

2.3 100-KR-4 Operable Unit

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This section discusses groundwater conditions in the 100-KR-4 Operable Unit, which includes all groundwater potentially impacted by contaminant releases from the facilities and waste sites within the 100-KR-1, 100-KR-2, and 100-KR-3 source operable units. Most of the facilities and waste sites associated with former production reactor operations are contained within the 100-K Area, which includes the KE and KW Reactors and their support facilities. A description of 100-K Area facilities, reactor operations, and designated waste sites as grouped into operable units, is presented in WHC-SD-EN-TI-239, which is the primary source for historical information presented below. The operable unit lies within a larger groundwater interest area, as defined by the Groundwater Performance Assessment Project (groundwater project) (see Figure 2.1-1 in Section 2.1). These interest areas are defined to facilitate scheduling, data review, and interpretation. Figure 2.3-1 is a location map showing 100-K Area facilities, waste sites, monitoring wells, and shoreline monitoring sites.

The principal groundwater issues during fiscal year (FY) 2004 (the period October 2003 thru September 2004) for the 100-K Area involved (a) a chromium plume created by past disposal to a large infiltration trench located near the river, (b) contamination associated with past discharges to the ground near the KE and KW Reactor buildings, and (c) groundwater conditions near the fuel storage basins associated with each reactor building. Remedial actions during FY 2004 included (a) removing contaminated facilities and soil associated with past operations, (b) removing and re-packaging irradiated fuel stored in basins at each reactor building, (c) initiating cleanup of the highly contaminated fuel storage basins themselves, and (d) operating the pump-and-treatment system that removes hexavalent chromium from the aquifer beneath the 116-K-2 trench.

*Chromium is the
contaminant of
concern currently
being targeted by
interim remedial
action.*

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

CERCLA Long-Term Monitoring

- Twenty-five wells are sampled annually or biennially for contaminants of concern and constituents of interest.*
- Riverbank springs (three locations) and aquifer tubes (sixteen locations) are sampled annually along the 100-K Area river shore.*
- During FY 2004, all wells were sampled as scheduled; several aquifer tube sites and riverbank springs that were scheduled did not produce water for samples.*

CERCLA Interim Remedial Action Performance Evaluation

- Four compliance wells and nine extraction wells are sampled monthly for hexavalent chromium.*
- Eight performance wells are sampled monthly or semiannually to track changes in chromium and co-contaminant concentrations.*
- Treatment system influent and effluent chromium concentrations are sampled weekly.*
- During FY 2004, all wells were sampled as scheduled except for missing monthly samples for several wells in December.*

Facility Monitoring

- Five wells are sampled quarterly to detect potential shielding water loss to the ground from the KW and KE Basins.*
- Four wells are sampled quarterly to monitor plumes created by past leakage from the KE Basin.*
- Riverbank springs (two locations) and aquifer tubes (six locations) are sampled annually to monitor conditions at the rivershore.*
- In FY 2004, all wells were sampled as scheduled.*

Groundwater flow is generally to the northwest, toward the Columbia River.

Groundwater flow beneath the 100-K Area is generally to the northwest, with average rates of flow toward the river in the range 0.1 to 0.3 meter per day, as estimated from hydraulic gradients, and from migration rates of plumes. Figure 2.3-1 shows water-table elevation contours; flow direction is generally perpendicular to contours. The best-supported estimate for groundwater movement between the KE Reactor and the river is 0.12 meter per day, and is based on the migration of a plume created by a leak from the KE Basin in 1993. This suggests a 10- to 12-year travel time for fully dissolved waste constituents, such as nitrate, to travel from the vicinity of the KE Reactor to the river (PNNL-14031). Waste constituents that interact with sediment, such as strontium-90 and carbon-14, travel more slowly. Groundwater discharge to the Columbia River occurs through the riverbed sediment, and to a limited degree, as riverbank springs during periods of low river stage.

The current movement of contaminant plumes beneath most of the 100-K Area is controlled by the flow of groundwater under natural conditions, i.e., there are no effluent disposal operations that alter gradients. The exception is the region to the northeast of the KE Reactor where the pump-and-treat system is operating. Here, treated effluent is injected back into the aquifer. A mound has formed on the water table, and a radial flow pattern has developed around the injection sites (DOE/RL-2004-21).

Near the Columbia River, the groundwater system is influenced by fluctuations in river discharge, which is controlled 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 discharge, contaminants carried by groundwater may become diluted prior to release to the river through riverbed sediment and via riverbank springs.

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 of 1954* 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 potential concern in the operable unit, and (b) evaluate the performance of the pump-and-treat system that removes chromium from groundwater contaminated by past disposal to the 116-K-2 trench.

During FY 2004, essentially all sampling and analysis activities, as described in monitoring plans approved by the regulatory agencies, were implemented. Changes to schedules presented in the plans were caused by the loss of one monitoring well (199-K-33) because of remedial action excavation activity; the addition of several wells to the pump-and-treat system and a replacement well for 199-K-33 (new well 199-K-132); and minor changes to scheduling dates and analysis suites in response to new information that became available during the year (see Appendices A and B).

Plume areas (square kilometers) above the drinking water standard at the 100-KR-4 Operable Unit:

- Chromium — 0.09**
- Nitrate — 0.30**
- Strontium-90 — 0.13**
- Tritium — 0.26**
- Trichloroethene — 0.03**

2.3.1 Groundwater Contaminants

Chromium has been identified as a contaminant of concern in the 100-KR-4 Operable Unit that warrants interim remedial action (ROD 1996a). Where groundwater containing chromium discharges into the river environment, there exists a potential risk of harm to aquatic life. A pump-and-treat system currently operates to reduce the concentrations and total mass of chromium in groundwater in part of the operable unit. Other contaminants of potential concern in the operable unit include carbon-14, nitrate, strontium-90, technetium-99, trichloroethene, and tritium. These constituents are being monitored while source removal actions continue.

The following descriptions of contaminants refer to conditions at wells that monitor the uppermost hydrologic unit. Only one well exists in the 100-K Area that is completed to monitor conditions below the uppermost aquifer, and groundwater at that deep well is essentially contaminant free.

2.3.1.1 Chromium

Chromium was used in large quantities at each of the single-pass production reactor areas during the years of operation (1955 through 1971 for KE and KW Reactors). Sodium dichromate was added to reactor coolant as a corrosion inhibitor. The hexavalent form of chromium is fully soluble in water and is toxic to aquatic organisms and humans. The relevant Washington State standards are: 10 µg/L for aquatic organisms (measured as hexavalent chromium) and 100 µg/L (measured as total chromium) for drinking water supplies.

The distribution of chromium in groundwater beneath the 100-K Area during 2004 is shown in Figure 2.3-2. The contour shapes reflect the various source locations and the direction of plume migration inferred from water-table gradients.

Chromium Beneath 116-K-2 Trench. The largest area of chromium contamination is associated with the 116-K-2 trench, which received large volumes of reactor coolant. The interpretation shown in Figure 2.3-2 assumes that chromium detected at well 699-78-62, which is east of the 100-K Area (Figure 2.3-1), was pushed inland by radial flow around a mound beneath the 116-K-2 trench during the operating years. (Note: If this assumption is incorrect, the area of contamination is considerably smaller.) The trench plume is the target of a pump-and-treat system intended to protect aquatic receptors in the Columbia River by extracting and treating groundwater (ROD 1996a), thus reducing the flux of chromium to the river ecosystem and the total amount of chromium in the environment. The system began operating in October 1997 (see Section 2.3.2).

Concentrations at wells that monitor the trench plume are typically <100 µg/L (the drinking water standard) and appear to be decreasing with time or remaining nearly constant, with exceptions at several locations. The decrease is a combined consequence of the pump-and-treat operation and natural attenuation by dispersion. Figures 2.3-3, 2.3-4, and 2.3-5 illustrate concentration trends for monitoring wells within this plume area.

Exceptions to the generally decreasing trend occur at wells 199-K-111A and 199-K-18, both located near the southwest edge of the plume, where concentrations have been increasing during recent years, although a leveling-off of the rate of increase appears to have started (Figure 2.3-4). The cause for these trends is believed to be related to the altered flow pattern in the area as a result of the extraction and injection of groundwater. Chromium concentrations are higher at aquifer tube site AT-K-3, compared to conditions immediately upstream and downstream along this segment of shoreline. It appears that an area of elevated chromium may be present in the region immediately south of well 199-K-18.

At the northeast end of the trench, chromium concentrations are gradually decreasing, though conditions at wells 199-K-37 and 199-K-130 suggest recently rising trends (Figure 2.3-5). Also, newly installed well 199-K-131, which is located ~300 meters northeast of well 199-K-130, revealed chromium concentrations that suggest the plume boundaries extend farther to the northeast than previously anticipated. Results from aquifer tubes for this part of shoreline indicated a gradually decreasing trend in concentrations (PNNL-14444).

Chromium Near KE and KW Reactors. Two additional areas contain elevated concentrations of chromium, although the extent of each is poorly defined. Near KE Reactor, a plume extends from the southeast side of the water treatment plant basins, where contaminated soil in the vicinity of a former sodium dichromate storage tank and railcar transfer station is the likely source (WHC-SD-EN-TI-239). Periodic events appear to remobilize chromium and create concentration changes in groundwater, as seen at well 199-K-36 (Figure 2.3-6). Leakage of clean water from the water treatment plant basins may provide the remobilization mechanism. Migration downgradient beyond the KE Reactor does not appear to have occurred, as shown by the low concentrations at well 199-K-23.

