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Revision 0

Supplement to the 100-HR-3 and 100-KR-4 Remedial Design Report and Remedial Action Workplan for the Expansion of the 100-KR-4 Pump-and-Treat System

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

United States Department of Energy
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Richland, Washington 99352

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LIST OF TERMS

Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
ERDF	Environmental Restoration Disposal Facility
FH	Fluor Hanford, Inc.
gpm	gallons per minute
GTS	groundwater treatment system
HEIS	Hanford Environmental Information System
HMI	human/machine interface
IX	ion exchange
OIC	operator interface control
OU	operable unit
PLC	programmable logic controller
QAPjP	quality assurance project plan
QC	quality control
ROD	Record of Decision
RAO	remedial action objective
RDR/RAWP	remedial design report/remedial action work plan
TCLP	toxicity characteristic leaching procedure
WAC	*Washington Administrative Code*
WSCF	Waste Sampling and Characterization Facility

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METRIC CONVERSION CHART

Into Metric Units

If You Know	*Multiply By*	*To Get*
Length		
inches	25.4	millimeters
inches	2.54	centimeters
feet	0.305	meters
yards	0.914	meters
miles	1.609	kilometers
Area		
sq. inches	6.452	sq. centimeters
sq. feet	0.093	sq. meters
sq. yards	0.836	sq. meters
sq. miles	2.6	sq. kilometers
acres	0.405	hectares
Mass (weight)		
ounces	28.35	grams
pounds	0.454	kilograms
ton	0.907	metric ton
Volume		
teaspoons	5	milliliters
tablespoons	15	milliliters
fluid ounces	30	milliliters
cups	0.24	liters
pints	0.47	liters
quarts	0.95	liters
gallons	3.8	liters
cubic feet	0.028	cubic meters
cubic yards	0.765	cubic meters
Temperature		
Fahrenheit	subtract 32, then multiply by 5/9	Celsius
Radioactivity		
picocuries	37	millibecquerel

Out of Metric Units

If You Know	*Multiply By*	*To Get*
Length		
millimeters	0.039	inches
centimeters	0.394	inches
meters	3.281	feet
meters	1.094	yards
kilometers	0.621	miles
Area		
sq. centimeters	0.155	sq. inches
sq. meters	10.76	sq. feet
sq. meters	1.196	sq. yards
sq. kilometers	0.4	sq. miles
hectares	2.47	acres
Mass (weight)		
grams	0.035	ounces
kilograms	2.205	pounds
metric ton	1.102	ton
Volume		
milliliters	0.033	fluid ounces
liters	2.1	pints
liters	1.057	quarts
liters	0.264	gallons
cubic meters	35.315	cubic feet
cubic meters	1.308	cubic yards
Temperature		
Celsius	multiply by 9/5, then add 32	Fahrenheit
Radioactivity		
millibecquerels	0.027	picocuries

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1.0 INTRODUCTION

1.1 PURPOSE OF EXPANSION

This supplement to the *Remedial Design and Remedial Action Work Plan for the 100-HR-3 and 100-KR-4 Groundwater Operable Units' Interim Action* (DOE/RL-96-84) supports the expansion of the pump-and-treat system remediating the hexavalent chromium plume associated with the 116-K-2 Trench (Figure 1-1). The *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) defines the regulatory performance criteria for cleanup of the chromium plume in the 100-KR-4 Operable Unit (OU). This expansion implementation will satisfy the requirement of *The Second CERCLA Five Year Review Report for the Hanford Site* (DOE/RL-2006-20) (Action Item 5-1). The expansion design described in this document may require modification if actual field conditions, especially plume extent and aquifer parameters, are significantly different than assumed conditions, subject to EPA approval.

The original 100-KR-4 pump-and-treat design was to remediate the hexavalent chromium plume downgradient of the 116-K-2 Trench (also known as the Mile-Long Trench). The design included six extraction wells and four injection wells. This supplemental report will provide hydrogeologic background and engineering requirements to support the expanded remedial action for the chromium plume near the 116-K-2 Trench. A separate remedial design report/remedial action work plan (RDR/RAWP) supplement was prepared to address the chromium plume downgradient of the KW Reactor (DOE/RL-2006-52, Rev. 1). The quality assurance project plan (QAPjP) has been updated and is included as Appendix A.

The goals of the 100-KR-4 pump-and-treat system expansion are as follows:

- Control the northward migration of the chromium plume before it reaches the 100-NR-2 OU
- Protect the Columbia River by removing high-concentration areas and eliminate gaps in coverage between extraction wells
- Remediate the remainder of the 116-K-2 Trench chromium plume to below the remedial action objective (RAO).

To accomplish the remediation goals for the Mile-Long Trench area, the plan is to install an ion-exchange (IX) system that will have an initial treatment capacity of 1,135.6 L/min (300 gallons per minute [gpm]) with the ability to increase the capacity to 2,271.2 L/min (600 gpm). The actual system operational capacity will depend on aquifer conditions.

As defined in the Record of Decision (ROD) (EPA et al. 1996), the purpose of this remedial action is to address groundwater contamination that may pose ecological threats. The pump-and-treat system to be implemented will achieve three RAOs, as identified in the interim action ROD:

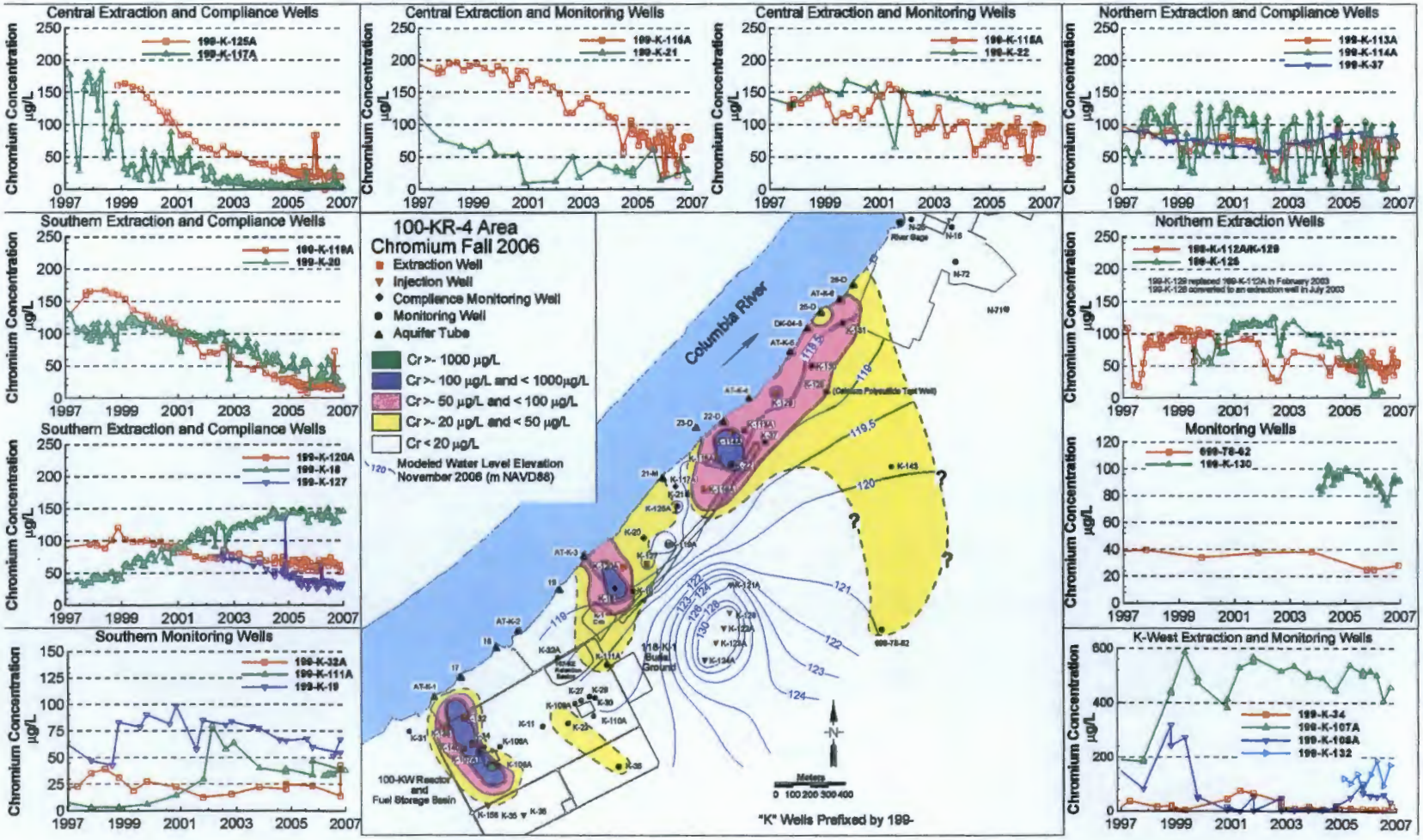
- Provide protection of aquatic receptors in the river bottom substrate from contaminants in ground water entering the Columbia River
- Provide protection of human health by preventing exposure to contaminants in the groundwater
- Provide information that will lead to the final remedy.

1.2 MODIFICATIONS TO THE 100-KR-4 PUMP-AND-TREAT NETWORK SINCE 1997

The 100-KR-4 pump-and-treat network of wells has been modified as follows since the start of operations in 1997:

- 1998: Extraction well 199-K-125A replaced extraction well 199-K-118A, which had been plagued with heavy silt in-flow and had never operated properly.
- 1999: Added compliance well 199-K-126 to monitor movement of the plume toward the 100-N Area.
- 2002: Extraction well 199-K-127 was added to improve capture between existing extractions wells 199-K-119A and 199-K-120A.
- 2003: Compliance well 199-K-126 was converted to an extraction well, monitoring well 199-K-130 was added to monitor chromium approaching 100-NR-2, and extraction well 199-K-112A was replaced with extraction well 199-K-129.
- 2004: Converted compliance well 199-K-114A to an extraction well to improve capture where chromium concentrations were high in aquifer sampling tubes 22 and 23. Added monitoring well 199-K-114A to monitor chromium closer to the 100-NR-2 area. Added aquifer sampling tubes AT-K-1 through AT-K-6.
- 2005: Utilized extraction well 199-K-126 in a calcium polysulfide treatability test.
- 2006: Installed monitoring well 199-K-143 to provide a sampling point to assess the inland extent of the hexavalent chromium plume between former extraction well 199-K-126 and monitoring well 699-78-62. The fall 2006 chromium concentration in this well was about 20 µg/L, and the data confirmed the feasibility of the proposed injection well locations for the upcoming pump-and-treat system expansion.

Figure 1-1. 2006 Hexavalent Chromium Plume, 100-KR-4.



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2.0 UPDATED CONCEPTUAL MODEL FOR THE 100-KR-4 HEXAVALENT CHROMIUM PLUME

This section discusses the updated conceptual model for the chromium plume targeted by the expanded 100-KR-4 pump-and-treat system.

2.1 SOURCES OF HEXAVALENT CHROMIUM IN GROUNDWATER

Raw Columbia River water was treated extensively with flocculants to remove parent elements so they would not form radioisotopes when the treated water passed through the reactors and was irradiated. However, sodium dichromate dehydrate, $Na_2Cr_2O_7 \cdot 2H_2O$, was added to reactor coolant water as a rust inhibitor starting at a concentration of approximately 1.8 mg/L. When the chromium was irradiated, the radioisotope chromium-51 was formed. This isotope has a half-life of about 27.7 days, and concentrations were not reduced when the coolant water was moved to retention basins for an hour or less before disposal to the Columbia River. To reduce the amount of chromium-51 in effluent, the amount of sodium dichromate added during raw water processing was decreased from 1.8 mg/L to 1.0 mg/L in 1961 and to 0.5 mg/L in 1968 for selected reactors (DUN-1968). In 1968, the 12-month daily release average of chromium-51 was approximately 750 Ci/day in the 100-K Area.

The 116-K-2 Trench received about 300 billion L (79 billion gal) of hexavalent chromium contaminated water from the KE and KW Reactor floor drains and from the KE and KW retention basins from 1955 through 1971 (PNL-6456). The trench reportedly received about 300,000 kg of dissolved sodium dichromate; therefore, the dissolved dichromate concentration averages to about 1 mg/L. The trench is oriented parallel to and approximately 250 m (820 ft) from the Columbia River.

2.2 RADIONUCLIDES DISPOSED TO THE 116-K-2 TRENCH

Radioactive liquid wastes were also disposed to the 116-K-2 Trench, resulting in a total estimated 1977 inventory of about 2,100 Ci of radionuclides (UNI-946). Many of the isotopes in the Mile-Long Trench's radionuclides inventory have moderate-length half-lives (e.g., europium-152, which has a half-life of about 13 years, composes about 50% of the radionuclide inventory, followed by europium-154 with a half-life of 8.8 years, cesium-137 with a half-life of 30 years, and nickel-63 with a half-life of 100 years).

2.3 100-K AREA HYDROGEOLOGY

The stratigraphic unit with the greatest impact on the design of the pump-and-treat system is Unit E of the Ringold Formation, which contains the uppermost unconfined aquifer in the 100-K Area. The current average depth to groundwater ranges from less than 7.6 m (25 ft) in well 199-K-18 located near the Columbia River to about 23 m (76 ft) inland well 699-78-62 (Table 2-1).

The Ringold Unit E is underlain by fine-grained paloesols and overbank deposits, the Ringold Upper Mud (WHC-SD-EN-TI-112). Below the top of the Ringold Upper Mud, the aquifer appears to be at least semi-confined, based on water levels measured in adjacent wells 199-K-32A and 199-K-32B located downgradient of the KE Reactor (Figure 2-1).

The Ringold Upper Mud Unit appears to form a ridge on the inland side of the 116-K-2 Trench from the existing injection wells north to the river, through the downstream end of the trench (Figure 2-2). The top of the Ringold Upper Mud directly affects the saturated thickness of the Ringold Unit E, as shown in Figure 2-2. Where the top of the Ringold Upper Mud is highest, the saturated Ringold Unit E is thinnest. The Hanford formation overlies the Ringold Unit E at elevations above about 130 m (425 ft), as shown on Figures 2-3 and 2-4, which include a geologic cross-section parallel to the Columbia River and also sections normal to the river through the west and east ends of the 100-KR-4 pump-and-treat area. Cross-section locations are displayed in Figure 2-2. Table 2-2 contains a summary of available well development data for wells in the 116-K-2 Trench area.

2.4 100-K AREA HEXAVALENT CHROMIUM PLUME DISTRIBUTION AND INTERPRETATION

The target chromium plume for the original 100-KR-4 pump-and-treat system is displayed in Figure 2-5. The plume was believed to be limited to the area downgradient of the 116-K-2 Trench based on existing wells. The original 1997 extraction and injection well fields are also displayed in Figure 2-5.

Sample results from more recently installed monitoring wells have resulted in the interpretation of the chromium distribution shown in Figure 2-6 (i.e., the June 2007 100-KR-4 hexavalent chromium plume).

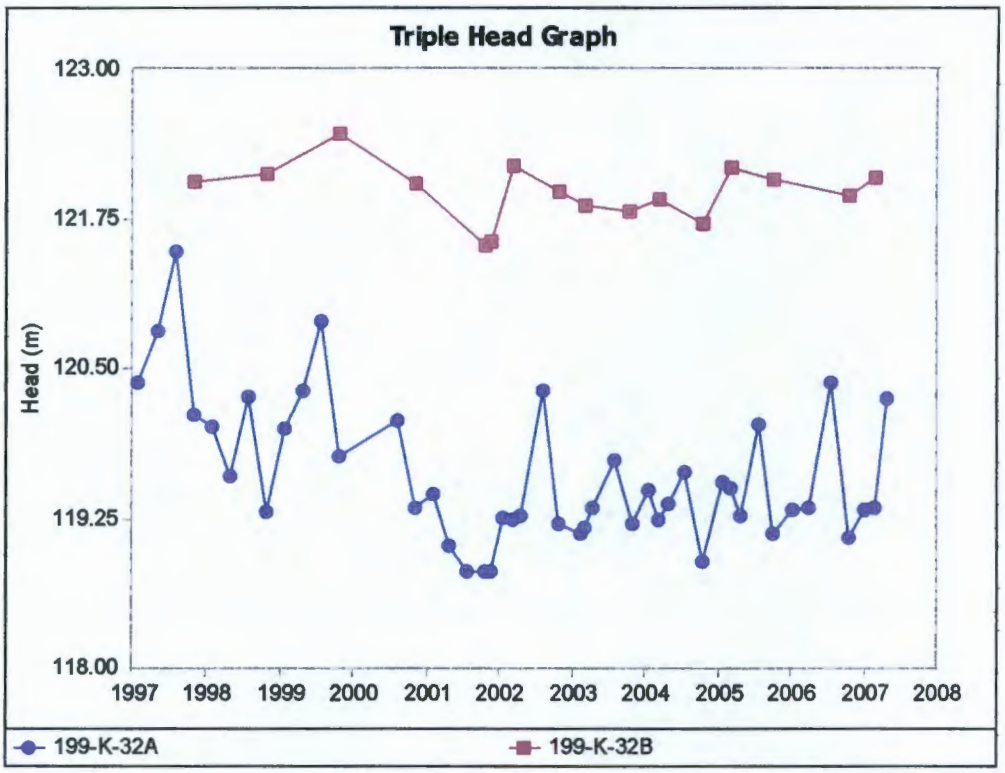
The highest historic hexavalent chromium concentrations in pump-and-treat extraction or monitoring wells have been about 200 µg/L. If sodium dichromate were added to raw water at a concentration of 0.5 to 1.0 mg/L during the 1960's (DUN-4847), the range of maximum resultant hexavalent chromium concentration would be 176 to 352 µg/L. Therefore, it is reasonable to attribute the historic plume concentrations to sodium dichromate added to raw water as a rust inhibitor and not a continuing source of highly concentrated sodium dichromate.

Most extraction wells in the existing 100-KR-4 pump-and-treat area were constructed with fully penetrating screens with lengths that varied from about 6 to 21 m (20 to 70 ft). Compliance monitoring well 199-K-117A was sampled at four depths below the water table from January 1998 through December 2002 to attempt to determine the vertical distribution of hexavalent chromium. The well was sampled on a monthly basis with a Kabis™ sampler at the following depths below ground surface: 9.1, 12.2, 16.5, and 19.5 m (30, 40, 54, and 64 ft). When the Columbia River stage was low, the 9.1-m (30-ft) sample sometimes could not be collected or was collected slightly deeper.

Hexavalent chromium concentrations for 2002, the last year that well 199-K-117A was sampled at multiple depths, are presented in Table 2-3, as well as sample depth and specific conductance. There appears to be some increase with depth for some sampling events but not for others. For example, the shallowest sample (9.1 m [30 ft]) in April 2002 had the highest hexavalent chromium concentration and the highest specific conductance reading. The depth-discrete sampling was discontinued at the end of 2002 because it appeared that, there was no clear correlation between depth and concentration.

Kabis™ is a trademark of Sibak Industries Limited, Inc., San Marcos, California.

Figure 2-1. Hydrographs of Wells 199-K-32A (Shallow) and 100-K-32B (Deep).



NOTES:

1. Well 199-K-32A is screened 45 to 65 ft below ground surface in the Ringold Unit E uppermost unconfined aquifer.
2. Well 199-K-32B is screened 157 to 167 ft below ground surface in the first producing horizon below the top of the Ringold Upper Mud Unit.

Figure 2-2. Elevation – Top of Ringold Upper Mud and Saturated Thickness Ringold Unit E.

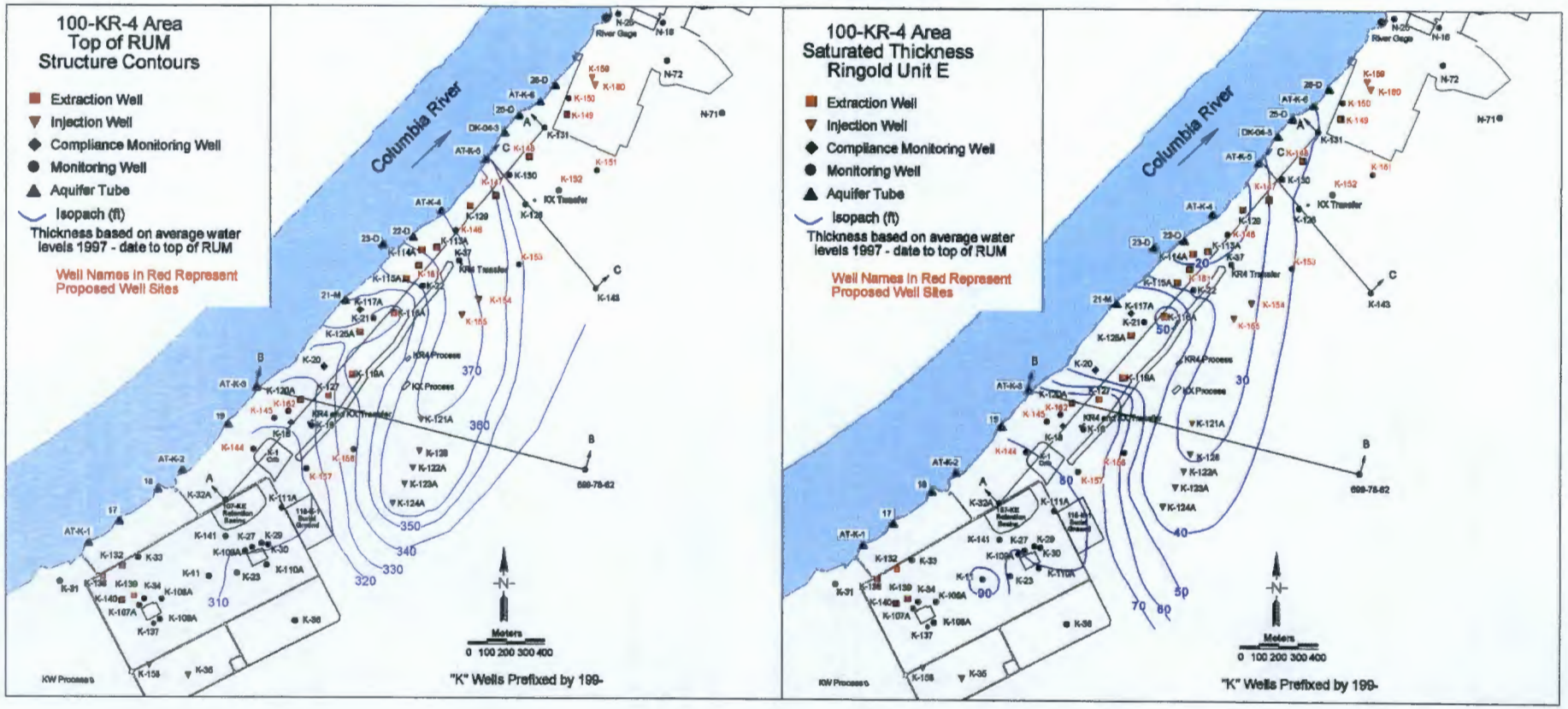


Figure 2-3. Section A-A' Along the Columbia River – View Northwest.

