5.0 100-KR-4 Operable Unit

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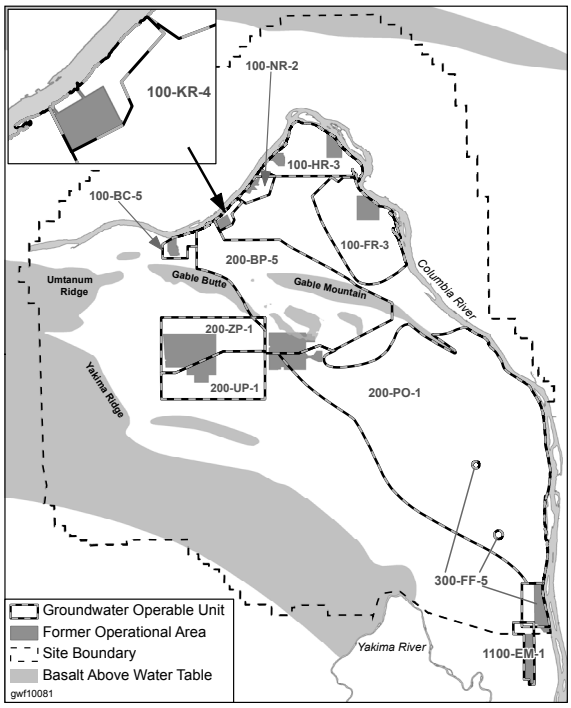

The 100-KR-4 Operable Unit (OU) is located along the Columbia River in the north-central portion of the Hanford Site (Figure 5-1). The 100-KR-4 OU, as defined in the *Integrated 100 Area Remedial Investigation/Feasibility Study Work Plan, Addendum 2: 100-KR-1, 100-KR-2, and 100-KR-4 Operable Units* (DOE/RL-2008-46-ADD2), comprises the groundwater affected by hexavalent chromium releases associated with past operation of the deactivated KE and KW Reactors and from the associated support facilities and waste sites within the 100-K Area (Figure 5-2).

The Washington State ambient water quality standard for protection of freshwater aquatic life from hexavalent chromium in the Columbia River is 10 µg/L. As defined in the current interim action Record of Decision (ROD) (EPA/ROD/R10-96/134, *Declaration of the Record of Decision for the 100-HR-3 and 100-KR-4 Operable Units, Benton County, Richland, Washington*), the remedial action goal (compliance concentration) for hexavalent chromium is 20 µg/L in compliance wells. The compliance concentration of 20 µg/L hexavalent chromium is based on the estimated 1:1 mixing of groundwater (and the associated hexavalent chromium) with infiltrated river water within a hydrologic mixing zone that separates the groundwater aquifer from the hyporheic zone of the river. The net concentration of hexavalent chromium entering the hyporheic zone of the river after this mixing process should be less than the 10 µg/L aquatic standard. The federal drinking water standard (DWS) for total chromium is 100 µg/L; Washington State has a groundwater cleanup level for hexavalent chromium of 48 µg/L (WAC 173-340 "Model Toxics Control Act – Cleanup").

Although hexavalent chromium is currently the only groundwater contaminant of concern (COC) for the 100-KR-4 OU, other groundwater constituents are monitored on a routine basis. Strontium-90 and tritium are listed in the interim ROD (EPA/ROD/R10-96/134) as target analytes. Carbon-14 and nitrate are target analytes monitored under the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) monitoring program because of their detection above their DWSs in certain wells or due to a previous qualitative risk assessment (DOE/RL-94-48, *100-KR-4 Operable Unit Focused Feasibility Study*). Trichloroethene and chloroform have been determined by preliminary remedial investigation (RI)/feasibility study (FS) risk assessment calculations to be contaminants of potential concern (COPCs). Other contaminants detected at concentrations below risk-based levels are discussed in this chapter due to concerns over their potential future impact to groundwater. For ease of discussion, all of the contaminants (other than hexavalent chromium) addressed in this chapter (e.g., strontium-90, nitrate, tritium, trichloroethene, carbon-14, and technetium-99) are hereafter denoted as "contaminants of interest."

To mitigate the risks associated with hexavalent chromium contamination in the 100-KR-4 OU, three CERCLA interim action ion exchange-based pump-and-treat systems have been installed, and all three systems operated during calendar year (CY) 2010. The original 100-KR-4 treatment system (referred to as KR4), which

was the first of the systems installed, began operations in October 1997. This system was designed to capture and treat groundwater contaminated with hexavalent chromium near the former 116-K-2 Trench. When the KR4 system was installed, the extent of hexavalent chromium contamination was thought to be limited to the area around the 116-K-2 Trench and, to a lesser extent, around the KW and KE Reactor sites. Over time, however, additional groundwater characterization efforts demonstrated that elevated levels of hexavalent chromium were more extensive in the KW Reactor area than previously recognized and that contaminated groundwater also extended substantially farther to the northeast (downriver) than originally believed. The northeastern extent of the hexavalent chromium contamination associated with the 100-KR-4 OU was ultimately determined to extend past the southwestern boundary of the 100-NR-2 OU (Figure 5-2).

The Second CERCLA Five-Year Review Report for the Hanford Site (DOE/RL-2006-20) determined that the more recently identified areas of hexavalent chromium groundwater contamination also required remediation. This finding led to the development of plans to add two additional pump-and-treat systems (KW and KX) to substantially expand the remedial treatment capacity beyond that provided by the KR4 treatment system alone. The KW system was subsequently installed and began operating in January 2007 to remediate the contaminated groundwater in the KW Reactor area. The KX system began operations in February 2009 and treats groundwater contaminated with hexavalent chromium in the area between the northern section of the 116-K-2 Trench and the N Reactor fence line. The extraction and injection wells that comprise the well fields for these systems during CY 2010, as well as the associated monitoring wells and other monitoring locations, are shown in (Figure 5-2). A separate and much smaller hexavalent chromium plume, located downgradient of the KE Reactor area, is also treated by the KX system. Each system is a critical component of the overall remedial approach implemented to prevent hexavalent chromium in the 100-KR-4 OU from reaching the Columbia River at concentrations greater than the 10 µg/L aquatic water quality criterion.

The monitoring and extraction wells installed during the initial stages of the KR4 and KW pump-and-treat systems were designed to penetrate the upper section of the unconfined aquifer. Virtually all of the wells installed in the last 3 to 4 years in the 100-KR-4 OU (including the new KW and KX system wells) have fully penetrated the aquifer and have been screened over an interval selected on the basis of analytical results obtained during drilling. Thus, the well fields of each system include some extraction wells screened over the full vertical extent of the groundwater contamination.

Specific areas of concern occur at the downgradient KW system, where extraction wells 199-K-132 and 199-K-138 penetrate only the upper 6.1 to 7.6 meters of the ~26-meter-thick aquifer. A new well will be drilled during CY 2011 to address the lack of deep well control in this area. Vertical profiling of hexavalent chromium concentrations (and selected other constituents of interest) will be conducted during drilling activities to determine the vertical extent of contamination in this portion of the KW plume. The data will be used to guide the selection of the screened interval when this borehole is completed as a monitoring or extraction well. In preparation for the final ROD, an RI/FS was initiated in 2010 at the 100-KR-4 OU and will continue into 2011. Information has been collected that will further delineate the nature and extent of contamination, support the refinement of the existing conceptual site model, and contribute to the selection of the final remedy.

Hexavalent chromium, as sodium dichromate, was added as an anti-corrosion agent to cooling water that passed through the KE and KW Reactors during operation from 1955 to 1971. Typical sodium dichromate concentrations in the cooling water during the early years of reactor operations were 2,000 µg/L (~700 µg/L as hexavalent chromium), then decreased to 1,000 µg/L in the mid-1960s, and then 500 µg/L (~170 µg/L as hexavalent chromium) in the last stages of operations. After a single pass through the reactors, spent cooling water was discharged to the 107-KE and KW retention basins (Figure 5-2) to allow short-lived radionuclides to decay and the water to cool. The water was then discharged to the Columbia River. Infiltration and overland flow of contaminated cooling water from leaks at the 107-KE/KW retention basins and piping resulted in contamination of the vadose zone beneath these structures. The 107-KE and –KW Retention Basin sites were cleaned up and closed out in 2004 and 2005.

The 116-K-1 Crib and 116-K-2 Trench were constructed to receive radiologically contaminated water associated with fuel rod failures in the reactors and percolate it into the vadose zone. A pre-operational failure at the 116-K-1 Crib led to construction of the 116-K-2 Trench; contaminated cooling water was never purposely discharged to the 116-K-1 Crib. Valves beneath and downstream of the 107-KE and KW retention basins partially failed and led to discharges to both structures, although the 116-K-2 Trench received the overwhelming majority of cooling water. The 116-K-2 Trench is estimated to have received spent cooling water (contaminated with hexavalent chromium and short-lived radionuclides) at a rate of 18,900 to 37,900 liters per minute for up to 16 years (1955 through 1971), for a total of 160 to 320 billion liters. The 116-K-1 Crib received an estimated 30 million liters of cooling water during 16 months of operation (1955 through 1956). Photographs from the mid-1960s show water ponded in the 116-K-1 Crib.

Historical process information suggests that small volumes of high-concentration solutions (up to 70% by weight) of sodium dichromate were released to the 100-K Area by leaks and spills during the transfer of sodium dichromate from railcars to storage tanks at the 183.1-KE and -KW headhouses. The current and historical presence of hexavalent chromium concentrations in groundwater around the 183.1-K headhouses greatly exceed the concentrations found in reactor cooling water in and groundwater beneath the 116-K-2 Trench. Mobile residuals from the high-concentration sodium dichromate solutions may potentially remain in the vadose zone and may represent a potential future source of groundwater contamination. Characterization data from the RI/FS has revealed low concentrations of hexavalent chromium in the vadose zone at three wells, two of which were drilled adjacent to the two 183.1-KE and KW headhouses. After remediation of the vadose zone is complete and natural vegetation cover has been re-established, any residual vadose source term and the driving force necessary to transport it to the water table (i.e., infiltrating precipitation) will be greatly reduced.

In addition to hexavalent chromium, groundwater contaminants such as tritium, strontium-90, and carbon-14 may be associated with other 116-K liquid waste sites or with the 118-K-1 Burial Ground. These radionuclides were generated as neutron activation or fission products during reactor operations. These sites were active during reactor fuels storage operations and are discussed below. Other target analytes such as nitrate, technetium-99, trichloroethene, and chloroform have no obvious relation to particular waste sites but may be related to unidentified processes.

The unconfined aquifer in the 100-KR-4 OU ranges from 5.2 meters to more than 32 meters in thickness in wells. This aquifer is primarily made up of low to

moderately permeable sands and gravels of the Ringold Formation unit 5 (unit E). The Ringold unit 5 is disconformably overlain by the coarse, flood-deposited gravels and interbedded sand and silt lenses of the Hanford formation. The Hanford formation comprises the bulk of the vadose zone in the 100-KR-4 OU, although near the northeast end of the 116-K-2 Trench, the Hanford formation locally supports the unconfined aquifer at high river stage. The vadose zone ranges from less than 0.3 meters in thickness near the Columbia River to 32 meters in thickness southeast of the 183.1-KE headhouse. The contact between the Ringold unit 5 and Hanford units is a contrast between the denser, less permeable, locally cemented Ringold unit 5 and the more open, coarser-grained Hanford formation. The maximum Hanford formation thickness detected during RI characterization was 19.8 meters. The silt- and clay rich Ringold Formation upper mud unit (RUM) disconformably underlies the Ringold unit 5; this unit retards the downward migration of contaminated groundwater and is considered to form the base of the unconfined aquifer.

Long-term groundwater flow in the vicinity of the 100-K Area is generally to the northwest, toward the Columbia River (Figure 5-3). At any given time, however, the hydraulic gradient and groundwater flow direction within the aquifer proximal to the river is strongly influenced by short-term (e.g., daily) and longer term (e.g., seasonal) fluctuations in river stage. As would be expected, longer term changes in the river stage produce more extensive and longer lived changes in the water levels, hydraulic gradient, and flow directions in the unconfined aquifer.

Groundwater in the shallow unconfined aquifer typically has a pH generally ranging between 7.5 and 8.5 and an average dissolved oxygen concentration of ~8.0 mg/L. This groundwater can be classified as predominantly calcium-bicarbonate-type water but, due to anthropogenic activities, it also contains notable but variable concentrations of sulfate and nitrate. Mineral saturation/solubility calculations indicate that the groundwater in the unconfined aquifer is saturated, or nearly saturated, with respect to calcium carbonate (calcite).

Daily and seasonal changes in the stage of the Columbia River in the 100 Area are largely controlled by the scheduled releases of water by the upstream Priest Rapids hydroelectric dam. Seasonal high water levels in the river during the spring and summer are due to increased runoff associated with the melting of snow pack in the mountains. The river stage affects the hydraulic gradient in the 100-KR-4 OU, which steepens toward the Columbia River during seasonal periods of low river flow (i.e., in the fall). During the spring when the river stage is high, the groundwater gradient toward the river flattens and eventually reverses as river water infiltrates into the aquifer. The reversal is observed inland based on the hydraulic conductivity of the local geology. The effect is most pronounced after the seasonal river stage has peaked. The daily to seasonal water-level fluctuations are also thought to promote a minor flow component parallel to the river in near-shore areas that gradually transport groundwater contaminants downriver before discharging to the river. This effect would be most pronounced during seasonal high river stage when the gradient along the river is locally reversed. This process may have contributed, in part, to the migration of the chromium plume from the 116-K-2 Trench past the boundary of the 100-NR-2 OU (Figure 5-2).

The substantial influx of river water into the aquifer during the spring and summer (high river stage) also affects the concentrations of hexavalent chromium and other contaminants of interest in many parts of the unconfined aquifer. The concentrations of these contaminants can be much lower in groundwater samples collected from near-shore wells (and to a lesser extent at upgradient wells) during the spring or

summer than at other times of the year. The concentrations of these constituents in groundwater tend to attain their maximum annual values in the fall of each year with the onset of low river stage conditions. The hydraulic effects of the pump-and-treat systems at the 100-KR-4 OU are superimposed on these seasonal fluctuations, and the efficiency of the treatment system (i.e., mass of hexavalent chromium captured per unit volume of water extracted) typically decreases during high river stage and reaches a maximum during low river stage.

This chapter summarizes the CY 2010 groundwater monitoring results, discusses the nature and extent in groundwater of hexavalent chromium and other constituents of interest, and summarizes the CERCLA characterization activities and pump-and-treat operations for the 100-KR-4 OU for the period of January 1 through December 31, 2010 (CY 2010).

5.1 Contaminant Monitoring

This section summarizes and presents the CERCLA analytical results obtained from groundwater monitoring wells supporting the 100-K Area pump-and-treat remedial action and other areas in the 100-KR-4 OU. The analytical results presented in this chapter are from unfiltered samples analyzed at the Waste Sampling and Characterization Facility laboratory or offsite laboratories. The following documents define the sampling strategies that were implemented for CY 2010:

- DOE/RL-96-84, Rev. 0, *Remedial Design Report and Remedial Action Work Plan for the 100-HR-3 and 100-KR-4 Groundwater Operable Units' Interim Action*
- DOE/RL-96-90, Rev. 0, *Interim Action Monitoring Plan for the 100-HR-3 and 100-KR-4 Operable Units*
- DOE/RL-2006-52, Rev. 2, *The KW Pump and Treat System Remedial Design and Remedial Action Work Plan, Supplement to the 100-KR-4 Groundwater Operable Unit Interim Action*
- DOE-RL-2006-75, Rev. 1 (reissue), *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*.

Plume areas (square kilometers) in the 100-KR-4 Operable Unit:

Carbon-14, 2,000 pCi/L — *
Chromium, 100 µg/L — 0.02
Chromium, 20 µg/L — 0.61
Nitrate, 45 mg/L — 0.143
Strontium-90, 8 pCi/L — 0.04
Trichloroethene, 5 µg/L — 0.03
Tritium, 20,000 pCi/L — 0.164

**** No annual average plume created this year.***

Most monitoring locations in the 100-KR-4 OU are sampled in the spring during high river stage and in the fall at low river stage. However, owing to the variable effects of the high river stage on groundwater contaminant concentrations during the spring, only the fall data has been used to evaluate the year-to-year changes in concentrations of hexavalent chromium and the other constituents of interest. Separate data tables are presented that summarize the available fall 2010 data for each contaminant. The relevant fall 2008 and 2009 data are also presented to allow a comparison of the fall results for the monitoring locations over a 3-year period. The calculated percent increase or decrease in contaminant concentrations at each monitored location between both CY 2008/CY 2009 and CY 2010 is also presented.

As discussed in Chapter 1.0, the fall 2010 sampling event was delayed by a work stoppage. Although sampling activities resumed on November 8, 2010, the completion of the fall sampling event was further delayed by weather and holidays. As a result, only 33 of 61 wells originally scheduled were sampled during the fall timeframe. In addition, only 9 of the 68 aquifer tubes at the 100-KR-4 OU were sampled within the required timeframe. To increase the robustness of the data set,

analytical data from September 2010 were used (where available) as supplemental data for those locations not sampled in October, November, or December 2010. Data collected prior to September 1 and after December 31 were not used in the fall 2010 data set, as the data were deemed not to be sufficiently representative of fall groundwater conditions. All of the analytical results presented in this chapter have undergone appropriate quality assurance/quality control evaluations and were obtained from samples collected from properly installed and developed monitoring and extraction wells or aquifer tubes. Data tables and plume maps provided in this report use only unfiltered analytical results from laboratory analyses collected during routine sampling. Vertical profile data collected while drilling RI/FS boreholes during CY 2010 were not used.

The spring and fall 2010 data collected at the 100-KR-4 OU were used to construct updated spring and fall plume maps for hexavalent chromium and other selected contaminants. Due to the work stoppage, the abundance and geographic distribution of plume data collected during fall 2010 alone were not sufficient to construct a new hexavalent chromium plume map. As an alternative approach, the data from the fall sampling event were used to revise and update the fall 2009 plume contours presented in *Hanford Site Groundwater Monitoring and Performance Report for 2009: Volumes 1 & 2* (DOE/RL-2010-11). Consequently, the fall 2010 plume maps for hexavalent chromium at the 100-KR-4 OU are based on modifications to fall 2009 plume contours using the available fall 2010 data.

The construction of the fall 2010 plume maps for the other contaminants of interest was also affected by these sampling issues; therefore, the fall 2010 plume maps for these constituents were also constructed using 2010 data to guide the modification of the existing fall 2009 plume maps. The paucity of fall 2010 data were more problematic for updating the distributions of some of these other constituents of interest (e.g., carbon-14 and strontium-90), as the distributions of these contaminants are generally far more limited than hexavalent chromium and are defined by fewer monitoring locations. Consequently, the absence of fall 2010 data for a few key monitoring locations greatly hindered the revision of the plumes for these constituents.

The monitoring results and plume maps for hexavalent chromium and other groundwater contaminants of interest at the 100-KR-4 OU are discussed in the following sections:

- Hexavalent chromium, Section 5.1.1
- Tritium, Section 5.1.2
- Strontium-90, Section 5.1.3
- Carbon-14, Section 5.1.4
- Nitrate, Section 5.1.5
- Volatile organic compounds (e.g., trichloroethene and chloroform), Section 5.1.6
- Other results, including technetium-99, total petroleum hydrocarbons, special sampling for nickel-63, etc., Section 5.1.7.

5.1.1 Hexavalent Chromium Monitoring Results

The groundwater distribution of hexavalent chromium within the 100-KR-4 OU during the spring and fall of 2010 is presented in Figure 5-4. The distribution of hexavalent chromium in the OU can be considered to comprise four separate plumes (KR4, K North, K East, and K West) that can be differentiated by geographic distribution and by the location and nature of probable source areas. The KR4 and

the K North plumes are located on the southwestern and northeastern ends of the 116-K-2 Trench, the original source area. These two plumes are currently being remediated by the KR4 and KX pump-and-treat systems (Figure 5-2). The K East plume is located downgradient of the KE Reactor and appears to be confined to the area near KX extraction wells 199-K-141 and 199-K-178. The source of this plume is likely leakage that occurred from the 183.1-KE headhouse serving the KE Reactor. The fourth hexavalent chromium plume, the K West plume, is located near the KW Reactor and supporting water treatment facilities. The sources of this plume likely include leaks and spills of high-concentration sodium dichromate solutions during unloading or storage at the 183.1-KW headhouse. The K West plume is currently being remediated by the KW pump-and-treat system.

5.1.1.1 116-K-2 Trench Area (KR4 and K North Plumes)

Reactor coolant discharges to the 116-K-2 Trench between 1955 and 1971 resulted in a groundwater mound that substantially raised the water table over a very large section of the OU (up to 4 meters at well 699-78-62, ~1,170 meters inland from the trench, near well 199-K-172). This extensive mound of contaminated water created a large dilute groundwater plume (the 116-K-2 plume), which has been partially remediated by pump-and-treat operations that began in 1997. These remedial activities divided the original plume, which once fully encompassed the 116-K-2 Trench, into a southwest segment (hereafter referred to as the KR4 plume) and a northeast segment (hereafter referred to as the K North plume) that are centered at opposite ends of the 116-K-2 Trench (Figure 5-4).

The K North plume extends ~1.4 kilometers along the Columbia River from the northeastern third of the 116-K-2 Trench to the southern fence line of N Reactor. This northern section of the K North plume is believed to extend inland from the river at least as far as monitoring well 199-K-182 (~1 kilometer), where a hexavalent chromium concentration of 80.5 µg/L was detected in September 2010 (Table 5-1). The plume is unbounded around this well. The southern section of the K North plume is believed to extend inland to the vicinity of extraction well 199-K-171, which is ~1.9 kilometers from the river (Figure 5-2).

The KR4 plume is the smaller of the two 116-K-2 Trench plumes and is found at wells in the area between the southwestern end of the 116-K-2 Trench and the northeastern corner of the fence line around the K Reactors. This plume extends ~0.6 kilometers inland from the river to the vicinity of monitoring well 199-K-111A, located adjacent to the 118-K-1 Burial Ground (Figure 5-2). The sources for this plume are the original trench plume, possibly combined with chromium from the KE headhouse.

The following observations regarding hexavalent chromium distribution associated with the 116-K-2 Trench are based on the data collected from this area during the fall sampling events between CY 2008 and CY 2010 (Table 5-1):

- Hexavalent chromium concentrations were less than 20 µg/L in 14 of 32 wells sampled in fall 2010.
- Hexavalent chromium concentrations decreased between fall 2009 and fall 2010 (results compared included nondetect qualifiers) in 21 of 23 wells sampled during both of these years. When the 2010 data are compared to available 2008 data, concentrations in 26 of 28 wells decreased between fall 2008 and fall 2010.
- The hexavalent chromium concentration at well 199-K-111A currently defines the upgradient extent of the KR4 plume. The concentration of hexavalent chromium at this well during fall 2010 was 46.4 µg/L, an increase of 54.7% since

fall 2008. An upward trend continued in early 2011. This increase may reflect the mobilization of hexavalent chromium contamination in the vadose zone by the infiltration of substantial amounts of dust-suppression water that was used during remediation activities at the 118-K-1 Burial Ground.

- The maximum fall 2010 hexavalent chromium concentration of 139 µg/L was observed in KR4 plume well 199-K-18, which is a 27.6% decrease from 192 µg/L in fall 2009. Hexavalent chromium concentrations increased at this well from the startup of KR4 pump-and-treat operations in 1997 through June 2010, when the trend reached 203 µg/L. It is possible that the effects of a recirculation cell created between the pump-and-treat extraction wells and injection wells is finally being observed in this well. Also, operations of downgradient extraction wells 199-K-145 and 199-K-162 are likely removing the mass of chromium around monitoring well 199-K-18.
- Well 199-K-145, located downgradient of well 199-K-18 (in the KR4 plume), is the only well downgradient of the 116-K-2 Trench with hexavalent chromium concentrations higher during fall 2010 than observed in fall 2008 (field data values of 37 µg/L and 62 µg/L, respectively). All other extraction wells showed declining concentrations of hexavalent chromium. The well was shut down in October 2010 to support upgrades to the KR4 pump-and-treat system. Upon resuming operation in January 2011, hexavalent chromium concentrations were ~25% lower.
- Four aquifer tubes were sampled downgradient of the 116-K-2 Trench plume area during fall 2010. However, only tube AT-K-3-D, at the leading edge of the KR4 plume, is located along a section of shoreline where the discharge of hexavalent chromium had been previously measured. Concentrations of hexavalent chromium in this aquifer tube decreased 9.3%, from 62.8 µg/L to 56.9 µg/L, between fall 2009 and fall 2010.
- Well 199-K-22, located downgradient of the 116-K-2 Trench, was not sampled in fall 2010. This well has had detected chromium concentrations above 100 µg/L since the start of treatment. A slowly decreasing trend was observed between 2008 and 2010, and concentrations dropped below 100 µg/L in 2011.
- Groundwater samples collected between 2008 and 2010 from monitoring wells (199-K-19, 199-K-21, and 199-K-117A) and extraction wells (199-K-119A, 199-K-120A, 199-K-125A, and 199-K-127) in the area between the Columbia River and the central section of the 116-K-2 Trench indicate that the central portion of the hexavalent chromium groundwater contamination historically associated with the trench has been remediated to less than 20 µg/L.
- The hexavalent chromium concentrations in extraction wells 199-K-149 and 199-K-150 (near the northern boundary of the K North plume) decreased from 82 to 8 µg/L and from 70 to 2 µg/L, respectively. The northern boundary of the K North plume appears to have shifted southeast since 2008 due to hydraulic influence of these extraction wells and injection wells 199-K-159 and 199-K-160.

5.1.1.2 KW Reactor Area

Wells 199-K-137 and 199-K-165 (in the central portion of the K West plume, just upgradient of the KW Reactor) were characterized in fall 2008 by hexavalent chromium concentrations of 1,390 and 2,530 µg/L, respectively. Data from fall 2010 are not available for upgradient wells 199-K-173 and 199-K-35 (formerly located between the former 183-KW headhouse and sedimentation basin, decommissioned

in May 2010). Hexavalent chromium concentrations peaked at 771 µg/L in well 199-K-35 (February 2010) and 968 µg/L in well 199-K-173 (August 2010). The presence of elevated concentrations in the KW plume extends upgradient of the 183.1-KW headhouse based on preliminary groundwater vertical profile data collected during installation of the borehole for new RI/FS well 199-K-195 (Figure 5-2). The maximum hexavalent chromium concentrations of 1,970 and 4,890 µg/L were found in an interval ~6 to 9 meters below the groundwater table. Below that interval, hexavalent chromium concentrations dropped to nondetect levels before increasing to 753 µg/L at a sampling interval 3.3 meters above the RUM.

These concentrations are above the normal hexavalent chromium concentrations found in plumes sourced by operational coolant water (700 to 170 µg/L). This suggests that the likely source of the K West plume was leaks and spills of concentrated sodium dichromate solutions and not the discharge of coolant water. Newly installed well 199-K-195 was sampled in April 2011 and a hexavalent chromium concentrations of 3,300 µg/L was detected. The well was decommissioned in late April to permit continued waste site remediation efforts around the former 183.1-KW headhouse. Table 5-2 provides the fall sampling data for the K West plume and the KW Reactor area in general for CY 2008 through CY 2010. The table also includes the percent change in hexavalent chromium concentrations occurring between 2009 and 2010 and between 2008 and 2010 for those wells with data from these years. The following observations on the hexavalent chromium distribution are primarily based on the data presented in Table 5-2:

- Fall 2010 hexavalent chromium concentrations were less than 20 µg/L in six of twelve monitoring locations that were sampled.
- Hexavalent chromium concentrations decreased from 2008 to 2010 in all ten of the wells monitored in this area during both of these years.
- Hexavalent chromium concentrations decreased or were unchanged from 2009 to 2010 in eleven of twelve wells monitored during both of these years.
- The maximum hexavalent chromium concentration in the K West plume during fall 2010 was 321 µg/L in extraction well 199-K-165. In November 2008 (just prior to converting this former monitoring well to an extraction well), a concentration of 2,530 µg/L was recorded in this well (Table 5-2).
- Hexavalent chromium concentrations in downgradient extraction wells 199-K-132 and 199-K-138 have declined steadily, to 16.8 and 20.6 µg/L, respectively.

5.1.1.3 KE Reactor Area

The KE Reactor area hexavalent chromium plume has been monitored since the early 1990s when a number of CERCLA wells were installed upgradient and downgradient of KE Reactor. An initial plume was observed at well 199-K-36, located at the 183.1-KE headhouse, where hexavalent chromium concentrations spiked as high as 1,300 µg/L between 1998 and 2003. This plume may have been the result of localized spills or leaks of concentrated sodium dichromate solutions at the 183.1-KE headhouse and possibly by an influx of contaminated groundwater from the 116-K-2 Trench. None of the groundwater samples collected in the KE Reactor area between 2008 and 2010 contained high hexavalent chromium concentrations (e.g., greater than 700 µg/L) that have recently been observed at some monitoring locations in the KW Reactor area. Beginning in the late 1970s, the KE sedimentation basins and the downgradient KE and KW clear wells were used for N Reactor fuel storage. Leaks are suspected to have diluted any of the KE Reactor area groundwater

chromium plumes present in the last two decades. Table 5-3 presents hexavalent chromium data collected during the fall sampling events of CY 2010, CY 2009, and CY 2008. For those wells where sufficient data were collected, the table also presents the percent change in hexavalent chromium concentrations that occurred between 2009 and 2010 and/or between 2008 and 2010. The following observations address the general hexavalent chromium distributions within the KE plume and the KE Reactor area and are primarily based on the data presented in Table 5-3:

- Pump-and-treat operations during CY 2010 appear to have reduced the areal extent of the KE plume and the overall hexavalent chromium concentrations within the plume.
- Fall 2010 hexavalent chromium concentrations were less than 20 µg/L in seven of the eleven wells sampled and in the only aquifer tube sampled in the KE plume area.
- Hexavalent chromium concentrations decreased or were unchanged in four of the eight wells sampled in both fall 2008 and fall 2010. Concentrations decreased in four of the eleven wells sampled in both 2009 and 2010.
- The maximum reduction in hexavalent chromium concentrations in the plume between fall 2008 (421 µg/L) and fall 2010 (38 µg/L) was observed at extraction well 199-K-141.