Near KW Reactor, elevated chromium concentrations are present at several wells, with the suspected source being sodium dichromate in the vadose zone at as yet 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

The largest area of chromium contamination is associated with past disposal to the 116-K-2 trench. Concentrations are decreasing or constant in most wells.

associated with the system used to add sodium dichromate to coolant makeup water. Figure 2.3-7 shows concentration trends for wells located within this plume. (Note that the abrupt drop in concentrations at well 199-K-108A in 1999 was caused by groundwater being diluted from an unknown clean water source.) Monitoring results from sites near the Columbia River (well 199-K-31, aquifer tube sites AT-K-1 and AT-17, and riverbank spring SK-063) do not show evidence that this plume has yet reached the river. However, newly installed well 199-K-132, which is located mid-distance between KW Reactor and the Columbia River, revealed a hexavalent chromium concentration of ~120 µg/L in samples collected during well development.

2.3.1.2 Tritium

Tritium was common in effluent discharged during 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 shielding water contained in the KE and KW Basins; the soil columns beneath the former reactor atmosphere 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 for this radionuclide is 20,000 pCi/L.

The distribution of tritium in groundwater beneath the 100-K Area during 2004 is shown in Figure 2.3-8. The contour shapes reflect several past and present source locations, as well as the direction of plume migration inferred from water-table gradients. The highest tritium concentrations are associated with the areas immediately downgradient of the 116-KE-1 and 116-KW-1 condensate cribs at each reactor. These cribs were excavated and backfilled with clean material during the period December 2003 to March 2004. Some contaminated soil remained at the bottom of the excavations. Because tritium is present in the shielding water of each fuel storage basin, concentrations in groundwater are closely monitored for evidence of shielding water loss to the ground (PNNL-14033). There is evidence to suggest that tritium releases from materials in the 118-K-1 burial ground are currently affecting groundwater, causing the area of groundwater contamination north of the burial ground (Figure 2.3-8).

Tritium Near KE Reactor. The plume shown in Figure 2.3-8 near KE Reactor has been formed by tritium 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 possible releases from the vadose zone beneath the 116-KE-3 drain field and associated catch tank (100-K-68 “D-sump”). The tritium distribution pattern reflects a coalescing of plumes from these sources and the timing of release from each source. The highest concentrations are immediately downgradient of the former 116-KE-1 crib. Recent trends for tritium and carbon-14 at a well near this source are shown in Figure 2.3-9.

Tritium concentration trends in wells most likely to detect shielding water loss to the ground from KE Basin are shown in Figure 2.3-10. The recent increases at wells 199-K-27 and 199-K-109A are unexplained, although there is no evidence from facility operations suggesting a significant loss of shielding water. Technetium-99, a second indicator of shielding water, has not been detected at these wells. The earlier increased concentrations at well 199-K-29 during the period 2001 to 2002 are believed to reflect the plume associated with the former 116-KE-1 crib.

Tritium Near KW Reactor. The tritium plume mapped near the KW Reactor is associated with effluent disposed to the former 116-KW-1 crib during the operating years. An unexplained increase in tritium concentrations at well 199-K-106A, located downgradient of the crib, began in 2001, abruptly peaked in 2003, and remained at elevated levels during 2004 (Figure 2.3-11). Other constituents showing a similar trend included nitrate and groundwater temperature. Carbon-14, which was disposed to the crib but is less mobile than tritium, did not follow the tritium trend. The cause for the recent change in the tritium trend at

The KE and KW condensate cribs, which were continuing sources for tritium in groundwater, were removed during FY 2004.

Recent variability in tritium concentrations observed near each reactor building do not have a clear explanation.

well 199-K-106A is presumed to be remobilization of contaminants at the 116-KW-1 crib and underlying soil column, although a driving mechanism has not been positively identified. Also, technetium-99 was detected at low concentrations (25 to 65 pCi/L) in samples from well 199-K-106A collected during peak tritium concentrations. The origin for technetium-99 at this location is unknown.

There is no evidence in groundwater data to suggest water loss to the ground from the KW Basin in recent years. Tritium concentrations in wells most likely to detect shielding water are shown in Figure 2.3-12. The groundwater concentrations are significantly lower than concentrations in KW Basin shielding water. The recent change in concentrations at well 199-K-34 has no obvious explanation, but trend changes of this magnitude have occurred in the past.

Tritium Near 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 (Figure 2.3-13). Since that time, concentrations have steadily declined and are currently at 13,900 pCi/L (July 2004). The next nearest downgradient monitoring well is 199-K-18, located ~450 meters downgradient of 199-K-111A. Tritium concentrations show a gradual rise at that well.

The source for the tritium near the burial ground was the subject of a detailed investigation during 2002 of groundwater movement and soil gas in the vicinity of the burial ground (PNNL-14031). The best explanation to date for the elevated tritium trend is that a tritium plume lies to the east of the well, i.e., beneath the burial ground. This plume may have been displaced to the west under the influence of the groundwater mound that has formed beneath the pump-and-treat injection site (see water-table contours in Figure 2.3-1). Supporting this idea is (a) the pattern of groundwater movement inferred from water-table gradients, (b) gradually increasing chromium concentrations as the pump-and-treat plume shifts somewhat to the west (Figure 2.3-4), and (c) the absence of other constituents that would identify known tritium sources.

An additional soil-gas survey was conducted during 2003 along the perimeter of the burial ground on the side closest to the river (PNNL-14548). Soil gas was analyzed for helium isotopes (helium-3 is a decay product of tritium). An excess of helium-3, as compared to ambient air amounts, was measured at all sites, indicating the nearby presence of tritium. The pattern of isotope ratios suggests the likelihood of a tritium source in the burial ground, along with an underlying groundwater plume.

Tritium Near 116-K-2 Trench. Groundwater downgradient of the trench typically contains low concentrations of tritium, i.e., <2,000 pCi/L. The exception occurs at the southwest end of the trench, where recent concentrations range between 42,000 and 65,000 pCi/L at wells 199-K-18 and 199-K-120A (a pump-and-treat system extraction well) during the past few years. The trend at well 199-K-19 has risen steadily since 1992. The source for this tritium is uncertain; it may represent past disposal to the 116-K-1 crib or possibly tritium from a source farther inland, such as a previously unidentified burial ground source.

Tritium is being re-introduced to the aquifer via injection of the effluent from the pump-and-treat system (see Figure 2.3-1 for location of injection wells). The average tritium concentration in effluent was 8,600 pCi/L (November 2004), and most of the tritium comes from extraction well 199-K-120A, where concentrations were ~50,000 pCi/L in 2004. Injected effluent appears to have started arriving at downgradient wells 199-K-119A and 199-K-125A as early as 2000, as shown by increasing tritium concentrations at those wells (Figure 2.3-14). Increasing trends are also present at nearby wells 199-K-116A and 199-K-127.

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

Tritium concentrations in groundwater near the 100-K burial ground have decreased markedly during the past 2 years.

building. Release of carbon-14 from the cribs, which were excavated and backfilled during 2004, was the source for the two carbon-14 plumes near each reactor. The drinking water standard is 2,000 pCi/L, which is exceeded at several wells that monitor these plumes. The half-life for carbon-14 is 5,730 years. The radionuclide exchanges with carbon in carbonate minerals, and so its movement is more restricted and variable than a non-retarded constituent like tritium.

The two plumes appear to be positioned between the crib source locations and the Columbia River. There is some evidence that the plume front in the region of the 116-KW-1 crib has reached the river; samples from aquifer tube 17-D have shown concentrations up to 680 pCi/L in the past, which is above background levels. Measured concentrations along the shoreline in the region of the 116-KE-1 crib are very low and likely to be representative of background levels. Current concentrations of carbon-14 in groundwater at wells immediately downgradient of each crib are shown in Figures 2.3-9 and 2.3-11. Near the 116-KE-1 crib, the concentration is ~6,900 pCi/L and near the 116-KW-1 crib, ~15,300 pCi/L.

Carbon-14 has also been detected in an area upgradient of the 116-KW-1 condensate crib, at well 199-K-108A. Concentrations exceeded the drinking water standard during the mid-1990s, with monitoring results relatively constant at ~4,000 pCi/L. During 2000, groundwater at this location became diluted by clean water from an unknown source, and contamination indicators were dramatically reduced in concentration. During 2004, it appears as though the dilution by clean water has stopped, and monitoring data suggest a return to pre-diluted conditions has started.

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/injection wells during the reactor operating period. Strontium-90 is currently 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, which is based on a radiological dose rate. If strontium-90 is the only beta-emitting radionuclide present in a groundwater sample, the associated gross beta concentration will be approximately twice that for the strontium-90 concentration.

Strontium-90 Near the KE and KW Reactors. 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. Concentrations declined following the peak, and since 2002, have remained variable within the range of several hundred up to ~2,400 pCi/L (Figure 2.3-15). The elevated gross beta concentrations also observed in groundwater at this location appear to be caused primarily by strontium-90. The elevated concentrations during the period 1996 through 2000 correlate with a period of sustained high water-table conditions (see hydrograph on Figure 2.3-15), which may have remobilized strontium-90 that remains in the soil beneath the 116-KE-3 drain field. Infiltration of water from leaking fire hydrant utility lines during this time period may also have contributed to flushing residual contamination from the vadose zone beneath the former drain field (PNNL-12023).

Strontium-90 concentrations are lower at equivalent locations near KW Reactor and during 2004 continued to range from 20 to 50 pCi/L, with essentially constant trends. Leakage from hydrant utility lines has not been observed near the northwest corner of the KW Basin and adjacent drain field. There are indications at well 199-K-107A of temporarily elevated levels during the high water-table conditions in 1996 and 1997, based on gross beta measurements.

Strontium-90 Near the 116-K-2 Trench. The effluent disposed to the 116-K-2 trench contained strontium-90, which is still present in groundwater affected by trench operations.

Strontium-90 was apparently remobilized during the 1990s by high water-table conditions, and possibly by infiltrating water, thus affecting underlying groundwater.

The highest concentrations are generally <40 pCi/L and limited in areal extent; most observed concentrations are near or below the 8-pCi/L drinking water standard. Also, most concentration trends indicate a gradual decline.

