2.3 100-KR-4 Operable Unit

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The 100-KR-4 Operable Unit includes groundwater affected by contaminant releases from facilities and waste sites within the 100-K Area. Most of the facilities and waste sites are associated with former operation of the KE and KW Reactors and their support facilities. The operable unit lies within a larger 100-KR-4 groundwater interest area, informally defined to facilitate scheduling, data review, and interpretation (see Figure 1.0-1 in Section 1.0). Figure 2.3-1 shows monitoring wells, shoreline monitoring sites, waste sites, and facilities.

Chromium is the primary contaminant of concern in 100-K Area groundwater. Two pump-and-treat systems are cleaning up the aquifer.

Groundwater monitoring in the 100-K Area is conducted under two regulatory drivers: the *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA) governs the 100-KR-4 Operable Unit, while the *Atomic Energy Act* provides the basis for monitoring the fuel storage basins at each reactor building (i.e., K Basins). CERCLA requirements are further subdivided into monitoring conducted to (a) characterize and track all contaminants of concern or potential concern in the operable unit, and (b) evaluate the performance of the pump-and-treat systems that remove hexavalent chromium from groundwater.

Groundwater beneath the 100-K Area flows generally toward the northwest (Figure 2.3-2). Groundwater flow in 100-K Area is affected by two pump-and-treatment systems. The larger system has nine extraction wells between the 116-K-2 trench and the Columbia River and four injection wells upgradient of the trench. A water-table mound has formed causing a radial flow pattern to develop around the injection sites (Figure 2.3-2). The mound illustrated in Figure 2.3-2 was estimated using an analytical method that considered injection rates, transmissivity, and specific yield, as documented in PNNL-14031. Downgradient of the KW Reactor building, four wells extract groundwater, which is treated and injected into two wells south (upgradient) of the reactor building.

Groundwater monitoring in the 100-KR-4 groundwater interest area includes the following activities:

CERCLA Long-Term Monitoring (Appendix A)

- ***Twenty-nine wells are sampled monthly to biennially; one quarterly sample was missed.***
- ***Three riverbank springs and sixteen aquifer tubes sites are sampled annually along the 100-K Area river shore.***

CERCLA Interim Action Monitoring (Appendix A)

- ***Sixteen wells are sampled monthly to semiannually; six wells were not sampled as frequently as planned in FY 2007.***

Facility Monitoring (Appendix B)

- ***Fourteen wells are sampled quarterly to semiannually to detect potential shielding water loss to the ground from the KW and KE Basins.***
- ***Four wells are sampled monthly during basin cleanout.***

Near the Columbia River, the groundwater system is influenced by fluctuations in river stage, which is controlled primarily by releases from Priest Rapids Dam. The pattern of movement and the rate at which groundwater discharges to the river are affected by these fluctuations. Because river water infiltrates the banks during periods of high river stage, contaminants carried by groundwater may become diluted prior to their eventual release to the river through riverbed sediment and via riverbank springs.

Groundwater flows to the northwest, toward the Columbia River.

The river stage also affects the elevation of the water table beneath the 100-K Area. During periods of prolonged high river conditions, the elevated water table may contact and mobilize contaminants held in the normally unsaturated lower vadose zone. A good example of this phenomenon occurred during the seasonal high river conditions in 1996 and 1997, when higher than typical contaminant concentrations were observed at some locations associated with former liquid waste disposal sites.

2.3.1 Groundwater Contaminants

Chromium has been identified as a contaminant of concern that warrants interim remedial action in the 100-KR-4 Operable Unit (ROD 1996a). Where groundwater containing chromium discharges into the river environment, there exists a potential risk of harm to aquatic life. Other contaminants of interest in the operable unit include carbon-14, nitrate, strontium-90, technetium-99, trichloroethene, and tritium. These constituents are of interest primarily because their concentrations exceed drinking water standards. They are being monitored while waste sites are being remediated and while facilities are being decontaminated and decommissioned.

The following descriptions of contaminants in 100-K Area groundwater refer to conditions at wells that monitor the uppermost part of the unconfined aquifer. The 100-K Area contains only one well (199-K-32B) that is completed to monitor conditions below the upper aquifer; groundwater at that deep well is essentially free of contamination from past operations.

2.3.1.1 Chromium

Sodium dichromate was used in large quantities as a corrosion inhibitor at the KE and KW Reactors during their years of operation (1955 through 1971). The hexavalent form of chromium is soluble in water and is toxic to aquatic organisms and humans. The Washington State aquatic standard for hexavalent chromium is 10 µg/L, and the drinking water standard for total chromium is 100 µg/L. Chromium is a contaminant of concern for the 100-KR-4 interim action (ROD 1996a) with a cleanup goal of 22 µg/L.

Plume areas (square kilometers) at the 100-KR-4 Operable Unit:
- ***Carbon-14, 2,000 pCi/L — 0.09***
- ***Chromium, 100 µg/L — 0.07***
- ***Chromium, 20 µg/L — 2.6***
- ***Nitrate, 45 mg/L — 0.11***
- ***Strontium-90, 8 pCi/L — 0.08***
- ***Tritium, 20,000 pCi/L — 0.17***

Figure 2.3-3 illustrates the extent of chromium contamination beneath the 100-K Area in FY 2007. The largest chromium plume is associated with the 116-K-2 trench. A smaller plume lies downgradient of the KW Reactor building. In the KE area, one plume appears to originate near the KE water treatment plant, and a new well downgradient of the KE Reactor building also has elevated chromium.

Chromium Beneath the 116-K-2 Trench. The plume that originated at the 116-K-2 trench is largest in areal extent, but has relatively low concentrations (generally <100 µg/L). This trench received large volumes of reactor coolant from

1955 to 1971. The interpretation shown in Figure 2.3-3 assumes that chromium detected in wells 199-K-143 and 699-78-62, which are east of the trench, was pushed inland by radial flow around the large groundwater mound that was present during the operating years (HW-77170). Total chromium was detected above 100 µg/L in well 699-78-62 in 1988 and levels remained >20 µg/L in FY 2007. The trench plume is the target of interim remedial action (see Section 2.3.2).

Figure 2.3-4 is a cross section that illustrates the distribution of chromium with depth in the aquifer near the Columbia River. The concentrations shown are for samples collected during January and February 2007 from aquifer tubes. The variability in observed concentrations is the result of several factors, including vertical distribution of contamination in the groundwater plume, dilution of contaminants by river water at some tubes, and aquifer heterogeneity.

Concentrations at wells that monitor the trench plume are typically less than the drinking water standard and appear to be stable or decreasing, with exceptions at several locations. The overall decrease in the level of contamination is a combined consequence of the pump-and-treat operation and dispersion. Figures 2.3-5, 2.3-6, and 2.3-7 illustrate concentration trends for southwest, central, and northeast groups of wells, respectively.

At the southwest edge of the plume, well 199-K-18 presents an exception to the generally decreasing trends. Concentrations at well 199-K-18 have been increasing, with a maximum value of 156 µg/L in March 2007 (Figure 2.3-5). The start of the increasing trend at this location correlates with the start of the pump-and-treat system in October 1997, suggesting a relationship to the changes in groundwater flow patterns because of groundwater extraction and injection. Chromium concentrations are also relatively higher at nearby aquifer tube site AT-K-3 (80 µg/L in the deep tube in FY 2007).

Data from aquifer tubes suggest that chromium-contaminated groundwater is moving north from 100-K Area.

In the central portion of the plume, chromium levels have declined by an order of magnitude in extraction well 199-K-125A and compliance well 199-K-117A (Figure 2.3-6). Levels remain above the drinking water standard in well 199-K-22, near the trench, and fluctuate seasonally in extraction well 199-K-114A, near the river. Aquifer tubes monitoring the central portion of the trench show decreasing chromium trends (Figure 2.3-8). The decline may be due to the effects of the pump-and-treat system (Section 2.3.2.2).

At the northeast end of the trench, chromium trends are mixed (Figure 2.3-7). Concentrations are gradually decreasing in some wells (e.g., 199-K-129 and 199-K-130). Well 199-K-37 has a relatively stable trend for the past several years. Concentrations at well 199-K-131, which is located ~300 meters northeast of well 199-K-130, were up to 87 µg/L in FY 2007. Results from aquifer tubes for this part of the shoreline confirm the presence of the plume at this location (Figure 2.3-9). The tube site farthest north, AT-26, has had increasing chromium concentrations since 2002 and the FY 2007 maximum was 51 µg/L. The increase may indicate northward migration of the plume.

Chromium Near KE Reactor. Near KE Reactor, a plume with concentrations below the drinking water standard extends from the southeast side of the water treatment plant basins to the southwest corner of the reactor building. The source is likely to be contaminated soil in the vicinity of a former sodium dichromate storage tank and railcar transfer station (WHC-SD-EN-TI-239). Chromium concentrations have varied, as seen at well 199-K-36 (Figure 2.3-10).

DOE recently installed two new wells (199-K-141 and 199-K-142) downgradient of KE Reactor. Well 199-K-141 shows chromium levels above the drinking water standard, ranging from 186 to 288 µg/L in FY 2007. Nearby well 199-K-142 has much lower levels, 8 to 20 µg/L. The contamination in well 199-K-141 does not appear to be connected to that in wells 199-K-36 and 199-K-23, because wells located between these locations have very low chromium levels.

Well 199-K-32A, located farther downgradient of KE Reactor, had low levels of chromium in FY 2007 (14 µg/L). Chromium usually is undetected at aquifer tube sites AT-18 and AT-K-2.

A new pump-and-treat system is operating on the chromium plume near KW Reactor. One well had unexpectedly high concentrations (>2,000 µg/L).

Chromium Near KW Reactor. A chromium plume originating near KW Reactor exceeds the drinking water standard in several wells (see Figure 2.3-3). Concentrations were measured at >2,000 µg/L in new well 199-K-137 (Figure 2.3-11). The suspected source for this contamination is sodium dichromate in the vadose zone at unidentified locations. Candidate locations include the storage tank and transfer station at the southeast side of the KW Water Treatment Plant (same as at KE), and also the underground piping associated with the system used to add sodium dichromate to coolant water. Chromium concentrations in well 199-K-107A are ~500 µg/L and steady (Figure 2.3-11). Concentrations in three of the four extraction wells in the KW plume also were above the drinking water standard when first sampled, but declined during FY 2007 (Figures 2.3-12 and 2.3-13).

Chromium concentrations in aquifer tubes downgradient of the KW plume are very low. Tube sites AT-17 and AT-K-1 had FY 2007 levels <10 µg/L.

2.3.1.2 Tritium

Tritium was common in liquid effluent discharged to the ground during 100-K Reactor operations. However, some of the tritium currently observed in groundwater was introduced after the shutdown of the reactors in 1971. Current sources and potential sources for providing tritium to groundwater include loss of shielding water from the KE and KW Basins, the soil columns beneath the former gas condensate cribs located to the east of each reactor building, and possibly irradiated materials contained in the 118-K-1 burial ground. Tritium has a radioactive decay half-life of 12.3 years. The drinking water standard is 20,000 pCi/L.

Figure 2.3-14 shows the distribution of tritium in groundwater beneath the 100-K Area. The highest tritium concentrations are associated with locations immediately downgradient of the 116-KE-1 and 116-KW-1 cribs. During operating years, the cribs received liquid effluent containing high concentrations of tritium and carbon-14. These waste sites were excavated and backfilled with clean material during FY 2004. Some contaminated soil remained at the bottom of the excavations.

Because high concentrations of tritium are present in the shielding water of each fuel storage basin, tritium in groundwater is closely monitored for evidence of shielding water loss to the ground (PNNL-14033). Also, evidence exists to suggest that tritium is being released from materials in the 100-K burial ground and may be impacting groundwater in the area north of the burial ground.

Tritium Near KE Reactor. The KE tritium plume was formed from past disposal to the former 116-KE-1 condensate crib; leaks to the ground from KE Basin (1976 to 1979, and again in 1993); and possibly mobilization of contamination from the vadose zone beneath the 116-KE-3 drain field and associated catch tank. The tritium distribution pattern reflects a coalescing of plumes from these sources. Figure

2.3-15 shows concentration trends for tritium and co-contaminant carbon-14 at well 199-K-30, located near the core of this plume.

The leading edge of the tritium plume created by the 1993 leak from the KE Basin is believed to have reached the Columbia River. It took ~3 years for the plume to pass well 199-K-27, which is located at the KE Basin, so several years would also be necessary for the entire plume to cross the shore line. The plume from the 1993 leak has mixed with the tritium plume from the former KE condensate crib, and it is difficult to differentiate each plume in the shoreline region. Tritium concentrations in each of these plumes near the river are lower than the drinking water standard.

