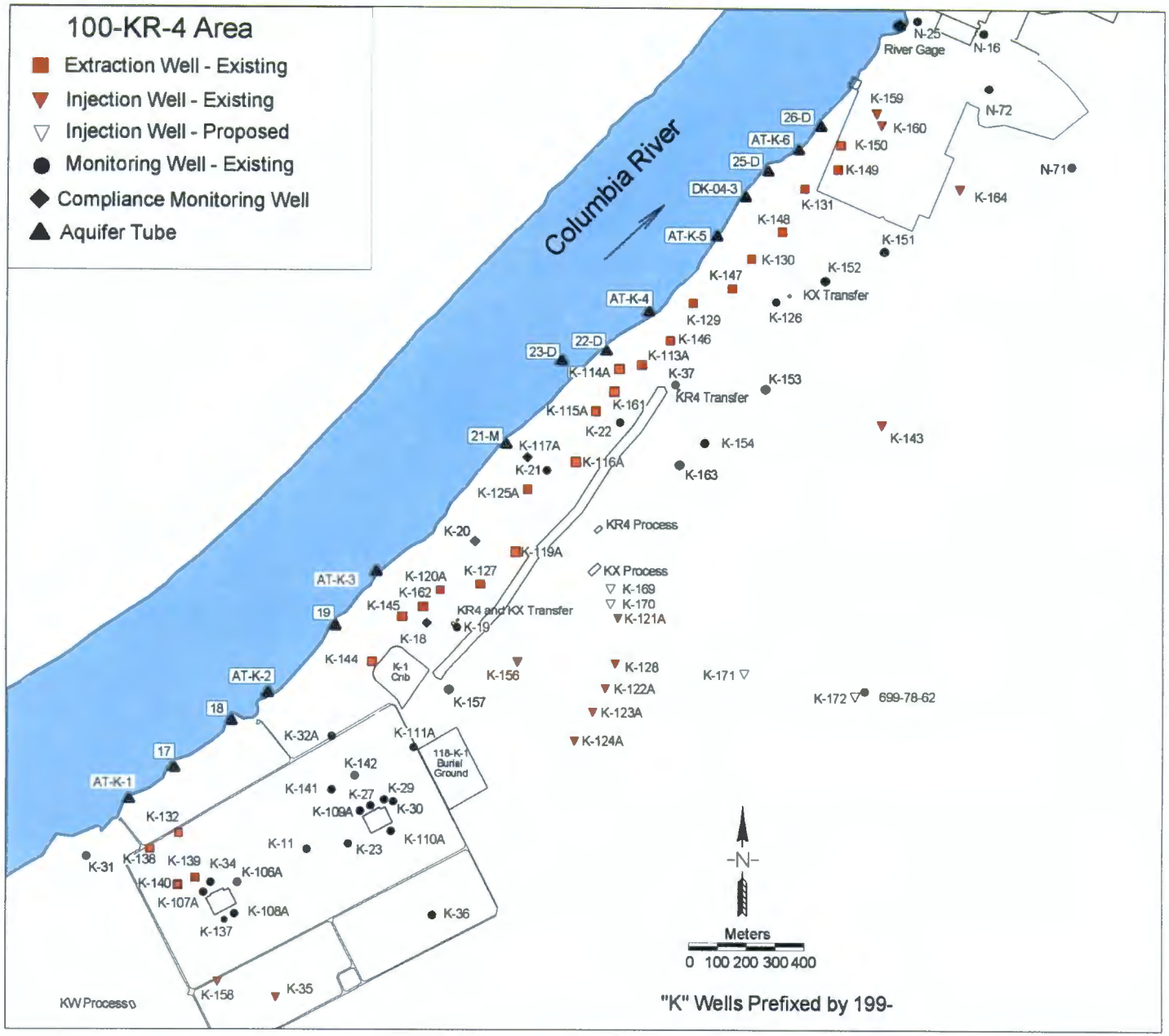


Figure 3-2. 100-KR-4 Operable Unit Wells and Aquifer Sampling Tubes.

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

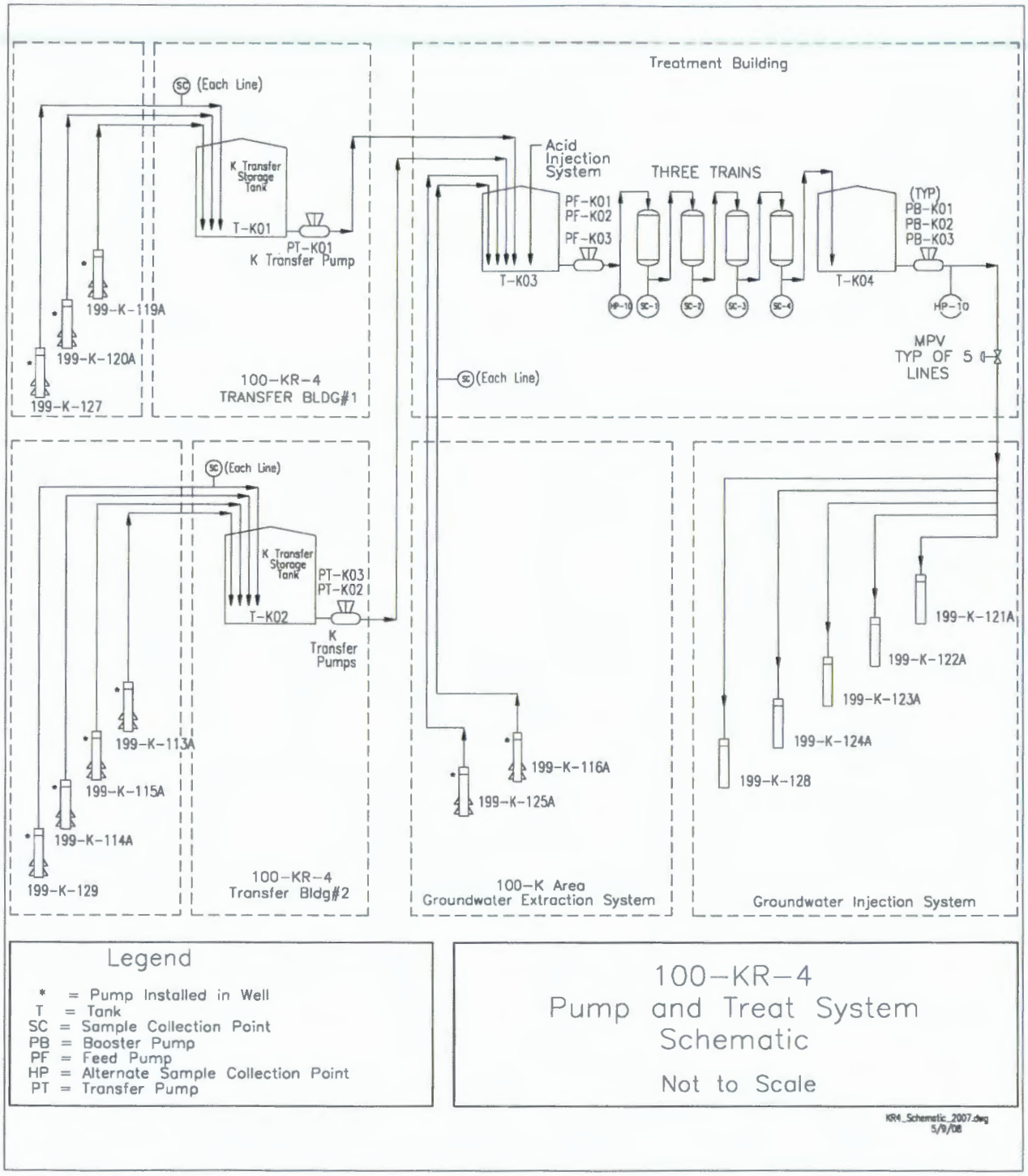
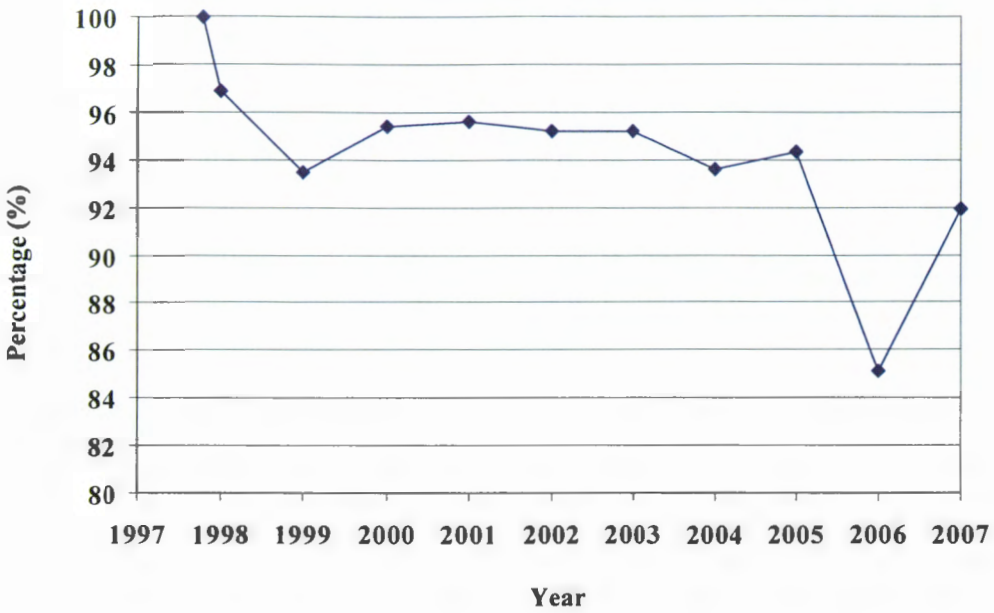


Figure 3-4. 100-KR-4 Pump-and-Treat System Average Removal Efficiencies.



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 2007.

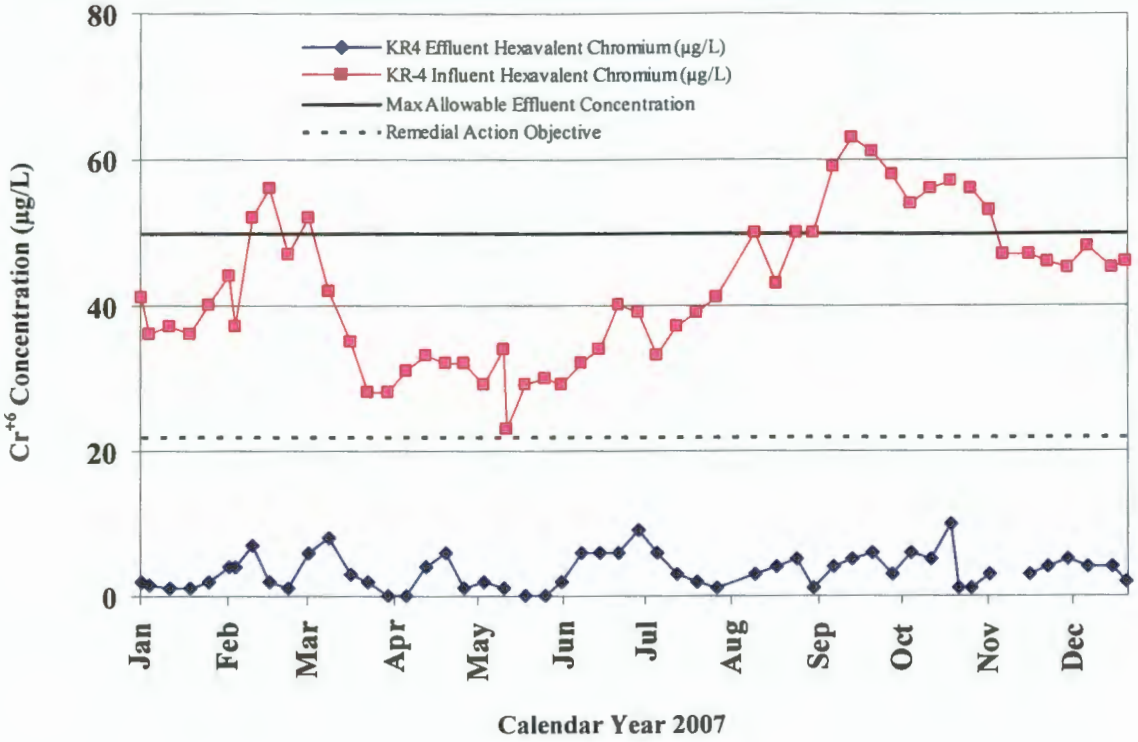
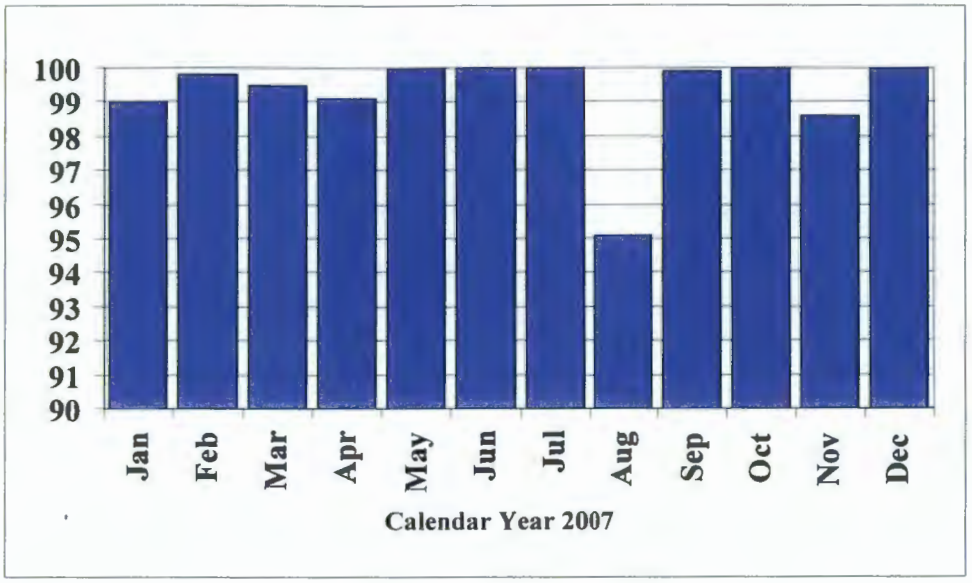


Figure 3-6. 100-KR-4 Pump-and-Treat System Availability and On-Line Percentages for Calendar Year 2007.



100-KR-4 pump-and-treat system availability for 2007:[a]	
Total possible run-time (hours)	8,760
Scheduled downtime (hours)	28.8
Planned operations (hours)	8,731.2
Unscheduled downtime (hours)	67.6
Total time on-line (hours)	8,663.6
Total availability (%)	98.9
Scheduled system availability (%)	99.6

[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)].

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

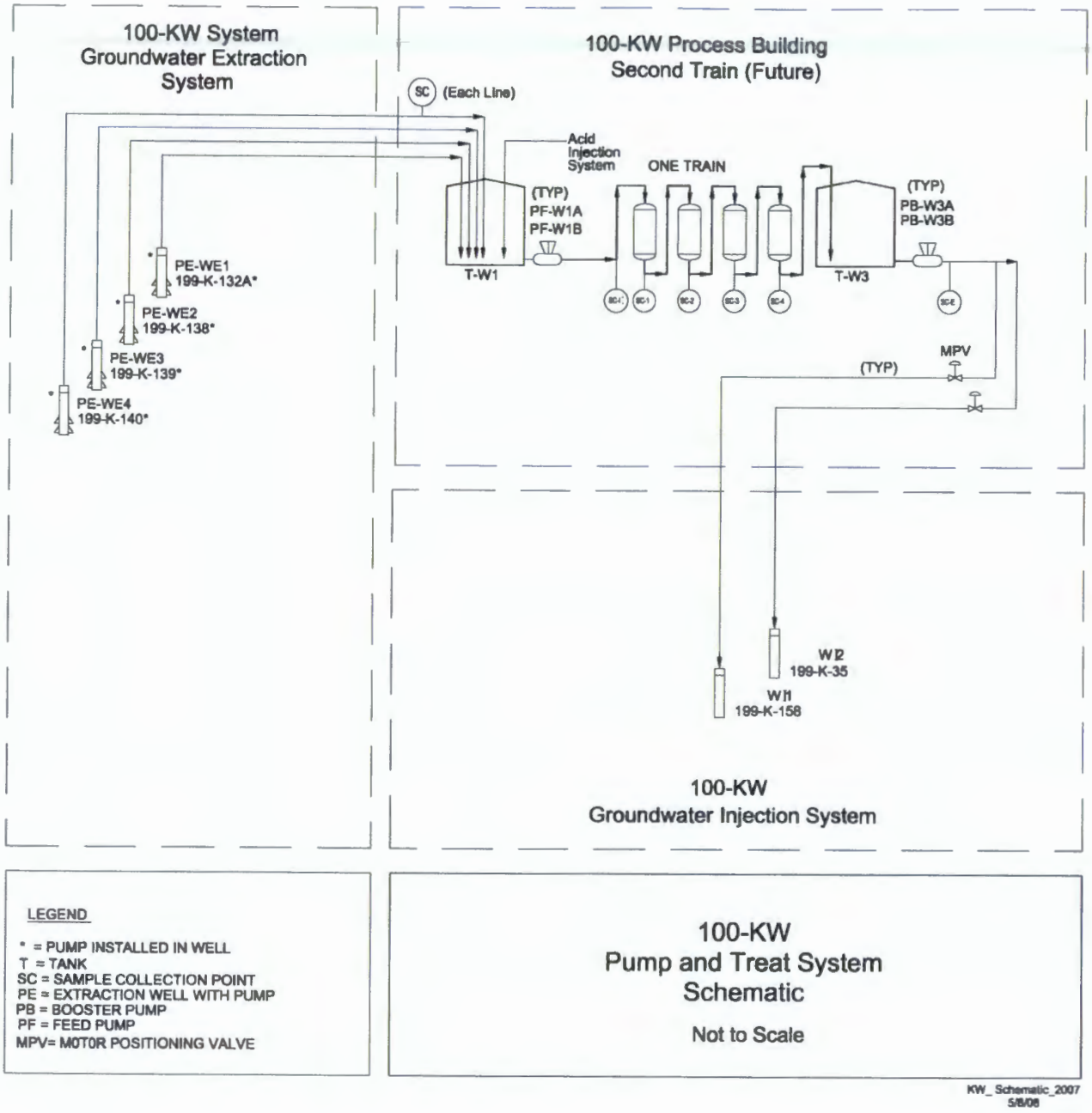


Figure 3-8. KW Reactor Pump-and-Treat Trends of Influent and Effluent Hexavalent Chromium Concentrations, Calendar Year 2007.