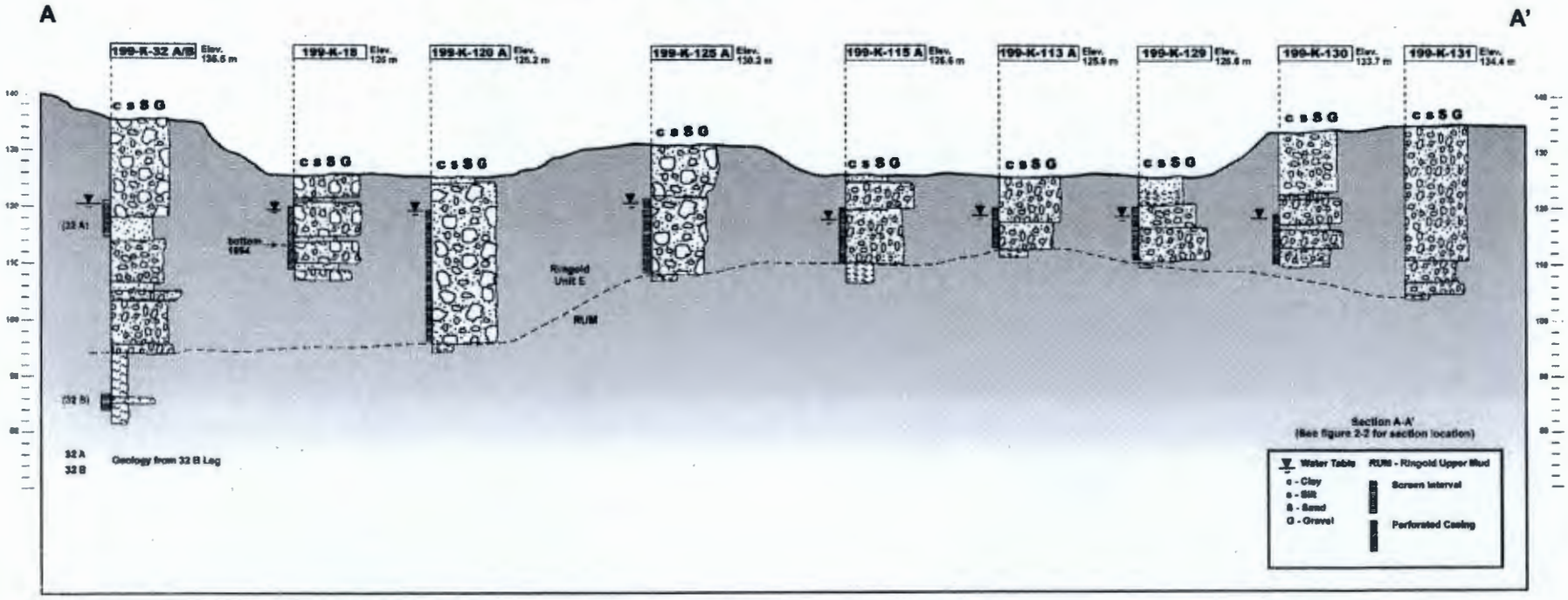


Figure 2-4. Section B-B' and C-C' Through 100-KR-4 Area, View Northeast.

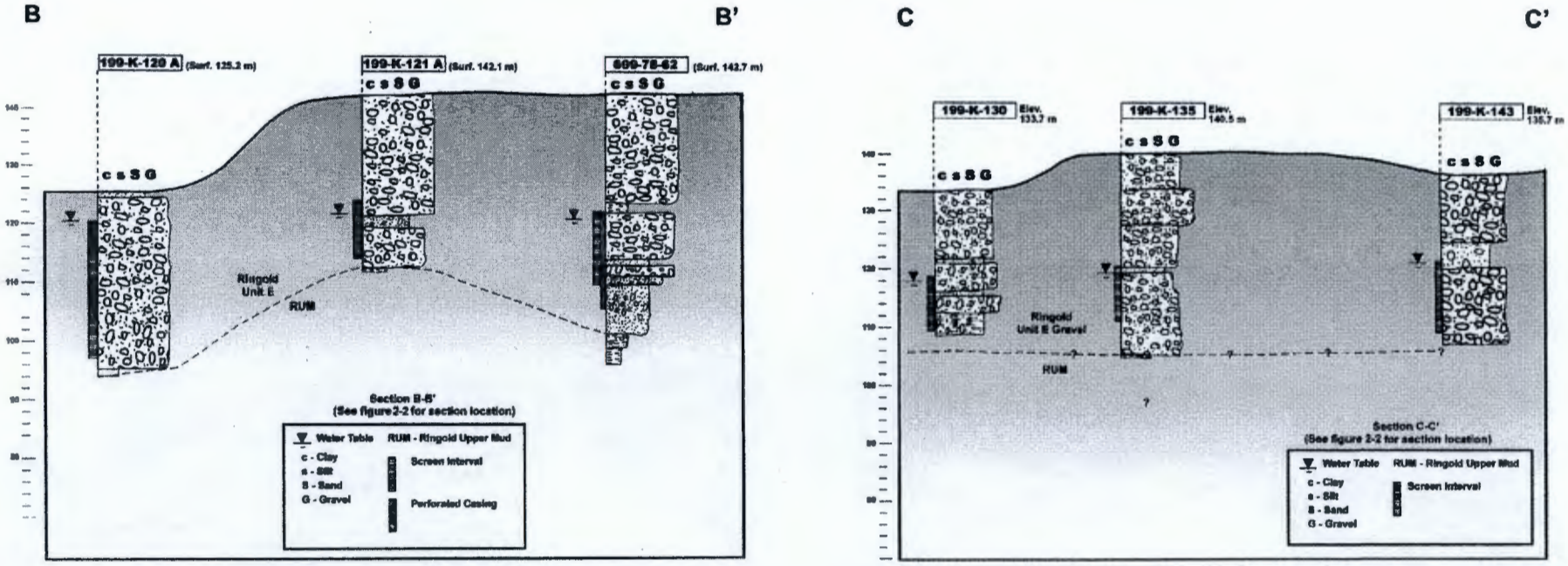


Figure 2-5. 1997 100-KR-4 Target Chromium Plume.

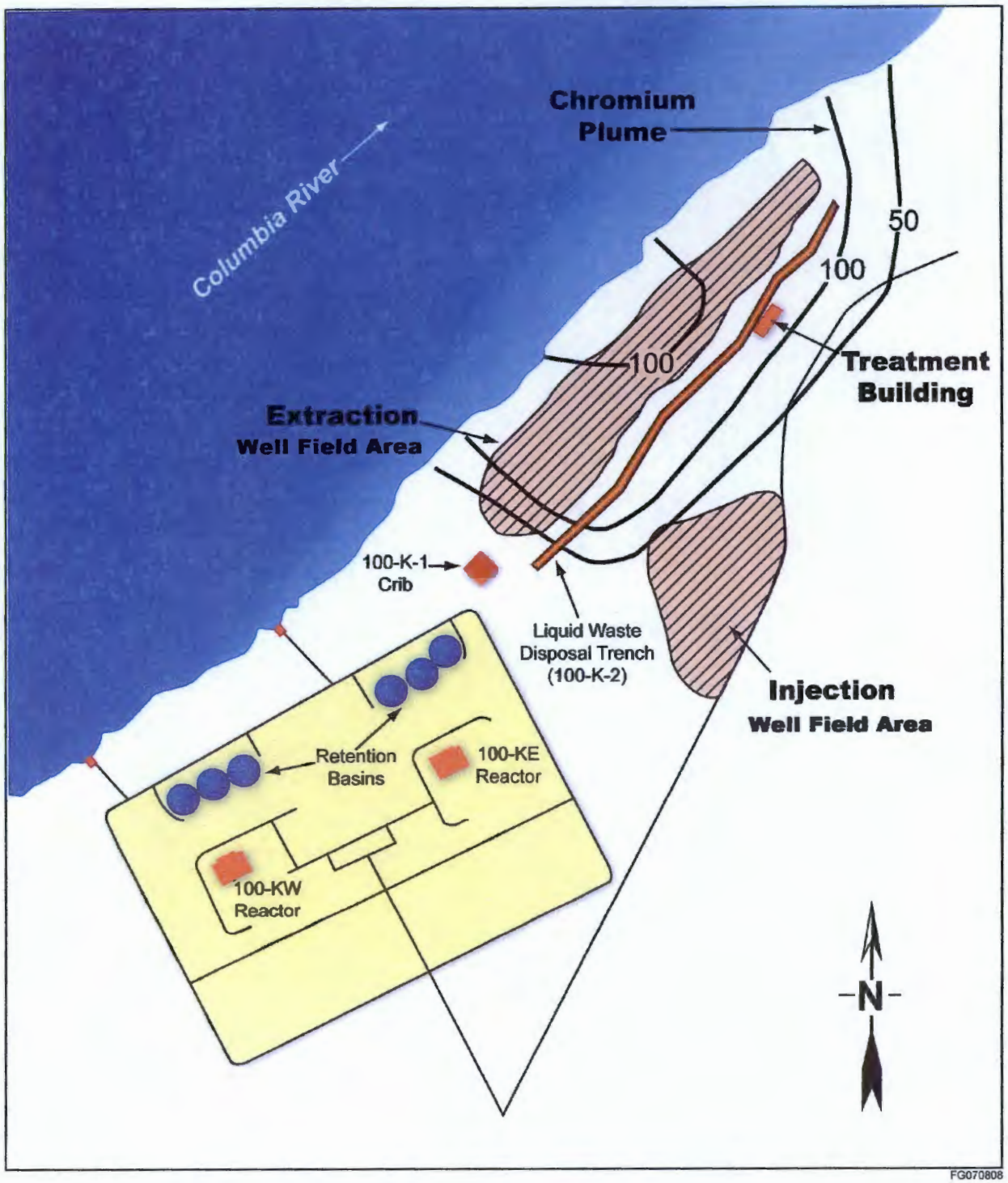


Figure 2-6. 100-KR-4 Hexavalent Chromium Plume – June 2007.

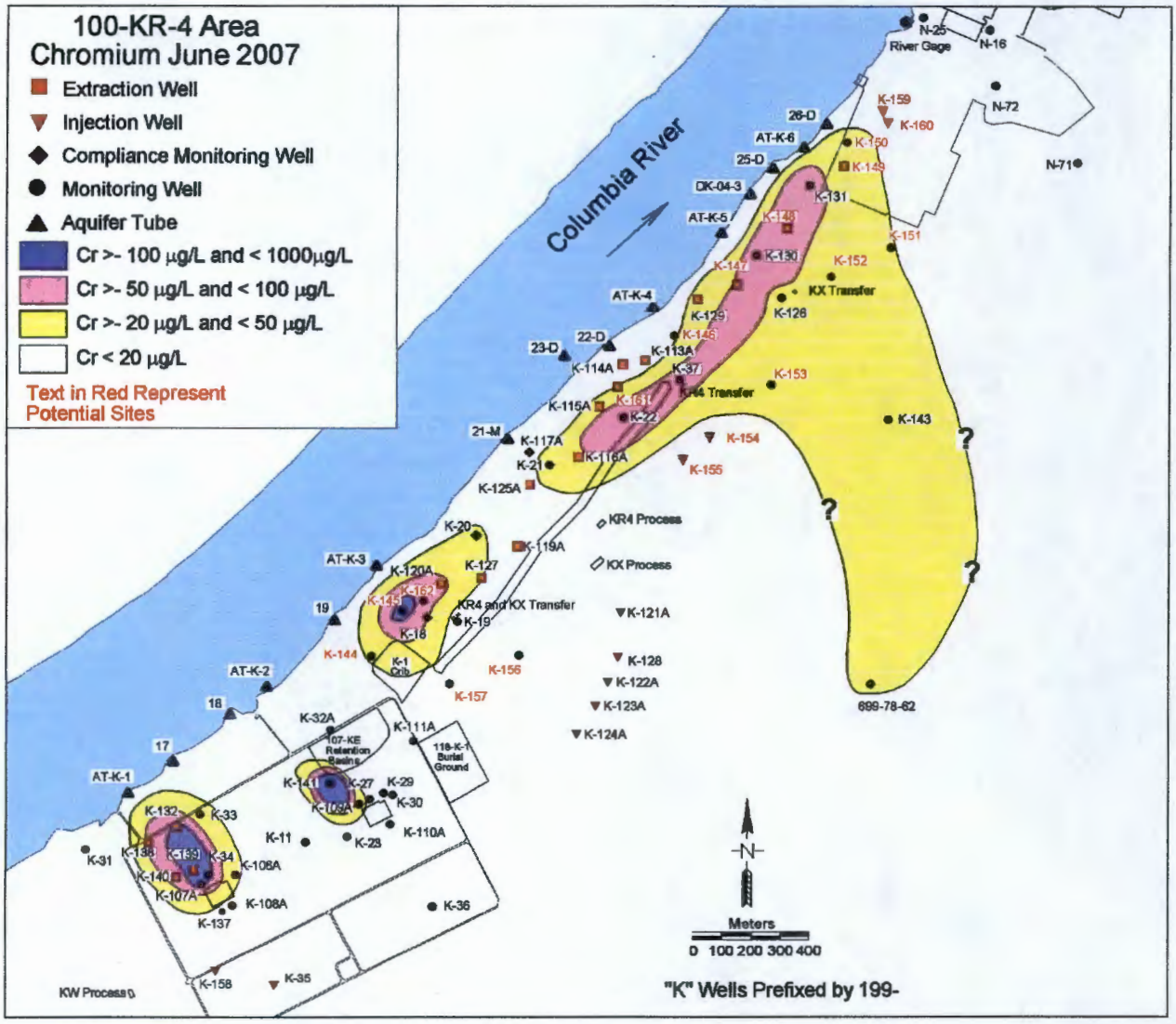


Table 2-1. Construction Details, Average Depth to Water, and Average Aquifer Thickness in 100-KR-4 Pump-and-Treat System Wells. (2 sheets)

Well Name	Date Completed	Depth To Bottom/Ringold Upper Mud (ft)	Screened Interval (ft/type)	Average Depth to Water (ft) 1997-2007	Avg Aquifer Thickness (ft)	Well Use Original/Current
199-K-18	Oct. 1954	39/NR	18 to ND/8-in. PCS	23.6	-	C
199-K-19	Apr. 1955	47/NR	26 to 46/est 7-in GS	35.7	-	M
199-K-20	May 1955	47/NR	10 to 50/ 8-in. PCS	36.2	-	C
199-K-21	May 1955	49/NR	10 to 50/8-in. PCS	37.4	-	M
199-K-22	May 1955	49/NR	29 to 49/6-in TS	39.8	-	M
199-K-32A	July 1992	65/NR	45 to 65/4-in. SS-0.010	55.8	-	M
199-K-32B	Aug. 1992	176/136	157 to 167/4-in. SS-0.010	48.5	87.5	M
199-K-37	June 1992	63/NR	43 to 63/4-in. SS-0.010	55.8	-	M
199-K-111A	July 1994	185/155	65 to 85/4-in. SS-0.040	70.6	84.4	M
199-K-112A	Sept. 1996	48/48	21 to 46/6-in. SS-0.040	-	20 (est)	E
199-K-113A	Sept. 1996	43/41	20 to 40/6-in. SS-0.040	-	17 (est)	E
199-K-114A	Sept. 1996	51/41	21 to 36/6-in. SS-0.060	-	17 (est)	C/E
199-K-115A	Oct. 1996	61/54	21 to 41/6-in. SS-0.030	-	29 (est)	E
199-K-116A	Oct. 1996	92/87	31 to 86/6-in. SS-0.040	-	51 (est)	E
199-K-117A	Oct. 1996	73/68	28 to 68/6-in. SS-0.040	30.9	37.1	C
199-K-118A	Sept. 1996	81//76	33 to 73/6-in. SS-0.040	-	-	E
199-K-119A	Oct. 1996	92/89	36 to 86/6-in. SS-0.040	-	47 (est)	E
199-K-120A	Oct. 1996	101/96	19 to 94/6-in. SS-0.040	-	77 (est)	E
199-K-121A	Sept. 1996	98/96	60 to 90/6-in. SS-0.030	-	27 (est)	I
199-K-122A	Sept. 1996	101/100	65 to 95/6-in. SS-0.040	-	33 (est)	I
199-K-123A	Sept. 1996	98/NR	60 to 90/6-in. SS-0.030	-	-	I
199-K-124A	Sept. 1996	100/NR	57 to 77;82 to 92/6-in. SS-0.030	-	-	I
199-K-125A	Aug. 1998	78/75	32 to 72/6-in. SS-0.020	-	42 (est)	E
199-K-126	July 1999	90/NR	64 to 84/6-in. SS-	72	-	C/E/treatability test well

Table 2-1. Construction Details, Average Depth to Water, and Average Aquifer Thickness in 100-KR-4 Pump-and-Treat System Wells. (2 sheets)

Well Name	Date Completed	Depth To Bottom/Ringold Upper Mud (ft)	Screened Interval (ft/type)	Average Depth to Water (ft) 1997-2007	Avg Aquifer Thickness (ft)	Well Use Original/Current
199-K-127	Feb. 2002	115/NR	50 to 100/6-in. SS-0.020	-	-	E
199-K-128	Jan. 2002	98/NR	55 to 90/6-in. SS-0.030	-	-	I
199-K-129	Feb. 2003	51/48	21 to 46/6-in. SS-0.020	-	20 (est)	E
199-K-130	Feb. 2003	80/NR	46 to 76/6-in. SS-0.020	51.1	-	M
199-K-131	Sept. 2004	100/94	52 to 82/6-in. SS-0.020	53.8	40.2	M
199-K-143	Feb. 2007	95/NR	53 to 88/6-in. SS-0.020	54	-	M
699-78-62	May 1957	150/120	67 to 107/6-in. TS-0.015	76	44	M

NOTES:

1. Aquifer thickness in extraction and injections wells is based on depth to water in the well before well became operational.
2. Average water level based on recorded measurements in heis database for period 1997 through 2007.
3. Well screen slot-size measurements = (inches x 10^{-3}); for example, 0.020 – 20 x 10^{-3} inches). This is commonly referred to as "20-slot" screen.

C = compliance well
E = extraction well
est = estimated
I = injection well
M = monitoring well
NR = formation not reached in well
PCS = perforated carbon steel
SS = stainless steel
TS = telescoping screen

Table 2-2. Well Development Summary for Existing 100-KR-4 Pump-and-Treat Wells. (2 sheets)

Well	Date	Avg Dtw (ft) (TOC)	DTB	Q (gpm)	Drawdown (ft)	Specific Capacity (gpm/ft dd)	Sat. Thickness (ft)	Aquifer Description
199-K-112A	10/31/96	32.7	48.8	29	10.5	2.76	15	18 to 48 ft: sandy gravel; 48 to 54 ft: sandy silt
199-K-113A	10/3/96	23.6	43.08	25	19.4	1.29	17	22 to 29 ft: sandy gravel; 29 to 41 ft: silty sandy gravel; 41 to 44 ft: sandy silt
199-K-114A	10/4/96	28.0	39.11	85	1.8	47.2	17	21 to 24 ft: sandy gravel; 24 to 41 ft: silty sandy gravel; 41 to 51 ft: sandy silt
199-K-115A	10/4/96	26.81	53.98	38	12.8	2.97	26	16 to 24 ft: sandy gravel; 24 to 54 ft: silty sandy gravel; 54 to 61 ft: silt
199-K-116A	10/16/96	40.65	93.68	82	.067	122.4	50	21 to 55 ft: sandy gravel; 55 to 66 ft: silty sandy gravel; 66 to 87 ft: sandy gravel; 87 to 92 ft: sandy silt
199-K-117A	10/17/96	29.4	70.96	80	5	16	42	14 to 36 ft: sandy gravel; 36 to 50 ft: silty sandy gravel; 50 to 68 ft: sandy gravel; 68 to 73 ft: sandy silt
199-K-118A	10/23/96	36.57	75.15	52	47	1.11	-	19 to 37 ft: sandy gravel; 37 to 75.5 ft: silty sandy gravel; 75.5 to 81 ft: sandy silt
199-K-119A	10/17/96	45.94	89.4	68	12.7	5.35	47	16 to 22 ft: sandy gravel; 22 to 50 ft: silty sandy gravel; 50 to 89 ft: sandy gravel; 89 to 92 ft: clay (Ringold Upper Mud)
199-K-120A	10/15/96	20.25	97	80	2.5	32	76	3 to 43 ft: sandy gravel; 43 to 82 ft: silty sandy gravel; 82 to 96 ft: sandy gravel; 96 to 101 ft: sandy silt
199-K-121A	10/1/96	71.12	93.49	25	23.5	6.2	28	54 to 72 ft: sandy gravel; 72 to 79 ft: gravelly sand; 79 to 96 ft: sandy gravel; 96 to 98 ft: sandy silt
199-K-122A	10/1/96	69.88	98	17	10.5	8.5	33	39 to 75 ft: sandy gravel; 75 to 100 ft: silty sandy gravel; 100 to 101 ft: sandy silt
199-K-123A	10/2/96	71.26	93.1	12	19.2	4.8	-	38 to 72 ft: sandy gravel; 72 to 81 ft: silty sandy gravel; 81 to 98 ft: sandy gravel
199-K-124A	10/2/96	73.07	94.9	12	14.5	2.9	-	36 to 65 ft: sandy gravel; 65 to 75: silty sandy gravel; 75 to 88 ft: silty sandy gravel; 88 to 100 ft: sandy gravel
199-K-125A	8/8/98	35.78	75.2	45	7.2	6.25	43	28 to 60 ft: sandy gravel; 60 to 75 ft: silty sandy gravel; 75 to 78 ft: silt

Table 2-2. Well Development Summary for Existing 100-KR-4 Pump-and-Treat Wells. (2 sheets)

Well	Date	Avg Dtw (ft) (TOC)	DTB	Q (gpm)	Drawdown (ft)	Specific Capacity (gpm/ft dd)	Sat. Thickness (ft)	Aquifer Description
199-K-126A	7/26/99	67.02	84.41	17	-	-	25	57 to 63 ft: gravelly silty sand; 63 to 70.5 ft: gravelly sand;70.5 to 87 ft: sandy gravel; 87 to 90 ft: gravel
199-K-127	2/27/02	-	103.1	-	-	-	72	15 to 45 ft: silty sandy gravel; 45 to 61.4 ft: sandy gravel; 61.4 to 115 ft: silty sandy gravel
199-K-128	1/7/02	-	93.4	-	-	-	25	55 to 72 ft: slightly silty gravelly sand; 72 to 97.9 ft: sandy gravel
199-K-129	2/21/03	-	49.5	-	-	-	-	28 to 31 ft: gravelly sand; 31 to 48 ft: sandy gravel; 48 to 51 ft: silt (Ringold Upper Mud)
199-K-130	2/24/03	51.82	78.9	50	8.8	5.68	30	48 to 60 ft: gravelly sand; 60 to 80 ft: sand and gravel
199-K-131	9/22/04	53.87	84.85	25	3.9	6.41	48	30 to 75 ft: sandy gravel; 75 to 94 ft: gravelly sand; 94 to 98 ft: silty sandy gravel; 98 to 99 ft: silt (Ringold Upper Mud)
199-K-143	2/25/07	53.8	95				-	
699-78-62	2/19/07	76.0	106					

DTB = depth to bottom
gpm = gallons per minute
gpm/ft dd = gallons per minute per foot withdrawn
Q = pumping rate
TOC = top of casing

Table 2-3. Hexavalent Chromium Concentrations for 2002 at Well 199-K-117A. (2 sheets)

Date Sampled	Cr^{+6} Concentration (µg/L)	Depth (ft)	Specific Conductance (µS/cm)	Average for Sampling Round Cr^{+6} (µg/L)
1/16/02	13	32	177	16.25
1/16/02	14	40	172	
1/16/02	16	54	175	
1/16/02	22	64	181	
2/25/02	36	32	217	34.6
2/25/02	36		208	
2/25/02	32	54	212	
2/25/02	36		211	
2/25/02	33			
3/27/02	26	40	209	26
3/27/02	25	54	206	
3/27/02	27	64	207	
4/19/02	16	30	208	12.5
4/19/02	12	40	179.1	
4/19/02	10	54	176.1	
4/19/02	12	64	172.8	
5/21/02	11	30	184	9.2
5/21/02	4	54	195	
5/21/02	10	40	198	
5/21/02	12	64	176	
5/21/02	9			
6/19/02	11	30	202	10
6/19/02	9	40	190	
6/19/02	11	54	189	
6/19/02	11			
6/19/02	8	64	187	
8/6/02	14		201	16.25
8/6/02	14		162	
8/6/02	15		198	
8/6/02	22		204	
8/28/02	12	32	200	12.5
8/28/02	12	40	199	
8/28/02	12	54	197	
8/28/02	14	64	197	
10/1/02	18		207	19
10/1/02	18		199	
10/1/02	18		198	
10/1/02	22		204	
10/21/02	12			12

Table 2-3. Hexavalent Chromium Concentrations for 2002 at Well 199-K-117A. (2 sheets)

Date Sampled	Cr^{+6} Concentration (µg/L)	Depth (ft)	Specific Conductance (µS/cm)	Average for Sampling Round Cr^{+6} (µg/L)
10/21/02	12	40	205	
10/21/02	12			
10/21/02	12			
11/27/02	10	36	184	10
12/30/02	11	40	206	8.35
12/30/02	5.7	40		

3.0 REMEDIAL DESIGN

This section describes the engineering, hydrogeologic, and regulatory design basis for the 100-KR-4 chromium plume pump-and-treat system and provides a general description of the system's components and their functions.