5.1.2 Tritium Monitoring Results

Tritium is highly mobile and is a common contaminant in groundwater beneath the K Reactor area. Tritium forms by neutron activation during reactor operations and by fission in fuel rods. Tritium is associated with the 116-KE-1 and 116-KW-1 gas condensate cribs, located just east of the KE and KW Reactor buildings. Tritium is also associated with the 116-KE-3 and 116-KW-2 Cribs, which received shielding water from the fuel storage basins of the respective reactors. Leaks occurring from buried silos in the 118-K-1 Burial Ground is a third source (PNNL-14031). Figure 5-5 presents tritium activity plume maps for the spring and fall of 2010. The DWS for tritium is 20,000 pCi/L.

5.1.2.1 116-K-2 Trench Tritium Plume

The source of the 116-K-2 Trench tritium plume is the silos buried within the central portion of the 118-K-1 Burial Ground. The fall 2010 sampling results, as well as the 2008 and 2009 results, are summarized in Table 5-4 and highlights are presented below:

- Fall 2010 tritium concentrations were less than the DWS in fifteen of eighteen wells sampled.
- Well 199-K-18 increased from 29,000 to 230,000 pCi/L between fall 2008 and fall 2010. A new, nearby RI/FS well, 199-K-192, encountered tritium concentrations of 1,400,000 to 350,000 pCi/L in the upper 6.2 meters of the unconfined aquifer. Downgradient of well 199-K-18, extraction wells 199-K-120A and 199-K-162 had decreased tritium concentrations below 8,000 pCi/L, while 199-K-145 increased to 63,000 pCi/L.
- Tritium concentrations decreased or were unchanged from 2008 to 2010 in six of ten wells and from 2009 to 2010 in twelve of thirteen wells.
- At well 199-K-157, the maximum fall 2010 tritium concentration was 27,000 pCi/L. However, tritium concentrations have decreased more than 90% in this well since 2008 (320,000 pCi/L). Another well displaying an increase

in tritium for the period of 2008 to 2010 was 199-K-111A, which increased more than 300% from 2008 to 2010 (from 6,000 pCi/L in 2008 to 26,000 pCi/L in 2010). Concentrations remained at this level in 2011.

- In the K North plume, a large increase in tritium from 2008 to 2010 was 203 pCi/L (nondetect) to 5,200 pCi/L in extraction well 199-K-163, upgradient of the northeast end of the 116-K-2 Trench. This well is located north of the KR4 pump-and-treat system injection field.
- During drilling of RI/FS well 199-K-192, a tritium concentration of 1,400,000 pCi/L was encountered in groundwater profiling samples collected near the top of the aquifer. Concentrations decreased to 14,000 pCi/L at 15.2 meters below the groundwater table. Minor tritium concentrations were detected in temporary wells 199-K-200 and 199-K-201.
- Tritium taken up by KR4 extraction wells around monitoring well 199-K-18 passes through the treatment system with no uptake on the ion-exchange resins, and it is injected at wells upgradient of the 116-K-2 Trench. Downgradient monitoring and extraction wells 199-K-119A, 199-K-125A and 199-K-127 have been sampled for tritium since the start of pump-and-treat operations. All three wells steadily increased from low concentrations to between 7,500 to 8,300 pCi/L in 2010; however, the concentration in only well 199-K-127 has not begun to decline.

5.1.2.2 KW Reactor Area Tritium Plume

The source of the elevated tritium in the KW Reactor area is likely the 116-KW-1 gas condensate crib, located on the east side of the KW Reactor. An inventory of 56.5 Ci of tritium (decayed through 1986) was reported for this crib. None of the samples collected from this area during fall 2010 indicated tritium above the 20,000 pCi/L DWS. Although none of the KW Reactor area tritium exceedances could be mapped, the wells sampled and the results obtained are shown in Figure 5-5. The results for 2008, 2009, and 2010 are summarized in Table 5-5. Pertinent observations are as follows:

- The maximum fall 2010 tritium concentration of 7,500 pCi/L was observed in well 199-K-132.
- Tritium concentrations increased from 2008 to 2010 in six of seven wells, with a maximum increase of 215% (to 4,100 pCi/L) in well 199-K-34.
- Well 199-K-106A was characterized by an 85% decrease in tritium from 2008 to 2010 (from 21,000 pCi/L in 2008 to 3,200 pCi/L in 2010). Tritium at this well had previously been as high as 2.24 million pCi/L in 2005. Tritium then trended downward to 430,000 pCi/L in April 2009 before experiencing a significant decline to 3,900 pCi/L in the next quarterly sampling.
- The highest tritium concentration in characterization samples from the four new KW Reactor area RI/FS wells (199-K-183, 199-K-184, 199-K-185, and 199-K-195) was 8,800 pCi/L at well 199-K-184.

5.1.2.3 KE Reactor Area Tritium Plume

The source of the small zone of tritium contamination identified as the KE Reactor area tritium plume was likely the 116-KE-1 gas condensate crib, located on the east side of the KE Reactor. The fall 2010 results, as well as the 2008 and 2009 results, are summarized in Table 5-6 and highlights are presented below:

- Tritium concentrations exceeded the 20,000 pCi/L DWS in only two of the nine wells sampled in the KE Reactor area during fall 2010 (wells 199-K-29 and 199-K-111A).
- The tritium concentrations in well 199-K-29 increased from 7,100 pCi/L in fall 2008 to 130,000 pCi/L in fall 2010. This result is being verified because it is much higher than the tritium activity trend for the well; the value is also more in line with the tritium trend at well 199-K-30.
- Tritium concentrations in well 199-K-30 decreased significantly from 2008 (410,000 pCi/L), to 2009 (140,000 pCi/L), and 2010 (16,000 pCi/L). The result from 2010 is the only reported tritium value below the DWS since the start of sampling in 1992.
- Monitoring wells 199-K-30 and 199-K-29 have been decommissioned to permit access for demolition of the 117-KE filter facility. Monitoring for this area of the plume will be conducted in the future at new monitoring well 199-K-189, which was installed as part of the RI/FS investigation. Groundwater profiling data collected during installation of this borehole found tritium concentrations ranging between 140,000 and 1,600 pCi/L near the top of the aquifer, 0 to 12.2 meters below the water table.

5.1.3 Strontium-90 Monitoring Results

Strontium-90 in the environment is the result of fuel rod failures in the reactor or in the fuel storage basins. At the KE and KW Reactors, at least 270 fuel rod failures were reported during operations (PNWD-2161 HEDR, *Fuel Element Failures in Hanford Single-Pass Reactors 1944-1971*). Cooling water contaminated by the failures were reserved in an empty 107-KE or –KW retention basin while the fuel rod was changed out and then discharged to the 116-K-2 Trench. Strontium-90 has also been released to 100-KR-4 OU groundwater via discharges to the 116-KW-2 and 116-KE-3 fuel storage basin cribs, or by the basins themselves. The DWS for strontium-90 is 8 pCi/L, and plume maps showing the distribution of strontium-90 exceedances in the groundwater of the 100-KR-04 OU are provided in Figure 5-6. The following discussion summarizes the nature and extent of the strontium-90 plumes associated with the 116-K-2 Trench, the KW Reactor, and the KE Reactor.

5.1.3.1 116-K-2 Trench Strontium-90 Plumes

Strontium-90 results collected from wells in the 116-K-2 Trench area during the fall monitoring events in CY 2008, CY 2009, and CY 2010 are shown in Table 5-7. Notable observations for strontium-90 distribution in the 116-K-2 Trench area are as follows:

- Strontium-90 concentrations were below the DWS of 8 pCi/L in thirteen of the eighteen locations sampled during fall 2010. Of the remaining five locations, strontium-90 was detected at concentrations above the 8 pCi/L DWS in two locations, and the detection limit for strontium-90 was above the 8 pCi/L DWS in the remaining three locations.
- The two monitoring wells identified with exceedances of strontium-90 in the 116-K-2 Trench area during the fall of CY 2010 were 199-K-19 (12 pCi/L) and 199-K-21 (17 pCi/L) (Figure 5-2). Well 199-K-19 defines the small plume located downgradient of the southeastern end of the trench, and well 199-K-21 defines the plume located downgradient of the central area of the trench (Figure 5-6).

- The strontium-90 concentration at well 199-K-19 increased from 7.5 to 12 pCi/L (60%) between fall 2009 and 2010, while the concentrations at well 199-K-21 decreased from 22 to 17 pCi/L (23%) during the same period (Table 5-7).
- Strontium-90 was detected in groundwater at new temporary RI/FS monitoring well 199-K-200 at concentrations of 130 to 190 pCi/L in early 2011. New RI/FS well 199-K-192 detected strontium-90 at a concentration of 19 pCi/L at the top of the aquifer. Strontium-90 is not detected at well 199-K-18, which is downgradient of the other two wells.

5.1.3.2 KW Reactor Area Strontium-90 Plume

The source of the KW Reactor area strontium-90 plume is assumed to be the former 116-KW-2 Crib, which received effluent from the 105-KW fuel rod basin (KW Basin). The fall 2010 results, as well as the 2008 and 2009 results, are summarized in Table 5-8 and highlights are presented below:

- Fall strontium-90 concentrations were less than the 8 pCi/L DWS in four of six wells sampled.
- Two DWS exceedances for strontium-90 were observed in the fall 2010 data. At well 199-K-107A, a fall 2010 strontium-90 concentration of 14 pCi/L was reported, essentially unchanged from 13 pCi/L observed in the well in fall 2009. The strontium-90 concentration at well 199-K-34 decreased from 36.4 pCi/L in 2008, to 16 pCi/L in October 2009, but then rose to 45 pCi/L in December 2010. The strontium-90 concentration in this well increased to 50 µg/L in January 2011.

5.1.3.3 KE Reactor Area Strontium-90 Plume

The source of the KE Reactor area strontium-90 plume is assumed to be effluent that was discharged from the 105-KE fuel rod basin (KE Basin) to the 116-KE-3 Crib. The strontium-90 results collected from wells sampled in the KE Reactor area during the fall of CY 2008, CY 2009, and CY 2010 are presented in Table 5-9. All seven of the monitoring wells sampled in this area during the fall of CY 2010 had strontium-90 concentrations that were less than the 8 pCi/L maximum DWS (Table 5-9). Former monitoring well 199-K-109A had the highest strontium-90 concentration measured in this area over the previous 3 years (1,120 pCi/L in March 2008). Well 199-K-109A was decommissioned in April 2008 to support demolition of the KE Basin; data have not been collected from the suspected core of this plume since that time. New monitoring well 199-K-189 was installed in the vicinity of decommissioned well 199-K-109A, and data collected in 2011 will be used to update the KE Reactor area strontium plume map. Based on the current absence of a nearby alternative location to well 199-K-109A, the CY 2008 data from decommissioned well 199-K-109A were used to produce an estimated plume boundary for strontium-90 exceedances in the KE Reactor area for the spring and fall of 2010 (Figure 5-6). Additional observations for this plume area include the following:

- The maximum strontium-90 concentration measured in wells in this area during the fall of CY 2010 was 4.4 pCi/L in well 199-K-32A.
- The maximum strontium-90 increase from 2009 to 2010 was 17% in well 199-K-32A. The fall 2009 result was 3.8 pCi/L, which increased to 4.4 pCi/L in 2010.
- Strontium-90 concentrations in well 199-K-141 (a KX system extraction well located downgradient of the KE Basin and former well 199-K-109A) increased from nondetect values when first drilled, to 5.9 pCi/L in July 2010, and to

12 µg/L in January 2011, before declining to 9.7 pCi/L when resampled in February 2011. Gross beta activity also increased. Verification samples taken in early March 2011 confirmed this trend. Verification sampling results are being evaluated for possible impact to operations.

5.1.4 Carbon-14 Monitoring Results

Carbon-14 is a neutron activation product of nitrogen, which was used as a blanket cover gas. The gas helped to cool the reactor and also removed water vapor from leaks in the core. In 1961, nitrogen replaced a helium-carbon dioxide blend as the cover gas. Carbon-14 in groundwater in the 100-KR-4 OU originates from two major sources: the 115-KE and 115-KW gas condensate facilities, and the 116-KE-1 and 116-KW-1 gas condensate cribs. Each crib has an estimated 110 Ci inventory of carbon-14. The DWS for carbon-14 is 2,000 pCi/L. Figure 5-7 presents plume maps for the spring and fall of 2010. The following discussion provides the carbon-14 results for the KW and KE Reactor areas for CY 2010.

5.1.4.1 KW Reactor Area Carbon-14 Plume

The suspected source of carbon-14 detected in wells around the KW Reactor is the 115-KW gas condensate facility and the 116-KW-1 gas condensate crib (Figure 5-2). The fall 2010 results, as well as the 2008 and 2009 results, are summarized in Table 5-10 and highlights are as follows:

- Well 199-K-106A, which was not sampled in fall 2010, is located downgradient of the 116-KW-1 gas condensate crib. Carbon-14 concentrations have trended above the 2,000 pCi/L DWS at this location since 1995, and the result from the fall of 2009 was 3,970 pCi/L (Table 5-10). The June 2010 carbon-14 concentrations at this well were 10,100 pCi/L. Sampling at former downgradient monitoring well 199-K-33, active until March 2003, detected carbon-14 concentrations of between 6,300 and 16,000 pCi/L between 1992 and 2003.
- The highest carbon-14 concentration during the fall of 2010 was 2,590 pCi/L observed at monitoring well 199-K-34, located west of well 199-K-106A.
- The maximum carbon-14 concentration at an extraction well was 2,350 pCi/L in 199-K-132. For the remainder of the extraction wells in the KW system, carbon-14 concentrations did not exceed 540 pCi/L. Monitoring wells 199-K-107A and 199-K-108A yielded carbon-14 concentrations of 625 and 265 pCi/L in fall 2010. These wells are cross-gradient and upgradient, respectively, of the source waste site (the 116-KW-1 Crib). Groundwater contaminated with carbon-14 is extracted by downgradient extraction wells and is passed through the KW treatment system. Some removal of carbon-14 using DOWEX-21K® (registered trademark of Dow Chemical Company, Midland, Michigan) resin is observed. The December 2010 sampling results indicated carbon-14 at a concentration of 700 pCi/L present in the influent tank of the ion-exchange system, and 580 pCi/L was observed in the effluent tank. Most of the carbon-14 remaining in the treated effluent is reinjected upgradient of the KW Reactor area carbon-14 plume via wells 199-K-158, 199-K-174, and 199-K-175.
- Although not collected as part of the fall sampling event, vertical profile data were collected through the unconfined aquifer during the installation of four new RI/FS wells installed in the KW Reactor area during CY 2010 and CY 2011 (199-K-183, 199-K-184, 199-K-185, and 199-K-195) (Figure 5-2). Only vertical profile samples collected from well 199-K-185, downgradient of the 107-KW retention basins, had carbon-14 concentrations exceeding the DWS, reaching a maximum

of 2,390 pCi/L in a sample collected near the top of the aquifer. This well replaced former well 199-K-33, in which the carbon-14 trend exceeded the DWS by three to eight times. Samples from well 199-K-184 yielded a maximum carbon-14 concentration of 1,640 pCi/L. The carbon-14 concentrations in the vertical profile samples collected during borehole installations for wells 199-K-183 and 199-K-185 did not exceed 900 pCi/L.

5.1.4.2 KE Reactor Area Carbon-14 Plume

The suspected source of the carbon-14 detected in wells around the KE Reactor is the 115-KE gas condensate facility and the 116-KE-1 gas condensate crib. The CY 2010 results, as well as the 2008 and 2009 results, are summarized in Table 5-11 and highlights presented below:

- Fall 2010 carbon-14 concentrations were less than the 2,000 pCi/L DWS in six of eight wells sampled.
- The maximum fall 2010 carbon-14 concentration was 4,110 pCi/L in monitoring well 199-K-30. The only other well displaying carbon-14 above the DWS was 199-K-29 at 3,120 pCi/L. Both values were on-trend when the wells were decommissioned.
- The carbon-14 concentration in well 199-K-30 decreased from 6,130 pCi/L in fall 2008 to 5,830 pCi/L in fall 2009, and again to 4,110 pCi/L in fall 2010.
- Extraction well 199-K-178 (downgradient of the 116-KE-1 Crib) yielded a fall 2010 concentration of 226 pCi/L. Downgradient monitoring wells 199-K-32A and 199-K-142 maintained relatively low carbon-14 concentrations of 192 and 242 pCi/L, respectively. These values were generally consistent with the range of values observed for these wells in 2008 and 2009. Five new RI/FS wells (199-K-189,199-K-186, 199-K-187, 199-K-188, and 199-K-190) were installed during 2010 in the KE Reactor area (Figure 5-2). Groundwater profiling samples collected during installation of these boreholes yielded carbon-14 concentrations up to 1,200 pCi/L in a sampling interval 3.1 meters below the top of the aquifer at well 199-K-189, while the maximum carbon-14 concentrations observed in wells 199-K-186, 199-K-187, 199-K-188, and 199-K-190 ranged from 60 to 716 pCi/L.

5.1.5 Nitrate Monitoring Results

Nitrate is present in most 100-KR-4 OU wells at concentrations below the DWS (45 mg/L). The source of nitrate is unknown but may be associated with reactor or water plant operations, decontamination activities, or septic systems. The following discussion presents the nitrate plumes (Figure 5-8) around the 116-K-2 Trench area, the KW Reactor area, and the KE Reactor area.

5.1.5.1 116-K-2 Trench Nitrate Plume

The fall 2010 results for the 116-K-2 Trench nitrate plume, as well as the 2008 and 2009 results, are summarized in Table 5-12 and highlights are presented below:

- The maximum fall 2010 nitrate concentration was 60.6 mg/L in well 199-K-18, followed by 26.7 mg/L in well 199-K-19. Nitrate trends at both wells have been decreasing since 2008. Although the data suggest that the 116-K-2 Trench is the source for this plume, some nitrate may also be derived from the 118-K-1 Burial Ground or the septic system for the KE Reactor (located northeast of the structure).
- Nitrate concentrations decreased in the five wells sampled in both 2008 and 2010.

- Nitrate concentration decreased in ten of twelve wells sampled in both 2009 and 2010. The maximum decreases were 70% at extraction well 199-K-161 and 56% in monitoring well 199-K-117A.
- Monitoring well 199-K-21 was the only well with an increase in nitrate concentrations from 2009 to 2010 (from 10.7 to 14.8 mg/L). However, concentrations decreased in this well between 2008 and 2010 (from 17.7 to 14.8 mg/L).

5.1.5.2 KW Reactor Area Nitrate Plume

The source for the KW Reactor area nitrate plume appears to be the 116-KW-1 gas condensate crib. The fall 2010 results, as well as the 2008 and 2009 results, are summarized in Table 5-13 and highlights are as follows:

- The fall 2010 nitrate concentrations were less than the 45 mg/L DWS in six of seven wells sampled.
- The maximum fall 2010 nitrate concentration was 73.9 mg/L in well 199-K-106A. It and former downgradient monitoring well 199-K-33 have usually ranged two to three times above the DWS
- The maximum observed reduction in nitrate concentration between 2008 and 2010 ranged from 193 mg/L to 22.4 mg/L (88.4%) in extraction well 199-K-166.
- Nitrate increased from 2008 to 2010 in four of seven wells sampled in both years, with a maximum increase of 21.2% in extraction well 199-K-132 (from 28.3 to 34.3 mg/L).

5.1.5.3 KE Reactor Area Nitrate Plume

The fall 2010 results for the KE Reactor area nitrate plume, as well as the 2008 and 2009 results, are summarized in Table 5-14 and highlights are as follows:

- Fall 2010 nitrate concentrations were less than the 45 mg/L DWS in eight of nine wells sampled.
- The maximum reported nitrate concentrations from the KE Reactor area in fall 2010 were 46.5 mg/L in monitoring well 199-K-29 and 25.1 mg/L in monitoring well 199-K-30. It is suspected that, based on proximity to the 116-KE-1 gas condensate crib and the nitrate trends at the two wells, the data have been reversed. The laboratory and field records are being checked for evidence that the samples may have been interchanged. Although trends do not differ significantly, the relative proximity of wells 199-K-30 versus 199-K-29 to the 116-KE-1 gas condensate crib makes the reported results problematic.
- Nitrate concentrations decreased from 2008 to 2010 in five of seven wells sampled in both years. The maximum decrease was 68.5% in monitoring well 199-K-30, from 79.7 mg/L in 2008 to 25.1 mg/L in 2010.
- The maximum increase in nitrate from 2008 to 2010 was 27.1% in monitoring well 199-K-36, increasing from 22.1 mg/L in 2008 to 28.1 mg/L in 2010.

5.1.6 Volatile Organic Compounds Monitoring Results

Trichloroethene is a chlorinated organic compound found around the KW Reactor area at concentrations slightly above the 5 µg/L DWS in a few wells. The spring and fall 2010 plumes are presented in Figure 5-9 and highlights are summarized below:

- Sampling conducted at seventeen wells in the 100-K Area for the risk assessment phase of the ongoing RI/FS indicated the presence of trichloroethene.

- Contaminant trends for trichloroethene were the highest at wells downgradient of the 116-KW-1 gas condensate crib (35 µg/L in 1995 at well 199-K-106A and 20 µg/L in 1994 at the now decommissioned well 199-K-33), which suggests that the source was likely the 116-KW-1 Crib. Since startup of KW pump-and-treat activities, the distribution of trichloroethene has spread away from these two wells.
- Most wells downgradient of the 116-KW-1 gas condensate crib have had one or more detections of trichloroethene exceeding the DWS, whereas most wells upgradient of the crib have detections below the DWS.

Chloroform is another chlorinated organic compound that has been detected at monitoring locations within the 100-KR-4 OU. Although the detected concentrations are well below the 80 µg/L DWS, some concentrations are above the risk assessment action level of 0.71 µg/L. The distribution of chloroform within the KW plume area is summarized below:

- Chloroform was detected at well 199-K-151, near the southwestern boundary of the N Reactor Area. Additional detections were found in wells near the head end of the 116-K-2 Trench and downgradient of the 116-KE-1 Crib.
- The chloroform levels at monitoring well 199-K-151 ranged up to 6.3 µg/L; however, no known source waste site has been identified.
- Well 199-K-18 had chloroform concentrations up to 2.1 µg/L during the three risk assessment sampling events. Previous results from 1992 and 1993 had concentrations estimated between 6 and 8 µg/L.
- Chloroform concentrations at well 199-K-32A during 2010 were as high as 2.3 µg/L and follow a series of 1992 to 1993 results ranging between 11 and 17 µg/L.
- Wells 199-K-29 and 199-K-30, downgradient of the 116-KE-1 gas condensate crib, reached levels of 19 and 14 µg/L, respectively, in 1992 and 1993.
- Other wells examined during the 100-K Area risk assessment sampling had chloroform concentrations generally below the detection limit of 1 µg/L.

5.1.7 Other Contaminants of Interest

5.1.7.1 Technetium-99

Technetium-99 is a long-lived fission product generated during100-K Area reactor operations. Technetium-99 concentrations at upgradient KW system extraction and monitoring wells (e.g., 199-K-173 and 199-K-165) ranged between 14 and 37 pCi/L in January 2011, while concentrations at downgradient extraction and monitoring wells (e.g., 199-K-107 and 199-K-132) ranged between 13 and 35 pCi/L in November 2010. Sampling at well 199-K-31, located upriver from the KW pump-and-treat area, had a detected technetium-99 concentration of 48 pCi/L in December 2010. Overall, technetium-99 concentrations in 100-KR-4 OU groundwater during CY 2010 were ~6% (or less) of the 900 pCi/L DWS.

5.1.7.2 Total Petroleum Hydrocarbons

As noted in the CY 2009 annual groundwater report (DOE/RL-2010-11), several wells in the KW Reactor area encountered total petroleum hydrocarbons (diesel and gasoline) while being drilled. Well 199-K-167 and replacement well 199-K-173 both encountered a diesel-saturated interval in vadose zone sediments at depths of ~8.5 to 9.1 meters below ground surface. Analytical results at wells around and downgradient of the 166-KW fuel storage vault have occasionally reported low detections of total

petroleum hydrocarbons (diesel or gasoline). The results at wells 199-K-165 and 199-K-168 showed detections, typically in the uppermost aquifer sample taken while the well was being drilled. Sampling during CY 2010 did not detect any of the total petroleum hydrocarbons in these wells.

While drilling RI/FS well 199-K-186, downgradient of the 166-KE fuel storage vault, a zone of diesel-saturated sediments was found at a depth of 12.8 to 14.6 meters below ground surface. Total petroleum hydrocarbons were not been reported in groundwater samples. Well 199-K-110A, located north of the 166-KE fuel bunker, detected a low concentration of diesel fuel in December 2010. An estimated ("J" qualified result close to detection levels with large analytical errors) concentration of 78 µg/L was reported.

5.1.7.3 Nickel-63

Nickel-63 is an activation product with a half-life of 101 years and a DWS of 50 pCi/L. Small amounts of nickel-63 were released to the environment in the 100-K Area as a result of KE and KW Reactor operations. A one-time nickel-63 sampling event was performed from March through July 2010 at wells downgradient of the 116-K-2 Trench at the request of Washington Closure Hanford. Concern regarding the presence of nickel-63 in the soil column led to sampling of the monitoring and extraction wells downgradient of the trench; wells 199-K-106A and 199-K-30, downgradient of the 116-KE-1 and 166-KW-1 Cribs, were also sampled. Most results were nondetects; however, nickel-63 was detected at a few wells, including 4.24 and 4.42 pCi/L at wells 199-K-18 and 199-K-30, respectively.

5.2 CERCLA Groundwater Activities

A variety of activities were underway at the 100-KR-4 Groundwater OU during CY 2010. Following approval of the 100-K Area RI/FS work plan (DOE/RL-2008-46-ADD2) and the *Sampling and Analysis Plan for the 100-K Decision Unit Remedial Investigation/Feasibility Study* (DOE/RL-2009-41), a series of drilling and sampling tasks supporting characterization were initiated (Section 5.2.1). The remedial process optimization (RPO) project was developed in greater detail in CY 2010; however, the design and implementation await a determination of the remedial approach following the final ROD (Section 5.2.2) before proceeding. Planning for implementation of the Phase 3 RPO requirements began in CY 2010.

Two of the three pump-and-treat systems (KX and KW) were operated with minimal interruptions for the entire year, and the third system (KR4) operated with minimal interruptions until shutdown in the fourth quarter CY 2010 for a system upgrade. Section 5.2.3 discusses system performance for the three pump-and-treat systems.

All remediation work performed at the 100-KR-4 OU is conducted in accordance with CERCLA requirements, as presented in the following documents:

- **DOE/RL-96-84, Rev. 0 and Rev. 0A, *Remedial Design Report and Remedial Action Work Plan for the 100-HR-3 and 100-KR-4 Groundwater Operable Units' Interim Action*:** The work plan describes the design and operation requirements for the original KR4 pump-and-treat system.
- **DOE/RL-96-90, Rev. 0, *Interim Action Monitoring Plan for the 100-HR-3 and 100-KR-4 Operable Units*:** This document established the initial operational,

monitoring, and sampling requirements for the 100-KR-4 OU to demonstrate satisfactory operations and control of the plume by the KR4 treatment system.

- **DOE/RL-2006-20, Rev. 1, *The Second CERCLA Five-Year Review Report for the Hanford Site*:** This document identified the need for the following:
  - Determine the southeastern extent of the chromium groundwater plume inland from the 116-K-2 Trench (Action 3-1). Three wells (199-K-153, 199-K-154, and 199-K-163) were installed in November 2008 to address this issue. Hexavalent chromium was detected at concentrations between 50 and 150 µg/L and extended the 50 and 100 µg/L contours further to the southeast.
  - Remediate the small hexavalent chromium plume reaching the Columbia River as detected at near-shore aquifer tubes (Action 4-1). The 379-liter-per-minute-capacity KW pump-and-treat system began operation in January 2007. The KW system capacity was expanded to 757 liters per minute in April 2009.
  - Expand the 100-K Area treatment capacity by 379 liters per minute to enhance remediation of the chromium plume between the 116-K-2 Trench and the N Reactor perimeter fence line (Action 5-1). The 2,271-liter-per minute-capacity KX treatment system was constructed and began operation in February 2009, reaching full treatment capacity in May 2009.
  - Add wells between the 116-K-2 Trench and the N Reactor perimeter fence line for groundwater extraction, and connect to the pump-and-treat system (Action 5-2). Wells 199-K-138, 199-K-149, and 199-K-150 were drilled in late 2007 and early 2008. Along with existing wells 199-K-130 and 199-K-131, the five wells were converted to extraction wells and connected to the KX treatment system, thus completing the required action.
- **DOE/RL-2006-52, Rev. 1 and Rev. 2, *The KW Pump-and-Treat System Remedial Design and Remedial Action Work Plan, Supplement to the 100-KR-4 Groundwater Operable Unit Interim Action*:** Revision 1 established the initial operational, monitoring, and sampling requirements for the 379-liter-per-minute-capacity KW pump-and-treat system. Revision 2 addressed the addition of new extraction and injection wells and the additional 379-liter-per-minute capacity from the added treatment train at the KW system.
- **DOE/RL-2006-75, Rev. 1 (reissue), *Supplement to the 100-HR-3 and 100-KR-4 Remedial Design and Remedial Action Work Plan for the Expansion of the 100-KR-4 Pump-and-Treat System*:** This document established the initial operational, monitoring, and sampling requirements for the 2,271-liter-per-minute-capacity KX pump-and-treat system. This document will be reissued as a new document to incorporate changes from Phase 3 well additions.
- **DOE/RL-2008-46, Rev. 0, *Integrated 100 Area Remedial Investigation/Feasibility Study Work Plan***; and ***DOE/RL-2008-46-ADD 2, Rev. 0, Integrated 100 Area Remedial Investigation/Feasibility Study Work Plan: 100-KR-1, 100-KR-2 and 100-KR-4 Operable Units*:** These documents provide the basis for vadose zone and groundwater characterization needed to support preparation of the RI/FS and proposed plan in order to reach a final ROD for the 100-K Area.
- **DOE/RL-2009-41, Rev. 0, *Sampling and Analysis Plan for the 100-K Decision Unit Remedial Investigation/Feasibility Study*:** This document provided specific

sampling and analytical requirements for testing at thirteen groundwater wells and two boreholes planned for the 100-KR-4 OU.