2.3.1.5 Other Constituents

Nitrate is widely distributed beneath the 100-K Area; potential sources include currently active septic systems and past-practices waste sites. The distribution patterns do not clearly delineate specific source sites. Nitrate exceeds the 45-mg/L drinking water standard in some areas. Concentration trends vary depending on monitoring location; the cause for the variability is likely to be shifts in plume position because of groundwater flow.

Trichloroethene has been detected at wells 199-K-106A and 199-K-33, which are located downgradient of the 116-KE-1 crib, at concentrations above the 5-µg/L drinking water standard. Concentrations in FY 2004 continued at ~10 µg/L, although trends at both wells suggest gradually decreasing concentrations. A replacement well for 199-K-33, which was decommissioned in June 2003, was installed in July 2004; analytical data for samples from this new well (199-K-132) are not yet available.

In the past, several metals have been measured in filtered samples at concentrations above the drinking water standard (e.g., aluminum, iron, manganese, and nickel). These occurrences have not been positively connected to waste sites or waste streams. They are not considered contaminants of concern because of (a) limited areal extent, (b) sporadic occurrence, and (c) possibility that their occurrence may be related to well construction and, therefore, not representative of groundwater conditions.

2.3.2 Interim Groundwater Remediation for Chromium

This CERCLA interim remedial action involves a pump-and-treat system designed to remove hexavalent chromium from groundwater in the region between the 116-K-2 trench and the Columbia River (DOE/RL-96-84). Hexavalent chromium poses a threat to aquatic organisms that use the riverbed substrate for habitat. Fall Chinook salmon, which spawn in riverbed gravels, are of particular concern in the Hanford Reach. As described in the record of decision (ROD 1996a), the protection standard for aquatic life is 11 µg/L as measured in riverbed substrate pore water. Because some dilution of contaminants by river water occurs along the pathway between the aquifer and riverbed substrate, the record of decision considers a value of 22 µg/L in near-river compliance wells as being protective of aquatic life.

The interim remedial action consists of a pump-and-treat system involving nine extraction wells, five injection wells, and an ion-exchange resin treatment system that removes hexavalent chromium from the extracted groundwater (DOE/RL-2004-21). The system began operating in October 1997. Performance monitoring of the pump-and-treat system is described in an interim remedial action monitoring plan (DOE/RL-96-90). Four wells, located between the extraction wells and the Columbia River, have been identified as compliance monitoring locations. Eight additional wells are used to help evaluate the performance of the system regarding aquifer conditions. Eleven aquifer tube sites located along the rivershore, which include four sites newly equipped during 2004, are also monitored. Lists of sampling frequencies and analyses performed are included in Appendix A.

The results of the interim remedial action for chromium are described in an annual summary report for each calendar year, which is prepared by

Nitrate and trichloroethene concentrations exceed drinking water standards in some 100-K Area monitoring wells.

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 identifies the cleanup goal at compliance wells as 22 µg/L.

the remedial action contractor (e.g., DOE/RL-2004-21). Highlights from the summary report for calendar year 2003 (the most recent report available), with updates for volumes treated and mass removed through September 2004, are presented in the following sections.

2.3.2.1 Progress During FY 2004

During the period October 1, 2003, through September 30, 2004, ~518.9 million liters of groundwater were extracted and treated, and 31.5 kilograms of chromium were removed. Since the startup of operations in October 1997, the total volume extracted is ~2.59 billion liters and total mass of chromium removed is ~244.3 kilograms. The yearly average flow rate for each extraction well ranges between 52 and 162 liters per minute, with a combined average flow rate of 995 liters per minute during 2003 (DOE/RL-2004-21).

A new monitoring well (199-K-131) was installed during FY 2004 to help define the northern extent of the plume. The first result for hexavalent chromium in groundwater at this well showed a concentration of 63 µg/L, which exceeds the remedial action goal of 22 µg/L for the interim remedial action. This result suggests that the chromium plume associated with the trench extends farther to the northeast than previously anticipated.

2.3.2.2 Influence on Aquifer Conditions

Chromium concentrations within the target plume area show generally decreasing trends, though two wells show distinctly increasing trends (Figures 2.3-3, 2.3-4, and 2.3-5). Strong decreasing trends are present at wells 199-K-20 and 199-K-117A. A more gradual decrease is indicated at well 199-K-114A, where groundwater is periodically diluted by river water. Increasing concentrations occur at wells 199-K-18 and 199-K-130. The cause for these increases is discussed in Section 2.3.1.1.

Concentrations at or below the remedial action goal (22 µg/L) for near-river wells are consistently observed only at well 199-K-117A. Chromium levels in compliance well 199-K-114A have fluctuated above and below the target level for several years, depending on river stage (Figure 2.3-3). As a result, well 199-K-114A will be converted to an extraction well in early FY 2005.

In addition to the pump-and-treatment system, other technologies are being considered for cleanup of groundwater contaminated by hexavalent chromium. A treatability test involving the injection of calcium polysulfide into the aquifer is scheduled for FY 2005 in the vicinity of well 199-K-126. While this technology has been used to remediate several chromium sites in the United States, it has not been applied at the Hanford Site. The calcium polysulfide acts to reduce hexavalent chromium in the aquifer by converting it to the less-toxic and less mobile trivalent form.

Chromium concentrations in aquifer tubes along the shore segment affected by the plume appear to have decreased with time, although the results are limited in number and are not adjusted for mixing with river water (PNNL-14444). When results are available for tube samples from several depths at a particular site, the deeper site typically shows the higher concentration, thus revealing the diluting effect of river water that infiltrates the riverbank during high river stage.

The injection of treated effluent at five wells has created a mound of uncertain magnitude on the water table. The injected treated effluent appears to have migrated downgradient as far as extraction wells 199-K-119A and 199-K-125A, as shown by the increasing tritium concentrations in those wells during recent years (Figure 2.3-14). Tritium is a good tracer for the effects of injection, as effluent concentrations are higher than in groundwater near most of the extraction wells. The mounding may also have caused the boundary of the chromium plume, and perhaps an unmapped tritium plume, to shift to the west, where the boundary(ies) may now be detected at well 199-K-111A (Figures 2.3-4 and 2.3-13).

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

Levels of chromium contamination appear to be generally decreasing in the area of the pump-and-treat system.

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 concentrations are increasing; and (3) height and extent of the mound created at the injection site.

2.3.3 Facility Monitoring: 100-K Basins

Basins within the KE and KW Reactor buildings have been used to store irradiated fuel from the last run of the 100-N Reactor, along with other miscellaneous fuel recovered during remedial actions at other reactor areas. As of fall 2004, all of this fuel has been removed, re-packaged, and moved to a better storage facility in the Central Plateau as part of the Spent Nuclear Fuels Project. Tri-Party Agreement (Ecology et al. 1989) Milestone M-34-00 covers the fuel removal and basin cleanup project. The following activities were accomplished during FY 2004:

- Completed removal of all irradiated nuclear fuel (~2,300 tons) in October 2004.
- Started removal of contaminated sludge (~50 cubic meters) at KE Basin in June 2004.
- Filled discharge chute at KE Basin with concrete in August 2004. Leakage via construction joints associated with this structure was the source of previous shielding water loss that impacted groundwater in 1993.

Groundwater Monitoring. Groundwater monitoring near the K Basins is conducted under a subtask within the groundwater project. The K Basins sampling and analysis schedule complements schedules associated with the 100-KR-4 Operable Unit. The monitoring plan (PNNL-14033) describes the objectives for the subtask:

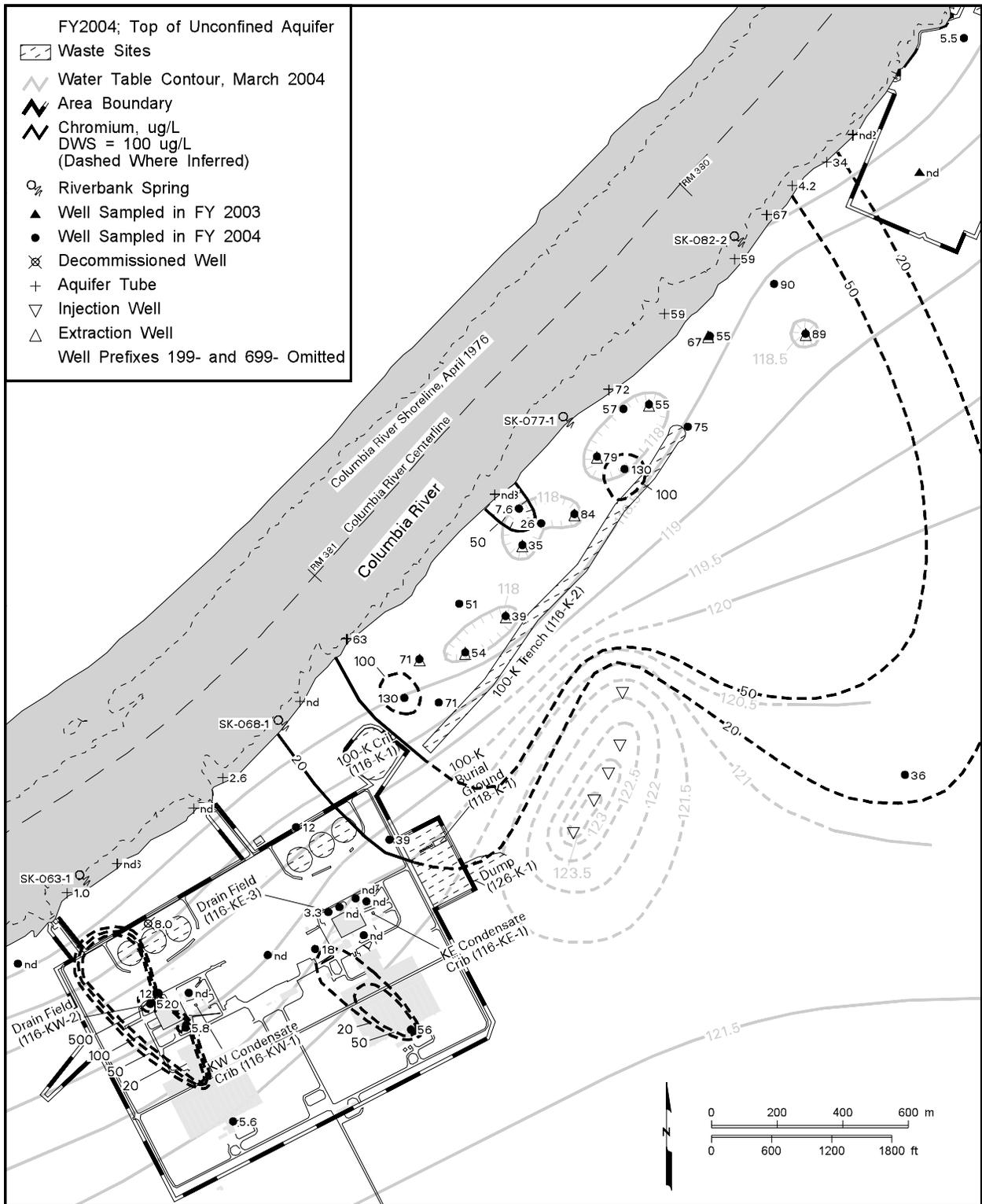
- Characterize groundwater conditions between the K Basins and the Columbia River to provide a periodic status of current conditions and the attenuation of plumes.
- Distinguish between groundwater contamination associated with K Basins and contamination from other past-practices sources to help guide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