Tritium concentration trends at wells immediately downgradient of the KE Reactor are shown in Figure 2.3-16. Wells 199-K-27 and 199-K-109A are the wells most likely to detect loss of basin water to the ground. The increases at those wells that started in early 2003 remain unexplained, although there was no evidence from facility operations suggesting a significant loss of shielding water. Since 2003, technetium-99, a second indicator of shielding water, ranged from undetected to 77 pCi/L in these wells. Tritium concentrations in these wells were below the drinking water standard in FY 2007.

The highest tritium concentrations beneath 100-K Area are downgradient of the former KE and KW condensate cribs.

The tritium trend at well 199-K-29 also showed an increase that started in January 2001 (Figure 2.3-16). Levels fluctuated around the drinking water standard in FY 2007. This well is located off to the side of the flow path directly beneath the KE Basin. The trend most likely reflects downgradient migration and lateral spread of the plume associated with the former 116-K-1 condensate crib, rather than water loss from the KE Basin.

Tritium Near KW Reactor. The plume near the KW Reactor is most likely associated with effluent disposed during the operating years to the former 116-KW-1 condensate crib. An unexplained increase in tritium concentrations at well 199-K-106A, located downgradient of the crib, began in 2001, peaked sharply in 2003 and early 2005, and declined to 30,000 pCi/L by August 2007 (Figure 2.3-17). Other constituents showing a similar trend include chloride, nitrate, and possibly technetium-99. Carbon-14, which was disposed to the crib but is less mobile than tritium, does not follow the tritium trend. The cause for the trends at well 199-K-106A is presumed to be mobilization of contaminants associated with the crib and underlying soil column, although a driving mechanism has not been positively identified.

There is no evidence in groundwater monitoring data to suggest water loss to the ground from the KW Basin in recent years. Wells 199-K-34 and 199-K-107A are most likely to detect shielding water. FY 2007 tritium concentrations ranged from 2,900 to 10,000 pCi/L in well 199-K-34 and <1,000 pCi/L in well 199-K-107A.

Tritium Downgradient of the 118-K-1 Burial Ground. Tritium concentrations at well 199-K-111A, located at the northwest corner of the burial ground, began rising abruptly in mid-2000 to a peak value of 98,200 pCi/L in April 2002. Since that time, concentrations declined to a level of ~10,000 pCi/L. No monitoring wells exist along the direct downgradient flow path to the river. However, the nearest well just to the side of that flow path is well 199-K-18, located ~450 meters to the north of well 199-K-111A. Assuming a plume migration rate of 0.12 meter/day, the “pulse” of tritium that passed by well 199-K-111A starting in 2001 might possibly be detected at well 199-K-18 in ~10 years, i.e., ~2011. Tritium levels in well 199-K-18 have been between 20,000 and 40,000 pCi/L for at least 10 years.

The source for tritium in groundwater near the burial ground was the subject of a multifaceted investigation during 2002 and 2003 (PNNL-14031). Results suggested the likelihood of a tritium source in the burial ground, along with an underlying groundwater plume.

Tritium Near the 116-K-2 Trench. Tritium concentrations downgradient of the trench typically are below the drinking water standard. The exception occurs at the southwest end of the trench, where average concentrations during FY 2007 were ~29,000 and ~33,000 pCi/L at wells 199-K-18 and 199-K-120A (a pump-and-treat system extraction well), respectively. The source for tritium at this location is uncertain; it may represent past disposal to the 116-E-1 crib or 116-K-2 trench, or possibly tritium from a source farther inland, such as the 118-K-1 burial ground.

2.3.1.3 Carbon-14

Condensate from gas circulated through the KE and KW Reactors contained carbon-14 (along with tritium) and was discharged to infiltration cribs at the east side of each reactor building. Release of carbon-14 from the cribs, which were excavated and backfilled during 2004, is the source for the carbon-14 plumes near each reactor. The drinking water standard is 2,000 pCi/L, which continued to be exceeded during FY 2007 at several wells that monitor these plumes. The half-life for carbon-14 is 5,730 years. This radionuclide exchanges with carbon in carbonate minerals, and so its movement is more restricted and variable than a non-exchanging constituent like tritium.

Carbon-14 concentrations exceed the drinking water standard at several wells downgradient of former cribs near KE and KW Reactors.

The two plumes are positioned between the crib source locations and the Columbia River (see Figure 2.3-18 in PNNL-16346 for a FY 2006 map). Current concentrations of carbon-14 in groundwater at wells immediately downgradient of each crib continued to exceed the drinking water standard (Figures 2.3-15 and 2.3-17). Levels have declined in the past 10 years. Concentrations in aquifer tubes downgradient from the 116-KE-1 crib ranged from undetected to ~100 pCi/L. Aquifer tube 17-D, downgradient of KW Reactor, typically detects concentrations of carbon-14 in the hundreds of picocuries per liter, which are above background levels.

Carbon-14 also has been detected at well 199-K-108A in an area upgradient of the 116-KW-1 condensate crib. Concentrations exceeded the drinking water standard during the mid-1990s. During the period 2000 to 2004, groundwater at this location was diluted by clean water from an unknown source; specific conductance and contamination indicators were dramatically reduced in concentration. In 2005, dilution apparently ceased and concentrations began to rebound. In FY 2007, the carbon-14 concentration was 1,600 pCi/L, about the same as FY 2006.

2.3.1.4 Strontium-90

Strontium-90 was released to the environment at 100-K Area primarily via used reactor coolant. It may also have been present in fuel storage basin shielding water, which was discharged to nearby drain fields and injection wells during the reactor operating period. Strontium-90 continues to be present at relatively high concentrations in the shielding water at KE and KW Basins. The radionuclide is moderately mobile in the environment and has a half-life of ~29 years. The drinking water standard is 8 pCi/L.

Strontium-90 Near the KE Reactor. The highest concentrations in 100-K Area groundwater have been observed near the northwest corner of the KE Reactor, at well 199-K-109A, and reached a peak of ~18,000 pCi/L in 1997 (Figure 2.3-18). The elevated concentrations during the period 1996 through 2000 correlate with a period of sustained high water-table conditions. The presumed source is contamination in the vadose zone beneath the former drain field/injection well. Concentrations declined following that peak value, and FY 2007 results ranged from 56 to 757 pCi/L. Strontium-90 was not analyzed in wells farther downgradient.

Strontium-90 Near the KW Reactor. Strontium-90 concentrations near KW Reactor are much lower than near KE Reactor. The maximum concentration in FY 2007 was 26.6 pCi/L in well 199-K-107A, part of a gradually declining trend. Strontium-90 concentrations downgradient in extraction wells 199-K-139 and 199-K-140 ranged from undetected to 1.6 pCi/L in FY 2007.

Strontium-90 Near the 100-K Trench. The effluent disposed to the former 100-K trench contained strontium-90, which is still present in groundwater. FY 2007 concentrations exceeded the 8-pCi/L drinking water standard in three wells. The highest concentration was 31 pCi/L in well 199-K-21, downgradient of the central portion of the trench. Trends are declining gradually in most wells.

The highest concentration of strontium-90 in 100-K Area groundwater samples occurs near the northwest corner of the KE Reactor.

2.3.1.5 Nitrate

Nitrate is widely distributed beneath the 100-K Area, mostly at levels below the 45-mg/L drinking water standard. Potential sources include currently active septic systems and past-practices waste sites, but the distribution pattern does not clearly delineate specific source sites. Six wells had FY 2007 average concentrations above the drinking water standard: three near KW Reactor, two near KE Reactor, and one near the 116-K-2 trench. The highest concentration was 137 mg/L in well 199-K-106A, located near KW Reactor.

Nitrate concentrations exceed drinking water standards in some portions of the 100-K Area.

2.3.1.5 Trichloroethene

Trichloroethene was analyzed in samples from wells 199-K-106A and 199-K-132, which are located downgradient of the former 116-KW-1 condensate crib. Well 199-K-106A, located nearest the crib, shows an overall declining trend (Figure 2.3-19), with a FY 2007 maximum of 5.1 µg/L. Extraction well 199-K-132, located farther downgradient, had a concentration of 6.4 µg/L, an increase from the previous results. The drinking water standard for trichloroethene is 5 µg/L.

2.3.2 Operable Unit Activities

This section summarizes activities relating to the 100-KR-4 Operable Unit. Two pump-and-treat systems operate as an interim remedial action for hexavalent chromium.

2.3.2.1 Status of CERCLA Five-Year Review Action Items

The second CERCLA five-year review was published in November 2006 (DOE/RL-2006-20). The review identified four actions pertaining to the 100-K Area.

- **Action 3-1**. Install three additional wells to further delineate the 116-K-2 trench chromium plume (August 2008). One well, 199-K-143, has been installed to date. Additional wells were installed in early FY 2008 (Section 2.3.2.2).
- **Action 4-1**. Construct a new pump-and-treat facility to address the chromium groundwater plume in the KW Reactor area (August 2008). The KW pump-and-treat system began to operate in January 2007. Section 2.3.2.3 provides more information.

DOE plans to expand groundwater remediation in the 100-K Area in 2008.

- **Action 5-1**. Expand the 100-K Area pump-and-treat system by 378.5 liters/minute to enhance remediation of the plume between the 116-K-2 trench and the N Reactor perimeter fence (August 2008). Expansion began in FY 2007 and is continuing in FY 2008 (Section 2.3.2.2).
- **Action 5-2**. Add additional wells between the 116-K-2 trench and the N Reactor perimeter fence for groundwater extraction, and connect the additional wells to the pump-and-treat system (March 2007). DOE plans to expand the system in FY 2008 (Section 2.3.2.2).

2.3.2.2 116-K-2 Pump-and-Treat System

Interim remedial action under CERCLA at the 100-KR-4 Operable Unit initially targeted the chromium plume beneath the 116-K-2 trench. A pump-and-treat system removes hexavalent chromium from extracted groundwater and injects the treated effluent upgradient of the former trench (see Figure 2.3-1). A second area of contamination, near the KW Reactor complex, was added to the interim remedial action, and a new pump-and-treat system became operational in 2007. The remedial action objectives and criteria for success remain the same as for the initial target plume.

As described in the remedial design/remedial action work plan for the initial interim action (DOE/RL-96-84), the performance criteria for these pump-and-treat systems include achieving hexavalent chromium concentrations that do not exceed 22 µg/L in near-river wells. DOE/RL-2006-76 presents results of operational monitoring and additional details about the pump-and-treat systems for calendar year 2006. Results for calendar year 2007 will be included in an upcoming report on the 100 Areas pump-and-treat systems.

DOE plans to expand the 116-K-2 pump-and-treat system in FY 2008, which will fulfill five-year review Action Items 5-1 and 5-2. DOE/RL-2006-75 describes the design of the planned expansion.

During FY 2007, the pump-and-treat system at the 116-K-2 trench involved nine extraction wells, five injection wells, and an ion-exchange resin treatment system (DOE/RL-2006-08). The system began operating in October 1997. Figures 2.3-5 and 2.3-6 show chromium trend charts for wells in the 116-K-2 trench plume. Appendix A includes lists of sampling frequencies and analyses.

During FY 2007, the pump-and-treat system extracted and treated ~535 million liters of groundwater and removed ~20 kilograms of hexavalent chromium. Since the startup of operations in October 1997, the system has treated ~4.15 billion liters of groundwater and removed ~312 kilograms of chromium. The FY 2007 average flow rate for each extraction well ranged between 48 and 155 liters/minute, with a combined average flow rate of 1,067 liters/minute (DOE/RL-2006-76). There were no major operational changes to the 100-KR-4 pump-and-treat network during FY 2007.

The remedial action objectives for the 100-KR-4 Operable Unit (ROD 1996a) are:

- *Protect aquatic receptors in the river bottom from contaminants in groundwater entering the Columbia River.*
- *Protect human health by preventing exposure to contaminant in the groundwater.*
- *Provide information that will lead to the final remedy.*

The contaminant of concern is hexavalent chromium. The record of decision specifies 22 µg/L as the concentration at compliance wells that is protective of aquatic organisms in the river environment.