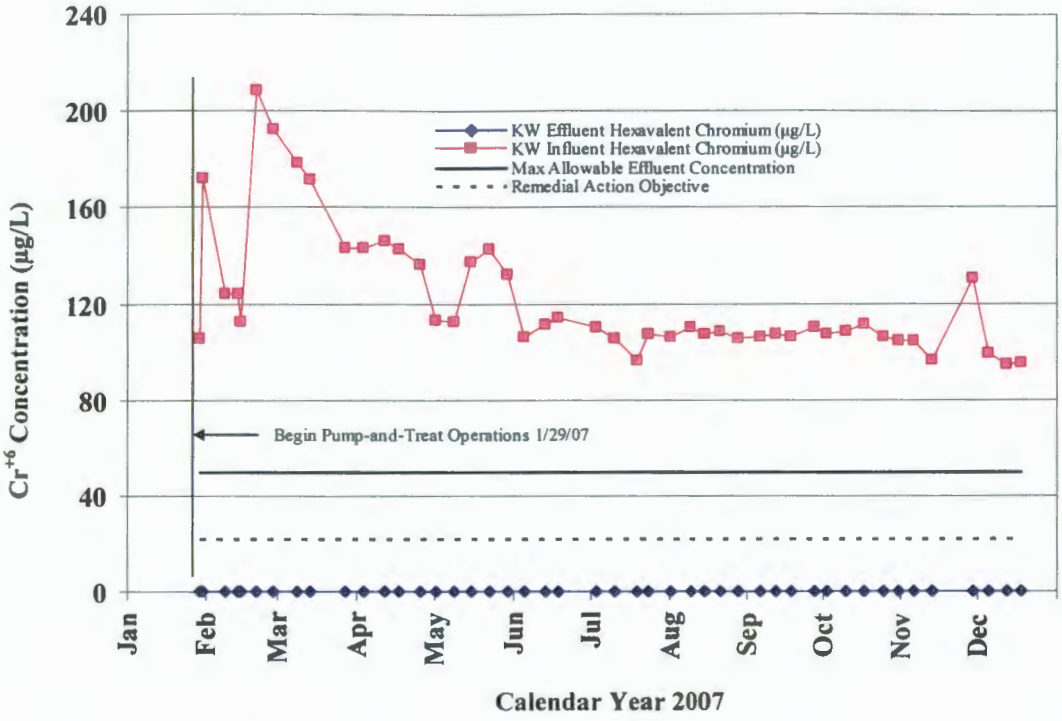
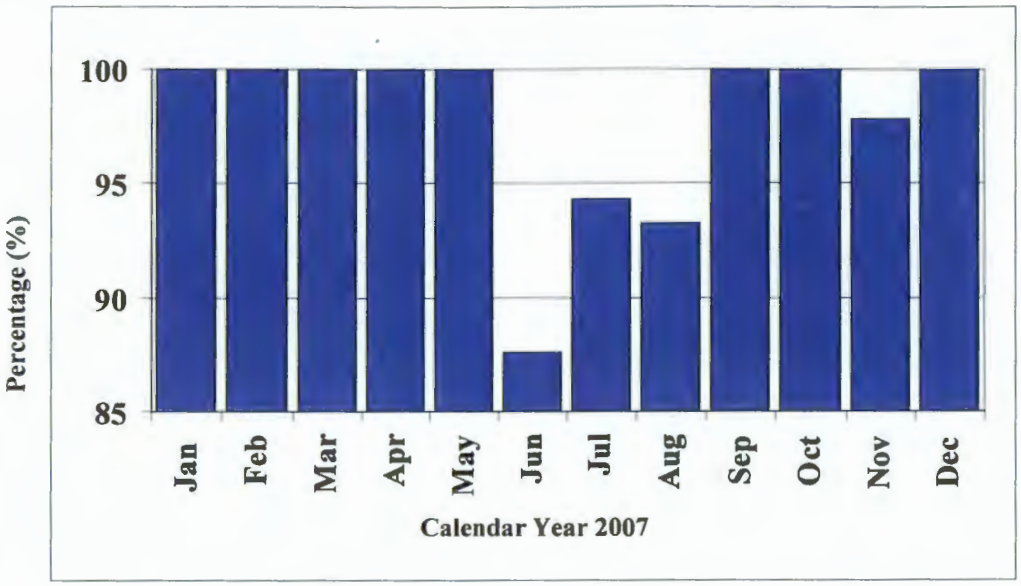


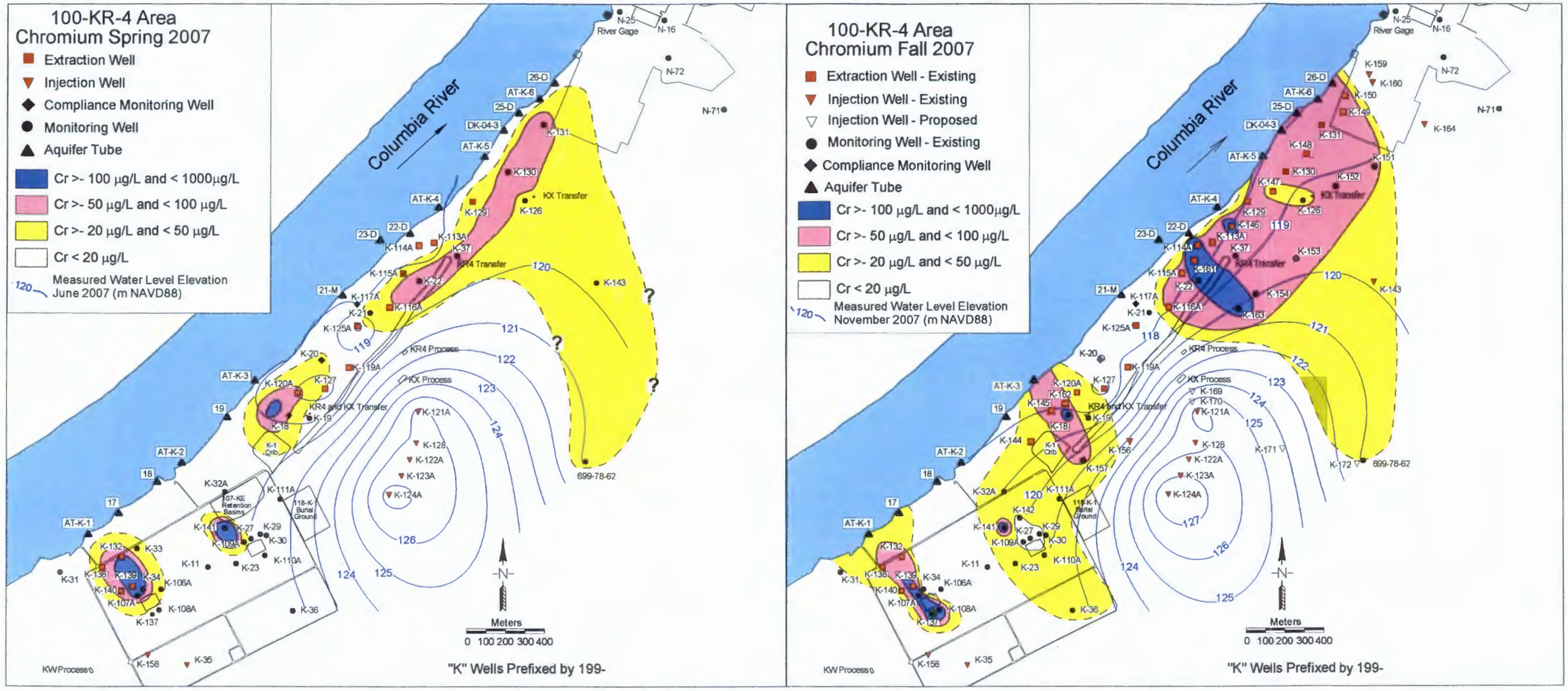
Figure 3-9. KW Reactor Pump-and-Treat System Availability and On-Line Percentages for Calendar Year 2007.



100-KW pump-and-treat system availability for 2007:[a]	
Total possible run-time (hours)	8,088
Scheduled downtime (hours)	45.2
Planned operations (hours)	8,042.8
Unscheduled downtime (hours)	194.5
Total time on-line (hours)	7,848.3
Total availability (%)	97.0
Scheduled system availability (%)	99.4

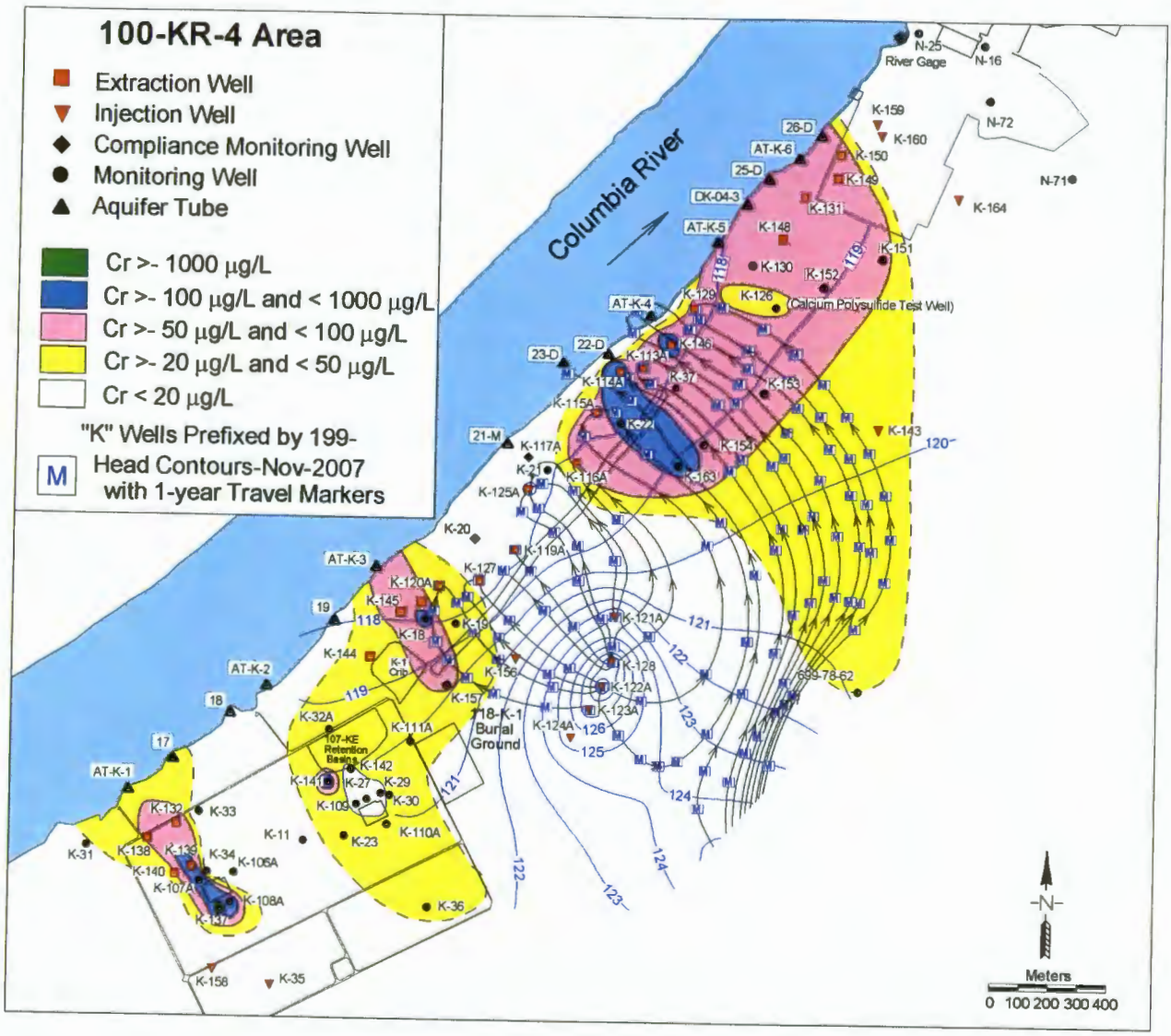
[a] Scheduled system availability [(total possible run-time – scheduled downtime) / total possible run-time].
Total availability [(total possible run-time – scheduled and unscheduled downtime) / total possible run-time)].

Figure 3-10. 100-K Area June and November 2007 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 3-11. Estimated Steady-State Hydraulic Capture Zone Developed for the 100-KR-4 Operable Unit.



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

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Figure 3-12. 100-KR-4 Chromium Plume, Fall 2007.

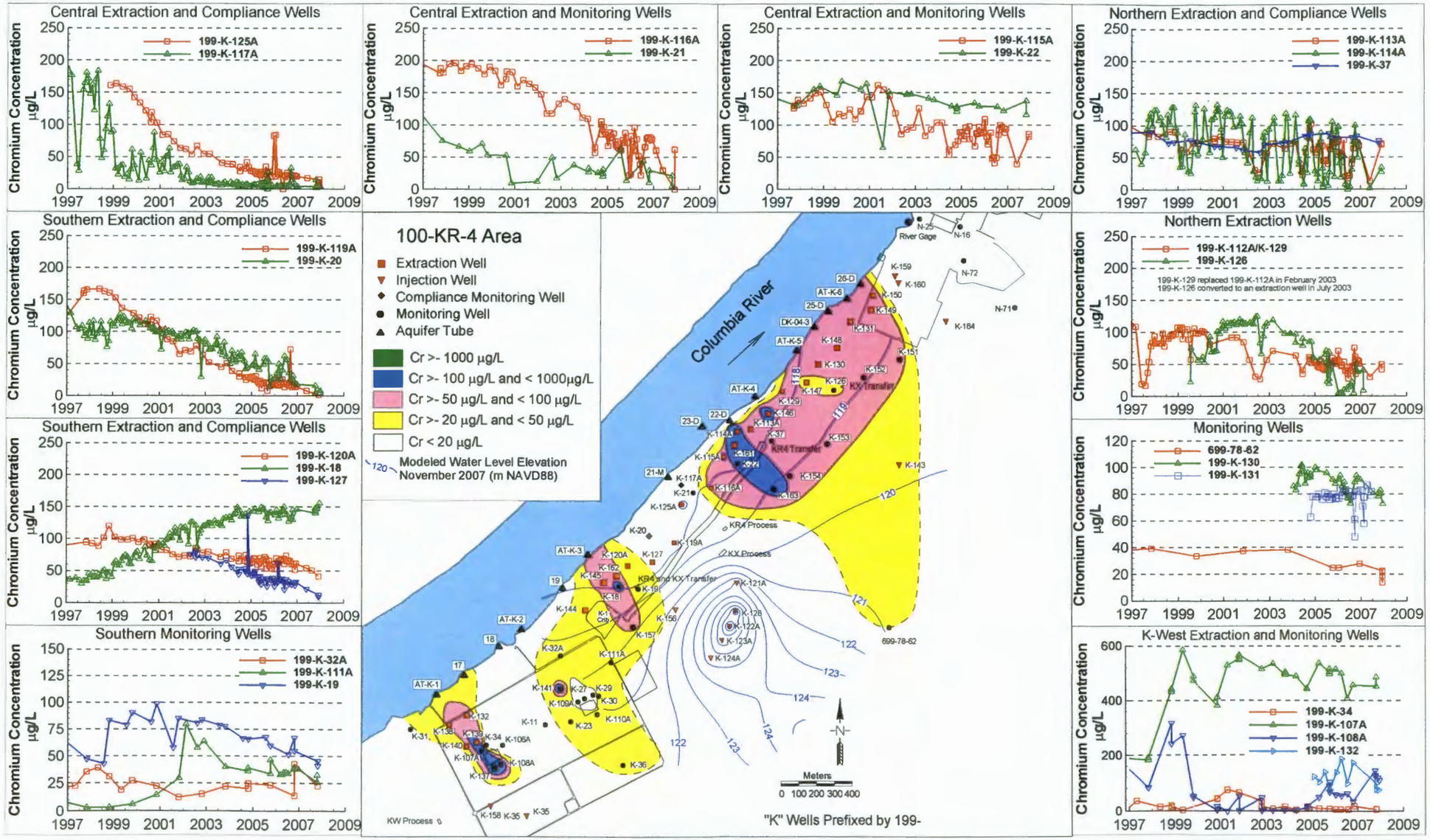


Figure 3-13. 100-KR-4 Chromium Plumes, 1997 to 2007.

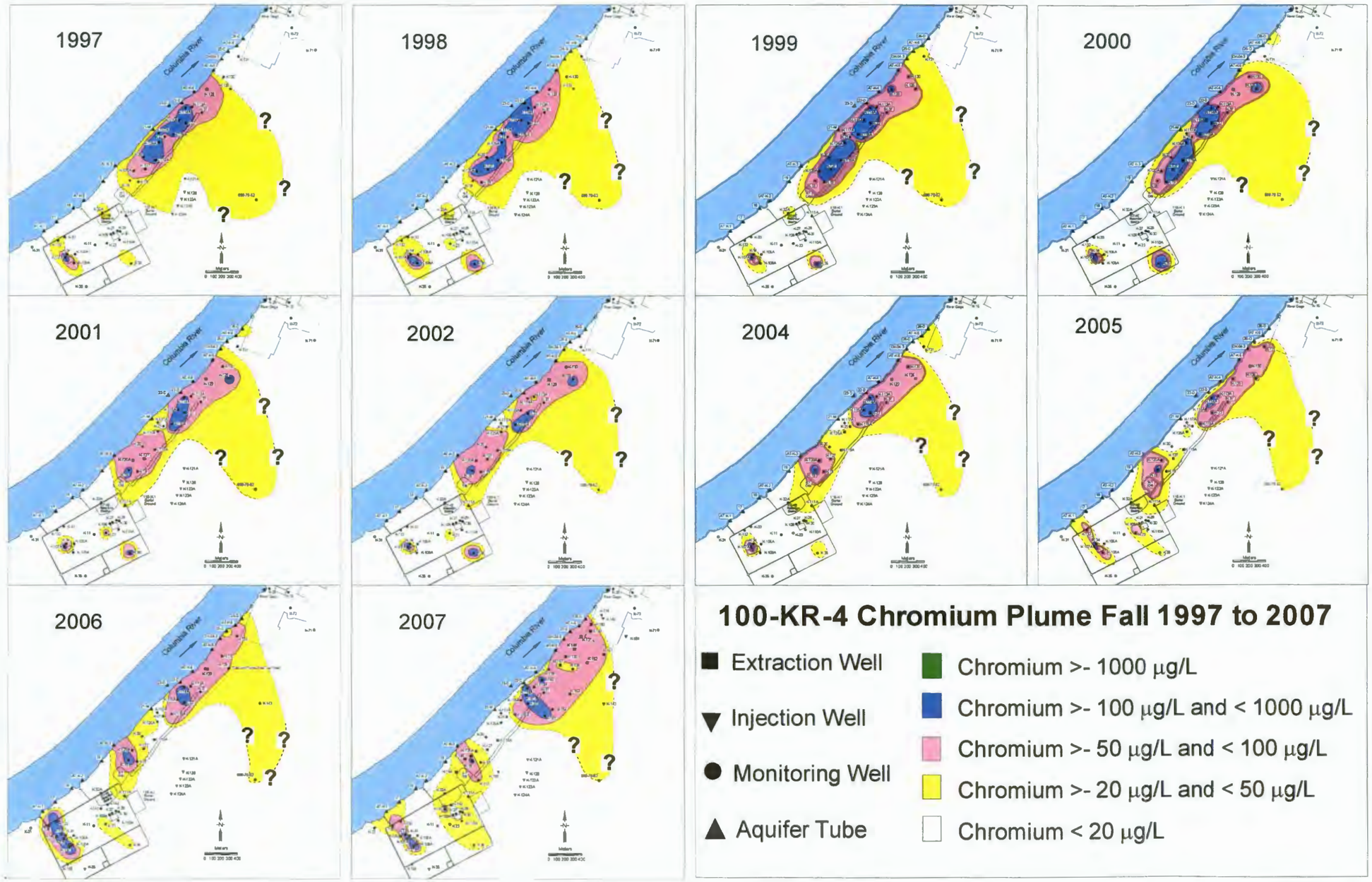


Table 3-1. 100-KR-4 Water-Level Data Used to Develop and Calibrate Numerical Groundwater Flow Models.