3.1 SUPPORTING DOCUMENTATION

The following subsections describe the conceptual design and final design documents for the expansion of the 100-KR-4 pump-and-treat system.

3.1.1 Conceptual Design Documents

Significant documents completed during the conceptual design phase include the following:

- *Design Criteria for the Expansion of the 100-KR-4 Pump-and-Treat System* (WMP-30899): This document identifies relevant criteria applicable to the pump-and-treat design and describes the design basis. The document serves as a project work plan for the design team.
- Drawings, specifications, and system design description: These items show the general layout of the pump-and-treat system and the configuration of the system's controls and interfaces.
- *Mitigation Action Plan for the 100-HR-3 and 100-KR-4 Pump-and-Treat Project* (DOE/RL-96-107): This document describes the prioritized actions designed to minimize or lessen project impacts on cultural or natural resources. It was prepared for the 100-HR-3 and 100-KR-4 pump-and-treat systems, but it can also be applied to the expansion of the 100-KR-4 pump-and-treat system.

3.1.2 Final Design Documents

The principal documents produced during the final design include final design drawings, specifications, and other related information for bidding on and construction of the pump-and-treat system. The final design drawings were incorporated into the following procurement packages:

- *Description of Work for the Installation of Eighteen Wells to Support the 100-KR-4 Pump-and-Treat System Expansion* (SGW-34556): This document provides information regarding the (1) location and construction of the new extraction and injection wells, (2) use of existing wells within the pump-and-treat system, and (3) management of drilling and development wastes generated during drilling, completion, and well development operations.
- Balance of plant procurement package: This package contains the final drawings and specifications necessary to construct the pump-and-treat system, exclusive of the wells. It includes detailed information on the site grading, piping layout, well controls, tank locations, the groundwater treatment system (GTS), and electrical mechanical connections.

3.2 ENGINEERING AND HYDROGEOLOGIC DESIGN BASIS

The primary RAO for the 100-KR-4 pump-and-treat system expansion is to prevent the discharge of hexavalent chromium to the Columbia River substrate at concentrations exceeding those that are considered protective of aquatic life in the river and riverbed sediments. This objective will be achieved by pumping groundwater from extraction wells located within the plume area, treating the groundwater to remove hexavalent chromium by applying an IX treatment method, and returning the treated groundwater to the aquifer via injection wells. This section describes the general approach used to select extraction and injection well locations, the criteria for piping and flow control and monitoring equipment (i.e., balance of plant), and the rationale for vessel alignment in the IX system.

3.2.1 General Approach

The 100-KR-4 expansion will incorporate the design criteria from the existing 100-KR-4 system and the experiences gained in 10 years of operating six pump-and-treat systems into a stand-alone pump-and-treat system. The system will be designed to meet the following expansion goals:

- Control the northward migration of the chromium plume before it reaches the 100-NR-2 OU
- Protect the Columbia River by removing high-concentration areas and eliminating gaps in capture between extraction wells
- Remediate the remainder of the chromium plume to less than the RAO.

Proposed well locations and well designs for the 100-KR-4 expansion were developed and evaluated by performing the following tasks and activities:

- Evaluating existing chromium plume maps and individual well trend plots
- Updating geologic cross-sections and isopach/structure contour maps
- Running analytical model simulations using extraction and injection rates estimated from specific capacity data derived from well development tests in existing wells
- Conducting onsite field discussions with affected Tribal members and cultural resources specialists
- Briefing the U.S. Environmental Protection Agency (EPA) regularly with conceptual design details.

3.2.2 Details of Design Basis

Details for the design basis are listed below:

- Plume area: The seasonal variations in the 100-KR-4 chromium plume are displayed in Figure 1-1 (i.e., the fall 2006 plume) and Figure 2-7 (i.e., the spring 2007 plume). These figures clearly show that chromium concentrations are lower in near river wells when the Columbia River stage is higher during the spring.
- Supplementary system groundwater wells: The system expansion will include extraction, injection, and monitoring wells. The well locations are shown in Figure 3-1.

- 100-KR-4 expansion well locations: Well design details, design flow rates, modeled flow rates, specific capacities, and estimated saturated aquifer thickness (Ringold Unit E) are presented in Table 3-1.
- Extraction wells: The design goals will focus on plume containment, filling gaps in extraction well capture, and mass reduction in the northern hexavalent chromium plume. Figure 3-2 is an analytical modeling simulation that displays the locations of the six extraction wells selected to stop the northward migration, fill gaps in capture, and reduce contaminant mass. The locations selected for the simulation have been adjusted as needed based on Tribal and cultural concerns, as well as existing operations. The modeled extraction rates used for the analytical simulations were selected to achieve capture. Design flow rates were selected based on extraction rates in nearby wells or the specific capacities developed from well development tests in nearby wells. Actual extraction rates will likely vary based on aquifer conditions.
- Injection wells: Treated groundwater will be injected in four wells, as shown in Figures 3-1 and 3-2. The modeled injection rates were input into an analytical simulation to evaluate the effect on containment of the northern plume. Modeled flow rates, design flow rates, specific capacities of nearby wells, and expected average saturated Ringold Unit E aquifer thicknesses are shown on Table 3-1.
- Monitoring wells to support system expansion: Ten monitoring wells will be installed in locations within and outside the northern and southern plume areas to provide data that will be used to evaluate the effectiveness of the expanded pump-and-treat system in meeting project goals. These wells could be added to the pump-and-treat network in the future, if needed. Proposed monitoring well locations are shown in Figures 3-1 and 3-2, and construction details are included in Table 3-1.
- IX system: The supplementary stand-alone IX system will include three treatment trains, each with a capacity of approximately 378.5 L/min (100 gpm). The treatment facility will be expandable to six trains and a capacity of 2,271.2 L/min (600 gpm).

3.2.3 Design Uncertainties

The design uncertainties are described below:

- Aquifer parameters: No long-term pumping tests have been conducted to determine sustainable well yields or to identify boundary conditions that could limit extraction well effectiveness. Pumping rates were estimated based on sustained rates at nearby wells or well-development data obtained following construction of existing monitoring wells. The effect of not having a long-term test could be that the long-term production rates may be lower from those assumed in the design, which could negatively affect capture. A possible response to low well efficiency would be to add additional wells to the extraction network. Well yields will be adjusted based on acceptance and operational tests.
- Placement of injection wells and receptive capacity: The proposed injection wells have been located where they will help to accelerate flow through the plume area and where chromium concentrations are expected to be relatively low based on the fall 2006 interpretation of the 100-KR-4 chromium plume (Figure 2-6). The current well locations are compatible with ongoing cleanup operations and existing infrastructure and have been identified to Tribal representatives. The receptive capacities of the wells have been

estimated based on nearby existing wells, if available. Flow rates may need to be adjusted if well-development testing after construction changes estimated receptive capacities.

- Variable river stage: For most of the year, the groundwater flow direction is toward the Columbia River. During periods of high river stage, the gradient may be reversed, which may improve capture between the extraction well and the river. During periods of lower river stage, the groundwater flow gradient may be steepened, which would result in a more narrow capture zone. It may be possible to widen capture zones by increasing pumping rates in those wells in which the saturated Ringold Unit E is thicker.
- Conceptual model limitations: The current conceptual model is based on a widely dispersed hexavalent chromium plume with few monitoring wells inland of the 116-K-2 Trench. High chromium concentrations are not expected if the source of the plume was reactor effluent disposed to the 116-K-2 Trench. If high concentrations of hexavalent chromium are detected, which could be attributed to an ongoing sodium dichromate source, the site conceptual model will require revision.

3.3 GENERAL DESCRIPTION AND OPERATION OF THE PUMP-AND-TREAT SYSTEM

The expanded 100-KR-4 pump-and-treat system will use a series of extraction wells equipped with submersible pumps to draw groundwater from the unconfined aquifer. Extracted groundwater will be conveyed through aboveground piping to a collection tank(s) where it will be combined with water from the other extraction wells. From the collection tank(s), the water will be pumped to an enclosed treatment system where chromium will be removed by IX. Treated groundwater will be transferred through an aboveground pipe to the injection well network.

3.3.1 Groundwater Extraction System

The groundwater extraction system in the expanded 100-KR-4 pump-and-treat network will consist of four new extraction wells (199-K-147, 199-K-148, 199-K-149, and 199-K-161) and two existing monitoring wells (199-K-130 and 199-K-131) that will be converted to extraction wells. Existing wells 199-K-130 and 199-K-131 were completed as 6-in. stainless-steel wells with 0.020-in. (20-slot) screens. Well 199-K-131 fully penetrated the Ringold Unit E aquifer. The saturated thickness of this well is about 14.6 m (48 ft) based on an average depth to water of 16.5 m (54 ft) (Table 2-2). The new extraction wells will be designed as fully penetrating, 6-in.-diameter, stainless-steel wells with 0.020-in. (20-slot) screens. Well design details are shown in Table 3-1.

The extraction rates for these wells were conservatively estimated from 75.7 to 151.4 L/min (20 to 40 gpm) for modeling purposes (Table 3-1). The extraction rates will be adjusted after well-development testing conducted after well construction is completed.

Extraction wells will be equipped with electric, adjustable-frequency drive, submersible pumps; pressure transducers for water-level monitoring; high/low set points for pump on/off control; high-pressure shut-off sensors; sample ports; and in-line flow sensors. The conveyance pipe at each well will allow water to drain back into the well in the event of system shutdown.

3.3.2 Groundwater Injection System

The groundwater system in the expanded 100-KR-4 pump-and-treat network will consist of four wells. Wells 199-K-159 and 199-K-160 are located at the northern end of the 100-KR-4 OU to provide a hydraulic barrier to migration of the hexavalent chromium plume toward the 100-NR-2 OU. Wells 199-K-154 and 199-K-155 will be located near the downstream end of the former 116-K-2 Trench, upgradient from the plume area where concentrations of hexavalent chromium have been detected above 100 µg/L in well 199-K-114A.

The wells will be fully penetrating to the top of the Ringold Upper Mud with 6-in.-diameter, stainless-steel casing and 0.020-in. (20-slot) screens. The well screen will extend at least 6.1 m (20 ft) above the average static water level in the wells. Well design details are displayed in Table 3-1. The initial injection rates for each well were set to 189.3 L/min (50 gpm) for the analytical modeling but are subject to change based on actual aquifer and vadose zone properties.

3.3.3 Balance of Plant

The balance of plant will include all control systems, piping, valves, pumps, and electrical and mechanical equipment that enables groundwater from the extraction wells conveyed to the treatment system and returned to the injection wells and to the aquifer.

The 100-KR-4 expanded pump-and-treat system has been designed to run with minimal operator interface. This capability results from the use of programmable logic controllers (PLCs) that receive and transmit electronic signals to and from the field control devices. Data are also transmitted via optical cable to the primary human/machine interface (HMI) where they can be viewed by the operator and system adjustments can be performed if necessary.

The HMI will be located in the treatment building and represents the primary link between the operator and the pump-and-treat system. From the operator interface control (OIC), the operator can view all tank levels, pump status, flow rates, pumping water levels, and alarm status. The OIC also serves as a data storage and retrieval device and will be configured so the system status can be viewed via a laptop computer from offsite locations.

Piping and electrical lines to wells will be run overland to minimize any cultural resource impacts. Freeze-control design will be included as part of the treatment system. No freeze protection will be applied to overland piping.

3.3.4 Groundwater Treatment System

The GTS will initially be constructed with a minimum treatment capacity of 1,135.6 L/min (300 gpm). This design capacity was based on experience gained from operation of the existing 100-KR-4 pump-and-treat system. Preliminary analytical modeling runs displayed in Figures 3-2 and 3-3 support the assumption that six extraction wells and four injection wells should significantly reduce northward migration and improve capture in the northern plume area. The GTS could be expanded to a 2,271.2 L/min (600 gpm) system at a later date.

The treatment system operational and acceptance testing has been scheduled for the summer of 2008 to implement the remedial action as quickly as possible.

The selected treatment process will use an IX system with Dowex® 21K resin that has effectively removed hexavalent chromium at the 100-HR-3 and 100-KR-4 pump-and-treat systems. If an

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alternate resin or other treatment system is identified, it may be used if approved by EPA. Spent resin may be regenerated offsite or at ETF, or otherwise managed in a manner approved by EPA for this remedial action.

The Dowex 21K resin beds capture hexavalent chromium and other ions with similar properties (e.g., uranium, which is naturally occurring in the 100 Areas in low concentrations). Co-contaminants such as strontium-90 and tritium are not removed by the resin.

The alignment of the vessels is designed to remove hexavalent chromium, which is the interim remedial action target contaminant. Individual vessels can be bypassed during resin changeout so the treatment system can continue operation.

Influent and effluent samples are collected at each vessel in the train and provide indications of resin saturation and removal effectiveness/efficiencies. As the resin in a vessel approaches saturation, the resin is removed and the vessel alignment is re-plumbed so the vessel with the freshest resin is always the polish, or last, vessel in the train. When saturated with hexavalent chromium resin in the lead, lag, and polish vessels are changed out so the treated groundwater will contain less than the standard 10 µg/L hexavalent chromium at reinjection.

3.3.5 System Monitoring and Shut-Off Devices

The expanded 100-KR-4 pump-and-treat system will include a number of devices designed to detect typical system upsets. To protect against tank overflows, high-level sensors are located in each collection tank. These sensors will shut down extraction wells when the high-level set point is exceeded. Leakage from pipe/joint failures can be detected by flow sensors that shut down the appropriate extraction well if the flow in the line drops below the low-flow set point. Blocked conveyance piping will be detected by high-pressure shut-off switches. Water-level drawdown in wells will be monitored by a sensor that shuts the pump off if the water level drops below the low-level set point.

Moisture sensors have been set in low points in the floor around pumps and trains and would shut the system down if water is detected. Chemical spill kits are available in the treatment facility and acid will be stored on spill pallets designed to absorb up to four times the volume of the container stored on them.

A relatively constant groundwater temperature of 10 to 13°C (50 to 55°F) is expected to provide sufficient freeze protection under normal operating and weather conditions. During extreme conditions, drainage of extraction and injection well piping will occur automatically after the system is shut down. External polyvinyl chloride piping and the collection tanks will be heat-traced and the GTS buildings heated and insulated.

Figure 3-1. Expanded 100-KR-4 Pump-and-Treat System – Existing and Proposed Wells.

Figure 3-2. Analytical Simulation of Expanded 100-KR-4 Pump-and-Treat System (North).

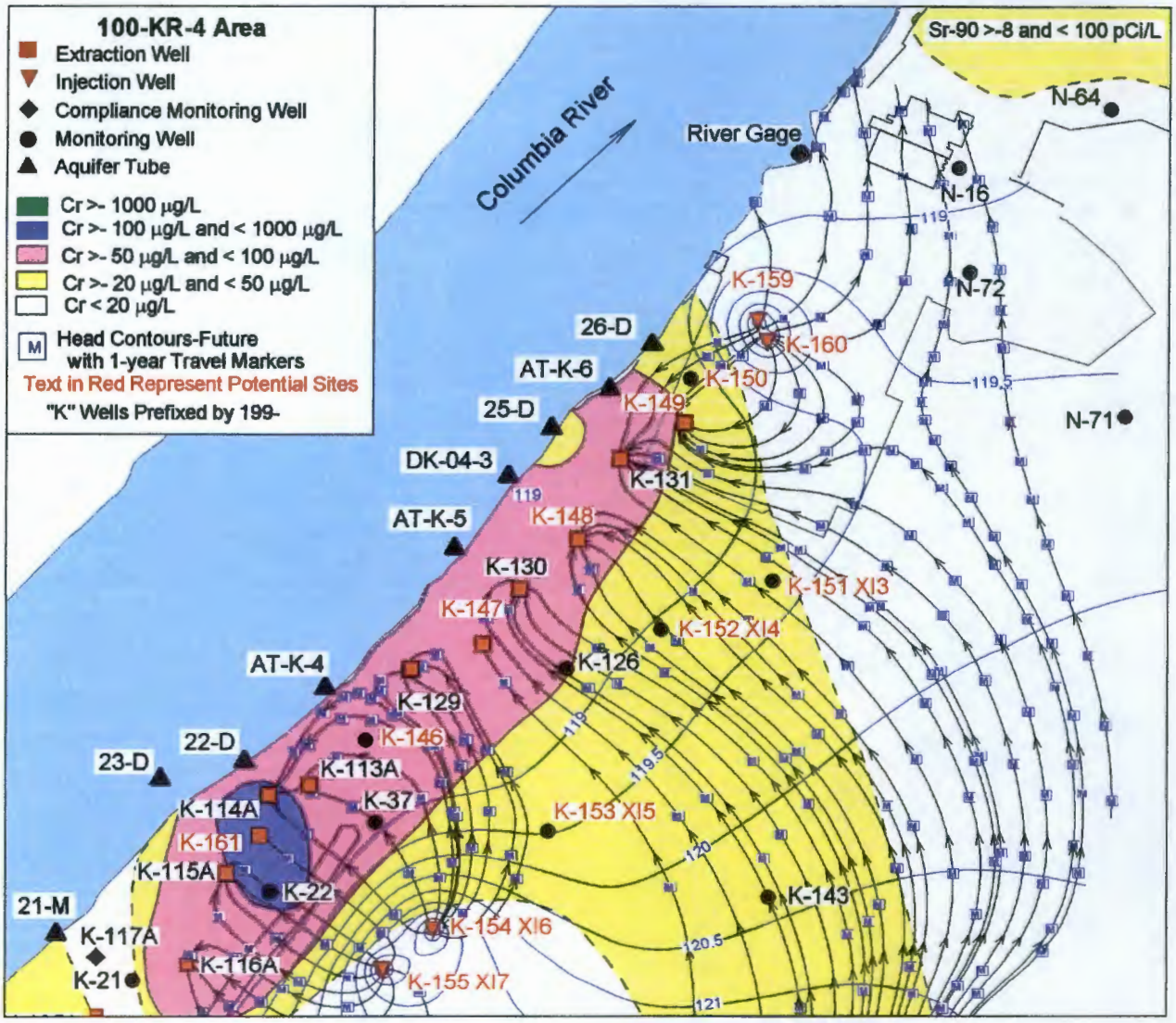


Figure 3-3. Analytical Simulation of Expanded 100-KR-4 Pump-and-Treat System (South).

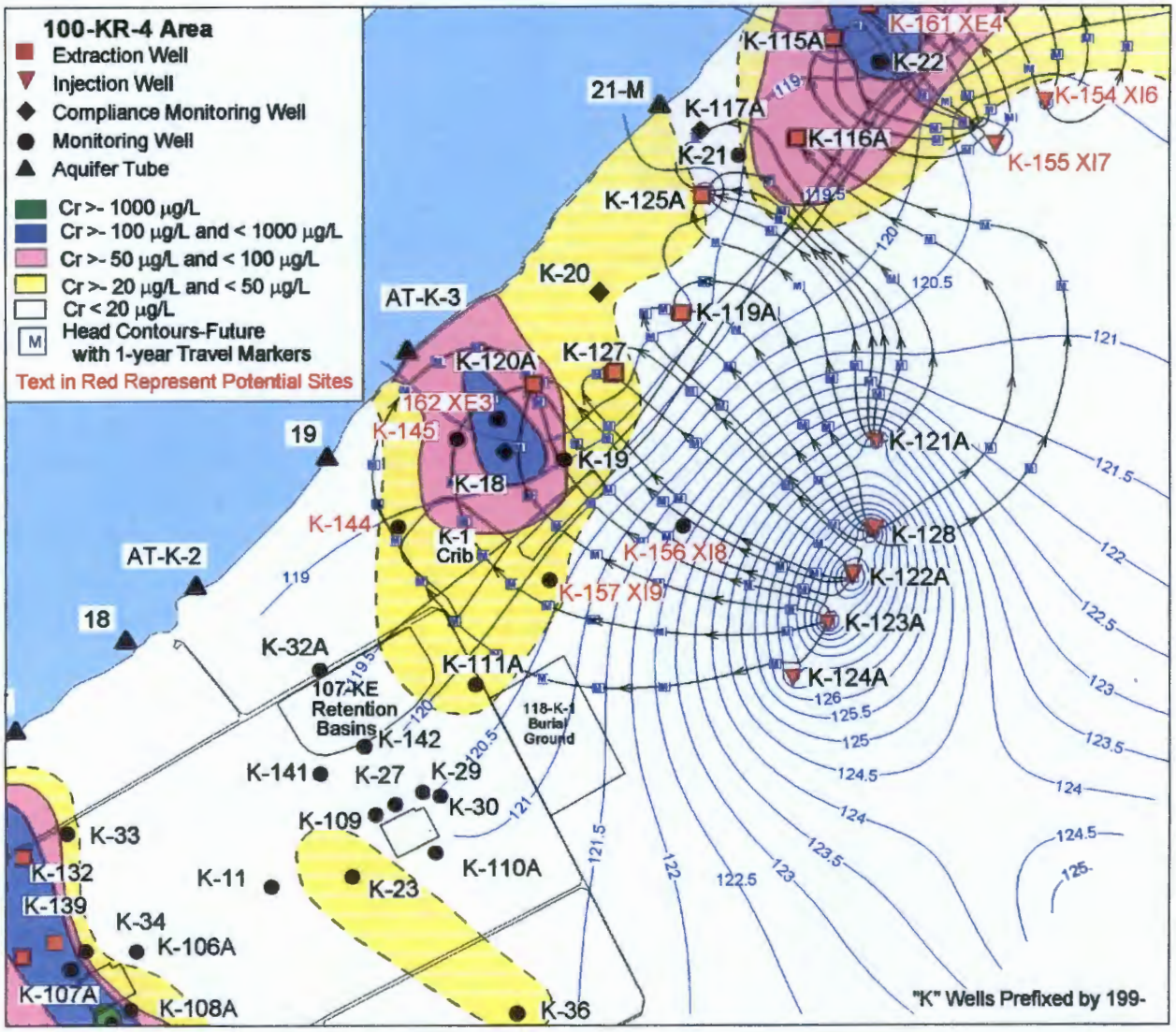


Table 3-1. 100-KR-4 Expansion - Estimated Flow Rates and Well Design Details.