Chromium concentrations within the target plume area show generally decreasing or stable trends (Figures 2.3-5, 2.3-6, and 2.3-7; see Section 2.3.1.1). During FY 2007, decreasing trends continued at wells 199-K-20 , 199-K-119A, and 199-K-120A. Relatively constant concentrations during FY 2007 were observed at wells 199-K-18, 199-K-117A, 199-K-125A, 199-K-37, 199-K-113A, 199-K-114A, 199-K-115A, 199-K-116A, 199-K-130, and 199-K-131. Concentrations consistently were at or below the remedial action goal (22 µg/L) only at wells 199-K-117A and 199-K-125A.

Several wells are strongly influenced by infiltration of river water, where contaminant concentrations are reduced by mixing of groundwater and river water. Periodic mixing is observed at well 199-K-114A, creating cyclic fluctuations of chromium concentrations (Figure 2.3-6). A continuous presence of river water is observed at well 199-K-117A, as indicated by the low specific conductance of the samples.

Chromium concentrations at some aquifer tube sites along the shore segment adjacent to the central portion of the plume have decreased with time (Figure 2.3-8). Concentrations were below the 22 µg/L remedial action goal at tube sites AT-21, AT-22, and AT-23 in FY 2007. At the northern end of the plume, chromium concentrations at tube sites have increased over the past four years (Figure 2.3-9). The increase suggests that the plume is moving northward.

The injection of treated effluent at five wells has created a water-table mound. The injected water has migrated downgradient and arrived at wells 199-K-20, 199-K-116A, 199-K-119A, and 199-K-125A, as shown by increasing tritium concentrations at those wells. Tritium is a good tracer for showing the effects of injection, as concentrations are higher in the treated effluent than in groundwater near most of the extraction wells.

Chromium concentrations are generally decreasing in the area of the 100-K trench pump-and-treat system.

Uncertainties regarding the pump-and-treat system's influence on aquifer conditions involve the (1) extent of plume inland of the trench, and whether or not chromium observed at well 699-78-62 is part of the plume; (2) source for chromium and tritium at wells 199-K-18 and 199-K-120A, where some concentration trends are increasing; (3) height and extent of the mound created at the injection site, and its influence on flow patterns; and (4) mass of potentially mobile chromium remaining in the lower vadose zone and in the aquifer upgradient of the trench.

Well 199-K-143 has been installed inland of the trench to help define the areal extent of the chromium plume (five-year review Action 3-1). Hexavalent chromium concentrations in this well ranged from 19 to 22 µg/L in FY 2007.

2.3.2.3 KW Pump-and-Treat System

DOE began to operate a new pump-and-treat system for chromium near KW Reactor in January 2007 (see Section 2.3.1.1 for description of the plume). This remedial action fulfills five-year review Issue 4, Action 4-1 (see Section 2.3.2.1). A remedial design/remedial action work plan (DOE/RL-2006-52) describes the new system. As currently designed, the system includes four extraction wells, two injection wells, and ion-exchange treatment equipment similar to that previously used in the 100-KR-4 and 100-HR-3 Operable Units. Initial treatment capacity is 379 liters/min, with provision for increases to 757 liters/min if required.

In FY 2007, the new pump-and-treat system extracted 122.5 million liters of water and removed 15.8 kilograms of hexavalent chromium. By the end of FY 2007, the hexavalent chromium concentrations in near-river extraction wells stabilized at ~50 µg/L in well 199-K-138 and ~100 µg/L in well 199-K-132 (Figure 2.3-12). Concentrations in inland extraction wells stabilized at ~25 µg/L in well 199-K-140 and ~220 µg/L in well 199-K-139 (Figure 2.3-13). Upgradient monitoring well 199-K-137 had chromium concentrations ~2,200 µg/L in FY 2007, but concentrations in this range have not yet appeared in downgradient wells.

Two pump-and-treat systems have removed 328 kilograms of chromium from 100-K Area groundwater.

2.3.2.4 Calcium Polysulfide Treatability Test

Four wells installed in late 2005 adjacent to well 199-K-126 to perform a treatability test using calcium polysulfide were sampled monthly in FY 2007. Chromium concentrations increased to 51 µg/L in well 199-K-126 in October 2006, and stabilized between 40-45 µg/L by August 2007. This test evaluated the practicality of treating chromium in the groundwater as an alternative to pump-and-treat systems. The study concluded that hexavalent chromium effectively was eliminated from the treated aquifer (DOE/RL-2006-17). The aquifer was chemically reduced and was expected to remain a permeable reactive barrier that will treat groundwater as it flows through.

2.3.3 Facility Monitoring — K Basins

The fuel storage basins located within the KE and KW Reactor buildings were used from the late 1970s to 2004 to store irradiated fuel from the 100-N Reactor, along with other miscellaneous fuel recovered during remedial actions at other reactor areas. Each basin holds ~4.9 million liters of shielding water that is highly contaminated with long-lived radionuclides, some of which are mobile in the environment (e.g., tritium and strontium-90). The KE Basin has leaked in the past, and the leakage has affected groundwater. The vadose zone beneath the basin is also known to contain radionuclides that are absorbed onto the soil. Information on the removal of spent fuel and contaminated sludge, and the demolition of these basins, can be found at DOE's Richland Operations Office web site (http://www.hanford.gov/rl; communications tab, programs, Spent Nuclear Fuel). Tri-Party Agreement (Ecology et al. 1989) Milestone M-34-00 covers the fuel removal and basin cleanup project, the latter now referred to as the K Basins Closure Project.

The K Basins sampling and analysis schedule complements other schedules associated with the 100-KR-4 Operable Unit. The monitoring plan for K Basins (PNNL-14033) describes the objectives for the monitoring:

- Characterize groundwater conditions between the K Basins and the Columbia River to provide a periodic status of current conditions and the attenuation of plumes.
- Distinguish between groundwater contamination associated with K Basins and contamination from other past-practices sources to help guide operational and remedial action decisions.
- Maintain a strategy for the potential expansion of monitoring capabilities to respond to future basin-related issues.

These objectives remain valid as long as shielding water remains in the basins. Once actual demolition and removal of the basins begins, the strategy and objectives for groundwater monitoring will be revisited. In the interim, two additional monitoring wells (199-K-141 and 199-K-142) have been installed in the area between

KE Basin and the Columbia River. The installation of three new wells (199-K-138, 199-K-139, and 199-K-140) downgradient of the KW Basin, as part of a pump-and-treat system for chromium in that area, also improves the monitoring capability near the KW Basin.

The primary indicator for detecting shielding water in groundwater is tritium, which is present at concentrations in the millions of picocuries-per-liter range in KE and KW Basin water. Other less mobile radionuclides (e.g., strontium-90, cesium-137) are also present at relatively high concentrations in shielding water. However, if small volumes or low rates of leakage were to occur, the strontium-90 and cesium-137 might not reach groundwater because they would be retained in the vadose zone and tritium levels might be too low to detect. One additional tracer for shielding water is technetium-99, which is mobile, like tritium, but is at relatively low concentrations in the shielding water.

Wells 199-K-27 and 199-K-109A are located adjacent to the KE Basin in a position most likely to detect basin leakage. During FY 2007, tritium concentrations remained relatively constant at levels below the drinking water standard (see Figure 2.3-16 and Section 2.3.1.2). The average annual tritium concentration in well 199-K-27 was 6,800 pCi/L, down from 15,000 pCi/L during the previous year. The average annual tritium concentration in well 199-K-109A was 3,200 pCi/L, similar to the previous year. Some unexplained variability at well 199-K-27 continues, but concentrations remain in the range of long-term monitoring. There is still no clear explanation as to the cause for the abrupt increase in concentrations that started in January 2003 at these wells. There has been no unexplained loss of water from the basin to account for the trend changes in groundwater.

Near the KW Reactor, tritium concentrations at well 199-K-106A, located downgradient of the former 116-KW-1 condensate crib began to rise in 2001 and spiked in mid-2003 and 2005 to over 1 million pCi/L (Figure 2.3-17). Levels declined in FY 2006 and 2007. The last tritium concentration in FY 2007 (August) was unusually low at 30,000 pCi/L, similar to the pre-pulse concentrations in 2000. The source for the tritium is likely to be the vadose zone beneath the former crib and not related to potential water loss from the KW Basin.

The annual average concentration of strontium-90 exceeded the drinking water standard (8 pCi/L) in two wells monitoring the KW Reactor area and one well monitoring the KE Reactor area. The highest concentrations were in the KE area where strontium-90 averaged 480 pCi/L in well 199-K-109A during FY 2007, down substantially from an average of 1,200 pCi/L during the previous year. Well 199-K-34 and 199-K-107A, located in KW area, averaged 20 and 27 pCi/L in FY 2007. See Section 2.3.1.4 for more detailed discussion of strontium-90 contamination in the 100-K Area.