Well	Model Analysis, Nov. 2007		Measured Water-Level Elevation, Nov. 2007 (m NAVD88a)	Modeled Water-Level Elevation, Nov. 2007 (m NAVD88a)
	Extraction Rate, L/min	Injection Rate, L/min		
199-K-129	35.8	—	116.63	117.07
199-K-113A	45.1	—	116.34	116.54
199-K-114A	82.4	—	117.86	117.25
199-K-115A	139.2	—	115.41	115.01
199-K-116A	142.8	—	118.01	117.94
199-K-119A	94.3	—	117.15	116.43
199-K-120A	189.1	—	117.44	117.13
199-K-125A	162.7	—	115.89	114.05
199-K-126	—	—	119.30	118.75
199-K-127	136.1	—	116.65	115.86
199-K-121A	—	145.2	122.36	122.36
199-K-122A	—	329.9	123.00	135.18
199-K-123A	—	123.8	123.18	129.64
199-K-124A	—	81.5	123.50	127.01
199-K-128	—	312.9	123.19	133.96
199-K-18	—	—	118.39	117.92
199-K-19	—	—	118.48	118.25
199-K-20	—	—	118.23	117.53
199-K-21	—	—	118.04	117.82
199-K-22	—	—	118.08	117.80
199-K-37	—	—	118.66	118.17
199-K-117A	—	—	118.06	117.67

[a] NAVD88, 1983, *North American Vertical Datum of 1988*, National Geodetic Survey, Federal Geodetic Control Committee, Silver Springs, Maryland.

Table 3-2. Change in Hexavalent and Total Chromium Concentrations from Baseline Through 2007 for Wells and Aquifer Tubes Monitoring the 116-K-2 Trench. (3 sheets)

Well or Aquifer Tube Name	Use	Baseline Sample					Fall 2007 Sample					Percent Change in Conc. Since Baseline Sampling (Negative = Decrease)		
		Filt. and Unfilt. 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} (µg/L)	Total Chromium Unfilt.	Total Chromium Filt.
199-K-18	C	12/16/96	40	12/16/96	40	40.1	10/11/07	145.5	10/11/07	143.5	144	263.8	258.8	259.1
199-K-19	M	12/16/96	40	12/16/96	84.8	85.8	10/17/07	41.5	10/17/07	45.7	42.6	3.8	-46.1	-50.3
199-K-20	C	2/25/97	129	11/15/96	148		10/5/07	4 (B)	10/5/07	16	13.6	-96.9	-89.2	
199-K-21	M	11/18/96	120	11/18/96	122	111	10/16/07	4.9	10/16/07	21.2	6.5	-95.9	-82.6	-94.1
199-K-22	M	11/25/96	130	11/25/96	165	153	10/16/07	116	10/16/07	137	104	-10.8	-17.0	-32.0
199-K-37	M	11/25/96	80	11/25/96	103	97.9	10/18/07	75.8	10/18/07	71.9	67.8	-5.3	-30.2	-30.7
199-K-113A	E	11/12/96	100				10/29/07	82				-18.0		
199-K-114A	C/E	2/26/97	62.3				10/29/07	109				75.0		
199-K-115A	E	9/12/97	126				10/29/07	104				-17.5		
199-K-116A	E	11/20/96	190				10/29/07	74				-61.1		
199-K-117A	C	11/21/96	200	5/27/98		81.9	11/7/07	3.4 (B)	10/5/07	4 (U)	5.8	-98.3		-92.9
199-K-119A	E	11/21/96	120				10/29/07	9				-92.5		
199-K-120A	E	11/26/96	90				10/29/07	49				-45.6		
199-K-125A	E	11/10/98	161				10/29/07	17				-89.4		
199-K-126	C/E/M	7/26/99	75.6	3/14/05	58.9		11/29/07	46	11/29/07	123 (R)		-39.2		
199-K-127	E	5/14/02	76				10/29/07	22				-71.1		
199-K-129/K-112A	E	11/12/96	120	6/13/06	20.6		10/29/07	58				-51.7		
199-K-130	M	3/26/03	50	3/7/06	79.2		11/7/07	81.6				63.2		
199-K-131	M	10/20/04	63				11/2/07	79.2				25.7		
699-78-62	M			3/2/88	106		12/3/07	21.8	12/3/07	18.4	21.4	-82.6	-82.6	
199-K-121A	I	11/13/96	150				10/17/07	0				-100.0		
199-K-122A	I	11/13/96	90				10/17/07	0				-100.0		
199-K-123A	I	11/14/96	71.3				10/17/07	0				-100.0		
199-K-124A	I	11/14/96	50				10/17/07	0				-100.0		

Table 3-2. Change in Hexavalent and Total Chromium Concentrations from Baseline Through 2007 for Wells and Aquifer Tubes Monitoring the 116-K-2 Trench. (3 sheets)

Well or Aquifer Tube Name	Use	Baseline Sample					Fall 2007 Sample					Percent Change in Conc. Since Baseline Sampling (Negative = Decrease)		
		Filt. and Unfilt. 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} (µg/L)	Total Chromium Unfilt.	Total Chromium Filt.
199-K-128	I						10/17/07	0						
199-K-143	M	2/23/07	22.2	2/23/07	23.3	20.2	11/16/07	23.9	11/16/07	21.6	18.4	7.7	-7.3	-8.9
199-K-147	E	11/15/07	38				See baseline							
199-K-148	E	11/14/07	74				See baseline							
199-K-149	E	11/14/07	64				See baseline							
199-K-151	M	12/14/07	44				See baseline							
199-K-154	M	11/20/07	99				See baseline							
199-K-159	I	11/12/07	7				See baseline							
199-K-160	I	11/13/07	10				See baseline							
199-K-163	M	11/16/07	129				See baseline							
199-N-16	M			9/25/96		4.4 U			9/12/07		4.9 (U)D			
199-N-71	M			3/26/96	52.2	4.4 U			12/18/07	13.6	4 U		-73.9	
199-N-72	M			3/21/96		3.7 U			12/18/07	10	6.4			
Aquifer Tubes														
19-D	AT	12/2/97	5 (U)				12/7/07	2 (U)				NC		
21-M	AT	11/24/97	41				11/29/07	7.9				-80.7		
22-M/D	AT	12/2/97	59				12/3/07	7.9				-86.6		
23-D	AT	12/2/97	81				11/28/07	2.7				-96.7		
26-D	AT	11/19/97	5 (U)				11/27/07	63.6				1172.0		

Table 3-2. Change in Hexavalent and Total Chromium Concentrations from Baseline Through 2007 for Wells and Aquifer Tubes Monitoring the 116-K-2 Trench. (3 sheets)

Well or Aquifer Tube Name	Use	Baseline Sample					Fall 2007 Sample					Percent Change in Conc. Since Baseline Sampling (Negative = Decrease)		
		Filt. and Unfilt. 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} (µg/L)	Total Chromium Unfilt.	Total Chromium Filt.
DK-04-2	AT	12/4/97	25				12/3/07	59.5				138.0		
AT-K-3-D	AT	3/2/04	37				12/3/07	80.9				118.6		
AT-K-4-M	AT	3/29/06	1 (U)				11/28/07	6.5				550.0		
AT-K-5-D	AT	3/2/04	58.7				11/28/07	57.3				-2.4		
AT-K-6-M	AT	3/2/04	34.2				11/27/07	64.9				89.8		

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.

Table 3-3. Change in Hexavalent Chromium and Total Chromium from Baseline Through 2007 in Wells and Aquifer Tubes Monitoring the KW Reactor Area.

Well Name	Use	Baseline Sample					Fall 2007 Sample					Percent Change in concentration Since Baseline Sampling (Negative = Decrease		
		Filt and Unfilt. Cr^{+6}		Total Chromium			Unfilt. Cr^{+6}		Total Chromium			Cr^{+6}	Total Chromium	
		Date Collected	Conc. (µg/L)	Date Collected	Unfilt. (µg/L)	Filt. (µg/L)	Date Collected	UF Cr^{+6} (µg/L)	Date Collected	Unfilt. (µg/L)	Filt. (µg/L)		Unfilt.	Filt.
199-K-34	M	1/22/07	22	11/15/96	12.9	8.4 (C)	10/18/07	10.4	10/18/07	7.7	4 (U)	-52.7	-40.3	
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)	10/19/07	4.3	10/19/07	24.9 (C)	20 (C)	-59.8		
199-K-107A	M	3/20/97	168	12/5/96	197	190	10/19/07	487 (D)	10/19/07	453	456	189.9	129.9	140.0
199-K-108A	M	3/20/97	197	12/9/96	160	154	10/5/07	125	10/5/07	128	120	-36.5	-20.0	-22.1
199-K-31	M			12/2/96	14.4	9 (B)			10/17/07	19.7	10.2	36.8	36.8	13.3
199-K-132	E	10/12/06	180	1/5/05		123	10/17/07	86	10/17/07	98.2	97.8	-52.2		-20.5
199-K-137	M	10/24/06	1,942	10/24/06	2,130	2,170	10/5/07	3,520 (D)	10/5/07	3,550	3,350	81.3	66.7	54.4
199-K-138	E	10/12/06	68	10/12/06	63	59.3	10/19/07	53.7	10/19/07	69.4 (C)	74.3 (C)	-21.0	10.2	25.3
199-K-139	E	10/31/06	293.5	10/31/06	284	284	10/5/07	198	10/5/07	186	196	-32.5	-34.5	-31.0
199-K-140	E	10/31/06	161	10/31/06	149	148	10/8/07	21.2	10/8/07	20.2 (C)	26.2 (C)	-86.8	-86.4	-82.3
17-D	AT	12/1/97	6	10/28/98		10.5	12/3/07	24.3	12/3/07	4.4	4.0 (U)	305.0		
AT-K-1-D/M	AT	3/2/04	2	3/2/04		4.4 (U)	12/3/07	41.9	12/3/07	7.5	9.8	1995.0		

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.

Table 3-4. Change in Hexavalent Chromium and Total Chromium from Baseline Through 2007 in Wells and Aquifer Tubes Monitoring the KE Reactor Area.

Well or Aquifer Tube Name	Use	Baseline Sample					Fall 2007 Sample					Percent Change in Conc. Since Baseline Sampling (Negative = Decrease)		
		Filt. and Unfilt. Cr^{+6}		Total Chromium			Unfiltered Cr^{+6}		Total Chromium				Total Chromium	
		Date Collected	Conc. (µg/L)	Date Collected	Unfilt. (µg/L)	Filt. (µg/L)	Date Collected	Unfilt. Cr^{+6} (µg/L)	Date Collected	Unfilt. (µg/L)	Filt. (µg/L)	Cr^{+6}	Unfilt.	Filt.
199-K-32A	M			12/09/96	25.3	21.7			10/17/07	22.8	11.1		-9.9	-48.8
199-K-32B	M			12/09/96	27.6	8.6			10/16/07	7.2	5		-73.9	-41.9
199-K-30	M			11/26/96	6.2 (B)	5.6 (B)			10/19/07	22.9 (C)	21.2 (C)		269.4	278.6
199-K-29	M			4/27/99		4.8 (U)			10/05/07	9.9	6.6			37.5
199-K-27	M				3.5 (U)	3.5 (U)			10/11/07	5.6	7.7			
199-K-23	M			12/06/96	219	38.3	10/18/07	31.4		38.3	30		-82.5	-21.7
199-K-11	M			12/04/96	12.4	8.9 (B)	12/18/07	2 (U)		7.9			-36.3	
199-K-110A	M			01/19/96	37.3	4.4 (U)			10/11/07	47.5	9.6		27.3	
199-K-111A	M	3/7/06	33	11/15/96	25.4	8.4	10/11/07	32.5	10/11/07	26.1		-1.5	2.8	
199-K-36	M	10/27/97	17.5	12/04/96	1,120	501	10/19/07	31.6	10/19/07	68.9 (C)	42.8 (C)	80.6	-93.8	-91.5
199-K-141	M	6/29/07	226	04/27/07	245		08/14/07	278	10/8/07	293	284	13.5	19.6	
199-K-142	M	06/29/07	17.5 (G)	04/27/07	7.8				10/08/07	11.8 (C)	7.6 (C)		51.3	
18-S	AT	12/1/97	5 (U)	10/28/98		5.6	12/3/07	2 (U)	12/3/07	4 (U)	5			-10.7
19-D	AT	12/2/97	5 (U)	4/26/05		3.8 (B)	12/7/07	5	12/7/07	4 (U)	4 (U)			
AT-K-2-D	AT	3/2/04	5.3											

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. 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.

Table 3-5. Change in Strontium-90 Concentrations from Baseline Through 2007 for Wells and Aquifer Tubes Monitoring the 116-K-2 Trench. (2 sheets)

Well or Aquifer Tube Name	Use	Baseline Sample		Fall 2007 (or Most Recent) Sample		Change in Sr-90 Conc. Since Baseline Sampling (%) (Negative Denotes Decrease)
		Date Collected	Sr-90 (pCi/L)	Date Collected	Sr-90 (pCi/L)	
199-K-18	C	12/16/96	0.0627 (U)		0.0404 (U)	NC
199-K-19	M	12/16/96	12.9	NS		NA
199-K-20	C	11/15/96	11.2	10/5/07	6.05	-46.0
199-K-21	M	11/18/96	28.2	10/16/07	32.5	15.2
199-K-22	M	11/25/96	9.1	10/16/07	7.3	-19.8
199-K-37	M	11/25/96	5.19	NS		NA
199-K-113A	E	11/12/96	6.57	11/26/07	-2.7 (U)	NC
199-K-114A	C/E	11/14/96	20.1	11/26/07	21	4.5
199-K-115A	E	11/12/96	15.5	11/26/07	6.4	-58.7
199-K-116A	E	11/20/96	3.29 (J)	11/26/07	3	-8.8
199-K-117A	C	11/21/96	1.57 (J)	10/5/07	1.55	-1.3
199-K-119A	E	11/21/96	0.925 (J)	11/26/07	-0.77 (U)	NC
199-K-120A	E	11/26/96	0.576 (U)	11/26/07	-17 (U)	NC
199-K-118A/125A	E	11/20/96	-0.0238 (U)	11/26/07	-11.9 (U)	NC
199-K-127	E	5/14/02	76	10/29/07	22	-71.1
199-K-129/K-112A	E	12/3/03	-0.236 (U)	11/26/07	-18 (U)	NC
199-K-130	M	10/14/03	0.402 (U)	10/5/07	0.138 (U)	NC
199-K-131	M	10/20/04	0.0217 (U)	10/5/07	0.17 (U)	NC
699-78-62	M	9/22/92	0.11 (U)	NS		NC
199-K-121A	I	11/13/96	0.174 (U)	NS	NA	NC
199-K-122A	I	11/13/96	0.0691 (U)	NS	NA	NC
199-K-123A	I	11/14/96	0.1425 (U)	NS	NA	NC
199-K-124A	I	11/14/96	0.186 (U)	NS	NA	NC
19-D/M	AT	10/30/00	0.26 (U)	12/7/07	1.77	NC
21-M	AT	12/2/97	1.73 (J)	11/29/07	1.07	-38.2
22-M/D	AT	12/2/97	17.9	1/22/07	-1.06 (U)	-86.6
23-D	AT	12/2/97	0.20 (U)	2/20/07	0.07 (U)	NC
DK-04-2	AT	11/2/98	-0.04 (U)	NS		NA
AT-K-3-D/M	AT	5/2/05	-0.04 (U)	12/3/07	0.01 (U)	NC
AT-K-4-M	AT	3/29/06	0.55	11/28/07	0.59 (U)	NC
AT-K-5-D/M	AT	3/2/04	-0.07 (U)	11/28/07	0.06 (U)	NC

Table 3-5. Change in Strontium-90 Concentrations from Baseline Through 2007 for Wells and Aquifer Tubes Monitoring the 116-K-2 Trench. (2 sheets)

Well or Aquifer Tube Name	Use	Baseline Sample		Fall 2007 (or Most Recent) Sample		Change in Sr-90 Conc. Since Baseline Sampling (%) (Negative Denotes Decrease)
		Date Collected	Sr-90 (pCi/L)	Date Collected	Sr-90 (pCi/L)	
AT-K-6-M	AT	3/2/04	-0.06 (U)	1/11/07	-0.79 (U)	NC

NOTES:
1. Well use: C = compliance, E = extraction, I = injection, M = monitoring; AT = aquifer tube.
2. Abbreviations: NA = not available, NC = not calculated, NS = not sampled.
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.

Table 3-6. Change in Strontium-90 in Wells and Aquifer Tubes Monitoring the KW Reactor Area.

Well Name	Use	Baseline Sample		Fall 2007 (or Most Recent) Sample		Change in Sr-90 Conc. Since Baseline Sampling (%) (Negative Denotes Decrease)
		Date Collected	Sr-90 (pCi/L)	Date Collected	Sr-90 (pCi/L)	
199-K-34	M	04/28/97	23.8	10/18/07	37.3	56.7
199-K-35	M	01/15/96	-0.02 (U)	NS		NC
199-K-106A	M	10/15/97	1.59 (U)	NS		NC
199-K-107A	M	10/15/97	41.7	10/19/07	24.2	-42.0
199-K-108A	M	04/24/97	1.30 (U)	11/16/07	0.29 (U)	NC
199-K-31	M	01/09/96	0.09 (U)	NS	NA	NC
199-K-132	E	01/27/05	0.03 (U)	11/29/07	-2.10 (U)	NC
199-K-137	M	NS	NA	12/05/07	-0.03 (U)	NC
199-K-138	E	04/12/07	0.00 (U)	11/29/07	1.8	NC
199-K-139	E	04/12/07	0.12 (U)	11/29/07	2.6	NC
199-K-140	E	04/27/07	1.51	11/29/07	0.17 (U)	NC
AT-K-1-D/M	AT	4/26/05	-0.02	12/3/07	NS	NA

NOTES:
1. Well use: C = compliance, E = extraction, I = injection, M = monitoring.
2. Abbreviations: AT = aquifer tube, NA = not available, NC = not calculated.
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.

Table 3-7. Change in Strontium-90 in Wells and Aquifer Tubes Monitoring the KE Reactor Area.

Well Name	Use	Baseline Sample		Fall 2007 Sample		Change in Sr-90 Conc. Since Baseline Sampling (%) (Negative Denotes Decrease)
		Date Collected	Sr-90 (pCi/L)	Date Collected	Sr-90 (pCi/L)	
199-K-32A	M	01/26/96	1.76 (J)	NS	NA	NC
199-K-32B	M (see note 1)	01/26/96	0.29 (U)	NS	NA	NC
199-K-30	M	01/18/96	0.19 (U)	10/19/07	-0.00734 (U)	NC
199-K-29	M	10/15/97	0.95 (U)	10/5/07	0.0118 (U)	NC
199-K-27	M	10/15/97	1.43 (U)	10/11/07	0.498	NC
199-K-23	M	07/30/97	0.11 (U)	NS	NA	NC
199-K-11	M	01/17/96	0.73 (U)	NS	NA	NC
199-K-109A	M	10/28/96	3,180	10/5/07	1505	-52.7
199-K-110A	M	04/23/97	1.61 (J)	NS	NA	NC
199-K-111A	M	01/19/96	0.25 (U)	NS	NA	NC
199-K-36	M	01/16/96	-0.13 (U)	NS	NA	NC
199-K-141	M	10/08/07	0.01 (U)	10/8/07	0.0111 (U)	NC
199-K-142	M	10/08/07	-0.07 (U)	10/8/07	-0.0742 (U)	NC
18-S	AT	11/5/99	0.06 (U)	NS	NA	NC
19-D	AT	10/30/00	0.26 (U)	1/22/07	0.13 (U)	NC
AT-K-2-M	AT	5/2/05	-0.03 (U)	NS	NA	NC

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, NS = not sampled.
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.