- ***Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al., 1989) Change Notice 273 (TPA-CN-273):** This change notice addressed a number of changes required to improve operations at the KR4 and KX pump-and-treat systems, as follows:
  - Realign wells between the two systems to contain the impact of a tritium plume potentially impacting groundwater quality at KX injection wells
  - Standardize sampling of extraction, compliance, and monitoring wells at the KR4 and KX systems
  - Identify five new wells with locations for the KR4 and KX systems, as well as the sampling requirements, proposed uses, and general well design in support of RPO
  - Delete requirements to prepare a semiannual report on the status of the pump-and-treat systems for the first half of each CY.

During CY 2010, Tri-Party Agreement Change Notice 357 was prepared and approved. This change notice modified the sampling and analysis plan to address the following:

- Relocate one well planned in a culturally sensitive area southeast of the 116-K-2 Trench to a location near the KE Reactor.
- Require additional soil sampling requirements for the seven wells within the K Reactor area fence line. Sampling is required at 1.5-meter intervals while drilling through the vadose zone at wells 199-K-185, 199-K-190, 199-K-186, 199-K-184, 199-K-188, and 199-K-195.
- Permit construction of well 199-K-188 (and 199-K-195) as temporary wells (polyvinyl chloride casing), which are located in areas expected to undergo structural demolition (183.1-KE headhouse and 183.2-KE sedimentation basin) and waste site soil remediation within one year or less following well installation. The wells will be removed during remediation as needed to complete surface-based remediation activities.
- Incorporate revisions to gamma energy analysis analyte list for soil and groundwater samples to conform to lists in other RI/FS sampling and analysis plans.

5.2.1 Remedial Investigation/Feasibility Study Activities

Drilling and sampling activities required by DOE/RL-2008-46-ADD2 and implemented through the sampling and analysis plan (DOE/RL-2009-41) began in CY 2010. The sampling and analysis plan was altered by Tri-Party Agreement Change Notice 357. The results of RI/FS characterization activities are preliminary and are not presented in this document. An upcoming RI/FS report will include data and conclusions.

A drilling program including thirteen wells and two boreholes, initiated in May 2010, was ~80% complete by the end of CY 2010 and was completed mid-March 2011. Groundwater and vadose zone soil sampling at 1.5-meter intervals as specified for the borings inside the reactor area was performed. For wells outside the reactor area, soil samples were taken at intervals of 4.6, 3, 1.5, and 0.6 meters above the estimated water table and at 1.5 meters below the water table.

Groundwater was sampled for the following general classes of analytes: metals, volatile organic compounds, and anions, as well as hexavalent chromium, carbon-14, strontium-90, and tritium. In addition, six field performance analyses are performed prior to groundwater sampling: pH, specific conductance, temperature, dissolved oxygen, oxidation-reduction potential, and turbidity. Soil was analyzed for metals, hexavalent chromium, and the following radionuclides: gross alpha, gross beta, gross gamma, cesium-137, cobalt-60, europium-152, europium-154, and strontium-90. Batch leaching followed by testing for metals, mercury, and hexavalent chromium was planned for selected locations. In addition, physical properties testing of split-spoon soil samples was performed at major formation or lithology changes, as well as at 3 and 1.5 meters above the Hanford/Ringold contact and 1.5 meters below the Hanford/Ringold contact.

All boreholes were geophysically logged, and slug tests were conducted in all groundwater wells following construction and development. For each well, screen placement was based on the vertical profile data for hexavalent chromium concentrations. Most wells will be used for monitoring, but some wells were constructed to accommodate potential future use as extraction or injection wells. Three aquifer tubes at one location downgradient of the KW Reactor were installed and samples were taken at low and intermediate river stages during CY 2010. A series of three sampling events to collect data for the 100-K Area RI/FS risk assessment was completed at seventeen wells during CY 2010. Preparation of the RI/FS report began in CY 2010, and Draft A is scheduled for submittal to the regulatory agencies in September 2011.

5.2.2 Remedial Process Optimization Activities

The RPO activities were implemented for the 100-KR-4 interim action in CY 2009. This process is intended to improve treatment system performance to meet the Tri-Party Agreement milestones described below. The goal of these milestones is to improve remediation of the hexavalent chromium plume and other plumes that have been determined to impact groundwater and the Columbia River. The key proposed milestones are as follows:

- ***Milestone M-016-110-TO-1:*** Take action necessary to contain or remediate hexavalent chromium groundwater plumes in each of the 100 Area OUs so ambient water quality standards are achieved in the hyporheic zone and river water column (December 31, 2012).
- ***Milestone M-016-110-TO-2:*** Take actions necessary to remediate hexavalent chromium plumes so hexavalent chromium will meet the DWS (December 31, 2020).
- ***Milestone M-016-110-TO-4*****:** Implement remedial actions selected in all 100 Area groundwater RODs so contamination above DWSs or ambient water quality standards does not enter the Columbia River unless otherwise specified in a CERCLA decision (December 31, 2016).

The RPO activities have included use of groundwater flow and fate and transport modeling to (1) identify those areas of the 100-KR-4 OU where hexavalent chromium contamination will likely continue to discharge to the Columbia River under the current operating scenarios for the KW, KX, and KR4 pump-and-treat systems; and (2) perform system design modeling to identify modifications to the current extraction and injection well configurations that will minimize, as much as is possible, the discharge of hexavalent chromium into the Columbia River. Additional modeling has been conducted to identify upgradient changes to the remedial system (including

implementation of alternate treatment technologies) that could be implemented to increase mass removal and decrease cleanup times for the 100-KR-4 OU. The RPO efforts are planned as four phases:

- Phase 1 addressed well realignments to the KR4/KX treatment systems to address tritium issues (completed in CY 2009).
- Phase 2 addressed the drilling of five additional wells for use at the KR4 and KX treatment systems (completed in CY 2010).
- Phase 3 will install four new wells for plume control in 2011: three extraction and/or monitoring wells at the KR4 treatment system, and one extraction well at the KW treatment system.
- Phase 4 will address the requirements presented in the final ROD and implemented in the remedial design report/remedial action work plan.

An evaluation of four long-term remediation alternatives continued through mid-year in CY 2010:

1. No action/monitored natural attenuation
2. Continued pump-and-treat actions with existing treatment systems
3. Expanded extraction and injection well fields for the pump-and-treat systems with other actions (bioremediation).
4. An advanced aggressive pump-and-treat with other actions (bioremediation).

Groundwater Modeling Results

The RPO fate and transport modeling conducted under the current system design conditions indicates that, despite the overall effectiveness of the existing remedial systems and well field designs, hexavalent chromium may continue to discharge to the Columbia River after CY 2012 in some areas of the 100-KR-4 OU at concentrations above the ambient water quality criterion of 10 µg/L. Plume areas that may continue to discharge to the river include the KW Reactor plume and the plume areas at either end of the 116-K-2 Trench. Phase 3 wells are designed to intercept key known or suspected plume discharge sites near the southwest end of the 116-K-2 Trench and at the KW plume. Remediation of some plume areas downgradient of the 116-K-2 Trench will, however, be challenging due to the presence of sensitive cultural sites. The RPO modeling has been continued in support of the RI/FS, and further results will be presented in the report (DOE/RL-2010-97) when it is issued in September 2011.

5.2.3 100-KR-4 OU Pump-and-Treat Systems (KR4, KX, and KW)

The primary COC in groundwater at the 100-KR-4 OU is hexavalent chromium, and three pump-and-treat systems have been implemented to remediate the groundwater and to protect the Columbia River in the 100-K Area. The boundaries of the 100-KR-4 OU were originally defined by the expected extent of contaminated groundwater underlying the 100-KR-1 and 100-KR-2 Source OUs. Over time, additional characterization efforts demonstrated that hexavalent chromium groundwater contamination (likely originating from the 116-K-2 Trench source area) has migrated to the northeast, past the southern boundary of the 100-NR-2 OU (Figure 5-4). The following three pump-and-treat systems and their respective injection/extraction well fields, comprise the primary interim actions implemented for the remediation of the hexavalent chromium groundwater contamination associated with the 100-KR-4 OU:

- KR4 treatment system (capacity of 1,136 liters per minute)
- KX pump-and-treat system (capacity of 2,271 liters per minute)
- KW pump-and-treat system (capacity of 757 liters per minute).

The following discussion briefly summarizes the performance of each system and any notable system modifications implemented during CY 2010. The *CY 2010 Annual Summary Report for the 100-HR-3, 100-KR-4, and 100-NR-2 Operable Unit Pump-and-Treat Operations* (DOE/RL-2011-25) provides additional information concerning the operation and performance of the 100-KR-4 OU pump-and-treat systems.

5.2.3.1 KR4 Pump-and-Treat System

The original 100-KR-4 OU pump-and-treat system (now referred to as the KR4 system) has been operating since 1997 and has treated the hexavalent chromium plume associated with the 116-K-2 Trench. This ion-exchange system includes ten extraction wells and five injection wells located as shown in Figure 5-10. Over time, the central portion of the plume has been remediated to concentrations below 20 µg/L, but the plumes at either end of the trench continue to require treatment. Overall, chromium concentrations decreased between CY 2009 and CY 2010 in the area being remediated by the KR4 extraction well system. A summary of operational parameters and system performance for CY 2010 is provided in Table 5-15.

Changes in CY 2010

New injection well 199-K-179 was placed into service for the KR4 system in early January 2010. Former KX extraction wells 199-K-144, 199-K-145, and 199-K-162 were realigned to the KR4 system in February 2010 and began pumping downgradient of well 199-K-18. Former injection well 199-K-124A, taken out of service in August 2009, is currently used as a monitoring well. Extraction wells 199-K-113A and 199-K-114A were turned off during high river stage (July through mid-August) due to low hexavalent chromium concentrations. The KR4 system was shut down on October 5, 2010, for system upgrades and maintenance, then remained offline for the remainder of CY 2010.

Treatment System Performance

Key operational and system highlights for the KR4 pump-and-treat system for CY 2010 are as follows:

- A total of 336.9 million liters of groundwater were treated and ~7.2 kilograms of hexavalent chromium were removed. The average flow rate during CY 2010 was 641 liters per minute, which is lower than the system design capacity of 1,136 liters per minute. From startup of the KR4 system through CY 2010, more than 5.64 billion liters of water have been treated and over 354.7 kilograms of hexavalent chromium have been recovered.
- The mass removal efficiency for CY 2010 was approximately 90.6%, which is higher than the 86.9% removal efficiency in CY 2009.
- The average influent hexavalent chromium concentration of 24.1 µg/L for CY 2010 was lower than the CY 2009 average of 31.3 µg/L.
- The average effluent hexavalent chromium concentration for CY 2010 of 2.0 µg/L was lower than the 3.9 µg/L reported in CY 2009.
- The total system availability for CY 2010 was 74.9%, which is lower than the 86.9% reported in CY 2009. The lower system availability is due to shutdown of the system from early October to January 2011 for upgrades. Similarly, the

scheduled system availability of 75.2% (a 0.3% difference) was lower than the 99.4% availability in 2009.

- The KR4 system has been effective in remediating the hexavalent chromium plume at the 116-K-2 Trench. Most of the plume has been remediated, with the exception of the hot spots at either end of the trench. Declining influent concentrations threaten to reduce the mass removal efficiency. Wells with higher hexavalent concentrations need to be connected to the KR4 system.

Monitoring Results

The remedial performance of the KR4 pump-and-treat system (i.e., the extent and effectiveness of plume capture) can be illustrated by evaluating the hexavalent chromium data from selected monitoring locations including, but not limited to, compliance monitoring wells 199-K-18, 199-K-20, and 199-K-117A and active extraction/compliance wells 199-K-114A and 199-K-129 (Figure 5-10). Recently collected data and long-term concentration trend data for these and other monitoring locations relevant to evaluating the performance of the KR4 system are discussed below.

The KR4 monitoring wells 199-K-125A and 199-K-119A are located downgradient of the central area of the 116-K-2 Trench. Both were former extraction wells but were taken offline in 2009. The concentrations of hexavalent chromium in these KR4 wells steadily decreased from ~40 µg/L in 2004 to below the field and laboratory detection limits (less than 2 µg/L) by January 2010 (Figure 5-10 and Table 5-1).

The general effectiveness of KR4 system extraction wells located in the central section of the 116-K-2 Trench area is clearly demonstrated by the progressive reduction in hexavalent chromium concentrations in downgradient compliance monitoring wells 199-K-20, 199-K-21, and 199-K-117A. The concentrations in wells 199-K-20 and 199-K-21 declined from ~50 to 60 µg/L, to ~5 to 6 µg/L, between 2004 and 2008 (Figure 5-10). The hexavalent chromium concentrations in nearby monitoring well 199-K-117A decreased from ~10 µg/L in 2004 to below the detection (2 µg/L) by 2008 (Figure 5-10 and Table 5-1). The effective remediation of the central area of the 116-K-2 Trench area has resulted in the division of the original 116-K-2 Trench plume into two plume remnants, referred to as at the KR4 plume and the K North plume. The effectiveness of the treatment is partly attributed to the higher hydraulic conductivity of the aquifer sediments in the central portion of the 116-K-2 Trench as compared to those at the ends of the trench.

Since KR4 system startup, monitoring well 199-K-22 has defined the 100 µg/L hexavalent chromium contour of the K North plume. The addition of extraction wells 199-K-154 and 199-K-163 temporarily increased the size of this plume. New temporary RI/FS well 199-K-201 has better defined the extent of this plume with +100 µg/L concentrations of hexavalent chromium in early 2011. Startup of these extraction wells are thought to have begun reducing the hexavalent chromium concentrations in well 199-K-22, as a +25% decrease was observed by April 2011.

The KR4 system extraction/compliance monitoring wells 199-K-114A and 199-K-113A are located near the Columbia River in the K North plume, at the northern end of the 116-K-2 Trench (Figure 5-10). Both of these wells appear to show a subtle decrease in hexavalent chromium concentrations in samples collected during the summer to early fall of 2010 relative to previous years. Concentrations in both wells remained below 10 µg/L during low river stage when concentrations of hexavalent chromium in near-shore plume wells are generally highest.

The KR4 system extraction/compliance well 199-K-129 is located near the Columbia River in the central area of the K North plume, further north than wells 199-K-114A and 199-K-113A (Figure 5-10). The long-term concentration trend for hexavalent chromium in this extraction well has gradually decreased from a high of ~60 µg/L in early 2004 to a low of 10 to 20 µg/L in late 2010. If the concentrations of hexavalent chromium in KR4 extraction wells 199-K-114A, 199-K-113A, and 199-K-129 continue to decrease during 2011, the interim action objective of protecting the river may be also achieved along this southern section of the K North plume.

Former compliance well 199-K-18 is located near the southern end of the 116-K-2 Trench (Figure 5-10). This well has defined the 100 µg/L contour for the hexavalent chromium KR4 plume. With the drilling of wells 199-K-145 and 199-K-162, this well is no longer the most downgradient well in the area. Hexavalent chromium concentrations in this well steadily increased from ~35 µg/L in 1997, to ~140 µg/L in 2004, and to ~200 µg/L by June 2010 (Figure 5-10). However, the concentrations in well 199-K-18 declined steadily during the remainder of 2010, reaching a concentration of 139 µg/L by December 2010 (Table 5-1). Hexavalent chromium concentrations had declined to 50% of the original peak values by early 2011. This abrupt reversal in the long-term increasing concentration trend for hexavalent chromium in this well likely reflects the February 2010 startup of three nearby KR4 extraction wells, 199-K-162, 199-K-145, and 199-K-120A. Of these three new extraction wells, the concentrations of hexavalent chromium measured at well 199-K-145 averaged ~60 µg/L during 2010, which was substantially higher than concentrations extracted by wells 199-K-162 and 199-K-120A. In the latter two wells, concentrations decreased below 10 µg/L soon after startup.

Although aquifer tubes are not official compliance points for treatment system performance, samples collected from these tubes are helpful for locating areas where hexavalent chromium may be discharging to the Columbia River at concentrations greater than 20 µg/L. Aquifer tube location AT-K-3-D is downgradient of monitoring well 199-K-18 and extraction wells 199-K-162, 199-K-145, and 199-K-120A. This aquifer tube has had concentrations ranging from ~32 to 85 µg/L since it was first sampled in 2004 (Figure 5-10); the December 2010 results were near the middle of that range. Given the recent startup of upgradient extraction wells 199-K-162, 199-K-145, and 199-K-120A and the abrupt decrease in concentrations in monitoring well 199-K-18 during 2010 (see discussion above), the concentrations of hexavalent chromium reaching this aquifer tube (and, therefore, the Columbia River) are expected to decrease substantially in this section of the KR4 plume within the next 1 to 2 years.

5.2.3.2 KX Pump-and-Treat System

The 2,270-liter-per-minute-capacity KX ion-exchange pump-and-treat system includes a well field that currently consists of twelve extraction wells and nine injection wells (Figure 5-2). The treatment system underwent acceptance testing in November 2008 and became fully operational in February 2009. A summary of operational parameters and the system performance for CY 2010 is provided in Table 5-16. The KX well field was primarily designed to remediate contaminated groundwater located between the northern end of the 116-K-2 Trench and the N Reactor fence line. Consequently, twelve of the fourteen KX system extraction wells are located in this area (Figure 5-11). A secondary objective of this the system is to remediate contaminated groundwater located downgradient of the KE Reactor, and two KX extraction wells have been dedicated for this purpose.

System Changes in CY 2010

High hexavalent chromium concentrations were observed at wells 199-K-153 and 199-K-171 in CY 2008 and CY 2009. These wells were realigned from monitoring and injection wells, respectively, to extraction wells during CY 2010 and were brought online in mid-March. In addition, two wells that previously served as extraction wells (199-K-149 and 199-K-150) were taken out of service in June 2010 due to low hexavalent chromium concentrations in groundwater. The wells are being converted to monitoring wells and may be converted to injection wells in 2011. New extraction well 199-K-178 and new injection well 199-K-180 were also put into service in mid-March 2010. Well 199-K-180 was completed in January 2010 and was sampled at that time. Hexavalent chromium concentrations did not exceed 6.5 µg/L, and the well was determined suitable for injection of treated water. Well 199-K-161 was shut down from July to September 2010 due to low hexavalent chromium levels during high river stage.

Treatment System Performance

Key operational and system highlights for the KX pump-and-treat system for CY 2010 include the following:

- A total of 904.5 million liters of groundwater were treated and ~39.8 kilograms of hexavalent chromium were removed. The average flow rate in CY 2010 was 1,720 liters per minute, which is 76% of the system design capacity of 2,271 liters per minute. Since startup, the KX system has treated more than 1.56 billion liters of water and removed 83.7 kilograms of hexavalent chromium.
- The mass removal efficiency for CY 2010 was 94.0%, which is slightly lower than 96.3% reported in CY 2009.
- The average influent hexavalent chromium concentration for CY 2010 of 47.2 µg/L was ~20% lower than the CY 2009 average of 58.4 µg/L. This is due to the generally lower mass within the original KX plume and the declining concentrations at some KX extraction wells.
- The average effluent hexavalent chromium concentration for CY 2010 of 2.8 µg/L was slightly higher than 2.1 µg/L reported in CY 2009.
- The total system availability for CY 2010 was 96.8%, which is slightly lower than the 98.1% availability reported in CY 2009. The scheduled system availability was higher, at 99.2% versus the 94.5% scheduled availability in 2009.

Monitoring Results

The fall 2010 chromium plume map and long-term concentration trends for the compliance and other selected wells relevant to evaluating the remedial performance of the KX pump-and-treat system are shown in Figure 5-11.

Concentrations of hexavalent chromium at extraction/compliance wells 199-K-150 and 199-K-149, at the northeast end of the KX system well field, remained below 10 and 20 µg/L, respectively, during CY 2010 (Figure 5-11). The low levels of hexavalent chromium in these well are likely maintained by continued injection of treated effluent at injections wells located further to the east and northeast (Figure 5-2). A rebound study was conducted using field analytical techniques to determine if residual hexavalent chromium remains accessible in the aquifer. When concentrations remained low during this study, the two wells were taken offline. Consideration is being given to converting the two wells to injection wells in CY 2011 for better control of this lobe of the plume. In addition, the hexavalent chromium

trend at nearby well 199-K-131 declined to 35 µg/L in fall 2010, with similar values noted in spring 2010.

Extraction/compliance well 199-K-130 remained above 20 µg/L, although the hexavalent chromium trend in this well is decreasing. Extraction/compliance well 199-K-148, with all hexavalent chromium analyses greater than 20 µg/L, trended downward during the first half of CY 2010. Subsequently, this well showed an increasing concentration trend, with the highest value in November 2010 at 52.6 µg/L, nearly 40% greater than the low value observed in August 2010. In CY 2011, hexavalent chromium concentrations at this well again declined. The performance of extraction wells 199-K-147, 199-K-146, and 199-K-161 is difficult to assess for CY 2010 because downgradient aquifer tube sampling was not performed in this area during the year. Previous sample analyses from downgradient aquifer tubes yielded nondetects to very low levels of hexavalent chromium. Hexavalent chromium concentrations were generally above 20 µg/L at wells 199-K-146 and 199-K-147 but were above 20 µg/L at well 199-K-161 only through April and May 2010. In general, hexavalent chromium trends at most wells downgradient of the inland extraction wells 199-K-163 and 199-K-154 (operational on May 28, 2010) dropped by 50% to 90% compared to fall 2010 data. Because this area overlaps with long-standing extraction by KR4 pump-and-treat system wells, the lower concentrations at both wells and aquifer tubes ensure improved control of the local chromium plume.

The KX system extraction wells 199-K-163 and 199-K-154, upgradient of the distal end of the 116-K-2 Trench, had fall 2010 concentrations of 54 and 85 µg/L, respectively. The relatively slow decline in elevated concentrations of hexavalent chromium observed in these extraction wells over the last several years (Figure 5-11) suggests that a substantial remnant of the 116-K-2 Trench coolant water plume remains in this portion of the aquifer. This, combined with lower hydraulic conductivities of the aquifer as demonstrated at well 199-K-22, may combine to explain the slow decrease in hexavalent chromium concentrations.

Two KX extraction wells are located within the KE Reactor area plume, directly downgradient of the KE Reactor. The hexavalent chromium concentration of 48 µg/L in fall 2010 at extraction well 199-K-178, located within the plume, was substantially lower than baseline sampling results (118 µg/L) observed shortly after the well was drilled in CY 2009. New well 199-K-181 was installed as a compliance well downgradient of the KE Reactor. Although the new well was not sampled in the fall of 2010, hexavalent chromium analyses from August 2009 through August 2010 were all less than 20 µg/L. This compliance well, together with wells 199-K-32A and 199-K-142, provides limits for the plume extending downgradient from the reactor, indicating that the plume has not spread laterally.

5.2.3.3 KW Pump-and-Treat System

The KW pump-and-treat system became operational in January 2007 and was designed to treat the hexavalent chromium plume located near the KW Reactor (Figure 5-12). The current well field configuration for the system consists of seven extraction wells and three injection wells (Figure 5-2). A summary of the operational parameters and system performance for the KW system during CY 2010 is provided in Table 5-17.

Changes in CY 2010

During CY 2010, extraction well 199-K-139 (previously taken out of service) was restarted on April 8 to replace proximal extraction well 199-K-140, which

yielded both low groundwater flows and low concentrations of hexavalent chromium. Well 199-K-140 remained available for sampling during 2010.

Treatment System Performance

Key operational and system highlights for the KW pump-and-treat system for CY 2010 are as follows:

- More than 387.15 million liters of groundwater were treated and ~54.14 kilograms of hexavalent chromium were removed. The average flow rate of 736 liters per minute is very close to the design capacity of 757 liters per minute. Since startup of operations, the KW system has treated over 1.05 billion liters of groundwater and has removed 137.4 kilograms of hexavalent chromium.
- The mass removal efficiency for CY 2010 was 96.9%, which is slightly higher than the mass removal efficiency for CY 2009 of 95.8%.
- The average influent hexavalent chromium concentration for CY 2010 of 144.0 µg/L was slightly lower than the average concentration of 155.4 µg/L reported for CY 2009.
- The average hexavalent concentration for the effluent during CY 2010 of 4.4 µg/L was very similar to the average effluent concentration of 4.2 µg/L reported for CY 2009.
- The total system availability for CY 2010 was 99.7%, which is slightly higher than the system availability of 98.6% reported in CY 2009. The scheduled system availability was 99.6%, which compared favorably to the CY 2009 scheduled availability of 95.6%. A total of 29.3 hours of scheduled downtime and 6.2 hours of unscheduled downtime contributed to the system's operational efficiency.

Monitoring Results

The remedial performance of the KW pump-and-treat system has been evaluated using the 2008 to 2010 hexavalent chromium data presented in Table 5-2 and the long-term concentration trends for selected KW pump-and-treat system monitoring locations (Figure 5-12).

Extraction/compliance wells 199-K-132 and 199-K-138 are located downgradient of the KW Reactor, near the leading edge of the KW Reactor area plume (Figure 5-12). Chromium concentrations at wells 199-K-132 and 199-K-138 were ~120 and 75 µg/L in January 2007 (Figure 5-12). Since startup of the KW pump-and-treat system, concentrations in these wells have steadily declined. The measured concentrations in these wells during November 2010 were 16.8 and 20.6 µg/L, respectively (Table 5-2). Although data from a single aquifer tube location are not definitive, the long-term data trend at aquifer tube AT-K-1-D is consistent with the inference that the leading edge of the KW Reactor area plume is being captured by these two extraction wells (Figure 5-12).

The concentrations in upgradient extraction wells 199-K-168, 199-K-139, 199-K-137, and 199-K-166 have either declined to a substantial degree or remained at near the 20 µg/L standard during CY 2010 (Figure 5-12). An exception to this general trend was observed at extraction well 199-K-165, located just upgradient of extraction wells 199-K-137 and 199-K-166. The hexavalent chromium concentration observed in this well in late 2008 was 2,850 µg/L. After extraction operations began at well 199-K-165 in early 2009, however, the concentrations declined precipitously to below 200 µg/L during the spring and summer of 2009. Since that time, concentrations in this extraction well have steadily increased, with values of 232 and 321 µg/L measured in the fall 2009 and fall 2010, respectively (Table 5-2). Concentrations in

early 2011 have declined. The hexavalent chromium trend in this extraction well is consistent, as it is the closest extraction well to the 183.1-KW headhouse, which is the putative source area for the leaks and spills of concentrated sodium dichromate that are believed to have created this plume.

Two monitoring wells, 199-K-35 and 199-K-173, located upgradient of the above-described extraction wells, demonstrated sharp spikes in hexavalent chromium concentrations that began in late CY 2009 and continued into CY 2010 (Figure 5-12). Well 199-K-35 was converted from an injection well to a monitoring well in late November 2009, and hexavalent chromium concentrations rapidly increased in samples collected from the well, reaching the maximum observed value of nearly 800 µg/L in early 2010, before declining to ~260 µg/L in April. After the April 2010 sampling event, well 199-K-35 was removed from service to facilitate demolition and soil remediation activities around the 183.1-KW headhouse and 183.2-KW sedimentation basins. Monitoring well 199-K-173 exhibited two separate spikes in hexavalent chromium concentrations during 2010, with concentrations briefly exceeding 900 µg/L at the peak of each spike (Figure 5-12). Peaks in chromium trends at downgradient extraction wells 199-K-165 and 199-K-166 roughly coincide in time but with lesser magnitudes to the trend observed at well 199-K-173.

One possible explanation for the abrupt development of these concentration spikes in the upgradient monitoring wells is the mobilization of residual source materials in the vadose zone by the heavy use of dust-suppression water during the demolition and remediation activities conducted near the 183.1-KW headhouse. Another possible explanation is that the startup of a new upgradient injection well 199-K-175 in April 2009 (Figure 5-2) and terminating injection of treated effluent at well 199-K-35 in late November 2009 may have accelerated the downgradient transport of a residual hot spot in the aquifer zone upgradient of well 199-K-35. The timing of the changes in these local injection activities appears to be consistent with the rapid downgradient transport of elevated hexavalent chromium concentrations such as those observed in wells 199-K-35 and 199-K-173.

5.2.3.4 Capture Zone Analysis

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The remedial performance of the KW, KR4, and KX pump-and-treat systems (i.e., extent and effectiveness of plume capture) is assessed by (1) evaluating the changes in hexavalent chromium concentrations over time in selected monitoring and extraction wells associated with the KR4, KW, and KX well fields; and (2) using two different methods of analysis to estimate the extent of plume capture by the three pump-and-treat systems under CY 2010 operating conditions.

To appropriately evaluate the effectiveness of plume capture in the 100-KR-4 OU, it was necessary to evaluate the combined effects the KR4, KW, and KX pump-and-treat systems (Figure 5-13), as well as the effectiveness of the capture zones for each individual treatment system (Figure 5-14). A brief discussion regarding the extent and effectiveness of the combined (OU-wide) capture zone (Figure 5-13) is provided below. More detailed descriptions of the methods used and the results of the capture zone evaluation are presented in the CY 2010 annual summary report (DOE/RL-2011-25).

