2.3 100 K Area

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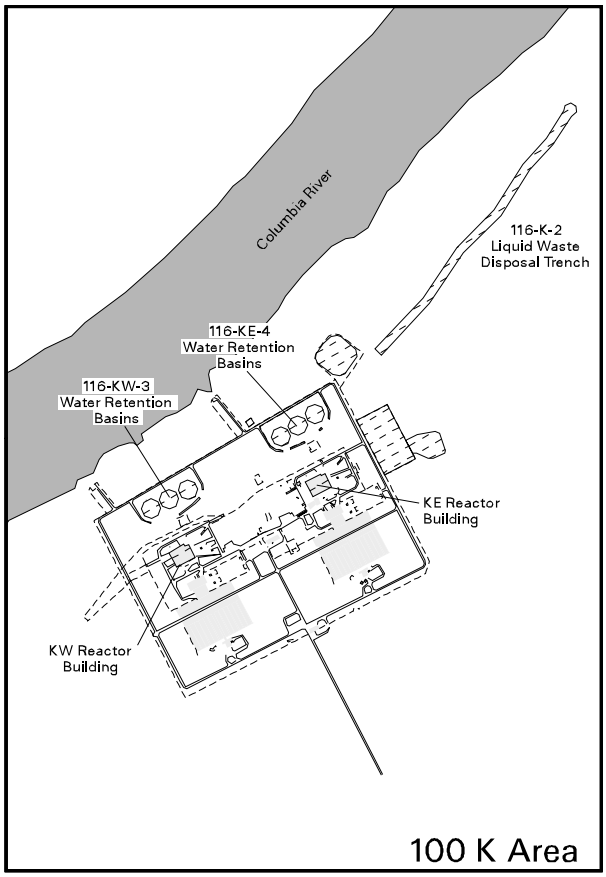
The KE and KW reactors were the largest of the original group of eight production reactors. They operated between 1955 and 1971. The 116-K-2 liquid waste disposal trench, which received used reactor coolant and decontamination solutions, was the largest soil column disposal facility in the 100 Areas.

The principal issues associated with groundwater contamination in the 100 K Area today involve a chromium plume located near the Columbia River; operating facilities that contain highly radioactive liquid and sludge; and carbon-14, strontium-90, and tritium contamination from past-practice disposal sites. An interim remedial action is in progress to reduce the amount of chromium reaching the Columbia River via groundwater flow. Removal of spent nuclear fuel, shielding water, and sludge from the 100-K Fuel Storage Basins is a top priority project for the Hanford Site and work is underway.

There are several potential sources of contamination that may add to existing groundwater plumes or create new plumes. These sources include locations where the vadose zone contains significant inventories of radionuclides from past disposal practices and the potential loss of shielding water and sludge from the KE and KW Fuel Storage Basins, located in the reactor buildings.



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Monitoring Objectives in 100 K Area

Groundwater monitoring is conducted in the 100 K Area:

- annually to describe the nature and extent of contamination in support of environmental restoration decisions
- monthly near the KE and KW Fuel Storage Basins to detect potential leakage
- various time intervals to evaluate the performance of the pump-and-treat system for chromium.

Additional information on current groundwater issues at the 100 K Area is available on the Internet at http://pnl45.pnl.gov/100k or at http://hanford.pnl.gov/groundwater. Information on the history of operations and waste sites at 100 K Area is presented in the technical baseline report for the 100-KR-4 Operable Unit (WHC-SD-EN-TI-239).

2.3.1 Groundwater Flow

Groundwater movement beneath the 100 K Area is generally toward the north-northwest, as suggested by contours for the water-table elevation (see Plate 2). The unconfined aquifer is contained within the gravelly sediment of Ringold Formation Unit E, which is generally considered a transmissive aquifer. Groundwater flow velocity in this aquifer between the reactors and the Columbia River is estimated to be between 0.01 and 0.4 meter per day (WHC-SD-EN-AP-174). The estimate assumes a hydraulic conductivity in the range 0.95 to 16 meters per day; gradients in the range 0.003 to 0.005; and an effective porosity of 0.2. Using a representative rate of 0.3 meter per day, a travel time of ~4 years is indicated for the pathway between the reactors and the river. In the vicinity of the 116-K-2 liquid waste disposal trench, the extraction and injection of water as part of the interim action pump-and-treat system influences the direction and rate of groundwater movement in the immediate vicinity of the associated wells (Section 2.3.9).

Because monitoring wells in the 100 K Area do not provide complete coverage, the configuration of the water table cannot be accurately described in some areas. Although the general direction of groundwater flow is fairly clear, the fine-scale details for direction and rate of flow between known sources and the Columbia River are less well understood. Also, the presence of engineered backfill and heterogeneity in hydraulic properties of the aquifer sediment contribute to uncertainty in describing pathways for contaminant transport. Near the river, flow rate and direction vary considerably in response to the fluctuating river stage.

In addition to lateral groundwater movement in response to the hydraulic gradient, there is also vertical movement in response to the fluctuating Columbia River stage. The water table typically moves up and down through a range of ~2 meters in wells located within several hundred meters of the Columbia River, decreasing to a range of ~0.3 meter in the 100 K Area wells located farthest inland (BHI-00917). Water-level fluctuations in these wells are even greater during years of extremely high river discharge (e.g., 1996 and 1997). The vertical movement of the water table may cause remobilization of contaminants held in the normally unsaturated vadose zone (PNNL-12023).

During the operating years 1955 to 1971, a large mound was created beneath the southwestern end of the 116-K-2 liquid waste disposal trench (HW-77170). The mound created a radial flow pattern that modified the flow field beneath the entire 100 K Area. The influence of the mound can be seen in historical monitoring trends for well 699-78-62, which is located ~1,600 meters inland from the trench (Figure 2.3-1). The gross beta contamination in this well is believed to be the result of groundwater flow reversal caused by the mound. The implication of the mound with respect to current groundwater conditions is that residual contaminated moisture from the previously saturated mound areas continues to slowly migrate downward to the water table, thus contributing to groundwater plumes.

2.3.2 Chromium

Chromium was introduced to 100 K Area groundwater from multiple sources. Infiltration of reactor coolant that contained 700 µg/L hexavalent chromium created the most widespread contamination because of mounding beneath the 116-K-2 liquid waste disposal trench. Additional sources include leakage and/or spillage of sodium dichromate stock solutions near rail-car transfer stations, storage tanks, and mixing facilities during the water treatment process. By early 1971, these sources no longer contributed to contamination and the nearly 30 years of groundwater movement since then have allowed the original plumes to disperse. The hexavalent form of chromium is highly soluble in groundwater as chromate (CrO_3^-) and moves at the same speed as groundwater because the anions are not sorbed significantly to the sediment.

The current distribution of chromium in 100 K Area groundwater is shown in Figure 2.3-2. Three areas of concern are apparent: (1) a large area of contamination between the 116-K-2 liquid waste disposal trench and the Columbia River, (2) a smaller area centered on the KW Reactor, and (3) an area near the 183-KE water treatment plant. The first area is the target plume for interim remedial action using a pump-and-treat system (DOE/RL-99-13). Chromium concentrations in this plume typically range from 75 to 150 µg/L, which is only slightly above the 100-µg/L maximum contaminant level for drinking water supplies. However, these concentrations are significantly above the 11-µg/L standard set by Washington State for the protection of freshwater aquatic organisms (WAC 173-201A-040). The concentration trends in this plume are described further in the section on groundwater remediation (Section 2.3.9).

The 100 K Area has three areas of chromium contamination: a plume between the 116-K-2 trench and the Columbia River and two smaller areas of contamination near the reactor buildings.

In the second area of concern, i.e., near the KW Reactor, concentrations range between 200 and 600 µg/L as illustrated in Figure 2.3-3. The specific source for the chromium in this plume is not known, though the source is likely to be leakage and/or spillage of sodium dichromate stock solution in upgradient areas. One potential site is the railcar transfer station and storage tanks located at the southeastern side of the 183-KW water treatment plant. A second potential source area is the vicinity of the coolant storage clearwells located on the southeastern side of the KW Reactor.

The western extent of this plume is uncertain because monitoring wells do not cover that area. The plume does not appear to have reached the Columbia River because similar concentrations are not observed in wells 199-K-31 and 199-K-33, which are located between KW Reactor and the Columbia River (Figure 2.3-3). The increasing trends in wells 199-K-107A and 199-K-108A suggest plume movement in this area. The travel time between KW Reactor and well 199-K-33 has been estimated at between 1.6 and 4.9 years, depending on the assumed groundwater flow rate (WHC-SD-EN-TI-280, Rev. 0). Additional near-river sites are available to monitor the arrival of this plume. They include aquifer sampling tubes (BHI-01153) and riverbank seepage sites near the KW water intake structure.

The third area of chromium contamination appears to originate near well 199-K-36, located at the southeastern end of the 183-KE water treatment plant. In the previous annual groundwater report (PNNL-12086), relatively high chromium concentrations were reported for samples from this well, with a maximum value of 2,710 µg/L on January 16, 1996. The source for the chromium is most likely past leaks or spills of sodium dichromate stock solution during railcar transfer operations and from storage tanks located near that well. Remobilization of sodium dichromate from the vadose zone may occur in association with water leakage from the nearby KE filter plant. Chromium concentrations in well 199-K-36 averaged 210 µg/L during fiscal year 1999.

2.3.3 Strontium-90

Strontium-90 is not distributed widely in 100 K Area groundwater, though there are several waste sites where contamination in the vadose zone is expected, thereby creating a potential source for future groundwater contamination. Strontium-90 contamination is anticipated wherever liquid effluents associated with irradiated nuclear fuel were disposed. The principal sites for soil column disposal were the 116-K-2 liquid waste disposal trench and the fuel storage basin drain fields/injection wells associated with each reactor. The radionuclide is adsorbed onto sediment particles in the vadose zone and aquifer. It is considered a moderately mobile radionuclide in groundwater and has a radioactive decay half-life of 29.1 years. The drinking water standard is 8 pCi/L.

The current levels of strontium-90 contamination between the 116-K-2 liquid waste disposal trench and the Columbia River range up to a maximum near 50 pCi/L (well 199-K-21). Trends for two wells are illustrated in Figure 2.3-4. The radionuclide is a co-contaminant with chromium in this area. However, it is not removed by the ion exchange resin that removes chromium from extracted groundwater and is, therefore, returned to the aquifer via the injection wells. Strontium-90 analyses on treated effluent revealed concentrations of 3.83 and 4.1 pCi/L during the period February 1, 1998, and December 31, 1998 (DOE/RL-99-13).

Near the KE Reactor, samples from well 199-K-109A reveal a variable trend in strontium-90 levels. Figure 2.3-5 shows the historical trends, along with data for tritium concentrations. The source for the strontium-90 detected in this well has been previously identified as past-practice disposal to the nearby drain field/injection well (PNNL-12023). This facility (waste site 116-KE-3) received effluent from the basin that may have contained strontium-90 released from damaged fuel elements, as well as tritium. Increased infiltration of water from the surface, caused by leaking fire hydrant utility lines, apparently remobilized contamination held in the normally unsaturated vadose zone.

Strontium-90 is also elevated somewhat above the drinking water standard near the KW Reactor (Figure 2.3-6). Again, the suspected source is the adjacent drain field/injection well (waste site 116-KW-2).

2.3.4 Tritium

The distribution of tritium in 100 K Area groundwater is shown on Plate 3. The shapes of the contours drawn to describe the plumes for fiscal year 1999 have been modified somewhat compared to previous representations. The revised shapes reflect the most current information on groundwater flow direction and the presumed locations where tritium was (and still is) introduced to groundwater. These locations and their associated sources include

- northeastern side of each reactor building, where condensate from reactor atmosphere gas apparently continues to migrate downward through the soil column beneath the 116-KW-1 and 116-KE-1 cribs (carbon-14 is a co-contaminant with tritium in this effluent).
- past leakage from the KE basin; the most recent event occurred in 1993, and the plume moved north-northwest past well 199-K-27, but has apparently not yet arrived in downgradient wells 199-K-32A and 199-K-111A (Figure 2.3-7), or the plume is too small to be detected by the existing well network.
- past disposal to the 116-K-2 liquid waste disposal trench, which created a mound that left contaminated moisture in the vadose zone, when waste disposal ended in 1971.

The tritium distribution map for fiscal year 1999 shows contamination near the 116-K-2 trench as separate from the plume near the reactor buildings.

The source for the relatively high tritium concentrations in the vicinity of pump-and-treat extraction well 199-K-120A is not fully understood. One explanation is that residual vadose zone moisture containing tritium from past disposal to the 116-K-2 liquid waste disposal trench continues to feed a small groundwater plume in the vicinity of wells 199-K-18, 199-K-19, and 199-K-120A. An alternative explanation is that the tritium represents shielding water from the 116-KE-1 basin lost during the period 1976 to 1979, or alternatively, groundwater from beneath the 116-KE-1 gas condensate crib. However, if either of these sources is responsible, similar concentrations would be expected in wells along the pathway between those sources and

well 199-K-120A, (i.e., wells 199-K-18 and 199-K-19), which is not the case (Figure 2.3-8). Also, long-term water-level data do not suggest a gradient directed from the KE Reactor toward well 199-K-120A, so a circuitous route would be required to link the well to those sources.