Table 3-8. Change in Tritium Concentrations from Baseline Through 2007 for Wells and Aquifer Tubes Monitoring the 116-K-2 Trench. (2

Well or Aquifer Tube Name	Use	Baseline Sample		Fall 2007 (or Most Recent) Sample		Change in H-3 Conc. Since Baseline Sampling (%) (Negative Denotes Decrease)
		Date Collected	H-3 (pCi/L)	Date Collected	H-3 (pCi/L)	
199-K-18	C	7/31/96	24,597	10/11/07	31,300	27.3
199-K-19	M	12/16/96	11,000	10/17/07	3,600	-67.3
199-K-20	C	11/15/96	431	10/5/07	5,600	1,199.3
199-K-21	M	11/18/96	841	10/16/07	330	-60.8
199-K-22	M	11/25/96	463	10/16/07	180 (U)	NC
199-K-37	M	11/25/96	268 (U)	10/18/07	46 (U)	NC
199-K-113A	E	11/12/96	104 (U)	11/26/07	-6.8 (U)	NC
199-K-114A	C/E	11/14/96	302 (U)	11/26/07	-29 (U)	NC
199-K-115A	E	11/12/96	334 (J)	11/26/07	-4.5 (U)	NC
199-K-116A	E	11/20/96	536	11/26/07	2,900	441.0
199-K-117A	C	11/21/96	587	10/5/07	200 (U)	NC
199-K-119A	E	11/21/96	547	11/26/07	7,000	NC
199-K-120A	E	11/26/96	85,100	11/26/07	34,000	-60.0
199-K-118A/125A	E	11/20/96	551	11/26/07	6,400	1,061.5
199-K-127	E	5/14/02	364 (J)	11/26/07	4,800	1,218.7
199-K-129/K-112A	E	11/12/96	150 (U)	11/26/07	93 (U)	NC
199-K-130	M	10/14/03	3,990	10/5/07	1,250	-68.7
199-K-131	M	10/20/04	3,800	10/5/07	4,300	13.2
699-78-62	M	9/22/92	-81 (U)	12/3/07	7.2 (U)	NC
199-K-121A	I	11/13/96	350 (J)	5/22/07	7,600	NC
199-K-122A	I	11/13/96	212 (U)	5/22/07	7,600	NC
199-K-123A	I	11/14/96	260 (J)	5/22/07	7,600	NC
199-K-124A	I	11/14/96	67.3 (U)	5/22/07	7,600	NC
19-D/M	AT	12/2/97	10.7 (U)	12/7/07	180 (U)	NC
21-M	AT	12/2/97	224 (U)	11/29/07	120 (U)	NC
22-M/D	AT	12/2/97	95.10 (U)	12/3/07	68 (U)	NC
23-D	AT	12/2/97	284 (U)	11/28/07	39 (U)	NC
DK-04-2	AT	12/4/97	5,620	12/3/07	3,800	-32.4
AT-K-3-D/M	AT	5/2/05	2,980	12/3/07	2,900	-2.7
AT-K-4-M	AT	3/29/06	96.5 (U)	11/28/07	-46 (U)	NC
AT-K-5-D/M	AT	3/2/04	951	11/28/07	120 (U)	NC
AT-K-6-M	AT	3/2/04	5,240	11/27/07	3,900	-25.6

Table 3-8. Change in Tritium Concentrations from Baseline Through 2007 for Wells and Aquifer Tubes Monitoring the 116-K-2 Trench. (2

Well or Aquifer Tube Name	Use	Baseline Sample		Fall 2007 (or Most Recent) Sample		Change in H-3 Conc. Since Baseline Sampling (%) (Negative Denotes 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, NS = not sampled.
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.

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

Well Name	Use	Baseline Sample		Fall 2007 (or Most Recent) Sample		Change in H-3 Conc. Since Baseline Sampling (%) (Negative Denotes Decrease)
		Date Collected	H-3 (pCi/L)	Date Collected	H-3 (pCi/L)	
199-K-34	M	10/29/96	5,750	10/19/07	1,800	-68.7
199-K-35	M	12/04/96	1,470	11/29/07	1,800	22.4
199-K-106A	M	10/15/97	3,260	10/19/07	10,000	206.7
199-K-107A	M	10/15/97	1,380	10/19/07	750	-45.7
199-K-108A	M	10/28/96	524	11/16/07	460	-12.2
199-K-31	M	10/29/97	1,370	10/17/07	1,300	-5.1
199-K-132	E	01/27/05	910	11/29/07	4,000	339.6
199-K-137	M	10/26/06	320	10/05/07	1,500	368.8
199-K-138	E	10/12/06	520	11/29/07	5,700	996.2
199-K-139	E	10/31/06	680	11/29/07	1,000	47.1
199-K-140	E	10/31/06	680	11/29/07	2,000	194.1
AT-K-1-D	AT	3/2/04	198 (U)	12/3/07	140 (U)	NC

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 3-10. Change in Tritium in Wells and Aquifer Tubes Monitoring the KE Reactor Area.

Well Name	Use	Baseline Sample		Fall 2007 Sample		Change in H-3 Conc. Since Baseline Sampling (%) (Negative Denotes Decrease)
		Date Collected	H-3 (pCi/L)	Date Collected	H-3 (pCi/L)	
199-K-32A	M	10/29/96	7,200	10/17/07	4,900	-31.9
199-K-32B	M (see note 1)	12/09/96	115 (U)	10/16/07	42 (U)	NC
199-K-30	M	10/29/96	328,000	10/19/07	270,000	-17.7
199-K-29	M	10/28/96	11,400	11/2/07	17,000	49.1
199-K-27	M	10/28/96	42,200	11/2/07	4,600	-89.1
199-K-23	M	12/06/96	219 (U)	10/18/07	42 (U)	NC
199-K-11	M	12/04/96	804	NS		NC
199-K-110A	M	10/28/96	391 (J)	10/11/07	96 (U)	NC
199-K-111A	M	11/15/96	280 (U)	10/11/07	10,000	NC
199-K-36	M	12/04/96	2,100	10/19/07	210 (U)	NC
199-K-141	M	04/27/07	4,500	10/8/07	4,800	6.7
199-K-142	M	04/27/07	377	10/8/07	330	-12.5
18-S	AT	12/1/97	38.3 (U)	12/3/07	310	NC
19-D	AT	12/2/97	10.7 (U)	12/7/07	180 (U)	NC
AT-K-2-M	AT	5/2/05	177 (U)	12/3/07	130 (U)	NC

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.
6. NC = not calculated

Table 3-11. Change in Carbon-14 Concentrations from Baseline Through 2007 for Wells and Aquifer Tubes Monitoring the 116-K-2 Trench.

Well or Aquifer Tube Name	Use	Baseline Sample		Fall 2007 (or Most Recent) Sample		Change in C-14 Conc. Since Baseline Sampling (%) (Negative Denotes Decrease)
		Date Collected	C-14 (pCi/L)	Date Collected	C-14 (pCi/L)	
199-K-18	C	01/24/96	18.6 (J)	01/28/05	6.4 (U)	NC
199-K-19	M	01/25/96	13.8 (J)	NS	NA	NC
199-K-20	C	01/25/96	13.3 (J)	NS	NA	NC
199-K-21	M	01/23/96	15.4 (J)	NS	NA	NC
199-K-22	M	01/09/96	7.84 (J)	NS	NA	NC
199-K-37	M	01/10/96	5.5 (J)	NS	NA	NC
699-78-62	M	1/23/96	0.92 (U)	NS	NA	NC
18-S	AT	10/28/98	100	12/3/07	31.1	-68.9
19-D/M	AT	10/30/00	2.14 (U)	12/7/07	4.38 (U)	NC
AT-K-3-D/M	AT	5/2/05	20	12/3/07	13.9	-30.5

NOTES:

1. Well use: C = compliance, M = monitoring, AT = aquifer tube.
2. Abbreviations: NA = not available, NC = not calculated, NS = not sampled.
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.

Table 3-12. Change in Carbon-14 in Wells and Aquifer Tubes Monitoring the KW Reactor Area.

Well Name	Well Use or Aquifer Tube	Baseline Sample		Fall 2007 (or Most Recent) Sample		Change in C-14 Conc. Since Baseline Sampling (%) (Negative Denotes Decrease)
		Date Collected	C-14 (pCi/L)	Date Collected	C-14 (pCi/L)	
199-K-34	M	11/15/96	3,460	10/18/07	4,380	26.6
199-K-35	M	01/15/96	25.7 (J)	NS	NA	NC
199-K-106A	M	12/05/96	18,000	10/19/07	5,400	-70.0
199-K-107A	M	01/16/96	395	10/19/07	198	-49.9
199-K-108A	M	12/09/96	3,470	10/05/07	1,290	-62.8
199-K-31	M	01/09/96	43.2 (J)	10/17/07	19.9	-53.9
199-K-132	E	10/03/05	3,150	11/29/07	5,140	63.2
199-K-137	M	10/24/06	2,545	11/29/07	3,040	19.4
199-K-138	E	10/12/06	67.3	11/29/07	133	97.6
199-K-139	E	10/31/06	105.4	11/29/07	1,350	1,180.8
199-K-140	E	10/31/06	51.3	11/29/07	720	1,303.5
AT-K-1-D	AT	3/2/04	22.5	12/3/07	32.1	42.7

NOTES:

1. Well use: E = extraction, M = monitoring, AT = aquifer tube.
2. Abbreviations: 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: J = value reported is an estimate.

Table 3-13. Change in Carbon-14 in Wells and Aquifer Tubes Monitoring the KE Reactor Area.

Well Name	Use	Baseline Sample		Fall 2007 Sample		Change in C-14 Conc. Since Baseline Sampling (%) (Negative Denotes Decrease)
		Date Collected	C-14 pCi/L)	Date Collected	C-14 (pCi/L)	
199-K-32A	M	12/09/96	192 (J)	10/17/07	183	-4.7
199-K-32B	M (see note 1)	01/26/96	-0.18 (U)	NS	NA	NC
199-K-30	M	11/26/96	12,500	10/19/07	6,400	-48.8
199-K-29	M	04/23/97	4,610	10/05/07	2,310	-49.9
199-K-27	M	03/24/97	320	04/20/01	172	-46.3
199-K-23	M	01/25/96	60.1 (J)	01/17/00	84 (J)	39.8
199-K-11	M	01/17/96	319	12/18/07	147	-53.9
199-K-110A	M	01/19/96	112 (J)	10/16/03	61.4	-45.2
199-K-111A	M	01/19/96	66.5 (J)	10/11/07	157	136.1
199-K-36	M	01/16/96	261	NS	NA	NC
199-K-141	M	04/27/07	69.4	10/08/07	80.7	16.3
199-K-142	M	04/27/07	227	10/08/07	304	33.9
18-S	AT	10/28/98	100	12/3/07	31.1	-68.9
19-D	AT	10/30/00	2.14 (U)	12/7/07	4.38 (U)	NC
AT-K-2-M	AT	5/2/05	39.8	12/3/07	6.34 (U)	NC

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 = no change in concentration, NS = not sampled.
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.

Table 3-14. Change in Nitrate Concentrations from Baseline Through 2007 for Wells and Aquifer Tubes Monitoring the 116-K-2 Trench.

Well or Aquifer Tube Name	Use	Baseline Sample		Fall 2007 (or Most Recent) Sample		Change in Nitrate Conc. Since Baseline Sampling (%) (Negative Denotes Decrease)
		Date Collected	Nitrate (µg/L)	Date Collected	Nitrate (µg/L)	
199-K-18	C	12/16/96	98,300	10/11/07	70,850	-27.9
199-K-19	M	12/16/96	54,400	10/11/07	40,200	-26.1
199-K-20	C	11/15/96	21,000	10/5/07	13,900	-33.8
199-K-21	M	11/18/96	18,500	10/16/07	24,600	33.0
199-K-22	M	11/25/96	21,600	10/16/07	19,200	-11.1
199-K-37	M	11/25/96	5,360	10/18/07	10,300	NA
199-K-117A	C	5/26/99	2,630	10/5/07	1,920	-27.0
199-K-129	E	10/10/06	16,200	NS	NA	NC
199-K-130	M	9/21/06	23,500	NS	NA	NC
699-78-62	M	1/23/96	8,150	12/3/07	13,500	NC
19-D/M	AT	12/2/97	3,000 (U)	12/7/07	890	NC
21-M	AT	12/2/97	3,000 (U)	11/29/07	71.3 (B)	NC
22-M/D	AT	12/2/97	4,000	12/3/07	859	-78.5
23-D	AT	12/2/97	3,000 (U)	11/28/07	100 (B)	NC
DK-04-2	AT	12/4/97	3,000 (U)	12/3/07	8,150	NC
AT-K-3-D/M	AT	5/2/05	-0.04 (U)	12/3/07	0.01 (U)	NC
AT-K-4-M	AT	3/29/06	0.55	11/28/07	0.59 (U)	NC
AT-K-5-D/M	AT	3/2/04	-0.07 (U)	11/28/07	0.06 (U)	NC
AT-K-6-M	AT	3/2/04	-0.06 (U)	1/11/07	-0.79 (U)	NC

NOTES:

1. Well use: C = compliance, E = extraction, I = injection, M = monitoring; AT = aquifer tube.
2. Abbreviations: NA = not available, NC = not calculated, NS = not sampled.
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 3-15. Change in Nitrate in Wells and Aquifer Tubes Monitoring the KW Reactor Area.

Well Name	Use	Baseline Sample		Fall 2007 (or Most Recent) Sample		Change in Nitrate Conc. Since Baseline Sampling (%) (Negative Denotes Decrease)
		Date Collected	Nitrate (µg/L)	Date Collected	Nitrate (µg/L)	
199-K-34	M	10/29/96	50,000	10/18/07	40,400	-19.2
199-K-35	M	1/20/94	8,700	10/19/06	14,200	63.2
199-K-106A	M	7/30/96	84,000	10/19/07	79,700	-5.1
199-K-107A	M	10/28/96	22,500	10/19/07	20,900	-7.1
199-K-108A	M	7/30/96	33,000	10/5/07	68,600	107.9
199-K-31	M	12/2/96	10,900	10/17/07	23,600	116.5
199-K-132	E	1/27/05	36,300	10/24/07	26,100	-28.1
199-K-137	M	10/24/06	17,600	10/5/07	17,800	1.1
199-K-138	E	8/14/06	94,300	10/19/07	20,700	-78.0
199-K-139	E	8/28/06	32,300	10/5/07	26,800	-17.0
199-K-140	E	9/6/06	73,000	10/8/07	21,200	-71.0
AT-K-1-D/M	AT	3/2/04	753	12/3/07	992	31.7

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 3-16. Change in Nitrate in Wells and Aquifer Tubes Monitoring the KE Reactor Area.

Well Name	Use	Baseline Sample		Fall 2007 Sample		Change in Nitrate Conc. Since Baseline Sampling (%) (Negative Denotes Decrease)
		Date Collected	Nitrate (µg/L)	Date Collected	Nitrate (µg/L)	
199-K-32A	M	12/9/96	28,800	10/17/07	19,100	-33.7
199-K-32B	M (see note 1)	12/9/96	9,690	10/16/07	10,600	9.4
199-K-30	M	10/29/96	52,200	10/19/07	54,000	3.4
199-K-29	M	10/28/96	25,800	10/5/07	17,000	-34.1
199-K-27	M	8/28/96	24,000	10/11/07	30,100	25.4
199-K-23	M	12/6/96	58,400	10/18/07	75,300	28.9
199-K-11	M	12/4/96	27,300	12/18/07	46,900	71.8
199-K-110A	M	10/28/96	17,000	10/11/07	11,200	-34.1
199-K-111A	M	11/15/96	54,400	10/11/07	41,600	-23.5
199-K-36	M	12/4/96	29,700	10/19/07	25,600	-13.8
199-K-141	M	4/27/07	24,800	10/8/07	32,000	29.0
199-K-142	M	4/27/07	3,540	10/8/07	4,360	23.2
18-S	AT	12/1/97	3,000 (U)	12/3/07	13,400	NC
19-D	AT	12/2/97	3,000 (U)	12/7/07	890	NC
AT-K-2-M	AT	3/2/04	319	12/3/07	108 (B)	-66.1

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.

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 OU and the 100-HR-3 OU (Figure 4-1). The 100-NR-2 OU consists of the groundwater underlying and in the vicinity of the source OUs that are associated with the 100-N Area. The 100-NR-2 pump-and-treat system is currently in cold-standby status 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 100-NR-2 extraction and injection wells and the associated monitoring wells in relation to the primary facilities; the figure also shows the location of the apatite barrier. The authorization for this 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 in the development of 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 ROD (EPA et al. 1999). The purpose of this section is to report groundwater monitoring data collected in CY07 and to describe the observed effects of the cold-standby status on the aquifer. The effects of the apatite barrier will be discussed in a separate report.

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 CY07. Section 4.2 describes changes in groundwater conditions before, during, and after the pump-and-treat system was active. Section 4.3 discusses QC chemical analysis. Conclusions and recommendations are presented in Section 4.4 and 4.5, respectively. Cost information is presented in Section 5.0.

4.1 OVERVIEW

The progress on source removal and groundwater remediation activities for CY07 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 major strontium-90 source areas, the 116-N-1 and 116-N-3 Cribs, was completed in 2005 and 2006. The sites were backfilled in 2006.

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 barrier and testing bioremediation), (3) assessing ecological risk of contaminated groundwater, and (4) removing any free product (e.g., diesel) in monitoring wells.

Because the pump-and-treat system was in cold-standby status during CY07, the total volume of water processed and activity of strontium-90 removed were unchanged from CY06:

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 CONDITIONS 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. Figure 4-3 illustrates the March 2007 water table compared with April 2006, when groundwater extraction and injection wells were active. As the effects of extraction and injection dissipated after March 2006, the hydraulic gradient evened out. In 2007, the 119-m (390.4-ft) contour moved farther south, and the 118-m (387.1-ft) contour moved closer to the river.

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 to aid in fish migration. Figure 4-4 shows daily average river stage at the 100-N Area gauging station from CY04 through CY07. The average river stage during CY07 was 118.24 m (387.93 ft), which is slightly lower than CY06 (118.40 m [388.45 ft]) and about the same as CY04 and CY05 (118.20 m and 118.21 m [387.79 ft and 387.83 ft], respectively). In CY07, the river stage was highest between late March and early June, with a peak daily average of 120.42 m (395.08 ft) on March 31. The river stage was lowest in September and October, with a minimum daily average of 116.22 m (381.3 ft) on October 7.

Water levels in the wells respond to changes in river stage. The response is more damped and delayed further inland. For example, the highest daily average water level in well 199-N-34 was on July 3, which was 94 days after the peak river level. The daily average water level in well 199-N-34 ranged 0.69 m (2.26 ft) in CY07, compared to 4.20 m (13.78 ft) at the river. Hydrographs for selected wells in the 100-NR-2 OU are presented in Appendix J.

A series of three-point problems were solved to calculate gradient in various well triangles in the 100-N Area. For selected wells equipped with transducers, net annual gradient and flow were calculated. The following general observations can be made:

- Net groundwater flow during CY07 was to the north-northwest or northwest beneath the former pump-and-treat area.
- Net flow velocity during CY07 was approximately 0.04 m/day (0.13 ft/day) (approximately 15 m/year [49 ft/year]).
- When the river stage is low, groundwater flow direction was toward the river (northwest), which was also the net direction of flow.
- When the river stage was high, groundwater flow direction was away from the river (southeast) overall, and east-northeast in inland areas.

- The water-table gradient and velocity are as much as an order of magnitude larger during low river stage than during high river stage.