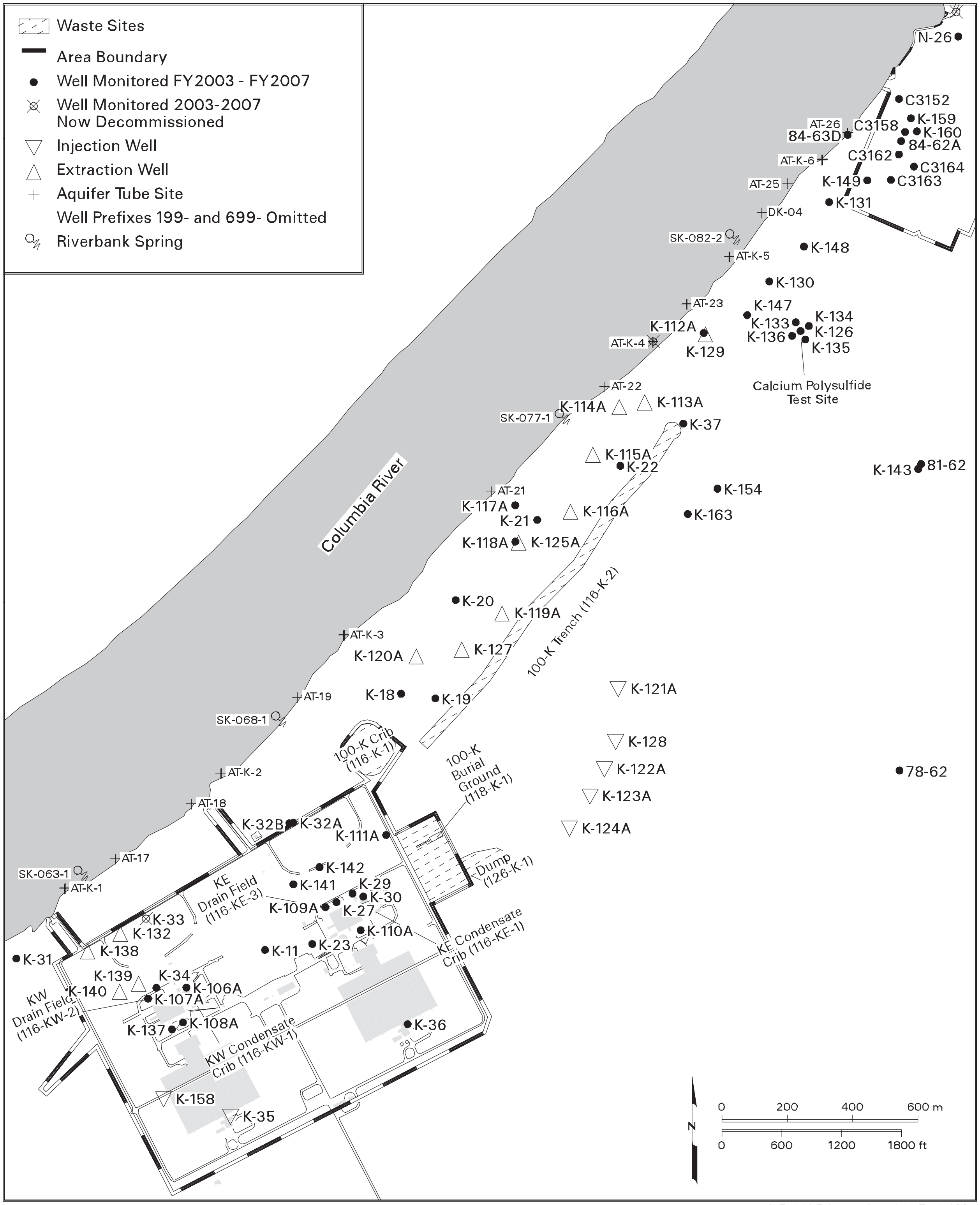

Figure 2.3-1. Groundwater Monitoring Wells in 100-K Area

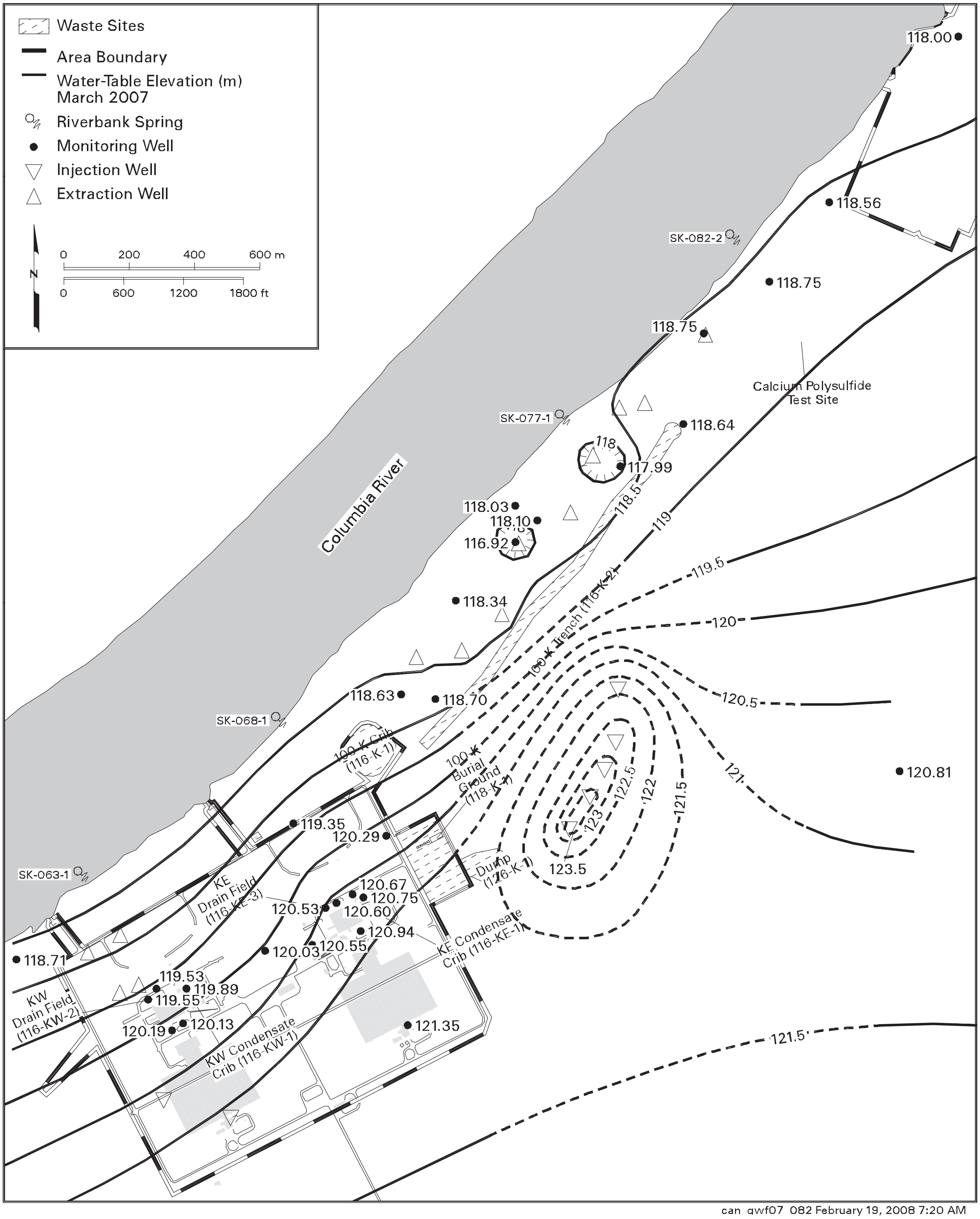

Figure 2.3-2. 100-K Area Water-Table Map, March 2007

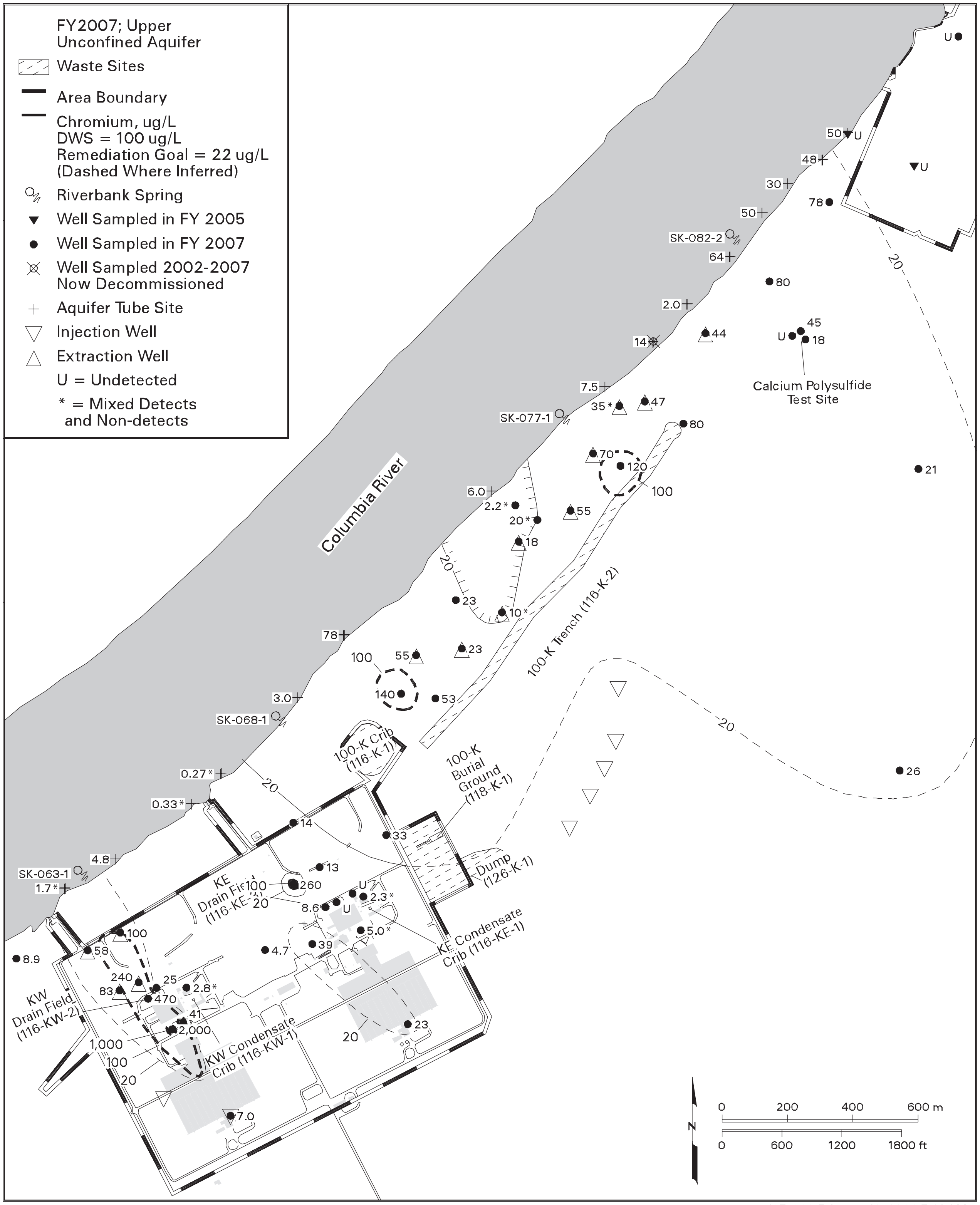

Figure 2.3-3. Average Chromium Concentrations in 100-K Area, Upper Part of Unconfined Aquifer

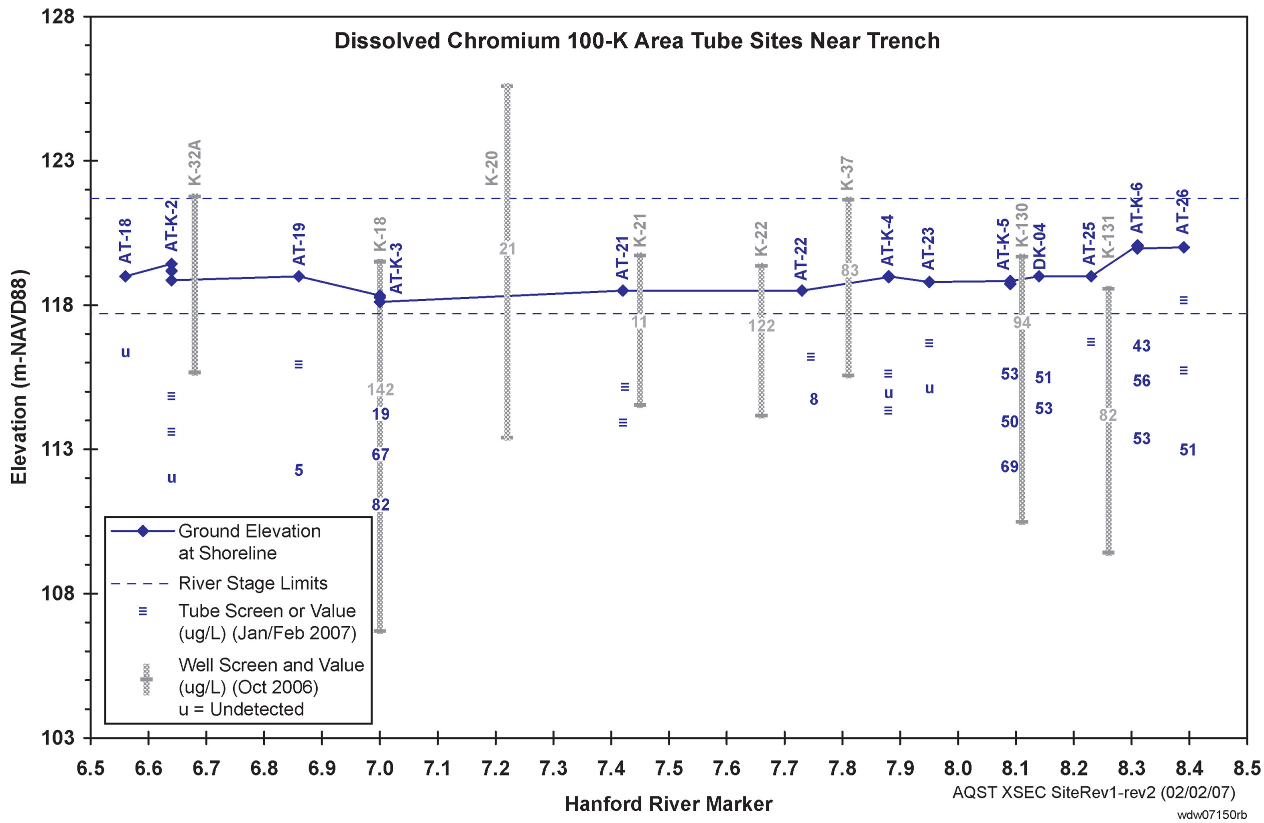

Figure 2.3-4. Sample Elevations and Chromium Concentrations in Wells and Aquifer Tubes in 100-K Area (from SGW-35028)