A field sampling program was conducted during summer 1999 to determine whether a tritium plume in groundwater could be detected by analyzing soil gases sampled from the overlying vadose zone. A grid of locations was sampled in the 100 K Area that covered the general area north and east of the KE Reactor (see Figure 3.3-7). No tritium was detected in the soil moisture samples. Analyses for helium-3, which would indicate the presence of tritium in the underlying groundwater, also did not suggest the presence of a plume (Section 3.3.3).

2.3.5 Carbon-14

This radionuclide was included along with tritium in the condensate from reactor atmosphere gas that was disposed to the cribs located on the northeastern side of the KE and KW reactors (116-KE-1 and 116-KW-1). Carbon-14 disperses more slowly than does tritium because of interaction with carbonate minerals, so the distribution pattern is not exactly the same as for tritium (PNNL-12023). Unfortunately, the different geochemical characteristics for carbon-14 and tritium limited attempts to use the ratio of the two constituents as an exclusive indicator of effluent from these gas condensate cribs, though some patterns are evident (PNNL-12023).

The highest concentrations of carbon-14 are found in wells near and downgradient of the condensate cribs. Figure 2.3-9 illustrates the concentrations found in wells associated with the 116-KE-1 crib and Figure 2.3-10 illustrates concentrations associated with the 116-KW-1 crib. The derived concentration guide for this radionuclide is 70,000 pCi/L. The half-life is very long (5,730 years), suggesting that some of the existing plume will eventually be exposed at the Columbia River before it decays, although a portion will likely remain fixed in carbonate minerals.

2.3.6 Nitrate

Nitrate is widely distributed in groundwater beneath all the reactor areas. There are multiple sources that potentially contribute to the plumes, including past-practice disposal to the soil column of decontamination solutions, such as nitric acid (WHC-SD-EN-TI-239) and septic system drain fields. The maximum contaminant level is 45 mg/L. This level is exceeded in numerous 100 K Area wells. The fiscal year 1999 maximum observed value near the reactor buildings is ~175 mg/L (well 199-K-30) and near the 116-K-2 liquid waste disposal trench is ~130 mg/L (well 199-K-19).

Nitrate levels have been gradually rising in numerous wells in the 100 Areas for as yet unexplained reasons. There are no current operations that would account for the increase. Examples of changing concentrations in 100 K Area wells are presented in Figure 2.3-11. The prominent increase in nitrate that occurred in many wells during 1985 is also not fully understood.

2.3.7 Other Constituents of Interest

Three other constituents detected in one or two wells in the 100 K Area are discussed in this section.

2.3.7.1 Plutonium

During late May and early April 1999, scientists from Woods Hole Oceanographic Institute completed sampling at wells 199-K-27, 199-K-32A, 199-K-36, and 199-K-110A as part of a plutonium speciation study. The research is funded by the U.S. Department of Energy's (DOE) Environmental Management Science Program and is in its third year (EMSP Project No. DE-FG07-96ER14733). The research is a joint project between Woods Hole and Pacific Northwest National Laboratory. The purpose for the research is "...to study the association of actinides with dissolved organic complexes in subsurface waters."

These researchers analyzed groundwater from the 100 K Area in 1998. Because of the atom ratios, they concluded that the plutonium detected in the samples is

from a local source rather than from atmospheric fallout. The concentrations they report represent extremely small amounts of plutonium. For example, the largest value reported was 1.87 femtogram per liter for plutonium-239, which in units commonly used to report monitoring results equates to 0.00000000187 μg/L or 0.000116 pCi/L. The results for samples collected in April 1999 are expected by April 2000.

A specific analysis for plutonium is not performed during the periodic sampling events conducted at 100 K Area. The tools and methods used by the researchers to achieve their ultra-low detection levels are not practical for producing the quantity of environmental data typically used to support decisions. Other contamination indicators are monitored that would indicate the presence of plutonium at concentrations of environmental concern.

2.3.7.2 Trichloroethylene

This organic constituent is a minor contaminant of concern resulting from the past disposal/spillage of organic solvents. Two wells downgradient of the KW reactor building revealed samples containing trichloroethylene at levels above the 5 μg/L maximum contaminant level for drinking water supplies (Figure 2.3-12). Concentrations appear to be decreasing with time.

2.3.7.3 Nickel

Nickel has not been tracked as a contaminant of concern for human or ecological health reasons (BHI-00917). However, concentrations exceed the 100 μg/L maximum contaminant level in wells 199-K-36 and 199-K-110A. There is no obvious waste site source for nickel contamination and its occurrence is scattered. Nickel appears to be elevated only in relatively new monitoring wells, which have stainless steel casing and screens. Therefore, a sampling anomaly is suspected, perhaps the result of corrosion of the stainless steel (Hewitt 1994). There is a tendency for nickel concentrations to increase with increasing chloride concentrations in well 199-K-36 (Figure 2.3-13). A similar correlation is observed in well 199-K-108A (also stainless steel construction) between chromium and chloride concentrations, thus suggesting corrosion of the steel, which would be enhanced by the presence of chloride.

2.3.8 100-K Fuel Storage Basins Monitoring

The 100-K fuel storage basins are operating facilities that are used to store irradiated fuel elements from the N Reactor. The KE basin contains ~1,150 metric tons of fuel stored in unsealed canisters, while KW basin contains ~953 metric tons stored in sealed containers (HNF-SD-SNF-TI-009). Because of the unsealed containers and greater proportion of damaged fuel elements, the KE basin is the more contaminated facility.

A focused feasibility study is available that provides detailed information on the fuel, shielding water, and sludge, along with a description of alternatives for cleanup (DOE/RL-98-66, Rev. 0). Following this study, a proposed plan for interim remedial action at the basins was issued for public review and comment (DOE/RL-98-71, Rev. 0). Finally, a record of decision has been signed that describes the selected remedial action (ROD 1999a). Work began in fiscal year 1999 with equipment that will be used to move the fuel canisters. The schedule for activities is described under Tri-Party Agreement Major Milestone M-34-00A (Ecology et al. 1989).

The Hanford Groundwater Monitoring Project provides monitoring services to the Spent Nuclear Fuel Project in support of basin leak detection efforts. In addition, the groundwater project maintains baseline information on the characteristics of groundwater movement throughout the 100 K Area. A complete description of the monitoring strategy and data quality objectives for the 100-K fuel storage basins is presented in a monitoring plan (WHC-SD-EN-AP-174).

2.3.8.1 Groundwater Flow

The general movement of groundwater beneath the KE and KW Fuel Storage Basins is from the south-southeast to the north-northwest, i.e., toward the Columbia River (see Plate 2). Several factors may

influence the details of groundwater movement beneath the basins, including currently operating facilities that may lose clean water (e.g., fuel storage basin emergency makeup water stored in clearwells) and heterogeneity in the hydraulic properties of the aquifer sediment. The distribution and rate of downward movement of water infiltrating from the surface may be influenced by engineered backfill associated with buildings and pipelines.

2.3.8.2 Tritium

Tritium is a key constituent for monitoring potential leakage from the KE and KW Fuel Storage Basins. The tritium concentration for KE basin shielding water is 2.64 million pCi/L and for KW basin is 59,500 pCi/L (September 1999 measurements). Additional nearby sources for tritium are past-practice disposal sites located at the eastern side of each reactor building. These soil infiltration sites (referred to as gas condensate cribs or French drains) received condensate from reactor atmosphere gases. The condensate contained significant quantities of carbon-14 and tritium. These constituents continue to migrate downward beneath the disposal sites and to contaminate the underlying groundwater. The levels of tritium in gas condensate are comparable to, or even exceed, basin water concentrations, thus complicating the ability to identify the specific source for tritium observed in groundwater near the basins.

Figure 2.3-14 shows the tritium concentrations in KE basin wells that are most likely to detect basin leaks. The entire record for these wells illustrates that leakage during the period 1976 through 1979 must have already passed these wells by the time of their installation because there is no evidence of a tritium pulse. The volume of water lost during that period is estimated at ~57 million liters (WHC-SD-SNF-TI-013, Rev. 0) and the basin water tritium concentration was ~600,000 pCi/L. A subsequent period of leakage in 1993 is clearly revealed by the tritium pulse that passed well 199-K-27. That leakage is estimated at ~341,000 liters (WHC-SD-SNF-TI-013, Rev. 0) and the basin water concentration at that time was ~3 million pCi/L. (The cause for the 1990 tritium pulse in 199-K-27 is not known). Well 199-K-28 apparently does not produce samples that are fully representative of aquifer conditions because it appears to be sufficiently close to well 199-K-27 to have also detected the 1993 leakage.

Tritium is monitored in wells near operating fuel-storage basins. The basins leaked in the past, but there is no evidence of leaks in fiscal year 1999.

Tritium concentrations in groundwater near the KW Fuel Storage Basin are generally lower than near the KE basin (Figure 2.3-15; note order-of-magnitude scale difference). There has been no documented leakage from the KW basin. The tritium observed in well 199-K-34 is most likely attributable to the KW gas condensate crib.

Concentration trends for tritium in groundwater near the KE and KW gas condensate cribs are included here to illustrate the other major sources for tritium in groundwater near the reactors. Figure 2.3-16 shows the tritium concentrations and specific conductance values for groundwater immediately downgradient of the KE gas condensate crib. The concentrations at that location are believed to represent the downward migration of tritium (and carbon-14) in vadose zone moisture. The strong positive correlation between tritium concentrations and specific conductance values suggests that downward migration is promoted by increased infiltration of water from the surface. The increase in specific conductance in groundwater at the KE gas condensate crib has been attributed to infiltration of precipitation (e.g., snow melt) containing ice control salt (WHC-SD-EN-TI-280, Rev. 2).

Figure 2.3-17 shows the same constituents for the KW gas condensate crib. A similar correlation between tritium and specific conductance is absent at this location, and there is currently no clear explanation for the tritium peak (~600,000 pCi/L) that occurred during 1995. Leakage from the KW Fuel Storage Basin is not a possibility because basin water concentrations

were only one-tenth the concentrations observed in the well shown in Figure 2.3-17. Specific conductance at the KW crib is significantly higher than natural background (~650 versus ~350 µS/cm for background).

2.3.9 Groundwater Remediation

A groundwater pump-and-treat system began operating in the 100 K Area in October 1997. The extraction wells are located between the 116-K-2 liquid waste disposal trench and the Columbia River. The treatment system removes chromium from the extracted groundwater. The treated effluent is injected back into the aquifer at an upgradient location. This interim remedial action is described in a record of decision for the 100-KR-4 Operable Unit (ROD 1996b), which also includes remedial actions in the 100 D and 100 H Areas (100-HR-3 Operable Unit).

The goal of the pump-and-treat system in the 100 K Area is to reduce the amount of chromium reaching the Columbia River, where the chemical might harm young salmon.

2.3.9.1 Interim Remedial Action Objectives

The record of decision (ROD 1996b) contains the following specific remedial action objectives that pertain to operation of the pump-and-treat system:

- protect aquatic receptors in the river bottom substrate from contaminants in groundwater entering the Columbia River
- protect human health by preventing exposure to contaminants in the groundwater
- provide information that will lead to the final remedy.

The record of decision stipulates that the interim action pump-and-treat system will continue to operate until the selection of a final remedy, or when U.S. Environmental Protection Agency and Washington State Department of Ecology are satisfied that termination (or intermittent operation) is appropriate. Conclusion of the pump-and-treat system occurs when sampling results indicate that the concentration of hexavalent chromium is below 22 µg/L in the compliance wells, and the data indicate that the concentration will remain below the compliance value. Other criteria for terminating pump-and-treat operations include the effectiveness of the treatment technology not justifying further operation or the availability and feasibility of an alternate and superior treatment technique (ROD 1996b).

2.3.9.2 Remediation Progress During Fiscal Year 1999

Progress was made toward achieving the remedial action objectives at the 100-KR-4 Operable Unit in fiscal year 1999. The pump-and-treat operation is successfully intercepting and capturing groundwater containing elevated concentrations of hexavalent chromium. This prevents that groundwater from discharging into the Columbia River. Figure 2.3-18 shows the flow lines and hydraulic capture estimated to occur during a low-flow period in the Columbia River (November 1998), when groundwater flow to the Columbia River is greatest. A description of the numerical modeling used to create this figure is presented in DOE/RL-99-13.

Although designed primarily to prevent or reduce the amount of contaminated groundwater that discharges into the Columbia River, the pump-and-treat system also reduces overall contamination in the operable unit by the process of contaminant mass removal. The pump-and-treat program collects hydraulic monitoring data, contaminant monitoring data, and treatment system operation data to assess treatment system performance and to provide the basis to select the final remedy as part of the record of decision.

During fiscal year 1999, the pump-and-treat system extracted 296.2 million liters of groundwater and removed 37.6 kilograms of hexavalent chromium (Table 2.3-1). Extraction well operating flow rates averaged between 95.5 and 106.5 liters per minute for the year, with maximum sustained pumping rates

ranging between 115.1 and 174.4 liters per minute at the different wells. Average concentrations for hexavalent chromium in the extraction wells ranged between 74 and 185 μg/L, with an average influent concentration of 136 μg/L delivered to the treatment system during the fiscal year. The effluent concentration averaged 9 μg/L during the year, with hexavalent chromium being undetected during 16 of the 55 individual effluent sampling events.