Well Name	Estimated Depth (ft)	Estimated Saturated Thickness (ft)	Estimated Specific Capacity (gpm/ft)	Estimated Design Extraction/ Injection Rate (gpm)	Modeled Flow Rate (gpm)
Extraction Wells					
199-K-130	80 (drilled Feb. 2003)	40	5.7	70	40
199-K-131	99.3 (drilled Sept. 2004)	40	6.4	75	40
199-K-148	100	35	6 (K-130 +K-131)/2	70	40
199-K-147	75	30	4 (K-112A+K-130)/2	20	20
199-K-149	100	40	6.4 (K-131)	40	40
199-K-161	60	25	3 (K-115A)	25	25
Injection Wells					
199-K-160	100	50	NDA	80	55
199-K-159	100	50	NDA	80	50
199-K-155	80	30	6 (K-121A)	70	50
199-K-154	80	30	6 (K-121A)	70	50
Performance Wells					
199-K-150	100	40	NDA		None
199-K-151	110	40	NDA		None
199-K-152	110	35	NDA		None
199-K-153	100	35	NDA		None
199-K-156	135	65	2 (K-111A)		None
199-K-157	145	75	2 (K-111A)		None
199-K-144	110	80	2(K-111A)		None
199-K-145	110	80	17 (K-111A+K-120A)/2)		None
199-K-162	100	75	17 (K-111A+K-120A)/2)		None
199-K-146	60	20	2		None

NOTE: Estimated design extraction and injection rates will be adjusted after well drilling to reflect aquifer conditions.

gpm = gallons per minute
NDA = no data available

4.0 100-KR-4 EXPANSION SYSTEM IMPLEMENTATION

This section discusses the planned construction, startup, operation, and maintenance activities for the expansion of the 100-KR-4 pump-and-treat system.

4.1 CONSTRUCTION

The following subsections describe the construction tasks associated with the 100-KR-4 pump-and-treat implementation.

4.1.1 Well Drilling

Eighteen new wells will be drilled for the 100-KR-4 pump-and-treat system expansion. These wells include the following:

- Extraction wells: 199-K-147, 199-K-148, 199-K-149, and 199-K-161
- Injection wells: 199-K-154, 199-K-155, 199-K-159, and 199-K-160
- Performance wells: 199-K-144, 199-K-145, 199-K-146, 199-K-150, 199-K-151, 199-K-152, 199-K-153, 199-K-156, 199-K-157, and 199-K-162.

Two existing wells (199-K-130 and 199-K-131) will also be incorporated into the 100-KR-4 pump-and-treat system as extraction wells. Many extraction and performance wells will also be used as compliance wells (as described in Section 5.0).

Well construction will be controlled by the 100-KR-4 pump-and-treat expansion description of work (WMP-30101). Schematic diagrams of typical new injection and extraction are provided in Figures 4-1 and 4-2, respectively. Note that new wells will be designed as extraction or injection wells, depending on location in the plume area.

This response action will avoid or minimize impacts to cultural resources, and the steps taken for cultural resource protection will be documented. The management of drill cuttings and other waste from drilling operations will be conducted in accordance with the *Interim Action Waste Management Plan for the 100-HR-3 and 100-KR-4 Operable Units* (DOE/RL-97-01).

New extraction wells will be tested to provide well-specific capacity and other aquifer properties. Injection wells will also be tested by injecting potable water to confirm adequate capacity.

4.1.2 Balance of Plant

In general, the balance of plant includes all system components, from the extraction well pumps through the injection well pipes. The major balance of plant components includes the following:

- Extraction well pumps
- Extraction well head assemblies and control equipment
- Piping from well heads to the transfer building tank
- Piping from transfer building tank to process building influent tank
- Influent storage tank, feed pumps, and piping to the IX unit
- Piping from the IX unit to the effluent tank
- Booster pumps (HMI), flow control values, and piping to injection well assemblies
- Injection well head assemblies
- Injection well pipes

- Power supplies for equipment and instrumentation
- Instrumentation
- Control system.

Balance of plant will follow the schedule presented in Section 6.0 of this addendum.

4.1.3 Groundwater Treatment System Construction and Delivery

Construction of the three 378.5–L/min (100-gpm) IX units occurred at the vendor's facility and they were delivered to the treatment facility as completed products. The three 378.5-L/min (100-gpm) IX units are equipped with appropriate flanges and electrical and control connections to allow connection to the balance of plant described above.

Construction of the three 378.5-L/min (100-gpm) IX units was controlled through a procurement contract to be issued to the IX unit manufacturer. The procurement contract included a schedule for delivery of the three 100 gpm IX units, which were delivered in February 2007 and are in storage in the process building.

4.1.4 Restoration of Disturbed Areas

Disturbance of natural vegetation and habitat is expected to be minimal because most, if not all, of the expanded pump-and-treat area has been disturbed by prior construction or cleanup operations. A cultural resource and ecological review has been conducted to identify controls to limit disturbances. Where disturbances do occur, restoration will be conducted in accordance with the existing mitigation action plan (DOE/RL-96-107). Areas of potential disturbance include the following:

- Drill pads and access roads
- Water transfer lines
- Power pole installations.

Construction of drill pads, and possibly access roads, will be necessary to allow access for drilling equipment and follow-up sampling rigs. Following completion of the interim action, the wells will likely be used for monitoring; therefore, the roads will still be required for well access.

At the completion of the interim action, the need for the transfer pump buildings will be evaluated. If the buildings are needed by another project, they will be transferred to that project. If the buildings are not needed and no other source remediation is scheduled for the future, the buildings will be demolished and the site restored. A similar evaluation will be conducted for water transfer lines and power poles.

4.1.5 Safety and Health During Construction

A site-specific health and safety plan has been prepared and implemented for well drilling and construction activities. The health and safety plan will address the health and safety considerations for construction, construction oversight personnel, and visitors. Every subcontractor performing work associated with the 100-KR-4 pump-and-treat expansion project will be required to submit a subcontractor health and safety plan. Subcontractor health and safety plans will be reviewed for compliance with Hanford Site requirements and will be approved by prime contractor representatives before the subcontractor begins work.

4.2 ACCEPTANCE TESTING

After construction, the startup phase will be initiated. The plan is to have the plant essentially at capacity when it is turned over to operational testing in August 2008.

An acceptance testing plan will be developed prior to system startup. The plan will address acceptance testing, testing of system components, and testing and startup of the overall system. The startup procedure will ensure that the system meets design requirements, will operate safely, and will result in a fully functioning treatment system.

It is anticipated that the startup of the extraction network will involve a phased approach. One extraction well will be started and then additional wells started in 1- to 3-day increments until all wells are operational. This ramping-up period will allow the wells and the transfer piping to be observed and troubleshooting to be performed as needed.

If a problem is found in one treatment system during startup activities, an evaluation will be conducted to determine whether the problem is unique to that component or if it affects the entire system.

4.3 OPERATIONAL TESTING

Operational testing of the system will be conducted after acceptance testing has been completed. It is anticipated that some downtime may occur because of weather conditions.

An operational testing plan will be developed to identify activities and documents that will be completed to support system operations. The plan will identify persons responsible for various operational testing items and will include the appropriate procedures and checklists for the operational testing plan. Instrumentation calibrations will be performed prior to start of the operational testing.

4.4 OPERATION AND MAINTENANCE

The following subsections describe the operation and maintenance of the extraction well system, treatment system, and injection well system.

4.4.1 Controlling Documents

System operations will be controlled by operations and maintenance procedures. Defined preventative maintenance will be prepared prior to startup of operations and will specify the maintenance and calibration schedules.

The 100-KR-4 health and safety plan will be modified prior to startup of operations. The health and safety plan will identify the requirements for safe operation of the treatment system.

The operations waste management plan will be modified to manage waste produced during system operations. The waste management plan will specify waste characterization requirements for various waste types, waste storage requirements, and waste disposal requirements. This waste management plan will be finalized before startup of operations.

4.4.2 Extraction Well System Operation and Maintenance

Operation of the extraction well system will be on a continuous basis during the initial phase of the remedial action. A revised pumping system, or changes in well use, may be implemented as

RAOs are close to being met. Individual well pumping rates are monitored continuously and the data will be stored in the project-specific database.

Extraction wells may be shut down occasionally so maintenance activities can be performed. Maintenance activities will be limited and are likely to include possible well redevelopment activities and pump maintenance. The efficiency of the extraction wells may change over time because well screens and filter packs may plug, especially where existing monitoring wells have been converted to extraction or injection wells. If performance is degraded, occasional maintenance may be necessary to clear the well screens and filter packs. Well pumps may fail occasionally and require replacement. Downtime for maintenance will be kept to the minimum required. Although unlikely, extraction wells may be shut down occasionally during extremely cold weather. In the event of a shutdown, transfer lines from the extraction wells to the transfer pump building are designed to drain back to the extraction wells by gravity drainage. In the event of an extended shutdown for cold weather, undrained water in the water transfer lines may freeze. This may render the transfer lines unusable until thawed and necessitate shutdown of the extraction wells. However, the water transfer lines are designed to freeze and thaw without damage to the lines.

4.4.3 Treatment System Operation and Maintenance

Operation of the treatment system will be controlled by an operating procedure that will be developed as the system design progresses. The operating procedure will be finalized before startup of full-scale operations. Preventative maintenance and instrument calibration requirements will be defined by preventative maintenance schedules. Operation of the treatment system will be essentially continuous or will be of durations necessary to process water from continuous operation of the extraction well network. The network will not be shut down during resin changeouts.

The expected facility operational availability will be 95%, as measured by the amount of time the system is processing ground water through the IX trains, divided by the amount of time the system was neither undergoing planned maintenance nor debilitated by events beyond control of the Soil and Groundwater Remediation Project (e.g., utility power outages, range fires, etc.).

4.4.4 Injection Well System Operation and Maintenance

The injection well system will operate in conjunction with the treatment system to inject treated water. The injection system will include four new wells (199-K-154, 199-K-155, 199-K-159, and 199-K-160). As the 100-KR-4 remedial action progresses, the efficiency of the injection wells may decrease because of air entrainment, bio-fouling, well screen encrustation, or other effects. If injection well efficiency decreases significantly, maintenance will be performed, as practicable, to address the problem.

Figure 4-1. Well Design for Injection Wells 199-K-154, 199-K-155, 199-K-159, 199-K-160, and Wells 199-K-151, 199-K-152, 199-K-153, 199-K-156, 199-K-157.

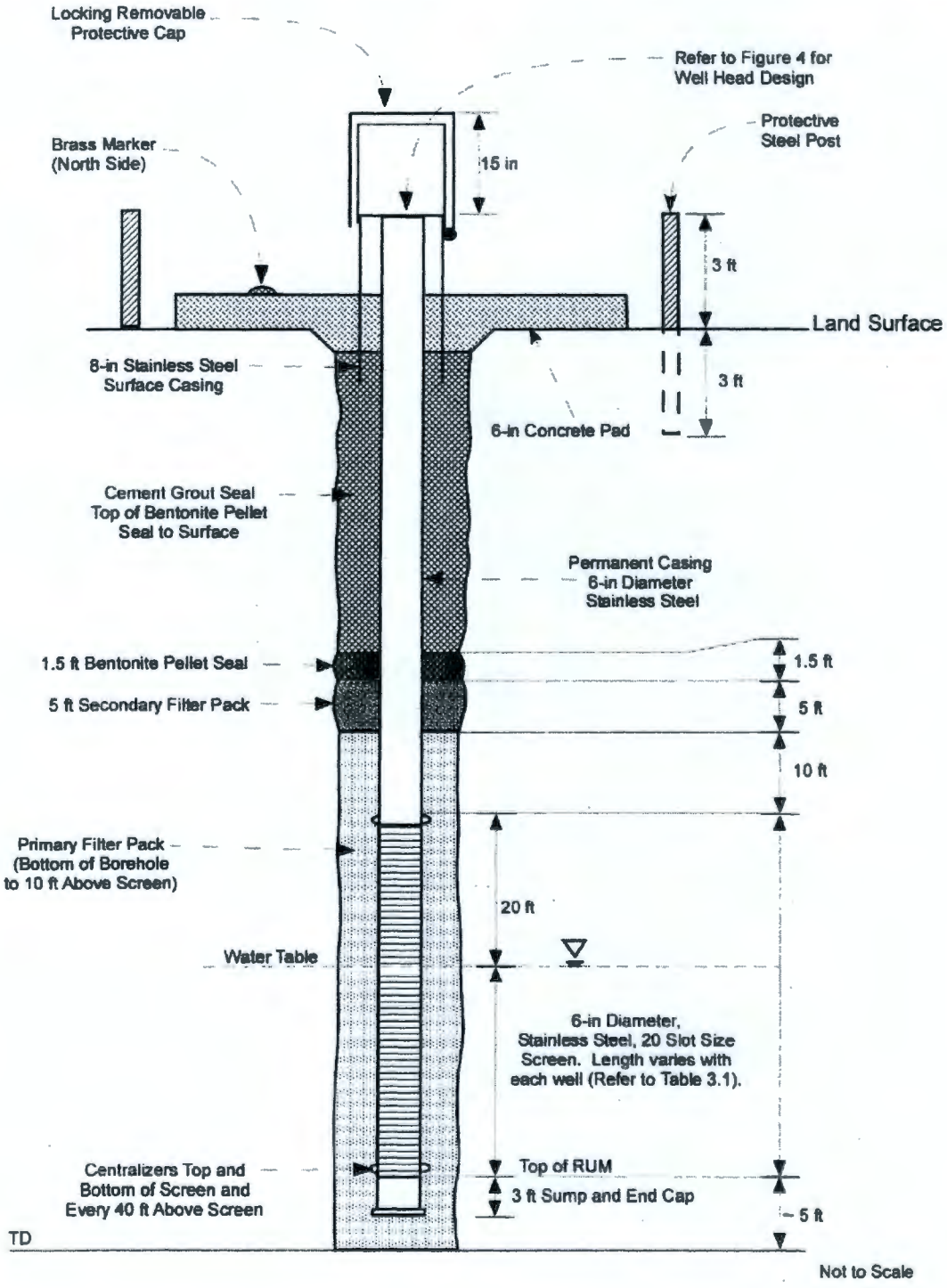
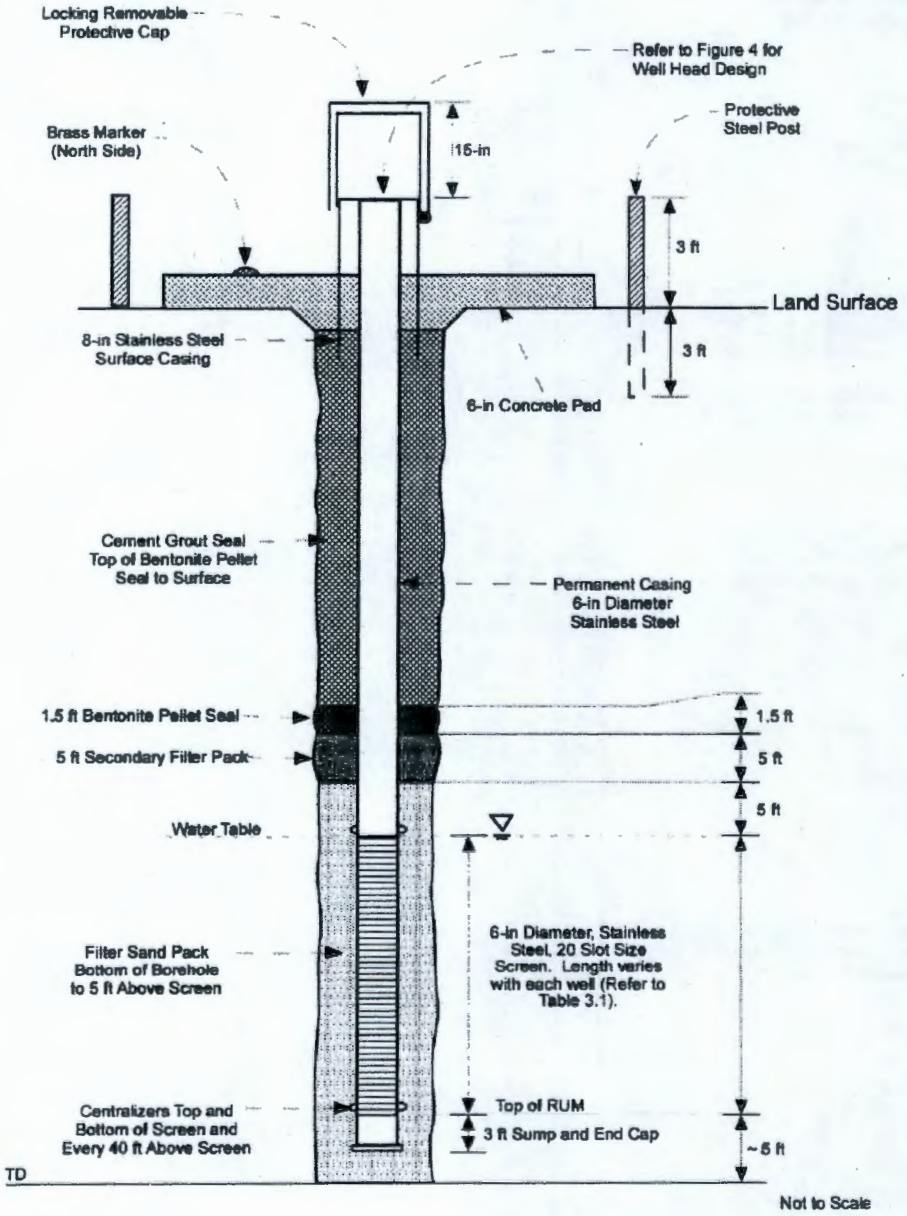


Figure 4-2. Well Design for Extraction Wells199-K-147, 199-K-148, 199-K-149, 199-K-161, and Wells 199-K-144, 199-K-145, 199-K-146, 199-K-150, and 199-K-162.



5.0 100-KR-4 PUMP-AND-TREAT EXPANSION MONITORING PROGRAM

This section discusses the approach for monitoring performance of the 100-KR-4 pump-and-treat system and the method for assessing system effectiveness. The monitoring program is displayed in Table 5-1 and will include the following distinct monitoring elements:

- Compliance monitoring: The objectives for compliance monitoring are to perform the appropriate sampling, analysis, and data evaluation necessary to meet the requirements of the 100-KR-4 OU interim action ROD (EPA et al. 1996).
- Performance monitoring: The objectives for performance monitoring are to obtain water-level and water quality data necessary to optimize performance of the groundwater extraction system, to document aquifer and chromium plume response to pumping and injection, and to obtain supplemental data to support final remedy selection.
- Operations monitoring: The objectives for operations monitoring are to conduct the appropriate level of sampling, analysis, and equipment inspection to ensure the safe operation and functioning of the groundwater extraction, injection, and treatment systems.

The monitoring activities described in this section are designed to meet the requirements of the 100-KR-4 OU interim action ROD within which the expanded 100-KR-4 pump-and-treat system will be operating. Sampling and analysis procedures to support the performance monitoring and operational monitoring will be conducted in accordance with the updated QAPjP (see Appendix A).

The following wells are designated as compliance wells for the original pump-and-treat system and the expansion described in this document:

- Original 100-KR-4 pump-and-treat system: wells 199-K-18, 199-K-20, 199-K-114A, 199-K-117A, and 199-K-129
- 100-KR-4 expansion: wells 199-K-130, 199-K-131, 199-K-144, 199-K-145, 199-K-146, 199-K-147, 199-K-148, 199-K-150, and 199-K-162.

5.1 100-KR-4 PUMP-AND-TREAT EXPANSION MONITORING APPROACH

This section describes how the expanded 100-KR-4 pump-and-treat system will be monitored to demonstrate its effectiveness and how the monitoring data will be evaluated to show that the RAOs are being met, or that adequate progress is being achieved.

The interim action ROD, which covers 100-KR-4 pump-and-treat implementation and monitoring, describes three RAOs to allow for measurement of success:

- Protect aquatic receptors from chromium-contaminated groundwater discharging to the Columbia River by lowering hexavalent chromium concentration to less than 22 µg/L in compliance wells.
- Protect human health from exposure to groundwater containing above 100 µg/L chromium and other co-contaminants exceeding EPA/Washington State Department of Ecology (Ecology) maximum contaminant concentrations
- Provide information to select a final remedy.

The expanded 100-KR-4 pump-and-treat system was designed to achieve three goals:

- Control the northward migration of the chromium plume before it reaches the 100-NR-2 OU
- Protection of the Columbia River by removing high-concentration areas and eliminating gaps in coverage between existing 100-KR-4 extraction wells
- Remediation of the remainder of the plume to below the 22 µg/L RAO.

5.1.1 Protection of Aquatic Receptors

Protection of aquatic receptors is the primary RAO requiring a high level of data quality and technical consideration. Because it is impractical to routinely monitor chromium concentrations at potential aquatic receptor exposure points, onshore monitoring of groundwater near the river and data evaluation will be used to assess the effectiveness of the expanded 100-KR-4 pump-and-treat system in achieving this objective. Protection of aquatic receptors will be demonstrated by evaluating pump-and-treat monitoring data to show the following:

- Decrease the concentration of chromium in groundwater discharged to the river to below 11 µg/L (and 22 µg/L as measured in near-river wells). Chromium concentrations will be regularly monitored at locations as near to the river as practicable. The wells below have been designated as compliance wells. Some of the wells will also serve as extraction wells to best meet the goals of the interim action.
  - Original 100-KR-4 pump-and-treat system: wells 199-K-18, 199-K-20, 199-K-114A, 199-K-117A, and 199-K-129
  - 100-KR-4 expansion: wells 199-K-130, 199-K-131, 199-K-144, 199-K-145, 199-K-146, 199-K-147, 199-K-148, 199-K-150, and 199-K-162.
- Establish hydraulic gradient control. Groundwater elevations will be measured in selected wells adjacent to and inland from the river. A decreased hydraulic gradient between the aquifer and the river, or groundwater flow from the river toward the extraction wells, will be a positive indication of interim action effectiveness.

5.1.2 Protection of Human Health

The primary pathway for human exposure to groundwater containing chromium and other co-contaminants is seeps along the riverbank. Control of this pathway will be achieved by implementing the following actions for the duration of the interim action, or until such time that the pathway is eliminated or contaminant concentrations decline below health-based levels:

- Maintain institutional controls that prevent access to areas where seeps or ground water which contain contaminants above MCLs and risk-based levels to only those activities authorized in this remedial action
- Maintain signs along the river shoreline within the 100-KR-4 area, indicating a restricted access area.
- Modify, if necessary, the existing groundwater-used notification to identify areas where chromium and other co-contaminants exceed protective levels. The notification would consist of maps and narrative descriptions of areas where groundwater use is restricted.