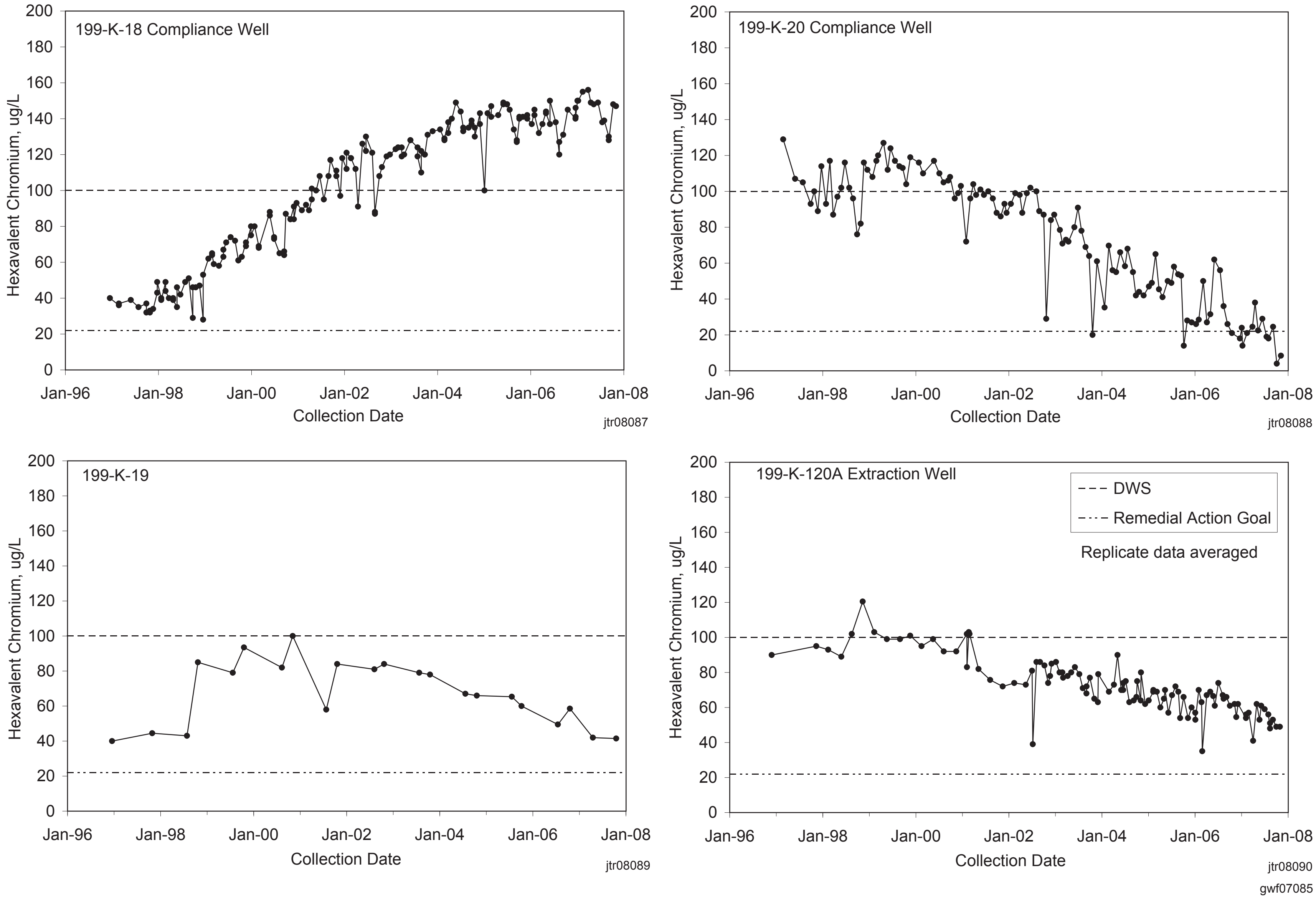

Figure 2.3-5. Chromium Concentrations at Wells Located at the Southwest Edge of the 116-K-2 Trench Plume

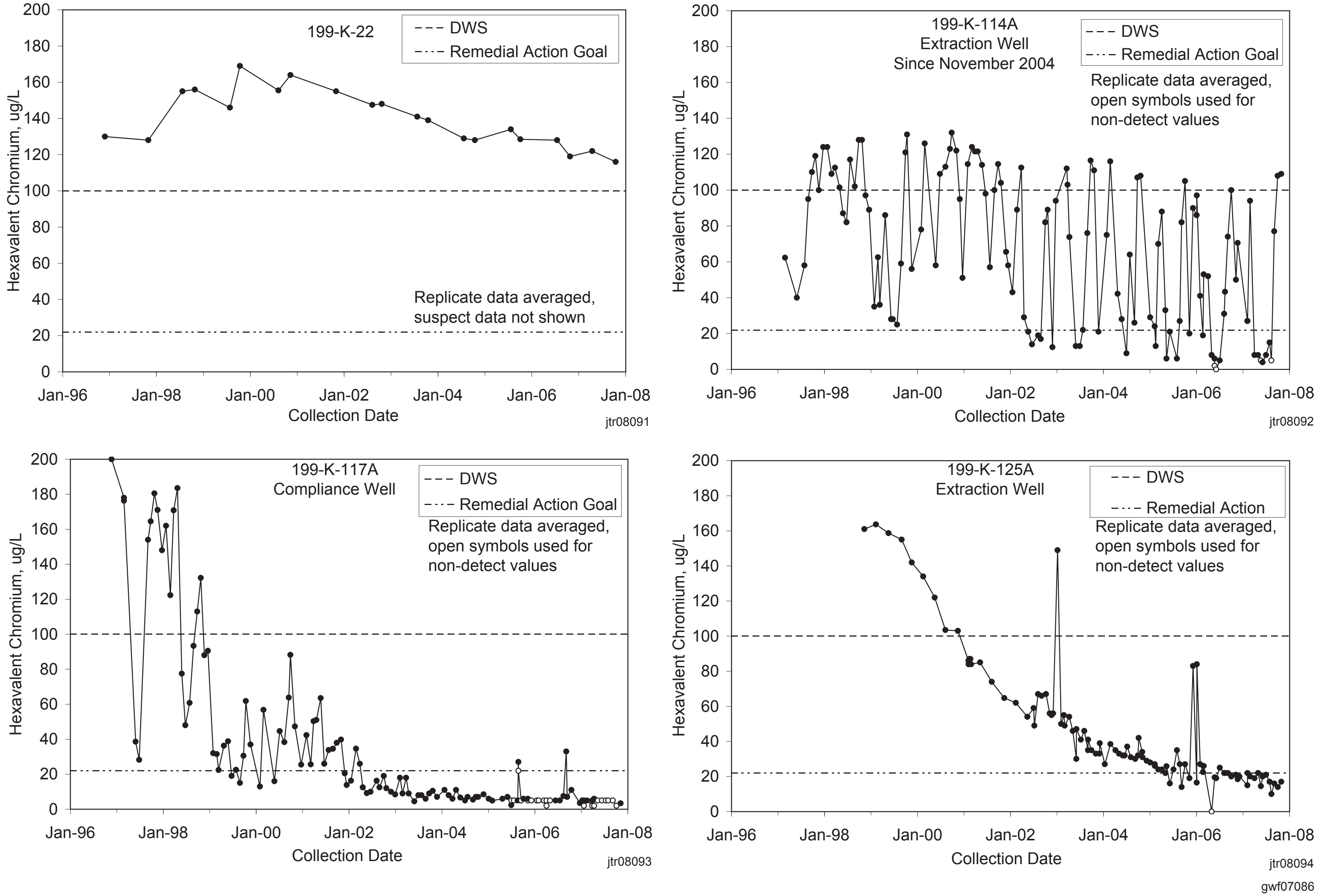

Figure 2.3-6. Chromium Concentrations at Wells Located in the Central Portion of the 116-K-2 Trench Plume

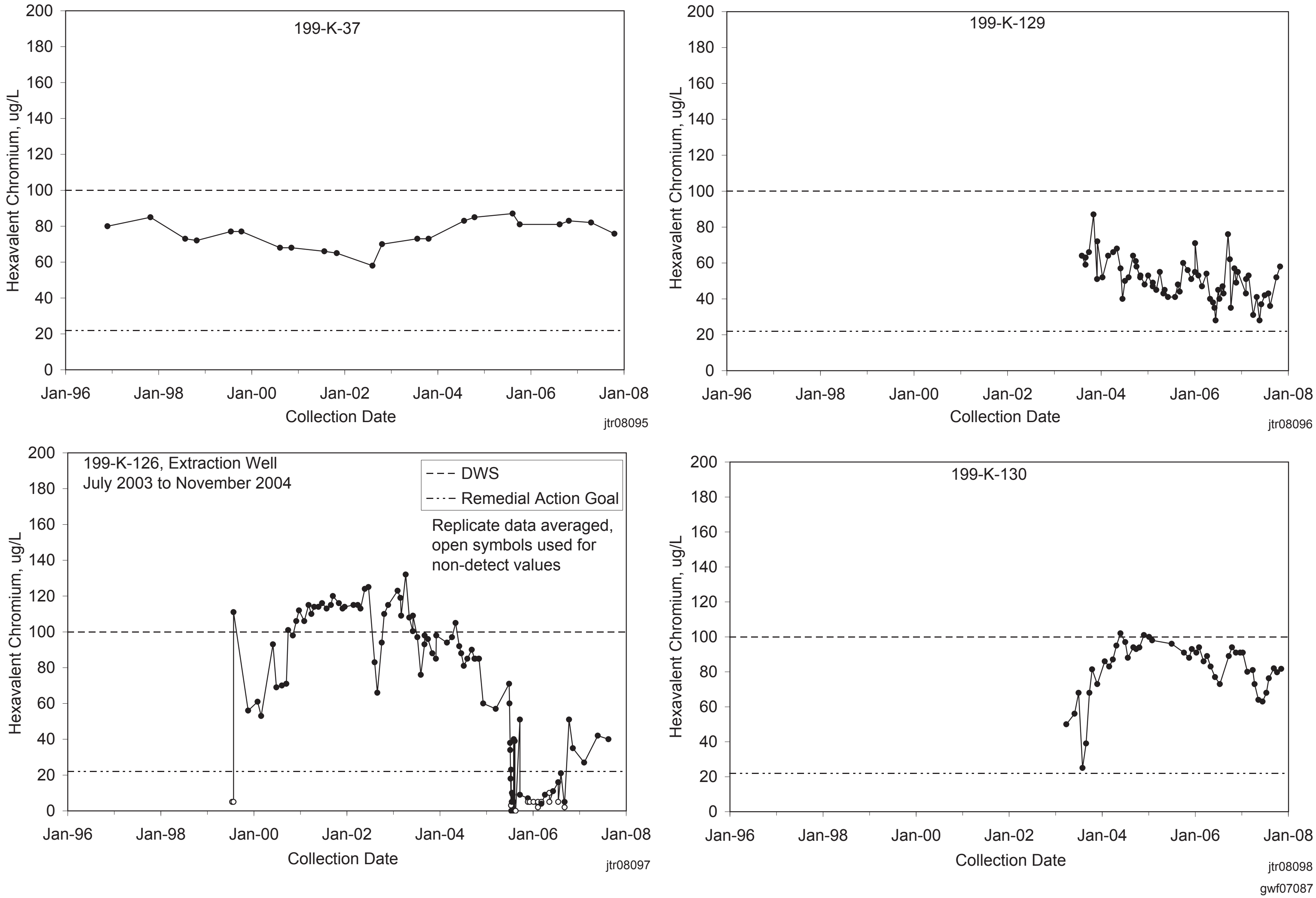

Figure 2.3-7. Chromium Concentrations at Wells Located at the Northeast Edge of the 116-K-2 Trench Plume

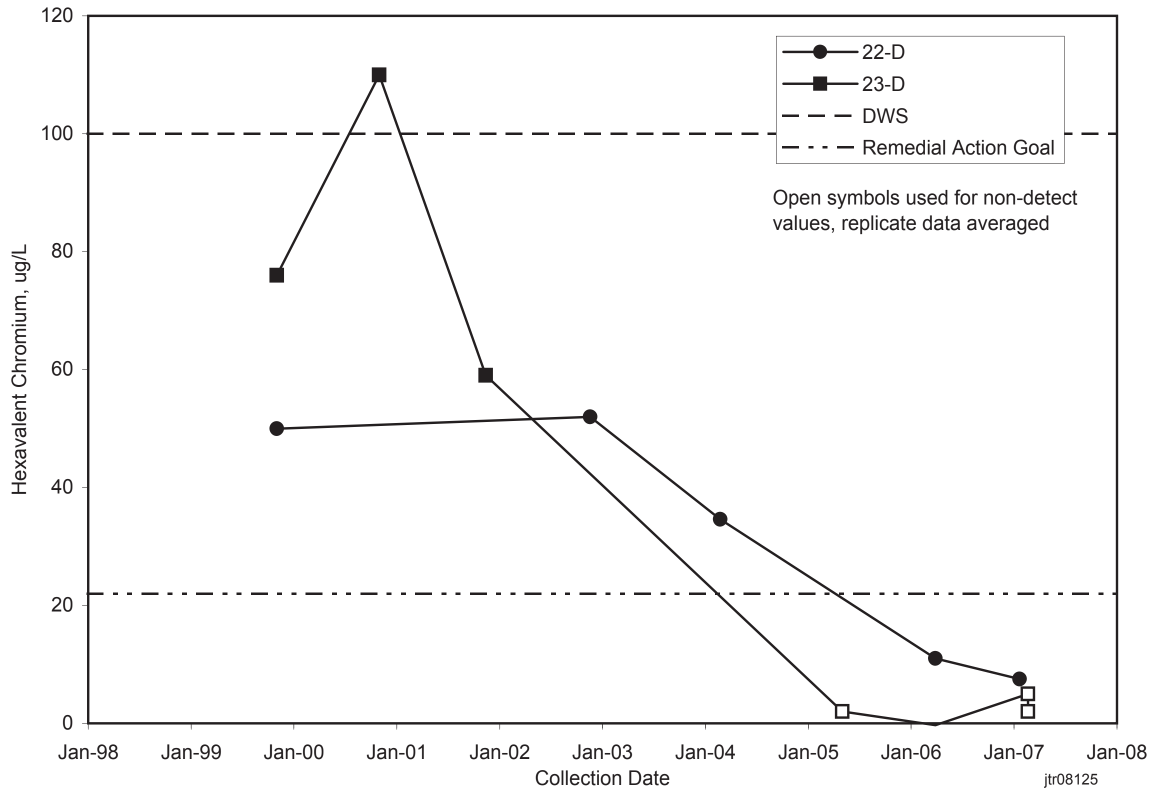

Figure 2.3-8. Chromium Concentrations in Aquifer Tubes Along Central Portion of 116-K-2 Trench Plume