A total of 69.7 kilograms of hexavalent chromium has been removed since startup of the pump-and-treat system in October 1997. An estimate for the total amount of chromium in the plume targeted for remedial action suggests a mass of 250 kilograms (DOE/RL-94-95, Rev. 1). Uncertainty in this estimate is primarily associated with the lack of data on the vertical distribution of chromium in the aquifer and the distance inland to which the plume extends. An order-of-magnitude estimate for the rate at which chromium is discharging to the Columbia River via groundwater flow is 0.04 kilograms per day (BHI-00469). This equates to a total mass flux of ~29 kilograms that would have entered the Columbia River since October 1997. The actual flux is believed to be less because of the pump-and-treat system.

2.3.9.3 Influence on Aquifer Conditions

The concentration of hexavalent chromium measured in several of the six extraction wells exhibited a slight downward trend during the last 2 years. However, the concentration has not declined below 22 μg/L, the target concentration listed in the record of decision. After rebounding from consecutive flood stage years in the Columbia River in 1996 and 1997, the concentration of hexavalent chromium exhibited a downward trend in five of the six extraction wells between May 1998 and July 1999, and then a reversal of trend began in several wells (Figures 2.3-19 and 2.3-20). An explanation for the reversal to an increasing trend is not currently available. Extraction well 199-K-120A has exhibited a constant trend since operations began.

Concentrations have remained relatively constant or increased slightly over the last 2 years in three of the five compliance wells (Figure 2.3-21). Concentrations averaged 61, 115, and 97 μg/L, in wells 199-K-18, 199-K-20, and 199-K-112A, respectively, during fiscal year 1999. Except for the most recent sampling results, the trends observed in the other two compliance wells, 199-K-114A and 199-K-117A, appear to behave similarly.

Because the elevated concentration of hexavalent chromium persisted in the compliance wells, the annual summary report (DOE/RL-99-13) recommended continued operation of the pump-and-treat system. A new monitoring well (199-K-126A) was installed northeast of the trench following a recommendation to define the downgradient extent of the plume (DOE/RL-97-96). Additional plans are in progress to convert compliance well 199-K-112A to an extraction well and thereby increase the capture area beyond the northern end of the trench. The declining concentration of hexavalent chromium measured in the extraction wells indicates that the pump-and-treat system is lowering the concentration of hexavalent chromium in the aquifer, but the rate of decline indicates that many years of pumping may be required before the remedial action objectives have been entirely satisfied.

2.3.10 Water Quality at Shoreline Monitoring Locations

Groundwater samples are collected annually from riverbank seepage sites during the seasonal low river stage and from aquifer sampling tubes located near the low-river stage shoreline.

2.3.10.1 Aquifer Sampling Tubes

The Environmental Restoration Contractor installed aquifer sampling tubes at ~300-meter intervals along the 100 K Area shoreline during the fall 1997. One to three polyethylene tubes were installed at various depths at each tube site near the low-water shoreline. Samples collected from the tubes during the fall 1998 sampling were screened for carbon-14, gross beta, hexavalent chromium, nitrate, and tritium.

Hexavalent chromium concentrations ranged from a high of 112 μg/L (filtered sample) downgradient of

the 116-K-2 trench to undetected from a tube sample slightly upriver of the 100 K Area. Nitrate concentrations from samples collected downgradient of the 116-K-2 trench ranged from 10 mg/L to undetected. Tritium concentrations ranged from 4,500 pCi/L from a tube site upstream of the 100 K Area to undetected downgradient of the 116-K-2 trench. Gross beta concentrations ranged from 4 pCi/L downgradient of the KW Reactor to 55 pCi/L downgradient of the 116-K-2 trench.

The maximum carbon-14 concentration was 680 pCi/L in a sample collected from a tube downgradient of the KW retention basins. This tube site is also downgradient of well 199-K-33 where samples have contained over 10,000 pCi/L carbon-14.

2.3.10.2 Riverbank Seepage

The CERCLA monitoring project collected samples from one riverbank seepage site (SK-062) along the 100 K Area shoreline during October 1998. This site is near the river water intake structure for KW Reactor. Maximum concentrations of contaminants of concern were: 4.95 pCi/L gross beta, 29 mg/L nitrate, 0.03 pCi/L strontium-90, and 11,900 pCi/L tritium. Results for chromium are not available. Tritiuim has declined in concentration at this seepage site. The median concentration during the period 1993 to 1997 was 18,000 pCi/L (PNNL-12088, Table A.7).

2.3.10.3 Special Shoreline Studies

Independent researchers from the Government Accountability Project sampled mulberry bush leaves from a shoreline location near the southwestern end of the 116-K-2 liquid waste disposal trench (GAP 1999a). They speculate that the radioactivity observed in their samples is related to an underground stream that transports strontium-90 very rapidly from past-practice sources to the Columbia River. No field data exist to support their speculation, other than the vegetation samples. The bushes sampled are located in an area of extensive former surface contamination caused by breakouts from the nearby 116-K-1 crib and 116-K-2 liquid waste disposal trench (WHC-SD-EN-TI-239; historical photo is available on the internet at http://pnl45.pnl.gov/100k).

Table 2.3-1. Summary of 100 K Area Pump-and-Treat Performance for Fiscal Year 1999

Well or Sample Location	Annual Average Flow Rate (L/min)	Maximum Sustained Flow Rate (L/min)	Total Volume Pumped (x 10^6 L)	Average Hexavalent Chromium Concentration (µg/L)	Hexavalent Chromium Mass Removed (kg)
199-K-113A	95.5	115.1	46.3	74	3.0
199-K-115A	103.2	157.2	53.3	130	6.4
199-K-116A	106.5	174.4	54.5	185	9.6
199-K-119A	95.5	100.7	40.8	155	6.0
199-K-120A	101.2	163.6	52.2	105	5.0
199-K-125A	102.9	157.4	49.1	161	7.5
K-Influent	574	745	296.2	136	37.6
K-Effluent	574	745	296.2	9	--

Data Source: Project Specific Database for the 100-KR-4 Operable Unit.

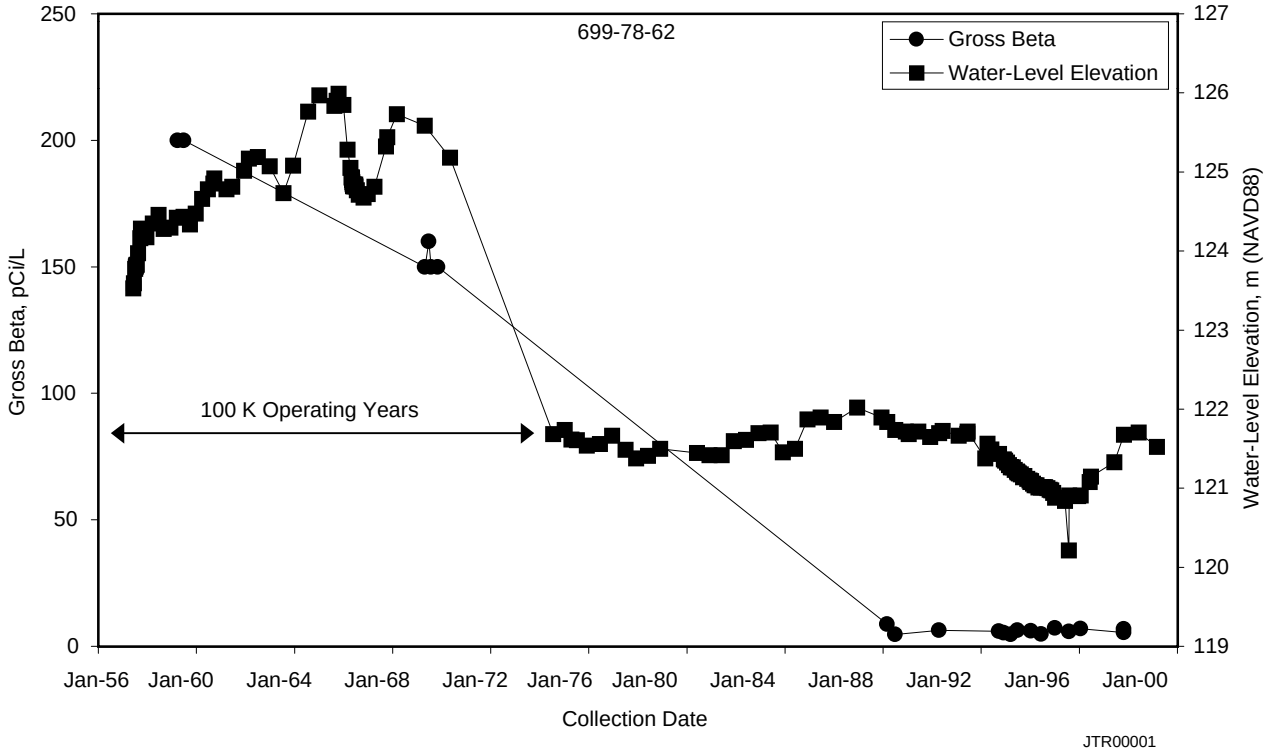


Figure 2.3-1. Influence of Groundwater Mound During the 100 K Operating Years, 1955 to 1971

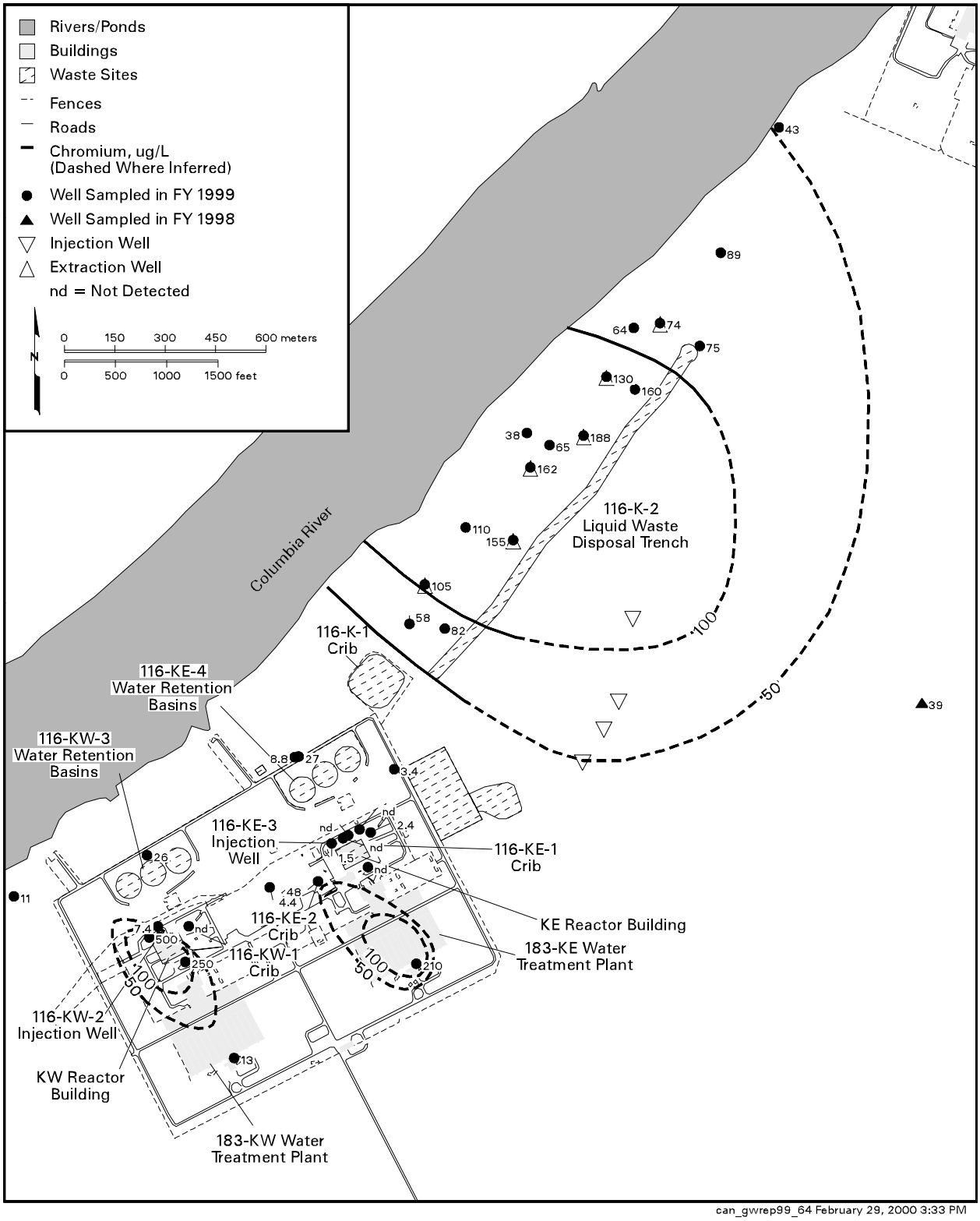


Figure 2.3-2. Average Chromium Concentrations in 100 K Areas, Top of Unconfined Aquifer