Figure 5-13(a) and (b) depicts separate representations of the combined site-wide capture zone for the 100-KR-4 OU that were calculated independently based on the results of groundwater modeling analysis and high-frequency water-level mapping,

respectively. The data inputs and assumptions for these different methods of capture zone analysis are not the same, and the depictions of the extent and aggregate performance of the capture zones generated by the two methods will be different. For example, the groundwater modeling approach (Figure 5-13[a]) depicts areas of current and future capture zone effectiveness of the 100-KR-4 OU systems based on the actual operating conditions of the systems during all of CY 2010. This includes the fourth quarter of CY 2010, when the KR4 system was shut down for upgrades. This approach is useful for evaluating the extent that periods of reduced extraction during 2010 would, if not remedied, reduce the long-term capture efficiency of the affected system. Conversely, Figure 5-13(b) presents the areas where the extent of plume capture is based (with the exception of small-duration stoppages) on the hydraulic conditions imposed on the aquifer while the systems were actually operating during CY 2010. This approach to capture zone mapping does not include the hydraulic effects of long-term, nonroutine shutdown events such as that occurring at the KR4 system during 2010. Consequently, the capture zone performance illustrated in Figure 5-13(b) provides a better representation of the long-term effectiveness of the capture zones for the treatments systems, assuming that the current operating conditions will continue in the future.

A comparison of Figure 5-13(a) and (b) shows many similarities and some key differences in the estimates of capture zone effectiveness obtained using these two different methods for the 100-KR-4 OU. Both approaches indicate that the northern and southern areas of the capture zone distributions have a capture efficiency of upgradient groundwater of between 80% and 100%. However, the groundwater model-based capture effectiveness/efficiency map (Figure 5-13[a]) suggests that the central area of the overall capture zone distribution (KR4 plume area) will capture the upgradient plume with a much lower efficiency (e.g., 50% to 70%) than predicted in Figure 5-13(b). This difference primarily reflects the fact that the model-based analysis treats the reduced annual average extraction rates in this area during CY 2010 (including the planned 3-month shutdown at the KR4 system) as the standard operating conditions over the full multi-year simulation period. Consequently, the substantially higher overall capture efficiencies (e.g., 80% to 100%) for the composite capture zone presented in Figure 5-13(b) are believed to represent a more realistic estimate of the long-term capture efficiency of the overall system. As previously discussed, Figure 5-14(a), (b), and (c) includes the chromium plume and breaks out the capture zones for each of the three treatment systems as calculated by the high-frequency capture method described above.

5.2.4 Calcium Polysulfide Treatability Test

During the summer of 2005, a treatability test was conducted in the northern section of the 100-KR-4 OU to evaluate the practicality of treating hexavalent chromium in the aquifer with calcium polysulfide. The study concluded that hexavalent chromium concentrations in groundwater in the treated area were significantly reduced after the test. The results demonstrated that this method could be an effective alternative to pump-and-treat systems (DOE/RL-2006-17, *Treatability Test Report for Calcium Polysulfide in the 100-K Area*).

During the treatability test, groundwater from central extraction well 199-K-126 was mixed with calcium polysulfide and injected into four wells (199-K-133, 199-K-134, 199-K-135, 199-K-136) radially arrayed at a distance of 30 meters from the extraction well (Figure 5-2). Calcium polysulfide and emulsified vegetable oil circulated through the aquifer, reducing hexavalent chromium and the aquifer materials, creating a persistent zone of chemical reduction.

Each of the five wells was sampled quarterly through 2009 and once in 2010. Hexavalent chromium in the injection wells remained at detection limits (~3 µg/L), indicating that the zone of reduction has persisted for over the 5-year period following test completion. Dissolved oxygen and nitrate also remained low throughout CY 2010, which is another indication that reducing conditions persist in the aquifer.

Hexavalent chromium concentrations in well 199-K-126 increased to ~40 µg/L (about one-half the concentration in groundwater outside the treated area) one year after the test was completed and remained near that level in CY 2010. Dissolved oxygen and nitrate were also slightly lower in the extraction well compared to pre-test measurements.

5.3 100-K Basins

Groundwater monitoring at the 105-KE (KE Basin) and 105-KW (KW Basin) fuel storage basins (Figure 5-2) has been conducted since the late 1970s; however, the monitoring frequency was decreased as fuel has been removed from the basins. Furthermore, with demolition of the KE Basin and 115-KE gas recirculating building and 117-KE filter house support structures, as well as ongoing remediation of the surrounding contaminated soil, all of the close-in wells monitoring these structures have been decommissioned. Replacements have not been drilled. Regulatory drivers include a K Basin interim remedial action under CERCLA, environmental restoration program OU activities under CERCLA, and site-wide environmental surveillance associated with the *Atomic Energy Act of 1954*. Monitoring requirements are presented in several documents (most recently, PNNL-14033, *Groundwater Monitoring and Assessment Plan for the 100-K Fuel Rod Storage Basins*). PNNL-14033 addresses sampling of monitoring wells at waste sites associated with the K Basins and includes wells associated with the 115-K gas recirculation buildings, 116-KE-1 and 116-KW-1 Cribs, and the K Basins drain cribs (116-KE-3 and 116-KW-2).

The basins received and stored highly radioactive irradiated fuel rods, first from the respective reactors and then, beginning around 1978, fuel rods from the N Reactor. Other miscellaneous fuel discovered during remedial actions at other reactor basins was also stored here. Each basin held ~4.9 million liters of shielding water that was highly contaminated with long-lived radionuclides (e.g., strontium-90 and cesium-137), some of which are mobile in the environment (e.g., tritium). In addition, each basin was connected to a crib (116-KE-3 and 116-KW-2) designed to receive basin overflow water. These cribs were active into the early 1970s. The cribs, as well as leaks around the KE Basin, affected the adjacent vadose zone and groundwater. Trend data from decommissioned well 199-K-109A, downgradient of the 116-KE-3 Crib, indicate significant but declining concentrations of tritium and strontium-90 in the aquifer over the past two decades. A trend above the DWS was observed in early 2011 at downgradient KX extraction well 199-K-141, as strontium-90 concentrations increased to between 8.2 and 12 pCi/L. Based on groundwater monitoring data from downgradient wells, no indication of serious leaks at the KW Basin has been noted.

The fuel rods in the K Basins were removed by 2008 and sludge was pumped from the KE Basin to the KW Basin through CY 2009. Demolition of the KE Basin, substructure, and crib was completed in 2009. Contaminated soil around the basin and crib was remediated in CY 2009 and CY 2010, continuing to the present. Prior to demolition and remediation, two downgradient groundwater monitoring wells around the KE Basin (199-K-27 and 199-K-109A) were decommissioned in March 2008.

The KW Basin has been emptied of fuel rods but remains a depository for sludge from KE and KW Basins. The KW Basin and the 116-KW-2 Crib are scheduled for removal after 2015.

Based on reported contamination in the basin shielding water, the COCs at the monitoring wells include tritium, carbon-14, technetium-99, and other less mobile radionuclides such as strontium-90 and cesium-137. Tritium is considered to be the primary indicator of water loss from the fuel rod basin/crib system. Strontium-90 and, in particular, cesium-137 are not nearly as mobile as tritium in groundwater.

The previous KE and KW Basins sampling and analysis schedule complemented other 100-KR-4 OU groundwater sampling schedules. The K Basins monitoring plan (PNNL-14033) focused on the following objectives:

- Characterizing groundwater conditions between the KE and KW Basins and the Columbia River, and providing a status of current conditions and attenuation of plumes
- Distinguishing between groundwater contamination associated with KE and KW Basins and the contamination from other past-practice sources to help guide operational and remedial action decisions
- Maintaining a strategy for the potential expansion of monitoring capabilities to respond to future basin-related issues.

The monitoring plan (PNNL-14033) specified at least an annual sampling frequency for radionuclides, anions, and groundwater field parameters at all KE and KW Basins monitoring wells and downgradient aquifer tubes. A few close-in monitoring wells were designated for quarterly analysis for tritium and radionuclide screening test (gross alpha and gross beta). Although the basins are no longer filled with shielding water, a continuing sampling program is being maintained. Previous leakage at the KE Basin and the use of dust-suppression water during basin and vadose zone remediation warrant continued monitoring at downgradient wells for the foreseeable future. Based on current findings at extraction well 199-K-141 (Section 5.1.3.3), a quarterly sampling frequency should be initiated.

At this time, the four close-in downgradient wells around the KE Basin are no longer in existence. One new RI/FS well, 199-K-189, is located cross-gradient from the KE Basin and monitors an area less affected by historic discharges to the basin or the 116-KE-1 Crib. New wells are needed to replace those lost during remediation.

5.3.1 KE Basin

Two key monitoring wells downgradient of the KE Basin, 199-K-27 and 199-K-109A, were decommissioned and removed in April 2008 to provide access for demolition and remediation of the KE Basin and crib. These wells were replaced by downgradient wells 199-K-141 and 199-K-142, which are 120 meters closer to the Columbia River (Figure 5-2). High chromium concentrations in well 199-K-141 led to its conversion as an extraction well for the KX pump-and-treat system in 2009.

Tritium was routinely monitored at well 199-K-109A, reaching 420,000 pCi/L in October 1997 and then decreased to 13,000 pCi/L in March 2008. For well 199-K-27, tritium concentrations reached 628,000 pCi/L in March 1994 and declined to between 3,000 and 8,000 pCi/L for its last 16 months. Tritium concentrations for well 199-K-142 have ranged between 100 and 1,200 pCi/L since the start of sampling in April 2007. At downgradient well 199-K-141, tritium has trended between 400 and 4,800 pCi/L from April 2007 to February 2010. Sampling in July 2010 and January 2011 yielded similar tritium concentrations of 8,400 pCi/L.

Strontium-90 was routinely detected at well 199-K-109A at concentrations up to 18,600 pCi/L shortly after monitoring began in 1994. When the well was removed from service in 2008, strontium-90 concentrations of 910 to 1,120 pCi/L were detected. Strontium-90 was rarely detected at well 199-K-27 and it has not been detected at well 199-K-142. At well 199-K-141, strontium-90 has trended up from 18 months of mostly nondetects to 5.9 pCi/L in July 2010, and then to 12 pCi/L in January 2011.

Tritium concentrations at well 199-K-30 have fluctuated significantly above the 20,000 pCi/L DWS. Tritium reached a concentration of 3,320,000 pCi/L in 1993 in well 199-K-30 and has been below 100,000 pCi/L only three times in over 110 sampling events. One of those results, 16,000 pCi/L from a sample in December 2010 is the lowest tritium value reported for the well. In a similar number of samples, tritium at well 199-K-29 had not exceeded 100,000 pCi/L until sampling in December 2010, when the concentration reached 130,000 pCi/L. These two sample values are likely reversed, and the data set is being reviewed to ensure that the sample corresponds to the correct well.

5.3.2 KW Basin

The key downgradient monitoring wells around the KW Basin, 199-K-34 and 199-K-107A, currently remain intact. Extraction wells 199-K-139 and 199-K-168 (~55 meters downgradient of the 116-KW-2 Crib and well 199-K-107A) are also included. For CY 2010, tritium concentrations at the four wells ranged between 1,000 and 4,000 pCi/L and have not exceeded 10,000 pCi/L since sampling began in 1992. During CY 2010, tritium at downgradient extraction wells 199-K-132 and 199-K-138 ranged between 1,200 pCi/L and 7,500 pCi/L, respectively. These higher concentrations are attributed to a tritium plume associated with the 116-KW-1 gas condensate crib and well 199-K-106A. Tritium at this well reached a concentration of 2,240,000 pCi/L in 2005, was at 430,000 pCi/L in April 2009, and declined to 3,200 pCi/L in September 2010.

Strontium-90 concentrations at the KW Basin have consistently been above the 8 pCi/L DWS at wells 199-K-34 and 199-K-107A. Well 199-K-34 has typically trended between 16 and 40 pCi/L since 1992, while well 199-K-107A has trended slightly higher over the same timeframe. Extraction well 199-K-139, which is screened over the upper 7.6 meters of the aquifer, has had regular strontium-90 detections, but the concentrations have been below the DWS.

5.4 Conclusions

The following conclusions are presented for the 100-KR-4 OU:

- The hexavalent chromium groundwater plumes are generally well defined around the 116-K-2 Trench and the KE and KW Reactors. A data gap for the upgradient plume extent around well 199-K-171 will be closed after results are available from a new RI/FS well drilled in CY 2011. Uncertainty regarding the upgradient extent of chromium around well 199-K-182 persists, as concentrations exceeding 75 µg/L are routinely found. Several interior areas of plumes are unbounded. The 116-K-2 Trench plume, located in the area between wells 199-K-163/154 and 199-K-171, is not well characterized due to intermediate culturally sensitive areas that preclude drilling and remediation activities. An area around the 183.1-KW headhouse and 183.2-KW sedimentation basin has yielded unusually high spikes

of hexavalent chromium in groundwater. The cause for the spikes is not well understood and requires further investigation.

- The pump-and-treat systems continue to remove significant amounts of hexavalent chromium from the unconfined aquifer. During CY 2010, more than 101 kilograms of chromium were removed from over 1.63 billion liters of groundwater. Since startup of the respective pump-and-treat systems, more than 575 kilograms of chromium have been removed from 8.38 billion liters of water. Contaminant trends at most extraction and monitoring wells have declined; for a few other wells, hexavalent chromium concentrations have at least remained relatively constant. Only one extraction well, 199-K-145, has shown an increasing chromium trend, and this well is located downgradient of one of the two "hot spot" wells around the 116-K-2 Trench.
- Wells 199-K-18 and 199-K-22 are two prominent hexavalent chromium hot spots along the 116-K-2 Trench, with maximum CY 2010 concentrations at 203 and 143 µg/L, respectively, in the first half of the year. These hot spots are believed to be the result of injected treated water mounding at the center of the 116-K-2 Trench pushing the residual plume laterally toward both ends of the trench combined with low-conductivity sediments in the aquifer. At both wells, concentrations declined between CY 2009 and CY 2010, by 30% at well 199-K-18 and by 20% at well 199-K-22. Declining trends continued in 2011. These trends appear to be in response to pumping at nearby extraction wells. As a result, the size of the 100 µg/L contour around the two wells has decreased.

  It is possible that chromium at well 199-K-18 may have been augmented by process sewer discharges at the head end of the trench and may possibly include residual chromium from the KE Reactor area. Chromic acid and nitric acid were used during reactor decontamination and disposed to the 116-K-2 Trench and, thus, may contribute to the local plume.
- The impact of the hexavalent chromium plume along the Columbia River cannot be assessed for CY 2010 due to the absence of aquifer tube data that resulted from sampling delays. The fall 2010 depiction of the chromium plume along the Columbia River is largely based on the fall 2009 plume and has been modified only where fall 2010 data permit. Fall 2010 data (September through December 2010) are available for key aquifer tubes AT-K-1-D (2 µg/L, nondetect) and AT-K-3-D (57.7 µg/L).
- Leaks and spills during unloading of concentrated sodium dichromate at the 183.1-KE and -KW headhouses are not documented but are suspected as possible sources for more concentrated hexavalent chromium observed in CY 2009 at upgradient KW Reactor area extraction wells 199-K-137 and 199-K-165, as well as the spikes in CY 2010 observed at wells 199-K-35 and 199-K-173. During waste site remediation around the 183-KW headhouse and sedimentation basin, evidence of significant chromium within the 4.6- to 5.2-meter-deep excavations has been very limited. Data from a new RI/FS well have not indicated significant amounts of chromium in the vadose zone at either headhouse, but several spikes were observed in groundwater at the 183-KW headhouse.
- Tritium at concentrations below the 20,000 pCi/L DWS is widespread across the 100-KR-4 OU. Concentrations above the DWS are confined to plumes that appear to be derived from the 118-K-1 Burial Ground and the 116-KE-1 gas condensate crib. Tritium trends at the 116-KW-1 gas condensate crib were well

above the DWS from 2000 to early 2009, but were below 11,000 pCi/L in 2010. Tritium trends at wells associated with the 116-KE-1 Crib have routinely been above the DWS; these wells were recently decommissioned. Final sampling results indicated that well 199-K-29 was significantly above the DWS, while well 199-K-30 was below the DWS. Trends at the two wells are the reverse of their final sampling results, and the data are under review.

The tritium plume likely associated with the 118-K-1 Burial Ground is somewhat above the DWS at downgradient well 199-K-111A (32,100 pCi/L in September 2010) and well 199-K-157 (30,000 pCi/L in September 2010). The tritium concentration at well 199-K-18 has risen sharply in 2010, reaching to 230,000 pCi/L in December. Within the upper 16.8 meters of the aquifer in a new RI/FS well, 199-K-192, tritium concentrations ranged from 1.4 million pCi/L at the top of the aquifer to 27,000 pCi/L. These trends may be a response to dust-suppression water usage at the burial ground that began with remediation in CY 2009. (Note that of downgradient extraction wells 199-K-145, 199-K-162, and 199-K-120, only well 199-K-145 exceeded the DWS in early 2011 results.) Tritium at aquifer tube AT-K-3-D was at 6,000 pCi/L in December 2010. This plume appears to be moving under the influence of the burial ground remediation and is being captured and recirculated by the KR4 extraction wells.

- The distribution of strontium-90 correlates to the 116-K-2 Trench and the 116-KE-3 and 116-KW-2 fuel storage basin overflow cribs. Trends at wells immediately downgradient of the 116-KW-2 Crib have ranged between three to seven times the 8 pCi/L DWS. Wells further downgradient have detected strontium-90 concentrations below the DWS. Former well 199-K-109A, downgradient of the 116-KE-3 Crib, has ranged between two to more than three orders of magnitude higher than the DWS between 1994 and 2008, before the well was decommissioned. Strontium-90 at downgradient KE extraction well 199-K-141 began climbing in July 2010 and was at 12 pCi/L in early January 2011.
- Carbon-14 in groundwater is closely tied to discharges at the 116-KE-1 and 116-KW-1 gas condensate cribs and is present above the 2,000 pCi/L DWS at wells downgradient of the two cribs. The KW plume is more widespread and is being stretched by pumping at extraction well 199-K-132. Previous aquifer tube data did not indicate that carbon-14 is reaching the Columbia River (the tubes were not sampled in CY 2010). The 116-KE-1 Crib plume is confined to wells near the crib. Final samples prior to decommissioning indicate that carbon-14 is above the DWS at both wells 199-K-29 and 199-K-30 but has not moved further downgradient than has been shown in previous years.
- Nitrate is found above its DWS of 45 mg/L in a few wells but is present in most 100-KR-4 OU wells at low, but detectable, concentrations. Elevated but decreasing nitrate concentrations during CY 2010 were observed at well 199-K-18 (60.6 mg/L in December 2010) near the 116-K-2 Trench and at well 199-K-106A (73.9 mg/L in September 2010) near the 116-KW-1 gas condensate crib. A similar plume is likely present downgradient of the 116-KE-1 gas condensate crib, but nitrate concentrations appear to be reversed between the two monitoring wells.
- Trichloroethene has been occasionally found in most wells within the KW Reactor area at concentrations near or slightly above the 5 µg/L DWS. The plume appears to be focused at well 199-K-106A, just downgradient of the 116-KW-1 gas condensate crib; however, process history does not support routine use of

trichloroethene. The widespread but low concentrations of trichloroethene around this treatment system also suggest an upgradient source to the south of the K Reactor fence line.

- Chloroform has been reported at concentrations well below the 80 µg/L DWS but at levels of interest from the preliminary results of the RI/FS process. One remote well, 199-K-151, had a concentration of 7.1 µg/L in September 2010; the waste site source is not known for this well. Chloroform concentrations between 1 and 2 µg/L were reported at wells 199-K-11, 199-K-18, and 199-K-32A. No common waste site fits this well distribution.
- Total petroleum hydrocarbon (diesel) has been found in the vadose zone at wells 199-K-167 and 199-K-173 and at RI/FS well 199-K-188 near the 166-KW and 166-KE fuel storage bunkers. Diesel was detected in several wells downgradient of the KW bunker during vertical profile sampling while drilling several extraction wells in CY 2008. Sampling at downgradient wells in CY 2009 and CY 2010 did not detect total petroleum hydrocarbons in downgradient wells. Groundwater detections were not observed at well 199-K-188 during drilling; however, analytical results from well 199-K-110A returned an estimated value of 78 µg/L ("J" qualified) in December 2010.

5.5 Recommendations

Recommendations for groundwater monitoring are discussed in this section and are proposed for implementation:

- The hexavalent chromium plume is not bounded by well data around monitoring well 199-K-182, where chromium concentrations have consistently ranged between 75 and 81 µg/L. This well is scheduled to be converted to an extraction well during CY 2011. Additional wells upgradient of well 199-K-182 (i.e., to the south and southeast) are needed to bound the hexavalent chromium plume at well 199-K-182.
- Unknown plume conditions exist beneath the culturally sensitive area between extraction wells 199-K-171 and 199-K-163/199-K-154. The plume depiction does not suggest hexavalent chromium concentrations over 50 µg/L, but concentrations at the three wells ranged between 50 and 100 µg/L during CY 2010. The data uncertainty hinders accurate modeling of plume behavior and the estimation of needs for future remediation requirements. Data from this area must be gathered to assess the horizontal and vertical distribution of hexavalent chromium.
- Complete the Phase 3 well drilling program and realign new and existing wells to increase capture efficiency.
- The RI characterization at wells 199-K-188 and 199-K-195 has not fully clarified the hexavalent chromium distribution in the vadose zone and aquifer at the 183.1-KE and -KW headhouse structures. Little or no indication of chromium is seen in vadose zone samples or in groundwater at the KE headhouse. At the KW headhouse, chromium above operational levels was detected at both shallow and deep locations within the aquifer. Further characterization is needed to understand the lateral and vertical distribution of hexavalent chromium around both headhouses.
- Monitoring wells 199-K-29 and 199-K-30, downgradient of the 116-KE-1 gas condensate crib, were decommissioned in December 2010 following sampling and borehole logging. These wells have tracked the above-DWS carbon-14

and tritium activity trends for this crib. Similarly, previously decommissioned wells 199-K-27 and 199-K-109A, downgradient of the KE Basin and the 116-KE-3 Crib, tracked movement of strontium-90 and tritium. Only one well, 199-K-189, now lies downgradient but relatively close to the three waste sites; however, it is not well positioned to monitor plumes from the multiple waste sites. An increasing strontium-90 trend at well 199-K-141 suggests that a plume is moving toward the Columbia River. Replacement wells for 199-K-109A, 199-K-29, and 199-K-30 are needed to provide close-in coverage of mobile radionuclides.

- At least four existing wells or new RI/FS wells have been, or will be, removed to support remediation of soil waste sites, particularly around the 183.1-KE and -KW headhouses. These wells need to be replaced quickly to provide continuing coverage of groundwater plumes near these probable source sites. Sampling at the wells should be designed to provide quality analytical data on the vertical distribution of hexavalent chromium in the vadose zone and the aquifer.
- For appropriate existing wells, newly installed RI/FS wells, or Phase 3 RPO wells, passive sampling (used at the 100-D Area in 2010) should be implemented to provide a better understanding of vertical contaminant profiles across the aquifer. Vertical distribution of hexavalent chromium or other analytes observed in RI wells during drilling should be confirmed in an undisturbed setting and expanded to suitable monitoring wells at other locations.
- Few compliance wells are active within the 100-KR-4 OU groundwater monitoring network; however, additional wells are needed to meet the Tri-Party Agreement 2012 milestones listed in Section 5.2.2. Most wells located close to the Columbia River are used as extraction and compliance wells; however, there is a lack of wells further downgradient to determine the adequacy of remediation. Aquifer tubes are relied upon to indicate contaminant levels near the river but do not penetrate the full thickness of the aquifer to ensure a good data set. Cultural resources interfere with locating wells closer to the river in key areas.
- Evaluate the effectiveness of the 100-K Area pump-and-treat systems with respect to the 2012 Tri-Party Agreement Milestone M-016-110-TO1 target criteria. Groundwater concentration trends and hydraulic head data should be used with capture zone analyses and additional modeling to maximize capacity of existing treatment systems.

Table 5-1. Hexavalent Chromium Concentrations at the 116-K-2 Plume Wells and Aquifer Tubes, CY 2008 to CY 2010

Well or Aquifer Tube Name	Well Use[a]	Fall 2008, Filt. and Unfilt. Cr^{+6}		Fall 2009 Sample, Unfiltered Cr^{+6}		Fall 2010 Sample, Unfiltered Cr^{+6}		% Change in Cr^{+6} Conc. (Negative = Increase)	
		Date Collected	Conc. (mg/L)	Date Collected	Unfilt. Cr^{+6} (mg/L)	Date Collected	Unfilt. Cr^{+6} (mg/L)	2008 to 2010	2009 to 2010
199-K-18	C	10/23/08	156	10/22/09	192	12/8/10	139	10.9	27.6
199-K-19	P	10/23/08	28.7	10/18/09	13.7	12/3/10	7.3	74.6	46.7
199-K-20	C	10/27/08	5.5	10/28/09	2.3 (B)[b]	--[c]	--	--	--
199-K-21	P	10/23/08	6.7	10/18/09	6 (N)	12/3/10	5.5	17.9	8.3
199-K-22	P	10/23/08	108	10/22/09	120	--	--	--	--
199-K-37	P	10/27/08	71.2	10/22/09	56.7	12/3/10	27.1	61.9	52.2
199-K-111A	P	--	--	10/21/09	30.0	12/7/10	46.4		-54.7
199-K-113A	E/C-KR4	10/6/08	64	10/21/09	58	9/8/10	3	95.3	94.8
199-K-114A	E/C-KR4	10/6/08	85	10/21/09	62.9	--	--	--	--
199-K-115A	E/C-KR4	10/6/08	91	10/21/09	84.4	9/8/10	17	81.3	79.9
199-K-116A	E/C-KR4	12/1/08	54.5	10/21/09	25.3	--	--	--	--
199-K-117A	C	10/6/08	2 (U)	10/22/09	2 (U)	12/3/10	2 (U)	NC[d]	NC
199-K-119A	E/C-KR4	11/4/08	7	--	--	12/8/10	2 (U)	Dec[e]	--
199-K-120A	E/C-KR4	11/4/08	38	--	--	10/4/10	9	94.7	--
199-K-125A	C	11/4/08	12	--	--	--	--	--	--
199-K-126[f]	M	--	--	10/21/09	36.6	9/22/10	27.2	--	25.7
199-K-127	E/C-KR4	11/4/08	14	--	--	10/4/10	7	50.0	--
199-K-129/ K-112A	E/C-KR4	11/4/08	43	10/21/09	45.2	9/8/10	22	48.8	51.3
199-K-130	E/C-KX	11/18/08	49	10/20/09	49.7	11/22/10	37.5	23.5	24.5
199-K-131	E/C-KX	11/18/08	79	10/20/09	58	9/7/10	37	53.2	36.2
699-78-62	M	--	--	--	--	--	--	--	--
199-K-121A	I-KR4	--	--	--	--	--	--	--	--
199-K-122A	I-KR4	--	--	--	--	--	--	--	--
199-K-123A	I-KR4	--	--	--	--	--	--	--	--
199-K-124A	I-KR4	--	--	--	--	12/7/10	6.1	--	--
199-K-128	I-KR4	--	--	--	--	--	--	--	--
199-K-143	I-KR4	--	--	--	--	--	--	--	--
199-K-144	E/C-KR4	10/7/08	34	--	--	10/4/10	25	26.5	--
199-K-145	E/C-KR4	11/20/08	37	12/7/09	59	10/4/10	62	-67.6	-5.1
199-K-146	E/C-KX	11/24/08	58	10/20/09	44.8	10/4/10	21	63.8	53.1
199-K-147	E/C-KX	11/19/08	52	10/20/09	37.9	11/22/10	31.5	39.4	16.9
199-K-148	E/C-KX	11/12/08	146	10/20/09	85.3	11/22/10	52.6	64.0	38.3
199-K-149	E/C-KX	11/13/08	82	10/20/09	27.2	10/25/10	8	90.2	70.6
199-K-150	E/C-KX	11/19/08	70	10/20/09	8.8	10/11/10	2	97.1	77.3
199-K-151	P	11/24/08	60.7	10/22/09	26.4	9/20/10	7.9	87.0	70.1
199-K-152	P	9/24/08	75.5	10/22/09	69.9	9/21/10	59.4	21.3	15.0
199-K-153	M	9/24/08	38.4	--	--	11/22/10	30.2	21.4	--
199-K-154	E/C-KX	9/24/08	97.5	10/12/09	94	11/22/10	85.2	12.6	9.4
199-K-156	I-KX	--	--	--	--	--	--	--	--

Table 5-1. (Cont.)

Well or Aquifer Tube Name	Well Use[a]	Fall 2008, Filt. and Unfilt. Cr^{+6}		Fall 2009 Sample, Unfiltered Cr^{+6}		Fall 2010 Sample, Unfiltered Cr^{+6}		% Change in Cr^{+6} Conc. (Negative = Increase)	
		Date Collected	Conc. (mg/L)	Date Collected	Unfilt. Cr^{+6} (mg/L)	Date Collected	Unfilt. Cr^{+6} (mg/L)	2008 to 2010	2009 to 2010
199-K-157	P	9/24/08	64	10/29/09	51.5	12/7/10	30.2	52.8	41.4
199-K-159	I-KX	--	--	--	--	--	--	--	--
199-K-160	I-KX	--	--	--	--	--	--	--	--
199-K-161	E/C-KX	11/19/08	106	10/21/09	85.9	11/22/10	14.1	86.7	83.6
199-K-162	E/C-KR4	--	--	--	--	9/14/10	8	--	--
199-K-163	E/C-KX	9/24/08	128	10/12/09	96	11/22/10	52.2	59.2	45.6
199-K-164	I-KX	--	--	--	--	--	--	--	--
199-K-169	I-KX	--	--	--	--	--	--	--	--
199-K-170	I-KX	--	--	--	--	--	--	--	--
199-K-171	E-KX	9/5/08	79	--	--	11/22/10	53	32.9	--
199-K-172	I-KX	9/5/08	15	--	--	--	--	--	--
199-K-179	I-KX	--	--	--	--	--	--	--	--
199-K-180	I-KX	--	--	--	--	--	--	--	--
199-K-182	P	--	--	--	--	--	--	--	--
199-N-16	P	--	--	--	--	--	--	--	--
199-N-71	P	--	--	--	--	--	--	--	--
199-N-72	P	--	--	--	--	--	--	--	--
19-D[g]	AT	--	--	11/17/09	2 (U)	--	--	--	--
21-M	AT	--	--	11/18/09	2 (U)	--	--	--	--
22-M/D[h]	AT	--	--	11/21/09	7	--	--	--	--
23-D	AT	--	--	11/23/09	2 (U)	--	--	--	--
26-D	AT	--	--	--	--	--	--	--	--
C6246	AT	--	--	11/16/09	16	--	--	--	--
C6249	AT	--	--	11/17/09	20	--	--	--	--
C6250	AT	--	--	11/17/09	24.5	--	--	--	--
C6251	AT	--	--	11/21/09	3.5 (B)	--	--	--	--
C6252	AT	--	--	11/21/09	2.3 (B)	--	--	--	--
C6253	AT	--	--	11/21/09	49.4	--	--	--	--
C6254	AT	--	--	11/21/09	2 (U)	--	--	--	--
C6255	AT	--	--	11/21/09	5.4	--	--	--	--
C6256	AT	--	--	11/21/09	30.1	--	--	--	--
C6257	AT	--	--	11/21/09	2 (U)	--	--	--	--
C6258	AT	--	--	11/21/09	2 (U)	--	--	--	--
C6259	AT			11/21/09	2 (U)				
C6260	AT	--	--	11/23/09	2 (U)	--	--	--	--
C6263	AT	--	--	11/21/09	2 (U)	12/28/10	2(U)	--	--
C6264	AT	--	--	11/21/09	2 (U)	12/28/10	2(U)	--	--
C6265	AT	--	--	11/21/09	2 (U)	12/28/10	2(U)	--	NC
DK-04-2	AT	--	--	11/21/09	2 (U)	12/28/10	2(U)	--	NC

Table 5-1. (Cont.)