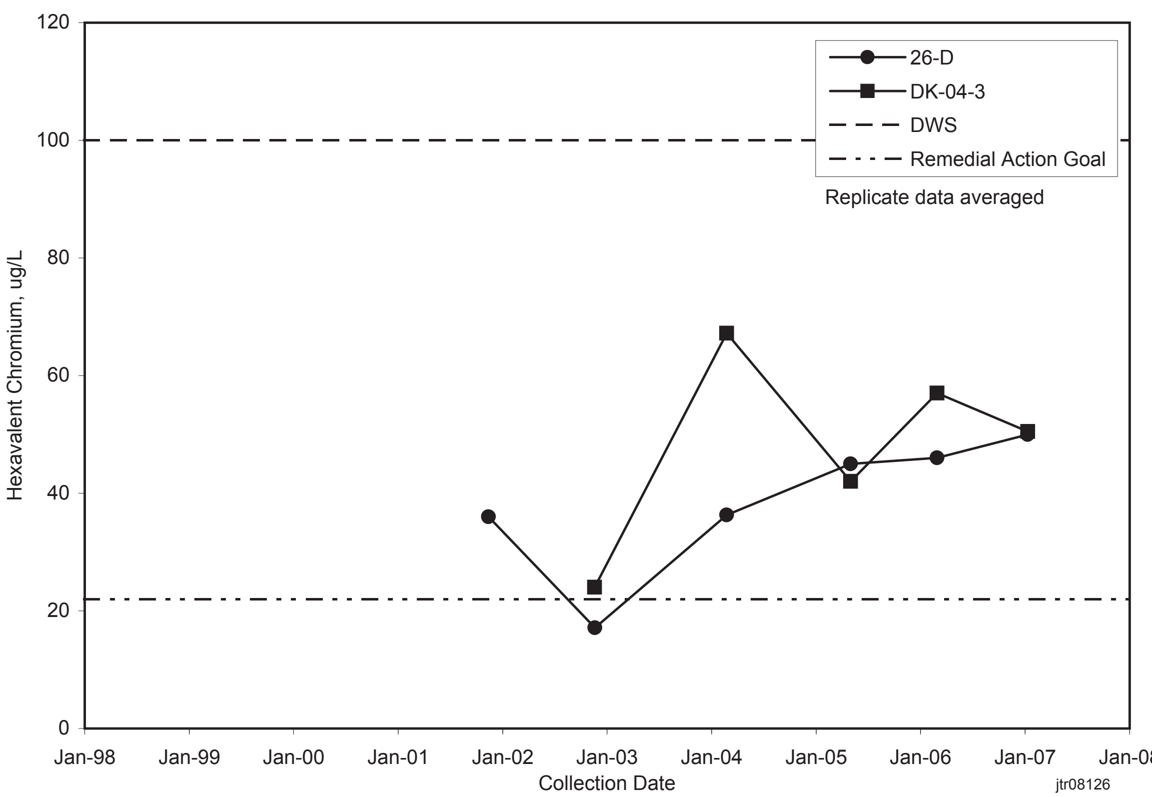

Figure 2.3-9. Chromium Concentrations at Aquifer Tubes Along North Portion of 116-K-2 Trench Plume

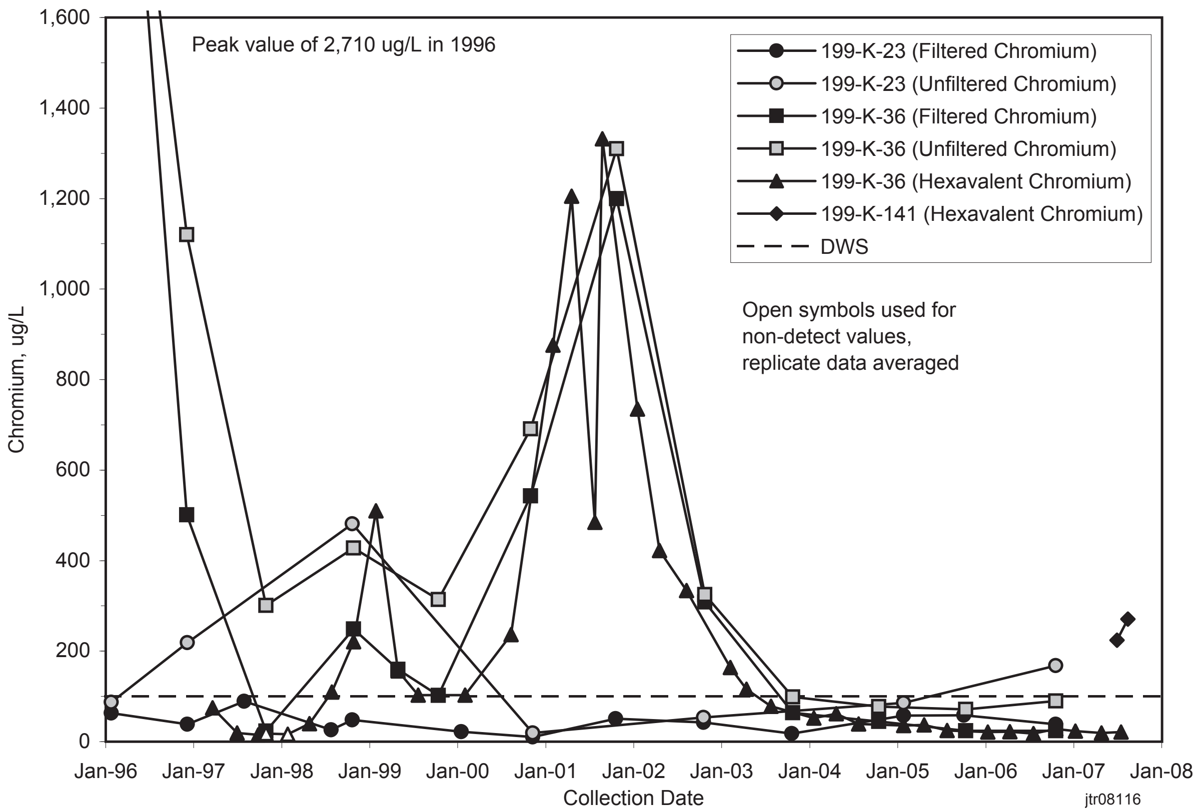

Figure 2.3-10. Chromium Concentrations Near KE Water Treatment Plant Basins and KE Reactor Building