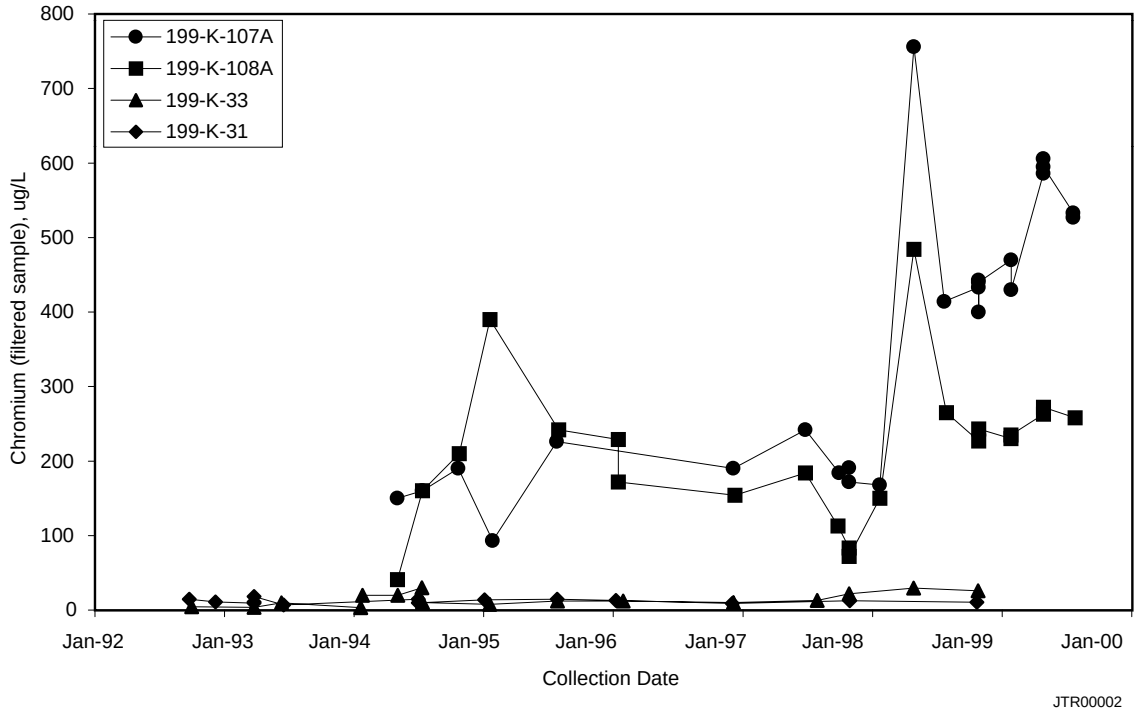


Figure 2.3-3. Chromium in Wells Near KW Reactor

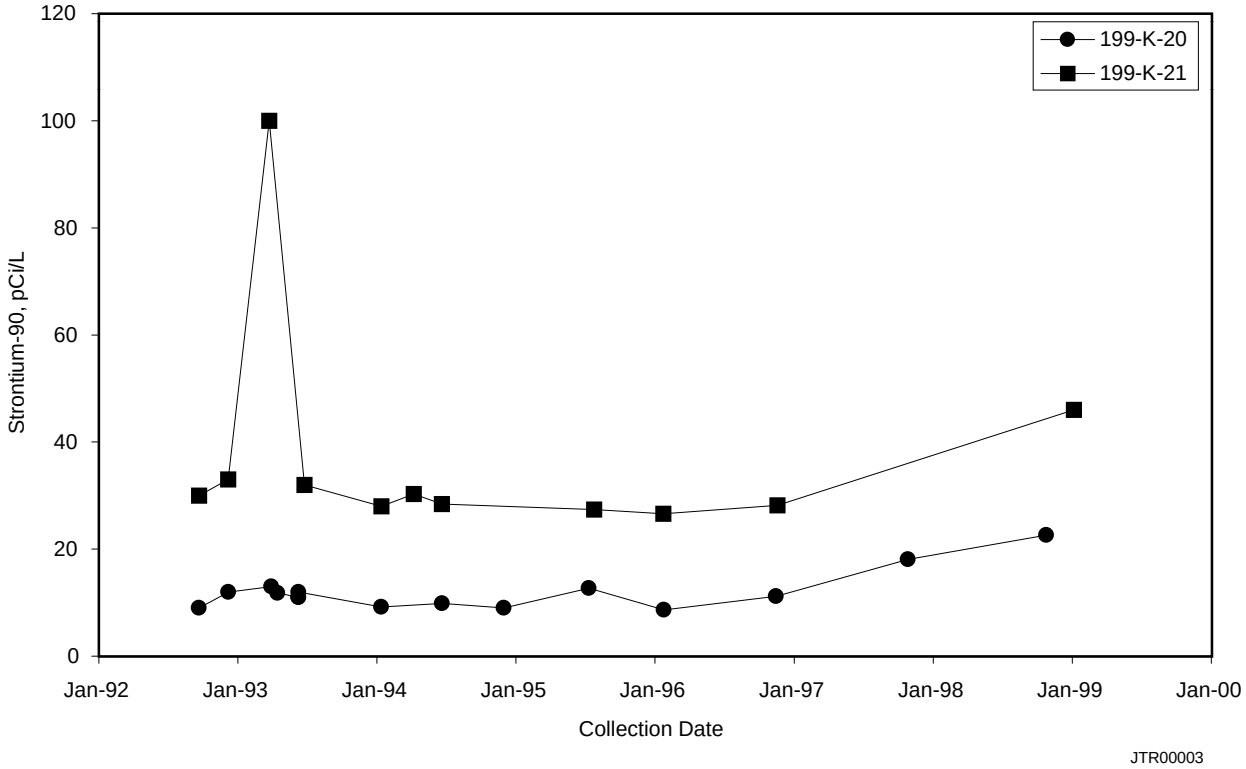


Figure 2.3-4. Strontium-90 in Wells Near 116-K-2 Liquid Waste Disposal Trench

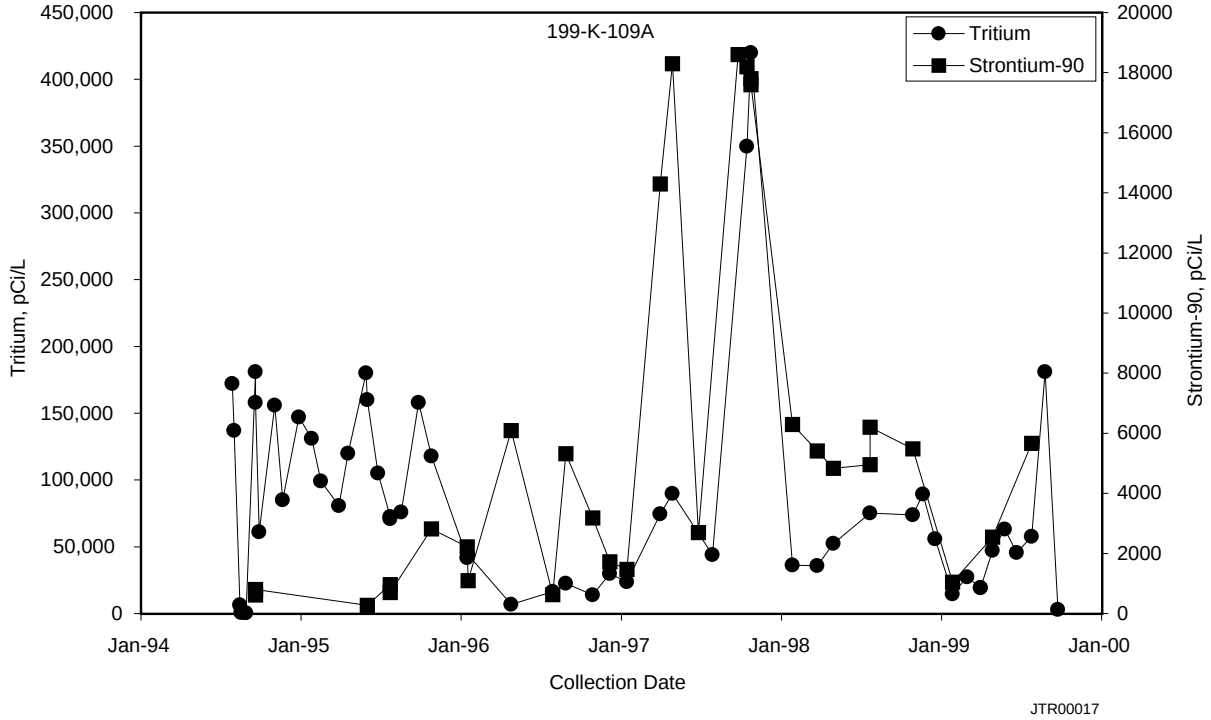


Figure 2.3-5. Strontium-90 and Tritium in Wells Near KE Reactor

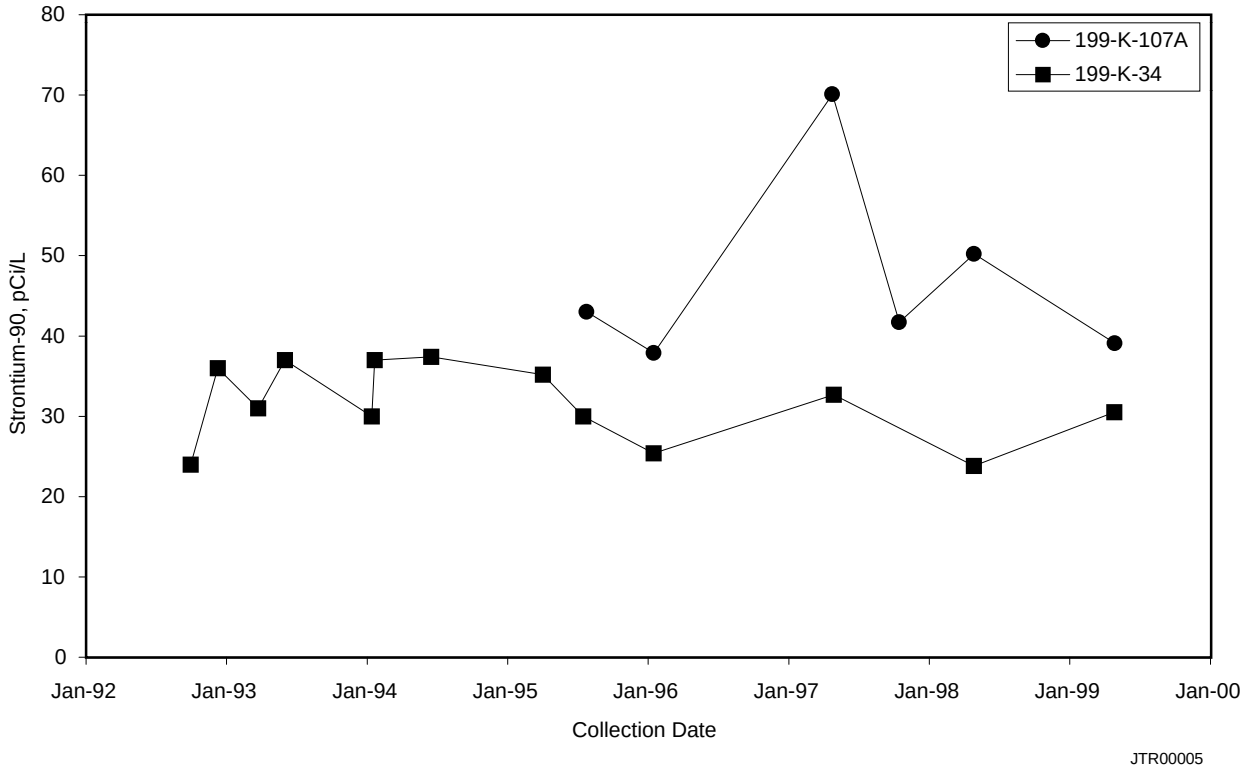
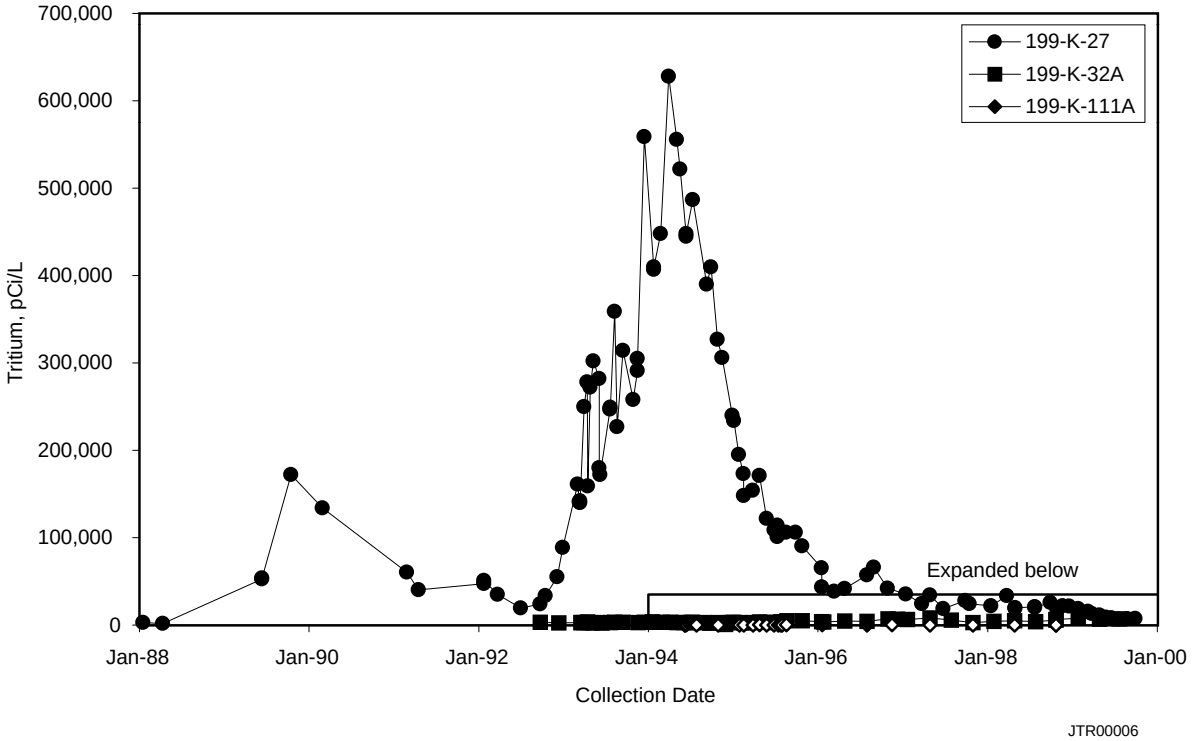