Well or Aquifer Tube Name	Well Use[a]	Fall 2008, Filt. and Unfilt. Cr^{+6}		Fall 2009 Sample, Unfiltered Cr^{+6}		Fall 2010 Sample, Unfiltered Cr^{+6}		% Change in Cr^{+6} Conc. (Negative = Increase)	
		Date Collected	Conc. (mg/L)	Date Collected	Unfilt. Cr^{+6} (mg/L)	Date Collected	Unfilt. Cr^{+6} (mg/L)	2008 to 2010	2009 to 2010
AT-K-3-D	AT	--	--	11/01/09	62.8	12/17/10	56.9	--	9
AT-K-4-M	AT	--	--	11/23/09	2 (U)	--	--	--	--
AT-K-5-D	AT	--	--	11/23/09	45.6	--	--	--	--
AT-K-6-M	AT	--	--	--	--	--	--	--	--

a. Well use: C = compliance, E = extraction, I = injection; M = monitoring, P = performance, X = KR4 expansion well, use to be determined. Column also lists the applicable pump-and-treat system where appropriate.

b. Laboratory qualifiers: B = analyte detected at a value less than contract required detection limit but greater than or equal to the instrument or method detection limit, D = analyte reported at a secondary dilution factor, U = not detected in sample; value shown is the detection limit.

c. Blank cells (marked as "--") indicate that the sample was not collected, the analysis was not performed, or the change in concentration was not calculated.

d. Change in hexavalent chromium concentration is not calculated (NC) when "U" (nondetect) values are used in the calculation. Where both values have a "U" qualifier, the values are assumed to not have changed significantly.

e. Where contaminant concentration comparisons involve one nonqualified result and one nondetect (U) result, the percent change was not calculated but rather and increase (inc.) or decrease (dec.) in concentration between years was noted.

f. Hexavalent chromium results from well 199-K-126 have been influenced by the calcium polysulfide treatability test that changed the color of groundwater and so strongly influenced the colorimetric EPA Method 7196 results. High out-of-trend results from this well have been rejected because of lingering calcium polysulfide influence.

g. Aquifer tube (AT) nomenclature regarding relative depth: D = deepest, M = middle, and S = shallowest.

h. Hexavalent chromium data from site AT 22 include sample results from either the middle or deep tubes in cluster as only one is sampled each year.

Table 5-2. Hexavalent Chromium Concentrations at the KW Reactor Wells and Aquifer Tubes, CY 2008 to CY 2010

Well Name	Well Use[a]	Fall 2008 Unfilt. Cr^{+6}		Fall 2009 Unfilt. Cr^{+6}		Fall 2010 Sample Unfilt. Cr^{+6}		% Change in Cr^{+6} Conc. (Negative = Increase)	
		Date Collected	Conc. (µg/L)	Date Collected	Conc. (µg/L)	Date Collected	Conc. (µg/L)	2008 to 2010	2009 to 2010
199-K-34	M	10/27/08	44.1	10/22/09	36.8	12/7/10	5.1	88.4	86.1
199-K-35	M	--[b]	--	12/22/09	188	Decommissioned	--	--	
199-K-106A	M	10/6/08	4.8	10/22/09	2.1 (B)[c]	--	--	--	--
199-K-107A	M	10/6/08	172	10/22/09	29.3	12/3/10	14.4	91.6	50.9
199-K-108A	M	10/6/08	81.5	10/22/09	5.2	12/8/10	2(U)	Dec.[d]	Dec.
199-K-31	M	--	--	10/22/09	5.6	12/8/10	5.6	--	0.0
199-K-132	E	10/23/08	41	10/20/09	20	11/22/10	16.8	59.0	16.0
199-K-137	M	10/28/08	1,390	10/26/09	211	11/1/10	109	92.2	48.3
199-K-138	E	10/28/08	40.5	10/12/09	38	11/22/10	20.6	49.1	45.8
199-K-139	E	10/31/08	124	11/10/09	117	11/15/10	25	79.8	78.6
199-K-140	E	10/28/08	14.1	10/20/09	13	--	--	--	--
199-K-165	E	11/10/08	2,530	10/20/09	232	11/15/10	321	87.3	-38.4
199-K-166	E	11/10/08	101	10/20/09	56.1	11/22/10	30.5	69.8	45.6
199-K-167	--	--	--	--	--	--	--	--	--
199-K-168	E	11/10/08	241	10/20/09	130	11/15/10	57	76.3	56.2
199-K-173	M	12/1/08	7.3	10/21/09	104	--	--	--	--
199-K-174	I	--	--	--	--	--	--	--	--
199-K-175	I	--	--	--	--	--	--	--	--
AT-K-1[e]	AT	--	--	11/1/09	7.5	12/17/10	2 (U)	--	74

a. Well use: C = compliance, E = extraction, I = injection, M = monitoring.

b. Blank cells (marked as "--") indicate that the sample was not collected, the analysis was not performed, or the change in concentration was not calculated.

c. Laboratory qualifiers: B = analyte detected at a value less than contract required detection limit but greater than or equal to the instrument or method detection limit, C = analyte detected in both the sample and the associated quality control blank, and the sample concentration was less than or equal to five times the blank concentration, D = analyte reported at a secondary dilution factor, U = not detected in sample; value shown is the detection limit.

d. Where contaminant concentration comparisons are both "U" (nondetect) then no percent change was calculated (NC), where comparisons involve one nonqualified result and one undetected (U) result, the percent change was not calculated but rather an increase (inc.) or decrease (dec.) in concentration between years was noted.

e. Change in hexavalent chromium concentration at site AT-K-1 included sample results from both the middle and deep tube in cluster because all tubes not sampled each year.

Table 5-3. Hexavalent Chromium Concentrations at the KE Wells and Aquifer Tubes, CY 2008 to CY 2010

Well Name	Well Use[a]	Fall 2008 Unfiltered Cr^{+6}		Fall 2009 Unfiltered Cr^{+6}		Fall 2010 Sample Unfiltered Cr^{+6}		% Change in Cr^{+6} Conc. (Negative = Increase)	
		Date Collected	Conc. (µg/L)	Date Collected	Conc. (µg/L)	Date Collected	Conc. (µg/L)	2008 to 2010	2009 to 2010
199-K-32A	P	10/27/08	13.1	10/22/09	11.8	12/3/10	9.0	42	23.7
199-K-32B	M	10/27/08	6.8	10/18/09	5.1	12/8/10	3.8(B)[b]	57.4	43.1
199-K-30	M	10/27/08	3.3	10/18/09	2.1 (B)	12/2/10	7.5	-127.3	-257.1
199-K-29	M	--[c]	--	--	--	12/2/10	2 (U)	--	--
199-K-23	M	10/27/08	2 (U)	--	--	--	--	--	--
199-K-11	M	10/6/08	2 (U)	10/28/09	2 (U)	12/3/10	5.3	Inc.[d]	Inc.
199-K-110A	M	--	--	10/18/09	2 (U)	12/8/10	2 (U)	NC[d]	NC
199-K-36	M	10/27/08	21.4	10/22/09	20.0	12/3/10	34.2	-59.8	-71.0
199-K-141	E-KX	10/28/08	421	11/23/09	91	10/4/10	38	91.0	58.2
199-K-142	M	10/28/08	5.8	10/22/09	3.3 (B)	12/8/10	4	3131.0	-21.22
199-K-178	E-KX	--	--	11/5/09	117	11/17/10	23.8	--	79.7
199-K-181	C	--	--	11/5/09	8.6	--	--	--	--
C6242	AT	--	--	11/18/09	2 (U)	--	--	--	--
C6243	AT	--	--	11/18/09	4.8 (B)	--	--	--	--
C6244	AT	--	--	11/18/09	5.2	--	--	--	--
C6245	AT	--	--	11/16/09	14.8	--	--	--	--
C6246	AT	--	--	11/16/09	16	--	--	--	--
C6247	AT	--	--	11/16/09	15.7	--	--	--	--
19-D	AT	--	--	11/17/09	2 (U)	--	--	--	--
AT-K-2-D[e,f]	AT	--	--	11/1/09	3.4 (B)	12/17/10	2 (U)	--	41.22

a. Well use: C = compliance, E = extraction, I = injection, M = monitoring. P = performance. Column includes applicable pump-and-treat system where appropriate.

b. Laboratory qualifiers: B = analyte detected at a value less than contract required detection limit but greater than or equal to the instrument or method detection limit, U = not detected in sample; value shown is the detection limit.

c. Blank cells (marked as "--") indicate that the sample was not collected, the analysis was not performed, or a change in concentration could not be calculated.

d. Where contaminant concentration comparisons are both "U" (nondetect) then no percent change was calculated (NC), where comparisons involve one nonqualified result and one nondetect (U) result, the percent change was not calculated but rather an increase (inc.) or decrease (dec.) in concentration between years was noted.

e. Aquifer tube (AT) nomenclature regarding relative depth: D = deep, M = middle, S = shallow.

f. Change in hexavalent chromium concentration at site AT-K-2 included sample results from both the middle and the deep tube in the cluster because all tubes were not sampled each year.

Table 5-4. Tritium Activities at the 116-K-2 Wells and Aquifer Tubes, CY 2008 to CY 2010

Well or Aquifer Tube Name	Well Use[a]	Fall 2008		Fall 2009 Sample		Fall 2010 Sample		% Change in Activity (Negative = Increase)	
		Date Collected	H-3 (pCi/L)	Date Collected	H-3 (pCi/L)	Date Collected	H-3 (pCi/L)	2008 to 2010	2009 to 2010
199-K-18	C	10/23/08	29,000	10/22/09	43,000	--[b]	--	--	--
199-K-19	P	10/23/08	2,900	10/18/09	3,900	12/3/10	4,800	-65.5	-23.1
199-K-20	C	10/27/08	5,400	10/28/09	6,100	--	--	--	--
199-K-21	P	10/23/08	240	10/18/09	5,800	12/3/10	58 (U)	Dec.[c]	Dec.
199-K-22	P	10/23/08	250	10/22/09	27 (U)[d]	--	--	--	--
199-K-37	P	10/27/08	188 (U)	10/22/09	680	12/3/10	300	-59.6	55.9
199-K-113A	E/C-KR4	--	--	10/21/09	170 (U)	--	--	--	--
199-K-114A	E/C-KR4	--	--	10/21/09	50 (U)	--	--	--	--
199-K-115A	E/C-KR4	--	--	10/21/09	56 (U)	--	--	--	--
199-K-116A	E/C-KR4	--	--	10/21/09	4,600	--	--	--	--
199-K-117A	C	10/6/08	200 (U)	10/22/09	41 (U)	12/3/10	-29 (U)	NC[c]	NC
199-K-119A	E/C-KR4	--	--	--	--	12/8/10	6,700	--	--
199-K-120A	E/C-KR4	--	--	--	--	--	--	--	--
199-K-118A/ 199-125A	C	--	--	--	--	--	--	--	--
199-K-126	M	--	--	--	--	--	--	--	--
199-K-127	E/C-KR4	--	--	--	--	--	--	--	--
199-K-129/ 199-K-112A	E/C-KR4	--	--	10/21/09	-22 (U)	--	--	--	--
199-K-130	E/C-KX	--	--	10/20/09	2,500	11/22/10	1,900	--	24.0
199-K-131	E/C-KX	--	--	10/20/09	3,300	--	--	--	--
699-78-62	M	11/23/08	1,700	11/23/08	1,700	--	--	--	--
199-K-121A	I-KR4	--	--	--	--	--	--	--	--
199-K-122A	I-KR4	--	--	--	--	--	--	--	--
199-K-123A	I-KR4	--	--	--	--	--	--	--	--
199-K-124A	I-KR4	--	--	--	--	12/7/10	6,900	--	--
199-K-128A	I-KR4	--	--	--	--	--	--	--	--
199-K-144	E/C-KR4	10/7/08	200,000	--	--	--	--	--	--
199-K-145	E/C-KR4	--	--	--	--	--	--	--	--
199-K-146	E/C-KX	--	--	10/20/09	150 (U)	--	--	--	--
199-K-147	E/C-KX	--	--	10/20/09	2,100	11/22/10	810	--	61.4
199-K-148	E/C-KX	--	--	10/20/09	3,800	11/22/10	2,500	--	34.2
199-K-149	E/C-KX	--	--	10/20/09	1,900	--	--	--	--
199-K-150	E/C-KX	--	--	10/20/09	7,800	--	--	--	--
199-K-151	P	11/24/08	4,500	10/22/09	1,200	9/20/10	940	79.1	21.7
199-K-152	P	12/8/08	800	10/22/09	280	9/21/10	150 (U)	81.3	46.4
199-K-153	M	12/1/08	0.9 (U)	--	--	11/22/10	740	--	--
199-K-154	E-KX	9/24/08	58.7 (U)	11/9/08	32 (U)	11/22/10	190 (U)	NC	NC
199-K-156	I-KX	--	--	--	--	--	--	--	--
199-K-157	P	11/18/08	320,000	10/29/09	290,000	12/7/10	27,000	91.6	90.7
199-K-159	I-KX	--	--	--	--	--	--	--	--

Table 5-4. (Cont.)

Well or Aquifer Tube Name	Well Use[a]	Fall 2008		Fall 2009 Sample		Fall 2010 Sample		% Change in Activity (Negative = Increase)	
		Date Collected	H-3 (pCi/L)	Date Collected	H-3 (pCi/L)	Date Collected	H-3 (pCi/L)	2008 to 2010	2009 to 2010
199-K-160	I-KX	--	--	--	--	--	--	--	--
199-K-161	E/C-KX	--	--	10/21/09	108 (U)	11/22/10	83 (U)	--	NC
199-K-162	E/C-KR4	--	--	--	--	--	--	--	--
199-K-163	E/C-KX	11/9/08	203 (U)	--	--	11/22/10	5,200	Inc.	--
199-K-164	I-KX	--	--	--	--	--	--	--	--
199-K-169	I-KX	--	--	--	--	--	--	--	--
199-K-170	I-KX	--	--	--	--	--	--	--	--
199-K-171	E-KX	9/5/08	670	--	--	11/22/10	2,300	-243.3	--
199-K-172	I-KX	9/5/08	-9.5 (U)	--	--	--	--	--	--
199-K-179	I-KX	--	--	11/5/09	7,500	--	--	--	--
199-K-180	I-KX	--	--	--	--	--	--	--	--
199-K-182	P	--	--	12/28/09	5,800	9/20/10	4,100	--	29.3
199-N-16	P	--	--	10/18/09	300	--	--	--	--
199-N-72	P	--	--	--	--	9/19/10	1,600	--	NC
199-N-71	P	--	--	10/21/09	1,050	12/5/10	1,000	--	4.8
19-D/M[e,f]	AT	--	--	11/17/09	130 (U)	--	--	--	--
21-M	AT	--	--	11/18/09	100 (U)	--	--	--	--
22-M/D	AT	--	--	11/21/09	71 (U)	--	--	--	--
23-D	AT	--	--	11/23/09	-220 (U)	--	--	--	--
26-D	AT	--	--	8/19/08	1,900	--	--	--	--
C6246	AT	--	--	--	--	--	--	--	--
C6250	AT	--	--	11/17/09	1,700	--	--	--	--
C6253	AT	--	--	11/21/09	620	--	--	--	--
C6256	AT	--	--	11/21/09	240	--	--	--	--
C6259	AT	--	--	11/21/09	730	--	--	--	--
C6260	AT	--	--	--	--	--	--	--	--
DK-04-2	AT	--	--	11/21/09	620	--	--	--	--
AT-K-3-D/M	AT	--	--	11/1/09	5,400.0	--	--	--	--
AT-K-4-M	AT	--	--	11/23/09	37 (U)	--	--	--	--
AT-K-5-D/M	AT	--	--	11/23/09	300	--	--	--	--
AT-K-6-M	AT	--	--	--	--	--	--	--	--

a. Well use: C = compliance, E = extraction, I = injection, M = monitoring, P = performance.

b. Blank cells (marked as "--") indicate that the sample was not collected, the analysis was not performed, or a change in concentration could not be calculated.

c. Change in tritium concentration not calculated = (NC) when both values include "U" (nondetect) qualifier. If one value has a "U" qualifier and the second value is unqualified, the change in concentration is shown as increase (inc.) or decrease (dec.).

d. Laboratory qualifiers: U = not detected in sample; value shown is the detection limit.

e. Aquifer tube (AT) nomenclature indicates relative depth: D = deep, M = middle, S = shallow.

f. Change in tritium concentration at some aquifer tube clusters may include sample results from both the middle and deep tube in cluster because all tubes not sampled each year.

Table 5-5. Tritium Activities at the KW Reactor Wells and Aquifer Tubes, CY 2008 to CY 2010

Well Name	Well Use[a]	Fall 2008		Fall 2009 Sample		Fall 2010 Sample		% Change in Activity (Negative = Increase)	
		Date Collected	H-3 (pCi/L)	Date Collected	H-3 (pCi/L)	Date Collected	H-3 (pCi/L)	2008 to 2010	2009 to 2010
199-K-34	P	10/27/08	1,300	10/22/09	4,400	9/20/10	4,100	-215.4	6.8
199-K-35	I	--[b]	--	--	--	--	--	--	--
199-K-106A	P	10/6/08	21,000	10/22/09	2,300	9/13/10	3,200	84.8	-39.1
199-K-107A	P	10/6/08	760	10/18/09	1,200	12/3/10	1,300	-71.1	-8.3
199-K-108A	P	10/6/08	920	10/22/09	220 (U)[c]	--	--	--	--
199-K-31	M	10/27/08	1,300	10/22/09	1,500	12/8/10	1,600	-23.1	-6.7
199-K-132	E	10/28/08	6,000	10/20/09	8,200	11/22/10	7,500	-25.0	8.5
199-K-137	E	10/28/08	1,600	10/20/09	940	--	--	--	--
199-K-138	E	10/28/08	1,200	10/20/09	1,100	11/22/10	1,500	-25.0	-36.4
199-K-139	E	10/30/08	1,500	11/10/09	1,600	--	--	--	--
199-K-140	M	10/28/08	1,600	10/20/09	1,700	--	--	--	--
199-K-165	E	11/10/08	684	10/20/09	970	--	--	--	--
199-K-166	E	11/10/08	1,190	10/20/09	2,600	11/22/10	1,400	-17.6	46.2
199-K-167	Abandoned	--	--	--	--	--	--	--	--
199-K-168	E	10/29/08	1,370	10/20/09	970	--	--	--	--
199-K-173	P	9/27/08	910	10/21/09	1,200	--	--	--	--
199-K-174	I	--	--	--	--	--	--	--	--
199-K-175	I	--	--	--	--	--	--	--	--
AT-K-1-D/M[d,e]	AT	--	--	11/1/09	100 (U)	--	--	--	--

a. Well use: C = compliance, E = extraction, I = injection, M = monitoring.

b. Blank cells (marked as "--") indicate that the sample was not collected, the analysis was not performed, or a change in concentration could not be calculated.

c. U = not detected in sample; value shown is the detection limit.

d. Aquifer tube (AT) nomenclature regarding relative depth: D = deep, M = middle, S = shallow.

e. Change in tritium concentration at site AT-K-1 included sample results from both the middle and deep tube in cluster because all tubes not sampled each year.

Table 5-6. Tritium Activities at the KE Reactor Wells and Aquifer Tubes, CY 2008 to CY 2010

Well Name	Well Use[a]	Fall 2008		Fall 2009 Sample		Fall 2010 Sample		Change in Tritium Activity, Negative = Increase	
		Date Collected	H-3 (pCi/L)	Date Collected	H-3 (pCi/L)	Date Collected	H-3 (pCi/L)	2008 to 2010	2009 to 2010
199-K-32A	P	10/27/08	4,200	10/22/09	3,900	12/3/10	2,500	40.5	35.9
199-K-32B[b]	M	10/27/08	140 (U)[c]	10/18/09	-29 (U)	--[d]	--	--	--
199-K-30	M	10/27/08	410,000	10/18/09	140,000	12/2/10	16,000	96.1	88.6
199-K-29	M	9/29/08	7,100	--	--	12/2/10	130,000	-1731.0	--
199-K-27	Decommissioned	--	--	--	--	--	--	--	--
199-K-23	M	10/27/08	120 (U)	--	--	--	--	--	--
199-K-11	M	10/6/08	140 (U)	10/28/09	66 (U)	12/3/10	330	-135.7	-400.0
199-K-109A	M	--	--	--	--	--	--	--	--
199-K-110A	M	10/6/08	160 (U)	10/18/09	96 (U)	12/8/10	140 (U)	NC[e]	NC
199-K-111A	P	10/6/08	6,000	10/21/09	7,515	12/7/10	26,000	-333.3	-246.0
199-K-36	M	10/27/08	172 (U)	10/22/09	48.4 (U)	12/3/10	130 (U)	NC	NC
199-K-141	E-KR4	10/28/08	4,300	--	--	--	--	--	--
199-K-142	P	10/28/08	1,200	10/22/09	290	12/8/10	117 (U)	90.3	59.7
199-K-178	E-KR4	--	--	10/8/09	3,100	11/17/10	1,100		64.5
199-K-181	C	--	--	10/8/09	340	--	--	--	--
C6241	AT	--	--	11/15/09	550	--	--	--	--
C6244	AT	--	--	11/18/09	2,100	--	--	--	--
18-S[f]	AT	--	--	11/18/09	160 (U)	--	--	--	--
19-D	AT	--	--	--	--	--	--	--	--
AT-K-2-M	AT	--	--	--	--	--	--	--	--

a. Well and aquifer tube use: M = monitoring, AT = aquifer tube, P = performance, E = extraction. Column includes applicable pump-and-treat system where appropriate.

b. Well 199-K-32B is screened within the Ringold upper mud unit and well 199-K-32A is screened within Ringold unit E.

c. Laboratory qualifiers: U = not detected in sample; value shown is the detection limit.

d. Blank cells (marked as "--") indicate that the sample was not collected, the analysis was not performed, or a change in concentration could not be calculated.

e. Change in tritium concentration is not calculated (NC) when both results include "U" (nondetect) qualifiers. If one compared result includes a "U" qualifier and the second is unqualified, the change in concentration is shown as increase (inc.) or decrease (dec.).

f. Aquifer tube nomenclature regarding relative depth: D = deep, M = middle, S = shallow.

Table 5-7. Strontium-90 Activities at the 116-K-2 Wells and Aquifer Tubes, CY 2008 to CY 2010

Well or Aquifer Tube Name	Well Use[a]	Fall 2008		Fall 2009		Fall 2010		Change in Sr-90 Conc.	Change in Sr-90 Activity
		Date Collected	Sr-90 (pCi/L)	Date Collected	Sr-90 (pCi/L)	Date Collected	Sr-90 (pCi/L)	2008 to 2010 (%) (Negative = Increase)	2009to 2010 (%) (Negative = Increase)
199-K-18	C	10/23/08	-1.38 (U)[b]	10/22/09	-6 (U)	--	--[c]	--	--
199-K-19	P	--	--	10/18/09	7.5	12/3/10	12	--	-60.0
199-K-20	C	10/27/08	3.05	10/28/09	-1.5 (U)	--	--	--	
199-K-21	P	10/23/08	26.7	10/18/09	22	12/3/10	17	36.3	22.7
199-K-22	P	10/23/08	6.78	10/22/09	-4.2 (U)	--	--	--	--
199-K-37	P	--	--	10/22/09	-7.7 (U)	12/3/10	-3.1 (U)	--	NC[d]
199-K-113A	E/C-KR4	--	--	10/21/09	5.9	--	--	--	--
199-K-114A	E/C-KR4	--	--	10/21/09	8.7	--	--	--	--
199-K-115A	E/C-KR4	--	--	10/21/09	6.1	--	--	--	--
199-K-116A	E/C-KR4	--	--	10/21/09	1.4	--	--	--	--
199-K-117A	C	10/6/08	0.18 (U)	10/22/09	-3.1 (U)	12/3/10	-1.2 (U)	NC	NC
199-K-119A	E/C-KR4	--	--	--	--	12/8/10	1.2 (U)	--	--
199-K-120A	E/C-KR4	--	--	--	--	--	--	--	--
199-K-125A	C	--	--	--	--	--	--	--	--
199-K-127	M	--	--	--	--	--	--	--	--
199-K-129/ 1990K-112A	E/C-KR4	--	--	10/21/09	-0.1 (U)	--	--	--	--
199-K-130	E/C-KR4	--	--	10/20/09	0.1 (U)	11/22/10	-11 (U)	--	NC
199-K-131	E/C-KX	--	--	10/20/09	-3 (U)	--	--	--	--
699-78-62	E/C-KX	--	--	--	--	--	--	--	--
199-K-121A	I-KR4	--	--	--	--	--	--	--	--
199-K-122A	I-KR4	--	--	--	--	--	--	--	--
199-K-123A	I-KR4	--	--	--	--	--	--	--	--
199-K-124A	I-KR4	--	--	--	--	12/7/10	-0.18 (U)	--	NC
199-K-143	I-KR4	--	--	--	--	--	--	--	--
199-K-144	E/C-KR4	--	--	--	--	--	--	--	--
199-K-145	E/C-KR4	--	--	--	--	--	--	--	--
199-K-146	E/C-KX	--	--	10/20/09	-2.5	--	--	--	--
199-K-147	E/C-KX	--	--	10/20/09	4.4	11/22/10	-4.9 (U)	--	NC
199-K-148	E/C-KX	--	--	10/20/09	0.69	11/22/10	-7.2 (U)	--	Dec.[e]
199-K-149	E/C-KX	--	--	10/20/09	-5.1 (U)	--	--	--	--
199-K-150	E/C-KX	--	--	10/20/09	-2.8 (U)	--	--	--	--
199-K-151	P	11/28/08	-7.2 (U)	10/22/09	-6.4 (U)	9/20/10	-4.7 (U)	--	NC
199-K-152	P	9/24/08	3	10/22/09	-7.2 (U)	9/21/10	-5.5 (U)	--	NC
199-K-153	M	9/24/08	-1.2 (U)	--	--	11/22/10	-10 (U)	--	--
199-K-154	E-KX	9/24/08	0.53 (U)	--	--	11/22/10	-8.1 (U)	--	--
199-K-156	I-KX	--	--	--	--	--	--	--	--
199-K-157	P	11/18/08	0.6 (U)	10/29/09	2.6	12/7/10	-0.45 (U)	NC	Dec.
199-K-159	I-KX	--	--	--	--	--	--	--	--
199-K-160	I-KX	--	--	--	--	--	--	--	--
199-K-161	E/C-KX	--	--	10/21/09	14.8	11/22/10	-2.2 (U)	--	--
199-K-162	E/C-KR4	--	--	--	--	--	--	--	--
199-K-163	E/C-KX	11/9/08	-0.953 (U)	--	--	11/22/10	-6.7 (U)	NC	--

Table 5-7. (Cont.)

Well or Aquifer Tube Name	Well Use[a]	Fall 2008		Fall 2009		Fall 2010		Change in Sr-90 Conc.	Change in Sr-90 Activity
		Date Collected	Sr-90 (pCi/L)	Date Collected	Sr-90 (pCi/L)	Date Collected	Sr-90 (pCi/L)	2008 to 2010 (%) (Negative = Increase)	2009to 2010 (%) (Negative = Increase)
199-K-164	I-KX	--	--	--	--	--	--	--	--
199-K-169	I-KX	--	--	--	--	--	--	--	--
199-K-170	I-KX	--	--	--	--	--	--	--	--
199-K-171	E-KX	9/5/08	-0.49 (U)	--	--	11/22/10	-7.2 (U)	NC	--
199-K-172	I-KX	9/5/08	-2 (U)	--	--	--	--	--	--
199-K-179	I-KX	--	--	11/5/09	-5.5 (U)	--	--	--	--
199-K-180	I-KX	--	--	--	--	--	--	--	--
199-K-182	P	--	--	--	--	9/20/10	-1.8 (U)	--	--
19-D/M[f,g]	AT	--	--	11/17/09	-1 (U)	--	--	--	--
21-M	AT	--	--	11/18/09	2.1 (U)	--	--	--	--
22-M/D[f]	AT	--	--	--	--	--	--	--	--
23-D	AT	--	--	--	--	--	--	--	--
C6246	AT	--	--	11/16/09	-2.7 (U)	--	--	--	--
C6250	AT	--	--	--	--	--	--	--	--
C6253	AT	--	--	--	--	--	--	--	--
C6256	AT	--	--	--	--	--	--	--	--
C6259	AT	--	--	11/21/09	-7 (U)	--	--	--	--
C6260	AT	--	--	--	--	--	--	--	--
DK-04-2	AT	--	--	--	--	--	--	--	--
AT-K-3-D/M[f]	AT	--	--	11/17/09	-1.7 (U)	--	--	--	--
AT-K-4-M	AT	--	--	11/23/09	-9.2 (U)	--	--	--	--
AT-K-5-D/M[f]	AT	--	--	11/23/09	0.14 (U)	--	--	--	--
AT-K-6-M	AT	--	--	--	--	--	--	--	--

a. Well use: C = compliance, E = extraction, I = injection, M = monitoring, P= performance. Column includes applicable pump-and-treat system where appropriate.

b. Laboratory qualifiers: U = not detected in sample; value shown is the detection limit.

c. Blank cells (marked as "--") indicate that the sample was not collected, the analysis was not performed, or the change in concentration was not calculated.

d. Change in strontium-90 concentration not calculated (NC) when "U" (undetected) values are compared.

e. Where contaminant concentration comparisons involve one nonqualified result and one undetected (U) result, the percent change was not calculated but rather an increase (inc.) or decrease (dec.) in concentration between years was noted.

f. Aquifer tube (AT) nomenclature indicates relative depth: D = deep, M = middle, S = shallow.

g. Change in strontium-90 concentration at some aquifer tube clusters may include sample results from both the middle and deep tube in cluster because all tubes not sampled each year.