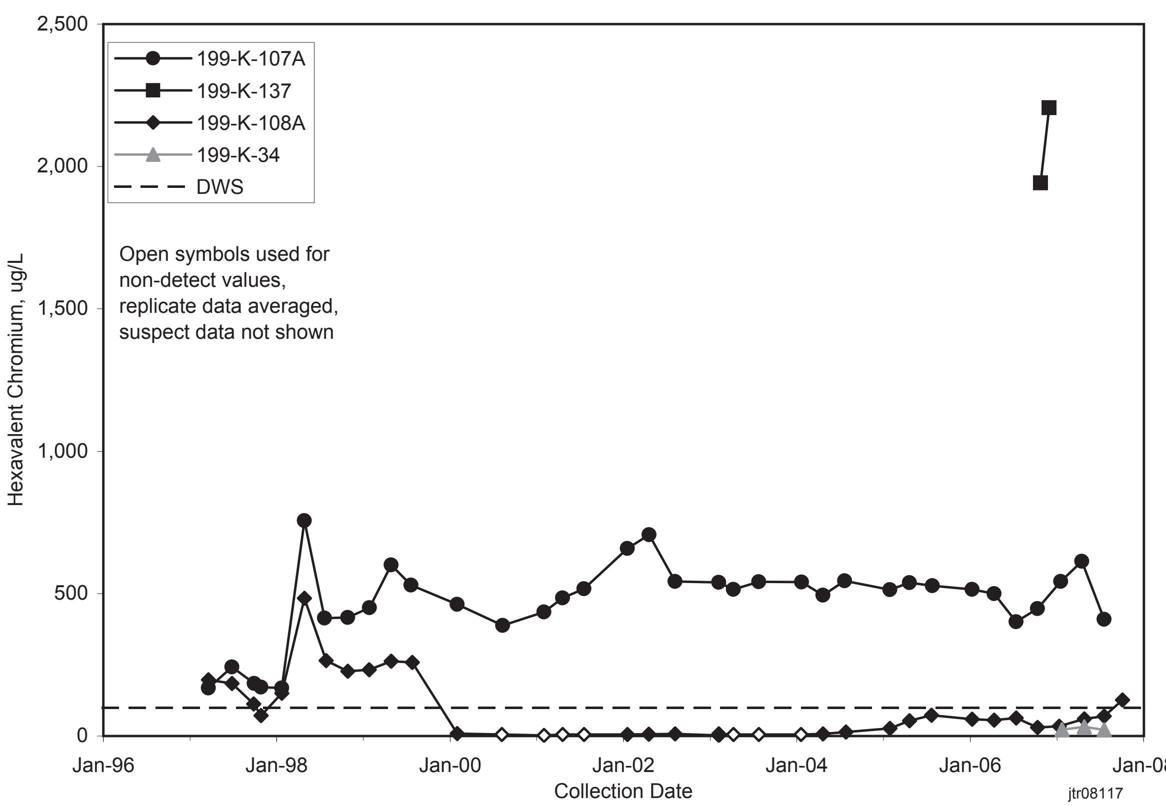

Figure 2.3-11. Chromium Concentrations Near KW Reactor Building

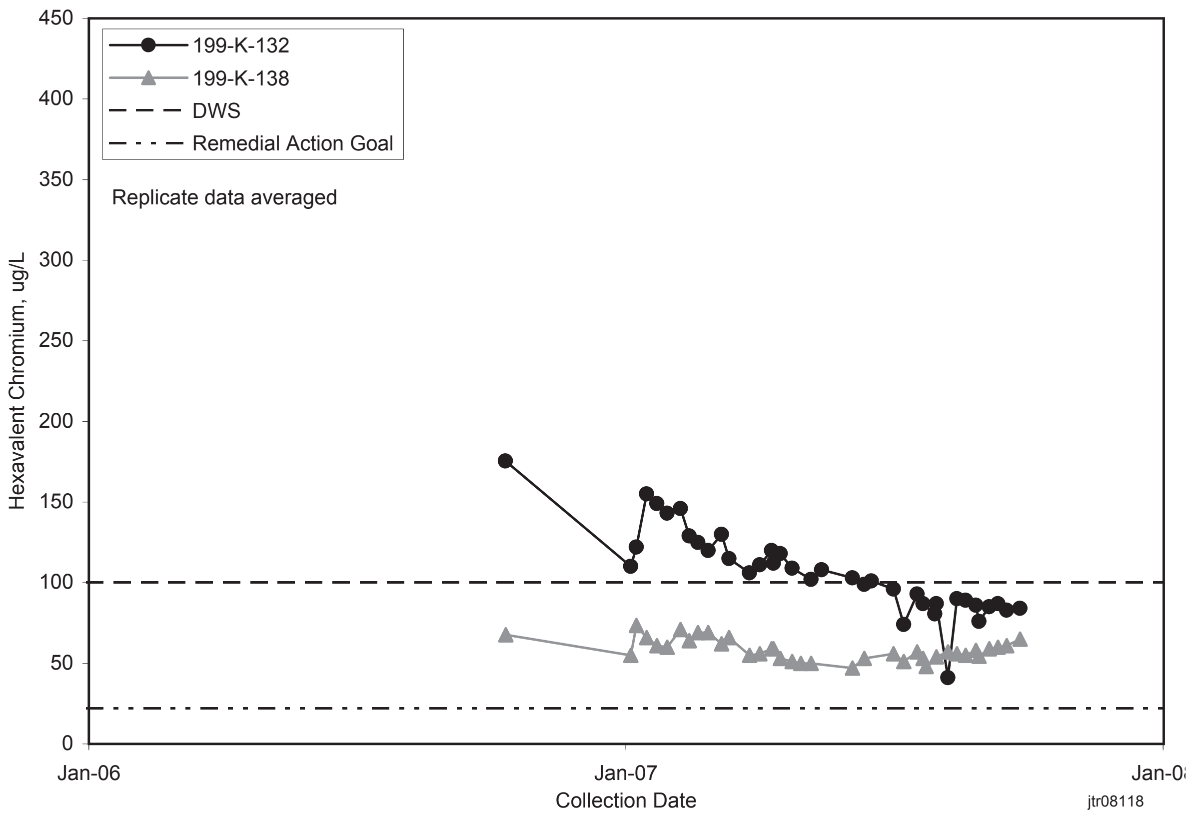

Figure 2.3-12. Chromium Concentrations in KW Near-River Extraction Wells

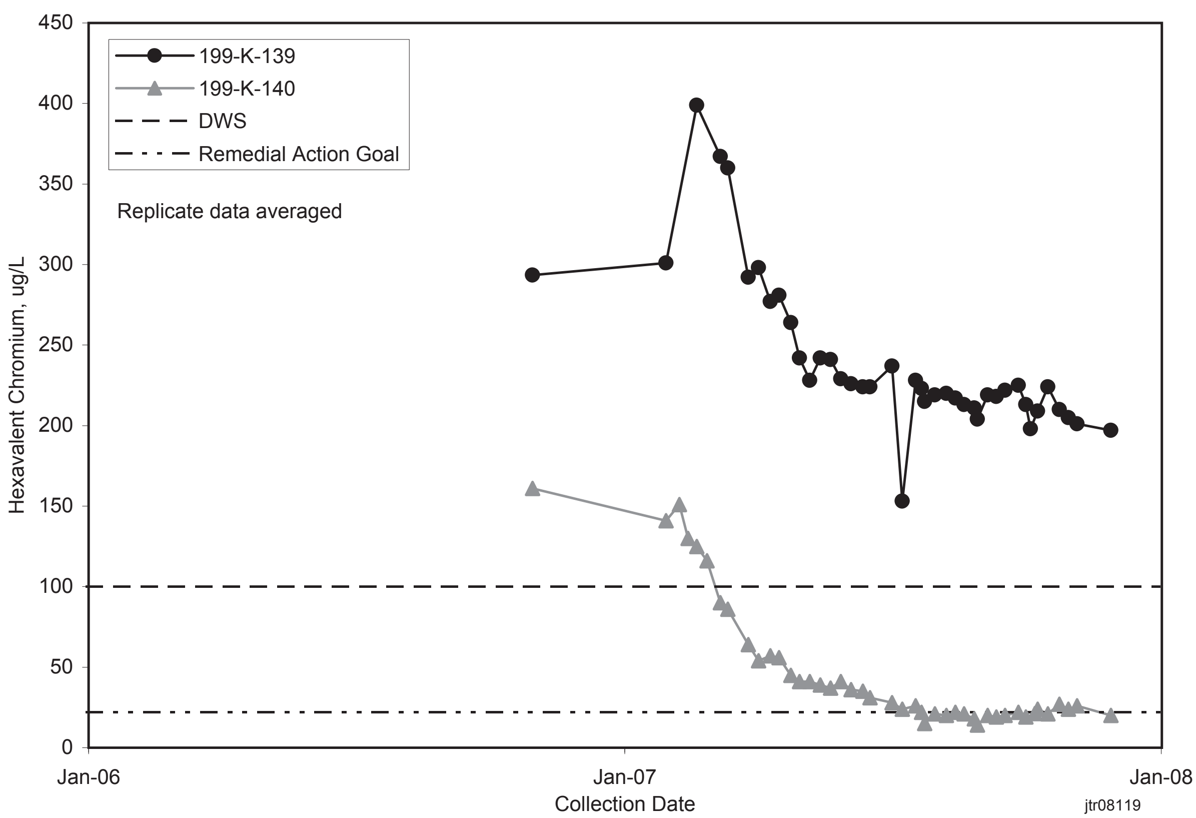

Figure 2.3-13. Chromium Concentrations in KW Inland Extraction Wells

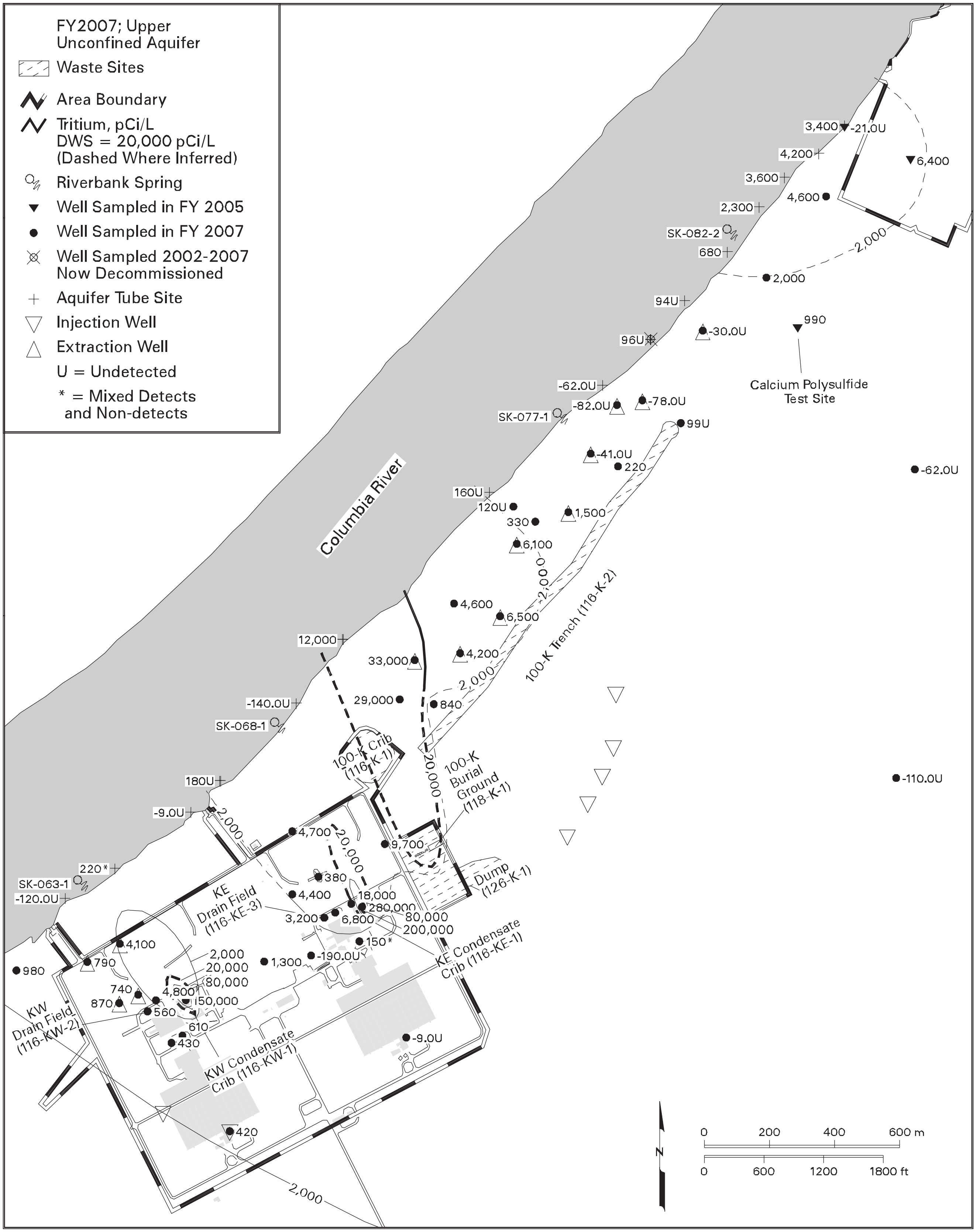

Figure 2.3-14. Average Tritium Concentrations in 100-K Area, Upper Part of Unconfined Aquifer

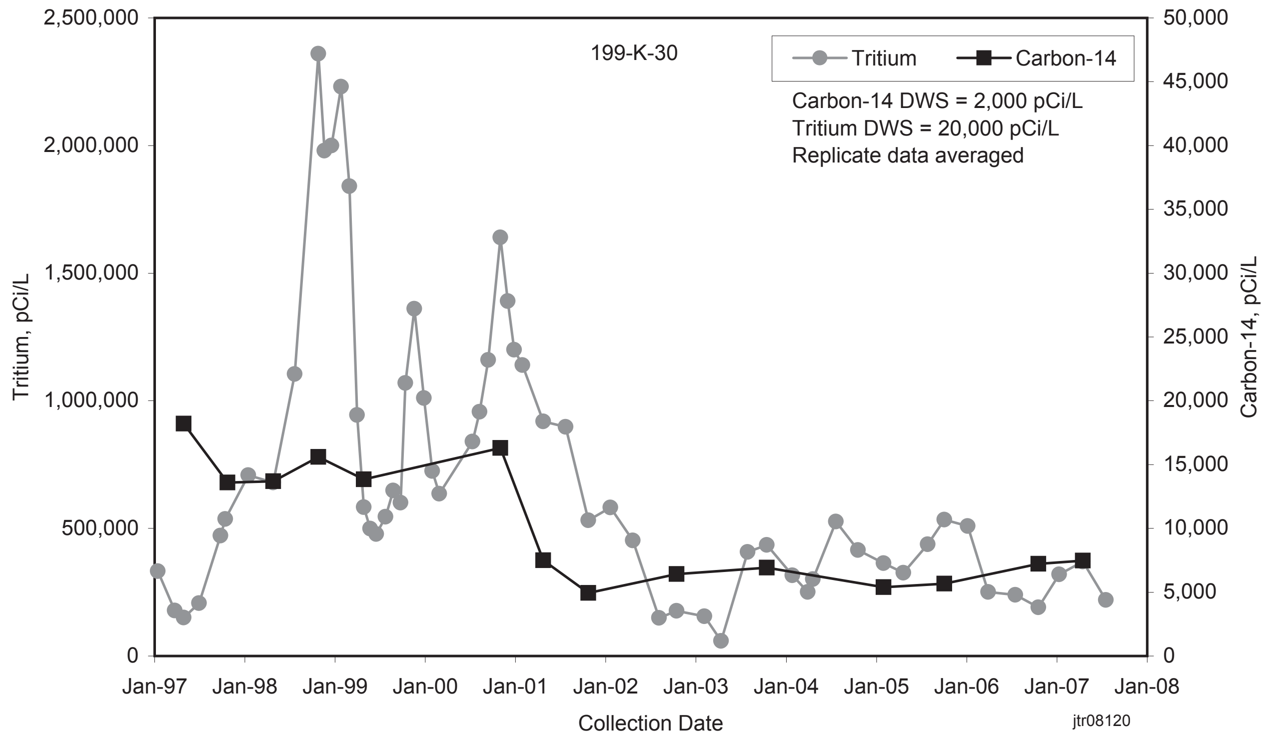

Figure 2.3-15. Tritium and Carbon-14 Concentrations Near Former 116-KE-1 Condensate Crib