5.1.3 Provide Information for Final Remedy

Monitoring of the expanded 100-KR-4 pump-and-treat system will generate data that can be used to assess the cost and technical feasibility of the pump-and-treat operation to decrease contaminant concentrations to levels protective of human health and the environment. During system operations, information will be reported annually on treatment cost, system efficiency, hydraulic impacts, and contaminant removal efficiency. The following subsections describe the approach that will be used for calculating these parameters.

5.1.3.1 Treatment Cost. The cost of treatment will be determined on the basis of dollars per liter of groundwater extracted and gram of chromium removed. The cost will be determined using the expanded 100-KR-4 pump-and-treat system (amortized over an assumed 10-year design lifetime), plus annual operations and maintenance costs, divided by the annual volume of groundwater extracted.

5.1.3.2 System Efficiency. System efficiency will be based collectively on chromium removal efficiency and system on-line percentage. Chromium removal efficiency will be determined based on the percentage of chromium removed by the system. This will involve subtracting the effluent from the influent concentration and dividing by the influent concentration. System on-line percentage will be determined by dividing the time that the GTS operates by the total time available for operation. Extraction well flow rates during the year will vary with river stage.

5.1.3.3 Hydraulic Impacts. An analytical model will be used to assess the hydraulic impacts of the expanded 100-KR-4 pump-and-treat system on capturing the chromium plume based on fall ground water levels and river stage.

5.1.3.4 Effectiveness of Contaminant Removal. The effectiveness of chromium removal will be determined using monitoring results after the expanded 100-KR-4 pump-and-treat interim action is terminated. Co-contaminants will not be included in this evaluation because they are not the subject of the interim action.

5.2 APPROACH FOR MONITORING SYSTEM DESIGN REQUIREMENTS

In addition to collecting data necessary to satisfy the RAOs, the interim action ROD (EPA et al. 1996) contains specific requirements for the design of the interim action monitoring network. These requirements include the following for the expanded pump-and-treat remedial action:

- Compliance points will be near-river wells located above the common high-water mark that are listed below:
  - Original 100-KR-4 pump-and-treat system: wells 199-K-18, 199-K-20, 199-K-114A, 199-K-117A, and 199-K-129
  - 100-KR-4 expansion: wells 199-K-130, 199-K-131, 199-K-144, 199-K-145, 199-K-146, 199-K-147, 199-K-148, 199-K-150, and 199-K-162
- Baseline sampling (pre-startup) will be conducted prior to startup of pump-and-treat operations in all new wells

- Sampling and hexavalent chromium analysis will be conducted weekly in extraction wells and monthly in compliance and performance wells for at least 3 months after startup of operations. Subsequently, extraction and compliance wells will be sampled at least monthly and performance wells will be sampled quarterly (Table 5-1).

The analyte list shall include the following:

- Unfiltered hexavalent chromium
- Specific conductance
- Temperature, pH, turbidity, and dissolved oxygen
- Tritium, strontium-90, carbon-14, and technetium-99.

The depth to water will be measured each time the well is sampled.

Compliance wells are necessary to assess the effect of the pump-and-treat system on the plume and to identify when the system has reached the RAO. The compliance wells are sampled to obtain water quality data and water-level data as close to the river as practicable. Data collected from the compliance wells will be used to assess the effectiveness of the interim action at protecting aquatic receptors. Because of access and space limitations along the river, and the effect of river stage on wells located near the Columbia River, some extraction wells will be used as compliance wells.

Performance wells are monitoring wells used for water-level and less frequent water quality measurements at inland areas and will provide verification of interim action effectiveness at reducing chromium flux toward the river. The five performance wells (199-K-151, 199-K-152, 199-K-153, 199-K-156, and 199-K-157) will be monitored quarterly after the 3-month startup to provide information regarding the effectiveness of the initial well network at remediating the plume in a timely manner. Data from these wells will also help evaluate whether additional wells are necessary or whether changes in well use (e.g., converting performance wells to extraction or injection wells) should be considered. These locations will be identified after monitoring system startup has been completed.

5.2.1 Monitoring Well Construction and Location

Monitoring wells will be constructed similar to extraction or injection wells and in accordance with *Washington Administrative Code* (WAC) 173-160 standards. New wells will be constructed so the well screen fully penetrates the saturated thickness of the aquifer to provide improved monitoring flexibility, to promote cost effectiveness, and to enable the wells to be converted to extraction wells or injection wells as needed to complete remediation. Transducers will be installed in selected wells to help evaluate plume capture. See Figures 4-1 and 4-2 for construction details.

5.2.2 Monitoring Parameters

Interim action performance will be based on the ability to capture the existing plume, hydraulically control chromium flux to the river, and reduce contaminant mass so interim action can be terminated. Proposed monitoring parameters include water-level measurements, field hexavalent chromium, co-contaminants, and the field parameters described in Section 5.2.

Pressure transducers will be installed in extraction wells, injection wells, and selected performance wells to help assess the effect of operations on the local hydrology (Table 5-1). Water-level data from the extraction wells and injection wells are available on a real-time basis

through the OIC (Operator Interface Control). Water-level data from compliance and performance monitoring wells will either be manually downloaded or telemetered to a central project location. The data will also be available in the Hanford Environmental Information System (HEIS) database.

Hexavalent chromium samples from monitoring wells will be analyzed at the Waste Sampling and Characterization Facility (WSCF) using a modified version of the EPA 7196 method. The practical quantitation limit of this colorimetric method is approximately 5 µg/L. Quality control (QC) will initially be provided through a 10% field duplicate and spike samples and 10% sample splits with an EPA-certified laboratory. These requirements may be reduced to 5% field duplicates and 5% field splits after review of QC results and concurrence by EPA.

Samples associated with routine pump-and-treat operations are collected and analyzed for hexavalent chromium by operators using a Hach® kit. The estimated practical quantitation limit for this method is 10 µg/L.

Monitoring for co-contaminants will be performed over the course of the interim action to obtain information for final remedy selection. The interim action ROD (EPA et al. 1996) identified the 100-KR-4 OU co-contaminants as tritium and strontium-90. Carbon-14 and technetium-99 are contaminants of interest. Monitoring for co-contaminants will be semi-annually in extraction wells and GTS influent and effluent; performance wells will be sampled annually for co-contaminants. Analyses will be performed by certified laboratories using methods listed in Table A-1 (Appendix A).

5.2.3 Sampling Frequency

Prior to system startup, an initial average chromium concentration will be established for each new well. The average will include several samples collected over the timeframe between well construction and system startup. An average concentration of several samples reduces the impact of temporal fluctuations, which could result in a biased high or low initial concentration.

During the first 3 months of operation (i.e., the startup period), extraction wells will be tested weekly and performance monitoring wells will be tested monthly for chromium to provide timely information on initial interim action performance. At the end of the 3-month startup period, the sampling frequency will be reduced to monthly for extraction and compliance wells and quarterly for performance wells until such time that an alternate frequency is warranted with EPA approval.

Sampling for co-contaminants will be performed semi-annually at each of the extraction well locations and from the GTS influent and effluent. This frequency will be maintained until an alternate frequency is determined with EPA approval. Sampling locations, parameters, and their frequencies are shown in Table 5-1.

5.2.4 Vertical Sampling

During the pre-startup period, extraction wells 199-K-130 and 199-K-131 will be sampled at multiple depths to assess the vertical distribution of chromium in the aquifer. Samples will be collected using an inflatable packer, Kabis™ sampler, or equivalent device to isolate discrete intervals from which the sample will be withdrawn. The samples will be collected at 1.5-m (5-ft) intervals to document chromium concentrations at all depths prior to remediation. The sampling

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will be conducted concurrently with the pre-startup baseline sampling. Test results will be used to determine whether vertical sampling should be incorporated into the expanded 100-KR-4 pump-and-treat monitoring program.

5.2.5 Sediment Sampling During Well Drilling

Several different types of samples will be collected during drilling of wells to provide archive samples, samples for chemical analysis, and to confirm the selection of well-screen slot size. Samples will be collected in accordance with existing procedures to the extent those procedures do not contradict this RDR/RAWP supplement.

- Archive sampling:
  - The primary purpose of collecting sediment samples during well drilling is to describe the materials on a geologic log that will be used to characterize local geologic units and also optimally site the well screen.
  - In addition, the geologist will collect cutting from surface to total depth at 1.5-m (5-ft) intervals, at changes in lithology, and in areas of suspicious coloration (e.g., stained soil). These samples will be archived so they can be reviewed at a later date if necessary.
- Samples collected for chemical analysis:
  - Split-spoon samples will be collected 1.5 and 3 m (5 and 10 ft) above the average water level in proposed extraction wells 199-K-161, 199-K-147, 199-K-148, and 199-K-149 and in proposed wells 199-K-144, 199-K-145, 199-K-146, 199-K-150, and 199-K-162. These wells are downgradient of the 116-K-2 Trench where the mounding during operations was likely the highest and the soil column was saturated from the surface to the existing water table (currently at a depth of about 21.3 m [70 ft]). These samples will be analyzed for hexavalent chromium using Method 7196A.
  - Suspiciously stained sediment from other wells can be processed similarly.
- Samples collected for particle size analysis:
  - Two split-spoon samples will be collected from the saturated zone in each well. The finer of the two samples will be selected for a sieve analysis that will provide particle size distribution. This distribution will be used to help confirm the suitability of the screen slot size.

5.3 TREATMENT SYSTEM PERFORMANCE CRITERIA APPROACH

The interim action ROD (EPA et al. 1996) requires that the GTS meet the following performance requirements:

- The GTS will reduce effluent chromium concentrations to the maximum extent practicable; however, groundwater above 50 µg/L will not be discharged.
- The extraction and treatment system will be designed and operated to run on an essentially continuous basis.
- The expanded 100-KR-4 pump-and-treat system will continue until selection of the final action, or until termination is determined to be appropriate.

5.3.1 Monitoring for Groundwater Treatment System Removal Efficiency and Injection Discharge

The interim action ROD (EPA et al. 1996) requires that the GTS remove chromium to the maximum extent practicable, with chromium concentrations not to exceed 50 µg/L in the GTS discharge. This requirement will be met through analysis of GTS influent and effluent samples.

During the startup period, GTS effluent sampling and analysis will be conducted weekly. The weekly data will be used for comparison with the 50 µg/L discharge limit and a target treatment level to be developed during the startup and operations periods. The target treatment level will represent a balance between the level that is technically feasible, cost effective, and optimizes resin use. Chromium removal efficiency will be determined from the difference between the weekly influent and effluent concentrations. The maximum 100-KR-4 effluent concentration in 2006 from the existing system was about 15 µg/L (DOE/RL-2006-76).

Analysis of samples collected from the GTS will be performed using the modified Hach method. Field analysis provides the most effective method for obtaining timely information on GTS operation. Laboratory confirmation of field analysis results will be performed initially on a weekly basis until confidence in field analyses is established. After establishing the precision of field analyses, laboratory confirmation analyses can be reduced to a monthly or quarterly frequency as approved by EPA.

5.3.2 Design for System Operation Efficiency

The groundwater extraction and treatment systems have been designed to operate on an essentially continuous basis. The design allows various system components to be isolated for maintenance and repair, thereby allowing other system components to continue operating.

5.3.3 Resin Regeneration and Disposal

Resin that has been saturated will be regenerated and reused until it must be replaced so frequently that it is no longer cost effective to use. All resins sent to ERDF to date from the existing 100-KR-4 and KW pump-and-treat facilities have passed TCLP-chromium disposal requirements.

5.4 INTERIM ACTION TERMINATION

The interim action ROD (EPA et al. 1996) provides three criteria for termination of the interim action: (1) successful completion of the interim action is demonstrated, (2) the interim action is no longer effective, and (3) a final remedy is selected. The proposed criteria for termination are described in the following subsections.

5.4.1 Successful Completion of the Interim Action

Successful completion of the interim action will be based on its ability to remove chromium to a level that provides long-term protection of aquatic receptors in the river. This success will be measured by water quality samples collected from the extraction wells. Pumping of the extraction wells will continue as long as chromium concentrations remain above 22 µg/L. Once water quality samples from the extraction wells have attained the RAO of 22 µg/L or below, the extraction wells will be turned off and will be sampled on a quarterly basis for one year and the data used to calculate an upper-confidence interval using methodology described in WAC 173-340-720(8)(e). If, at the end of the 1-year monitoring period, the upper-confidence

interval is less than the protective level, a request for interim action termination would be submitted. If, at any time during the 1-year compliance monitoring period the data indicate a confirmed increase above the protective level, the system would be restarted.

The pump-and-treat portion of the remedial action will continue until the selection of a final action or it is demonstrated to EPA's and Ecology's satisfaction that termination (of intermittent operation) is appropriate because (1) sampling indicates that hexavalent chromium is below the compliance value, and site data indicate that it will remain below the compliance value, or (2) based on an evaluation of the following criteria:

- The effectiveness of the treatment technology does not justify further operation.
- An alternate treatment technique, such as in situ chemical reduction or other improved treatment technique is evaluated and proves to be more effective, and/or less costly and is consistent with RAOs.

5.4.2 Interim Action No Longer Cost Effective

If the cost of chromium removal from the aquifer increases disproportionately to the environmental benefit received, the expanded 100-KR-4 interim action may no longer be cost effective. Additionally, if new technologies are developed that provide equivalent or greater environmental protection at a lower cost, the current interim action may no longer be cost effective. Any cost-effectiveness determination would be studied carefully and EPA concurrence obtained before implementation.

5.4.3 Selection of a Final Remedy

Selection of a final remedy includes evaluation of cumulative risks associated with residual contamination resulting from cleanup of the 100-KR-4 chromium plume or failure to reach cleanup goals because cleanup was determined to be technically impracticable. Prior to selecting a final remedy, a baseline risk assessment will be performed to assess the human health and ecological exposures that result from all remaining contaminants. A finding that unacceptable risk levels still remain would require that additional cleanup alternatives be evaluated and a final feasibility study report prepared. The final feasibility study report would be the basis for a final proposed plan and ROD.

5.5 REPORTING OF 100-KR-4 PUMP-AND-TREAT EXPANSION INTERIM ACTION DATA

The expanded 100-KR-4 pump-and-treat well chemistry and water-level data for the expanded 100-KR-4 system will be available for review in the HEIS database. The project performance will be reported as a section in the calendar year annual summary report for the 100-KR-4 pump-and-treat operations that is transmitted to EPA by May 31 each year. A semi-annual technical memorandum that is essentially a data transmittal will also be prepared to cover the period of January 1 through June 30 each year. These reports will highlight significant operational or monitoring changes observed during the reporting period.

Table 5-1. 100-KR-4 Pump-and-Treat Monitoring Schedule. (2 sheets)

Sample Group	Pre-Startup			Startup[d]			Operation		
	Water Level	Cr [b,c]	Co-Contaminants[a,c]	Water Level	Cr [b,c]	Co-Contaminants[a,c]	Water Level	Cr [b]	Co-Contaminants[a,c]
Extraction/Compliance Wells									
199-K-114A	Existing 100-KR-4 pump-and-treat network								
199-K-129									
199-K-130	T	X/Y	X	T	W	--	T	M	SA
100-K-131	T	X/Y	X	T	W	--	T	M	SA
100-K-147	T	X	X	T	W	-	T	M	SA
100-K-148	T	X	X		W	-	T	M	SA
100-K-149	T	X	X	T	W	-	T	M	SA
100-K-161	T	X	X	T	W	-	T		SA
Compliance Wells									
199-K-18	Existing 100-KR-4 pump-and-treat network						T	M	A
199-K-20							T	M	A
199-K-117A							T	M	A
199-K-144	T	X	X	T	M	-	T	Q	A
199-K-145	T	X	X	T	M	-	T	Q	A
199-K-146	T	X	X	T	M	-	T	Q	A
199-K-150	T	X	X	T	M	-	T	Q	A
199-K-162	T	X	X	T	M	-	T	Q	A
Injection Wells									
199-K-154	T	X	X	T	--	--	T	--	--
199--K-163	T	X	X	T	--	--	T	--	--
199-K-159	T	X	X	T	--	--	T	--	--

Table 5-1. 100-KR-4 Pump-and-Treat Monitoring Schedule. (2 sheets)

Sample Group	Pre-Startup			Startup[d]			Operation		
	Water Level	Cr [b,c]	Co-Contaminants[a,c]	Water Level	Cr [b,c]	Co-Contaminants[a,c]	Water Level	Cr [b]	Co-Contaminants[a,c]
199-K-160	T	X	X	T	--	--	T	--	--
Performance Wells									
199-K-151	T	X	X	T	M	--	T	Q	A
K-152	T	X	X	T	M	--	T	Q	A
K-153	T	X	X	T	M	--	T	Q	A
K-156	T	X	X	T	M	--	--	Q	A
K-157	T	X	X	T	M	--	T	Q	A
Treatment System									
Influent	--	--	--	--	W	--	--	M	SA
Effluent	--	--	--	--	W	--	--	M	SA

[a] Co-contaminants per the Record of Decision for the 100-HR-3 and 100-KR-4 Operable Units (EPA et al. 1996) are strontium-90 and tritium. Carbon-14 and technetium-99 are contaminants of interest.

[b] Groundwater samples associated with routine pump-and-treat operations are analyzed for hexavalent chromium by operators using a Hach ® kit. All other samples are analyzed at Waste Sampling and Characterization Facility using EPA Method 7196.

[c] Specific conductance, temperature, pH, turbidity, and dissolved oxygen will be measured for all laboratory samples.

[d] Startup duration is approximately 3 months.

A = annual M = monthly Q = quarterly SA = semi-annually
T = hourly transducer W = weekly X = one-time event Y = vertical profiling using Kabis ™ sampler

Hach® is a registered trademark of the Hach Company, Loveland, Colorado.

6.0 SCHEDULE

The following milestones are established for the expansion of the 100-KR-4 pump-and-treat system:

- December 31, 2008: The nominal 1,135.6 L/min (300-gpm) system expansion of the 100-KR-4 pump-and-treat system becomes operational.
- December 31, 2009: An additional 378.5 L/min (100-gpm) capacity is added to the 100-KR-4 system expansion and the expanded system becomes operational.

A system becomes operational after acceptance testing and operational testing have been completed.

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APPENDIX A

QUALITY ASSURANCE PROJECT PLAN

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LIST OF TERMS

ALARA	as low as reasonably achievable
CFR	*Code of Federal Regulations*
CRDL	contract-required detection limit
DOE	U.S. Department of Energy
DQO	data quality objective
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
ERDF	Environmental Restoration Disposal Facility
FH	Fluor Hanford, Inc.
HEIS	Hanford Environmental Information System
MCL	maximum contaminant level
MDC	minimum detectable concentration
OU	operable unit
PHMC	Project Hanford Management Contractor
PNNL	Pacific Northwest National Laboratory
QA	quality assurance
QC	quality control
QAPjP	quality assurance project plan
RAO	remedial action objective
RCT	radiological control technician
RDR/RAWP	remedial design report/remedial action work plan
RL	U.S. Department of Energy, Richland Operations Office
SAF	Sampling Authorization Form
SAP	sampling and analysis plan
Tri-Party *Agreement*	*Hanford Federal Facility Agreement and Consent Order*

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APPENDIX A

QUALITY ASSURANCE PROJECT PLAN

A1.0 INTRODUCTION

This quality assurance project plan (QAPjP) supports the data collection activities associated with monitoring the 100-KR-4 pump-and-treat-system expansion, which is described in the main text of this document. The monitoring activities will include well sampling and analytical testing to support pump-and-treat operations and to assess the impact of the remedial action on the chromium plume. Water-level measurements will also be conducted to provide hydraulic-head data to help evaluate capture of the plume by the extraction well network and the impact of injection.

The 100-KR-4 pump-and-treat-system expansion will consist of six extraction/compliance wells and four injection wells. In addition, 10 dual-purpose monitoring wells will be installed to help evaluate the effect of the expansion on the existing hexavalent chromium plume.

The selected groundwater treatment system incorporates an ion-exchange system using the Dowex® 21K resin that has successfully removed hexavalent chromium for the existing 100-HR-3 and 100-KR-4 Operable Unit (OU) pump-and-treat-systems. Spent resin will be regenerated, if feasible. Resin that cannot be regenerated will be sent to the Environmental Restoration Disposal Facility (ERDF), which is a low-level waste facility located on the Hanford Site.

A1.1 BACKGROUND AND LOCATION

Background information on contamination in the 100-KR-4 OU is available in *Calendar Year 2006 Annual Summary Report for the 100-HR-3, 100-KR-4, and 100-NR-2 Pump-and-Treat Operations* (DOE-RL-2006-76). A brief description of the conceptual model is provided in Section 2.0 in the main text of this remedial design report/remedial action work plan (RDR/RAWP) supplement. Historical hydrochemical data are available electronically in the Hanford Environmental Information System (HEIS) database and in *Conceptual Site Models for Groundwater Contamination at the 100-BC-5, 100-KR-4, 100-HR-3, and 100-FR-3 Operable Units* (BHI-00917).

The expanded 100-KR-4 pump-and-treat-system will be located in the 100-KR-4 OU, in the vicinity of the 116-K-2 Trench. Figure A-1 shows the locations of the proposed and existing wells in the project area.

A1.2 SITE DESCRIPTION AND HISTORY

The hexavalent chromium contaminant plume that is the target of this interim action is essentially parallel to the 116-K-2 Trench and extends from the 116-K-1 Crib to the south edge of the 100-NR-2 OU. The highest 2007 concentrations were 156 μg/L in well 199-K-18.

DOWEX® is a registered trademark of Dow Chemical Company, Midland, Michigan.

Sodium dichromate was added to reactor coolant water as a rust inhibitor while the reactor was operational from 1955 to 1970.

A1.3 CONTAMINANTS OF CONCERN

The interim action is being implemented to address the hexavalent chromium plume centered on the 116-K-2 Trench. The co-contaminants, which are constituents that may be above maximum contaminant levels (MCLs), are tritium and strontium-90.

A1.4 DATA QUALITY OBJECTIVES

The data quality objectives (DQO) process was used to prepare the sampling and analytical requirements for monitoring the 100-KR-4 pump-and-treat-system, as described in the *Interim Action Monitoring Plan for the 100-HR-3 and 100-KR-4 Operable Units* (DOE/RL-96-90). The sampling and analytical requirements for the 100-KR-4 pump-and-treat-system expansion have been carried over from the 100-KR-4 OU to the 100-KR-4 pump-and-treat-system.

A2.0 QUALITY ASSURANCE PROJECT PLAN

This QAPjP establishes the quality requirements for environmental data collection, including sampling, field measurements, and laboratory analysis. The QAPjP has been updated from the QAPjP in the *Interim Action Monitoring Plan for the 100-HR-3 and 100-KR-4 Operable Units* (DOE/RL-96-90) because an additional pump-and-treat-system has been added and the contractor changed from Bechtel Hanford, Inc. to Fluor Hanford, Inc. (FH). This QAPjP complies with the requirements of the following:

- U.S. Department of Energy (DOE) O 414.1C, *Quality Assurance*
- 10 *Code of Federal Regulations* (CFR) 830, Subpart A, "Quality Assurance Requirements"
- *EPA Requirements for Quality Assurance Project Plans* (EPA QA/R-5).