Figure 2.3-6. Strontium-90 in Wells Near KW Reactor



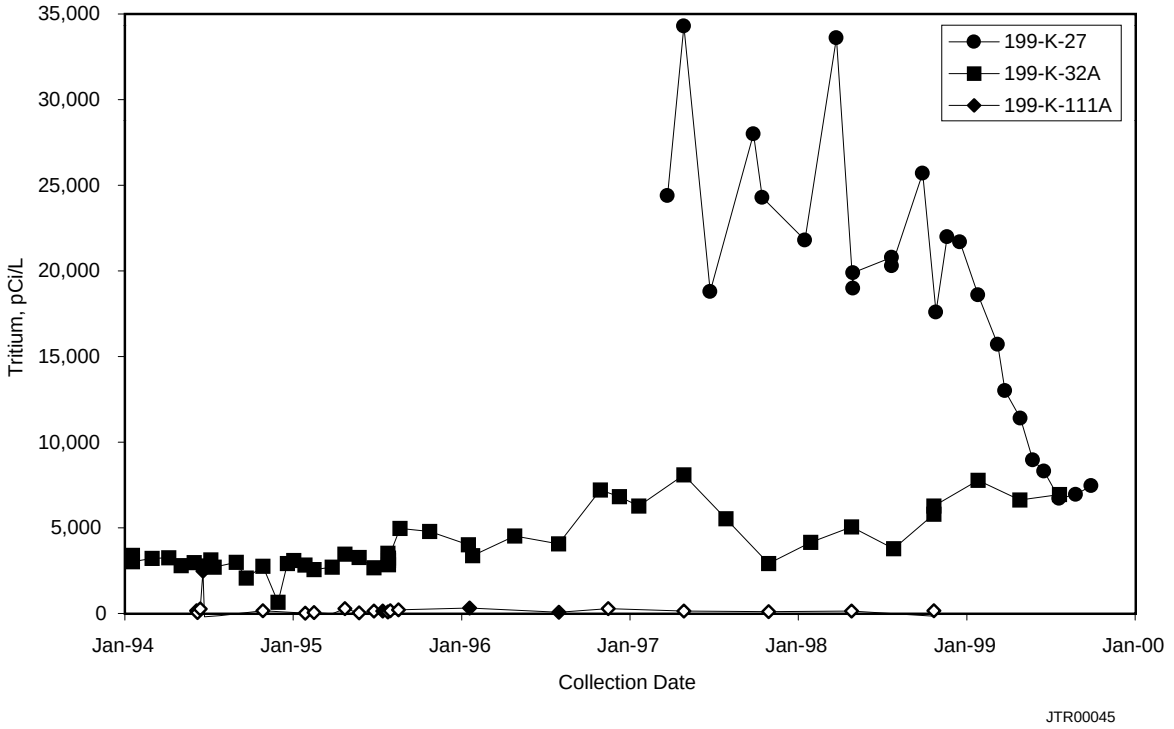


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Figure 2.3-7. Tritium in Wells Downgradient of KE Fuel Storage Basin