The primary indicator for detecting shielding water in groundwater is tritium, which is present at concentrations in the millions-of-picocuries range in the KE and KW Basins. 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, these contaminants might not show up in groundwater because they would be retained in the vadose zone. One additional tracer for shielding water is technetium-99, which is mobile, like tritium, but is at relatively low concentrations in shielding water. Therefore, it might not be apparent in groundwater if only small volumes of basin water are involved.

Recent Monitoring Issues. In January 2003, tritium concentrations increased at wells 199-K-27 and 199-K-109A, which are located adjacent to the KE Basin on its northwest side (see Figure 2.3-1 for locations and Figure 2.3-10 for concentration trends). There has been no unexplained loss of water from the basin to account for the trend changes in groundwater. However, it is possible that very low rates of loss from the basin to the ground might not be detected by basin volume monitoring and that a relatively small volume of shielding water could account for the trend changes seen in groundwater. Other past-practices disposal sites are located in the area but are not in the direct groundwater flow paths monitored by these wells.

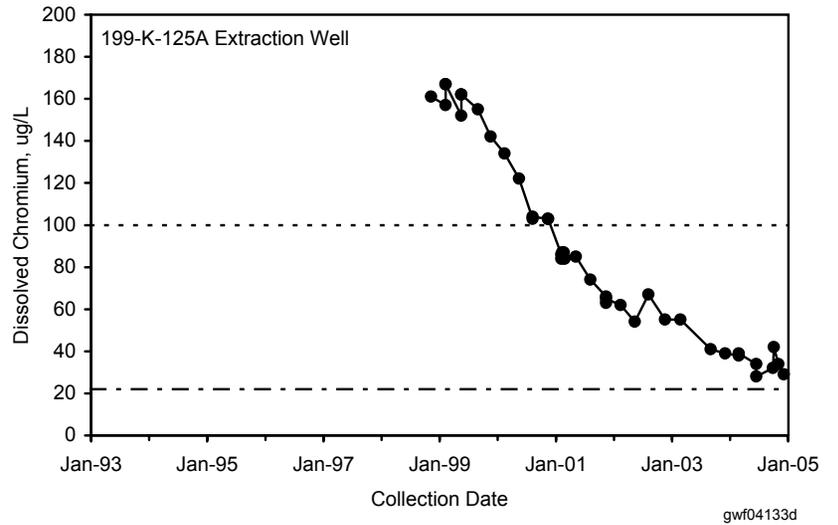
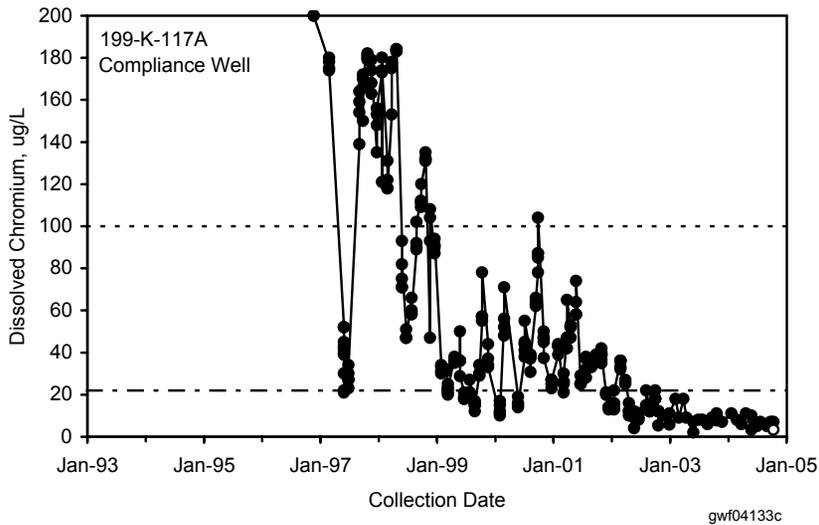
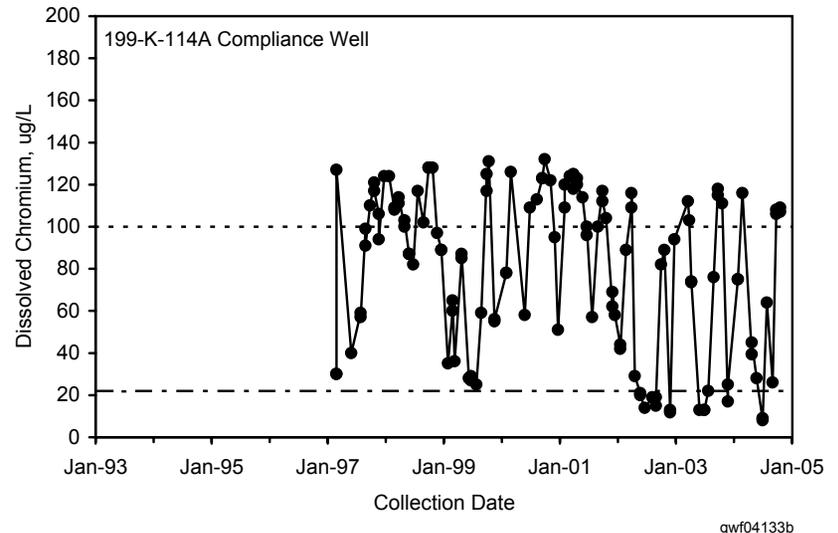
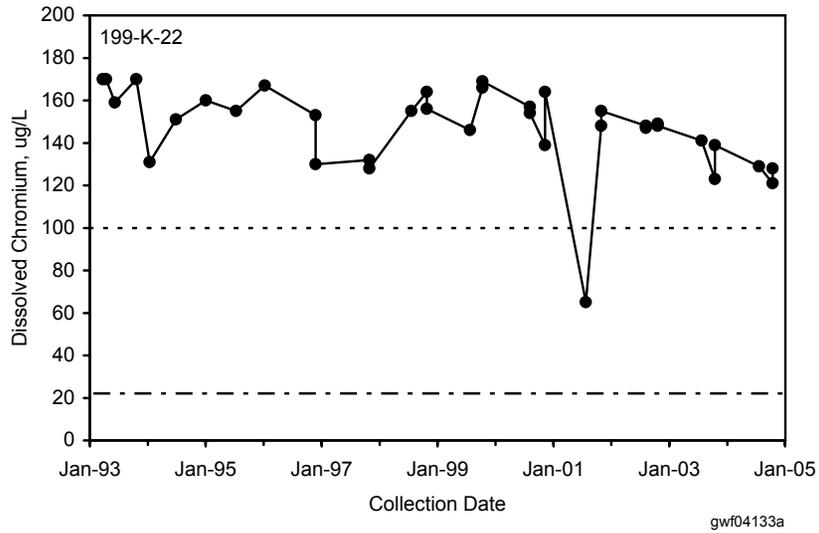
Near the KW Reactor, tritium concentrations at a well downgradient of the former 116-KW-1 condensate crib have been rising gradually since 2001, with a sharp peaking in mid-2003 (see Figure 2.3-11). The source for the tritium is believed to be the vadose zone beneath the former crib, and is not related to water loss from the KW Basin.

All spent fuel has been removed from the K Basins. Work to remove radioactive sludge is underway.