The following sections describe the quality requirements and the controls applicable to this investigation.

A2.1 PROJECT MANAGEMENT

The following subsections address the basic areas of project management, ensuring that the project has a defined goal, that the participants understand the goal and approach to be used, and that the planned outputs have been appropriately documented.

A2.1.1 Project/Task Organization

The Project Hanford Management Contractor (PHMC) Groundwater Remediation Project is responsible for planning, coordinating, sampling, preparing, packaging, and shipping soil samples to the laboratory. The project organization is described in the subsections that follow and is shown in Figure A-2.

A2.1.2 Groundwater Remediation Project Manager

The Groundwater Remediation Project Manager provides oversight for all activities and coordinates with the U.S. Department of Energy, Richland Operations Office (RL) and the regulators in support of sampling activities. In addition, the Groundwater Remediation Project Manager provides support to the 100 Areas Task Lead to ensure that work is performed safely and cost effectively. The Groundwater Remediation Project Manager maintains the approved QAPjP.

A2.1.3 100 Areas Task Lead

The 100 Areas Task Lead is responsible for direct management of sampling documents and requirements, field activities, and subcontracted tasks. The Task Lead works closely with Quality Assurance (QA), Health and Safety, and the Field Team Lead to integrate these and the other lead disciplines in planning and implementing the workscope. The 100 Areas Task Lead also coordinates with, and reports to, RL and the PHMC on all sampling activities. The 100 Areas Task Lead supports RL in coordinating sampling activities with the regulators.

A2.1.4 Quality Assurance Engineer

The QA Engineer is matrixed to the Groundwater Remediation Project Manager and is responsible for QA issues on the project. Responsibilities include oversight of implementation of the project QA requirements, review of project documents (including sampling and analysis plans [SAPs] and the QAPjP), and participation in QA assessments on sample collection and analysis activities, as appropriate.

A2.1.5 Waste Management Lead

The Waste Management Lead communicates policies and procedures and ensures project compliance for storage, transportation, disposal, and waste tracking in a safe and cost-effective manner. Other responsibilities include identifying waste management sampling/characterization requirements to ensure regulatory compliance of the characterization data to generate waste designations, profiles, and other documents that confirm compliance with waste acceptance criteria.

A2.1.6 Field Team Lead

The Field Team Lead has the overall responsibility for the planning, coordinating, and executing field characterization activities. Specific responsibilities include converting the sampling design requirements into field task instructions that provide specific direction for field activities. Responsibilities also include directing training, mock-ups, and practice sessions with field personnel to ensure that the sampling design is understood and can be performed as specified. The Field Team Lead communicates with the 100 Areas Task Lead to identify field constraints that could affect the sampling design. In addition, the Field Team Lead directs the procurement and installation of materials and equipment needed to support field work.

The Field Team Lead oversees field sampling activities that include sample collection, packaging, provision of certified clean sampling bottles/containers, documentation of sampling activities in controlled logbooks, chain-of-custody documentation, and packaging and transportation of samples to the laboratory or shipping center.

The Field Team Lead, samplers, and others responsible for implementation of the SAP and QAPjP will be provided with current copies of this document and any revisions thereto.

A2.1.7 Radiological Engineering Lead

The Radiological Engineering Lead is responsible for the radiological engineering and health physics support to the project. Specific responsibilities include conducting as low as reasonably achievable (ALARA) reviews, exposure and release modeling, and radiological controls optimization for all work planning. In addition, radiological hazards are identified and appropriate controls are implemented to maintain worker exposures to the hazards ALARA. The Radiological Engineering Lead interfaces with the project Health and Safety Representative and plans and directs radiological control technician (RCT) support for all activities.

A2.1.8 Sample and Data Management

The Sample and Data Management organization selects the laboratories that perform the analyses. This organization also ensures that the laboratories conform to Hanford Site internal laboratory QA requirements (or equivalent), as approved by RL, the U.S. Environmental Protection Agency (EPA), and the Washington State Department of Ecology (Ecology). Sample and Data Management receives the analytical data from the laboratories, enters the data into the HEIS database, and arranges for data validation. Validation will be performed on 10% of completed data packages by qualified PHMC personnel or by a qualified independent contractor.

A2.1.9 Health and Safety Representative

The responsibilities of the Health and Safety Representative include coordinating industrial safety and health support to the project as carried out through health and safety plans, activity job hazard analyses, and other pertinent safety documents required by Federal regulations or by internal FH work requirements. In addition, assistance is provided to project personnel in complying with applicable health and safety standards and requirements. Personal protective clothing requirements are coordinated with Radiological Engineering.

A2.2 PROBLEM DEFINITION/BACKGROUND

The purpose of the 100-KR-4 pump-and-treat-system expansion is to address the hexavalent chromium plume that presents a threat to human health or the environment. The interim action will achieve three remedial action objectives (RAOs) that were identified in *Record of Decision for the 100-HR-3 and 100-KR-4 Operable Units* (EPA et al. 1996), namely the following:

- Protect aquatic receptors from chromium-contaminated groundwater discharging to the Columbia River above 22 μg/L as measured in compliance wells

- Protect human health from exposure to groundwater containing chromium and other co-contaminants exceeding EPA/Ecology MCLs
- Provide information to select a final remedy

Extraction/compliance wells and monitoring wells must be sampled to verify that progress is being made to reach the three RAOs listed above. Influent into the groundwater treatment system and treated effluent are also sampled and analyzed to confirm satisfactory system operations.

A2.3 PROJECT/TASK DESCRIPTION

The monitoring elements and their objectives for this project are listed below:

- Operational monitoring: The objective for operational monitoring is to conduct the appropriate level of sampling, analysis, and equipment inspection necessary for safe operation and function of the pump-and-treat-system to treat to the maximum extent practicable, protecting the Columbia River and removing contaminant mass. Extraction wells, injection wells, influent, effluent, and the treatment system are sampled as part of this monitoring. Chromium removal efficiency is also calculated.
- Compliance monitoring: The objective for compliance monitoring is to perform the appropriate level of sampling, analysis, and data evaluation to determine whether the groundwater chemistry requirements of the interim action have been achieved.
- Performance monitoring: The objective for performance monitoring is to obtain water quality and groundwater-level data from monitoring wells within the plume area to determine whether groundwater extraction is reducing contaminant concentrations in the plume and to provide data to assess plume capture.

The use of individual wells in the network may change to respond to change or lack of change in groundwater chemistry.

A2.4 QUALITY OBJECTIVES AND CRITERIA

The QA objective of this plan is to develop implementation guidance that will provide data of known and appropriate quality. Data quality is assessed by accuracy and precision. The applicable quality control (QC) guidelines, quantitative target limits, and levels of effort for assessing data quality are dictated by the intended use of the data and the nature of the analytical method. Each of these is addressed below.

Groundwater quality objectives and criteria for measurement data are presented in Table A-1.

A2.4.1 Accuracy

Accuracy is an assessment of the closeness of the measured value to the true value. Accuracy of chemical test results is assessed by spiking samples with known standards and establishing the average recovery. A matrix spike is the addition to a sample of a known amount of a standard compound similar to the compounds being measured. For radionuclide measurements that are analyzed by gamma spectroscopy, laboratories typically compare results of blind audit samples against known standards to establish accuracy. Validity of calibrations are evaluated by

comparing results from the measurement of a standard to known values and/or by generation of in-house statistical limits based on three standard deviations (±3 standard deviations). Table A-1 lists the accuracy requirements for fixed laboratory analyses for the project.

A2.4.2 Precision

Precision is a measure of the data spread when more than one measurement has been taken on the same sample. Precision can be expressed as the relative percent difference for duplicate measurements. Analytical precision requirements for fixed laboratory analyses are listed in Table A-1.

A2.4.3 Detection Limits

Detection limits are functions of the analytical method used to provide the data and the quantity of the sample available for analyses. The minimum detection concentrations for radiological co-contaminants and contract-required detection limits (CRDLs) for hexavalent chromium and nitrate are listed in Table A-1.

A2.5 SPECIAL TRAINING/CERTIFICATION

Typical training or certification requirements have been instituted by the PHMC team to meet training requirements imposed by the Project Hanford Management Contract, regulations, DOE orders, contractor requirements documents, American National Standards Institute/American Society of Mechanical Engineers standards, the *Washington Administrative Code*, etc., for example:

- Training or certification requirements needed by sampling personnel will be in accordance with Hanford Site analytical quality requirements.

The environmental health and safety training program provides workers with the knowledge and skills necessary to safely execute assigned duties. Field personnel typically will have completed the following training before starting work:

- Occupational Safety and Health Administration 40-Hour Hazardous Waste Worker Training and supervised 24-hour hazardous waste site experience
- 8-Hour Hazardous Waste Worker Refresher Training (as required)
- Hanford General Employee Radiation Training
- Radiological Worker Training.

A graded approach is used to ensure that workers receive a level of training that is commensurate with their responsibilities and that complies with applicable DOE orders and government regulations. Specialized employee training includes pre-job briefings, on-the-job training, emergency preparedness, plan-of-the-day activities, and facility/worksite orientations.

Field personnel training records will be documented and kept on file by the training organization.

A2.6 DOCUMENTATION AND RECORDS

The 100 Areas Task Lead ensures that the Field Team Lead, samplers, and others responsible for implementation of the SAP and QAPjP are provided with current copies of this document and any revisions thereto.

Documentation and records, regardless of medium or format, are controlled in accordance with internal work requirements and processes that comprise a collection of document control systems and processes that use a graded approach for the preparation, review, approval, distribution, use, revision, storage/retention, retrieval, disposition, and protection of documents and records generated or received in support of FH work.

All information pertinent to field sampling and analysis will be recorded in bound logbooks. The sampling team will be responsible for recording all relevant sampling information in the logbooks. Entries made in the logbooks will be dated and signed by the individual making the entry.

Primary documents under the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al. 2003) (e.g., supplements to the RDR/RAWP, such as this document) will be submitted to the Administrative Record. All other documentation will be prepared, approved, and maintained in accordance with RL and contractor requirements for these processes.

A3.0 DATA GENERATION AND ACQUISITION

This section presents the requirements for sampling methods, sample handling and custody, analytical methods, and field and laboratory QC. Instrument calibration, maintenance supply inspection, and data management requirements are also addressed.

A3.1 SAMPLING PROCESS DESIGN

The goal of the operational sampling for the 100-KR-4 pump-and-treat-system expansion is to provide influent and effluent groundwater chemistry data to help calculate percent saturation of the resin and to breakthrough that could result in high chromium concentrations in treated effluent. Sampling will be conducted approximately weekly in the treatment train to account for fluctuations in influent concentrations that could lead to breakthrough concentrations in the effluent. Sampling frequency may decrease as trends are established.

The extraction wells will also be sampled to provide a check on the overall influent concentrations and also to provide information on the effect of river stage on groundwater chemistry. These wells will be sampled weekly to monthly during system startup and on a monthly to quarterly basis during operations. Sampling frequency may change as trends are established, or the use of individual wells in the pump-and-treat network and may be adjusted to optimize the efficiency of the system.

Performance wells will be sampled quarterly to assess the effect of remediation on the chromium contaminant plume.

Extraction well samples will be analyzed for co-contaminants strontium-90, carbon-14, tritium, and nitrate, as the Dowex 21K resin will not remove these contaminants and they will be reinjected.

Sample design specifications are presented in Section 3.0 in the main text of this document.

A3.2 SAMPLING METHODS

The proposed well and treatment train sampling for the 100-KR-4 pump-and-treat-system expansion will be performed in accordance with established sampling practices and requirements pertaining to sample collection, collection equipment, and sample handling.

Preservation requirements, containers, and holding times for chemical and radiological analytes of interest are presented in Table A-2. Final sample collection requirements will be identified on the Sampling Authorization Form (SAF).

If samples are not collected as scheduled or if insufficient quantity is collected or temperature controls or preservation requirements are not implemented, the 100 Areas Task Lead will be notified. The 100 Areas Task Lead and the Sample and Data Management Project Coordinator will decide whether a resampling is required.

Additional details on sampling methods are provided in Section 3.0 in the main text of this document.

A3.3 SAMPLE HANDLING AND CUSTODY

Level I EPA pre-cleaned sample containers will be used for samples collected for laboratory chemical and radiological analysis. Container sizes may vary depending on laboratory-specific volumes/requirements for meeting analytical detection limits. If, however, the dose rate on the outside of a sample jar or the curie content exceeds levels acceptable by an offsite laboratory, the Sampling Lead and Waste Site Remediation Task Lead can send smaller volumes to the laboratory after consultation with Sample and Data Management to determine acceptable volumes. The final container types and volumes will be indicated on the SAF.

The FH Sample and Data Tracking database will be used to track the samples from the point of collection through the laboratory analysis process. The HEIS database is the repository for the laboratory analytical results. The HEIS sample numbers will be issued to the sampling organization for this project in accordance with onsite organization procedures. Each chemical/ radiological and physical properties sample will be identified and labeled with a unique HEIS sample number. The sample location, depth, and corresponding HEIS numbers will be documented in the sampler's field logbook.

Each sample container will be labeled with the following information using a waterproof marker on firmly affixed, water-resistant labels:

- SAF
- HEIS number
- Sample collection date/time
- Name of person collecting the sample

- Analysis required
- Preservation method (if applicable).

A3.4 LABORATORY SAMPLE CUSTODY

Sample custody during laboratory analysis will be addressed in the applicable laboratory standard operating procedures. Laboratory custody procedures will ensure the maintenance of sample integrity and identification throughout the analytical process.

All information pertinent to field sampling and analysis will be recorded in field checklists and bound logbooks in accordance with existing sample collection protocols. The sampling team will be responsible for recording all relevant sampling information. Entries made in the logbook will be dated and signed by the individual making the entry. Program requirements for managing the generation, identification, transfer, protection, storage, retention, retrieval, and disposition of records by the PHMC also will be followed.

Sample custody will be maintained in accordance with existing Hanford Site protocols. The custody of samples will be maintained from the time that the samples are collected until the ultimate disposal of the samples, as appropriate. A chain-of-custody record will be initiated in the field at the time of sampling and will accompany each set of samples shipped to any laboratory. Wire or laminated waterproof tape will be used to seal the coolers. The analyses requested for each sample will be indicated on the accompanying chain-of-custody form. Chain-of-custody procedures will be followed throughout sample collection, transfer, analysis, and disposal to ensure that sample integrity is maintained. Each time the responsibility changes for the custody of the sample, the new and previous custodians will sign the record and note the date and time. The sampler will make a copy of the signed record before sample shipment and will transmit the copy to Sample and Data Management within 48 hours of shipping.

A custody seal (i.e., evidence tape) will be affixed to the lid of each sample jar or to the bag containing volatile organic analyte samples in such a way to indicate potential tampering with the sample. The container seal will be inscribed with the sampler's initials and the date.

The RCT will measure the contamination levels on the outside of each sample jar and the dose rates on each sample jar. The RCT also will measure the radiological activity on the outside of the sample container (through the container) and will document the highest contact radiological reading in millirem per hour (mR/hr). This information, along with other data, will be used to select proper packaging, marking, labeling, and shipping paperwork in accordance with U.S. Department of Transportation regulations (49 CFR, "Transportation") and to verify that the sample can be received by the analytical laboratory in accordance with the laboratory's acceptance criteria. The sampler will send copies of the shipping documentation to Sample and Data Management within 48 hours of shipping.

As a general rule, samples with activities of <1 mR/hr will be shipped to an offsite laboratory. Samples with activities between 1 mR/h and 10 mR/hr may be shipped to an offsite laboratory. Samples with dose rates in this range will be evaluated on a case-by-case basis by Sample and Data Management. Samples with activities of >10 mR/h will be sent to an onsite laboratory arranged for by Sample and Data Management.

A3.5 ANALYTICAL METHODS

The analytical parameters and methods are listed in Table A-1. These analytical methods are controlled in accordance with the laboratory's QA plan and the requirements of this QAPjP.

Errors reported by the laboratories are reported to the Sample and Data Management Project Coordinator, who initiates a Sample Disposition Record in accordance with FH procedures. This process is used to document analytical errors and to establish resolution with the Project Task Lead. In addition, the FH QA Engineer receives quarterly reports that provide summaries and summary statistics of the analytical errors.

A3.6 QUALITY CONTROL

The QC procedures must be followed in the field and laboratory to ensure that reliable data are obtained. When field sampling is performed, care should be taken to prevent the cross-contamination of sampling equipment, sample bottles, and other equipment that could compromise sample integrity.

Field QC samples will be collected to evaluate the potential for cross-contamination and laboratory performance. Field QC requirements include field duplicates, field splits, equipment rinsate blanks, and trip blank samples. The QC samples and the required frequency for collection are described in this section. The QC samples will be collected as part of the verification and confirmatory sampling activities.

The collection of QC samples for onsite measurements is not applicable to the field-screening techniques described in this report. Field-screening instrumentation will be calibrated and controlled as discussed in Sections 2.2.7 and 2.2.8 in the main text of this document, as applicable.

The laboratory method blanks, laboratory control sample/blank spike, and matrix spike are defined in Chapter 1 of *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods* (SW-846) and will be run at the frequency specified in that reference.

A3.6.1 Field Duplicates

Field duplicates are independent samples collected as close as possible to the same point in space and time, taken from the same source, stored in separate containers, and analyzed independently. These samples are not to be homogenized together. This QA will be provided by collecting 5% field duplicate samples.

A3.6.2 Field Splits

A split sample is divided into two separate aliquots in the field and sent to two independent laboratories. A split sample will be used to verify the performance of the primary laboratory. This QA will be provided by splitting 5% of field sample.

Split samples will be analyzed for all of the analytes listed in Table A-1.

A3.7 INSTRUMENT/EQUIPMENT TESTING, INSPECTION, AND MAINTENANCE

All onsite environmental instruments will be tested, inspected, and maintained in accordance with the manufacturer's operating instructions and approved work packages. Results from testing, inspection, and maintenance activities are documented in logbooks and/or work packages.

Analytical laboratory instruments and measuring equipment are tested, inspected, and maintained in accordance with the laboratories' QA plans. Daily response checks for radiological field survey instruments are performed in accordance with approved work packages.

Measurement and testing equipment used in the field or in the laboratory that directly affects the quality of analytical data will be subject to preventive maintenance measures to ensure minimization of measurement system downtime. Laboratories and onsite measurement organizations must maintain and calibrate their equipment. Maintenance requirements (e.g., parts lists and documentation of routine maintenance) will be included in the individual laboratory and the onsite organization QA plan or operating procedures (as appropriate). Calibration of laboratory instruments will be performed in a manner consistent with EPA's SW-846 or with auditable DOE Hanford Sitewide and contractual requirements. Calibration of radiological field instruments is discussed in Section 2.2.8 in the main text of this document.

Consumables, supplies, and reagents will be reviewed in accordance with SW-846 requirements and will be appropriate for their use. Note that contamination is monitored using the QC sample process discussed in Section 2.2 in the main text of this document.

A3.8 INSTRUMENT/EQUIPMENT CALIBRATION AND FREQUENCY

All onsite environmental instruments are calibrated in accordance with the manufacturer's operating instructions, internal work requirements and processes, and/or work packages that provide direction for equipment calibration or verification of accuracy by analytical methods. The results from all instrument calibration activities are recorded in logbooks and/or work packages.

Analytical laboratory instruments and measuring equipment are calibrated in accordance with laboratories' QA plans. Calibration of radiological field survey instruments on the Hanford Site is performed under contract by Pacific Northwest National Laboratory (PNNL) on an annual basis, as specified in their program documentation. Calibration is performed with certified standards and/or equipment with known relationship to nationally recognized standards, where appropriate.

A3.9 INSPECTION/ACCEPTANCE OF SUPPLIES AND CONSUMABLES

Supplies and consumables procured by FH that are used in support of sampling and analysis activities are procured in accordance with internal work requirements and processes that describe the FH acquisition system and the responsibilities and interfaces necessary to ensure that structures, systems, and components, or other items and services procured/acquired for FH meet the specific technical and quality requirements. The procurement process ensures that purchased items and services comply with applicable procurement specifications. Supplies and consumables are checked and accepted by users prior to use.

Supplies and consumables procured by the analytical laboratories are procured, checked, and used in accordance with the laboratories' QA plans.

A3.10 NONDIRECT MEASUREMENTS

Nondirect measurements include data obtained from sources such as computer databases, programs, literature files, and historical databases. Nondirect measurements will not be evaluated as part of this activity.

A3.11 DATA MANAGEMENT

Data resulting from the implementation of this QAPjP will be managed and stored in accordance with applicable programmatic requirements governing data management procedures. At the direction of the 100 Areas Task Lead, all analytical data packages shall be subject to final technical review by qualified personnel before the results are submitted to the regulatory agencies or prior to inclusion in reports. Electronic data access, when appropriate, shall be via a database (e.g., HEIS or a project-specific database). Where electronic data are not available, hardcopies shall be provided in accordance with Section 9.6 of the Tri-Party Agreement (Ecology et al. 2003).

Planning for sample collection and analysis shall be in accordance with the programmatic requirements governing fixed laboratory sample collection activities, as discussed in the sample teams' procedures. In the event that specific procedures do not exist for a particular work evolution, or if additional guidance to complete certain tasks is needed, a work package will be developed to adequately control the activities, as appropriate. Examples of the sample teams' requirements include the activities associated with the following:

- Chain-of-custody/sample analysis requests
- Project and sample identification for sampling services
- Control of certificates of analysis
- Logbooks, checklists
- Sample packaging and shipping.

Radiological controls are not expected within the scope of this investigation other than standard morning/afternoon checks of equipment and cuttings by the RCTs; however, if necessary, approved work control packages and procedures will be used to document radiological measurements.

Examples of the types of documentation for field radiological data include the following:

- Instructions regarding the minimum requirements for documenting radiological controls information in accordance with 10 CFR 835, "Occupational Radiation Protection"
- Instructions for managing the identification, creation, review, approval, storage, transfer, and retrieval of Hanford Site radiological records
- Minimum standards and practices necessary for preparing, performing, and retaining radiological-related records

- Indoctrination of personnel on the development and implementation of survey/ sample plans
- Requirements associated with preparing and transporting regulated material.

Data will be cross-referenced between laboratory analytical data and radiation measurements to facilitate interpretation of the investigation results.

Errors reported by the laboratories are reported to the Sample Management Project Coordinator, who initiates a Sample Disposition Record in accordance with PHMC procedures. This process is used to document analytical errors and to establish the resolution with the Project Task Lead. In addition, the FH QA Engineer receives quarterly reports that provide summaries and summary statistics of the analytical errors.

A4.0 ASSESSMENT AND OVERSIGHT ACTIVITIES

Assessment and oversight activities evaluate the effectiveness of project implementation and associated QA and QC activities. The purpose of assessment is to ensure that the QAPjP is implemented as prescribed.

A4.1 ASSESSMENTS AND RESPONSE ACTION

The PHMC Compliance and Quality Programs group may conduct random surveillance and assessments to verify compliance with the requirements outlined in this QAPjP, project work packages, the project quality management plan, procedures, and regulatory requirements.

Deficiencies identified by these assessments shall be reported in accordance with existing programmatic requirements. The Groundwater Remediation Project's QA engineers coordinate the corrective actions/deficiencies in accordance with PHMC's QA program. When appropriate, corrective actions will be taken by the Project Engineer and/or Task Lead.