Table 5-8. Strontium-90 Activities at the KW Reactor Wells and Aquifer Tubes, CY 2008 to CY 2010

Well Name	Well Use[a]	Fall 2008		Fall 2009 Sample		Fall 2010 Sample		% Change in Sr-90 Activity (Negative = Increase)	
		Date Collected	Sr-90 (pCi/L)	Date Collected	Sr-90 (pCi/L)	Date Collected	Sr-90 (pCi/L)	2008 to 2010	2009 to 2010
199-K-34	P	10/27/08	36.4	10/22/09	16	12/7/10	45	Dec.[b]	Dec.
199-K-35	I	--[c]	--	--	--	--	--	--	--
199-K-106A	P	--	--	10/22/09	6.3	--	--	--	--
199-K-107A	P	--	--	10/18/09	13	12/3/10	14	--	-7.7
199-K-108A	P	11/18/08	-2 (U)[d]	10/22/09	-11 (U)	--	--	--	
199-K-31	M	--	--	10/22/09	-2.4 (U)	12/8/10	-0.87 (U)	--	NC
199-K-132	E	--	--	10/20/09	-3.2 (U)	11/22/10	-6 (U)	--	NC
199-K-137	E	10/28/08	-0.686 (U)	10/20/09	-1.8 (U)	--	--	--	--
199-K-138	E	10/28/08	-0.602 (U)	10/20/09	-0.36 (U)	11/22/10	-9.2 (U)	NC[b]	NC
199-K-139	E	10/30/08	0.717 (U)	11/10/09	5.3	--	--	--	--
199-K-140	M	10/28/08	0.478	10/20/09	-1(U)	--	--	--	--
199-K-165	E	11/10/08	-1.89 (U)	10/20/09	-1.6 (U)	--	--	--	--
199-K-166	E	11/10/08	-1.41 (U)	10/20/09	-0.31 (U)	11/22/10	-8.8 (U)	NC	NC
199-K-167	Abandoned	--	--	--	--	--	--	--	--
199-K-168	E	11/10/08	-1.87 (U)	10/20/09	-1.4 (U)	--	--	--	--
199-K-173	P	12/1/08	0.78 (U)	10/21/09	-6 (U)	--	--	--	--
199-K-174	I	--	--	--	--	--	--	--	--
199-K-175	I	--	--	--	--	--	--	--	--
AT-K-1-D/M[e,f]	AT	--	--	--	--	--	--	--	--

a. Well use: C = compliance, E = extraction, I = injection, M = monitoring, P = performance. Column includes applicable pump-and-treat system where appropriate.

b. Change in strontium-90 concentration not calculated (NC) when both values are undetected (U); when and the other value is unqualified and one value is nondetect (U), the change is shown as increase (inc.) or decrease (dec.).

c. Blank cells (marked as "--") indicate that the sample was not collected, the analysis was not performed, or the change in concentration was not calculated.

d. Laboratory qualifiers: U = not detected in sample; value shown is the detection limit.

e. Aquifer tube (AT) nomenclature regarding relative depth: D = deep, M = middle, S = shallow.

f. Change in strontium-90 concentration at site AT-K-1 included sample results from both the middle and deep tube in cluster because all tubes not sampled each year.

Table 5-9. Strontium-90 Activities at the KE Reactor Wells and Aquifer Tubes

Well Name	Well Use[a]	Fall 2008		Fall 2009 Sample		Fall 2010 Sample		% Change in Sr-90 Activity (Negative = Increase)	
		Date Collected	Sr-90 (pCi/L)	Date Collected	Sr-90 (pCi/L)	Date Collected	Sr-90 (pCi/L)	2008 to 2010	2009 to 2010
199-K-32A	P	--[b]	--	10/22/09	3.8	12/3/10	4.4	--	72.5
199-K-32B[c]	M	--	--	10/18/09	2.3	--	--	--	--
199-K-30	M	--	--	10/18/09	-2.8 (U)[d]	12/2/10	-2.8 (U)	--	NC[e]
199-K-29	M	--	--	--	--	12/2/10	-5 (U)	--	--
199-K-27	Decommissioned	--	--	--	--	--	--	--	--
199-K-23	M	10/27/08	0.406 (U)	--	--	--	--	--	--
199-K-11	M	--	--	10/28/09	-0.76 (U)	--	--	--	--
199-K-109A	Decommissioned	3/19/08	1120	--	--	--	--	--	--
199-K-110A	M	--	--	10/18/09	-4.6 (U)	--	--	--	--
199-K-111A	P	--	--	12/22/09	-3.2 (U)	12/7/10	1.5	--	Inc.
199-K-36	M	--	--	10/22/09	-0.81 (U)	12/3/10	-14 (U)	--	NC
199-K-141	E-KR4	10/28/08	-0.498 (U)	--	--	--	--	--	--
199-K-142	P	10/28/08	-1.42 (U)	10/22/09	-3.4 (U)	9/21/10	-4.2 (U)	NC	NC
199-K-178	E-KR4	--	--	10/8/09	3.2	11/17/10	2.66	--	--
199-K-181	C	--	--	11/5/09	-11 (U)	--	--	--	--
C6241	AT	--	--	--	--	--	--	--	--
C6244	AT	--	--	11/18/09	2.3 (U)	--	--	--	--
18-S[f]	AT	--	--	--	--	--	--	--	--
19-D	AT	--	--	11/17/09	-1 (U)	--	--	--	--
AT-K-2-M	AT	--	--	--	--	--	--	--	--

a. Well and aquifer tube use: C = compliance, M = monitoring, P = performance, E = extraction, AT = aquifer tube. Column includes applicable pump-and-treat system where appropriate.

b. Blank cells (marked as "--") indicate that the sample was not collected, the analysis was not performed, or a change in concentration could not be calculated.

c. Well 199-K-32B is screened within the Ringold upper mud unit and well 199-K-32A is screened within Ringold unit E.

d. Laboratory qualifiers: U = not detected in sample; value shown is the detection limit.

e. Change in strontium-90 concentration is not calculated (NC) when both values have "U" qualifier. When one value is nondetect (U) and the second value is unqualified, the change is noted as an increase (inc.) or decrease (dec.).

f. Aquifer tube (AT) nomenclature regarding relative depth: D = deep, M = middle, S = shallow.

Table 5-10. Carbon-14 Activities at the KW Reactor Wells and Aquifer Tubes, CY 2008 to CY 2010

Well Name	Well Use[a]	Fall 2008		Fall 2009 Sample		Fall 2010 Sample		% Change in C-14 Activity (Negative = Increase)	
		Date Collected	C-14 (pCi/L)	Date Collected	C-14 (pCi/L)	Date Collected	C-14 (pCi/L)	2008 to 2010	2009 to 2010
199-K-34	M	10/27/08	4,680	10/22/09	1,910	12/7/10	2,590	--	--
199-K-35	M	--[b]	--	--	--	--	--	--	--
199-K-106A	M	10/6/08	2,860	10/22/09	3,970	--	--	--	--
199-K-107A	M	10/6/08	302	10/18/09	282	12/3/10	625	--	--
199-K-108A	M	10/6/08	2,210	10/22/09	946	12/8/10	265	--	--
199-K-31	M	10/27/08	240	10/22/09	565	12/8/10	396	-65.0	29.9
199-K-132	E	10/28/08	2,630	10/20/09	2,320	11/22/10	2,350	10.6	-1.3
199-K-137	M	10/28/08	1,830	10/20/09	950	--	--	--	--
199-K-138	E	10/28/08	192 (J)[c]	10/20/09	285	11/22/10	396	-106.3	-38.9
199-K-139	E	10/30/08	387	11/10/09	347	--	--	--	--
199-K-140	E	10/28/08	878	10/20/09	514	--	--	--	--
199-K-158	M	--	--	--	--	--	--	--	--
199-K-165	E	11/10/08	330	10/20/09	154	--	--	--	--
199-K-166	E	11/10/08	506	10/20/09	290	11/22/10	399	21.1	-37.6
199-K-168	E	10/29/08	643	10/20/09	290	--	--	--	--
199-K-173	P	12/1/08	215	10/21/09	582	--	--	--	--
199-K-174	I	--	--	--	--	--	--	--	--
199-K-175	I	--	--	--	--	--	--	--	--
AT-K-1-D[d]	AT	--	--	11/1/09	35.2	--	--	--	--

a. Well use: E = extraction, M = monitoring, P = performance, I = injection. Column includes applicable pump-and-treat system where appropriate.

b. Blank cells (marked as "--") indicate that the sample was not collected, the analysis was not performed, or a change in concentration could not be calculated.

c. Laboratory qualifiers: J = estimated value; constituent detected at a level less than the contract required detection limit and greater than or equal to the method detection limit.

d. Aquifer tube (AT) nomenclature regarding relative depth: D = deep, M = middle, S = shallow.

Table 5-11. Carbon-14 Activities at the KE Reactor Wells and Aquifer Tubes, CY 2008 to CY 2010

Well Name	Well Use[a]	Fall 2008		Fall 2009 Sample		Fall 2010 Sample		% Change in C-14 Activity (Negative = Increase)	
		Date Collected	C-14 (pCi/L)	Date Collected	C-14 (pCi/L)	Date Collected	C-14 (pCi/L)	2008 to 2010	2009 to 2010
199-K-32A	P	10/27/08	205	10/22/09	166	12/3/10	192	6.3	-15.7
199-K-32B[b]	M	--[c]	--	10/18/09	1.01 (U)[d]	12/8/10	3.43 (U)	--	NC[e]
199-K-30	M	10/27/08	6,130	10/18/09	5,830	12/2/10	4,110	33.0	29.5
199-K-29	M	--	--	--	--	12/2/10	3,120	--	--
199-K-23	M	--	--	--	--	--	--	--	--
199-K-11	M	10/6/08	106	10/28/09	108	12/3/10	131	-23.6	-21.3
199-K-110A	M	--	--	10/18/09	152	--	--	--	--
199-K-36	M	--	--	10/22/09	91	12/3/10	65.1	--	28.5
199-K-141	E-KR4	10/28/08	84.4	--	--	--	--	--	--
199-K-142	P	10/28/08	291	10/22/09	209	12/8/10	242	16.8	-15.8
199-K-178	E-KR4	--	--	10/8/09	200	11/17/10	226	--	-13.0
199-K-181	P	--	--	10/8/09	270	--	--	--	--
C6241	AT	--	--	11/15/09	158	--	--	--	--
C6244	AT	--	--	11/18/09	126	--	--	--	--
C6247	AT	--	--	11/16/09	295	--	--	--	--
18-S[f]	AT	--	--	11/18/09	22.6	--	--	--	--
19-D	AT	--	--	11/17/09	-0.451 (U)	--	--	--	--
AT-K-2-M	AT	--	--	11/1/09	188	--	--	--	--

a. Well and aquifer tube use: E = extraction, M = monitoring, P = performance. Column includes applicable pump-and-treat system where appropriate.

b. Well 199-K-32B is screened within the Ringold upper mud unit and well 199-K-32A is screened within Ringold unit E.

c. Blank cells (marked as "--") indicate that the sample was not collected, the analysis was not performed, or a change in concentration could not be calculated.

d. Laboratory qualifiers: U = not detected in sample; value shown is the detection limit.

e. Change in carbon-14 concentration not calculated (NC) when both results include "U" (nondetect) qualifier. When one compared result includes "U" qualifier, and the second result is qualified, the change in concentration is shown as increase (inc.) or decrease (dec.).

f. Aquifer tube (AT) nomenclature regarding relative depth: D = deep, M = middle, S = shallow.

Table 5-12. Nitrate Concentrations at the 116-K-2 Wells and Aquifer Tubes, CY 2008 to CY 2010

Well or Aquifer Tube Name	Use[a]	Fall 2008		Fall 2009 Sample		Fall 2010 Sample		Change in Nitrate Concentration	
		Date Collected	Nitrate (mg/L)	Date Collected	Nitrate (mg/L)	Date Collected	Nitrate (mg/L)	2008 to 2010	2009 to 2010
199-K-18	C	10/23/08	66.0	10/22/09	73	12/08/10	60.6	9.5	16.9
199-K-19	P	10/23/08	38.6	10/18/09	30.4	12/3/10	26.7	30.8	12.1
199-K-20	C	10/27/08	15.2	10/28/09	15.0	--	--	--	--
199-K-21	P	10/23/08	17.7	10/18/09	10.7	12/3/10	14.8	16.4	-37.6
199-K-22	P	10/23/08	16.5	10/22/09	21.4	--	--	--	--
199-K-37	P	10/27/08	10.2	10/22/09	10.4	12/3/10	6.77	33.6	34.9
199-K-113A	E/C-KR4	--[b]	--	10/21/09	9.38	--	--	--	--
199-K-114A	E/C-KR4	--	--	10/21/09	9.20	--	--	--	--
199-K-115A	E/C-KR4	--	--	10/21/09	11.0	--	--	--	--
199-K-116A	E/C-KR4	--	--	10/21/09	15.9	--	--	--	--
199-K-117A	C	10/6/08	6.02	10/22/09	4.36	12/3/10	1.92	68.1	56.0
199-K-129	E/C-KR4	--	--	10/21/09	8.81	--	--	--	--
199-K-130	E/C-KX	--	--	10/20/09	11.9	11/22/10	11.9	--	0.1
199-K-131	E/C-KX	--	--	10/20/09	13.4	--	--	--	--
199-K-143	I-KR4	--	--	--	--	--	--	--	--
199-K-144	E/C-KR4	--	--	--	--	--	--	--	--
199-K-145	E/C-KR4	--	--	--	--	--	--	--	--
199-K-146	E/C-KX	--	--	10/20/09	8.63	--	--	--	--
199-K-147	E/C-KX	--	--	10/20/09	10.5	11/22/10	11.4	--	-7.7
199-K-148	E/C-KX	--	--	10/20/09	14.6	11/22/10	13.8	--	5.5
199-K-149	E/C-KX	--	--	10/20/09	22.3	--	--	--	--
199-K-150	E/C-KX	--	--	10/20/09	16.2	--	--	--	--
199-K-151	P	--	--	10/22/09	9.60	9/20/10	6.6	--	31.3
199-K-152	P	--	--	10/22/09	8.45	9/21/10	7.61	--	10.0
199-K-153	M	--	--	--	--	11/22/10	10.4	--	--
199-K-154	E-KX	--	--	--	--	11/22/10	10.4	--	--
199-K-156	I-KX	--	--	--	--	--	--	--	--
199-K-157	P	--	--	10/29/09	41.9	12/7/10	22.3	--	46.8
199-K-159	I-KX	--	--	--	--	--	--	--	--
199-K-160	I-KX	--	--	--	--	--	--	--	--
199-K-161	E/C-KX	--	--	10/21/09	12.5	11/22/10	2.64	--	79.0
199-K-162	E/C-KR4	--	--	--	--	--	--	--	--
199-K-163	E/C-KX	--	--	--	--	11/22/10	14.3	--	--
199-K-164	I-KX	--	--	--	--	--	--	--	--
199-K-169	I-KX	--	--	--	--	--	--	--	--
199-K-170	I-KX	--	--	--	--	--	--	--	--
199-K-171	E-KX	--	--	--	--	11/22/10	14.2	--	--
199-K-179	I-KX	--	--	11/5/09	12.3	--	--	--	--
199-N-16	P	--	--	10/18/09	--	--	--	--	--
199-N-71	P	11/8/08	--	10/21/09	--	12/5/10	12.8	--	--
199-N-72	P	11/18/08	--	--	--	9/19/10	38.4	--	--

Table 5-12. (Cont.)

Well or Aquifer Tube Name	Use[a]	Fall 2008		Fall 2009 Sample		Fall 2010 Sample		Change in Nitrate Concentration	
		Date Collected	Nitrate (mg/L)	Date Collected	Nitrate (mg/L)	Date Collected	Nitrate (mg/L)	2008 to 2010	2009 to 2010
699-78-62	M	--	--	--	--	--	--	--	--
C6248	AT	9/30/08	--	--	--	--	--	--	--
C6250	AT	9/30/08	--	11/17/09	--	--	--	--	--
C6251	AT	11/6/08	--	--	--	--	--	--	--
C6253	AT	11/6/08	--	--	--	--	--	--	--
C6256	AT	11/5/08	--	11/21/09	--	--	--	--	--
C6259	AT	11/10/08	--	11/21/09	--	--	--	--	--
C6260	AT	11/10/08	--	--	--	--	--	--	--
18-S	AT	10/28/98	--	11/18/09	--	--	--	--	--
19-D/M[c,d]	AT	10/30/00	--	11/17/09	--	--	--	--	--
AT-K-3-D/M[c,d]	AT	--	--	11/1/09	--	--	--	--	--

a. Well use: C = compliance, M = monitoring. Column includes applicable pump-and-treat system where appropriate.

b. Blank cells (marked as "--") indicate that the sample was not collected, the analysis was not performed, or a change in concentration could not be calculated.

c. Aquifer tube (AT) nomenclature indicates relative depth: D = deep, M = middle, S = shallow.

d. Change in nitrate concentration at some aquifer tube clusters may include sample results from both the middle and deep tube in cluster because all tubes not sampled each year.

Table 5-13. Nitrate Concentrations at the KW Reactor Wells and Aquifer Tubes, CY 2008 to CY 2010

Well Name	Well Use[a]	Fall 2008		Fall 2009 Sample		Fall 2010 Sample		% Change in Nitrate Conc. (Negative = Increase)	
		Date Collected	Nitrate (mg/L)	Date Collected	Nitrate (mg/L)	Date Collected	Nitrate (mg/L)	2008 to 2010	2009 to 2010
199-K-34	M	10/27/08	53.1	10/22/09	53.1	12/7/10	32.6	38.6	38.6
199-K-35	M	--[b]	--	12/22/09	31.9	--	--	--	--
199-K-106A	M	10/6/08	89.9	10/22/09	96.1	9/13/10	73.9	17.8	23.1
199-K-107A	M	10/6/08	22.2	10/18/09	22.0	12/3/10	23.2	-4.5	-5.0
199-K-108A	M	10/6/08	69.1	10/22/09	61.5	--	--	--	--
199-K-31	M	10/27/08	24.0	10/22/09	24.1	12/8/10	24.6	-2.5	-2.0
199-K-132	E	10/28/08	28.3	10/20/09	31.7	11/22/10	34.3	-21.2	-8.2
199-K-137	M	10/28/08	16.5	10/20/09	26.4	--	--	--	--
199-K-138	E	10/28/08	21.3	10/20/09	--	11/22/10	22.1	-3.4	--
199-K-139	E	10/30/08	--	11/10/09	24.8	--	--	--	--
199-K-140	E	10/28/08	--	10/20/09	21.2	--	--	--	--
199-K-158	M	--	--	--	--	--	--	--	--
199-K-165	E	9/11/08	17.4	10/20/09	17.2	--	--	--	--
199-K-166	E	9/25/08	193	10/20/09	20.0	11/22/10	22.4	88.4	-11.9
199-K-168	E	--	--	10/20/09	18.9	--	--	--	--
199-K-173	P	9/27/08	17.4	10/21/09	19.1	--	--	--	--
199-K-174	I	--	--	--	--	--	--	--	--
199-K-175	I	--	--	--	--	--	--	--	--
AT-K-1-D[c]	AT	--	--	11/1/09	--	--	--	--	--

a. Well use: E = extraction, M = monitoring. Column includes applicable pump-and-treat system where appropriate.

b. Blank cells (marked as "--") indicate that the sample was not collected, the analysis was not performed, or a change in concentration could not be calculated.

c. Aquifer tube (AT) nomenclature regarding relative depth: D = deep, M = middle, S = shallow.

Table 5-14. Nitrate Concentrations at the KE Reactor Wells and Aquifer Tubes, CY 2008 to CY 2010

Well Name	Well Use[a]	Fall 2008		Fall 2009 Sample		Fall 2010 Sample		% Change in Nitrate Conc. (Negative = Increase)	
		Date Collected	Nitrate (mg/L)	Date Collected	Nitrate (mg/L)	Date Collected	Nitrate (mg/L)	2008 to 2010	2009 to 2010
199-K-32A	P	10/27/08	20.9	10/22/09	20.7	12/3/10	19.0	9.1	8.3
199-K-32B[b]	M	10/27/08	10.4	10/18/09	10.3	--[c]	--	--	--
199-K-30	M	10/27/08	79.7	10/18/09	31.1	12/2/10	25.1	68.5	19.2
199-K-29	M	--	--	--	--	12/2/10	46.5	--	--
199-K-23	M	10/27/08	63.7	--	--	--	--	--	--
199-K-11	M	10/6/08	69.1	10/28/09	49.1	12/3/10	39.7	42.5	19.1
199-K-110A	M	10/6/08	9.96	10/18/09	13.2	12/8/10	10.8	-8.4	18.2
199-K-111A	P	10/6/08	42.9	10/21/09	43.4	12/7/10	37.1	13.5	14.5
199-K-36	M	10/27/08	22.1	10/22/09	23.5	12/3/10	28.1	-27.1	-19.6
199-K-141	E-KR4	10/28/08	30.0	--	--	--	--	--	--
199-K-142	P	10/28/08	31.1	10/22/09	22.5	12/8/10	1.42	54.6	37.0
199-K-178	E-KR4	--	--	10/8/09	17	11/17/10	13.9		18.2
199-K-181	P	--	--	10/8/09	17.6	--	--	--	--
C6241	AT	--	--	--	--	--	--	--	--
C6244	AT	--	--	--	--	--	--	--	--
C6247	AT	--	--	--	--	--	--	--	--
18-S[d]	AT	--	--	--	--	--	--	--	--
19-D	AT	--	--	--	--	--	--	--	--
AT-K-2-M	AT	--	--	--	--	--	--	--	--

a. Well and aquifer tube use: M = monitoring. Column includes applicable pump-and-treat system where appropriate.

b. Well 199-K-32B is screened within the Ringold upper mud unit and well 199-K-32A is screened within Ringold unit E.

c. Blank cells (marked as "--") indicate that the sample was not collected, the analysis was not performed, or a change in concentration could not be calculated.

d. Aquifer tube (AT) nomenclature regarding relative depth: D = deep, M = middle, S = shallow.

Table 5-15. KR4 Pump-and-Treat System Operation Parameters, CY 2010

Total processed groundwater	**CY 2009**	**CY 2010**
Total amount of groundwater treated since October 1997 startup (million L)	5.31	5.65
Total amount of groundwater treated (million L)	317.5	336.9
Mass of hexavalent chromium removed		
Total amount of hexavalent chromium removed since October 1997 startup (kg)	347.5	354.7
Total amount of hexavalent chromium removed (kg)	14.98	7.21
Summary of operational parameters		
Removal efficiency (% by mass)	86.9%	90.6%
Regenerated resin installed (m^3)	29.4	45
New resin installed (m^3)	0	0
Number of resin vessel changeouts	--	20
Summary of system availability[a,b]		
Total possible run-time (hours)	8,760	8,760
Scheduled downtime (hours)	53.6	2,170.4
Planned operations (hours)	8,706.4	6,589.6
Unscheduled downtime (hours)	1,089.8	22.1
Total time online (hours)	7,616.6	6,567.5
Total availability (%)	86.9%	74.0%
Scheduled system availability (%)	99.4%	75.2%[c]

a. Scheduled system availability [(total possible run-time – scheduled downtime) ÷ total possible run-time].

b. Total availability [(total possible run-time – scheduled and unscheduled downtime) ÷ total possible run-time)].

c. The relatively low system availability in CY 2010 is due to system shutdown for upgrades and maintenance during the last 3 months of the year.

Table 5-16. KX Pump-and-Treat System Operational Parameters, CY 2009 and CY 2010

Total processed groundwater	**CY 2009**	**CY 2010**
Total amount of groundwater treated since the February 2009 startup (million L)	656	1,561
Total amount of groundwater treated (million L)	590	904
Mass of hexavalent chromium removed		
Total amount of hexavalent chromium removed since November 2008 startup (kg)	44	84
Total amount of hexavalent chromium removed (kg)	38	40
Summary of operational parameters		
Removal efficiency (% by mass)	96.3	94.0
Regenerated resin installed (m^3)	61.2	147
New resin installed (m^3)	97.4	52
Number of resin vessel changeouts	--	65
Summary of system availability[a,b]		
Total possible run-time (hours)	7,968.0	8,616
Scheduled downtime (hours)	152.2	68.6
Planned operations (hours)	7,816	8,547
Unscheduled downtime (hours)	288	215
Total time online (hours)	7,523	8,333
Total availability (%)	98.1%	96.7
Scheduled system availability (%)	94.5	99.2

a. Scheduled system availability [(total possible run-time – scheduled downtime) ÷ total possible run-time].

b. Total availability [(total possible run-time – scheduled and unscheduled downtime) ÷ total possible run-time)].

Table 5-17. KW Pump-and-Treat System Operation Parameters, CY 2009 and CY 2010

Total processed groundwater	**CY 2009**	**CY 2010**
Total amount of groundwater treated since January 2007 startup (million L)	667	1,054
Total amount of groundwater treated (million L)	298	387
Mass of hexavalent chromium removed		
Total amount of hexavalent chromium removed since January 2007 startup (kg)	83.28	137.42
Total amount of hexavalent chromium removed (kg)	49.25	54.14
Summary of operational parameters		
Removal efficiency (% by mass)	95.8%	96.9%
Regenerated resin installed (m^3)	24.9	93
New resin installed (m^3)	24.9	27
Number of resin vessel changeouts	--	41
Summary of system availability[a,b]		
Total possible run-time (hours)	8,760	8,760
Scheduled downtime (hours)	268.8	29.3
Planned operations (hours)	8,491.2	8,730.7
Unscheduled downtime (hours)	118.0	6.2
Total time online (hours)	8,372.2	8,724.5
Total availability (%)	95.6%	99.6%
Scheduled system availability (%)	98.6%	99.7%

a. Scheduled system availability [(total possible run-time – scheduled downtime) ÷ total possible run-time].

b. Total availability [(total possible run-time – scheduled and unscheduled downtime) ÷ total possible run-time)].