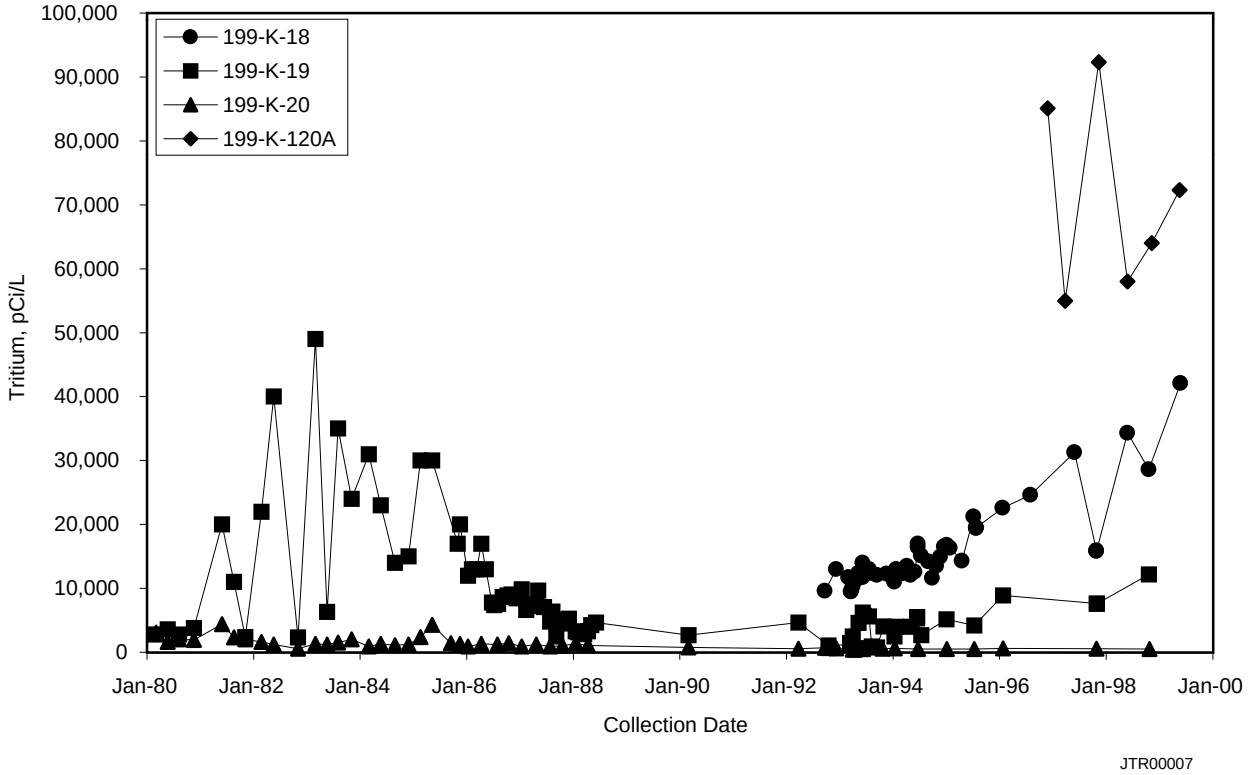


Figure 2.3-8. Tritium in Wells Northeast of KE Reactor

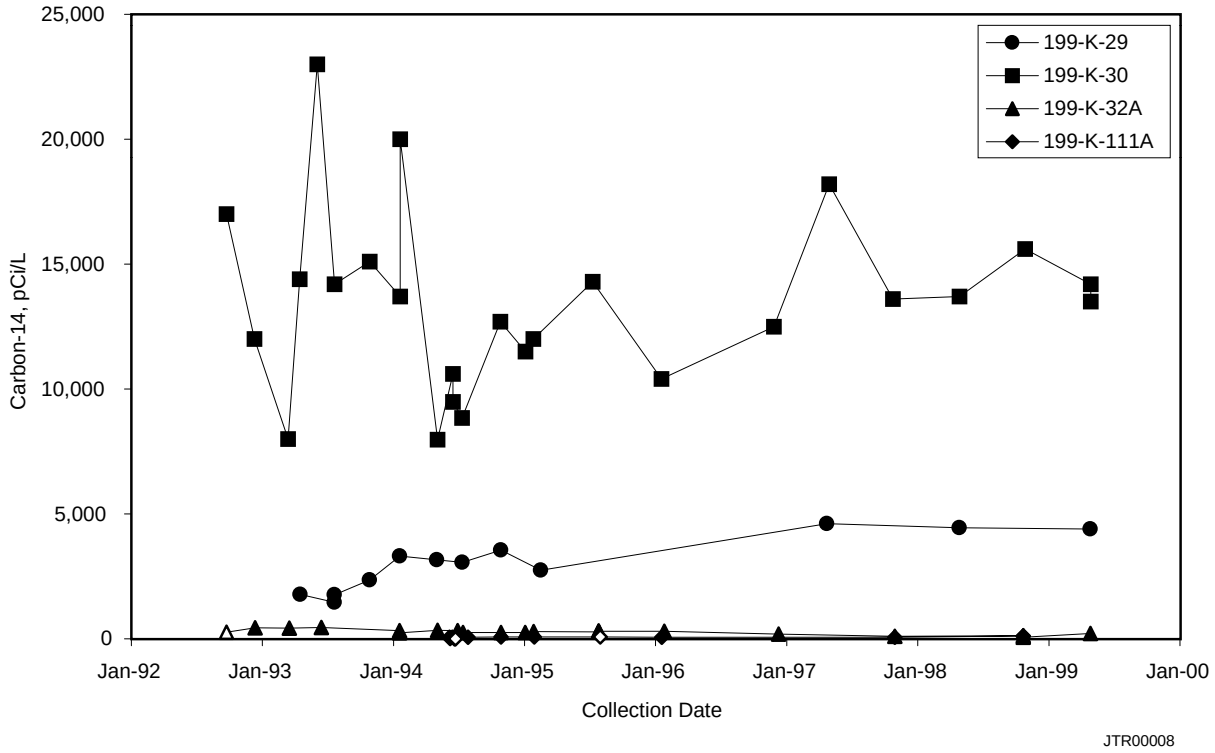


Figure 2.3-9. Carbon-14 in Wells Near KE Gas Condensate Crib

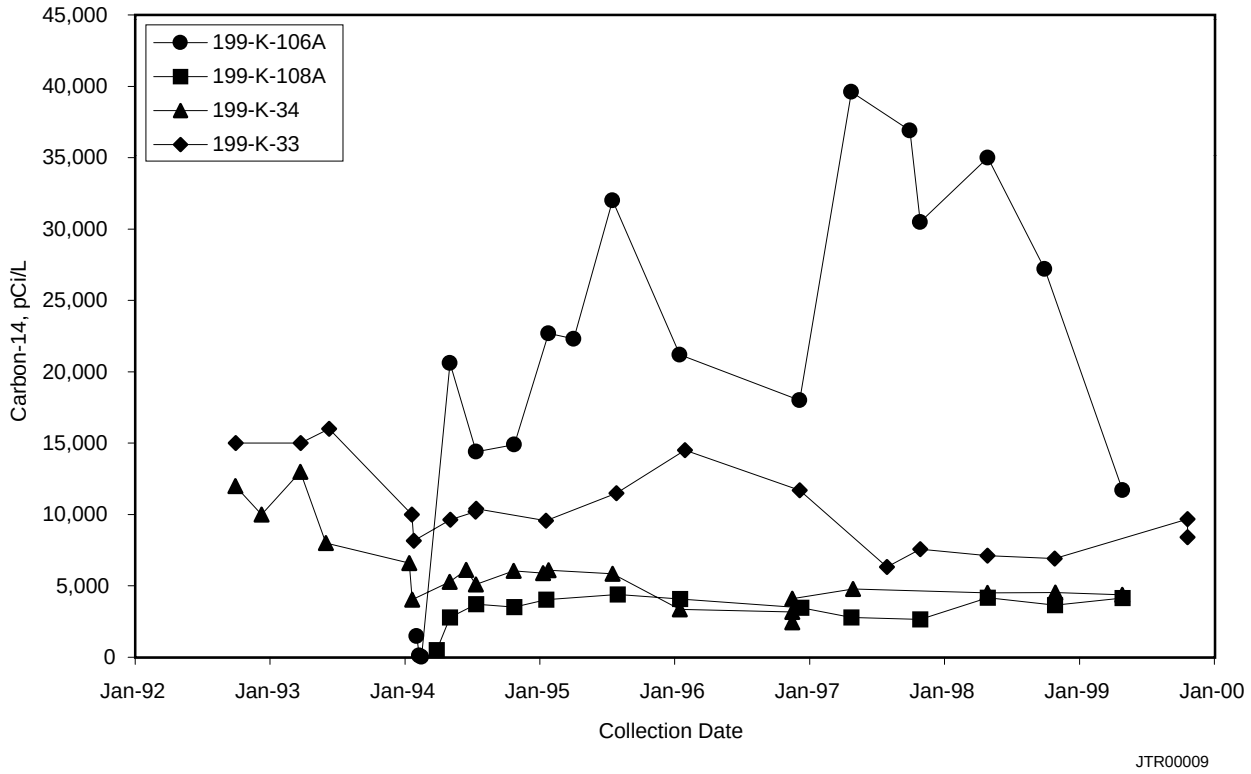


Figure 2.3-10. Carbon-14 in Wells Near KW Gas Condensate Crib

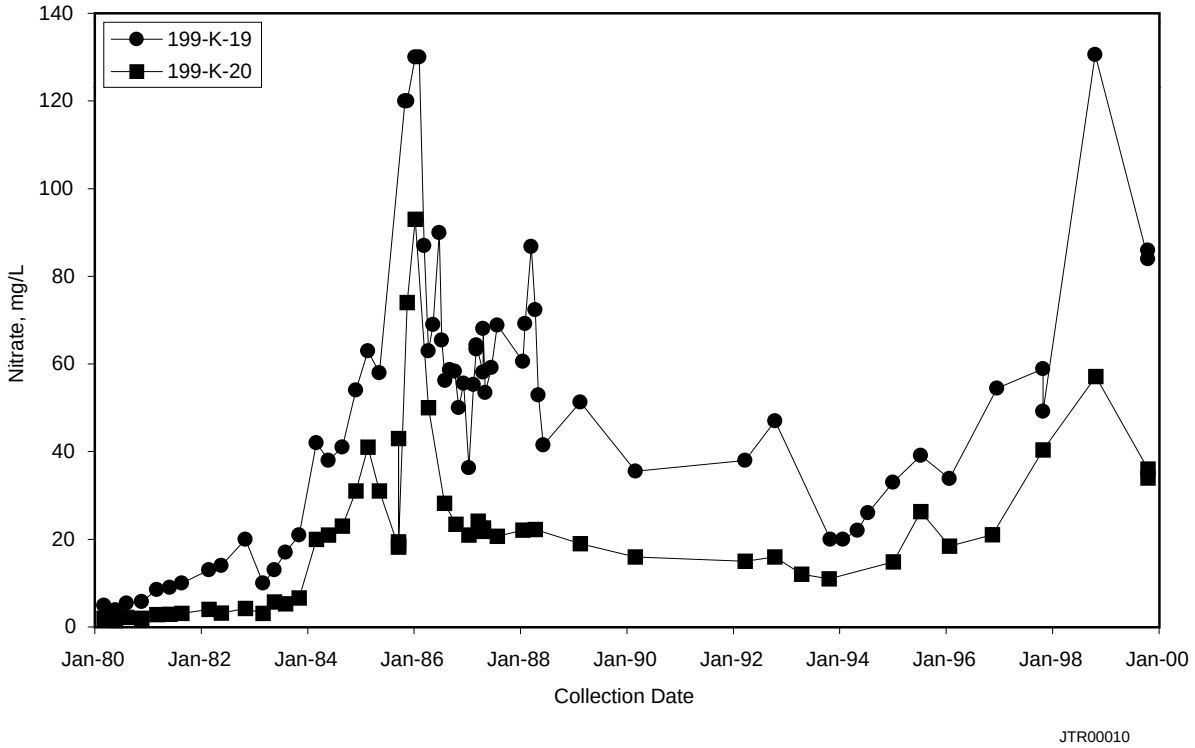


Figure 2.3-11. Example of Increasing Nitrate in Wells at 100 K Area

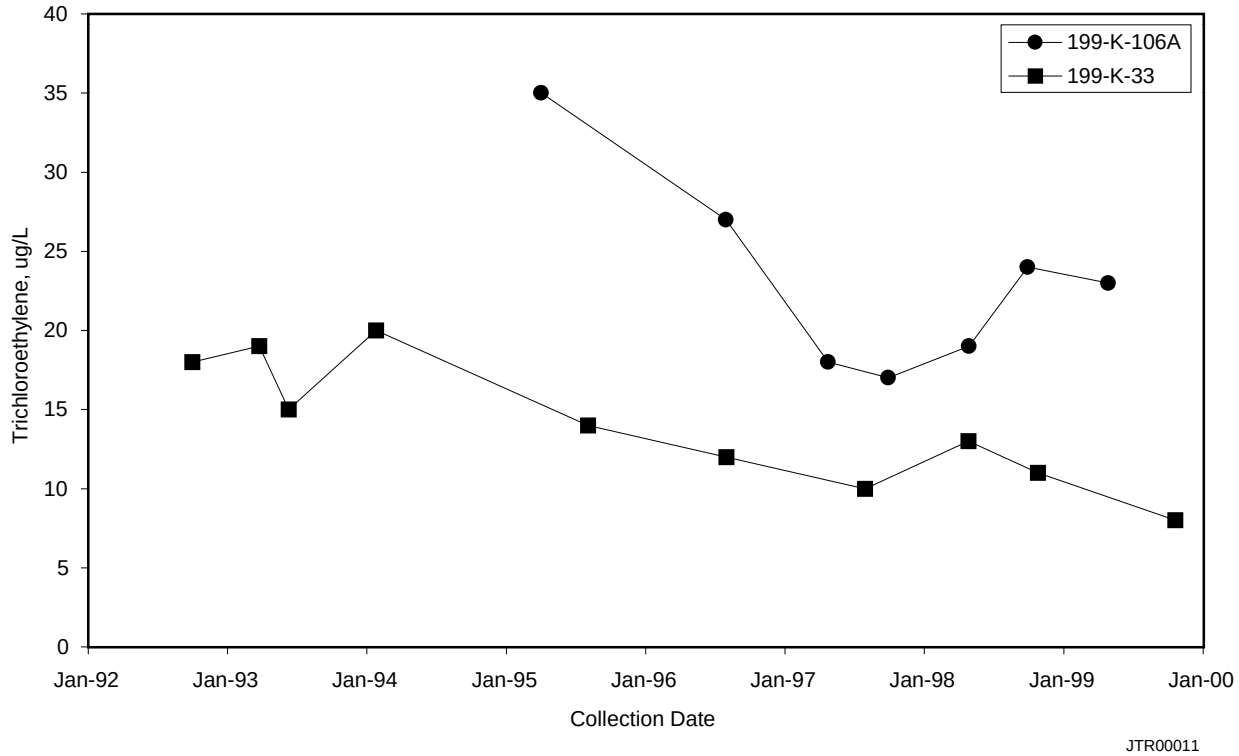


Figure 2.3-12. Trichloroethylene in Wells Near KW Reactor

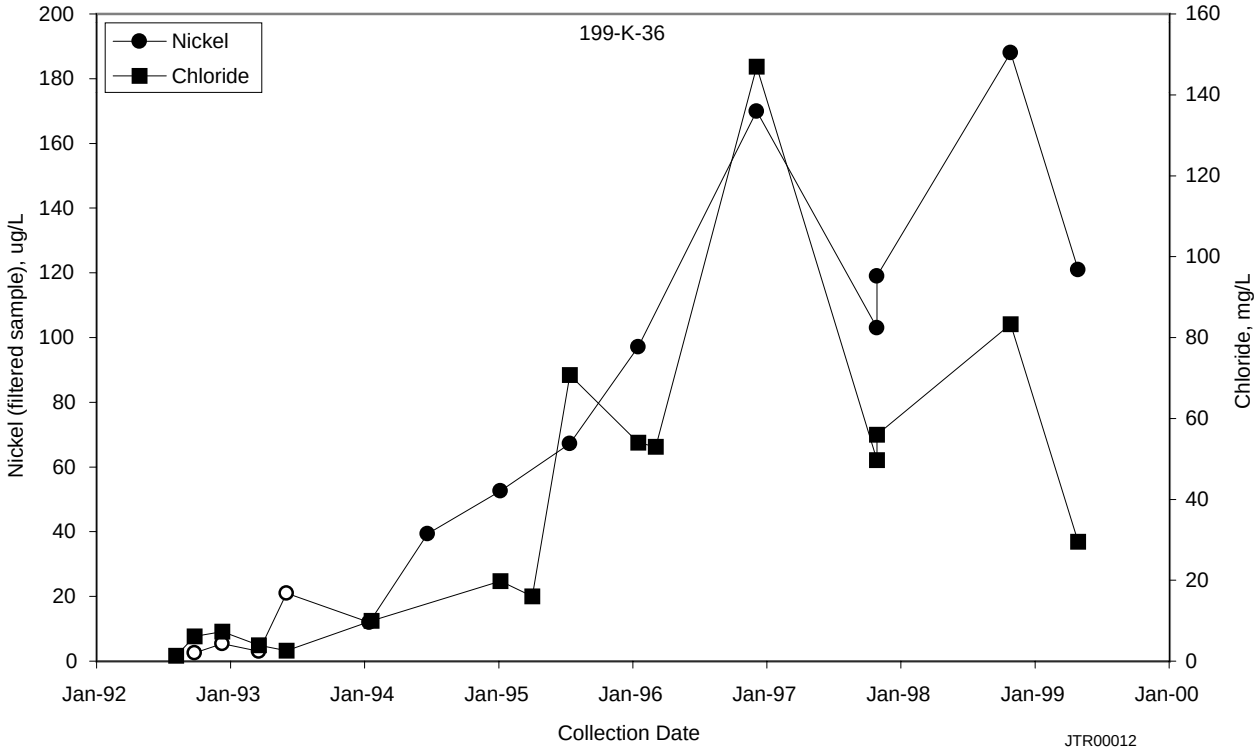
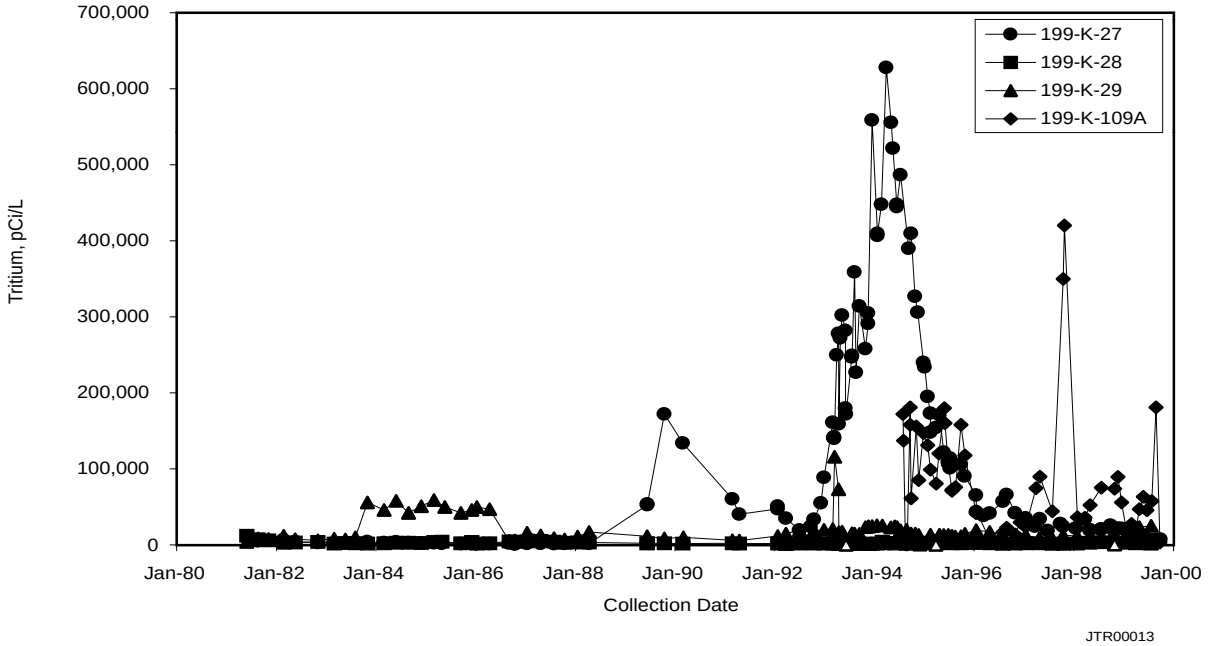