Detailed results are presented in the table below:

Well Triangle (prefix 199-)	Region	Date	Water-Table Gradient	Flow Direction (Degrees from North)	Velocity[a] (m/day)
N-50, N-71, N-3	Overall 100-N Area	6/12/07	0.0003	113 (SE)	0.013
		9/27/07	0.0021	317 (NW)	0.106
N-3, N-71, N-26	South 100-N Area	6/12/07	0.0005	130 (SE)	0.026
		9/27/07	0.0027	329 (NW)	0.14
N-34, N-71, N-72	Southeast 100-N Area (inland)	6/12/07	0.0002	70 (ENE)	0.0096
		10/26/07	0.0015	301 (NW)	0.076
N-3, N-50, N-99A	North 100-N Area (pump-and-treat area)	6/12/07	0.0005	135 (SE)	0.026
		10/26/07	0.0010	327 (NW)	0.052
		CY07 Avg.	**0.0009**	**343 (NNW)**	**0.038**
N-92A, N-34, N-146	North 100-N Area (pump-and-treat area)	6/12/07	0.001	164 (SSE)	0.051
		9/26/07	0.002	309 (NW)	0.103
		CY07 Avg.	**0.0012**	**331 (NW)**	**0.041**
N-50, N-34, N-92A	North 100-N Area	6/12/07	0.0004	138 (SE)	0.021
		9/27/07	0.0025	333 (NW)	0.128
		CY07 Avg.	**0.0011**	**347 (NNW)**	**0.038**

NOTE: Calendar year 2007 averages are computed from hourly transducer measurements over the entire calendar year and represent net gradient and flow direction. These are provided for triangles where all three wells contained transducers.

[a] Assuming hydraulic conductivity = 7.6 m/day (25 ft/day) and effective porosity = 0.15.

4.2.2 Contaminant Monitoring

This section summarizes the results of CY07 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. *Groundwater Monitoring Plan for the 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 E presents the sample results for CY07, as well as a historical summary of contaminant and co-contaminant monitoring results for wells and the aquifer tubes. Associated contaminant trend charts are presented in Appendix K.

4.2.2.1 Strontium-90 Monitoring Results. Strontium-90 was present in the 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 were 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. 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 4-5).

Strontium-90 trends in monitoring wells near the 116-N-1 facility show no obvious long-term decline in concentrations but do show significant variability related to water levels. Figure 4-6 shows strontium-90 concentrations and water levels in well 199-N-2 and in well 199-N-67, which has the highest levels of contamination. When the water table rises, strontium-90 from the vadose zone is mobilized and concentrations in groundwater increase. Concentrations increased in the mid-1990s, which correlated with several years of high river stage. Concentration peaks in 2006 and 2007 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 the table below, well 199-N-2 and three of the four former extraction wells showed high-percentage increases in strontium-90 concentrations between 2005 and 2007.

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, Fall 2007 (pCi/L)	% Change 1994 to 2007	% Change 2005 to 2007
Wells and Aquifer Tubes Monitoring 116-N-1 Strontium-90 Plume					
199-N-2	121	81	553 (Q)	357%	583%
199-N-3	927	1,310	1,460/1,360	52%	8%
199-N-14	1,210	1,070	1,310	8%	22%
199-N-46	--	2,690	3,840	--	43%
199-N-51	0.126 (U)/0.254 (U) (Aug. 1994)	--	0.0541 (U)	NC	NC
199-N-67	3,680	9,710	8,880	141%	-9%
199-N-75	2,110	307	2,150 (Q)	2%	600%
199-N-76	84.9	216	203	139%	-6%
199-N-80[a]	0.654 (Q)/0.734 (Q) (Aug. 1994)	-0.154 (U)	0.479	NC	NC

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, Fall 2007 (pCi/L)	% Change 1994 to 2007	% Change 2005 to 2007
199-N-92A	--	0.92/0.416 (U)	2.5	--	NC
199-N-96A	--	5.74	5.3 (Q)	--	-8%
199-N-99A	--	1,270	1,190	--	-6%
199-N-103A	--	422	963	--	128%
199-N-105A	--	1,360	2,130 (Q)	--	57%
199-N-106A	--	3,260	2,460	--	-25%
199-N-119	--	280	289 (U)	--	3%
199-N-120[a]	--	10.1	11.7 (Q)	--	16%
199-N-121[a]	--	0.272 (U)	0.153 (UQ)	--	NC
199-N-122	--	--	1,800	--	--
199-N-123	--	--	1,100	--	--
116m Array 3A	--	379	320 (Aug. 2007)	--	-16%
116m Array 4A	--	1,260	4,500 (Aug. 2007)	--	257%
116m Array 6A	--	477	1,200 (Aug. 2007)	--	152%
116m Array 7A	--	330	240 (Aug. 2007)	--	-27%
NVP-2-116.0	--	3,200	15,000	--	369%
Wells Monitoring 116-N-3 Strontium-90 Plume					
199-N-27	171	--	144/149[b]	-14%	--
199-N-28	120	25.1 (Mar. 2005)	35.6 (Mar. 2007)	-70%	42%
199-N-32	1.27	0.358 (U)	0.376 (UQ)	NC	NC
199-N-34	69.3	53.5 (Mar. 2005)	50.0 (Apr. 2007)	-28%	-7%
199-N-50	-0.0195 (U)	0.126 (U)/0.254 (U)	0.0541 (U)	NC	NC
199-N-64	0.185 (UQ) (Aug. 1994)	--	0.431 (U)	--	NC
199-N-70[a]	0.321	0.156 (U)	0.31 (U)	NC	NC
199-N-74	0.415	--	--	--	--
199-N-81	746	734	593/544	-24%	-22%

NOTES: Data from September unless otherwise noted. Duplicates shown with "/".
Lightly shaded cells show wells with concentrations above the drinking water standard (8 pCi/L).
[a] Screened at depth in Ringold Formation.
[b] Estimated as one-half gross-beta concentrations.
U = undetected
Q = associated with out-of-limits quality control samples
NC = not calculated because concentrations are too low

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 above). As shown for well 199-N-67 in Figure 4-6, the increase occurred in the years following high water table in the mid-1990s. Strontium-90 levels declined from the peak values of the late 1990s but remain higher than in 1994.

Figure 4-7 shows trend plots for the former extraction wells. Strontium-90 rebound was most evident in wells 199-N-75 and 199-N-103A, 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 2006 and 2007 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 and 2007.

Along the Columbia River shoreline, strontium-90 concentrations increased to new high in several aquifer tubes in August 2007. These tubes are all located in the core of the plume between array-4A and array-6A. Tube NVP2-116.0 detected the highest strontium-90 concentration (15,000 pCi/L). The new remedial action (i.e., apatite injections) may temporarily increase strontium-90 concentrations. Section 2.4 of DOE/RL-2008-01 discusses these changes. An upcoming report on the apatite barrier will contain additional details.

4.2.2.2 Tritium. The tritium plume has diminished since 1991 when effluent discharge to the 116-N-3 facility ceased. In CY07, only two wells (199-N-32 and 199-N-14) had concentrations exceeding the DWS (20,000 pCi/L). The maximum concentration was 23,000 pCi/L in spring 2007 at well 199-N-32, which is near the 116-N-3 facility. The table below lists the tritium concentrations in fall 2007 and the percentage change from fall 2006. Nearly all of the wells showed decreases in concentration. The shoreline aquifer tubes had very low or undetectable concentrations of tritium.

Well	Fall 2006 (pCi/L)	Fall 2007 (pCi/L)	% Change
199-N-2	18,400	17,000	-0.8
199-N-3	2,360 (Oct. 2006)	2,300/2,400	0%
199-N-14	20,400	20,000	-2%
199-N-27	16,800/17,300	14,000/15,000	-15%
199-N-32	25,300	21,000	-17%
199-N-46	1,780	1,500	-16%
199-N-50	10,000/9,470	9,570/8,900	-5%
199-N-51	8,120/8,220 (Oct. 2006)	6,400	-22%
199-N-64	13,300 (Oct. 2006)	11,000	-17%
199-N-67	19,900	15,000	-25%
199-N-70	15,600 (Oct. 2006)	15,000	-4%
199-N-75	14,600	16,000	10%
199-N-76	17,400	16,000	-8%
199-N-80	17,800	18,000	1%
199-N-81	18,000	16,000/16,000	-11%
199-N-92A	10,600	8,700	-18%
199-N-96A	3,320	1,600	-52%
199-N-99A	880	2,000	127%
199-N-103A	12,000	13,000	8%

Well	Fall 2006 (pCi/L)	Fall 2007 (pCi/L)	% Change
199-N-105A	18,700	15,000	-20%
199-N-106A	18,500	16,000	-14%
199-N-119	36.6 (U)	91 (U)	NC
199-N-120	188 (U)	130 (U)	NC
199-N-121	1,570	2,600	66%
199-N-122	1,890/1,780	1,200	-35%
199-N-123	1,960	75 (U)	NC

NOTES: Data from September unless otherwise noted. Duplicates shown with "/". Lightly shaded cells show wells with concentrations above the drinking water standard (20,000 pCi/L).
U = undetected
NC = not calculated because no tritium detected

4.2.2.3 Chromium. 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 FY07 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 concentration in the unconfined aquifer in FY07 was 33 µg/L in a filtered sample from well 199-N-64 in the central 100-N Area. The well is not located near any of the three major liquid waste sites. Chromium concentrations were even higher in this well in the 1990s, exceeding the DWS once. As with well 199-N-80, a down-hole video survey in 2000 showed screen corrosion, which is the probable cause of the elevated chromium.

4.2.2.4 Manganese. In CY07, manganese continued to exceed its secondary DWS (50 µg/L) in two wells affected by petroleum contamination: 199-N-16 (654 µg/L) and 199-N-18 (4,570 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 or aquifer sediment.

Manganese exceeded the secondary DWS in several wells near the apatite barrier (e.g., 199-N-122 and 199-N-147). The elevated metals are caused by reducing conditions associated with the treatment system. This is expected to be a transient effect.

4.2.2.5 Nitrate. Nitrate concentrations continued to exceed the DWS (45 mg/L as nitrate ion) in several wells in CY07. The highest concentrations continued to be in well 199-N-67 near the 116-N-1 facility, with a maximum concentration of 294 mg/L in spring 2007. The table below lists the concentrations in fall 2007 compared with fall 2006. The wells showing the largest percentage changes 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.

Well	Fall 2006 (mg/L)	Fall 2007 (mg/L)	% Change
199-N-2	70.4	77.9	10%
199-N-3	94.7 (Oct. 2006)	84.6/85.4	-11%
199-N-14	38.1	44	13%
199-N-16	11.1	12.8	13%
199-N-18	0.018	0.118	85%
199-N-21	76.1	62/60.6/57.5 (Oct. 2007)	-27%
199-N-27	35.1 (H)/37.2	35.5/33.8	-4%
199-N-32	85	75.3	-13%
199-N-46	14.6	5.2	-181%
199-N-67	168	175 (Q)	4%
199-N-70	27 (Oct. 2006)	28.6	6%
199-N-75	64.2	66	3%
199-N-76	47.8	50	4%
199-N-80	11.1	9.9 (Q)	-12%
199-N-81	39	39.4/40.1	3%
199-N-92A	19.5	16.8 (Q)	-16%
199-N-96A	23 (Oct. 2006)	16.4	-40%
199-N-99A	10.6	15 (Q)	29%
199-N-103A	39.8	36.3	-10%
199-N-105A	74.8	101	26%
199-N-106A	38.1	41.5	8%
199-N-119	7.5	3	-150%
199-N-120	5.8	5.5	-5%
199-N-121	12.8	30.3	58%
199-N-122	19.5	6.2	-215%
199-N-123	5.8	0.5	-1,060%

NOTES: Data from September unless otherwise noted. Duplicates shown with "/". Lightly shaded cells show wells with concentrations above the drinking water standard (45 mg/L).
H = holding time exceeded before sample analyzed
Q = associated with out-of-limits quality control data
U = undetected

4.2.2.6 Sulfate. None of the wells or aquifer tubes sampled for sulfate had CY07 concentrations above the 250 mg/L secondary DWS. The highest sulfate concentration in the 100-N Area in CY07 was 239 mg/L in well 199-N-59, located near the 120-N-1 percolation pond. Well 199-N-59 is not part of the interim action monitoring network.

Sulfate data are summarized in the following table for wells in near the 116-N-1 and 199-N-3 facilities. Shoreline wells are not included because the sulfate concentrations are low.

Well	Fall 2006 (mg/L)	Fall 2007 (mg/L)	% Change
199-N-2	55.2	58	5%
199-N-3	183 (Oct. 2006)	160 (N)/161 (N)	-14%
199-N-14	53	64	17%
199-N-21	102 (N)	105/106/99.5	2%
199-N-27	55.4/67.3	65.6/66	8%
199-N-32	61.2	63.3	3%
199-N-64	98.3 (Oct. 2006)	103	5%
199-N-67	62.1	59.8	-4%
199-N-75	70	80.4	13%
199-N-76	52	67.2	23%
199-N-81	64.4	65.3/65.5	1%
199-N-103A	95.6	63.6	-50%
199-N-105A	67 (C)	71.9	7%
199-N-106A	63.2 (C)	65.8	4%

NOTE: Data from September unless otherwise noted. Duplicates shown with "/".
C = analyte was detected in botht he sample and associated blank
N = spike sample outside control limits

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 TPH-diesel range was 630,000 mg/L in March 2003 (with an inch of free product). 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. The results varied widely: <0.13 mg/L, 26 mg/L, and 280 mg/L. A single sample collected in September 2007 had a reported result of 190 mg/L.

A passive treatment method to remove diesel from well 199-N-18 was deployed in October 2003. This 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 (i.e., acting as a sponge) while the device floats at the air/hydrocarbon/water interface. A bundle of four, 0.3-m (1-ft)-long cylinders of the material are lowered into the well to soak, after which the cylinders are removed, weighed, and replaced with a new pre-weighed bundle. The cylinders are changed every 2 months, when they are saturated with oil.

Evidence of low levels of hydrocarbon contamination have been observed in wells 199-N-3, 199-N-19, and 199-N-96A in the past (*Hanford Site Groundwater Monitoring for Fiscal Year 2002* [PNNL-14187]) but not in CY07. These wells are located near well 199-N-18 and may be influenced by contamination from the same source.

Smart Sponge™ is a trademark of AbTech Industries, Scottsdale, Arizona.

Total organic carbon concentrations were slightly elevated in shoreline wells 199-N-96A and 199-N-123. Concentrations ranged from undetected to 5,300 µg/L in CY07.

Petroleum hydrocarbons have been detected in some of the 100-N Area aquifer tubes. Appendix D of *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 a small oil sheen during installation of these tubes in January 2007.

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 up to 7.2 mg/L in FY07, which is slightly lower than the previous year.

4.3 QUALITY CONTROL

Field QC results for 100-NR-2 including field 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. The CY07 highlights of the QC data for 100-N Area sampling are summarized below. Tables showing the complete QC results are provided in Appendix G.

The EPA guideline (EPA/540/R-94/083) for field duplicates is ±20%. Only field duplicates with at least one result greater than five times the MDL or MDA are evaluated. A summary of evaluated field duplicates with RPDs >20% is provided in the table below. Of the 78 field replicate pairs of data evaluated, 97.4% were within acceptable limits. One of the field duplicates reported for chromium was slightly above the acceptance criteria of 20% (23.9%). In addition, one of the 10 duplicates for gross beta was also >20% (44.7). These results are not anticipated to affect the usability of 100-N Area sampling data. A complete list of field duplicates performed is provided in Appendix G.

Summary of Field Duplicates Exceeding Quality Control Limits

Constituent	Number of Duplicates	Number Evaluated	Number >20% RPD	Percent >20% RPD	Range of RPDs >20%
Chromium	6	1	1	100.00	23.9
Gross beta	10	9	1	11.11	44.7

While there are no EPA functional guidelines for the performance of laboratory split samples, results are typically evaluated against the criteria of precision within 20%. Only split samples where results are greater than five times the MDL or MDA at both laboratories were evaluated. A summary of split samples with RPDs >20% is provided in the table below. Of the 60 split sample pairs evaluated, 88.3% were within acceptable limits. The TPH (both diesel and gasoline range) showed extremely poor precision (160.9% to 200%). Due to the extreme variability in the data, it should be considered as suspect for the 100-N Area. These methods will be evaluated by S&GRP staff to determine if further corrective actions are needed. In addition, oil and grease,

sulfate, and zinc also had poor precision. The oil and grease precision was investigated, however no cause was identified for the poor precision. Other than TPH, the issues appear to be isolated incidents and are not expected to affect the usability of the 100-N Area data. The complete list of split samples performed is provided in Appendix G.

Summary of Split Samples Exceeding Quality Control Limits

Constituent	Number of Split Samples	Number Evaluated	Number Splits >20% RPD	Percent >20% RPD	Range of RPDs >20%
Oil and grease	1	1	1	100.00	148.2
Total petroleum hydrocarbons - diesel range	5	4	1	25.00	195.7
Total petroleum hydrocarbons - gasoline range	3	3	3	100.00	160.9 to 200.0
Sulfate	1	1	1	100.00	66.9
Zinc	5	1	1	100.00	27.5

For most chemical constituents, field trip blank results above two times the MDL 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 MDL. Metals are evaluated against two times the MDL. Radiological data are evaluated against two times the total MDA. The table below summarizes the blanks that exceed the QC criteria. Of the 280 results for blanks, 95% were within acceptance criteria. Most of the 14 out-of-limit results (80%) are associated with metals analysis at the WSCF, which were flagged as "C" by the laboratory, denoting that contamination was also found in the laboratory blank. This appears to be a laboratory contamination issue. Low-level metals data, which are "Q" qualified for contamination in the blank, should be treated as suspect. In addition, chloride, nitrogen in nitrate, and methylene chloride showed levels of contamination above the acceptance criteria. The chloride and nitrogen in nitrate levels of contamination are not expected to adversely affect the usability of 100-N Area data, as the levels are typically below the levels of concern for this area. Methylene chloride is a common laboratory contaminant, and it is anticipated that this contamination was introduced at the laboratory. A complete list of the field trip blanks is provided in Appendix G.

Summary of Out-of-Limit Field Trip Blanks

Constituent	Number of Blanks	Number Out-of-Limit	Percent Out-of-Limit	Range of Out-of-Limit Results
Chloride	7	1	14.29	109 µg/L
Nitrogen in nitrate	7	1	14.29	125 µg/L
Calcium	6	1	16.67	133 µg/L
Chromium	6	1	16.67	13.4 µg/L
Cobalt	6	1	16.67	12 µg/L

Constituent	Number of Blanks	Number Out-of-Limit	Percent Out-of-Limit	Range of Out-of-Limit Results
Magnesium	6	2	33.33	21.1 to 35 µg/L
Nickel	6	1	16.67	10.5 µg/L
Silver	6	2	33.33	15.3 µg/L
Sodium	6	1	16.67	98.7 µg/L
Zinc	6	2	33.33	11.2 to 15.2 µg/L
Methylene chloride	2	1	50.00	24 µg/L

In conclusion, most of the QC for the 100-N Area sampling was within acceptance criteria. Metals methods at the WSCF have already been evaluated and corrective actions appear to be effective (see the discussion on 100-HR-3 QC results for more information). Future anion data are being closely monitored by S&GRP staff to ensure data quality. Corrective actions are not anticipated at this time, and no adverse impact to 100-N Area anions data is expected. With few exceptions, all other data meets the expectations of the QC program, and QC indicates that the groundwater monitoring data are reliable and defensible.