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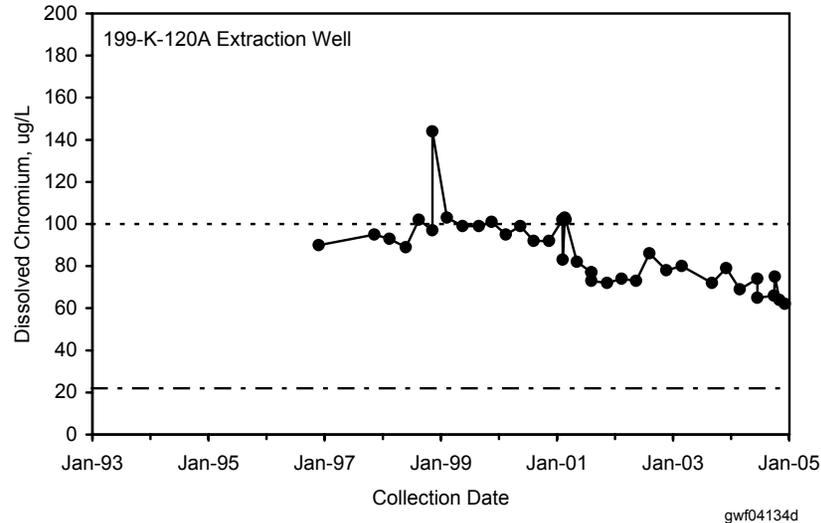
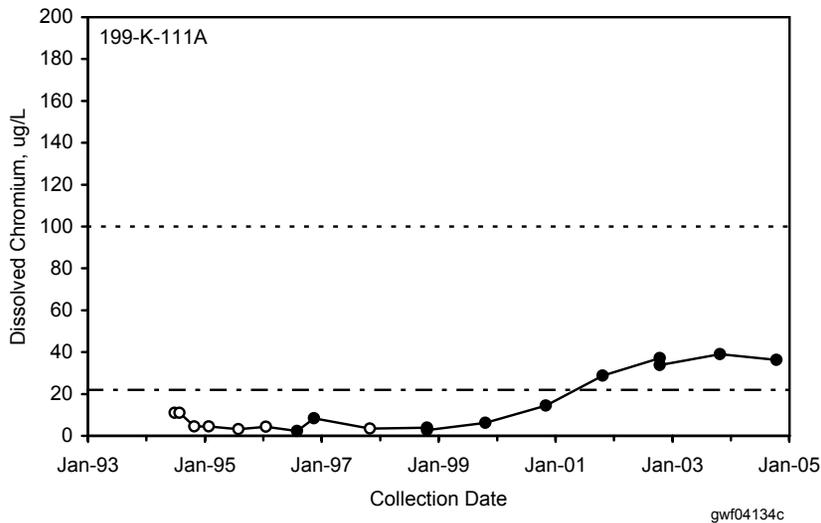
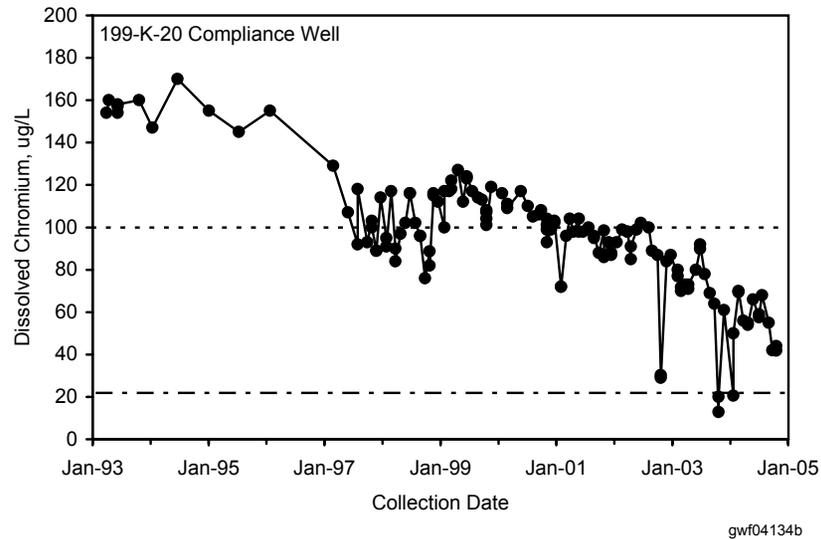
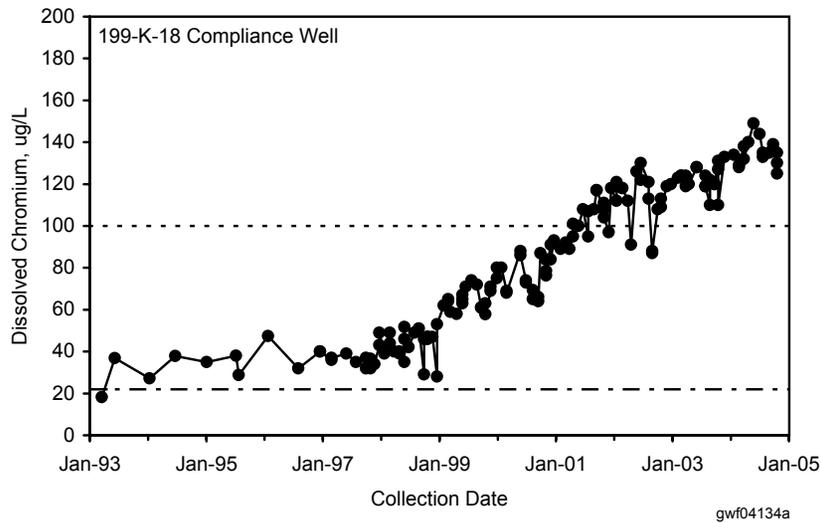
Figure 2.3-2. Chromium Distribution in 100-K Area Groundwater, FY 2004



----- DWS - - - - Remedial Action Goal

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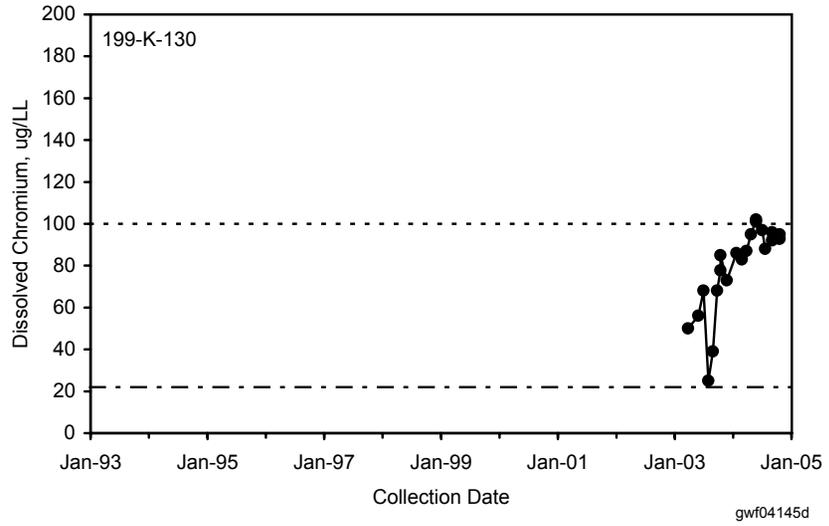
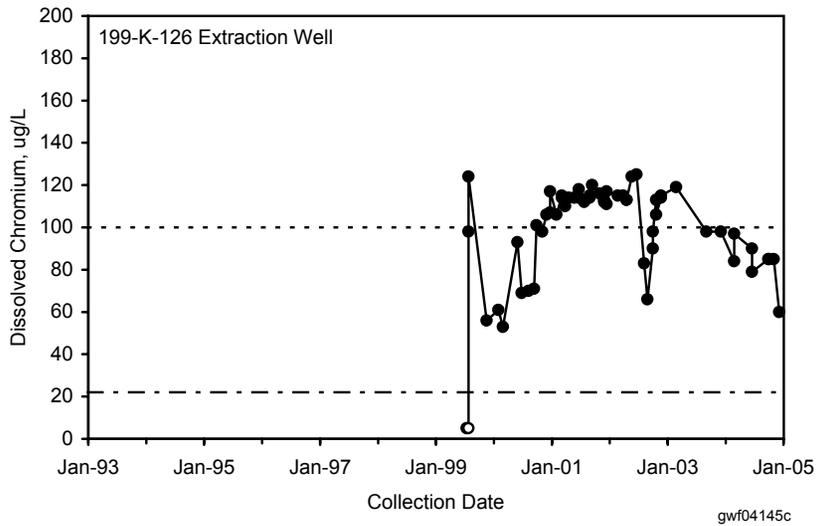
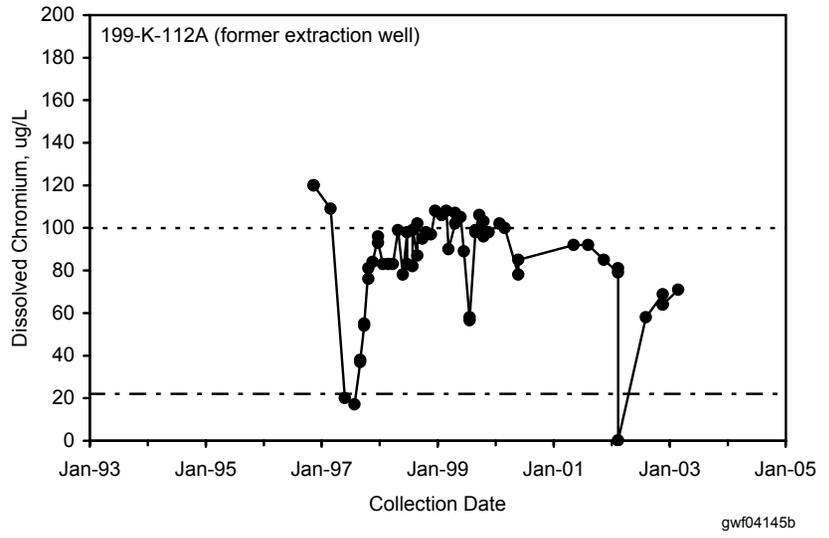
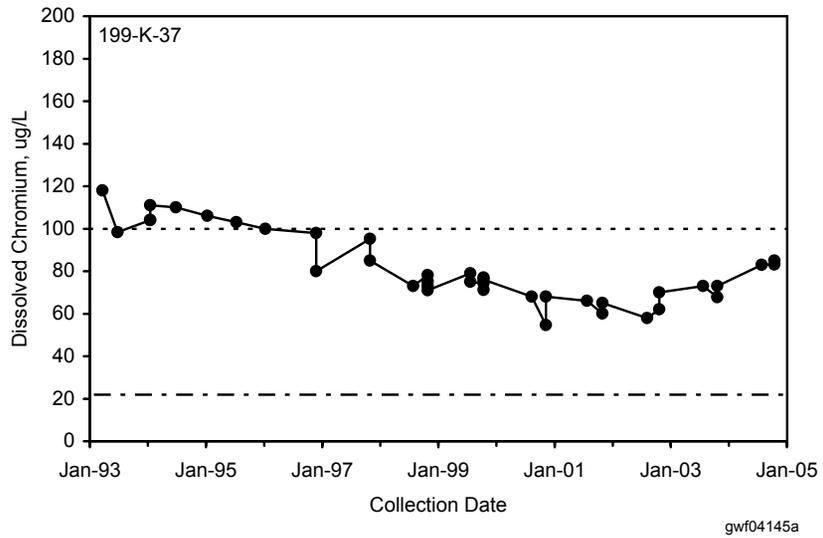
Figure 2.3-3. Chromium Concentrations in Wells Located in the Central Portion of the Interim Remedial Action Plume