Figure 5-1. 100-K Area Location Map

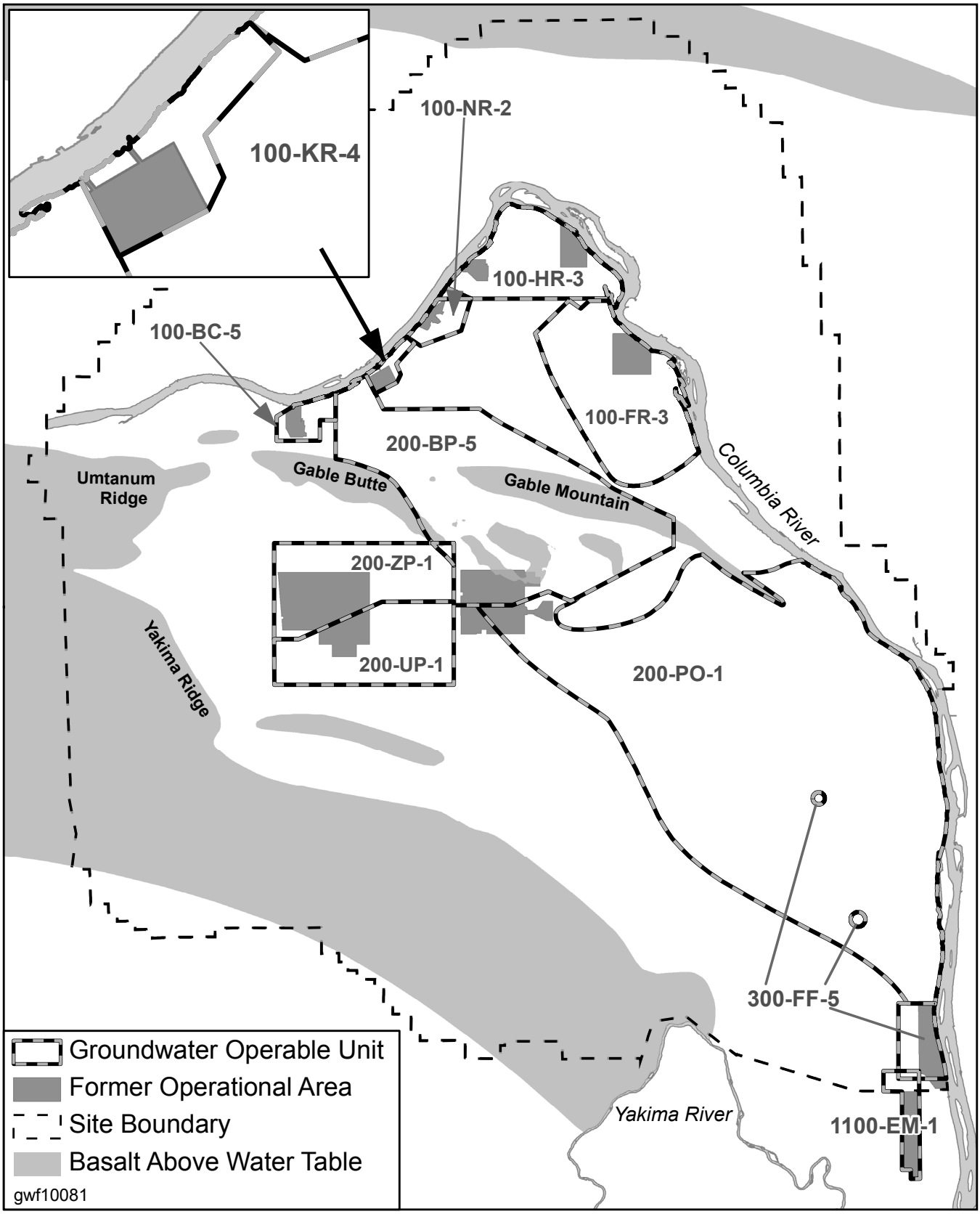

Figure 5-2. Overview of 100-KR-4 Operable Unit Wells and Facilities

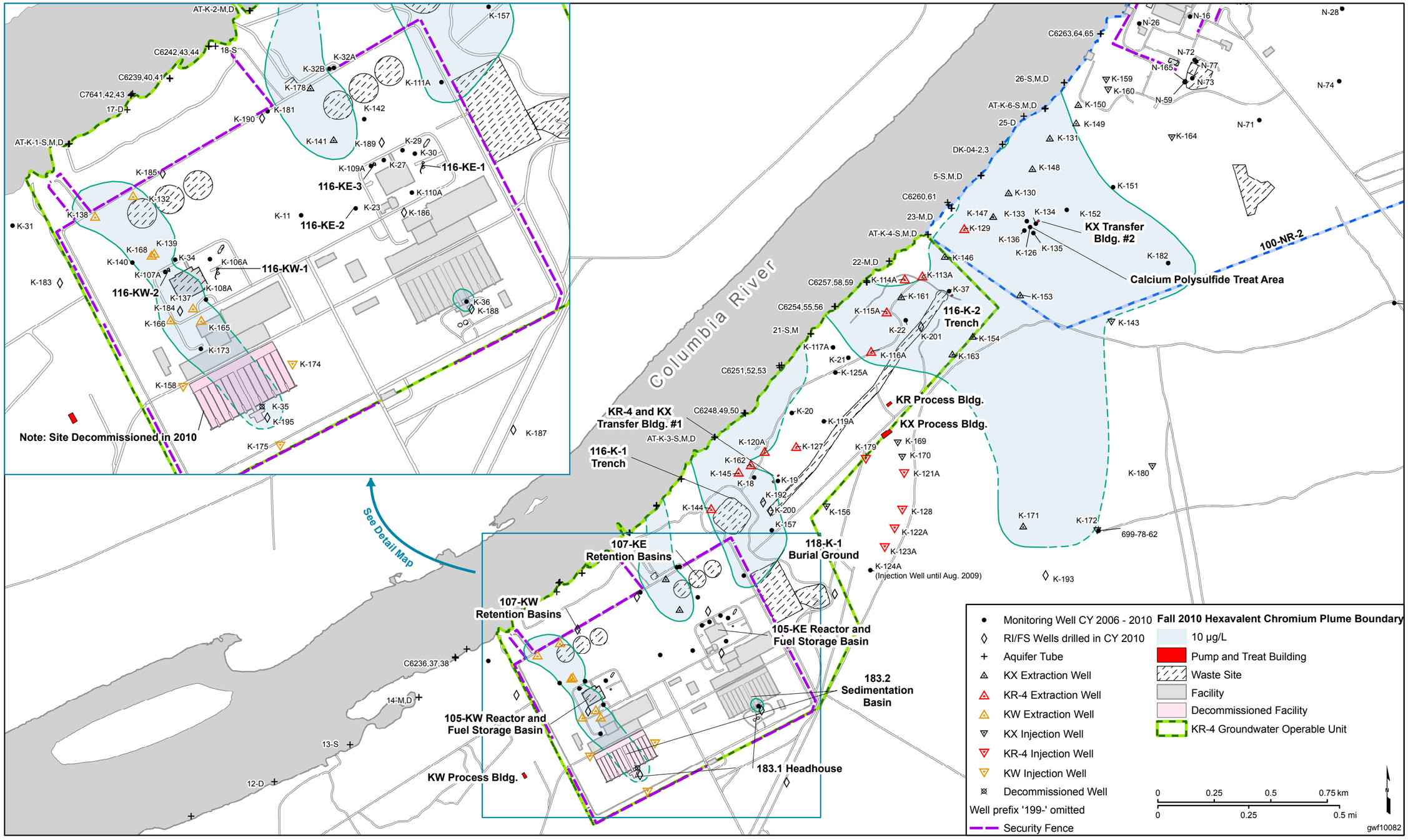

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Figure 5-3. Water-Level Contours at the 100-KR-4 Operable Unit

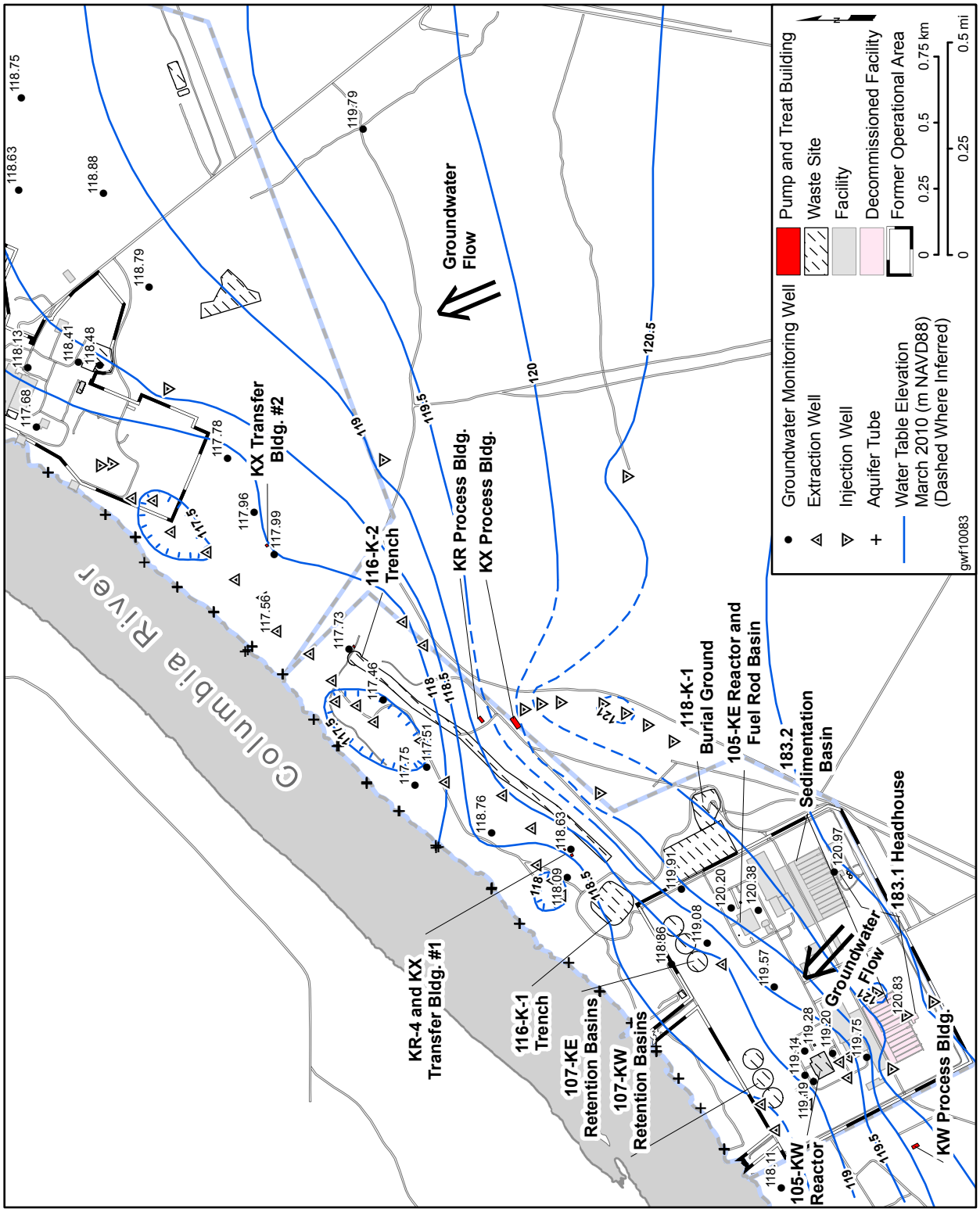

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Figure 5-4. Spring and Fall 2010 Hexavalent Chromium Plume Map

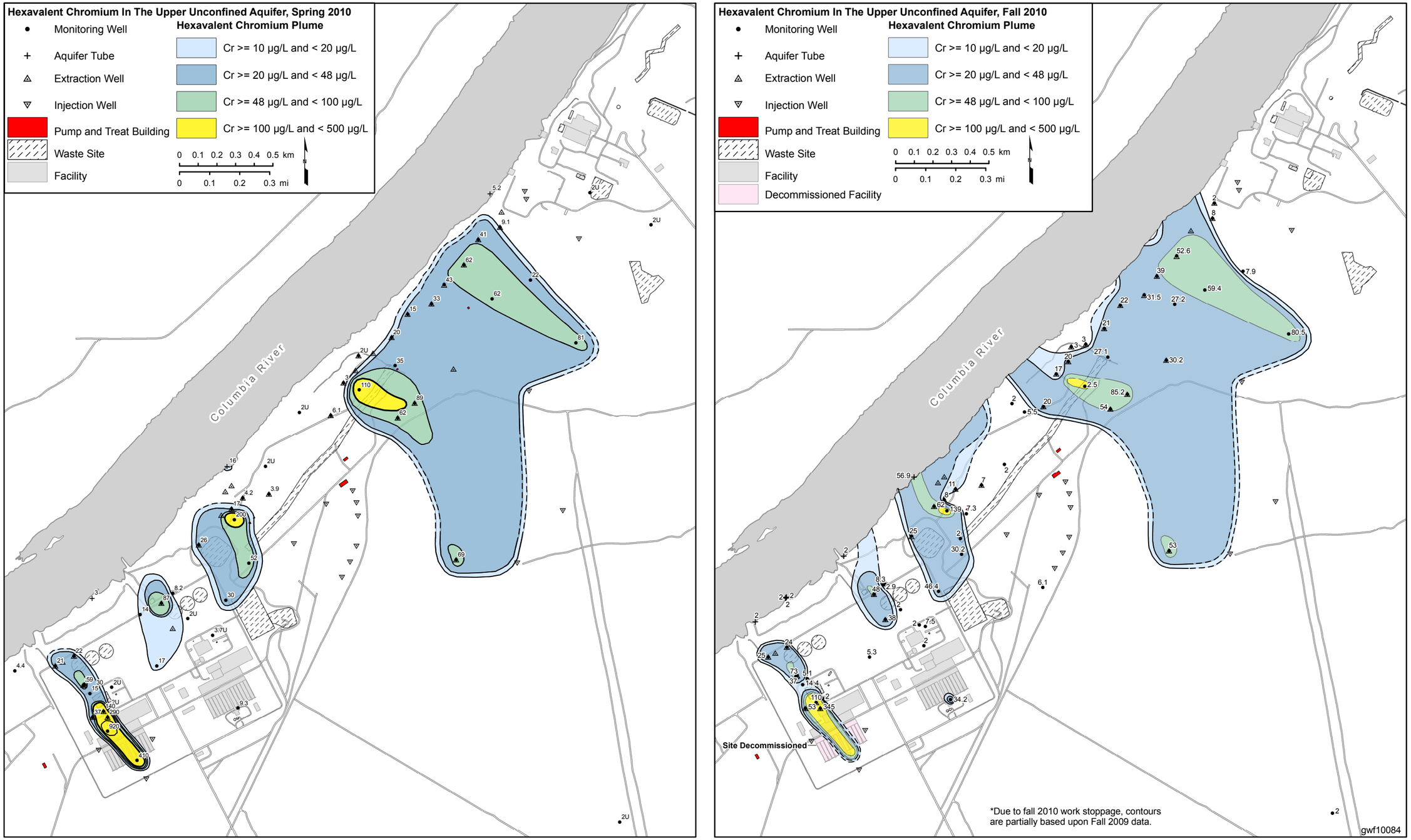

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Figure 5-5. Spring and Fall 2010 Tritium Plume Map

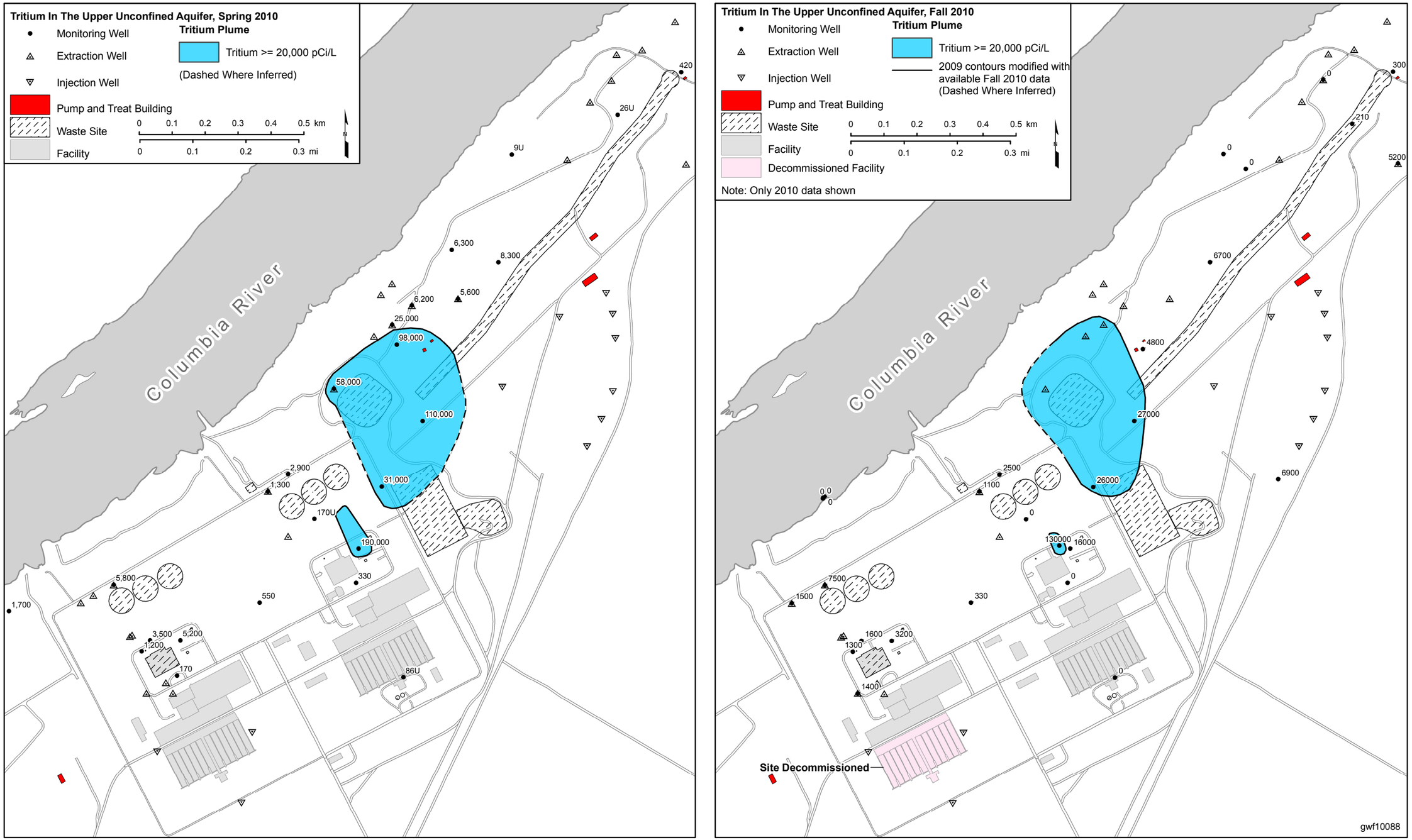

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Figure 5-6. Spring and Fall 2010 Strontium-90 Plume Map

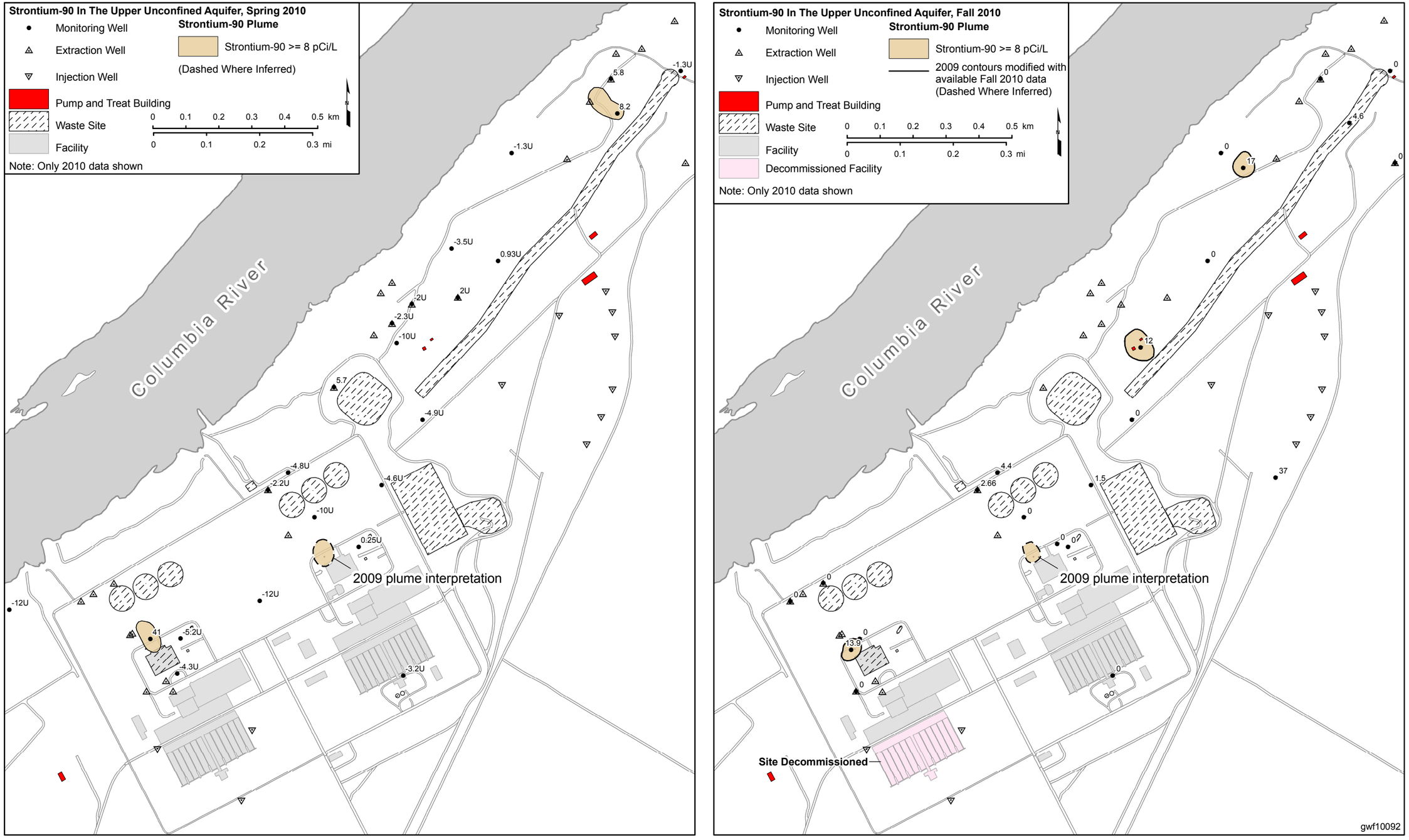

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Figure 5-7. Spring and Fall 2010 Carbon-14 Plume Map

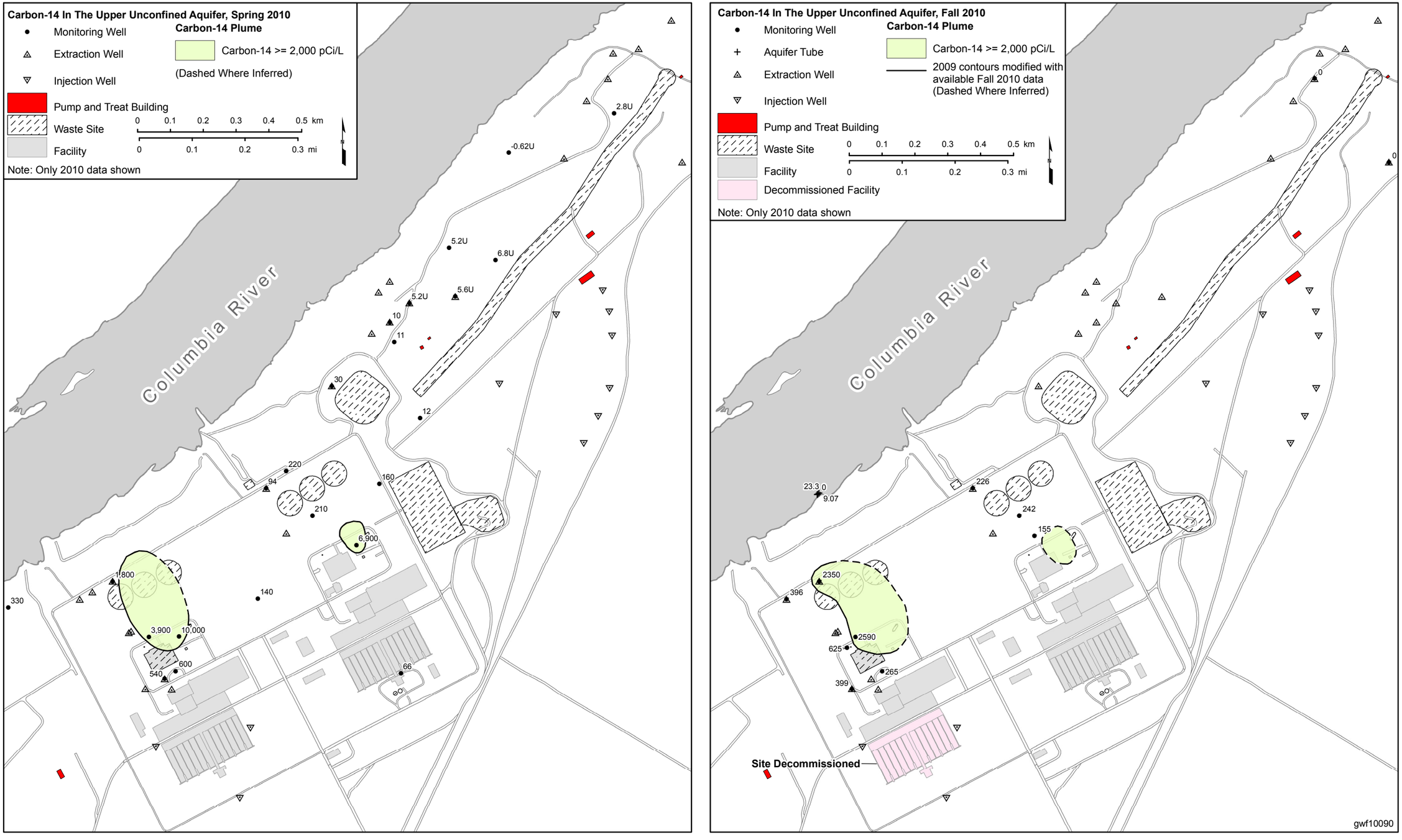

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Figure 5-8. Spring and Fall 2010 Nitrate Plume Map

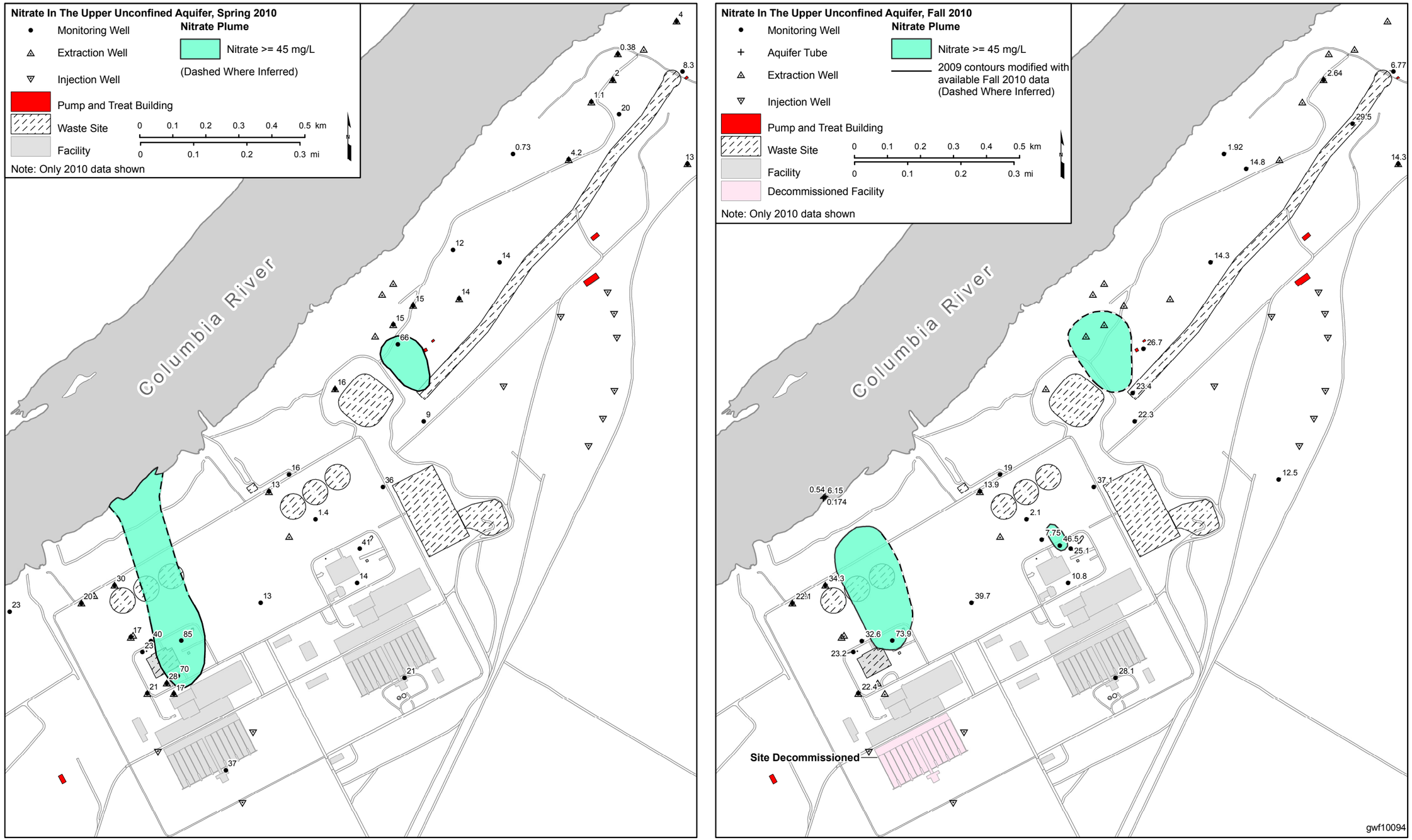

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Figure 5-9. Spring and Fall 2010 Trichloroethene Plume Map