Figure 2.3-13. Nickel in Well 199-K-36



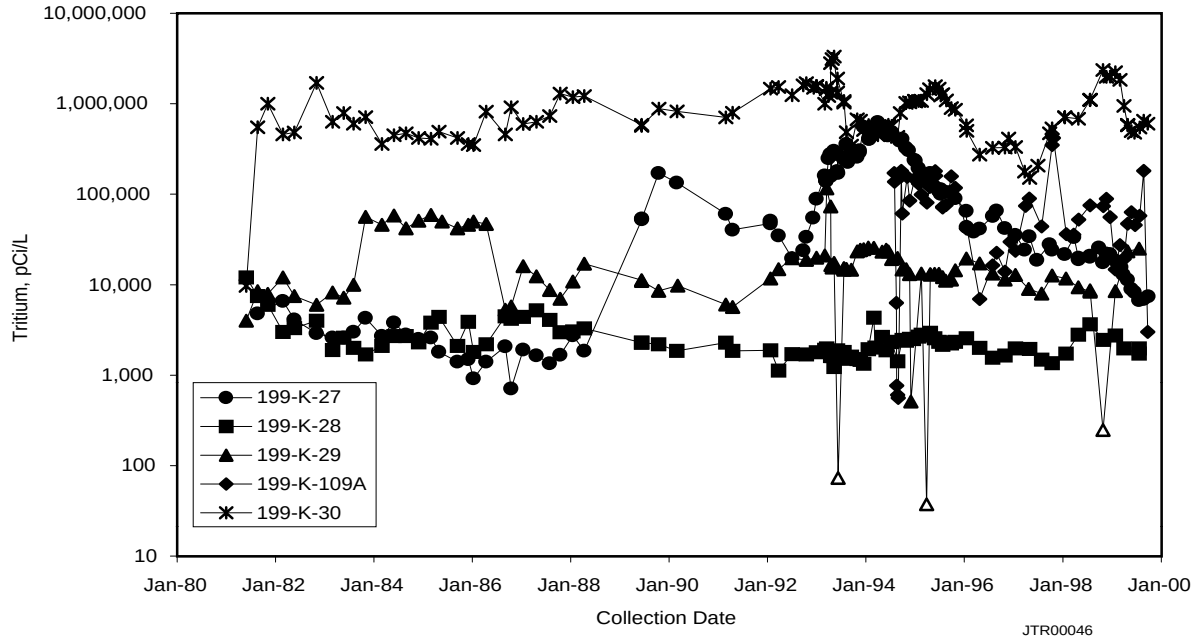
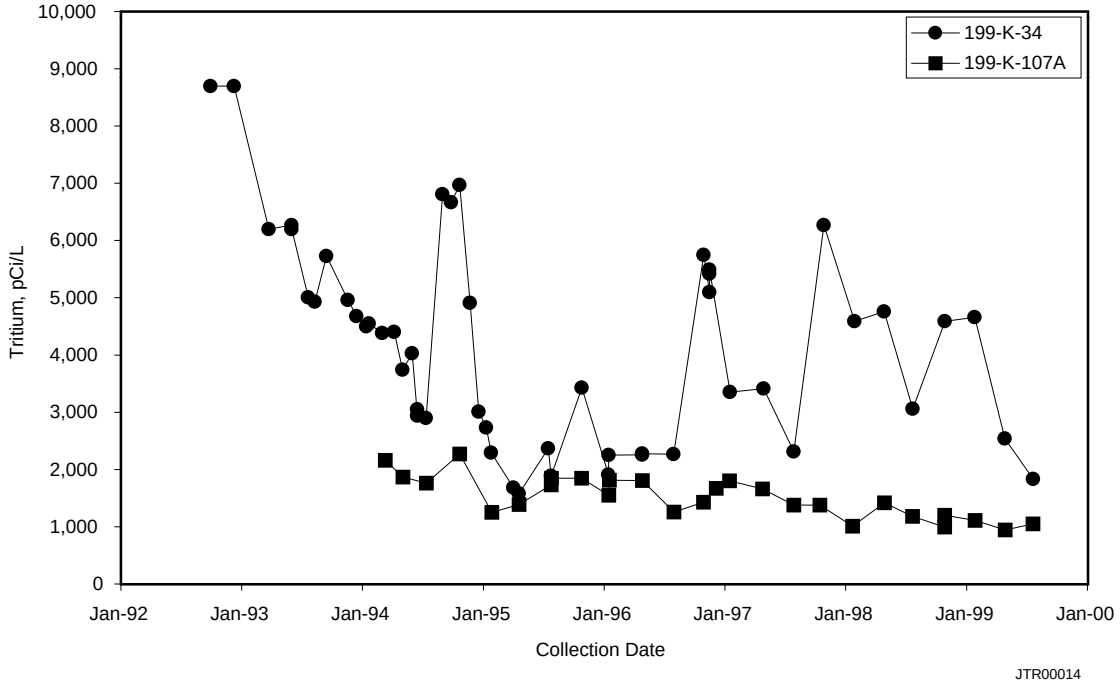


Figure 2.3-14. Tritium in Wells Adjacent to KE Fuel Storage Basin (note logarithmic scale on lower plot)



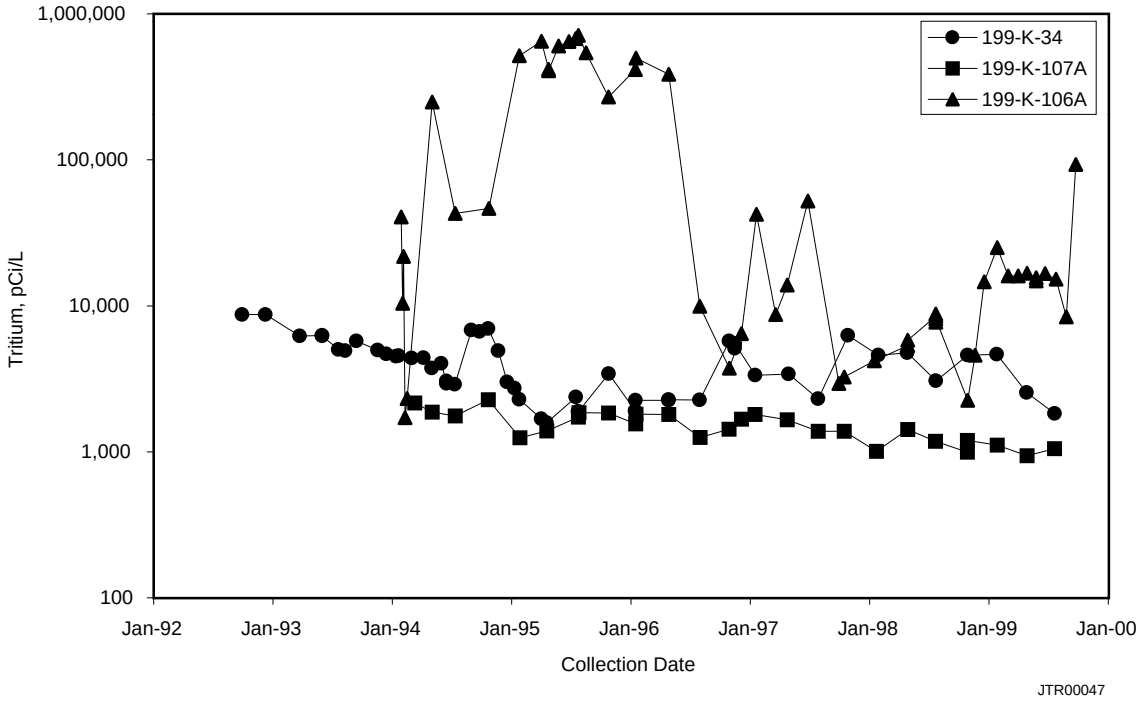


Figure 2.3-15. Tritium in Wells Adjacent to KW Fuel Storage Basin (note logarithmic scale on lower plot)

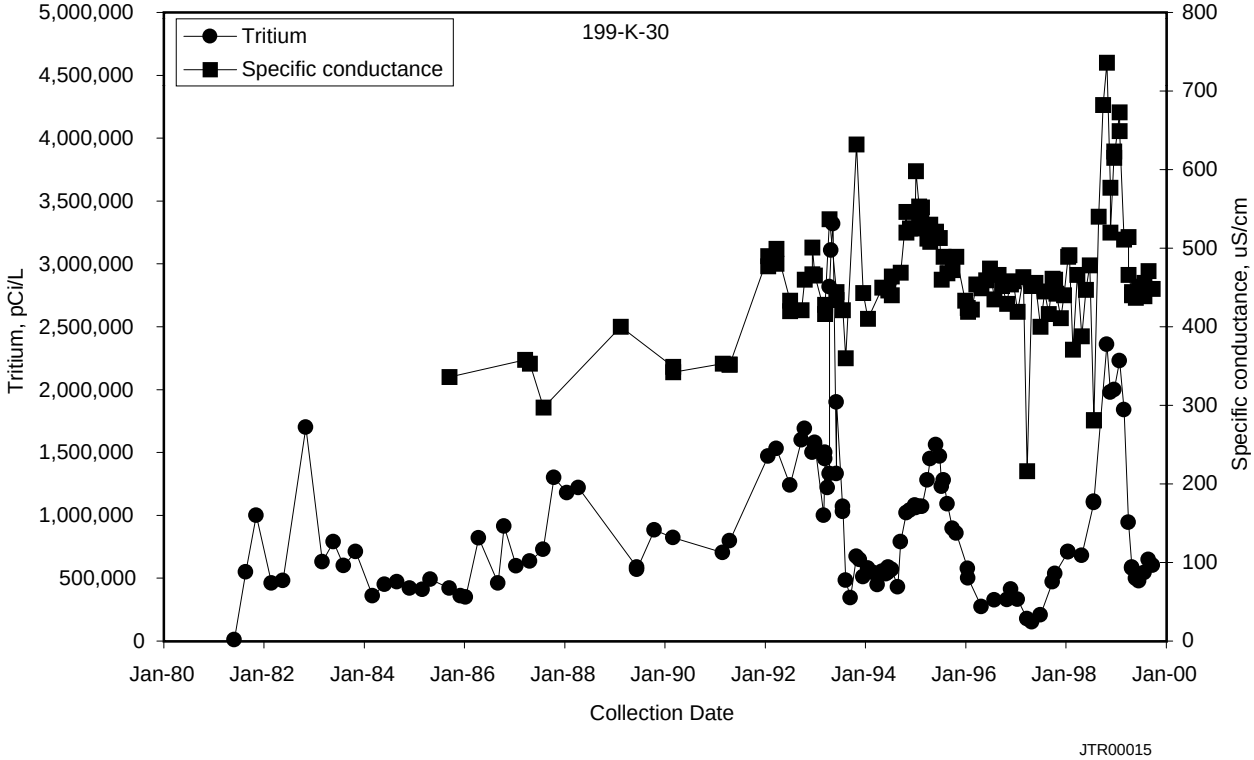


Figure 2.3-16. Tritium and Specific Conductance in Wells Near KE Gas Condensate Crib

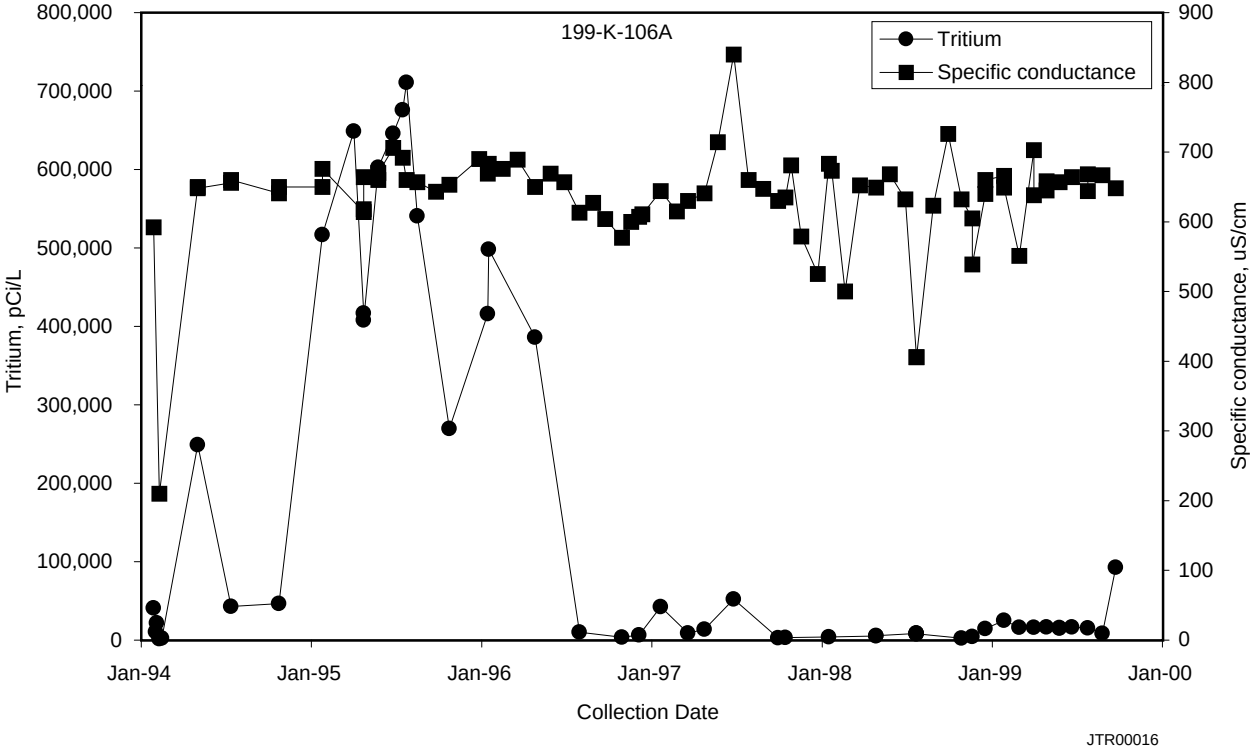


Figure 2.3-17. Tritium and Specific Conductance in Wells Near KW Gas Condensate Crib