4.4 CONCLUSIONS

- **RAO #1:** Maintain beneficial uses of the Columbia River and aquifer by reducing contaminant concentrations in the 100-NR-2 groundwater. Its goal was 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 starting March 9, 2006, when the pumps were shut off. The results of this 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 the peak values observed in the late 1980s and late 1990s. The reason for the recent 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.
  - Strontium-90 concentrations in some aquifer tubes temporarily rose in August 2007 in response to apatite barrier emplacement.
  - 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 90-m (295.3-ft) apatite PRB near the Columbia River shoreline in 2006 and 2007. This technology and others, including pump-and-treat, will be evaluated and presented to the Washington State Department of Ecology in a proposed plan by August 2008.

- **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.

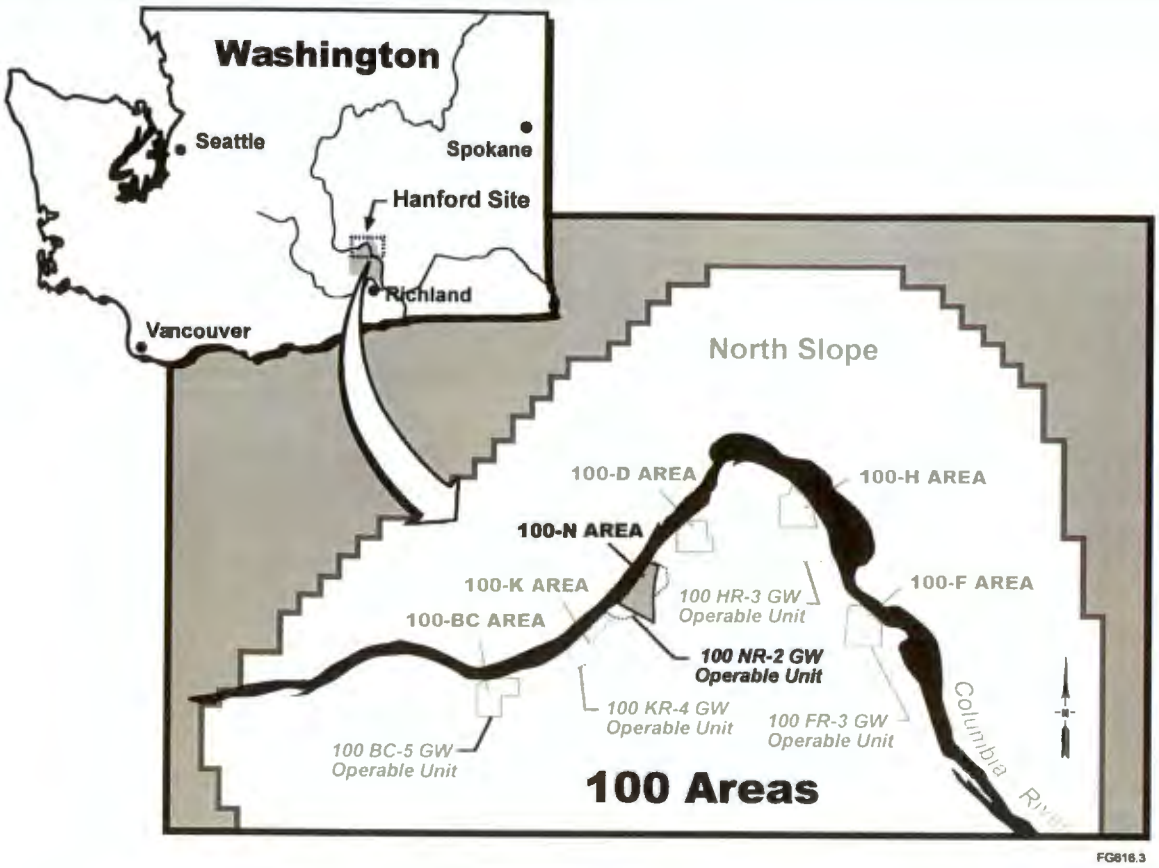
  The effectiveness of institutional controls established in the interim action ROD for 100-NR-2 (EPA et al. 1999) was evaluated and summarized for implementation and effectiveness in 2003. The *2004 Final Institutional Controls (IC) Assessment Report* (DOE/RL-2004-56) presents the results for the current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

4.5 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.
- Two years have passed since extraction wells were placed in cold-standby status, so frequent monitoring for rebound is no longer required. The frequency of monitoring former extraction wells should be decreased from quarterly 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 constituents.

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



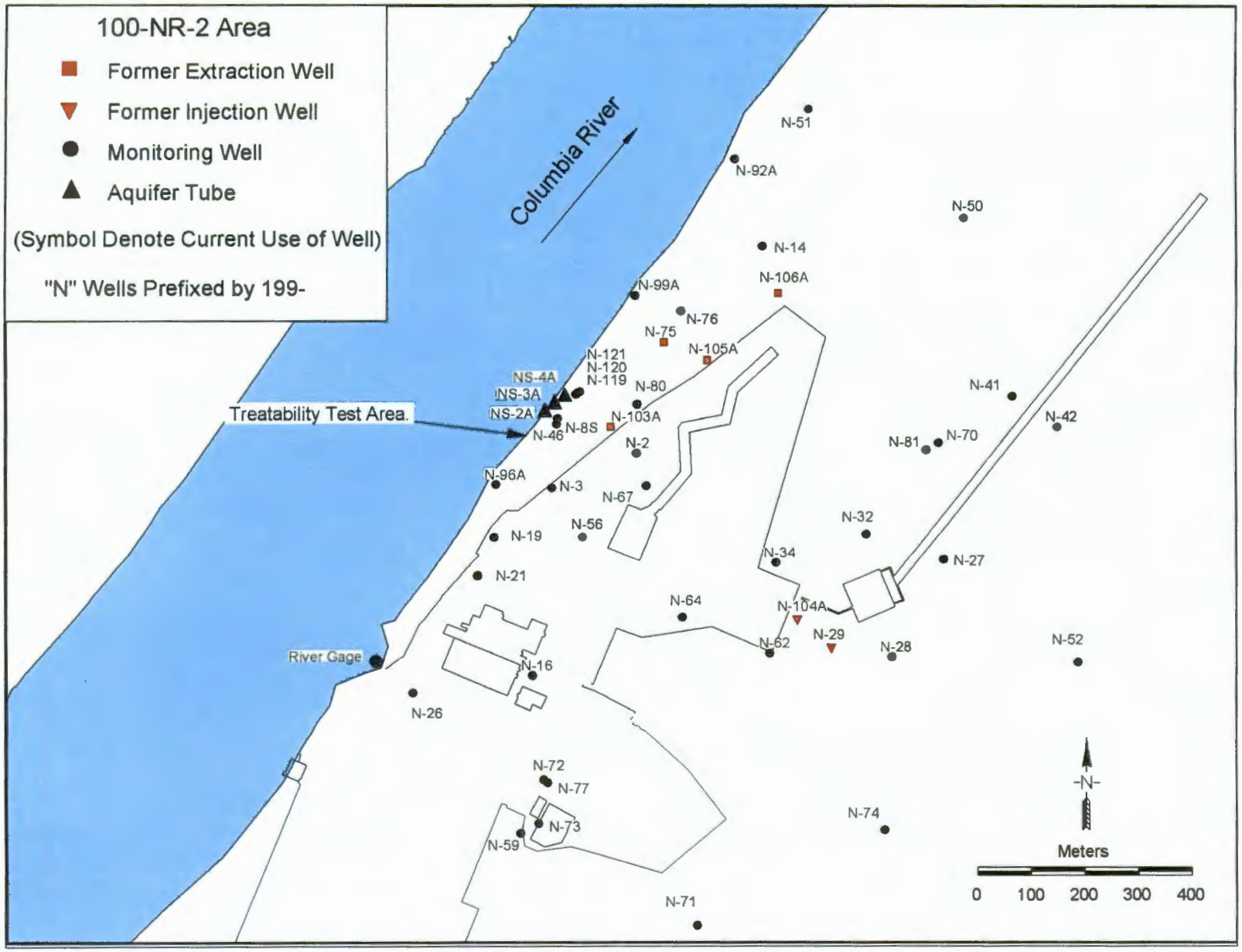


Figure 4-2. 100-NR-2 Operable Unit Wells. (2 sheets)

Figure 4-2. 100 NR 2 Operable Unit, Treatability Wells. (2 sheets)

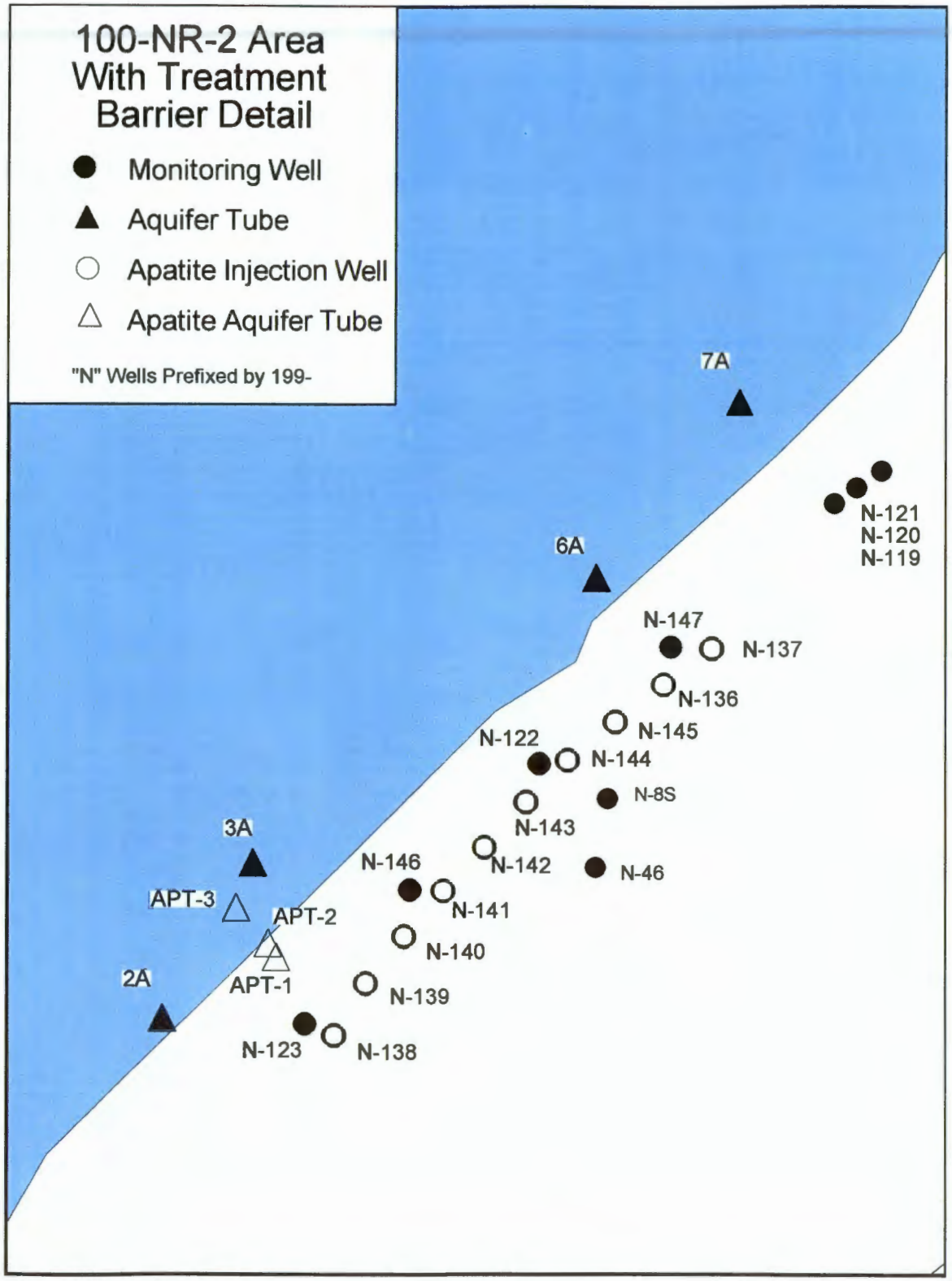


Figure 4-3. 100-N Area Water Table, March 2006 and 2007.

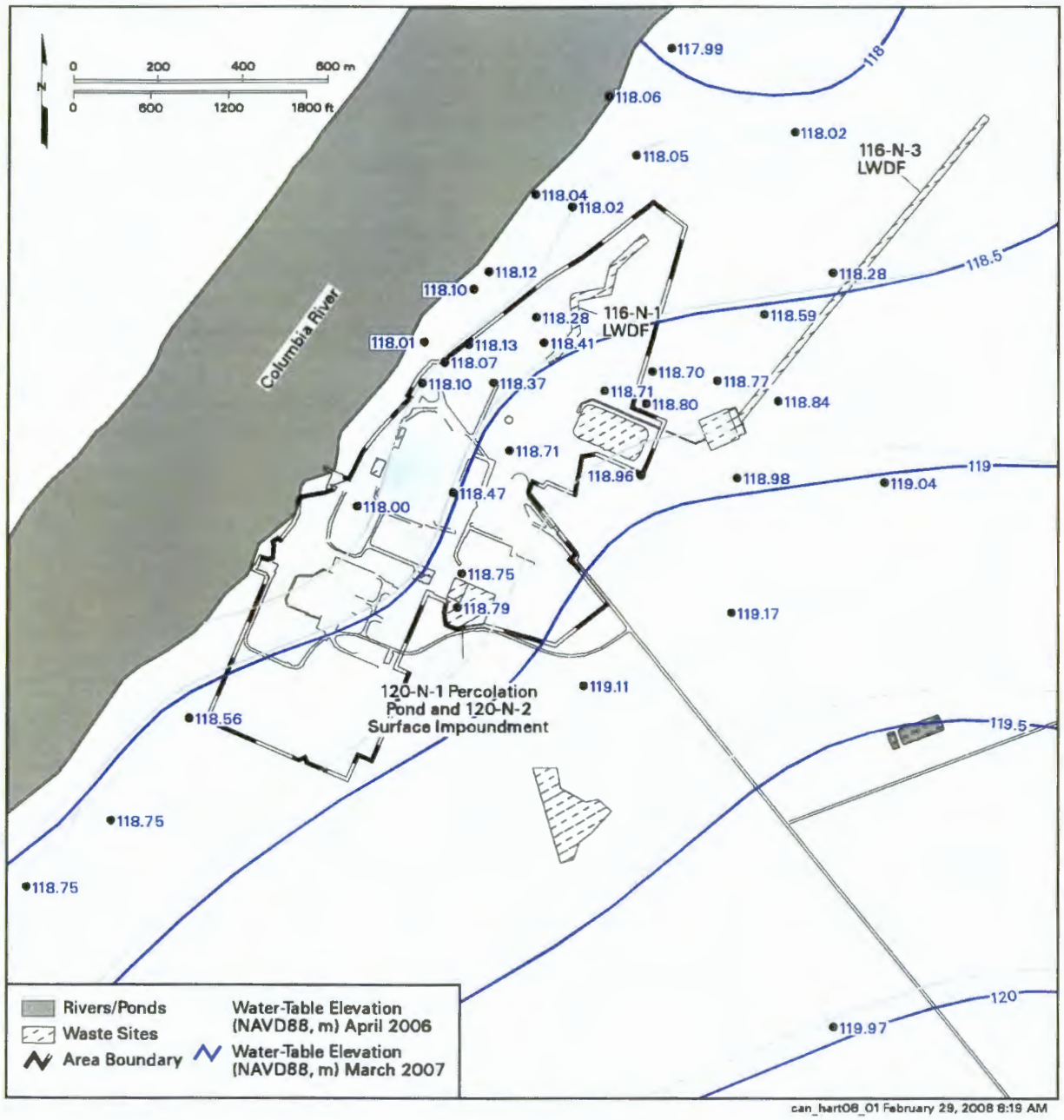


Figure 4-4. Elevation of Columbia River at 100-N Area
(Daily Average of Hourly Measurements).

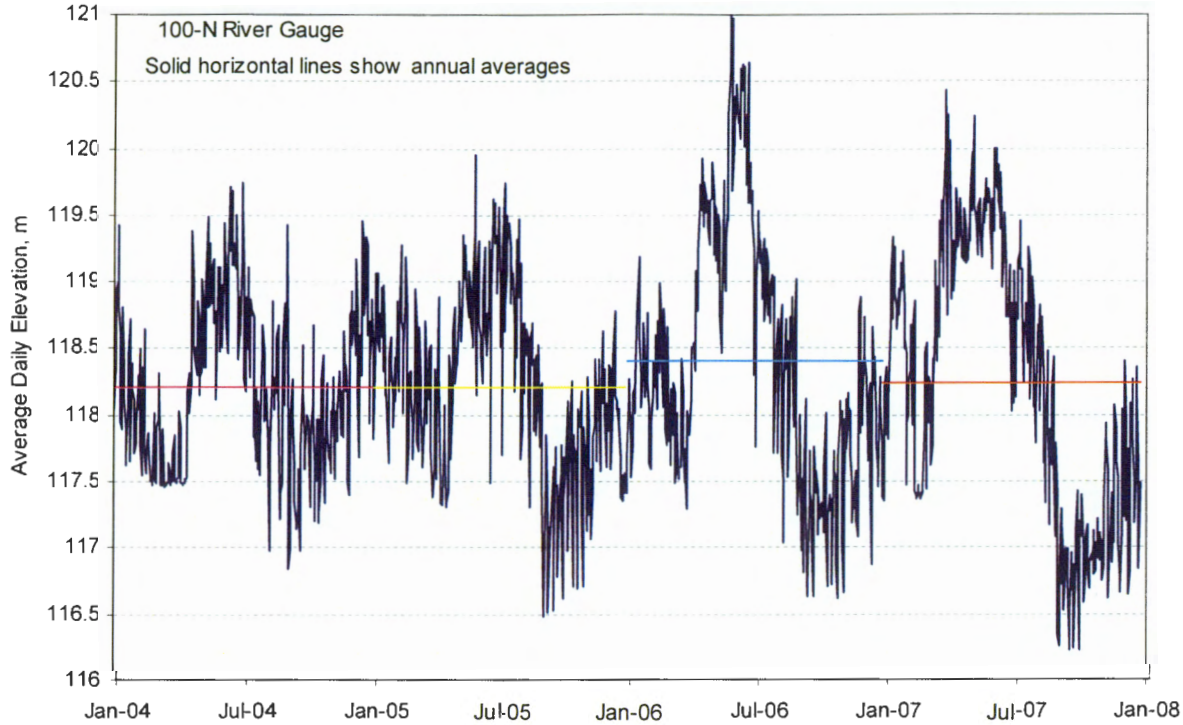
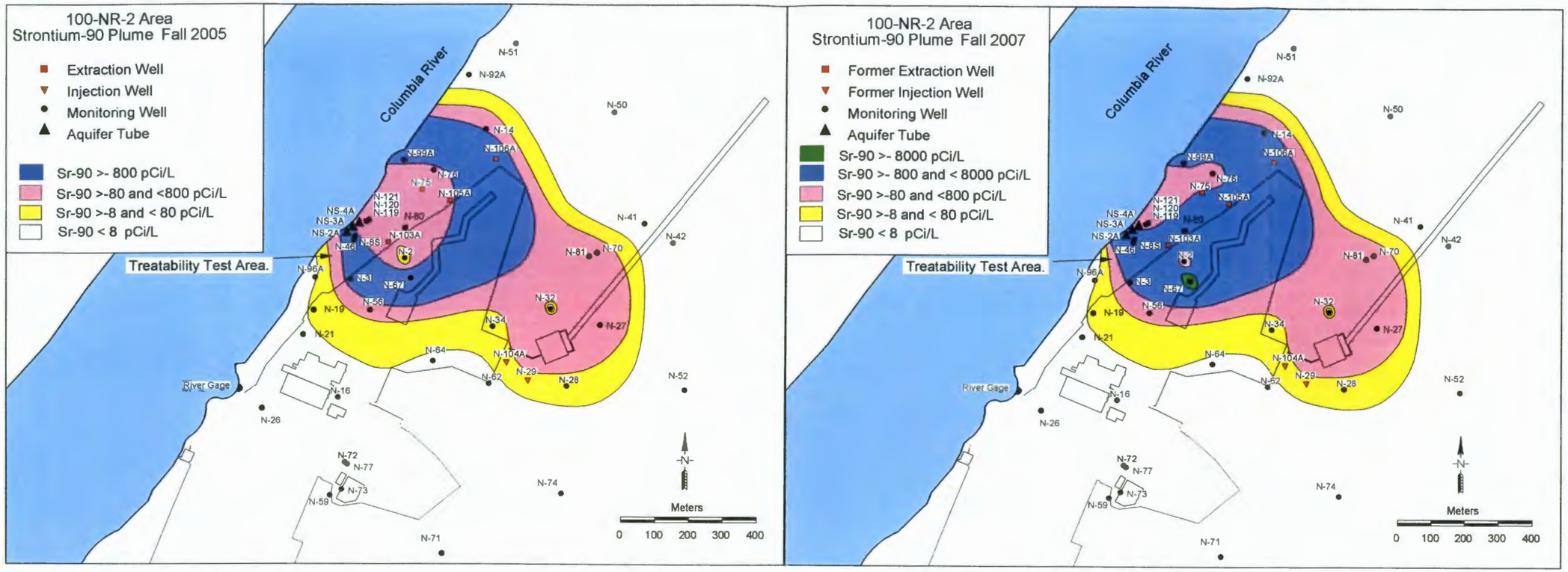
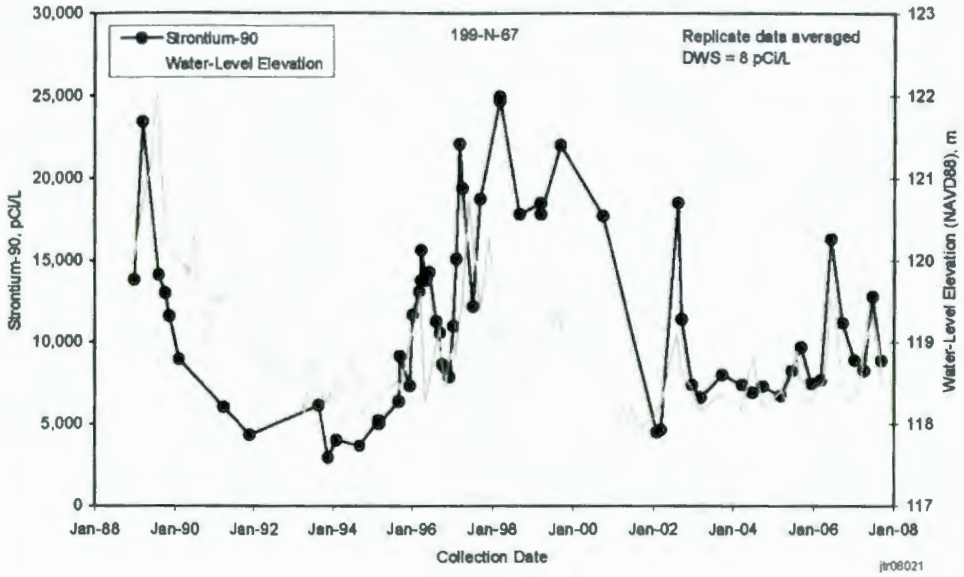