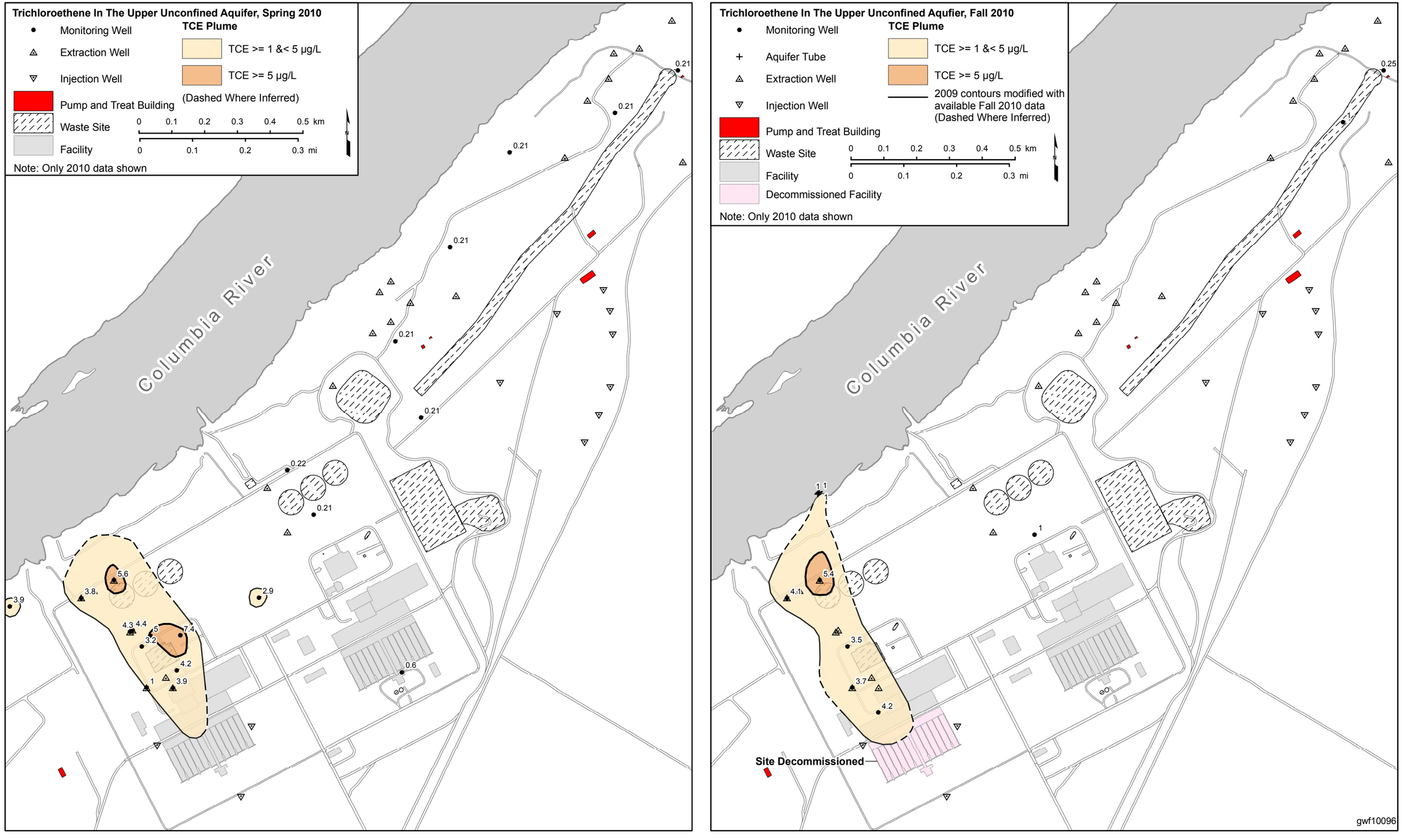

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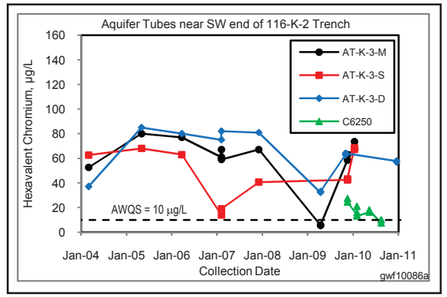
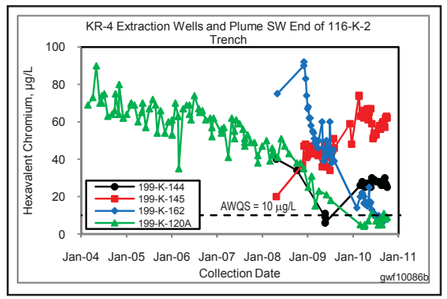
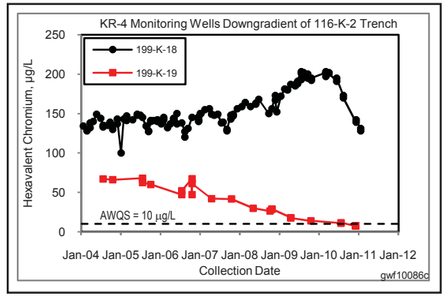
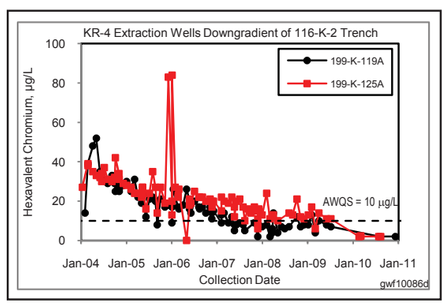
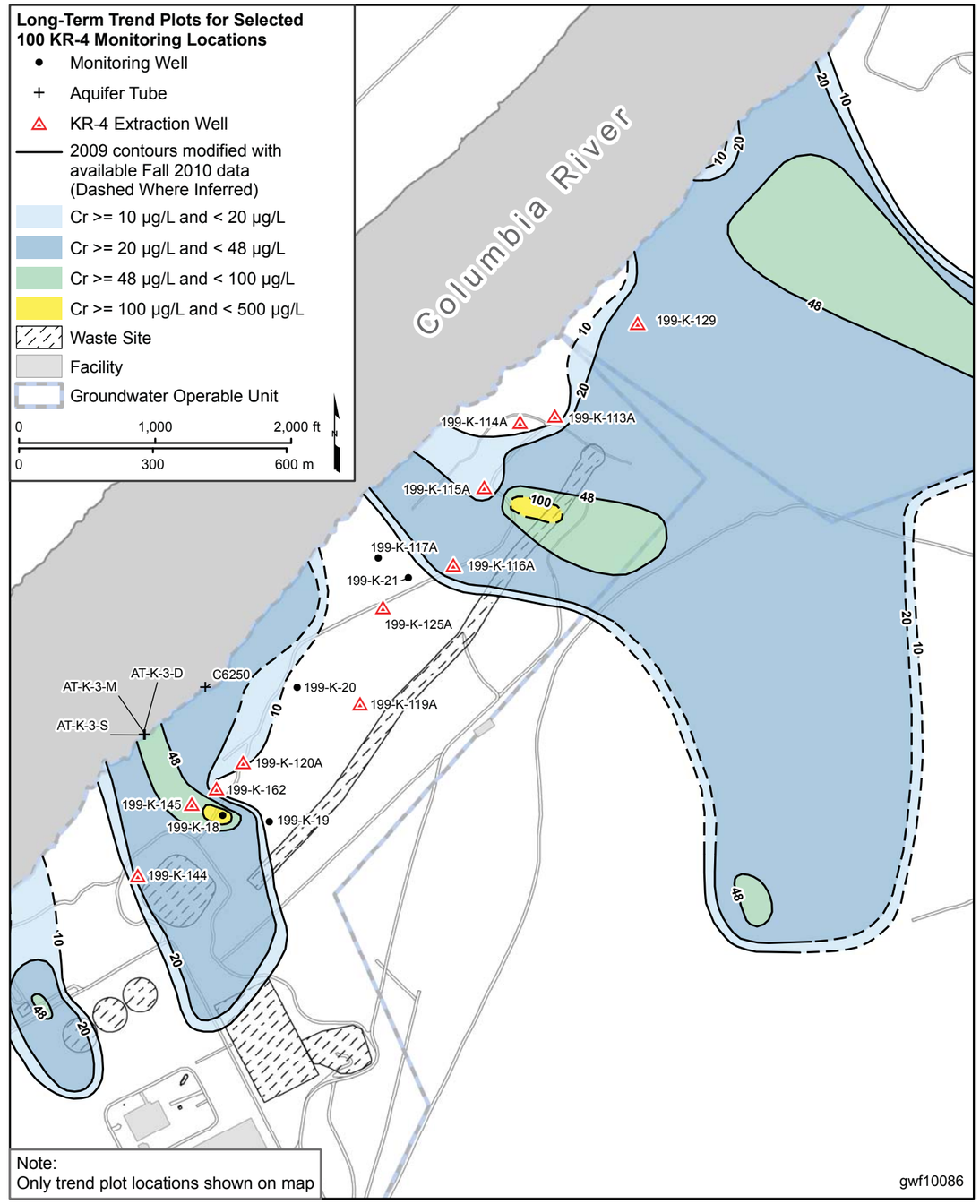
Figure 5-10. Fall 2010 Hexavalent Chromium Plume Map for KR4 Pump-and-Treat System

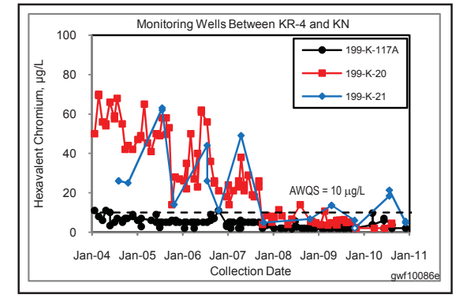


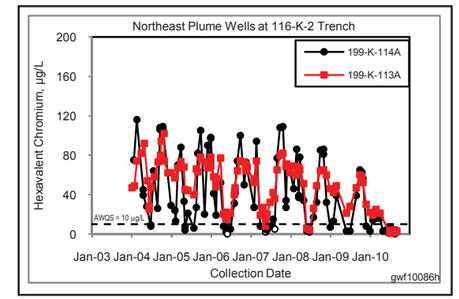












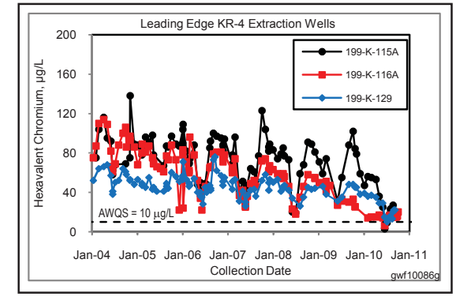


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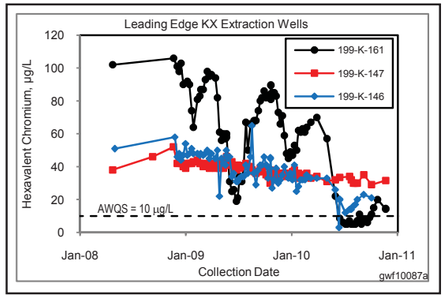
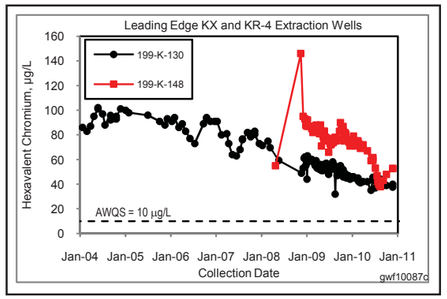
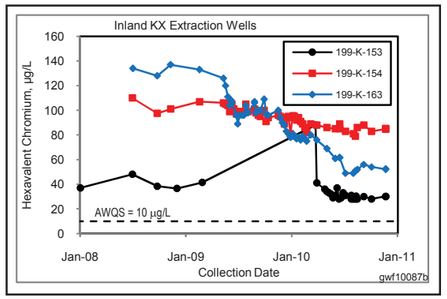
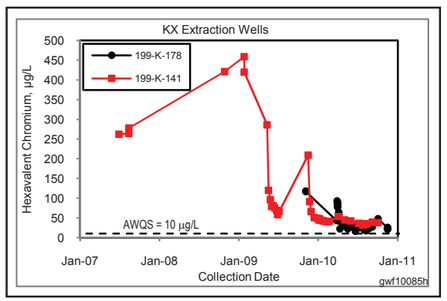
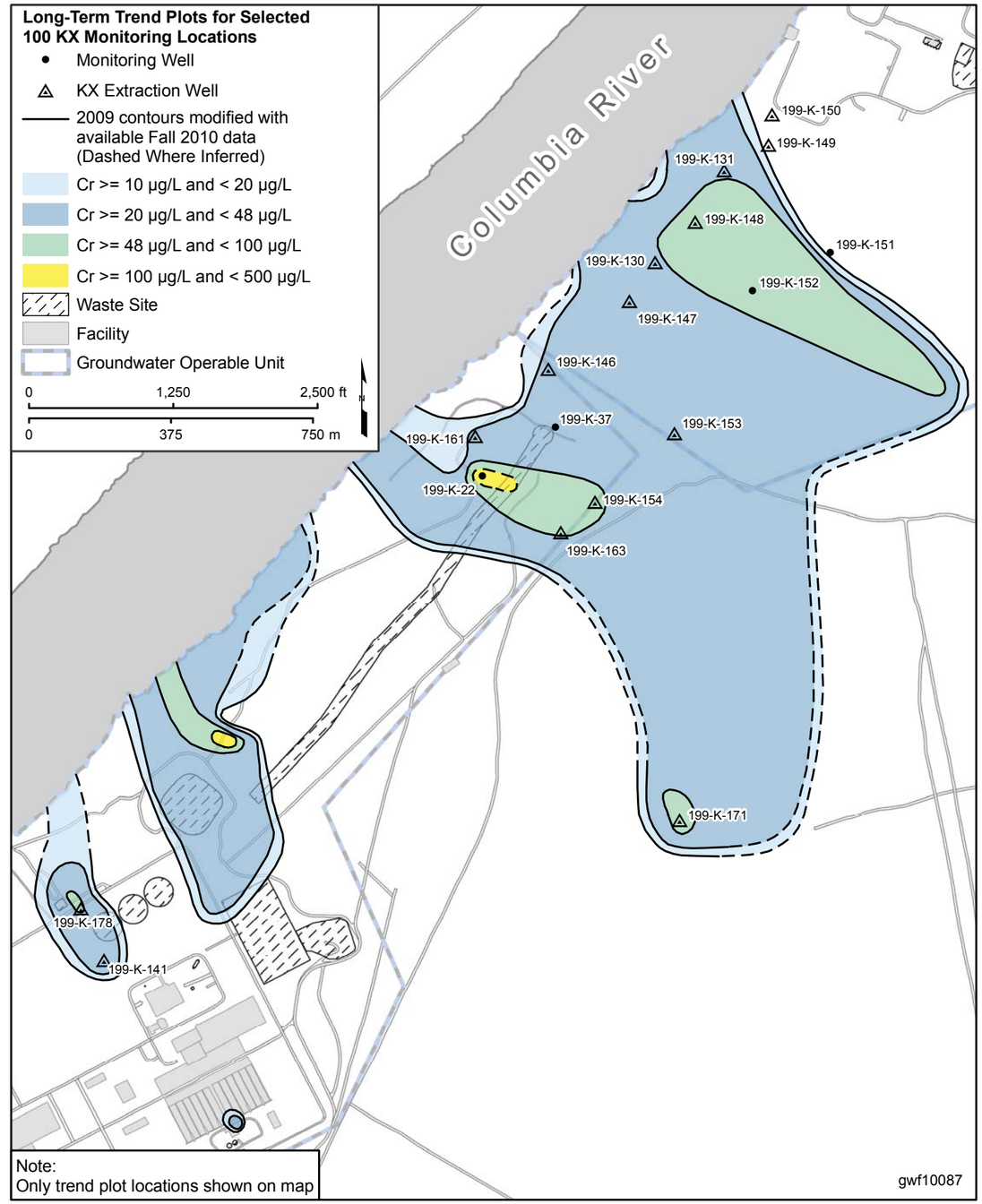
Figure 5-11. Fall 2010 Hexavalent Chromium Plume Map for KX Pump-and-Treat System

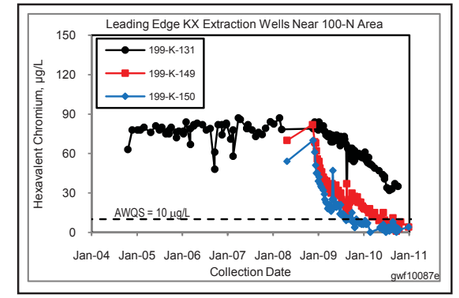


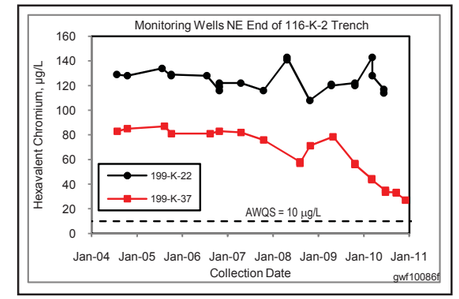












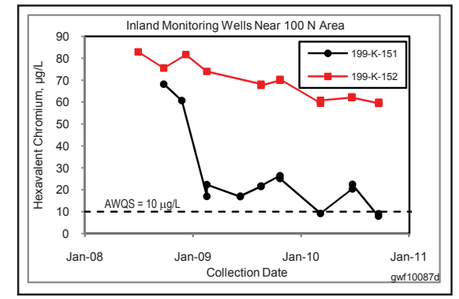


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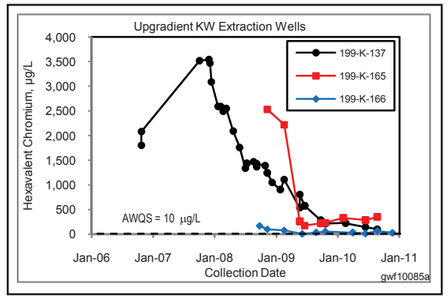
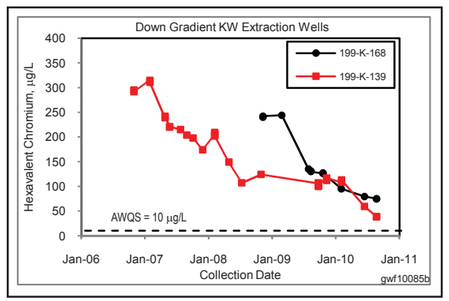
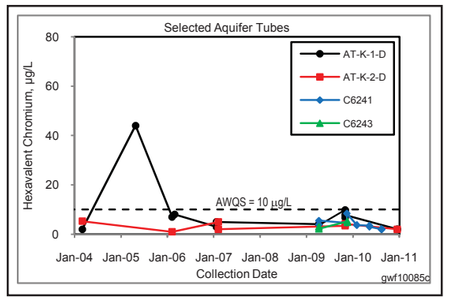
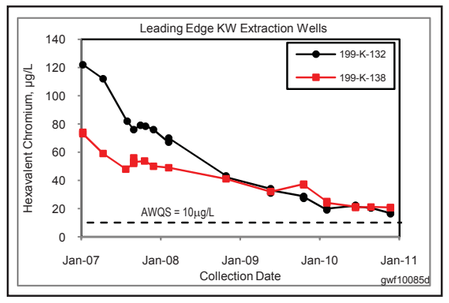
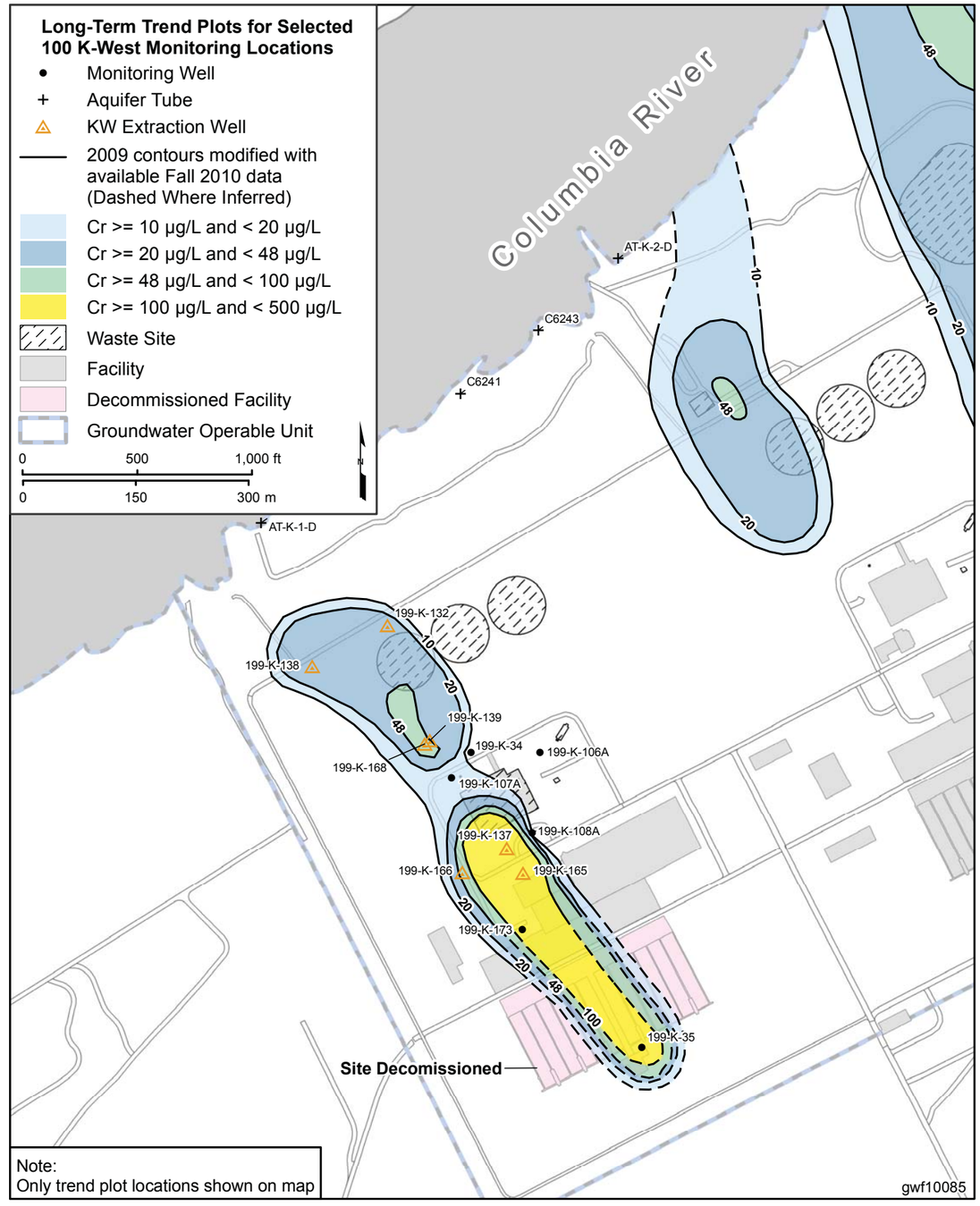
Figure 5-12. Fall 2010 Hexavalent Chromium Plume Map for KW Pump-and-Treat System

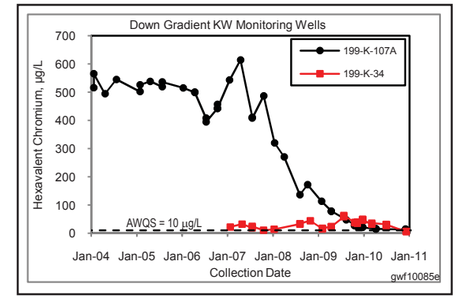


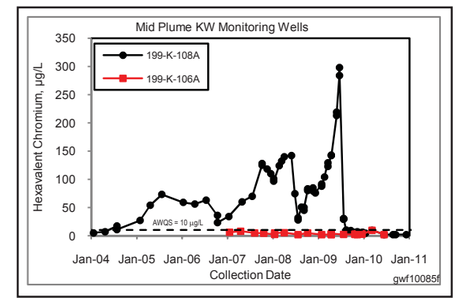












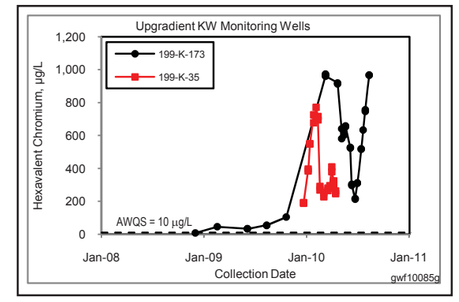


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Figure 5-13. Composite Capture Zone Efficiency/Effectiveness Maps for 100-KR-4 Operable Unit Pump-and-Treat Systems

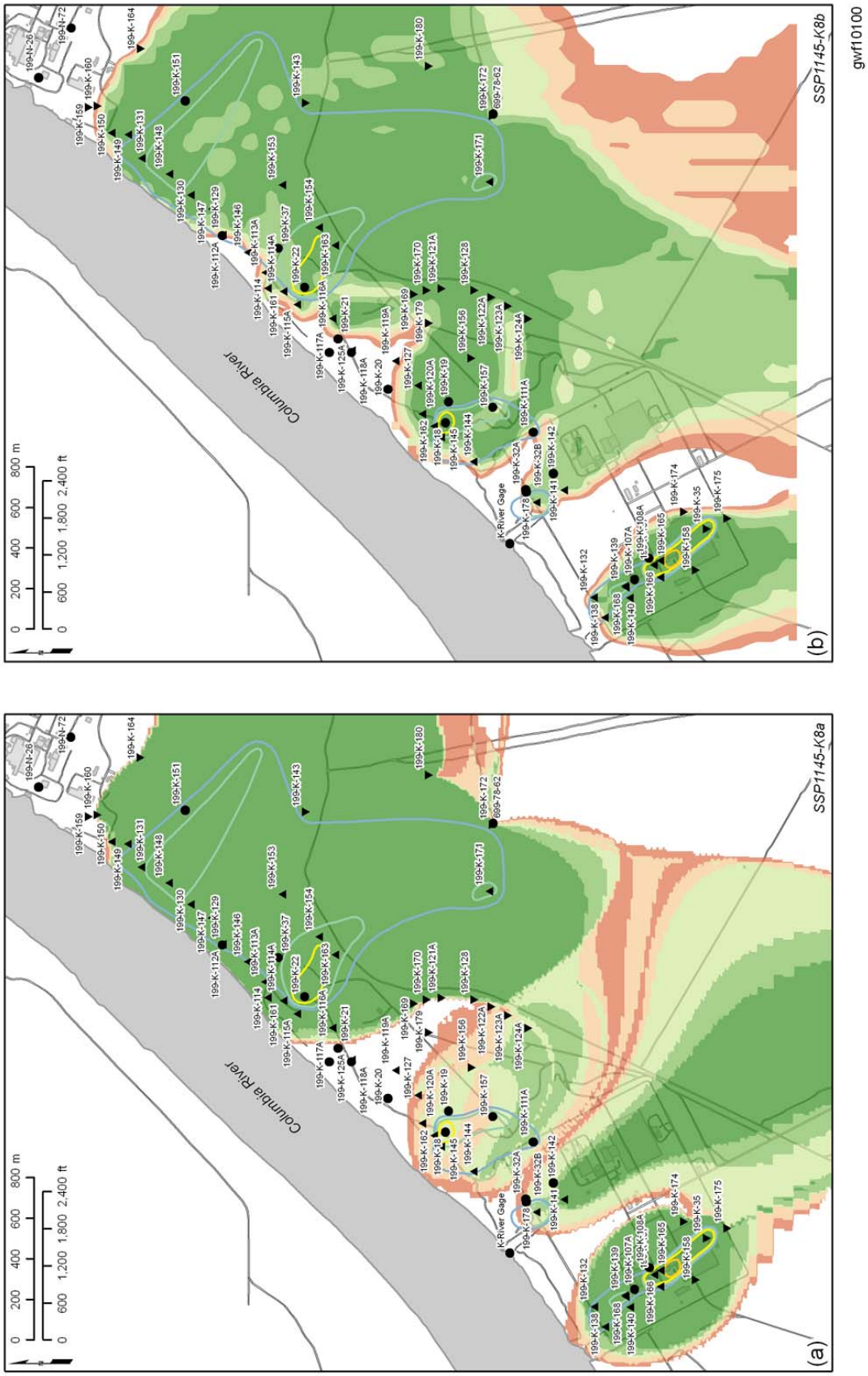
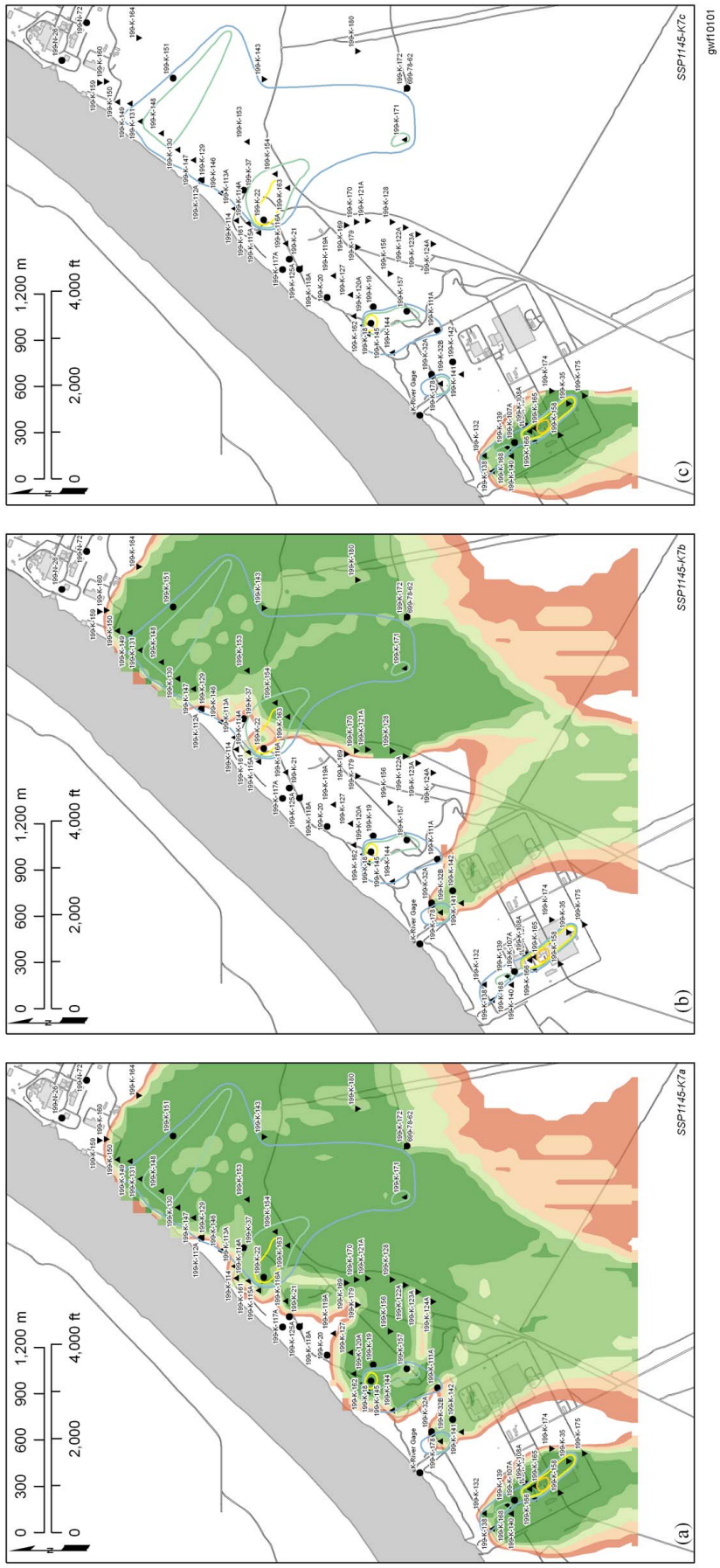
Figure 5-14. Individual Capture Zone Efficiency/Effectiveness Maps for the 100-KR-4 Operable Unit Pump-and-Treat Systems