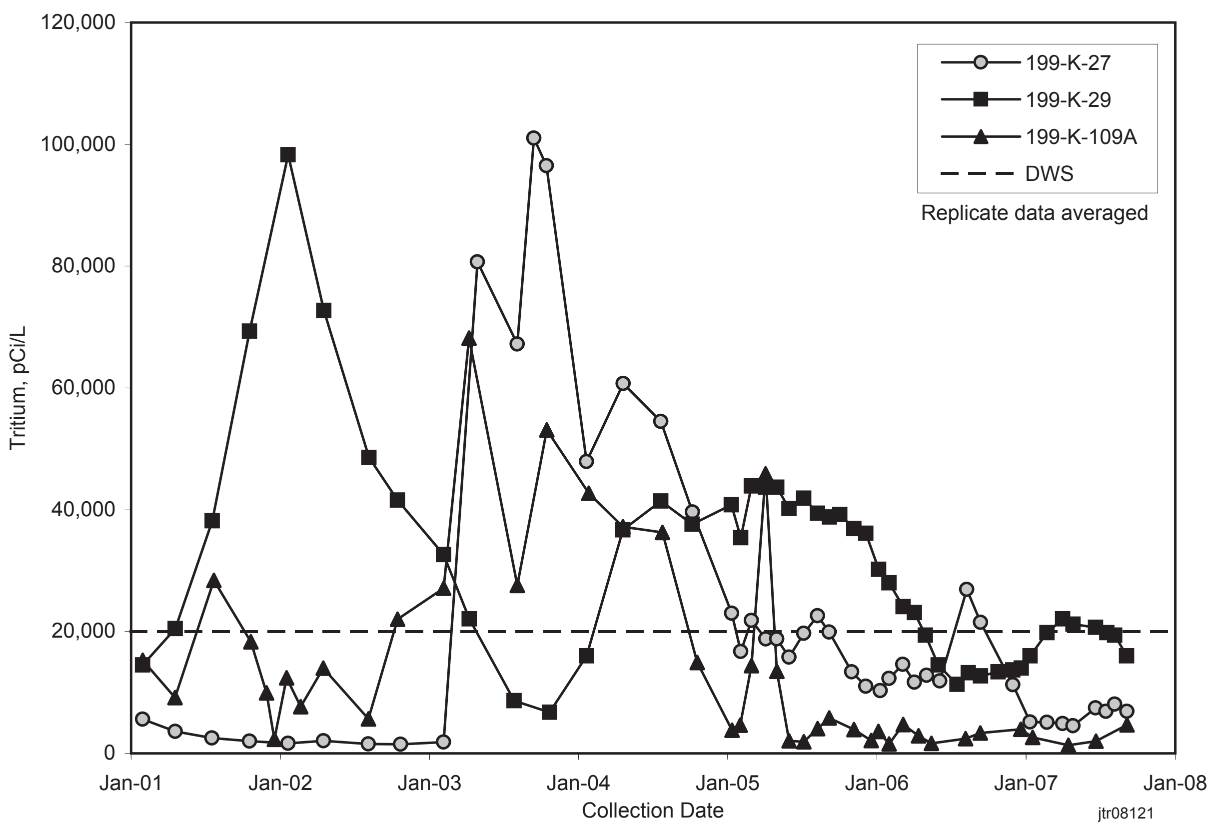

Figure 2.3-16. Tritium Concentrations Near KE Basin

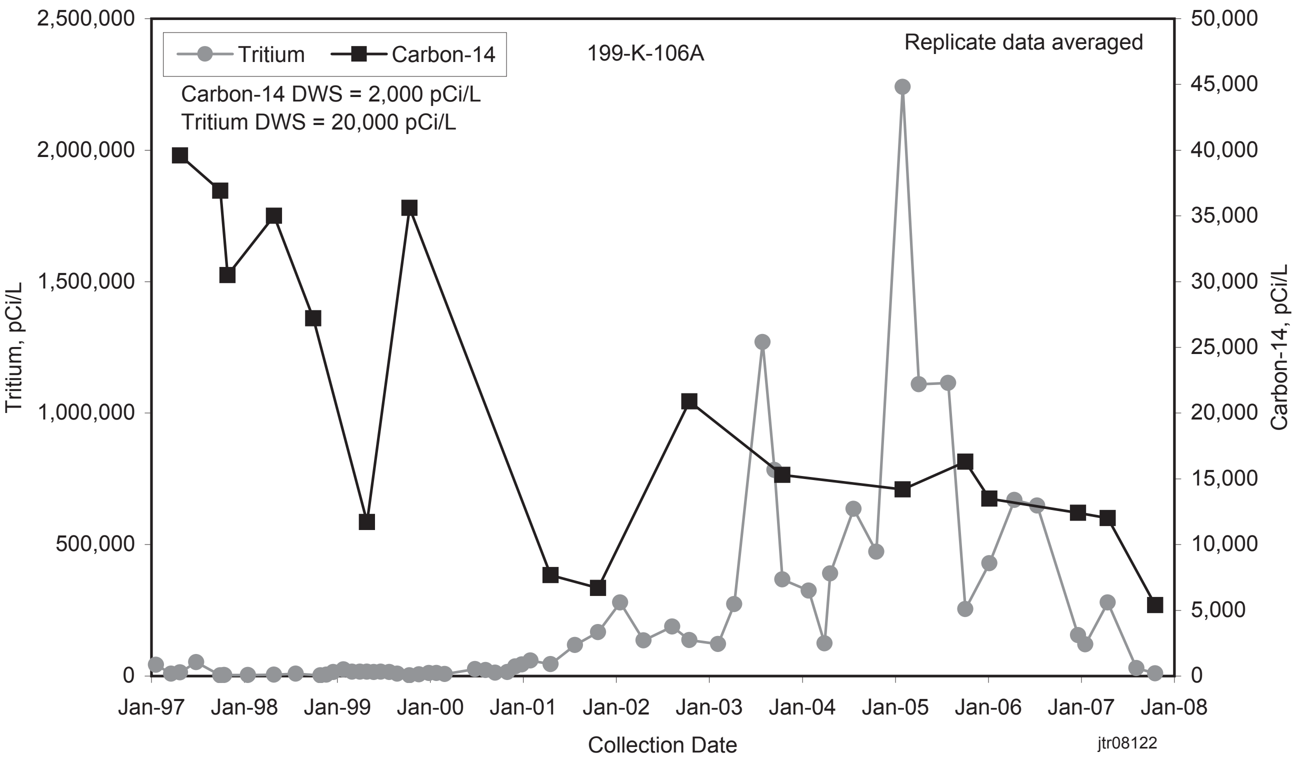

Figure 2.3-17. Tritium and Carbon-14 Concentrations Near Former 116-KW-1 Condensate Crib

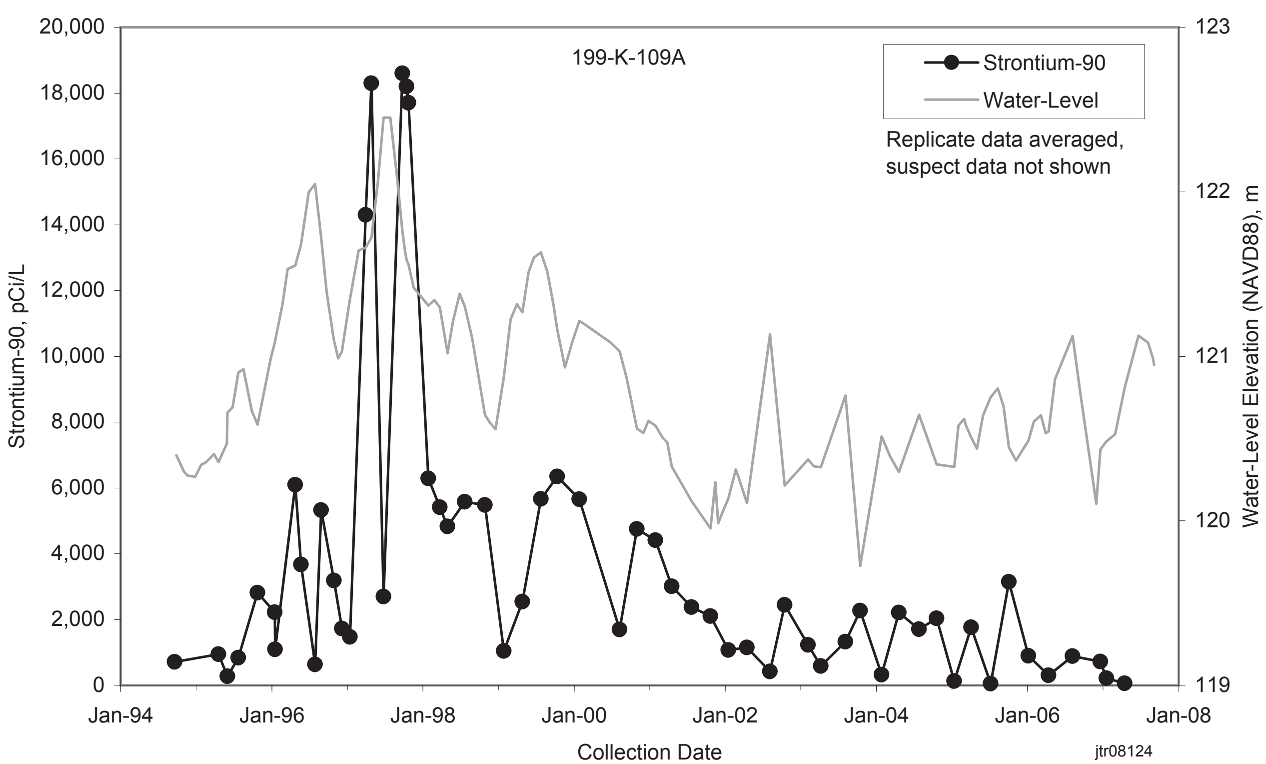

Figure 2.3-18. Strontium-90 Concentrations and Water-Table Elevation Near KE Basin

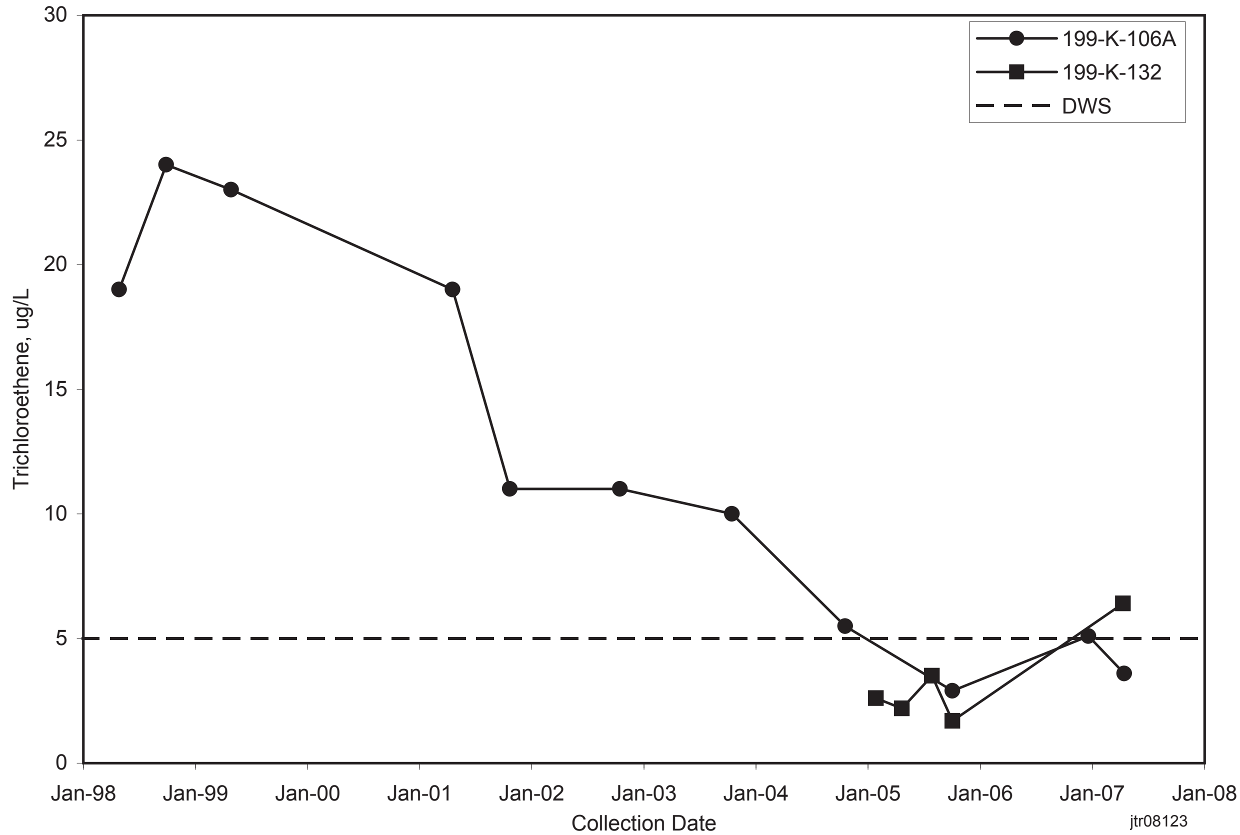

Figure 2.3-19. Trichloroethene Concentrations Near and Downgradient of KW Reactor Building