- - - - - DWS - - - - - Remedial Action Goal
 Open symbols used for non-detect values

gwf04134

Figure 2.3-4. Chromium Concentrations in Wells Located at the Southwest Edge of the Interim Remedial Action Plume



- - - - - DWS - - - - - Remedial Action Goal
 Open symbols used for non-detect values

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Figure 2.3-5. Chromium Concentrations in Wells Located at the Northeast Edge of the Interim Remedial Action Plume

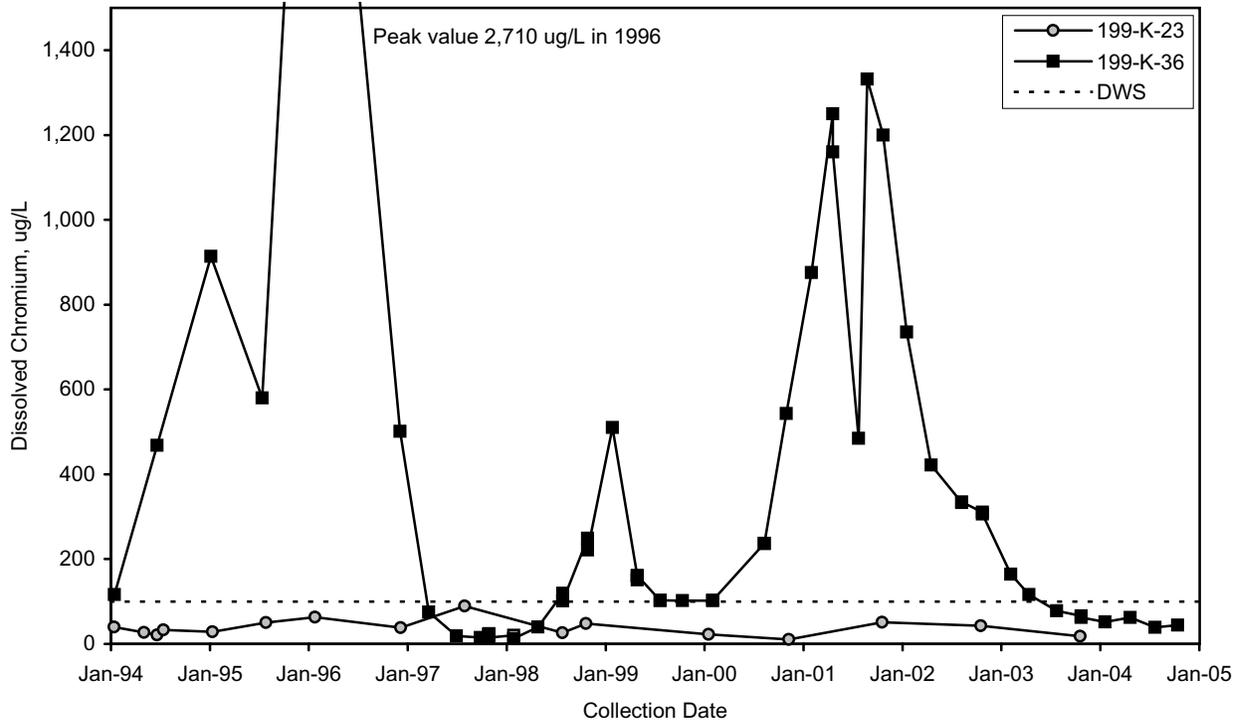