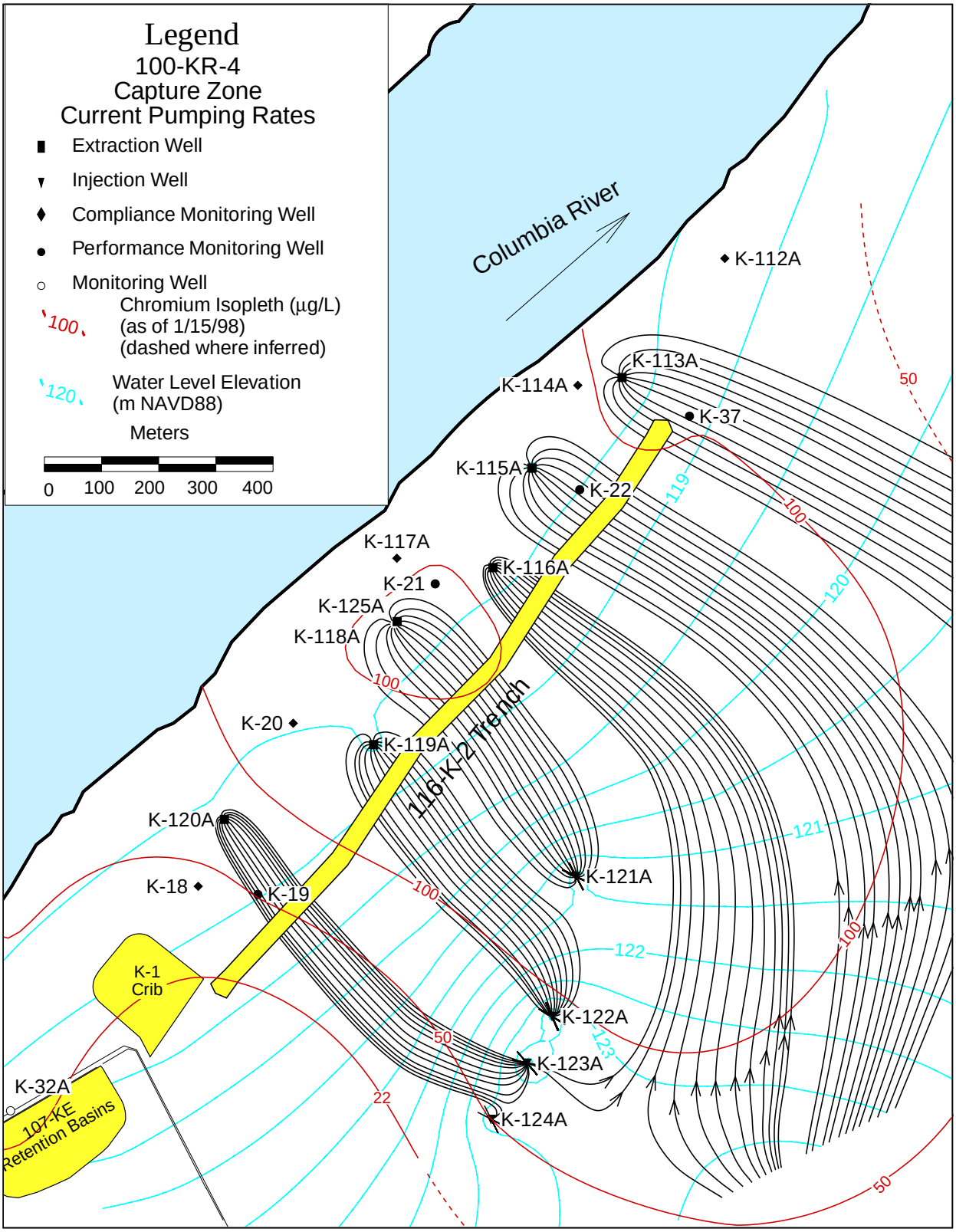


Figure 2.3-18. Capture Zone from 100-KR-4 Pump-and-Treat System (DOE/RL-99-13)

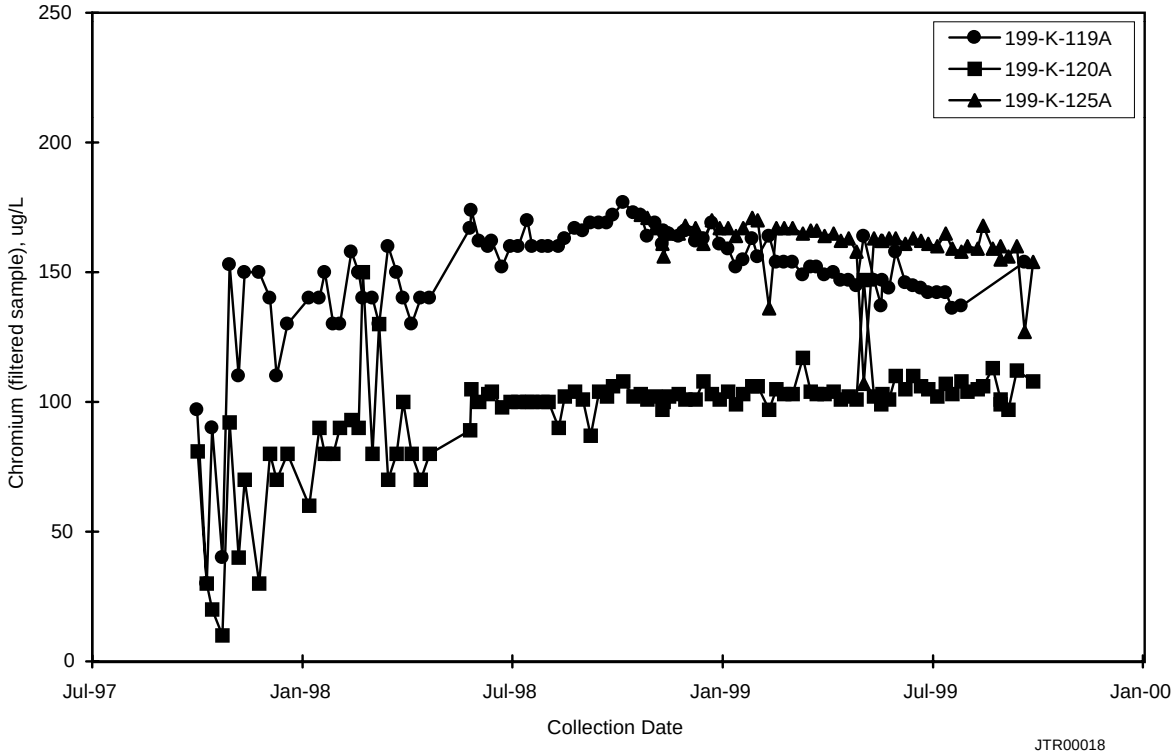


Figure 2.3-19. Chromium in Upstream Near-River Extraction Wells

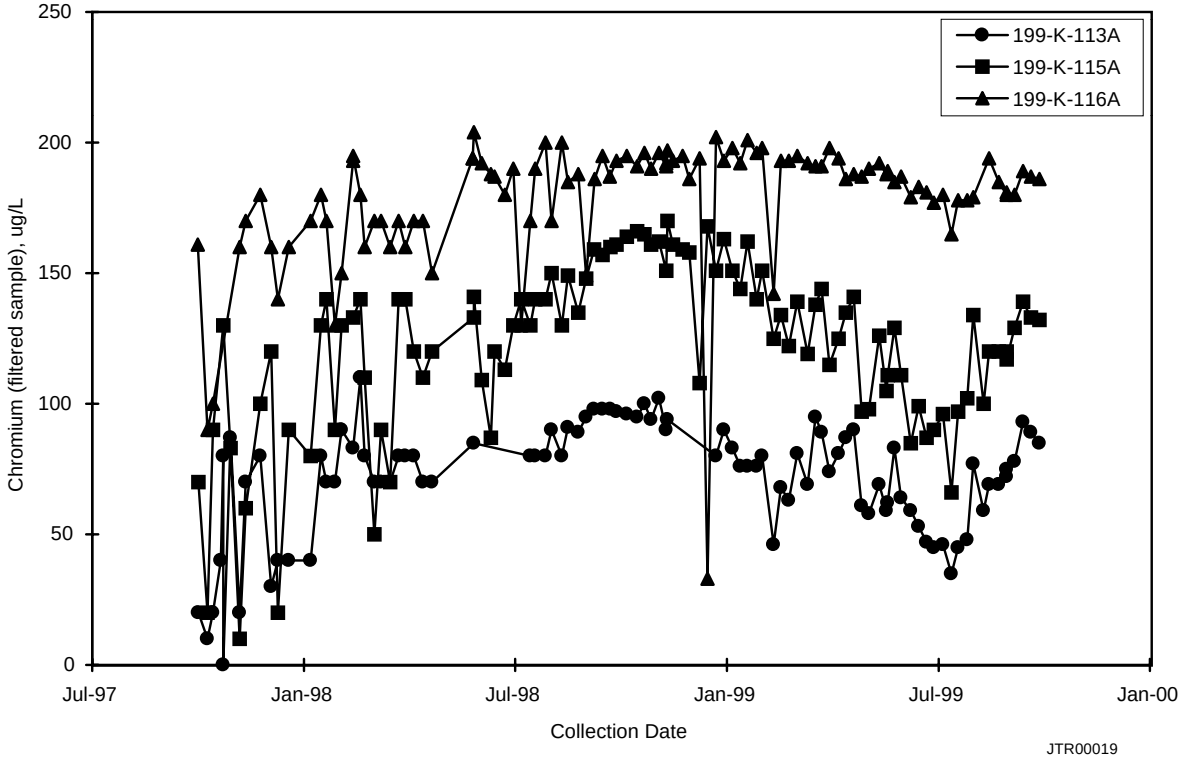


Figure 2.3-20. Chromium in Downstream Near-River Extraction Wells

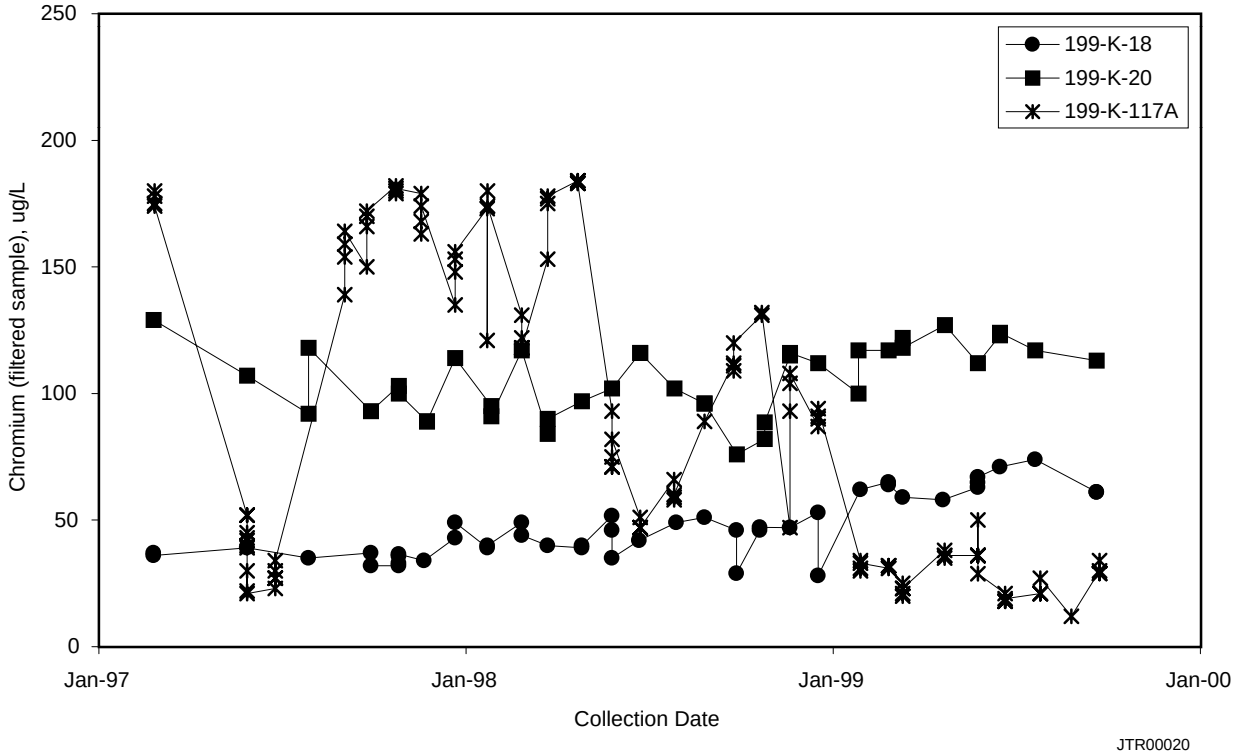


Figure 2.3-21. Chromium in Compliance Wells