Oversight activities in the analytical laboratories, including corrective action management, are conducted in accordance with the laboratories' QA plans.

A data quality assessment will be performed on the resulting analytical data in accordance with *Guidance for Data Quality Assessment, Practical Methods for Data Analysis* (EPA QA/G-9). The data quality assessment will determine if the data are the right type, quality, and quantity to support the intended use. The data evaluation for this project includes the following: (1) reviewing analytical data, including data packages and QA reports; (2) drawing conclusions from the data; and (3) interpreting and communicating the test results.

A4.2 REPORTS TO MANAGEMENT

Management will be made aware of all deficiencies identified by self-assessments. Identified deficiencies also will be reported to the Waste Site Remediation Manager, as appropriate.

A5.0 DATA VALIDATION AND USABILITY

Data validation and usability activities occur after the data collection phase of the project is completed. Implementation of these elements determines whether or not the data conform to the specified criteria, thus satisfying the project objectives.

A5.1 DATA REVIEW, VERIFICATION, AND VALIDATION

Data review, verification, and validation are performed on analytical data sets, primarily to confirm that sampling and chain-of-custody documentation is complete, sample numbers can be tied to the specific sampling location, samples were analyzed within required holding times, and analyses met the data quality requirements specified in the field sampling plan.

A5.2 VERIFICATION AND VALIDATION METHODS

Completed data packages will be validated by qualified Sample and Data Management personnel or by a qualified independent contractor. Validation will consist of verifying required deliverables, comparing requested versus reported analyses, and identifying transcription errors. Validation also will include evaluating and qualifying the results, based on holding times, method blanks, laboratory control samples, laboratory duplicates, and chemical and tracer recoveries, as appropriate. No other validation or calculation checks will be performed.

Relative to analytical data, physical data and/or field screening results are of lesser importance in making inferences of risk. Because of the secondary importance of such data, no validation for physical property data and/or field screening results will be performed; however, field QA/QC will be reviewed to ensure that the data are useable. Field instrumentation, calibration, and QA checks will be performed in accordance with the following.

- Calibration of radiological field instruments on the Hanford Site is performed under contract by PNNL, as specified in their program documentation.
- Daily calibration checks will be performed and documented for each instrument used to characterize areas that are under investigation. These checks will be made on standard materials that are sufficiently like the matrix under consideration that direct comparison of data can be made. Analysis times will be sufficient to establish detection efficiency and resolution.

The approval of field-data collection plans by the Radiological Engineering Manager represents the data validation and usability review for handheld field radiological measurements.

A5.3 RECONCILIATION WITH USER REQUIREMENTS

The data quality assessment process compares completed field sampling activities to those proposed in corresponding sampling documents and provides an evaluation of the resulting data. The purpose of the data evaluation is to determine if quantitative data are of the correct type and are of adequate quality and quantity to meet the project DQOs. The EPA's data quality assessment process (EPA QA/G-9) identifies five steps for evaluating data generated from this project, as summarized below:

- Step 1 – Review DQOs and sampling design: This step requires a comprehensive review of the sampling and analytical requirements outlined in the *Interim Action Monitoring Plan for the 100-HR-3 and 100-KR-4 Operable Units* (DOE/RL-96-90). Note that there are no accuracy or precision requirements for field screening analyses.
- Step 2 – Conduct a preliminary data review: In this step, a comparison is made between the actual QA/QC achieved (e.g., detection limits, precision, and accuracy) and the requirements determined during the DQO process. Field chromium results will be compared to laboratory results, as appropriate, and any significant deviations will be documented. Basic statistics may be calculated from the analytical data at this point, as appropriate to the data set, including an evaluation of the distribution of the data. This process is described in steps 3 through 5 below.
- Step 3 – Select the statistical test: Using the data evaluated in step 2, an appropriate statistical hypothesis test is selected and justified.
- Step 4 – Verify the assumptions: In this step, the validity of the data analyses is assessed by determining if the data support the underlying assumptions necessary for the analyses or if the data set must be modified (e.g., transposed or augmented with additional data) before further analysis. If one or more assumptions are questioned, step 3 is repeated.
- Step 5 – Draw conclusions from the data: The statistical test is applied in this step and the results either reject the null hypothesis or fail to reject the null hypothesis. If the latter is true, the data should be analyzed further. If the null hypothesis is rejected, the overall performance of the sampling design should be evaluated by performing a statistical power calculation to assess the adequacy of the sampling design.

A6.0 FIELD SAMPLING PLAN

A6.1 SAMPLING OBJECTIVES

The primary objective of this field sampling plan is to update the sampling requirements presented in the *Remedial Design and Remedial Action Work Plan for the 100-HR-3 and 100-KR-4 Groundwater Operable Units' Interim Action* (DOE/RL-96-84) and the *Interim Action Monitoring Plan for the 100-HR-3 and 100-KR-4 Operable Units* (DOE/RL-96-90) with the requirements for 100-KR-4 pump-and-treat-system expansion. The scope of the sampling will include groundwater wells and influent and effluent streams into the treatment system.

A6.2 SAMPLING LOCATIONS AND FREQUENCY

The wells associated with the 100-KR-4 pump-and-treat-system expansion are listed in Table A-3. This table also lists the sampling frequency and the analytical testing requirements. Sampling frequency may be modified during operations if trends are difficult to establish. Well use in the network may change in response to changes in plume concentrations or configuration. The data quality requirements are listed in Table A-1 and sample volumes and preservation requirements are provided in Table A-2.

A6.3 PRE-SHIPMENT

A representative portion of each sample to be shipped to an offsite laboratory will be analyzed for total activity analysis at the 222-S Radiological Counting Facility (or other suitable onsite laboratory) before the sample is shipped. Total activities will be used for sample pre-shipment characterization. Samples that slightly exceed the offsite laboratory criterion discussed in Section 2.2.3 (see main text of this document) may be reduced in volume to allow for offsite shipment. Onsite and offsite laboratories will be identified before field activities are initiated and will be mutually acceptable to the Sample and Data Management Group and the Waste Site Remediation Task Lead.

A7.0 SAMPLING PROCEDURES

Sampling, recording of field parameters, cleaning of sampling equipment, control of monitoring equipment, and other related task will be conducted in accordance with applicable FH procedures.

A7.1 SAMPLE MANAGEMENT

Sample management activities will be performed in accordance with appropriate FH procedures that are applicable to custody, containers, preservation, holding times, packaging, shipping, and field documentation.

A7.2 ANALYTICAL TESTING

A7.2.1 Field Analyses

Field screening analyses of hexavalent chromium and measurement of field parameters (e.g., specific conductance, temperature, dissolved oxygen, turbidity, and pH) will be conducted in accordance with applicable FH procedures.

A7.2.2 WSCF Laboratory Analyses

Analyses in WSCF will be conducted in accordance with the WSCF standard operating procedures. Data quality will meet the CRDLs and the accuracy and precision requirements specified in Table A-1.

A8.0 HEALTH AND SAFETY

All field operations will be performed in accordance with PHMC health and safety requirements and the appropriate Waste Disposal/Groundwater Remediation Project procedures. In addition, a work control package will be prepared in accordance with procedures that will further control site operations. This package will include an activity job hazard analysis, a site-specific health and safety plan, and applicable radiological work permits. Work will be performed in

accordance with the site-specific health and safety plans and applicable radiological work permits.

The sampling procedures and associated activities will take into consideration exposure reduction and contamination control techniques that will minimize radiation exposure to the sampling team, as required by the procedures previously mentioned.

Health and safety personnel will use data collected during the removal action as input to determine exposure levels to workers and to conduct health and safety assessments in accordance with the health and safety plan.

A9.0 MANAGEMENT OF INVESTIGATION-DERIVED WASTE

Waste generated by sampling activities will be managed consistent with the approved 100-KR-4 waste management plan. Unused samples and associated laboratory waste for analysis will be dispositioned in accordance with the laboratory contract and agreements for return to the Hanford Site. In accordance with 40 CFR 300.440, "National Oil and Hazardous Substances Pollution Contingency Plan" ("Procedures for Planning and Implementing Off-Site Response Actions"), Task Lead approval is required before unused samples or waste are returned from offsite laboratories.

A10.0 SCHEDULE

The following milestones are established for the expansion of the 100-KR-4 Pump-and-Treat System.

- December 31, 2008: The nominal 300 gallons per minute (gpm) system expansion of the 100-KR-4 pump-and-treat system becomes operational
- December 31, 2009: An additional 100 gpm capacity is added to the 100-KR-4 system expansion, and the expanded system becomes operatonal.

A system becomes operational after acceptance testing and operational testing have been completed.

A11.0 REFERENCES

10 CFR 830, Subpart A, "Quality Assurance Requirements," *Code of Federal Regulations*.

10 CFR 835, "Occupational Radiation Protection," *Code of Federal Regulations*.

40 CFR 300.440, "National Oil and Hazardous Substances Pollution Contingency Plan," "Procedures for Planning and Implementing Off-Site Response Actions," *Code of Federal Regulations*.

49 CFR, "Transportation," *Code of Federal Regulations*.

BHI-00917, 1996, *Conceptual Site Models for Groundwater Contamination at the 100-BC-5, 100-KR-4, 100-HR-3, and 100-FR-3 Operable Units*, Rev. 0, Bechtel Hanford, Inc., Richland, Washington.

DOE O 414.1C, *Quality Assurance*, U.S. Department of Energy, Washington, D.C.

DOE/RL-96-84, 2003, *Remedial Design and Remedial Action Work Plan for the 100-HR-3 and 100-KR-4 Groundwater Operable Units' Interim Action*, Rev. 0-A, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE/RL-96-90, 1997, *Interim Action Monitoring Plan for the 100-HR-3 and 100-KR-4 Operable Units*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE/RL-2006-76, 2007, *Calendar Year 2006 Annual Summary Report for the 100-HR-3, 100-KR-4, and 100-NR-2 Pump-and-Treat Operations*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

Ecology, EPA, and DOE, 2003, *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement), 2 vols, as amended, 89-10, Rev. 6, Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Olympia, Washington.

EPA QA/G-9, 2000, *Guidance for Data Quality Assessment, Practical Methods for Data Analysis*, EPA/600/R-96/084, QA00 Update, U.S. Environmental Protection Agency, Washington, D.C.

EPA QA/R-5, 2001, *EPA Requirements for Quality Assurance Project Plans*, EPA/240/B-01/003, U.S. Environmental Protection Agency, Quality Assurance Division, Washington, D.C.

EPA, Ecology, and DOE, 1996, *Declaration of the Record of Decision for the 100-HR-3 and 100-KR-4 Operable Units at the Hanford Site (Interim Remedial Actions)*, U.S. Environmental Protection Agency, Washington State Department of Ecology, and U.S. Department of Energy, Olympia, Washington.

SW-846, 1999, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods*, 3rd edition, as amended by Updates I (July 1992), IIA (August 1993), IIB (January 1995), and III, U.S. Environmental Protection Agency, Washington, D.C.

Figure A-1. Expanded 100-KR-4 Pump-and-Treat System – Existing and Proposed Wells.

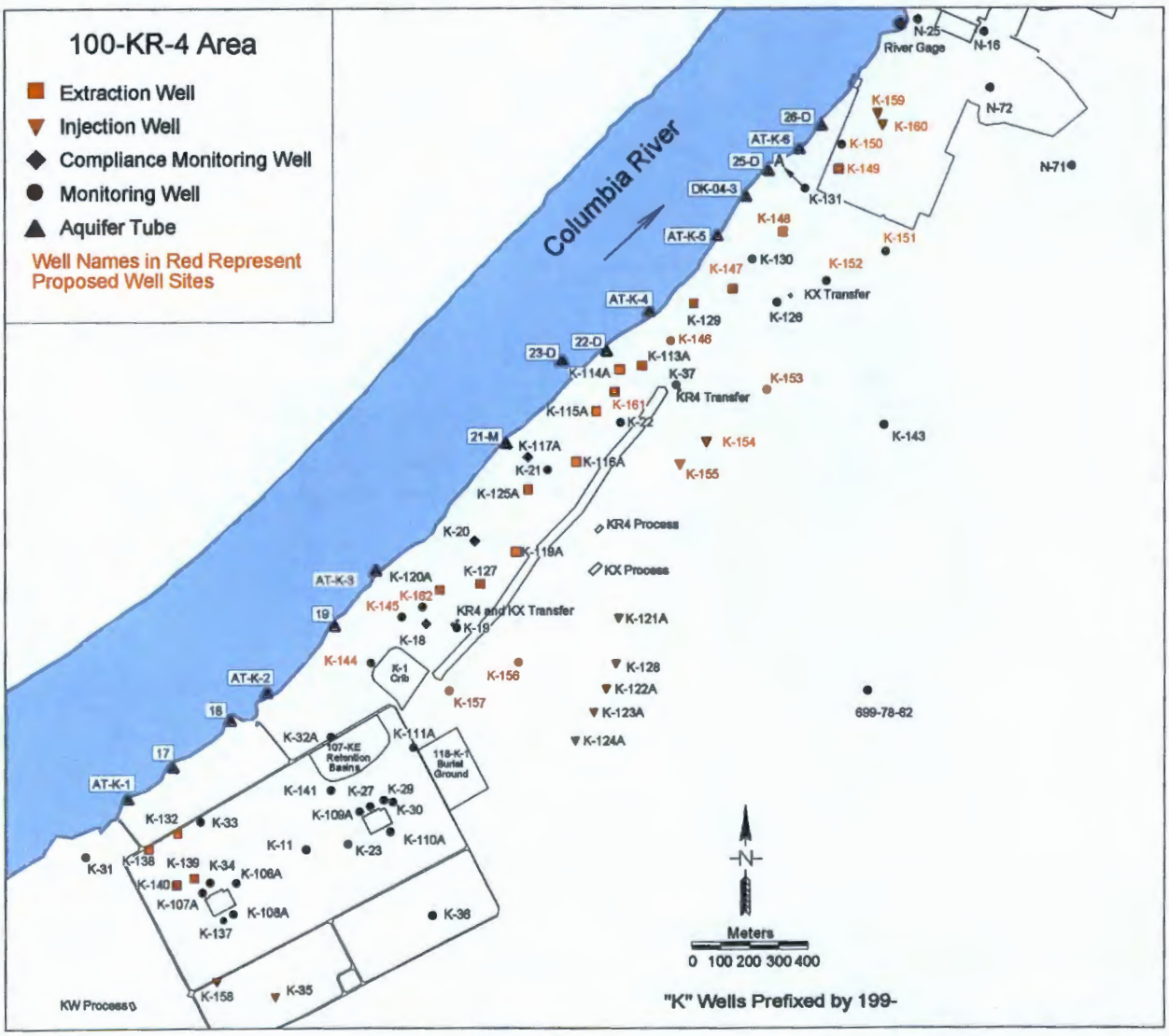

Figure A-2. Project Organization.

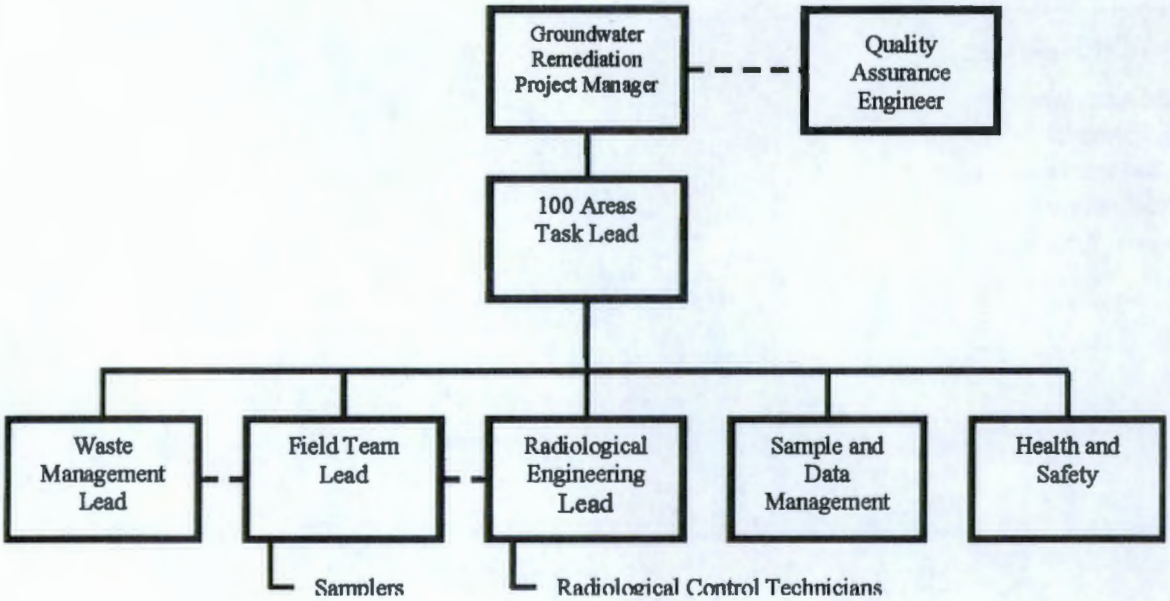

Table A-1. Performance Requirements for 100-KR-4 Pump-and-Treat Contaminant Analysis.

Type of Contaminant	Contaminant	Analytical Methods[a,d]	PQL (µg/L)[b]	Precision[c] Required	Accuracy Required[c]
Nonradiological					
Metals	Chromium, hexavalent	SW-7196	5	±20%	75-125%
	Chromium, hexavalent	Hach™	10	None	None
Radiological					
	Contaminant	**Methods**	**MDC (pCi/L)**	**Precision Required**	**Accuracy Required**
	Strontium-90	Gas proportional counting	2	±20%	75-125%
	Tritium	Liquid scintillation	400	±20%	75-125%
	Carbon-14	Liquid scintillation	200	±20%	75-125%
	Technetium-99	Liquid scintillation	15	+20%	75-125%

[a] Analytical method selection based on available methods by laboratories currently contracted to the Hanford Site. Equivalent methods may be substituted in future sampling and analysis plans or other documents. Four-digit methods are from EPA's *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods* (SW-846); other methods are referenced to source.

[b] Typical MDC based on current Hanford laboratory contracts. Practical Quantitation Limits (PQL) in documents may decrease depending on method selection and contract laboratory but will not increase. Units are "µg/L" for nonradiological contaminants of concern and "pCi/L" for future radiological contaminants of concern, unless otherwise noted. ListedPQL equivalent to WSCF method detection limit x10.

[c] Precision and accuracy in accordance with existing requirements for the 100-KR-4 pump-and-treat system.

[d] Specific procedures vary from laboratory to laboratory.

PQL = Practical Quantitation Limits
EPA = U.S. Environmental Protection Agency
MDC = minimum detectable concentration

Table A-2. 100-KR-4 Pump-and-Treat Monitoring Schedule. (2 sheets)

Sample Group	Pre-Startup			Startup[d]			Operation		
	Water Level	Cr [b,c]	Co-Contaminants[a,c]	Water Level	Cr [b,c]	Co-Contaminants[a,c]	Water Level	Cr [b]	Co-Contaminants[a,c]
Extraction/Compliance Wells									
199-K-114A	Existing 100-KR-4 Pump and Treat Network								
199-K-129	Existing 100-KR-4 Pump and Treat Network								
199-K-130	T	X/Y	X	T	W	--	T	M	SA
100-K-131	T	X/Y	X	T	W	--	T	M	SA
100-K-147	T	X	X	T	W	-	T	M	SA
100-K-148	T	X	X		W	-	T	M	SA
100-K-149	T	X	X	T	W	-	T	M	SA
100-K-161	T	X	X	T	W	-	T		SA
Compliance Wells									
199-K-18	Existing 100-KR-4 Pump and Treat Network						T	M	A
199-K-20	Existing 100-KR-4 Pump and Treat Network						T	M	A
199-K-117A	Existing 100-KR-4 Pump and Treat Network						T	M	A
199-K-144	T	X	X	T	M	-	T	Q	A
199-K-145	T	X	X	T	M	-	T	Q	A
199-K-146	T	X	X	T	M	-	T	Q	A
199-K-150	T	X	X	T	M	-	T	Q	A
199-K-162	T	X	X	T	M	-	T	Q	A
Injection Wells									
199-K-154	T	X	X	T	--	--	T	--	--
199--K-163	T	X	X	T	--	--	T	--	--

Sample Group	Pre-Startup			Startup[d]			Operation		
	Water Level	Cr [b,c]	Co-Contaminants[a,c]	Water Level	Cr [b,c]	Co-Contaminants[a,c]	Water Level	Cr [b]	Co-Contaminants[a,c]
199-K-159	T	X	X	T	--	--	T	--	--
199-K-160	T	X	X	T	--	--	T	--	--
Performance Wells									
199-K-151	T	X	X	T	M	--	T	Q	A
K-152	T	X	X	T	M	--	T	Q	A
K-153	T	X	X	T	M	--	T	Q	A
K-156	T	X	X	T	M	--	--	Q	A
K-157	T	X	X	T	M	--	T	Q	A
Treatment System									
Influent	--	--	--	--	W	--	--	M	SA
Effluent	--	--	--	--	W	--	--	M	SA

[a] Co-contaminants per "ROD for the 100-HR-3 and 100-KR-4 operable unit" (EPA 1996) are strontium-90 and tritium. Carbon-14 and Tc-99 are contaminants of interest.
[b] Groundwater samples associated with routine pump and treat operations are analyzed for hexavalent chromium by operators using a Hach ® kit. All other samples are analyzed at WSCF utilizing the EPA 7196 method.
[c] Specific conductance, temperature, pH, turbidity and dissolved oxygen will be measured for all laboratory samples.
[d] Startup duration is approximately 3 months.

A = annual M = monthly Q = quarterly SA = semi-annually
T = hourly transducer W = weekly X = one-time event Y = vertical profiling using Kabis ™ sampler

Hach® is a registered trademark of the Hach Company, Loveland, Colorado.

Table A-3. Field Sampling Requirements for 100-KR-4 Pump-and-Treat System.

Analysis	Matrix	# of Bottles	Type	Amount	Preservation	Packing Requirements	Holding Time
Radionuclides							
Strontium-89/90	Water	1	G/P	2 x 1,000 mL	HNO_3 to pH <2	None	6 months
Tritium (H-3)	Water	1	G	500 mL	None	None	6 months
Carbon-14	Water	1	G/P	125 mL	None	None	6 months
Technetium-99	Water	1	G/P	2 x 1L	pH < 2	None	6 months
Chemicals							
Chromium hexavalent (7196)	Water	1	G/P	500 mL	None	Cool 4°C	24 hours

APPENDIX B

ANALYTICAL MODELING

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APPENDIX B

ANALYTICAL MODELING

An analytical modeling program was used to generate the simulations used to help locate new extraction and injection wells for the 100-KR-4 pump-and-treat system expansion. The simulations, created using steady-state conditions, provide a graphical representation of estimated extraction well capture and stream traces with estimated water particle travel times.

Input parameters for the simulations include transmissivity, porosity, hydraulic head, and aquifer (Ringold Unit E) saturated thickness. Figures B-1 and B-2 display modeled November 2006 hydraulic head contours of the southern and northern 100-KR-4 pump-and treat-areas and show estimated capture based on steady-state conditions.