Figure 2.3-6. Chromium Concentrations Near KE Water Treatment Plant Basins

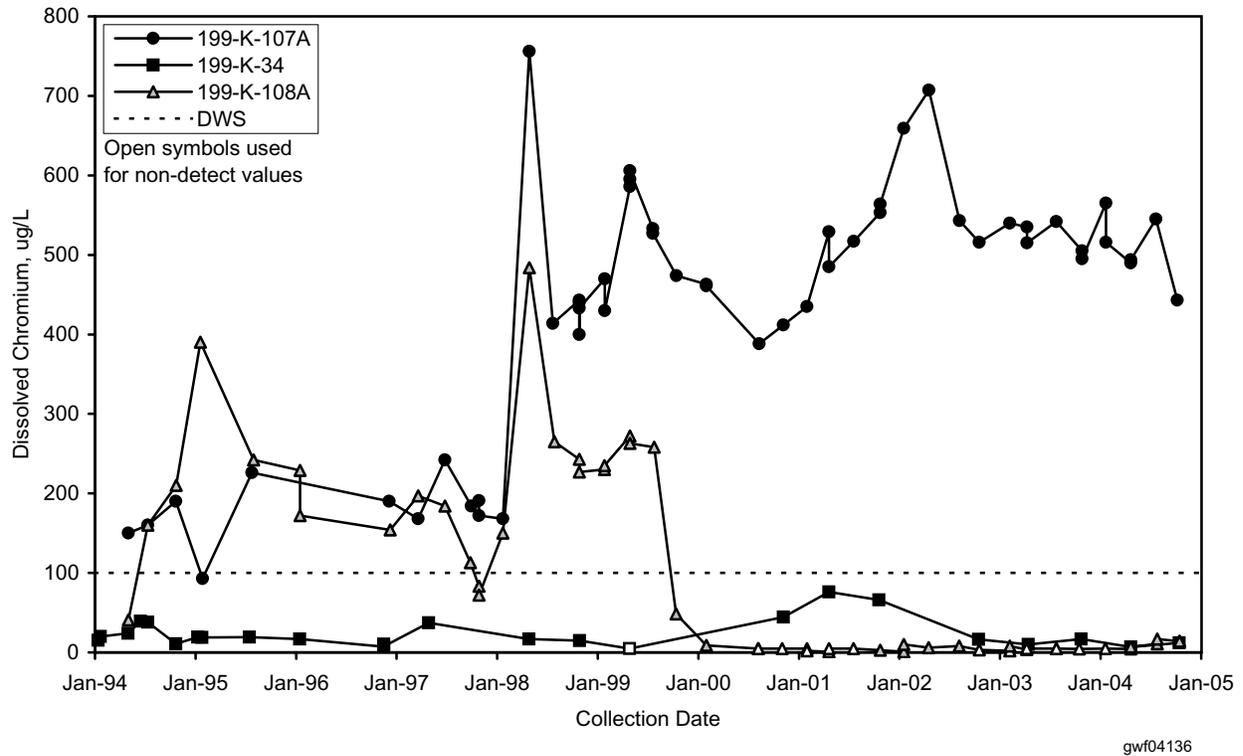


Figure 2.3-7. Chromium Concentrations Near KW Reactor

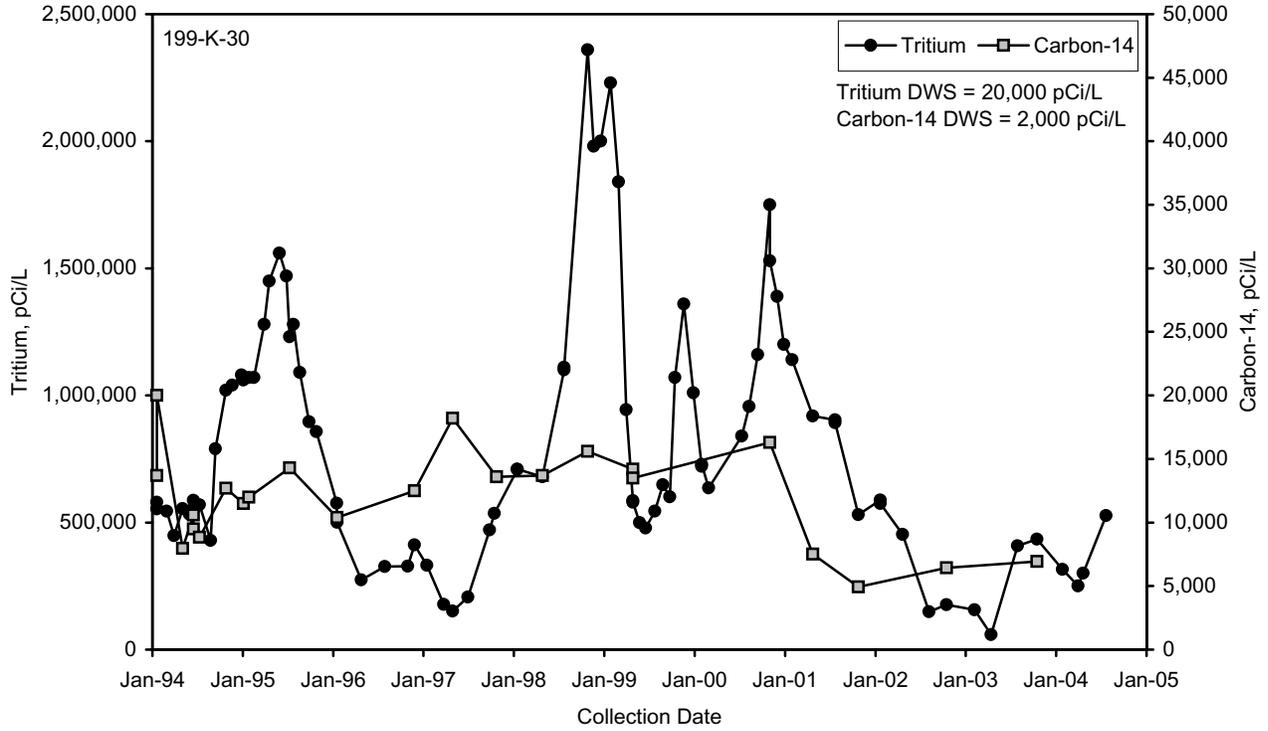


Figure 2.3-9. Tritium and Carbon-14 Concentrations Near the 116-KE-1 Crib

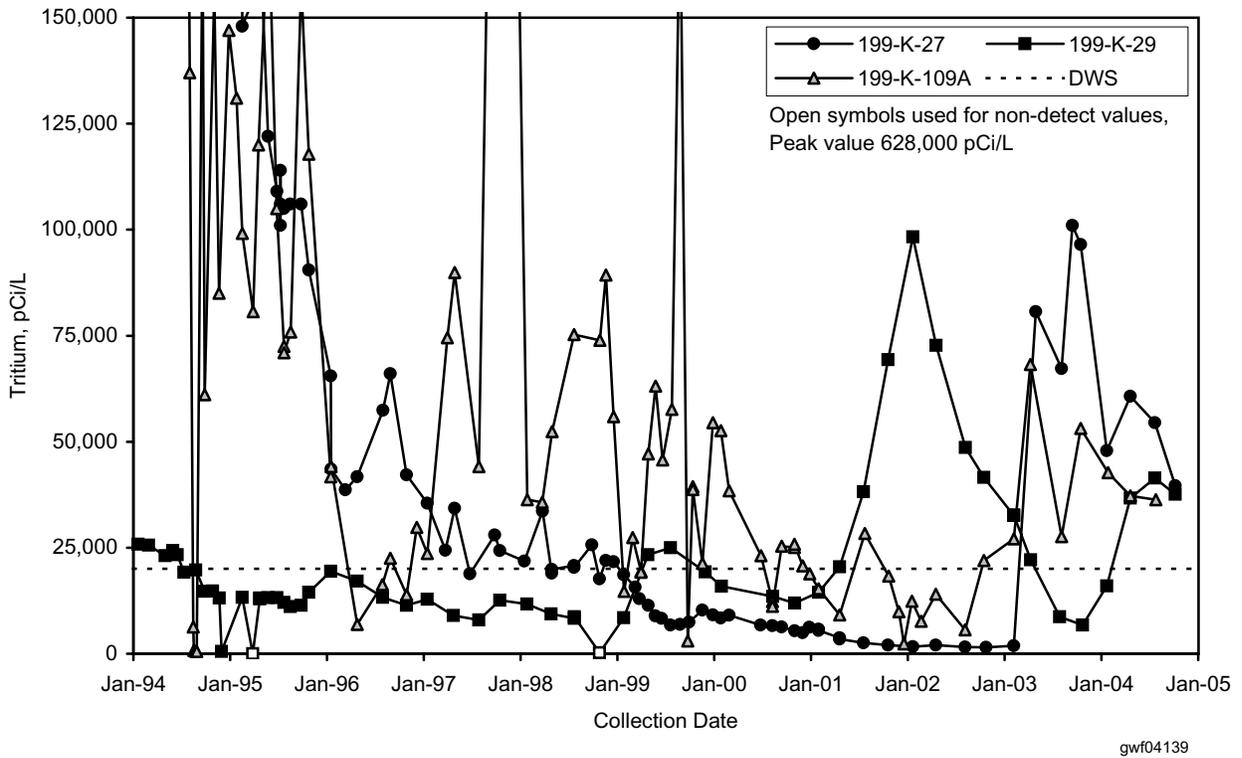


Figure 2.3-10. Tritium Concentrations Near KE Basin

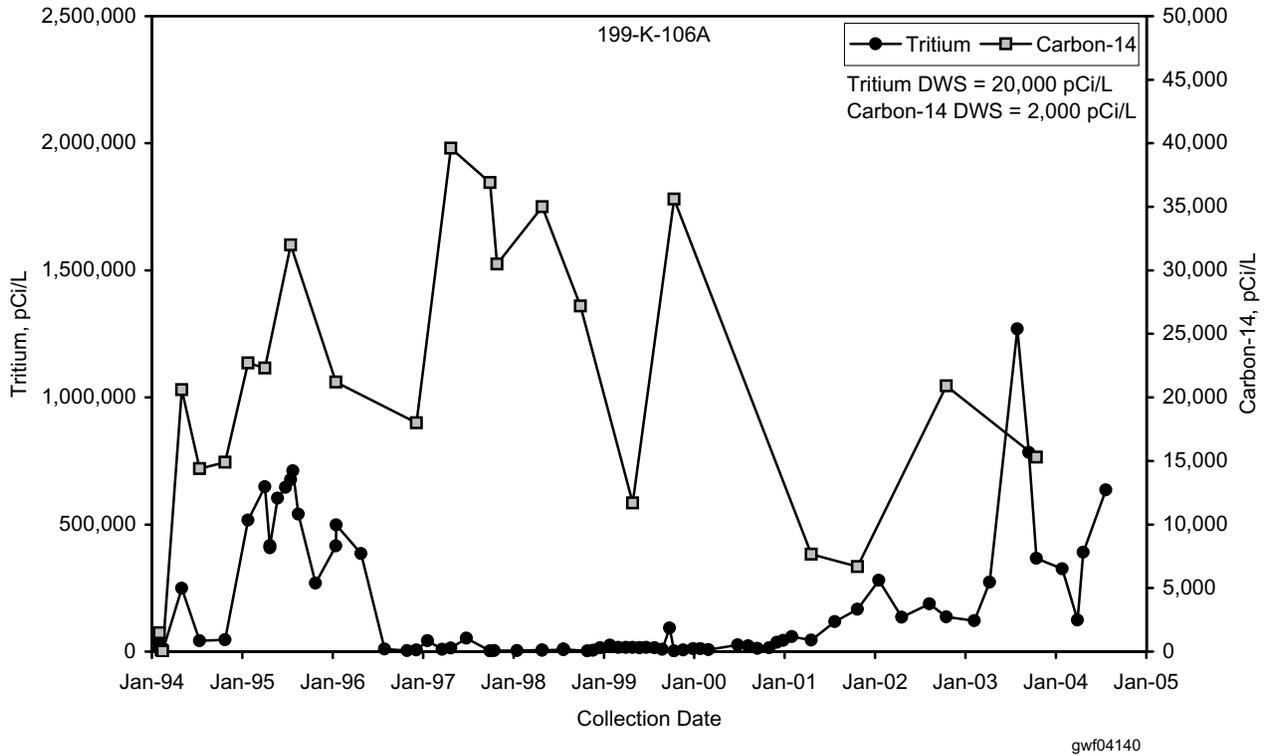


Figure 2.3-11. Tritium and Carbon-14 Concentrations Near the 116-KW-1 Crib