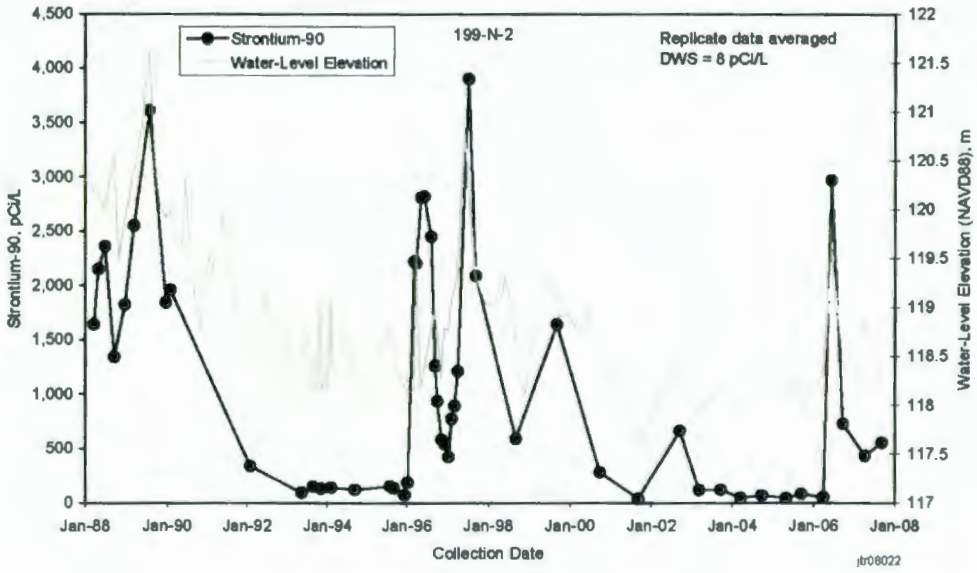
Figure 4-5. Average Strontium-90 Concentrations in 100-N Area, 2005 and 2007.



NOTE: This figure modified from *100 Area Shoreline Monitoring Plan* (PNNL-15798) and *Hanford Site Groundwater Monitoring for Fiscal Year 2007* (DOE/RL-2008-01).

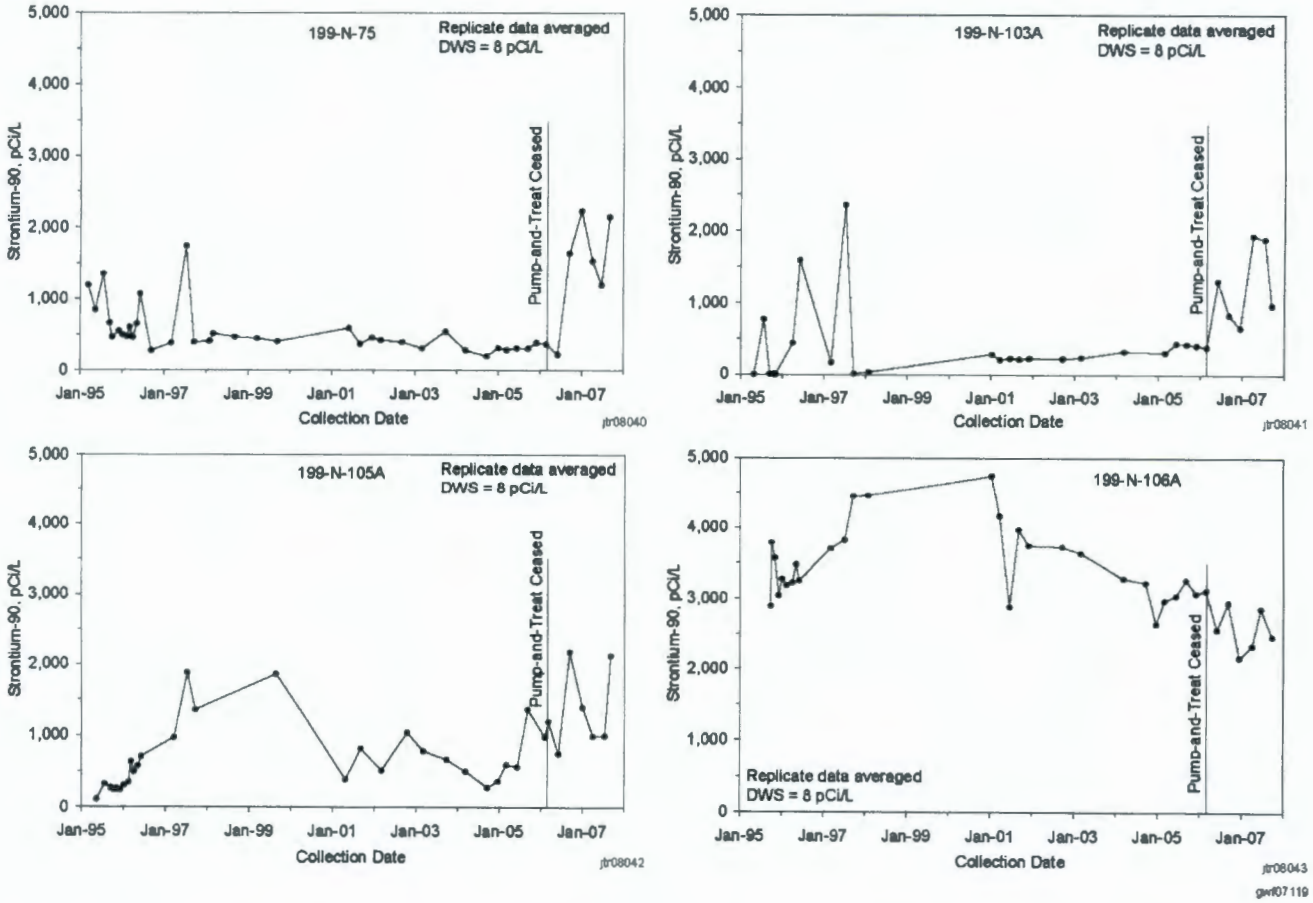
Figure 4-6. Strontium-90 Concentrations and Water Levels in Wells 199-N-2 and 199-N-67.





NOTE: This figure adapted from *Hanford Site Groundwater Monitoring for Fiscal Year 2008* (DOE/RL-2008-01.

Figure 4-7. Strontium-90 Concentrations in Former Extraction Wells in 100-N Area.



NOTE: This figure adapted from *Hanford Site Groundwater Monitoring for Fiscal Year 2008* (DOE/RL-2008-01.

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 FH's 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).
- **Waste management:** Includes the cost for the management of spent resin at 100-HR-3 and 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 FY07. A comparison between FY06 and FY07 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 FY07 are significantly lower when compared to FY06. The lower costs can be attributed to the completion of reconfiguration and system modification activities conducted in FY06. 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 (42.5%), waste management (27.2%), performance monitoring (13.7%), project support (10.8), and design (5.8%). Based on the total FY07 cost ($1,597,900), the yearly production rate of 315.4 million L (83.3 million gal), and 21.5 kg of hexavalent chromium removed, the annual treatment costs equate to $0.005/L, or $74/g of hexavalent chromium removed. These treatment costs are lower than FY06 treatment costs of $81/g of hexavalent chromium removed.

The cost breakdown for the DR-5 pump-and-treat system is presented in Figure 5-2. The total FY07 construction and operation costs are $938,700, which are less than the $1,351,600 reported for FY06. The FY07 cost breakdown indicates that the majority of the cost was for operations and maintenance (57.7%), followed (in decreasing order) by project support (25.6%), design

(10.7%), waste management (4.8%), and performance monitoring (1.2%). Based on the total FY07 cost of $938,700, the yearly production rate of 79.3 million L (20.9 million gal), and 53.9 kg of hexavalent chromium removed, the annual treatment costs equate to $0.012/L, or $17.00/g, of hexavalent chromium removed.

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 FY06, the total construction and operations costs were higher in FY07. The higher costs can be attributed to the design modifications to the pump-and-treat system, associated construction of new wells and processing of waste. 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 (47.5%), operations (18.1%), project support (11.0%), waste management (10.3%), performance monitoring (8.9%), and design (4.2%). Based on the FY07 cost ($4,449,800), the yearly production rate of 315.4 million L (83.3 million gal), and 21.7 kg of hexavalent chromium removed, the annual treatment costs equate to $0.014/L, or $204/g of hexavalent chromium removed. These treatment costs are higher than the FY06 treatment costs of $203/g of hexavalent chromium removed.

The cost breakdown for the first year of the KW Reactor pump-and-treat system is presented in Figure 5-4. The total FY07 construction and operation costs are $3,137,200. The FY07 cost breakdown indicates that the majority of the cost was for treatment system capital construction (69.7%), followed (in decreasing order) by waste management (12.9%), operations and maintenance (12.8%), design (0.4%), and performance monitoring (0.3%). Based on the total FY07 cost of $3,137,200, the yearly production rate of 172.5 million L (45.5 million gal), and 21.1 kg of hexavalent chromium removed, the annual treatment costs equate to $0.018/L, or $149/g, of hexavalent chromium removed.

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 ($385,800) 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 that is presented in the FY06 summary of costs. As shown in Figure 5-5, the cost breakdown indicates that the majority of the costs (in decreasing order) are charged to operations (51.8%), project support (20.7%), performance monitoring (16.3%), and waste management (11.2).

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

Cost Breakdown for 100-HR-3 Pump-and-Treat Construction and Operations										
Description	**Actual Costs (Dollars x 1,000)**									
	1998	**1999**	**2000**	**2001[a]**	**2002[b]**	**2003**	**2004**	**2005**	**2006**	**2007**
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	264.9	265.3	276.7	225.8	309.3	229.8	211.8	722.6	697.6	171.9
Operations and maintenance	1,533.3	1,650.8	799.1	739.2	816.6	733.7	1,049.5	618.5	891.2	679.6
Performance monitoring	0.4	--	173.7	219.9	120	163.2	120.3	353	489.6	219.5
Waste management	--	--	895.3	424.9	720.1	877.2	501.7	202.2	217.6	434.7[c]
Totals	**$1,799**	**$1,916**	**$2,202**	**$1,671**	**$2,732**	**$2,012**	**$2,576**	**$2,102.4**	**$2,351**	**$1,597.9**

[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 2007 Cost Breakdown (by Percentage)

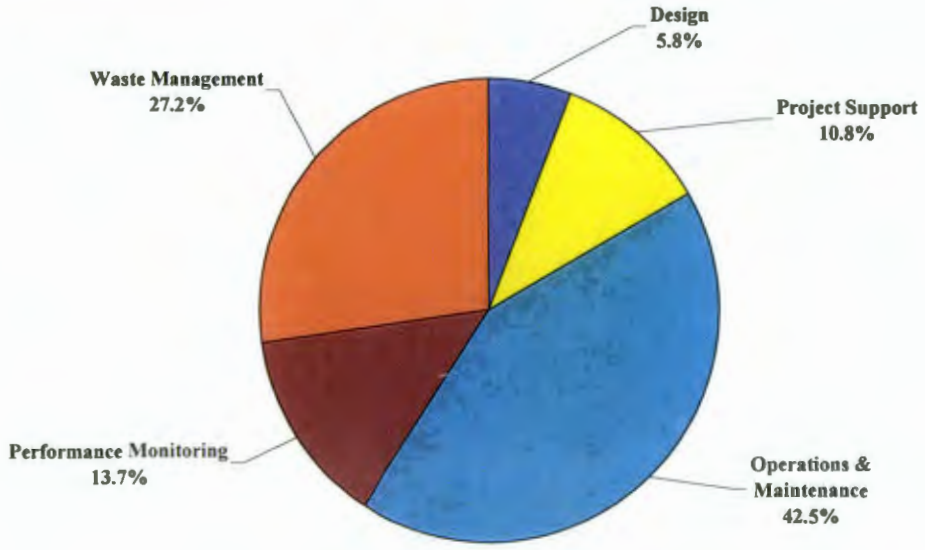


Figure 5-1. 100-HR-3 Pump-and-Treat System Costs. (2 sheets)

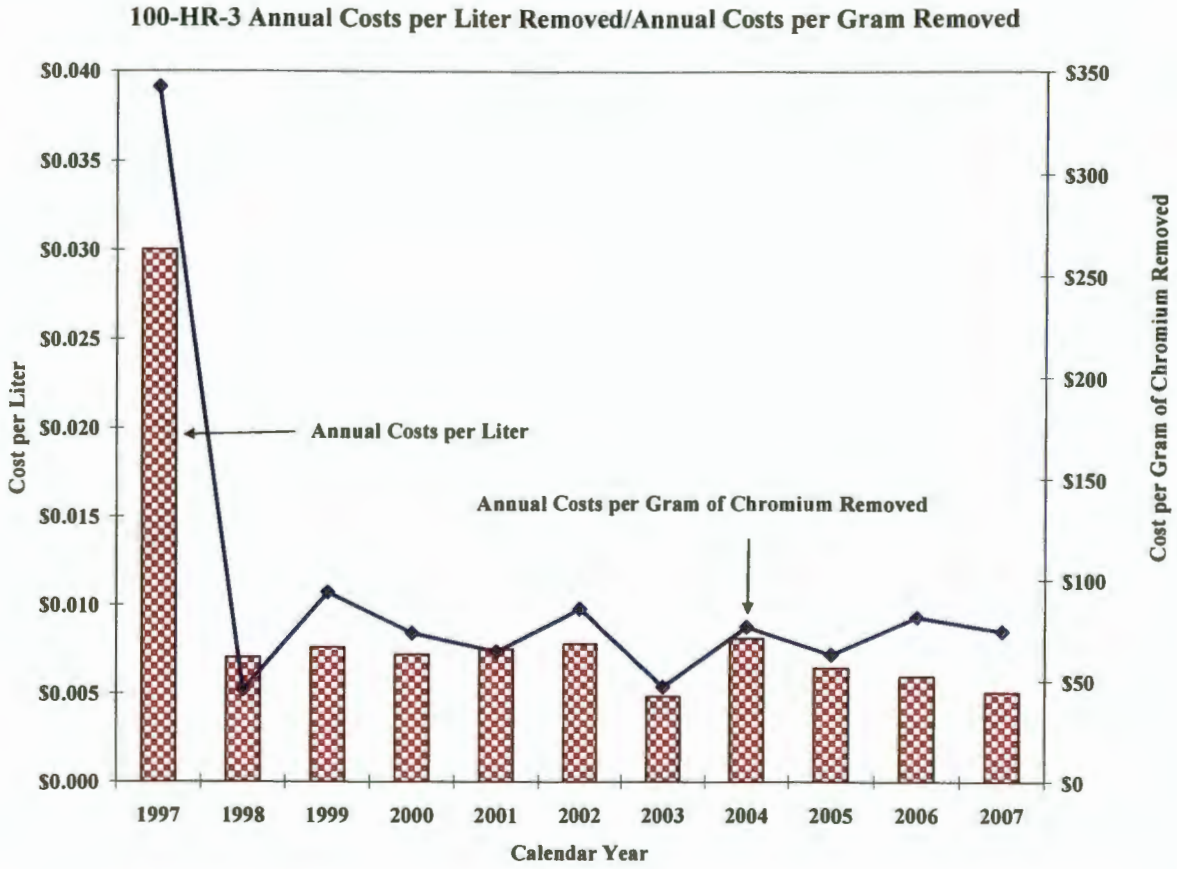


Figure 5-2. DR-5 Pump-and-Treat System Costs. (2 sheets)

Cost Breakdown for DR-5 Pump-and-Treat Construction and Operations				
Description	**Actual Costs (Dollars x 1,000)**			
	2004	**2005**	**2006**	**2007**
Design	244	246.9	196.8	100.4
Treatment system capital construction	1,620.3		22.2	
Project support	175.1	586.4	370.6	240.3
Operations and maintenance	48.3	459.6	605.7	541.3
Performance monitoring	1.7	106.2	1.6	11.3
Waste management	.7	28.3	154.7	45.4
Totals	**$2,090.1**	**$1427.4**	**$1,351.6**	**$938.7**

DR-5 Pump-and-Treat System, Fiscal Year 2007 Cost Breakdown (by Percentage)