Figures B-3 and B-4 provide modeled hydraulic conductivity values for the southern and northern 100-KR-4 pump-and-treat areas. The hydraulic conductivities range from around 3 m/day in the area of the existing 100-KR-4 injection wells to greater than 40 m/day upgradient of extraction well 199-K-116A.

Figures B-5 and B-6 are isopach maps of the saturated aquifer thickness in the southern and northern 100-KR-4 pump-and-treat area. The saturated thickness and hydraulic conductivity are used to calculate transmissivity, which is a model input parameter. Saturated thickness ranges from 8 m to greater than 25 m.

Figure B-1. Modeled Head South.

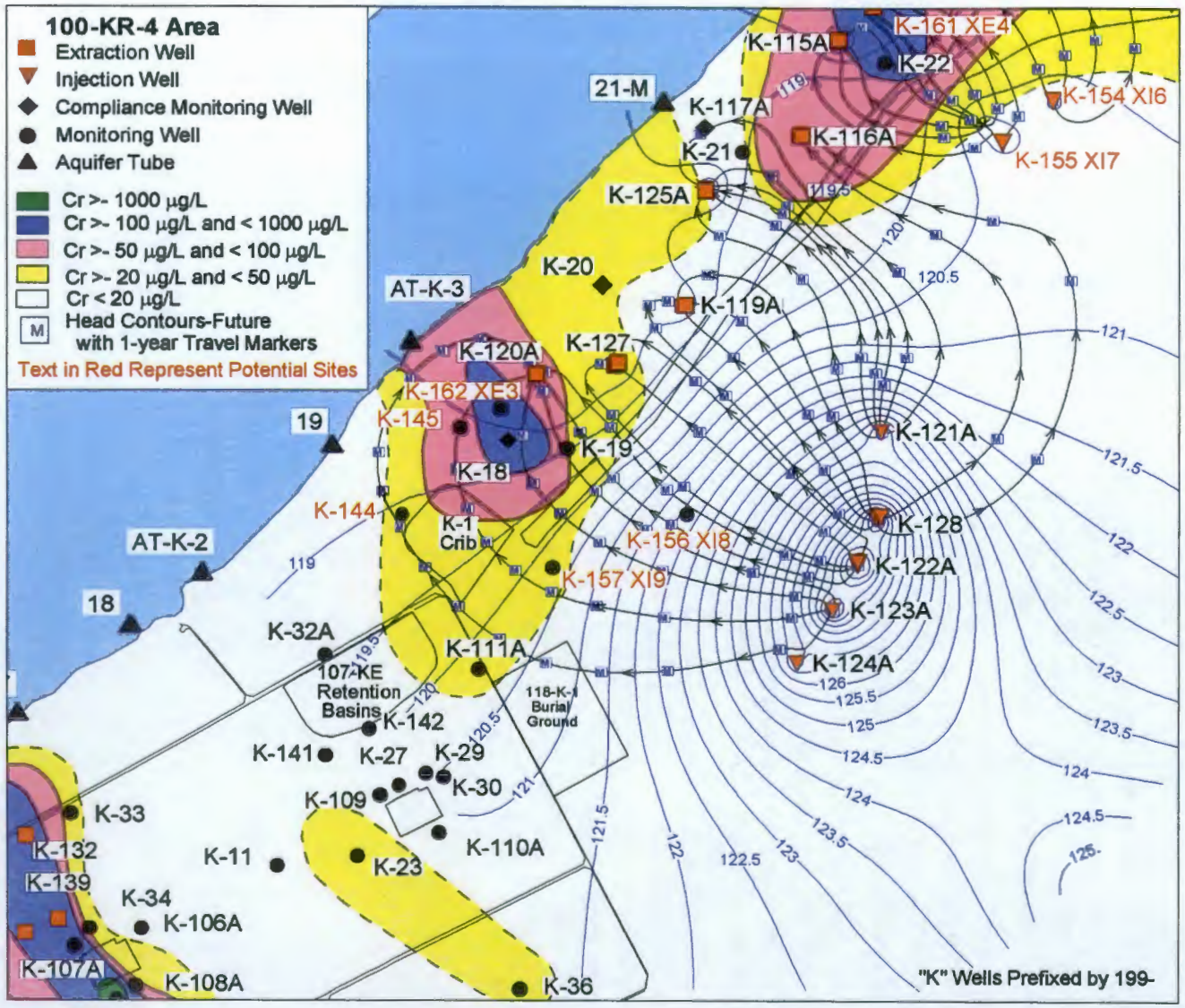


Figure B-2. Modeled Head North.

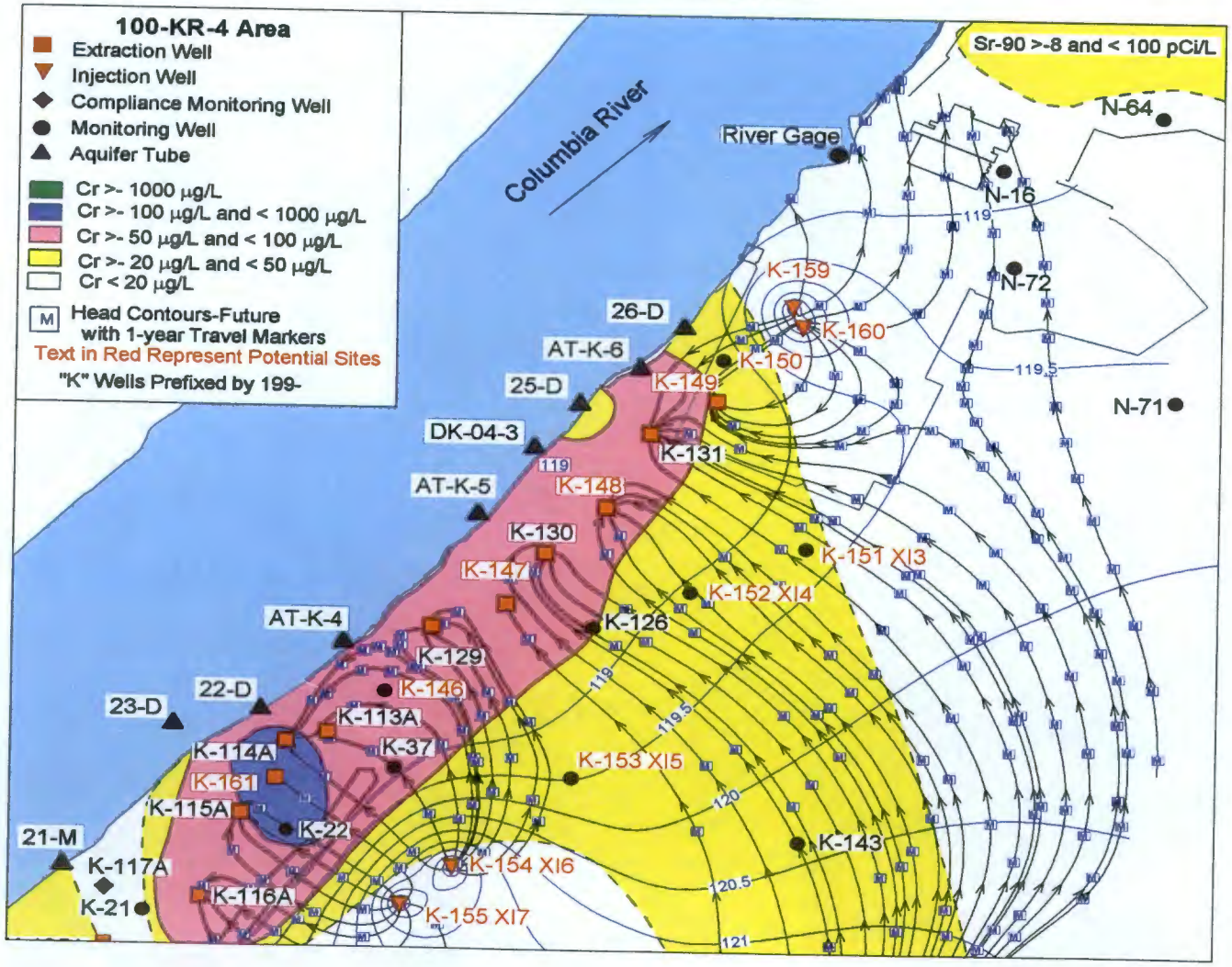


Figure B-3: Hydraulic Conductivity South

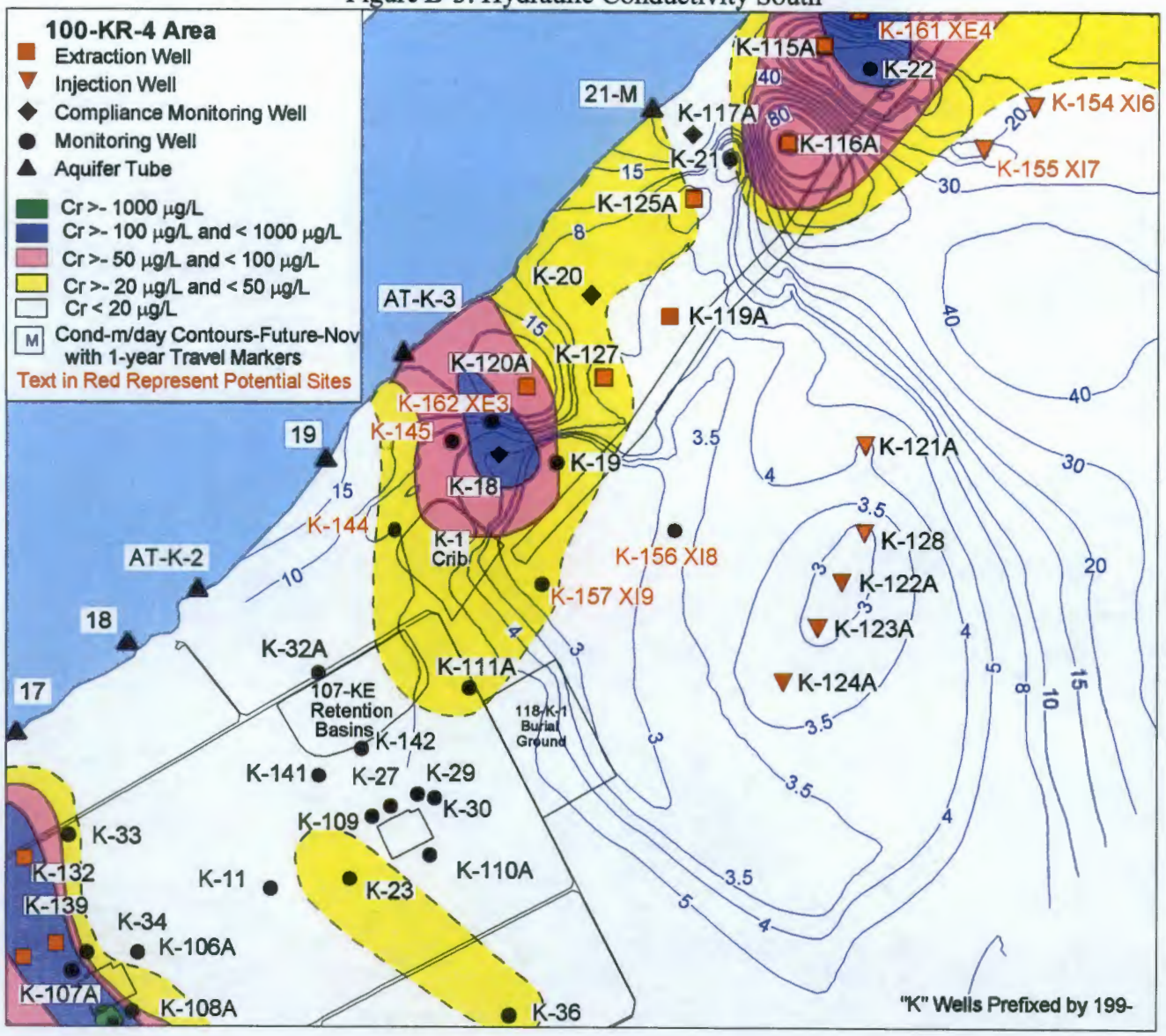


Figure B4: Hydraulic Conductivity North

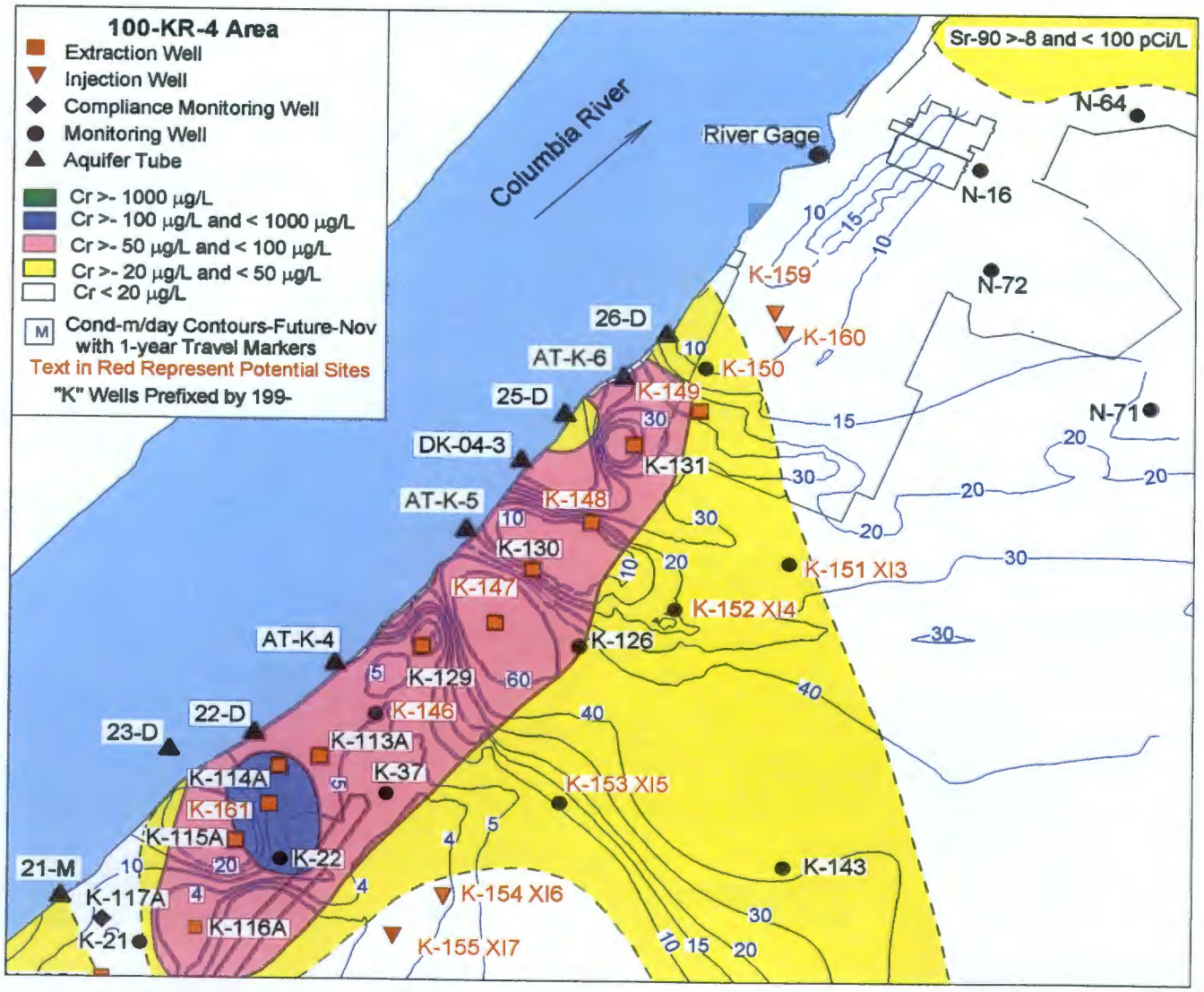


Figure B-5: Saturated Aquifer Thickness South

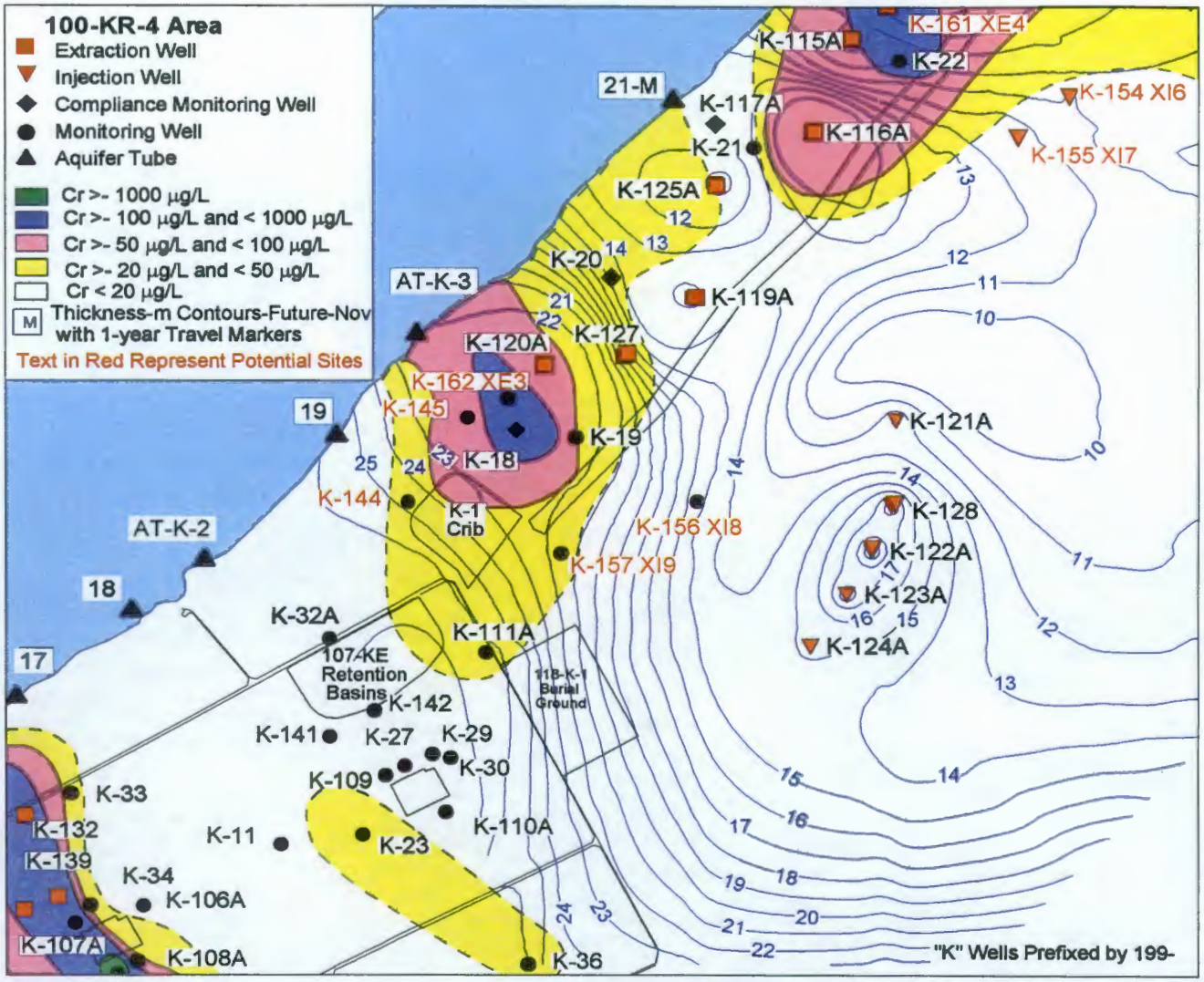
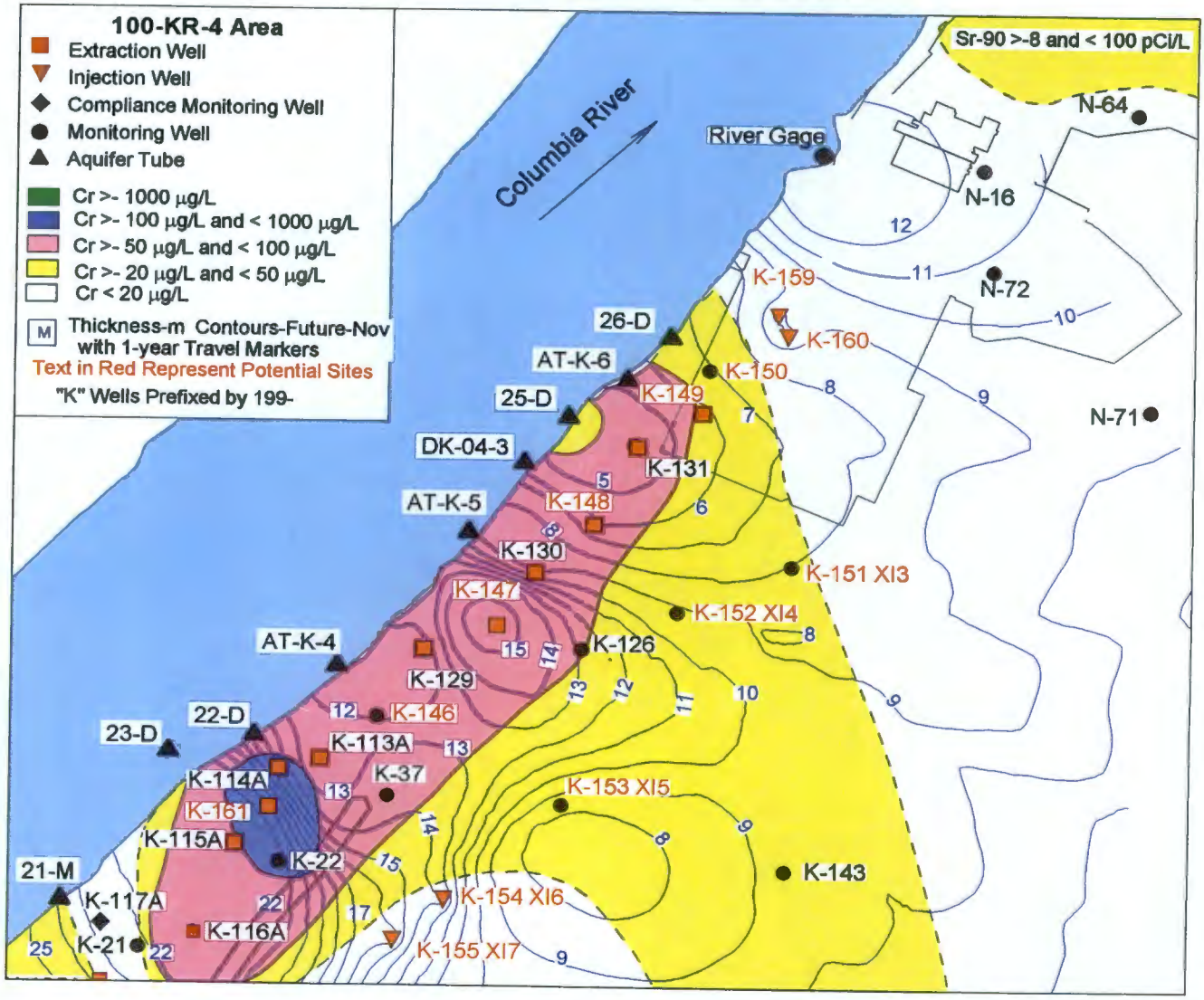


Figure B-6: Saturated Aquifer Thickness North



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