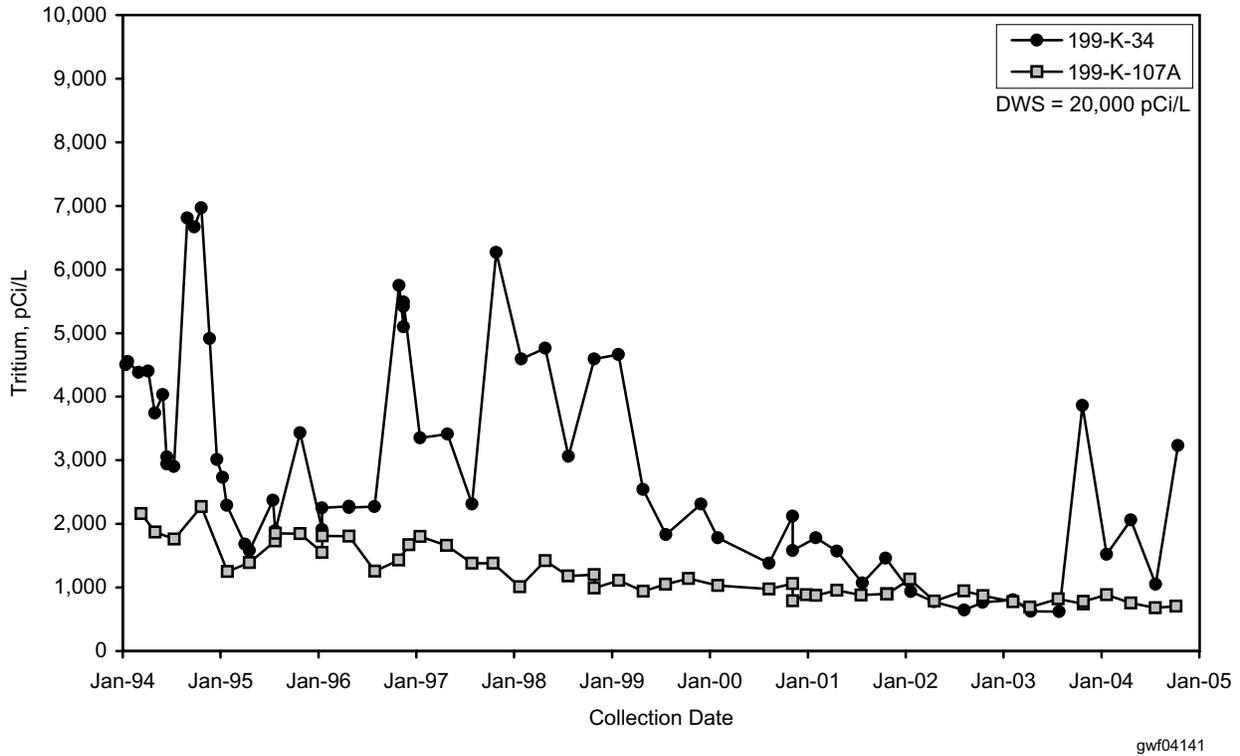


Figure 2.3-12. Tritium Concentrations Near KW Basin

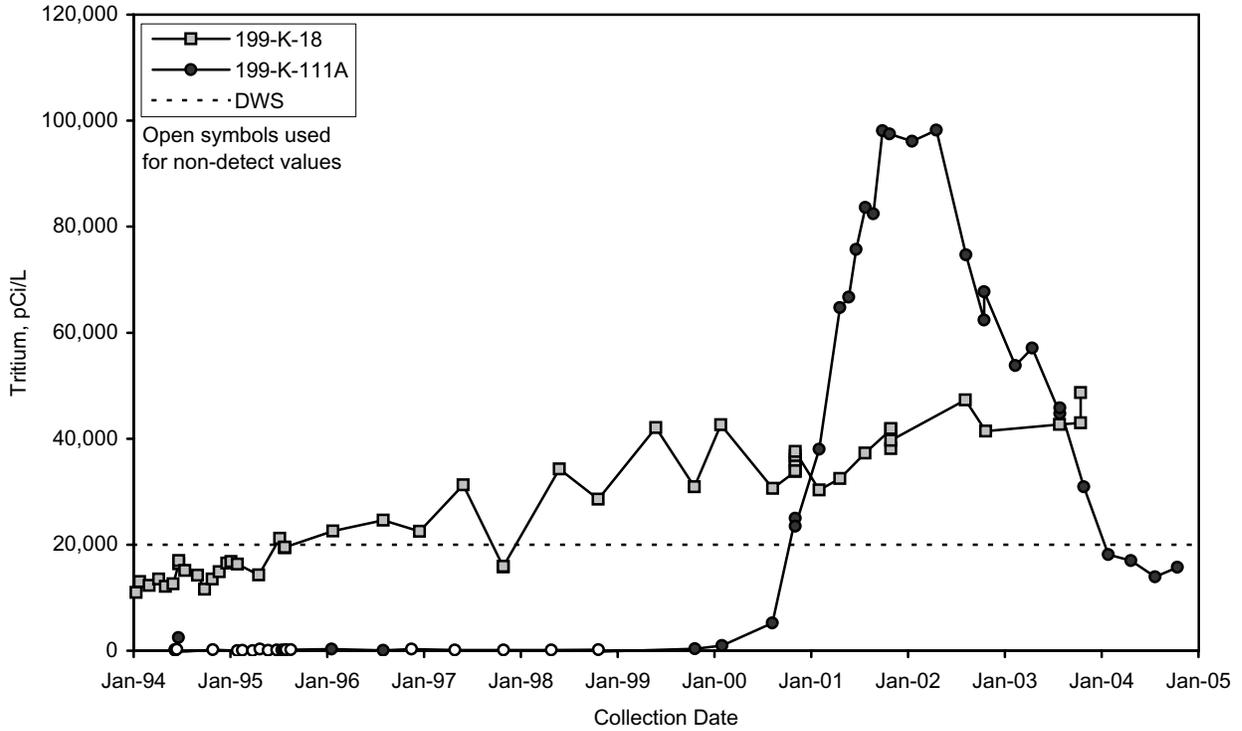


Figure 2.3-13. Tritium Concentrations Near 118-K-1 Burial Ground

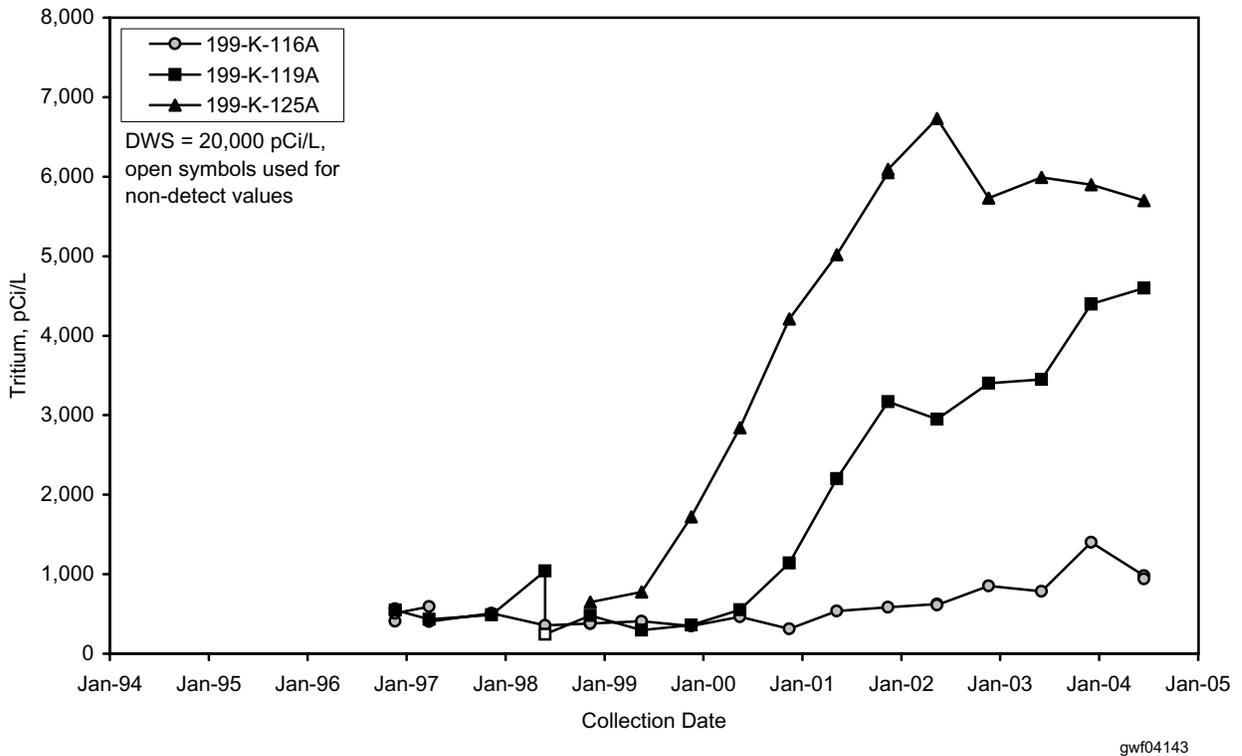


Figure 2.3-14. Tritium Concentrations in Wells Downgradient of the Pump-and-Treat Injection Site

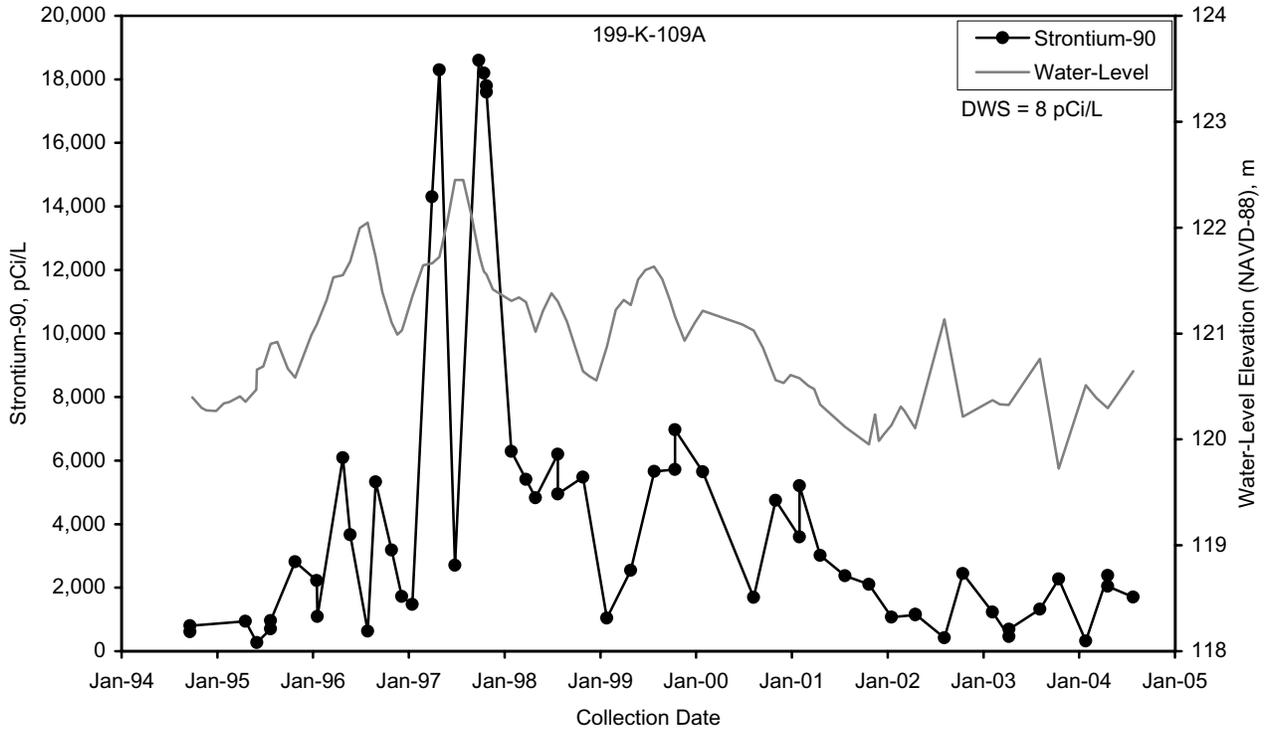


Figure 2.3-15. Strontium-90 Concentrations and Water-Table Elevation Near KE Basin