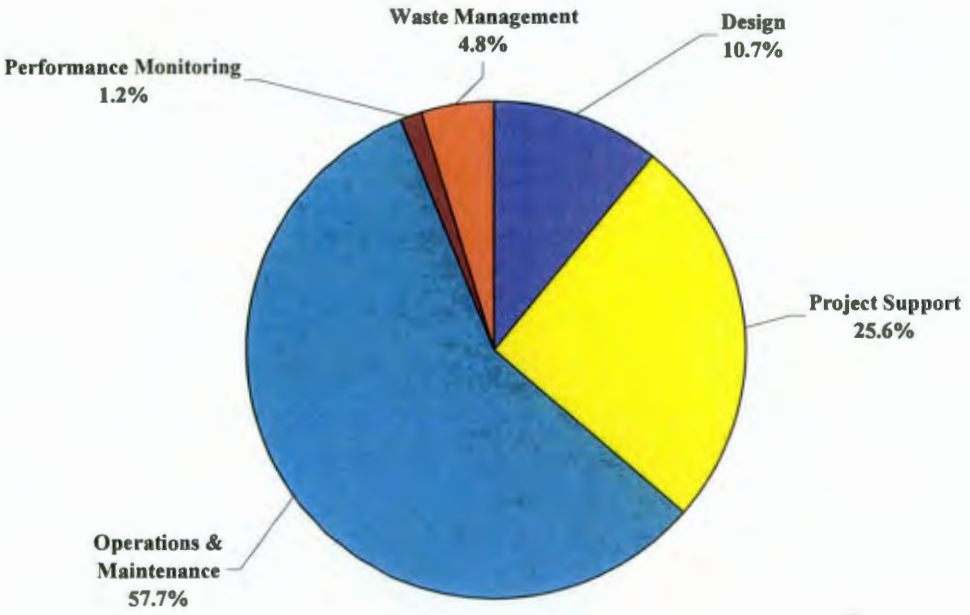


Figure 5-2. DR-5 Pump-and-Treat System Costs. (2 sheets)

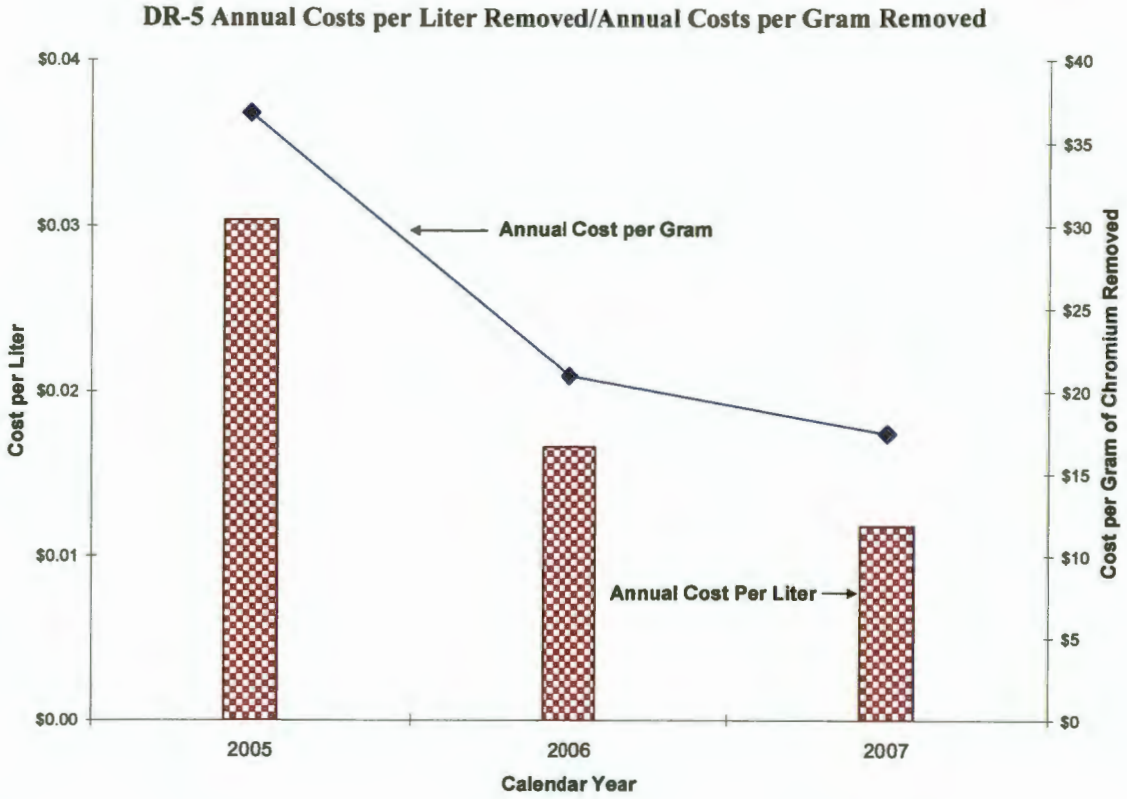


Figure 5-3. 100-KR-4 Pump-and-Treat System Costs. (2 sheets)

Cost Breakdown for 100-KR-4 Pump-and-Treat Construction and Operations										
Description	Actual Costs(Dollars x 1,000)									
	1998	1999	2000	2001[a]	2002[b]	2003	2004	2005	2006	2007
Design	85.4	0.2	--	96.5	55.2	70.8	163.9	190.8	97.8	187.0[c]
Treatment system capital construction	--	--	109.1	(0.1)	860.1	379.9	94.2	273.8	1,505.8	2,114.1[d]
Project support	208.4	157.2	143.0	188.2	257.8	171.0	211.8	851.9	530.5	489.8
Operations and maintenance	1,028.9	717.4	538.0	578.6	771.9	789.7	1,118.2	878.6	1,350.8	804.3
Performance monitoring	1.4	--	111.2	122.6	124.6	119.7	83.3	446.3	548.8	395.7
Waste management	--	--	481.8	367.5	343.3	684.7	475.8	198.3	230.2	458.9[e]
Totals	**$1,324**	**$875**	**$1,383**	**$1,353**	**$2,413**	**$2,216**	**$2,147**	**$2,839.7**	**$4,263.9**	**$4,449.8**

[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 2007 Cost Breakdown (by Percentage)

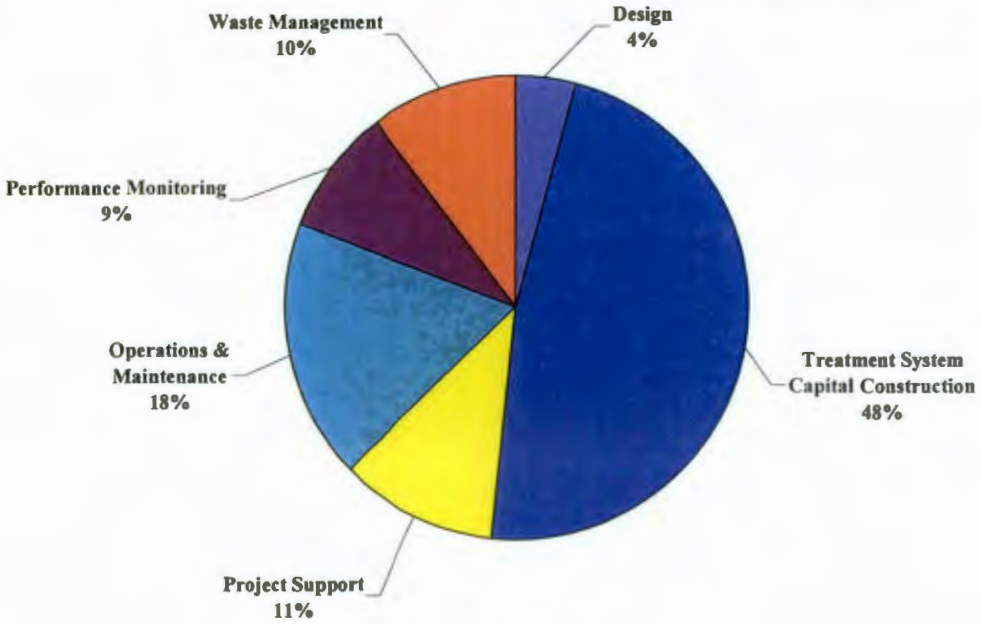


Figure 5-3. 100-KR-4 Pump-and Treat System Costs. (2 sheets)

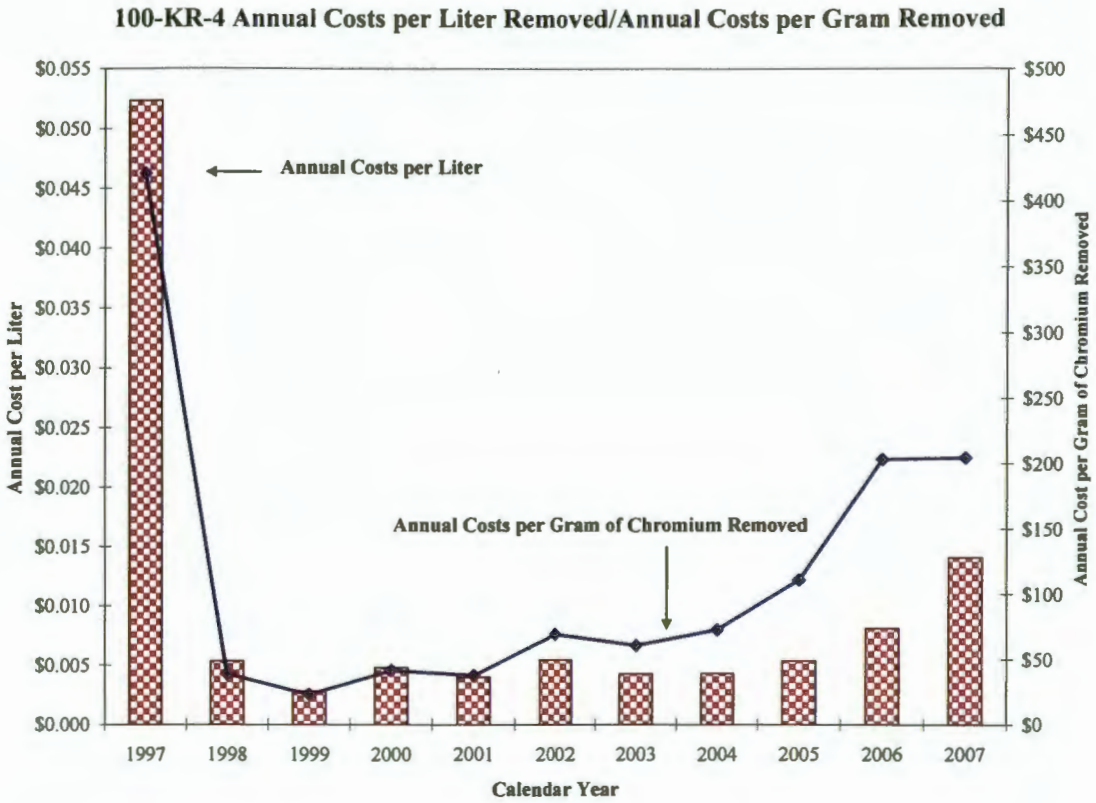


Figure 5-4. KW Reactor Pump-and-Treat System Costs. (2 sheets)

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

KW Reactor Pump-and-Treat System, Fiscal Year 2007 Cost Breakdown (by Percentage)

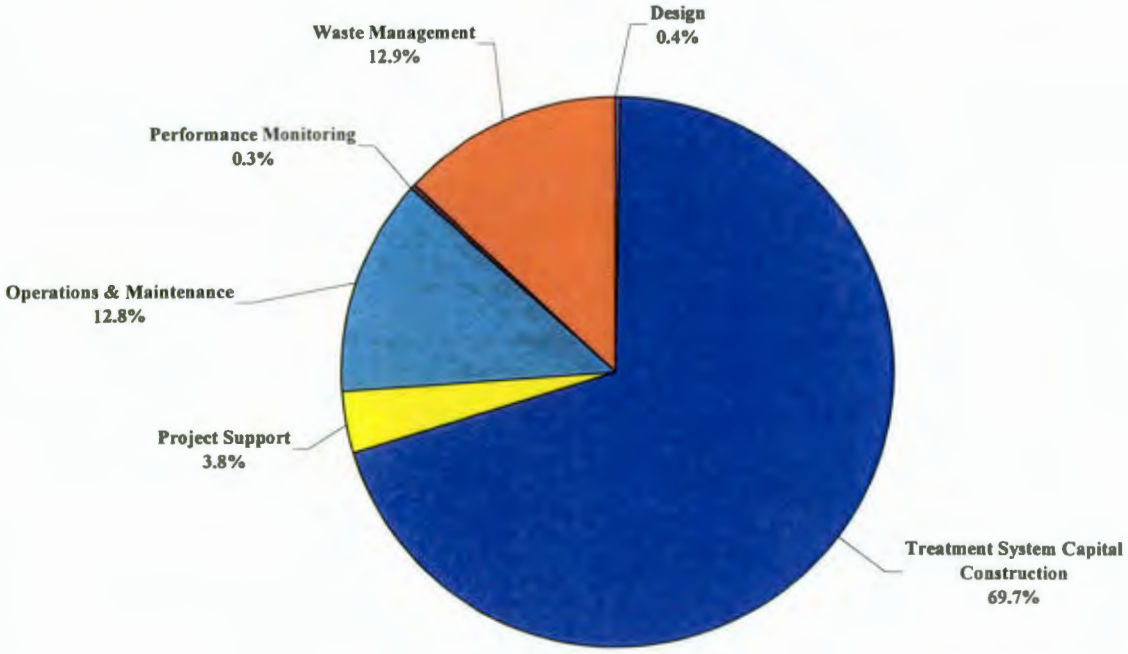


Figure 5-4. KW Reactor Pump-and-Treat System Costs. (2 sheets)

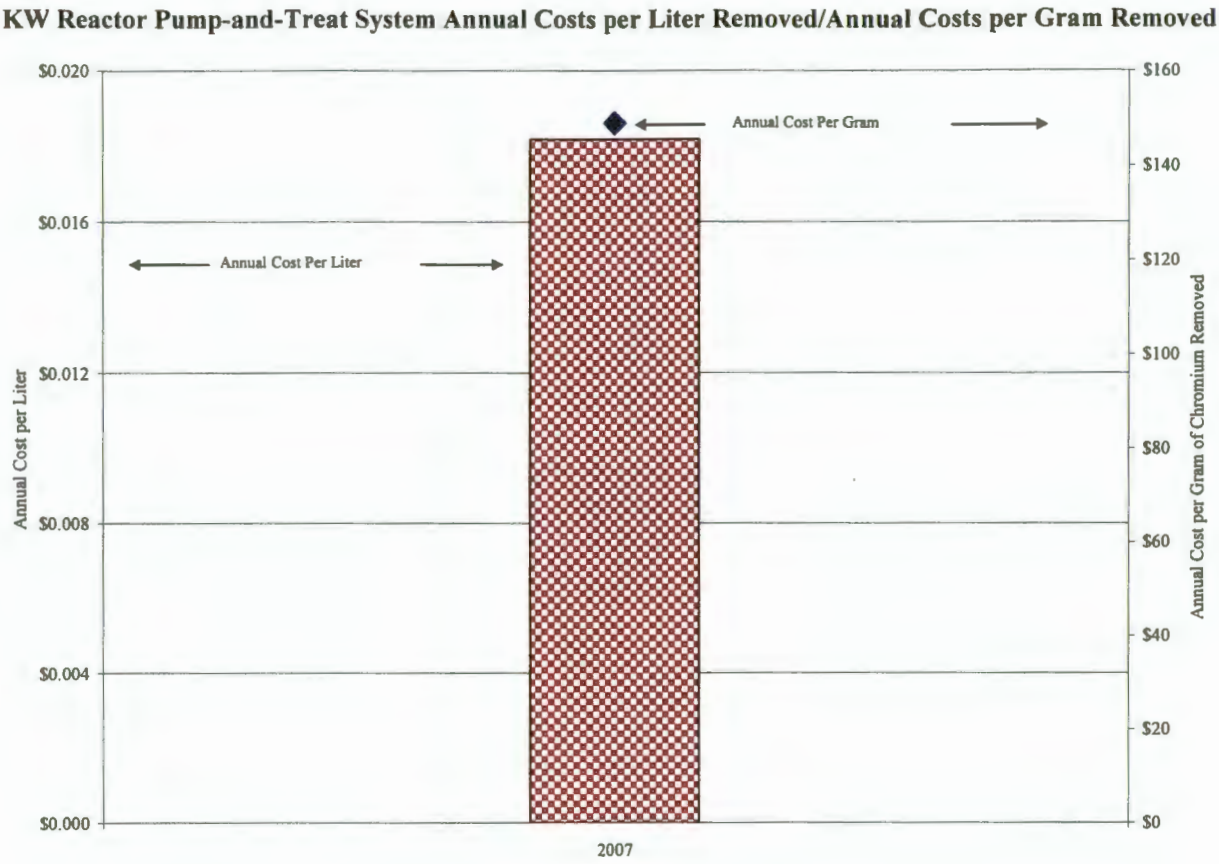
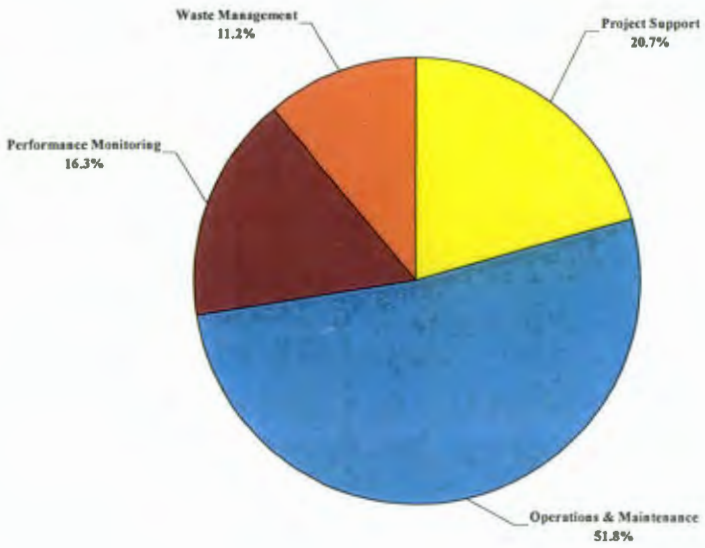


Figure 5-5. 100-NR-2 Pump-and Treat System Costs. (2 sheets)

Cost Breakdown for 100-NR-2 Pump-and-Treat Construction and Operations										
Description	**Actual Costs (Dollars x 1,000)**									
	1998	**1999**	**2000**	**2001[a]**	**2002[b]**	**2003**	**2004**	**2005**	**2006**	**2007**
Design	32.6	0.2	--	--	--	--	--	447.9	--	--
Treatment system capital construction	-	--	--	--	--	--	--	161.9	922.6	--
Project support	136.0	113.1	96.3	183.5	219.4	133.0	329.7	416.5	284.4	79.8
Operations and maintenance	425.2	657.4	462.2	631.5	631.8	604.3	553.0	650.6	592.6	199.9
Performance monitoring	--	--	82.6	83.1	72.4	51.6	79.6	408.7	182.2	62.7
Waste management	--	--	131.6	112.5	100	45.4	27.4	7.6	13.0	43.4
Field studies	--	--	--	--	--	--	--	--	--	--
Barrier maintenance	--	--	--	--	--	--	--	--	--	--
Totals	**$594**	**$771**	**$773**	**$1,011**	**$1,024**	**$834**	**$989.7**	**$2,093.2**	**$1,994.8**	**$385.8**

[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 2007 Cost Breakdown (by Percentage)



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